

## Comparing Python and R tools for running the X13-ARIMA-SEATS procedures

Michael Boldin, June 2022

The code below demos the Python RPY2 module to turn the ‘Python or R?’ question into a ‘Python and R’ solution, using

- \* JUPYTER Notebooks, for creating, editing, organizing and running code
- \* Census seasonal adjustment binary: x13as.exe \* R SEASONAL package library, sets up calls to x13as.exe
- \* Python STATSMODELS module, sets up calls to x13as.exe
- \* Python Module RPY2 – allows R and Python to work together plus common Python modules such as pandas, datetime, matplotlib ...

The code below:

1. Loads Python modules and sets up RPY2
2. Runs the R seasonal adjustment process on the Airline data
3. Runs Python seasonal adjustment process on GDP data
4. Passes Python data to R to run the seasonal adjustment process
5. Compares results from Python and R runs

The steps assume the X13-ARIMA-SEATS binaries are set up, and recognizes that only the HTML output mode of X13-ARIMA-SEATS is supported by the latest R seasonal package. Also only X11 methods are available for the module that uses Python as the interface to the X13-ARIMA-SEATS binaries, as it was developed for X12-ARIMA that did not have the SEATS option. By passing data back and forth between Python and R, the SEATS options can be used and explored through the R interface, which is especially useful when your data management steps are in Python.

For code, write to [mdboldin@gmail.com](mailto:mdboldin@gmail.com)

```
[1]: ## Jupyter notebook with PYTHON and R code examples for seasonal adjustment
## procedures that use interfaces with X13-ARIMA-SEATS binaries
## Michael Boldin (Lehigh University)
## June 2022 (revised 6/16/2022)
## for the Census Bureau's June 8 & 9, 2022
## ESMD Seasonal Adjustment Practitioners Workshop
```

```
[2]: ## Python modules set up

import os
import datetime as dt
import time
import numpy as np

import matplotlib.pyplot as plt

from IPython.core.interactiveshell import InteractiveShell
InteractiveShell.ast_node_interactivity = "all"
```

```

print('Python set up modules loaded')
print('Python version:\n', os.sys.version, '\nPlatform: ', os.sys.platform)
print("Base directory path:", os.getcwd() )
print("Date/time:", dt.datetime.now())

```

```

Python set up modules loaded
Python version:
 3.7.8 (tags/v3.7.8:4b47a5b6ba, Jun 28 2020, 08:53:46) [MSC v.1916 64 bit
(AMD64)]
Platform: win32
Base directory path: C:\Users\mdbol\Desktop\Notebooks\SeasAdj
Date/time: 2022-06-16 15:49:53.286998

```

[3] : *## PANDAS and STATSMODELS*

```

import pandas as pd
import statsmodels as sma
import statsmodels.api as sm

print('PANDAS version:', pd.__version__)

print()
sm_version = sma._version.version_json
print('STATSMODELS version info', sm_version)

```

```
PANDAS version: 1.0.3
```

```
STATSMODELS version info
{
  "date": "2022-02-08T18:05:00+0000",
  "dirty": false,
  "error": null,
  "full-revisionid": "c87540849e8ac616cf768353cc156d3478d0fc93",
  "version": "0.13.2"
}
```

[4] : *## PYTHON -- Check/Set R\_HOME as a system environment variable*

```

os.environ['R_HOME'] = r'C:\Program Files\R\R-4.0.2'

## X13 binary path for R
x13_path = r'C:\Users\mdbol\Desktop\WinX13\x13binaries'
os.environ['X13_PATH'] = x13_path
## Note: Need the HTML X13 version (as x13ashtml.exe ) for the R seasonal package
## and the non-HTML X13 version (x13as.exe) for Python

```

```

r_home = os.environ.get("R_HOME")
print('R_HOME:', r_home)

print('X13 PATHs:', x13_path, ' | ', os.environ.get("X13_PATH") )

```

R\_HOME: C:\Program Files\R\R-4.0.2  
 X13 PATHs: C:\Users\mdbol\Desktop\WinX13\x13binaries |  
 C:\Users\mdbol\Desktop\WinX13\x13binaries

```

[5]: print('Set up RPY2')

import rpy2
import rpy2.robj as ro
import rpy2.rinterface as ri
from rpy2.robj import r

## Extra RPY2 items
from rpy2.robj.packages import importr
from rpy2.robj import pandas2ri
from rpy2.robj.vectors import IntVector, FloatVector
import rpy2.ipython.html
import rpy2.robj.lib.ggplot2 as gp
from rpy2.ipython.ggplot import image_png

ri.initr()
pandas2ri.activate()

print('RPY2 version:', rpy2.__version__)

print('R location:', rpy2.situation.get_r_exec(r_home))

```

Set up RPY2  
 C:\Users\mdbol\AppData\Local\Programs\Python\Python37\lib\site-packages\rpy2\robj\packages.py:367: UserWarning: The symbol 'quartz' is not in this R namespace/package.  
 "The symbol '%s' is not in this R namespace/package." % name

RPY2 version: 3.4.2  
 R location: C:\Program Files\R\R-4.0.2\bin\x64\R

After loading the RPY2 module, we activate the ryp2.ipython features that lets us use special 'magic' commands in a Jupyter cell. With these features and a Jupyter-RPY2-R connection, we can use %%R to process R code in notebook that otherwise processes Python code.

```

[6]: ## Activate Jupyter (Ipython) RPY2 extensions
%load_ext rpy2.ipython

```

```
[7]: %%R
## R code below, note that %%R MUST BE the first line in the cell.

## Set up libraries for R run
library(reshape2)
library(lubridate)
library(tidyr)
library(shiny)
library(ggplot2)

## Packages to interface with X13-SEATS
library(seasonal)
library(seasonalview)

## Check seasonal library
##   uses X13_PATH as an OS environment item
## Another way to set this (in R): Sys.setenv(X13_PATH = "--x13as path--")
checkX13()
## Look for: R[write to console]: Congratulations! 'seasonal' should work fine!
```

```
R[write to console]:
Attaching package: 'lubridate'
```

```
R[write to console]: The following objects are masked from 'package:base':
date, intersect, setdiff, union
```

```
R[write to console]:
Attaching package: 'tidyr'
```

```
R[write to console]: The following object is masked from 'package:reshape2':
smiths
```

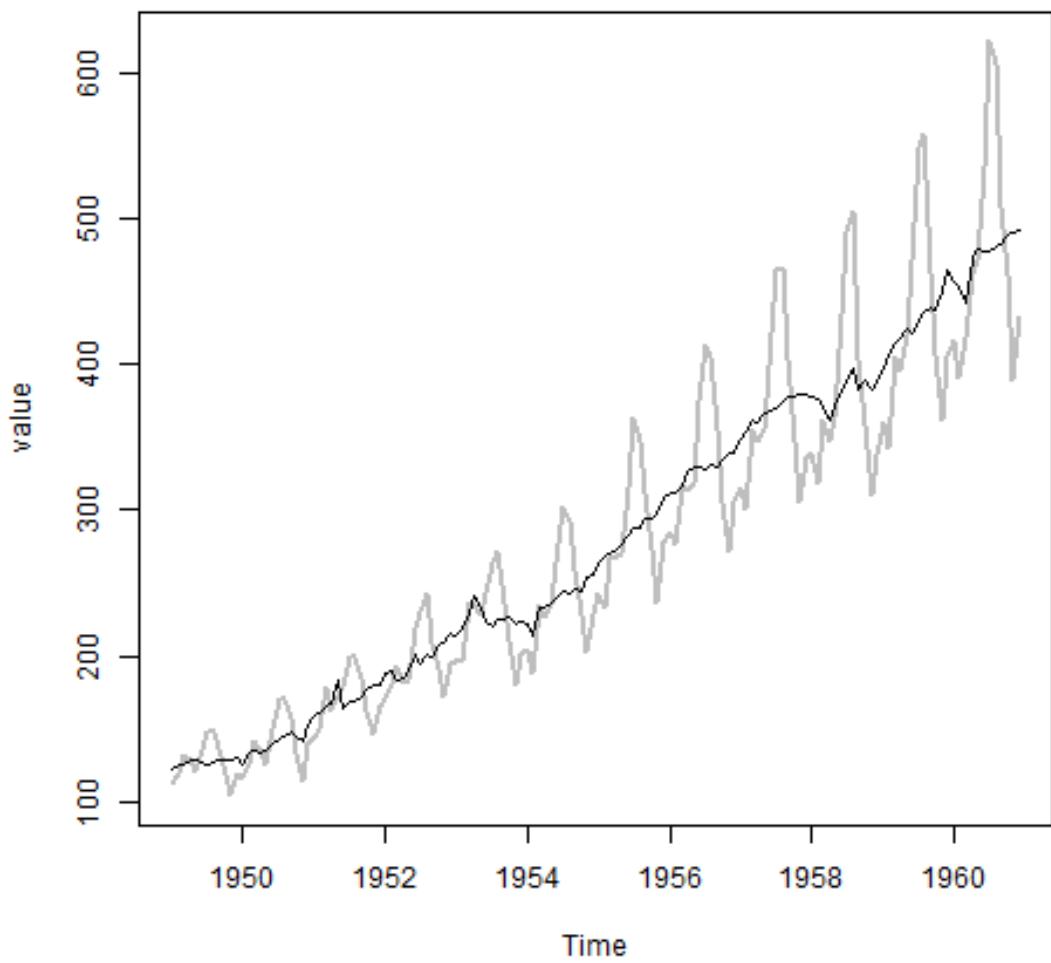
```
R[write to console]: The system variable 'X13_PATH' has been manually set to:
C:\Users\mdbol\Desktop\WinX13\x13binaries
Since version 1.2, 'seasonal' relies on the 'x13binary'
package and does not require 'X13_PATH' to be set anymore.
Only set 'X13_PATH' manually if you intend to use your own
binaries. See ?seasonal for details.
```

```
R[write to console]:
Attaching package: 'seasonalview'
```

```
R[write to console]: The following object is masked from 'package:seasonal':  
view  
  
R[write to console]: X-13 installation test:  
  
R[write to console]: - X13_PATH correctly specified  
R[write to console]: - binary executable file found  
R[write to console]: - command line test run successful  
R[write to console]: - command line test produced HTML output  
R[write to console]: - seasonal test run successful  
R[write to console]: Congratulations! 'seasonal' should work fine!
```

All of the R workspace items that are created in a %%R cell are available when running code in an new %%R cell

```
[8] : %%R  
  
## Run X13 seasonal adjustment on the Airline data using the X11 method  
  
# Set up data as time-series object (yts)  
y = melt(AirPassengers)  
yts = ts(y,start=c(1949,1),freq=12)  
#plot.ts(yts)  
  
## Run seasonal adjustment steps, argument x11="" selects the X11 method  
out1 <- seas(yts,x11="")  
summary(out1)  
  
## Seasonal adjusted series  
sa1 = out1$series$d11  
  
## Plot SA results with NSA data  
plot(yts,type='l',col='grey',lwd=2)  
lines(sa1,type='l',col='black',lwd=1)
```



