AUSTRIA MACRO-ECONOMIC ANALYSIS

In this part GDP, Inflation and Unemployment rate of Austria will be analyzed.

Introduction

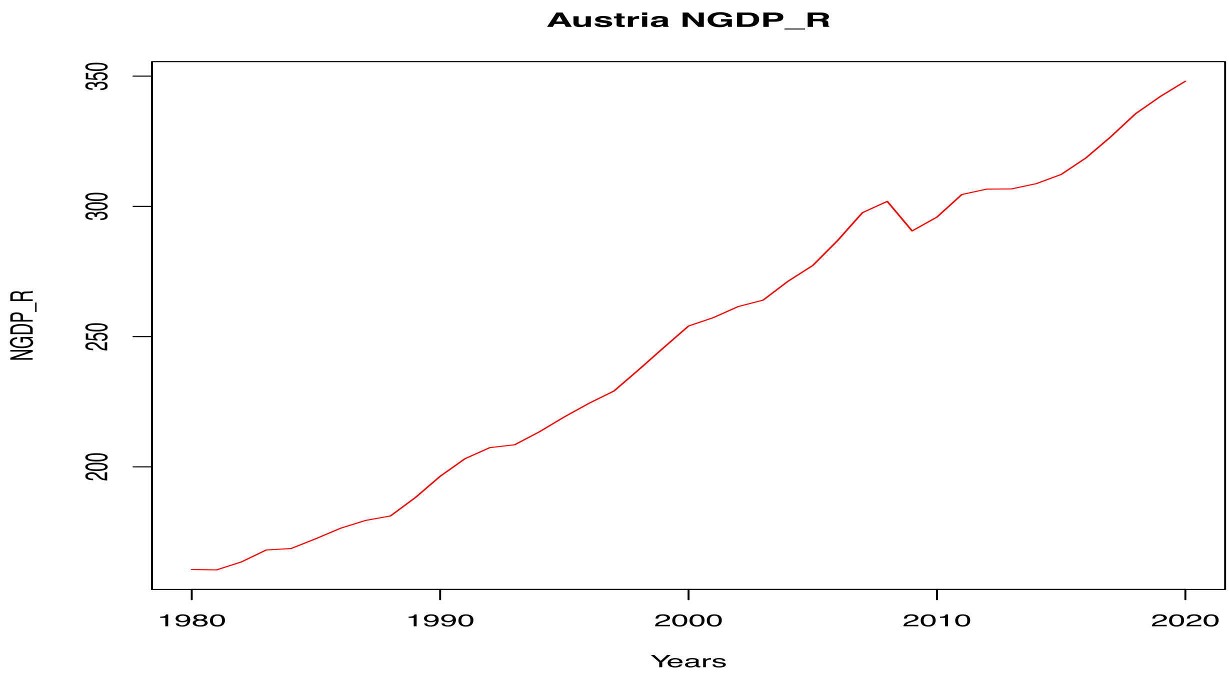
This project analyses the IMF-WEO database. More in details, data of Austria from 1980 to 2020 are considered. The aim of this second part is to inspect four variables: NGDP_R, NGDP_D, PCPI and LUR.
In the first stage these variables will be analysed one at a time. At the beginning, a representation of the data and of their growth rate will