[9] : %%R

```
## Using more of the SEAS options
out2 = seas(x=yts,
  ##x11="",
  #xreg = NULL,
  #xtrans = NULL,
  #seats.noadmiss = "yes",
  transform.function = "auto",
  regression.aictest = c("td", "easter"),
  outlier = "",
  automdl = "",
  composite = NULL,
```

```

na.action = na.omit,
out = FALSE,
dir = NULL,
## ... , almost any X13 option as an argument
arima.model = "(2 1 1)(1 1 2)"
#list = NULL,
)

summary(out2)
##out(out2)

```

R[write to console]: Model used in SEATS is different: (2 1 1)(1 1 1)

Call:

```

seas(x = yts, transform.function = "auto", regression.aictest = c("td",
  "easter"), outlier = "", automdl = "", composite = NULL,
  na.action = na.omit, out = FALSE, dir = NULL, arima.model = "(2 1 1)(1 1
2)")

```

Coefficients:

	Estimate	Std. Error	z value	Pr(> z )
Weekday	-0.0030831	0.0004219	-7.308	2.71e-13 ***
Easter[1]	0.0198819	0.0067414	2.949	0.003186 **
A01951.May	0.0982924	0.0186828	5.261	1.43e-07 ***
A01954.Feb	-0.0890126	0.0167223	-5.323	1.02e-07 ***
AR-Nonseasonal-01	0.5515664	0.1641999	3.359	0.000782 ***
AR-Nonseasonal-02	-0.1190824	0.0858697	-1.387	0.165509
AR-Seasonal-12	0.9160283	0.0324210	28.254	< 2e-16 ***
MA-Nonseasonal-01	0.6733151	0.1554459	4.332	1.48e-05 ***
MA-Seasonal-12	1.7986554	0.0857980	20.964	< 2e-16 ***
MA-Seasonal-24	-0.9290506	0.0837727	-11.090	< 2e-16 ***
---				
Signif. codes:	0	'***'	0.001	'**'
	0.01	'*'	0.05	'. '
	0.1	' '	1	

SEATS adj. ARIMA: (2 1 1)(1 1 2) Obs.: 144 Transform: log

AICc: 925.9, BIC: 955.4 QS (no seasonality in final): 0

Box-Ljung (no autocorr.): 35.01 . Shapiro (normality): 0.9919

Messages generated by X-13:

Warnings:

- At least one visually significant trading day peak has been found in one or more of the estimated spectra.

Notes:

- Model used for SEATS decomposition is different from the model estimated in the regARIMA modeling module of X-13ARIMA-SEATS.

```
[10]: ## Read GDP data from an external file, using pandas:

dat = pd.read_csv('gdp.csv')
a = dat.columns
a = [x.strip() for x in a]
dat.columns = a
d = [dt.datetime.strptime(x, '%Y-%m-%d') for x in dat['Date']]
dat['Date'] = d
dat.set_index(['Date'], inplace=True)
dat.tail()
```

```
[10]:          RGDP_sa  RGDP_nsa
Date
2021-01-01    6.136   -13.013
2021-04-01    6.563    19.256
2021-07-01    2.284     1.945
2021-10-01    6.723    13.322
2022-01-01   -1.518   -16.820
```

Set y-NSA and ya-SA data series

Here ya is the BEA's indirectly derived seasonality-adjusted data series (from components) that will be compared to results from running X13 methods

```
[11]: dfx = dat.copy()
#dfx = dfx['RGDP_nsa' 'RGDP_sa'].split()

## Pick a date range,
date1 = '1995-01-01'
date2 = '2022-12-31'
dfx = dat.query("Date >= @date1 and Date <= @date2")
dfx.head()

y = dfx['RGDP_nsa']
ya = dfx['RGDP_sa']
seasfactor = y - ya
```

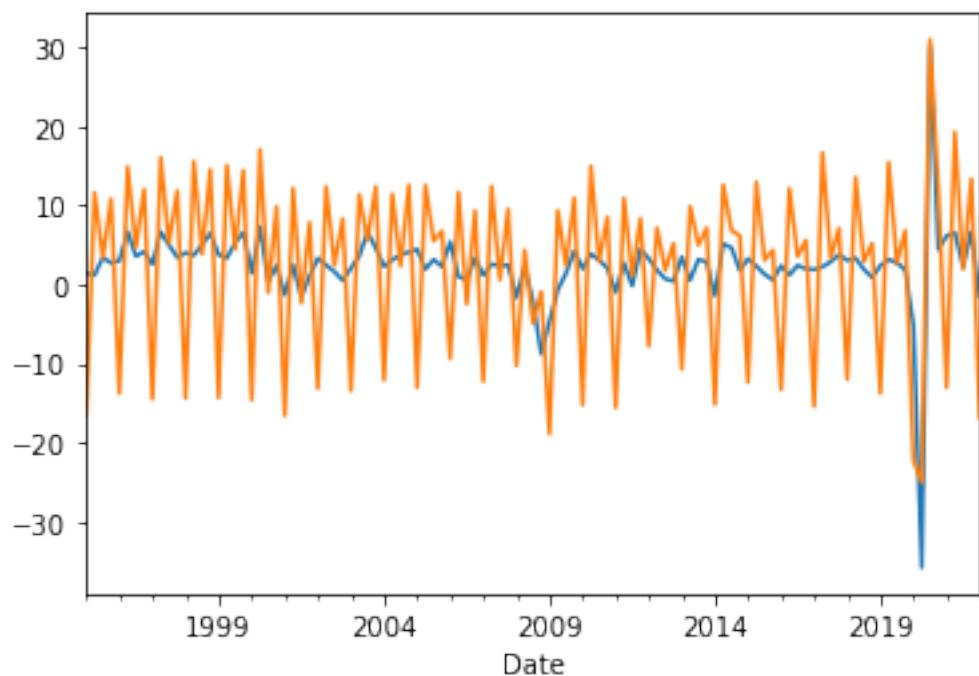
```
[11]:          RGDP_sa  RGDP_nsa
Date
1995-01-01    1.419   -16.496
1995-04-01    1.193    11.596
1995-07-01    3.403     3.369
1995-10-01    2.716    10.819
1996-01-01    2.996   -13.759
```

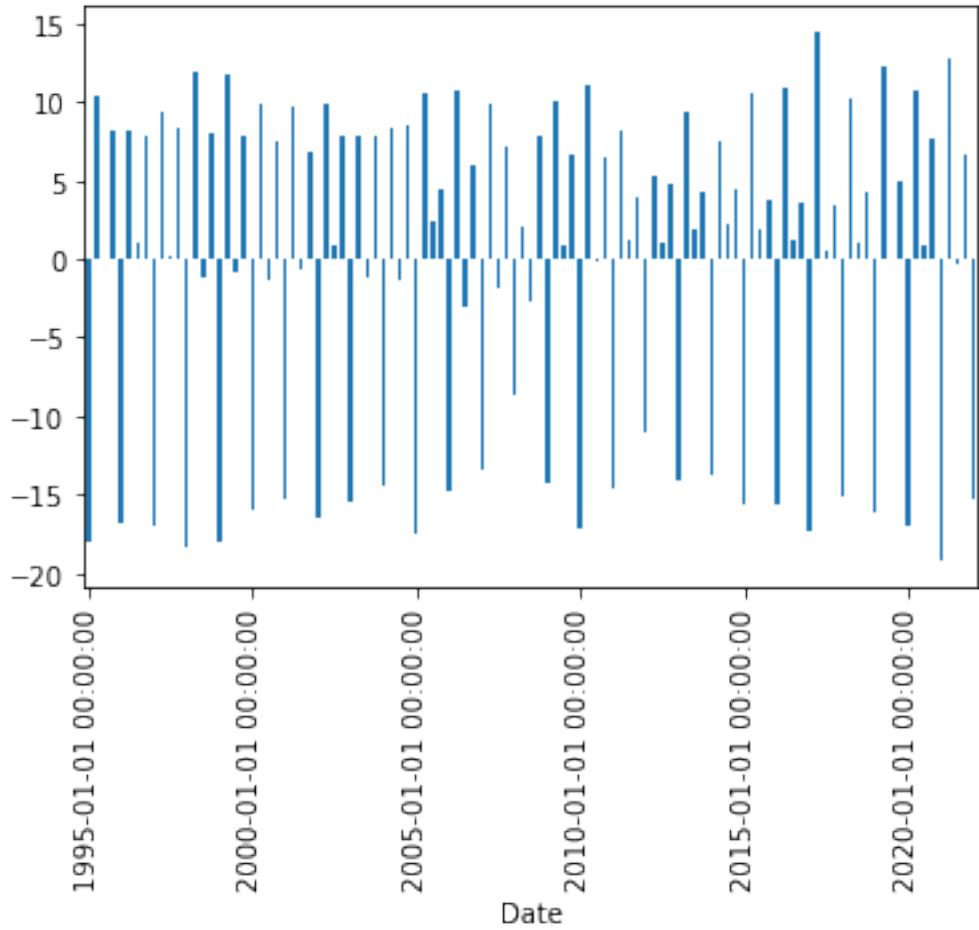
```
[14]: ## Plots of data series (NSA, SA) and implied seasonal factors
```

```
fig, ax = plt.subplots()
```

```
ax1a = ya.plot(ax=ax)
ax1b = y.plot(ax=ax)
plt.show()

fig, ax = plt.subplots()
ax2 = seasfactor.plot(ax=ax,kind='bar')
ax2 = ax.xaxis.set_major_locator(plt.MaxNLocator(6))
plt.show()
```





```
[15]: ## Python Seasonal Adjustment run, and show output
## Note output will include the spec setting sent to X13-ARIMA-SEATS
## as well as results, including outlier identifications (AO)

SArresults1 = sm.tsa.x13_arima_analysis(y,x12path=x13_path, freq=4)
print(SArresults1.results)
```

```
C:\Users\mdbol\Desktop\WinX13\x13binaries\x13as.exe
Reading input spec file from C:\Users\mdbol\AppData\Local\Temp\tmp8t6he4ed.spc
```

1

U. S. Department of Commerce, U. S. Census Bureau

X-13ARIMA-SEATS quarterly seasonal adjustment Method,  
Release Version 1.1 Build 57

This software application provides an enhanced version of Statistics Canada's X-11-ARIMA extension (Dagum, 1980) of the X-11 variant of the Census Method II of Shiskin, Young and Musgrave (1967).

It also provides an ARIMA model-based method following Hillmer and Tiao (1982) and Burman (1980) that is very similar to the update of the method of SEATS (Gomez and Maravall, 1996) produced at the Bank of Spain by G. Caporello and A. Maravall for TSW (Caporello and Maravall, 2004). The present application includes additional enhancements.

X-13ARIMA-SEATS includes an automatic ARIMA model selection procedure based largely on the procedure of Gomez and Maravall (1998) as implemented in TRAMO (1996) and subsequent revisions.

Primary Programmers: Brian Monsell, Mark Otto and,  
for the ARIMA model-based signal extraction,  
Gianluca Caporello and Victor Gomez

Series Title- RGDP\_nsa

Series Name- RGDP\_nsa

Jun 16, 2022 15.59.10

-Period covered- 1st quarter,1995 to 1st quarter,2022

-Type of run - additive seasonal adjustment

-Sigma limits for graduating extreme values are 1.5 and 2.5 .

-3x3 moving average used in section 1 of each iteration,

3x5 moving average in section 2 of iterations B and C,

moving average for final seasonal factors chosen by Global MSR.

-Spectral estimates of original series, table D11 and table E3 will be searched for

signfificant seasonal and trading day peaks

-Spectral plots generated for series starting in 1998.2

FILE SAVE REQUESTS (\* indicates file exists and will be overwritten)

C:\Users\mdbol\AppData\Local\Temp\tmpc2nxhe0e.d11 final seasonally adjusted data

C:\Users\mdbol\AppData\Local\Temp\tmpc2nxhe0e.d12 final trend cycle

C:\Users\mdbol\AppData\Local\Temp\tmpc2nxhe0e.d13 final irregular component

C:\Users\mdbol\AppData\Local\Temp\tmpc2nxhe0e.out program output file

C:\Users\mdbol\AppData\Local\Temp\tmpc2nxhe0e.err program error file

RGDP\_nsa PAGE 1, SERIES RGDP\_nsa

Contents of spc file C:\Users\mdbol\AppData\Local\Temp\tmp8t6he4ed.spc

```
Line #
-----
1: Series {
2:         data=(-16.496
3: 11.59599999999998
4: 3.368999999999998
5: 10.819
6: -13.759
7: 14.86099999999999
8: 4.669
9: 12.027000000000001
10: -14.452
11: 16.014
12: 5.166
13: 11.833
14: -14.357000000000001
15: 15.52799999999999
16: 3.867
17: 14.509
18: -14.305
19: 15.059000000000001
20: 4.466
21: 14.413
22: -14.582
23: 17.05599999999997
24: -1.006
25: 9.822000000000001
26: -16.563
27: 12.17
28: -2.319
29: 7.837000000000001
30: -13.135
31: 12.364
32: 2.415
33: 8.305
34: -13.395
35: 11.366
36: 5.536000000000005
37: 12.354000000000001
38: -12.068
39: 11.437000000000001
40: 2.338
41: 12.555
42: -13.011
43: 12.522
44: 5.519
45: 6.74
46: -9.376
```

47: 11.677  
48: -2.46  
49: 9.317  
50: -12.217  
51: 12.392000000000001  
52: 0.587000000000001  
53: 9.517000000000001  
54: -10.229  
55: 4.331  
56: -4.883  
57: -0.925  
58: -18.877  
59: 9.336  
60: 2.366  
61: 10.96099999999999  
62: -15.22  
63: 14.959000000000001  
64: 2.884  
65: 8.513  
66: -15.582  
67: 10.908  
68: 1.07  
69: 8.338  
70: -7.765  
71: 7.137000000000005  
72: 1.791999999999998  
73: 5.172999999999999  
74: -10.677999999999999  
75: 9.866  
76: 4.98  
77: 7.141  
78: -15.130999999999998  
79: 12.58599999999999  
80: 6.864  
81: 6.157999999999995  
82: -12.317  
83: 12.914000000000001  
84: 3.086000000000003  
85: 4.346999999999995  
86: -13.261  
87: 12.144  
88: 3.558000000000003  
89: 5.579  
90: -15.383  
91: 16.652  
92: 3.313  
93: 7.103  
94: -11.997

```

95: 13.530999999999999
96: 2.9130000000000003
97: 5.182
98: -13.762
99: 15.458
100: 2.676
101: 6.824
102: -22.148000000000003
103: -25.002
104: 30.965
105: 12.17
106: -13.013
107: 19.256
108: 1.945
109: 13.322000000000001
110: -16.82)
111: appendbcst=no
112: appendfcst=no
113: period=4
114: start=1995.1
115: title="RGDP_nsa"
116: name="RGDP_nsa"
117:
118: }
119: transform{function=auto}
120: outlier{}
121: automdl{
122: maxorder = (2 1)
123: maxdiff = (2 1)
124: }
125: x11{ save=(d11 d12 d13) }
      RGDP_nsa          PAGE    2, SERIES RGDP_nsa

```

A 1 Time series data (for the span analyzed)

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	TOTAL
1995	-16.	12.	3.	11.	9.
1996	-14.	15.	5.	12.	18.
1997	-14.	16.	5.	12.	19.
1998	-14.	16.	4.	15.	20.
1999	-14.	15.	4.	14.	20.

2000	-15.	17.	-1.	10.	11.
2001	-17.	12.	-2.	8.	1.
2002	-13.	12.	2.	8.	10.
2003	-13.	11.	6.	12.	16.
2004	-12.	11.	2.	13.	14.
2005	-13.	13.	6.	7.	12.
2006	-9.	12.	-2.	9.	9.
2007	-12.	12.	1.	10.	10.
2008	-10.	4.	-5.	-1.	-12.
2009	-19.	9.	2.	11.	4.
2010	-15.	15.	3.	9.	11.
2011	-16.	11.	1.	8.	5.
2012	-8.	7.	2.	5.	6.
2013	-11.	10.	5.	7.	11.
2014	-15.	13.	7.	6.	10.
2015	-12.	13.	3.	4.	8.
2016	-13.	12.	4.	6.	8.
2017	-15.	17.	3.	7.	12.
2018	-12.	14.	3.	5.	10.
2019	-14.	15.	3.	7.	11.
2020	-22.	-25.	31.	12.	-4.
2021	-13.	19.	2.	13.	22.
2022	-17.				-17.
AVGE	-14.	11.	4.	9.	

Table Total- 254. Mean- 2. Std. Dev.-  
11. Min - -25. Max -

31.

RGDP\_nsa PAGE 3, SERIES RGDP\_nsa  
Automatic ARIMA Model Selection

Procedure based closely on TRAMO method  
of Gomez and Maravall (2000)  
"Automatic Modeling Methods for Univariate Series",  
A Course in Time Series  
(Edited by D. Pena, G. C. Tiao, R. S. Tsay),  
New York : J. Wiley and Sons

Maximum order for regular ARMA parameters : 2

Maximum order for seasonal ARMA parameters : 1

Maximum order for regular differencing : 2

Maximum order for seasonal differencing : 1

Results of Unit Root Test for identifying orders of differencing:

Regular difference order : 0

Seasonal difference order : 1

Mean is not significant.

Automatic model choice : (0 0 0)(0 1 1)

Final Checks for Identified Model

Checking for Unit Roots.

No unit roots found.

Nonseasonal MA not within 0.001 of 1.0 - model passes test.

Checking for insignificant ARMA coefficients.

Final automatic model choice : (0 0 0)(0 1 1)

End of automatic model selection procedure.

Average absolute percentage error in within-sample forecasts:

Last year: 19.58 Last-1 year: 19.20 Last-2 year: 20.33

Last three years: 19.70

Estimation converged in 7 ARMA iterations, 43 function evaluations.

### Regression Model

Variable	Parameter Estimate	Standard Error	t-value
<b>Automatically Identified Outliers</b>			
A02008.4	-10.0705	2.59046	-3.89
A02020.2	-40.9050	2.69105	-15.20
A02020.3	28.2525	2.69105	10.50

ARIMA Model: (0 0 0)(0 1 1)

Seasonal differences: 1

Parameter	Estimate	Standard Errors
<b>Seasonal MA</b>		
Lag 4	0.6281	0.08359
Variance	0.82431E+01	
SE of Var	0.11377E+01	

### Likelihood Statistics

Number of observations (nobs)	109
Effective number of observations (nefobs)	105
Number of parameters estimated (np)	5
Log likelihood (L)	-260.7345
AIC	531.4691
AICC (F-corrected-AIC)	532.0751
Hannan Quinn	536.8462
BIC	544.7389

QS Statistic for regARIMA Model Residuals (full series): 0.51  
(P-Value = 0.7742)

QS Statistic for regARIMA Model Residuals (starting 1998.2): 0.35  
(P-Value = 0.8412)

### FORECASTING

Origin 2022.1  
Number 4

### Forecasts and Standard Errors

		Standard
Date	Forecast	Error
2022.2	16.51	2.939
2022.3	2.57	2.939
2022.4	10.26	2.871
2023.1	-15.86	2.871

Confidence intervals with coverage probability ( 0.95000

Date	Lower	Forecast	Upper
2022.2	10.75	16.51	22.27
2022.3	-3.19	2.57	8.33
2022.4	4.63	10.26	15.88
2023.1	-21.49	-15.86	-10.23

RGDP\_nsa PAGE 4, SERIES RGDP\_nsa

A 8 RegARIMA combined outlier component  
(AO outliers included)

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	AVGE
1995	0.	0.	0.	0.	0.
1996	0.	0.	0.	0.	0.
1997	0.	0.	0.	0.	0.
1998	0.	0.	0.	0.	0.
1999	0.	0.	0.	0.	0.
2000	0.	0.	0.	0.	0.
2001	0.	0.	0.	0.	0.
2002	0.	0.	0.	0.	0.
2003	0.	0.	0.	0.	0.
2004	0.	0.	0.	0.	0.

	0.	0.	0.	0.	0.
2005	0.	0.	0.	0.	0.
2006	0.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.
2008	0.	0.	0.	-10.	-3.
2009	0.	0.	0.	0.	0.
2010	0.	0.	0.	0.	0.
2011	0.	0.	0.	0.	0.
2012	0.	0.	0.	0.	0.
2013	0.	0.	0.	0.	0.
2014	0.	0.	0.	0.	0.
2015	0.	0.	0.	0.	0.
2016	0.	0.	0.	0.	0.
2017	0.	0.	0.	0.	0.
2018	0.	0.	0.	0.	0.
2019	0.	0.	0.	0.	0.
2020	0.	-41.	28.	0.	-3.
2021	0.	0.	0.	0.	0.
2022	0.				0.
AVGE	0.	-2.	1.	-0.	

Table Total- 5. -23. Mean- -0. Std. Dev.-  
 Min - -41. Max -  
 28.

A 8.A RegARIMA outlier component  
 From 2022.2 to 2023.1  
 Observations 4

-----  
 1st 2nd 3rd 4th AVGE

2022	0.	0.	0.	0.
2023	0.			0.

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B 1 Original series (prior adjusted)  
 (adjusted for regARIMA factors)

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	TOTAL
1995	-16.	12.	3.	11.	9.
1996	-14.	15.	5.	12.	18.
1997	-14.	16.	5.	12.	19.
1998	-14.	16.	4.	15.	20.
1999	-14.	15.	4.	14.	20.
2000	-15.	17.	-1.	10.	11.
2001	-17.	12.	-2.	8.	1.
2002	-13.	12.	2.	8.	10.
2003	-13.	11.	6.	12.	16.
2004	-12.	11.	2.	13.	14.
2005	-13.	13.	6.	7.	12.
2006	-9.	12.	-2.	9.	9.
2007	-12.	12.	1.	10.	10.
2008	-10.	4.	-5.	9.	-2.
2009	-19.	9.	2.	11.	4.
2010	-15.	15.	3.	9.	11.
2011	-16.	11.	1.	8.	5.

2012	-8.	7.	2.	5.	6.
2013	-11.	10.	5.	7.	11.
2014	-15.	13.	7.	6.	10.
2015	-12.	13.	3.	4.	8.
2016	-13.	12.	4.	6.	8.
2017	-15.	17.	3.	7.	12.
2018	-12.	14.	3.	5.	10.
2019	-14.	15.	3.	7.	11.
2020	-22.	16.	3.	12.	9.
2021	-13.	19.	2.	13.	22.
2022	-17.				-17.
AVGE	-14.	13.	2.	9.	

Table Total- 277. Mean- 3. Std. Dev.- 11.  
 11. Min - -22. Max - 19.

#### B 1.A Forecasts of (prior adjusted) original series

From 2022.2 to 2023.1

Observations 4

	1st	2nd	3rd	4th	TOTAL
2022		17.	3.	10.	29.
2023	-16.				-16.

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#### C 17 Final weights for irregular component

From 1995.1 to 2022.1

Observations 109

Lower sigma limit 1.50

Upper sigma limit 2.50

-----  
 1st 2nd 3rd 4th S.D.

1995	100.	100.	97.	100.	60.
1996	100.	100.	100.	100.	60.
1997	100.	100.	100.	100.	60.
1998	100.	100.	100.	84.	78.
1999	100.	100.	100.	100.	91.
2000	100.	0.	40.	100.	98.
2001	100.	100.	100.	100.	105.
2002	100.	100.	100.	100.	109.
2003	100.	100.	100.	100.	121.
2004	100.	100.	100.	100.	129.
2005	100.	100.	24.	0.	126.
2006	100.	100.	100.	100.	158.
2007	100.	100.	100.	100.	165.
2008	0.	80.	100.	49.	165.
2009	99.	100.	100.	100.	156.
2010	98.	100.	100.	100.	178.
2011	100.	100.	100.	100.	160.
2012	0.	35.	100.	100.	161.
2013	72.	100.	100.	100.	140.
2014	99.	100.	100.	100.	137.
2015	100.	100.	100.	100.	114.
2016	100.	100.	100.	100.	102.
2017	100.	0.	100.	100.	84.
2018	78.	100.	100.	82.	90.

2019	100.	100.	100.	100.	114.
2020	0.	100.	100.	100.	108.
2021	100.	100.	98.	0.	105.
2022	100.				105.

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D 8 Final unmodified SI ratios

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	AVGE
1995	-18.	10.	1.	7.	0.
1996	-18.	10.	0.	8.	0.
1997	-19.	11.	0.	7.	-0.
1998	-19.	11.	-1.	10.	0.
1999	-19.	10.	-1.	9.	-0.
2000	-19.	14.	-3.	8.	0.
2001	-18.	12.	-2.	7.	-0.
2002	-15.	9.	-0.	6.	0.
2003	-16.	8.	1.	8.	0.
2004	-16.	8.	-1.	9.	0.
2005	-17.	9.	1.	2.	-1.
2006	-14.	9.	-4.	8.	0.
2007	-15.	9.	-2.	8.	0.
2008	-9.	7.	-2.	12.	2.
2009	-18.	9.	1.	8.	-0.
2010	-19.	11.	-0.	7.	-0.

2011	-17.	10.	-0.	6.	-0.
2012	-10.	6.	1.	4.	0.
2013	-13.	7.	3.	5.	1.
2014	-17.	10.	3.	3.	-0.
2015	-15.	11.	1.	3.	-0.
2016	-15.	10.	2.	4.	0.
2017	-17.	15.	1.	4.	1.
2018	-15.	11.	1.	3.	0.
2019	-16.	12.	0.	5.	0.
2020	-23.	14.	-1.	7.	-1.
2021	-19.	14.	-2.	10.	1.
2022	-20.				-20.
AVGE	-17.	10.	-0.	7.	

Table Total- -9. Mean- -0. Std. Dev.-  
 11. Min - -23. Max -  
 15.  
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D 8.B Final unmodified SI ratios, with labels for outliers and extreme values

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th
1995	-18.	10.	1.*	7.
1996	-18.	10.	0.	8.
1997	-19.	11.	0.	7.
1998	-19.	11.	-1.	10.*
1999	-19.	10.	-1.	9.

2000	-19.	14.*	-3.*	8.
2001	-18.	12.	-2.	7.
2002	-15.	9.	-0.	6.
2003	-16.	8.	1.	8.
2004	-16.	8.	-1.	9.
2005	-17.	9.	1.*	2.*
2006	-14.	9.	-4.	8.
2007	-15.	9.	-2.	8.
2008	-9.*	7.*	-2.	12.&
2009	-18.*	9.	1.	8.
2010	-19.*	11.	-0.	7.
2011	-17.	10.	-0.	6.
2012	-10.*	6.*	1.	4.
2013	-13.*	7.	3.	5.
2014	-17.*	10.	3.	3.
2015	-15.	11.	1.	3.
2016	-15.	10.	2.	4.
2017	-17.	15.*	1.	4.
2018	-15.*	11.	1.	3.*
2019	-16.	12.	0.	5.
2020	-23.*	14.#	-1.#	7.
2021	-19.	14.	-2.*	10.*
2022	-20.			

Key to symbols:

- \* : extreme value as determined by X-11 extreme value procedure
- # : regARIMA outlier (either AO, LS, TC, or Ramp)
- & : more than one type of regARIMA outlier

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D 9 Final replacement values for SI ratios

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th
1995	*****	*****	1.	*****
1996	*****	*****	*****	*****
1997	*****	*****	*****	*****
1998	*****	*****	*****	9.
1999	*****	*****	*****	*****
2000	*****	11.	-2.	*****
2001	*****	*****	*****	*****
2002	*****	*****	*****	*****
2003	*****	*****	*****	*****
2004	*****	*****	*****	*****
2005	*****	*****	-1.	7.
2006	*****	*****	*****	*****
2007	*****	*****	*****	*****
2008	-14.	7.	*****	10.
2009	-18.	*****	*****	*****
2010	-19.	*****	*****	*****
2011	*****	*****	*****	*****
2012	-15.	8.	*****	*****

2013	-13.	*****	*****	*****
2014	-17.	*****	*****	*****
2015		*****	*****	*****
2016		*****	*****	*****
2017		12.	*****	*****
2018	-16.	*****	*****	3.
2019		*****	*****	*****
2020	-19.	*****	*****	*****
2021		*****	-2.	7.
2022		*****		

#### D 9.A Moving seasonality ratio

	1st	2nd	3rd	4th
I	1.306	1.154	1.093	1.100
S	0.362	0.316	0.309	0.360
RATIO	3.606	3.655	3.537	3.055

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#### D 10 Final seasonal factors

From 1995.1 to 2022.1

Observations 109

Seasonal filter 3 x 5 moving average

	1st	2nd	3rd	4th	AVGE
1995	-18.	11.	0.	8.	0.
1996	-18.	11.	0.	8.	0.
1997	-19.	11.	-0.	8.	0.
1998	-19.	11.	-1.	8.	-0.

1999	-18.	11.	-1.	8.	-0.
2000	-18.	11.	-1.	8.	-0.
2001	-17.	10.	-1.	8.	-0.
2002	-17.	10.	-1.	8.	-0.
2003	-16.	9.	-1.	8.	-0.
2004	-16.	9.	-1.	8.	-0.
2005	-15.	9.	-1.	8.	0.
2006	-15.	9.	-2.	8.	0.
2007	-15.	9.	-2.	8.	0.
2008	-16.	9.	-1.	8.	0.
2009	-16.	9.	-1.	8.	-0.
2010	-16.	9.	-0.	7.	-0.
2011	-16.	9.	1.	6.	-0.
2012	-16.	9.	1.	5.	-0.
2013	-16.	9.	2.	4.	-0.
2014	-15.	9.	2.	4.	-0.
2015	-16.	10.	2.	4.	-0.
2016	-16.	11.	2.	4.	0.
2017	-16.	11.	1.	4.	0.
2018	-17.	12.	0.	5.	0.
2019	-17.	12.	-0.	5.	0.
2020	-18.	13.	-1.	6.	0.
2021	-19.	13.	-1.	6.	0.
2022	-19.				-19.

AVGE	-17.	10.	-0.	7.
Table Total-	-20.	Mean-	-0.	Std. Dev.-
11.		Min -	-19.	Max -
13.				

D 10.A Final seasonal component forecasts

From 2022.2 to 2023.1

Observations 4

	1st	2nd	3rd	4th	AVGE
2022		14.	-1.	7.	6.
2023	-19.				-19.

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D 11 Final seasonally adjusted data

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	TOTAL
1995	2.	1.	3.	3.	9.
1996	5.	4.	5.	4.	18.
1997	4.	5.	5.	4.	18.
1998	4.	5.	4.	6.	20.
1999	4.	4.	5.	6.	20.
2000	3.	6.	0.	2.	12.
2001	1.	2.	-1.	0.	1.
2002	4.	3.	3.	1.	10.
2003	3.	2.	6.	5.	16.
2004	4.	3.	3.	5.	14.
2005	2.	4.	7.	-1.	12.

2006	6.	3.	-1.	1.	9.
2007	3.	4.	2.	1.	10.
2008	6.	-5.	-4.	-9.	-12.
2009	-3.	0.	3.	3.	4.
2010	1.	6.	3.	2.	11.
2011	1.	2.	0.	2.	5.
2012	8.	-2.	0.	0.	7.
2013	5.	1.	3.	3.	12.
2014	0.	3.	5.	2.	11.
2015	3.	3.	1.	1.	8.
2016	3.	1.	2.	2.	8.
2017	1.	5.	2.	3.	12.
2018	5.	2.	3.	1.	9.
2019	4.	3.	3.	1.	11.
2020	-4.	-38.	32.	6.	-4.
2021	6.	6.	3.	7.	21.
2022	2.				2.
AVGE	3.	1.	4.	2.	

Table Total- 274. Mean- 3. Std. Dev.-  
5. Min - -38. Max -  
32.

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D 12 Final trend cycle  
From 1995.1 to 2022.1  
Observations 109  
Trend filter 7-term Henderson moving average  
I/C ratio 1.41

	1st	2nd	3rd	4th	TOTAL
1995	1.	2.	2.	4.	9.
1996	4.	4.	4.	4.	17.
1997	5.	5.	5.	4.	19.
1998	4.	5.	5.	5.	19.
1999	5.	5.	5.	5.	20.
2000	4.	3.	2.	2.	10.
2001	1.	0.	0.	1.	2.
2002	2.	3.	3.	2.	10.
2003	2.	3.	5.	5.	15.
2004	4.	3.	3.	4.	14.
2005	4.	4.	4.	5.	17.
2006	4.	3.	1.	1.	9.
2007	3.	3.	3.	1.	10.
2008	-1.	-3.	-3.	-3.	-9.
2009	-1.	0.	2.	3.	4.
2010	3.	4.	3.	2.	12.
2011	1.	1.	1.	2.	5.
2012	2.	1.	1.	1.	5.
2013	2.	3.	2.	2.	9.
2014	2.	3.	3.	4.	12.
2015	3.	2.	2.	1.	8.
2016	2.	2.	2.	2.	7.
2017	2.	2.	3.	3.	10.

2018	3.	3.	2.	2.	10.
2019	3.	3.	2.	1.	10.
2020	1.	2.	4.	6.	13.
2021	6.	5.	4.	3.	18.
2022	3.				3.
AVGE	3.	3.	3.	3.	
Table Total-	286.	Mean-	3.	Std. Dev.-	
2.		Min -	-3.	Max -	
6.					
RGDP_nsa	PAGE 13, SERIES RGDP_nsa				

D 13 Final irregular component

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	S.D.
1995	1.	-1.	1.	-0.	1.
1996	0.	-0.	0.	-0.	0.
1997	-0.	0.	1.	-1.	1.
1998	0.	0.	-1.	1.	1.
1999	-1.	-1.	0.	1.	1.
2000	-1.	3.	-2.	0.	2.
2001	-1.	2.	-1.	-1.	1.
2002	1.	-0.	1.	-1.	1.
2003	1.	-1.	2.	-0.	1.
2004	-0.	-1.	-0.	1.	1.
2005	-1.	0.	3.	-6.	4.
2006	1.	0.	-2.	-0.	1.

2007	1.	0.	-0.	-0.	0.
2008	7.	-2.	-1.	-7.	5.
2009	-1.	-0.	1.	0.	1.
2010	-2.	2.	-0.	-1.	2.
2011	-0.	1.	-1.	0.	1.
2012	6.	-3.	-0.	-1.	4.
2013	3.	-2.	1.	1.	2.
2014	-2.	0.	1.	-1.	1.
2015	0.	1.	-1.	-1.	1.
2016	1.	-1.	0.	0.	1.
2017	-1.	3.	-0.	-0.	2.
2018	1.	-1.	1.	-1.	1.
2019	1.	-0.	0.	0.	0.
2020	-5.	-40.	28.	1.	25.
2021	-0.	1.	-1.	4.	2.
2022	-1.				1.
S.D.	2.	8.	5.	2.	

Table Total- 5.  
5.  
28.

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D 16 Combined adjustment factors  
From 1995.1 to 2022.1  
Observations 109

	1st	2nd	3rd	4th	AVGE
1995	-18.	11.	0.	8.	0.

1996	-18.	11.	0.	8.	0.
1997	-19.	11.	-0.	8.	0.
1998	-19.	11.	-1.	8.	-0.
1999	-18.	11.	-1.	8.	-0.
2000	-18.	11.	-1.	8.	-0.
2001	-17.	10.	-1.	8.	-0.
2002	-17.	10.	-1.	8.	-0.
2003	-16.	9.	-1.	8.	-0.
2004	-16.	9.	-1.	8.	-0.
2005	-15.	9.	-1.	8.	0.
2006	-15.	9.	-2.	8.	0.
2007	-15.	9.	-2.	8.	0.
2008	-16.	9.	-1.	8.	0.
2009	-16.	9.	-1.	8.	-0.
2010	-16.	9.	-0.	7.	-0.
2011	-16.	9.	1.	6.	-0.
2012	-16.	9.	1.	5.	-0.
2013	-16.	9.	2.	4.	-0.
2014	-15.	9.	2.	4.	-0.
2015	-16.	10.	2.	4.	-0.
2016	-16.	11.	2.	4.	0.
2017	-16.	11.	1.	4.	0.
2018	-17.	12.	0.	5.	0.
2019	-17.	12.	-0.	5.	0.

2020	-18.	13.	-1.	6.	0.
2021	-19.	13.	-1.	6.	0.
2022	-19.				-19.
AVGE	-17.	10.	-0.	7.	
Table Total-	-20.	Mean-	-0.	Std. Dev.-	
11.		Min -	-19.	Max -	
	13.				

D 16.A Combined adjustment component forecasts

From 2022.2 to 2023.1

Observations 4

	1st	2nd	3rd	4th	AVGE
2022		14.	-1.	7.	6.
2023	-19.				-19.

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E 4 Differences of annual totals

From 1995 to 2021

Observations 27

Year	Unmodified (D11)	Modified (E3)
1995	0.	0.
1996	0.	0.
1997	0.	0.
1998	-0.	-0.
1999	-0.	-0.
2000	-0.	-0.
2001	-0.	-0.
2002	-0.	-0.

2003	-0.	-0.
2004	-0.	-0.
2005	0.	0.
2006	0.	0.
2007	0.	0.
2008	0.	0.
2009	-0.	-0.
2010	-0.	-0.
2011	-0.	-0.
2012	-0.	-0.
2013	-0.	-0.
2014	-0.	-0.
2015	-0.	-0.
2016	0.	0.
2017	0.	0.
2018	0.	0.
2019	0.	0.
2020	0.	0.
2021	0.	0.

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E 5 Quarter-to-quarter differences in the original series

From 1995.2 to 2022.1

Observations 108

	1st	2nd	3rd	4th	AVGE
1995		28.	-8.	7.	9.

1996	-25.	29.	-10.	7.	0.
1997	-26.	30.	-11.	7.	-0.
1998	-26.	30.	-12.	11.	1.
1999	-29.	29.	-11.	10.	-0.
2000	-29.	32.	-18.	11.	-1.
2001	-26.	29.	-14.	10.	-0.
2002	-21.	25.	-10.	6.	0.
2003	-22.	25.	-6.	7.	1.
2004	-24.	24.	-9.	10.	0.
2005	-26.	26.	-7.	1.	-1.
2006	-16.	21.	-14.	12.	1.
2007	-22.	25.	-12.	9.	0.
2008	-20.	15.	-9.	4.	-3.
2009	-18.	28.	-7.	9.	3.
2010	-26.	30.	-12.	6.	-1.
2011	-24.	26.	-10.	7.	-0.
2012	-16.	15.	-5.	3.	-1.
2013	-16.	21.	-5.	2.	0.
2014	-22.	28.	-6.	-1.	-0.
2015	-18.	25.	-10.	1.	-0.
2016	-18.	25.	-9.	2.	0.
2017	-21.	32.	-13.	4.	0.
2018	-19.	26.	-11.	2.	-0.
2019	-19.	29.	-13.	4.	0.

2020	-29.	-3.	56.	-19.	1.
2021	-25.	32.	-17.	11.	0.
2022	-30.				-30.
AVGE	-23.	25.	-8.	5.	
Table Total-	-0.	Mean-	-0.	Std. Dev.-	
19.		Min -	-30.	Max -	
56.					

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E 6 Quarter-to-quarter differences in seasonally adjusted series (D11)

From 1995.2 to 2022.1

Observations 108

	1st	2nd	3rd	4th	AVGE
1995		-1.	2.	0.	0.
1996	2.	-0.	0.	-0.	0.
1997	-0.	1.	-0.	-2.	-0.
1998	1.	0.	-0.	2.	1.
1999	-2.	0.	1.	1.	-0.
2000	-3.	3.	-6.	2.	-1.
2001	-1.	1.	-3.	1.	-0.
2002	4.	-1.	1.	-3.	0.
2003	2.	-1.	4.	-2.	1.
2004	-1.	-1.	1.	1.	0.
2005	-3.	2.	3.	-8.	-2.
2006	7.	-3.	-4.	2.	1.
2007	2.	0.	-1.	-1.	0.
2008	5.	-10.	1.	-5.	-3.

2009	6.	3.	3.	0.	3.
2010	-2.	5.	-3.	-1.	-0.
2011	-1.	1.	-1.	2.	0.
2012	6.	-10.	3.	-0.	-1.
2013	5.	-4.	3.	-0.	1.
2014	-2.	3.	2.	-3.	-0.
2015	1.	-0.	-2.	-0.	-0.
2016	2.	-1.	1.	-0.	0.
2017	-1.	5.	-3.	1.	0.
2018	2.	-3.	1.	-2.	-1.
2019	3.	-1.	-0.	-1.	0.
2020	-6.	-34.	70.	-25.	1.
2021	-1.	0.	-3.	4.	0.
2022	-5.				-5.
AVGE	1.	-2.	2.	-1.	

Table Total- 0. Mean- 0. Std. Dev.-  
 8. Min - -34. Max - 70.

RGDP\_nsa PAGE 18, SERIES RGDP\_nsa

#### E 7 Quarter-to-quarter differences in final trend cycle (D12)

From 1995.2 to 2022.1

Observations 108

	1st	2nd	3rd	4th	AVGE
1995		0.	1.	1.	1.
1996	1.	0.	-0.	-0.	0.
1997	0.	0.	-0.	-0.	0.

1998	-0.	0.	1.	-0.	0.
1999	-0.	0.	0.	0.	0.
2000	-1.	-1.	-1.	-0.	-1.
2001	-0.	-1.	-0.	1.	-0.
2002	2.	1.	-0.	-1.	0.
2003	0.	1.	1.	-0.	1.
2004	-1.	-1.	0.	0.	-0.
2005	0.	0.	1.	1.	0.
2006	-1.	-2.	-2.	0.	-1.
2007	1.	1.	-1.	-1.	0.
2008	-2.	-2.	-1.	1.	-1.
2009	1.	2.	1.	1.	1.
2010	0.	0.	-0.	-1.	-0.
2011	-1.	-0.	1.	1.	-0.
2012	-0.	-1.	-0.	1.	-0.
2013	1.	1.	-0.	-1.	0.
2014	0.	1.	1.	0.	0.
2015	-1.	-1.	-1.	-0.	-1.
2016	0.	0.	-0.	-0.	0.
2017	0.	0.	1.	1.	0.
2018	-0.	-1.	-1.	0.	-0.
2019	1.	0.	-1.	-1.	-0.
2020	-0.	1.	2.	2.	1.
2021	0.	-1.	-1.	-1.	-1.

2022	-0.			-0.
AVGE	0.	0.	0.	0.
Table Total-	1.	Mean-	0.	Std. Dev.-
1.		Min -	-2.	Max -
2.				
RGDP_nsa	PAGE 19, SERIES RGDP_nsa			

E 8 Quarter-to-quarter differences in original series adjusted for calendar factors (A18)

From 1995.2 to 2022.1

Observations 108

	1st	2nd	3rd	4th	AVGE
1995		28.	-8.	7.	9.
1996	-25.	29.	-10.	7.	0.
1997	-26.	30.	-11.	7.	-0.
1998	-26.	30.	-12.	11.	1.
1999	-29.	29.	-11.	10.	-0.
2000	-29.	32.	-18.	11.	-1.
2001	-26.	29.	-14.	10.	-0.
2002	-21.	25.	-10.	6.	0.
2003	-22.	25.	-6.	7.	1.
2004	-24.	24.	-9.	10.	0.
2005	-26.	26.	-7.	1.	-1.
2006	-16.	21.	-14.	12.	1.
2007	-22.	25.	-12.	9.	0.
2008	-20.	15.	-9.	4.	-3.
2009	-18.	28.	-7.	9.	3.
2010	-26.	30.	-12.	6.	-1.

2011	-24.	26.	-10.	7.	-0.
2012	-16.	15.	-5.	3.	-1.
2013	-16.	21.	-5.	2.	0.
2014	-22.	28.	-6.	-1.	-0.
2015	-18.	25.	-10.	1.	-0.
2016	-18.	25.	-9.	2.	0.
2017	-21.	32.	-13.	4.	0.
2018	-19.	26.	-11.	2.	-0.
2019	-19.	29.	-13.	4.	0.
2020	-29.	-3.	56.	-19.	1.
2021	-25.	32.	-17.	11.	0.
2022	-30.				-30.
AVGE	-23.	25.	-8.	5.	

Table Total- -0. Mean- -0. Std. Dev.-  
 19. Min - -30. Max -  
 56.  
 RGDP\_nsa PAGE 20, SERIES RGDP\_nsa

#### E 18 Final adjustment ratios

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	AVGE
1995	-839.469	1110.885	108.602	344.045	181.016
1996	-291.069	345.909	103.020	289.251	111.778
1997	-350.559	299.662	96.924	319.868	91.474
1998	-335.870	331.919	87.262	231.604	78.729
1999	-349.268	364.261	82.324	232.621	82.485

2000	-438.460	267.827	-1950.031	535.853	-396.203
2001	-2453.863	622.994	175.150	26963.256	6326.884
2002	-370.943	466.238	73.983	1149.455	329.683
2003	-503.783	533.919	86.014	258.856	93.751
2004	-342.530	447.115	68.544	258.223	107.838
2005	-593.867	322.993	79.210	-499.308	-172.743
2006	-160.707	382.079	298.837	937.593	364.450
2007	-382.303	342.312	26.492	869.679	214.045
2008	-181.071	-92.368	134.722	10.152	-32.141
2009	714.999	6844.983	75.748	340.921	1994.163
2010	-1302.498	259.618	99.371	562.800	-95.177
2011	-2077.888	644.717	295.316	358.690	-194.791
2012	-94.024	-339.260	363.496	5086.343	1254.139
2013	-214.165	1686.275	154.058	251.946	469.528
2014	-4515.011	406.114	139.820	272.644	-924.108
2015	-370.142	442.175	271.850	577.554	230.359
2016	-509.630	819.611	179.371	289.940	194.823
2017	-1918.312	310.688	147.460	227.347	-308.204
2018	-259.093	841.929	115.799	1002.171	425.202
2019	-388.308	520.799	94.827	457.818	171.284
2020	531.457	65.769	97.950	196.343	222.880
2021	-234.399	326.226	66.798	193.693	88.080
2022	-775.167				-775.167
AVGE	-678.784	687.977	58.256	1545.161	

Table Total-	42862.	Mean-	393.	Std. Dev.-
2797.				
	Min -	-4515.		Max -
26963.				

E 18.A Final adjustment ratio forecasts

From 2022.2 to 2023.1

Observations 4

	1st	2nd	3rd	4th	AVGE
2022		566.365	68.491	288.713	307.856
2023	-475.675				-475.675

RGDP\_nsa PAGE 21, SERIES RGDP\_nsa

E 18.B Total adjustment factors

From 1995.1 to 2022.1

Observations 109

	1st	2nd	3rd	4th	AVGE
1995	-18.	11.	0.	8.	0.
1996	-18.	11.	0.	8.	0.
1997	-19.	11.	-0.	8.	0.
1998	-19.	11.	-1.	8.	-0.
1999	-18.	11.	-1.	8.	-0.
2000	-18.	11.	-1.	8.	-0.
2001	-17.	10.	-1.	8.	-0.
2002	-17.	10.	-1.	8.	-0.
2003	-16.	9.	-1.	8.	-0.
2004	-16.	9.	-1.	8.	-0.
2005	-15.	9.	-1.	8.	0.
2006	-15.	9.	-2.	8.	0.

2007	-15.	9.	-2.	8.	0.
2008	-16.	9.	-1.	8.	0.
2009	-16.	9.	-1.	8.	-0.
2010	-16.	9.	-0.	7.	-0.
2011	-16.	9.	1.	6.	-0.
2012	-16.	9.	1.	5.	-0.
2013	-16.	9.	2.	4.	-0.
2014	-15.	9.	2.	4.	-0.
2015	-16.	10.	2.	4.	-0.
2016	-16.	11.	2.	4.	0.
2017	-16.	11.	1.	4.	0.
2018	-17.	12.	0.	5.	0.
2019	-17.	12.	-0.	5.	0.
2020	-18.	13.	-1.	6.	0.
2021	-19.	13.	-1.	6.	0.
2022	-19.				-19.
AVGE	-17.	10.	-0.	7.	

Table Total- -20. Mean- -0. Std. Dev.-  
 11. Min - -19. Max -  
 13.

#### E 18.C Total adjustment factor forecasts

From 2022.2 to 2023.1

Observations 4

	1st	2nd	3rd	4th	AVGE
2022		14.	-1.	7.	6.
2023	-19.				-19.

```

QS statistic for seasonality:
Original Series                      138.75  (P-Value =
0.0000)
Original Series (EV adj)              187.07  (P-Value =
0.0000)
Residuals                            0.51    (P-Value =
0.7742)
Seasonally Adjusted Series           0.00    (P-Value =
1.0000)
Seasonally Adjusted Series (EV adj)  0.00    (P-Value =
1.0000)
Irregular Series                     0.00    (P-Value =
0.9984)
Irregular Series (EV adj)            0.00    (P-Value =
1.0000)

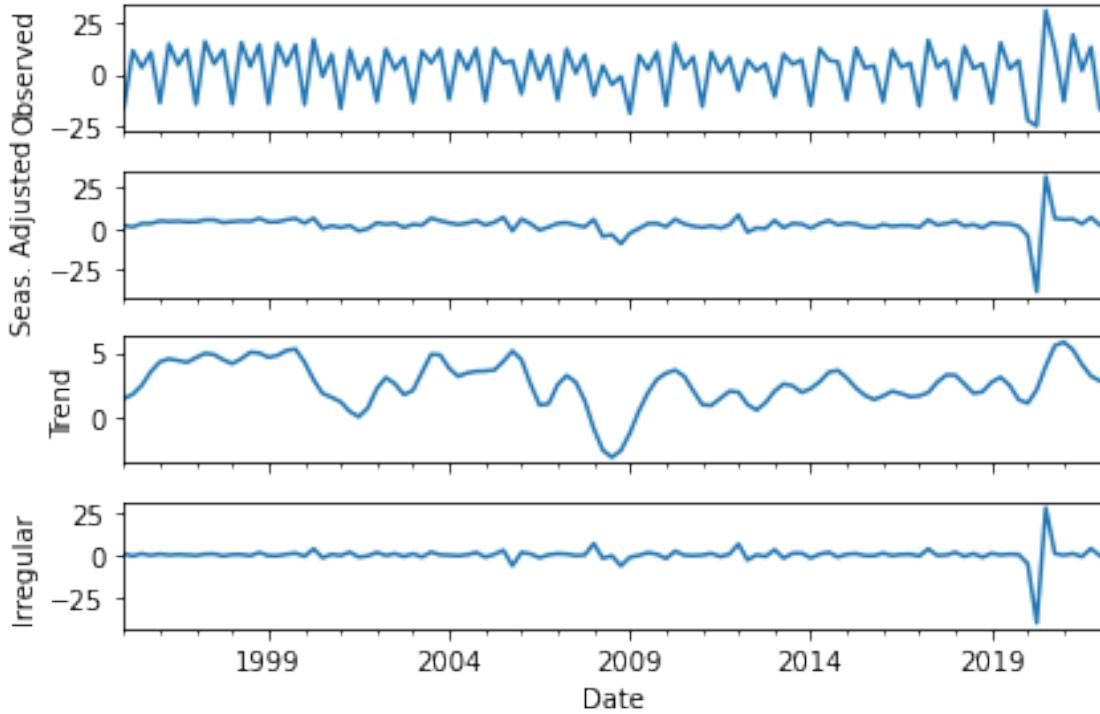
QS statistic for seasonality (starting 1998.2):
Original Series                      108.94  (P-Value =
0.0000)
Original Series (EV adj)              156.67  (P-Value =
0.0000)
Residuals                            0.35    (P-Value =
0.8412)
Seasonally Adjusted Series           0.00    (P-Value =
1.0000)
Seasonally Adjusted Series (EV adj)  0.00    (P-Value =
1.0000)
Irregular Series                     0.01    (P-Value =
0.9963)
Irregular Series (EV adj)            0.01    (P-Value =
0.9965)

C:\Users\mdbol\AppData\Local\Programs\Python\Python37\lib\site-
packages\statsmodels\tsa\x13.py:209: X13Warning: WARNING: Automatic
transformation selection cannot be done on a
series with zero or negative values.
warn(errors, X13Warning)

```

```
[16]: ## Plots from x13 results

fig = SAreresults1.plot()
plt.show()
```

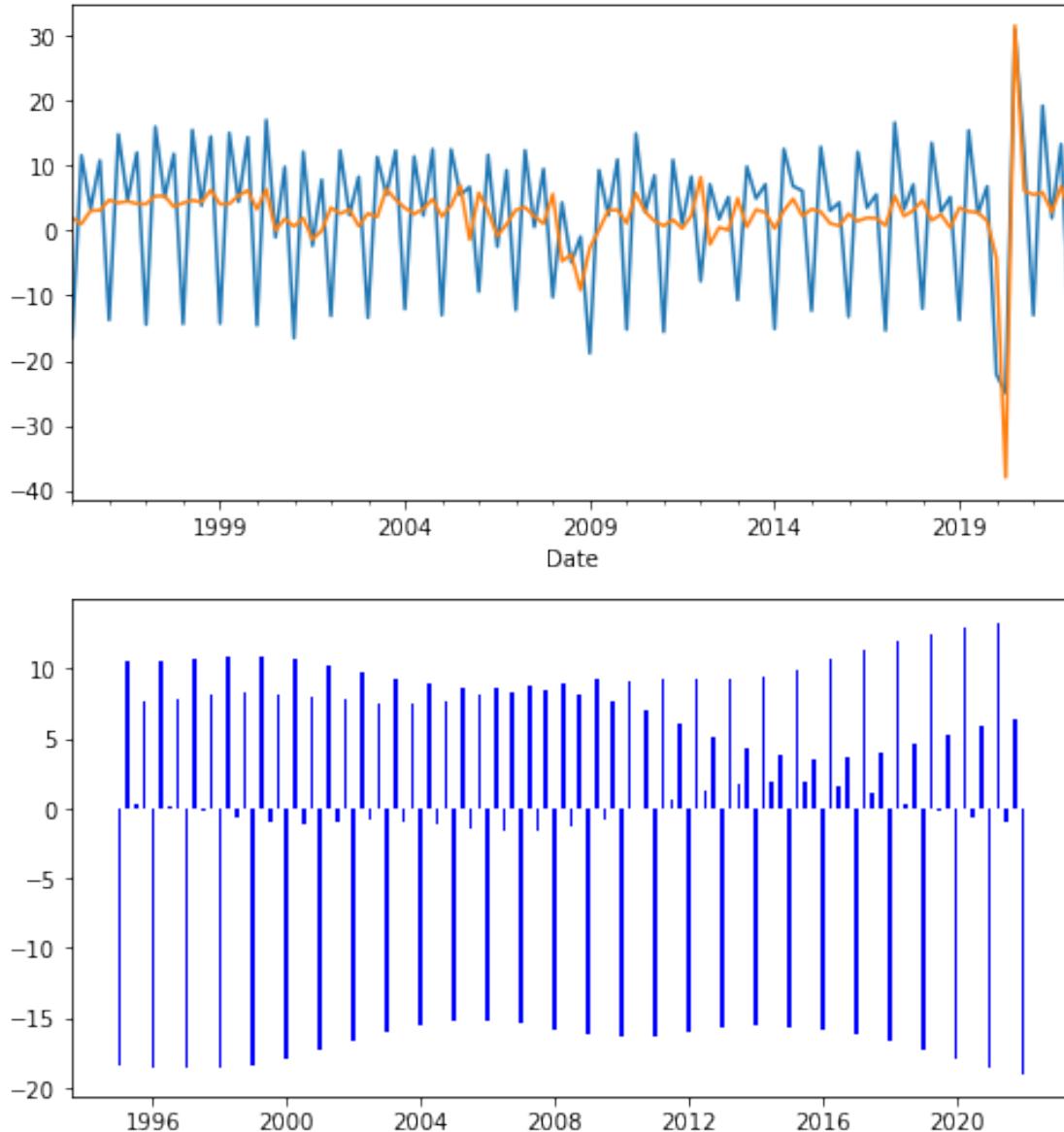


```
[17]: ## More Plots of seasonal adjustment results for GDP (real, pct change)

fig1, ax1 = plt.subplots(nrows=2, ncols=1, figsize=(8,2*4+1))

nsa = SAreresults1.observed
sa = SAreresults1.seasadj
ax2 = nsa.plot(ax=ax1[0])
ax2 = sa.plot(ax=ax1[0])

## Bar chart of computed seasonal factors
sf = nsa - sa
x = sf.index
ax2 = ax1[1].bar(x,sf, color= 'blue', width=40)
```



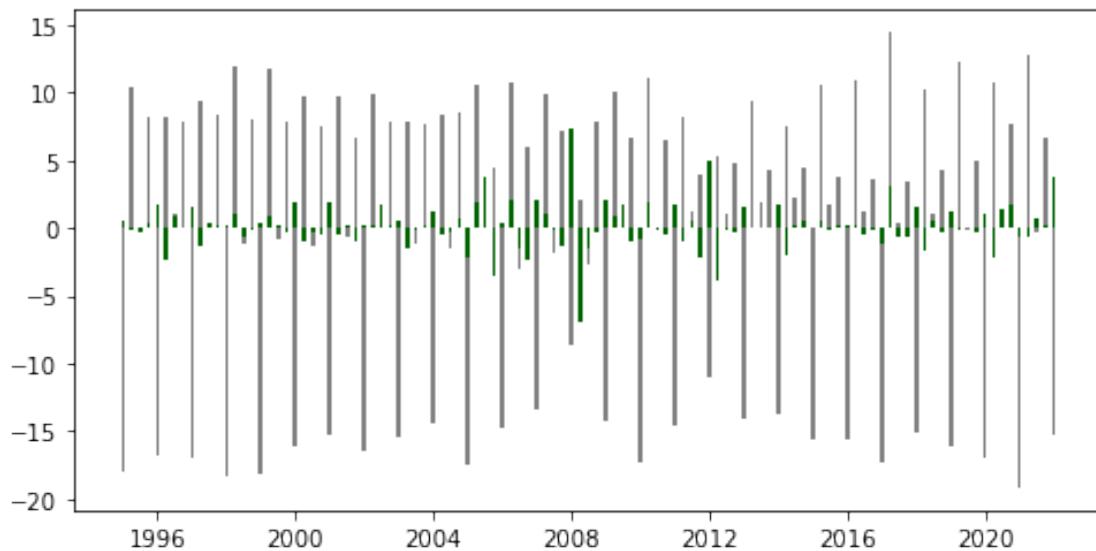
```
[18]: ## Comparisons to official seasonals for GDP (real, pct change)

## Seasonal factors for official, indirectly adjusted series
sfa = nsa - ya

## Difference between this run's results and official SA GDP series
yx = sa - ya

x = yx.index
fig1, ax1 = plt.subplots(nrows=1, ncols=1, figsize=(8,4))
ax1.bar(x,sfa, color= 'grey', width=40)
```

```
ax2 = ax1.bar(x,yx, color= 'darkgreen', width=40)
plt.show()
```



Dataframes and other data types can be pushed from Python to R and pulled from R to Python using `%%R` `%R`, `%Rpush` and `%RPull`. Examples are shown below

```
[19]: %%R -i dfx
## use RPY2 magic command (%R) to push dfx dataframe into R workspace

## The push allows us to see and use Python data in R
tail(dfx,10)
```

	RGDP_sa	RGDP_nsa
2019-10-01 00:00:00	1.876	6.824
2020-01-01 00:00:00	-5.214	-22.148
2020-04-01 00:00:00	-35.749	-25.002
2020-07-01 00:00:00	30.190	30.965
2020-10-01 00:00:00	4.461	12.170
2021-01-01 00:00:00	6.136	-13.013
2021-04-01 00:00:00	6.563	19.256
2021-07-01 00:00:00	2.284	1.945
2021-10-01 00:00:00	6.723	13.322
2022-01-01 00:00:00	-1.518	-16.820

```
[20]: %%R

## R seasonal adjustment run
y = dfx[, 'RGDP_nsa']
```

```

yts = ts(y,start=c(1995,1),freq=4)

## Three different runs:
##      X11 method, SEATS model selection, SEATS specified model
out1 <- seas(yts,x11="")
out2 <- seas(yts)
out3 <- seas(yts,arima.model = "(2 1 0)(0 1 1)")

#summary(out1)
#summary(out2)
#summary(out3)

sa1 = out1$series$d11
sa2 = out2$data[, 'final']
sa3 = out3$data[, 'final']

```

[21] :

```

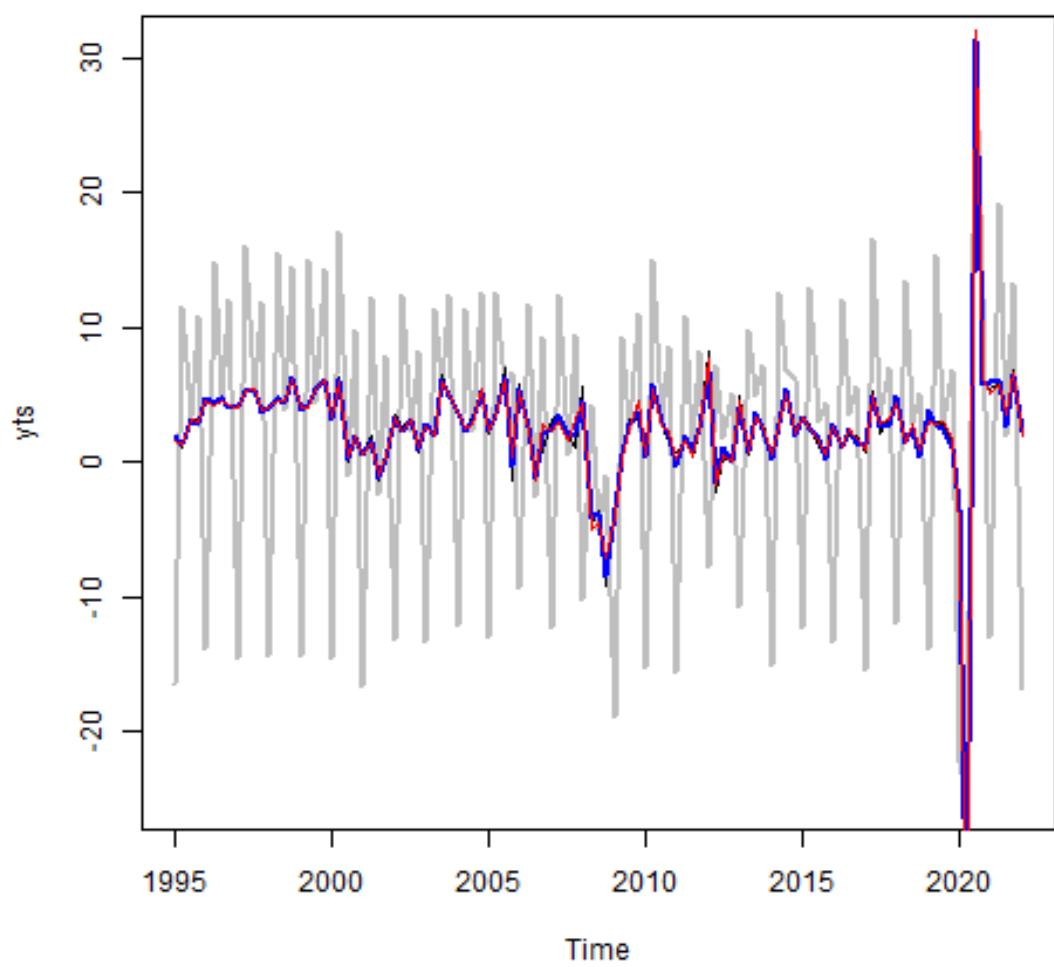
%%R

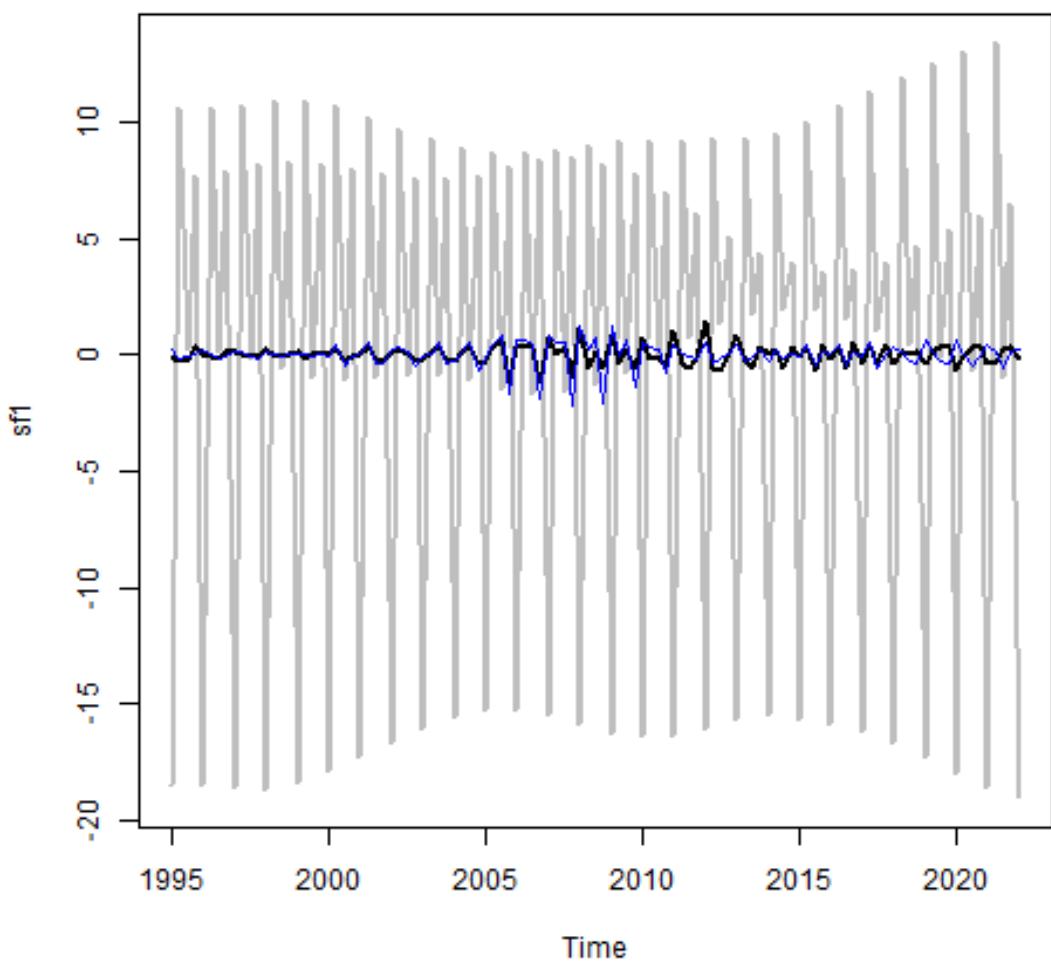
## R plots -- after SA runs

## NSA vs 3 SA versions
plot(yts,type='l',col='grey',lwd=2)
lines(sa1,type='l',col='black',lwd=1)
lines(sa2,type='l',col='blue',lwd=2)
lines(sa3,type='l',col='red',lwd=1)

## SA factors and differences in versions
sf1= yts-sa1
sf2= yts-sa2
sf3= yts-sa3
plot(sf1,type='l',col='grey',lwd=2)
lines(sf2-sf1,type='l',col='black',lwd=2)
lines(sf3-sf1,type='l',col='blue',lwd=1)

```





[22] : %%R

```
##Explore results
print(names(out1))
print(summary(out1))
```

```
[1] "series"      "udg"        "data"       "err"        "est"
[6] "model"       "fivebestmdl" "wdir"       "iofile"     "call"
[11] "list"        "x"          "spc"
```

Call:  
`seas(x = yts, x11 = "")`

```

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
A02008.4      -10.07055   2.59046 -3.888 0.000101 ***
A02020.2      -40.90500   2.69105 -15.200 < 2e-16 ***
A02020.3       28.25249   2.69105 10.499 < 2e-16 ***
MA-Seasonal-04  0.62814   0.08359  7.515 5.71e-14 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

X11 adj. ARIMA: (0 0 0)(0 1 1) Obs.: 109 Transform: none
AICc: 532.1, BIC: 544.7 QS (no seasonality in final): 0
Box-Ljung (no autocorr.): 24.33 Shapiro (normality): 0.9703 *
Messages generated by X-13:
Warnings:
- Automatic transformation selection cannot be done on a series
with zero or negative values.

```

[23] : %%R

```

## Specs passed to X13-ARIMA-SEATS
print(out1$spc)

```

```

series{
  title = "iofile"
  file =
"C:\Users\mdbol\AppData\Local\Temp\RtmpWmvIC8\x13301c4fd735d5/iofile.dta"
  format = "datevalue"
  period = 4
}

transform{
  function = auto
  print = aictransform
}

regression{
  aictest = (td easter)
}

outlier{

}

automdl{
  print = bestfivemdl
}

```

```

x11{
  save = (d10 d11 d12 d13 d16 e18)
}

estimate{
  save = (model estimates residuals)
}

spectrum{
  print = qs
}

```

[24]: *## Pull R sa series into Python workspace  
## and compare to Python run*

```

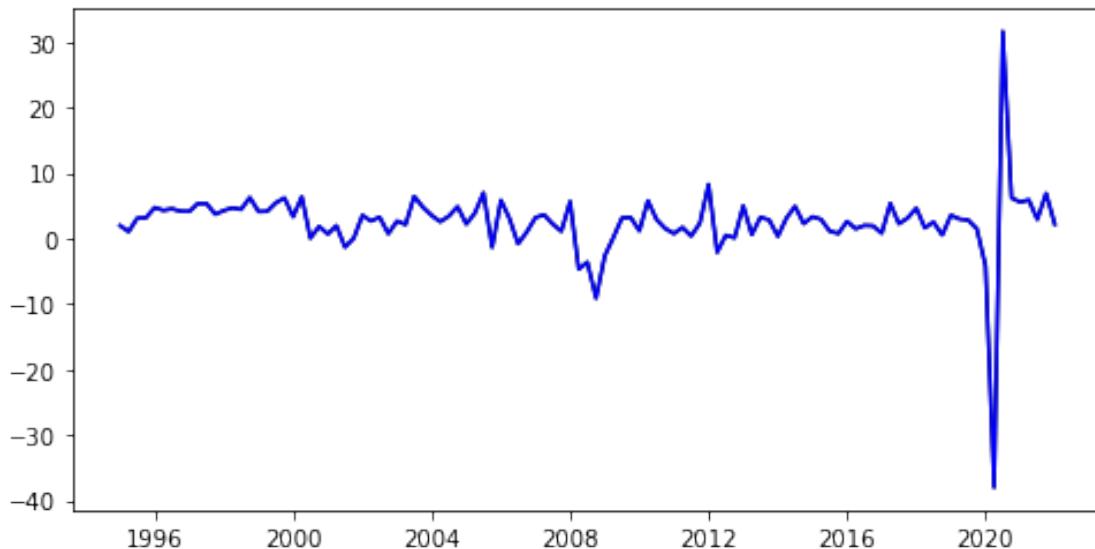
%Rpull  sa1

## Python code
rsa = pd.Series(sa1,index=sa.index)

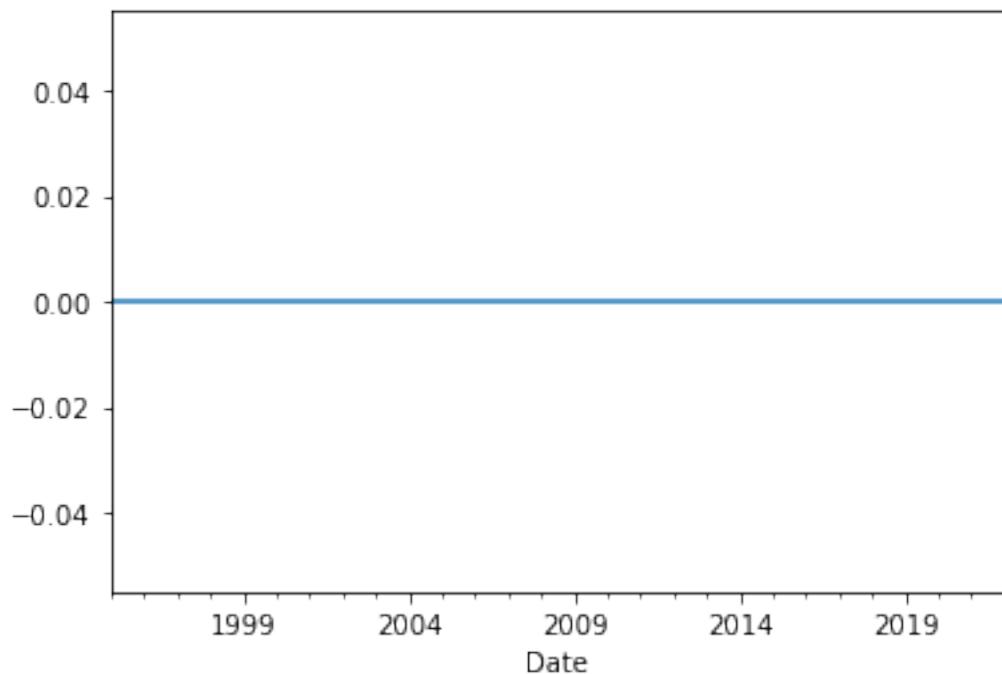
fig1, ax1 = plt.subplots(nrows=1,ncols=1,figsize=(8,4))
ax2 = ax1.plot(sa, color= 'black')
ax2 = ax1.plot(rsa, color= 'blue')
ax2 = plt.show()

## Showing no difference after rounding
x = rsa - sa
x = round(x,6)
x.mean(), x.std()
ax2 = x.plot()

```



[24]: (0.0, 0.0)



Summary: The Python and R interfaces to X13-ARIMA-SEATS binaries were demonstrated using a Jupyter notebook system. Also, by passing data back and forth between Python and R, it is shown how the broader options in the R interface can be used when the main data management steps are in Python.

For code, write to [mdboldin@gmail.com](mailto:mdboldin@gmail.com)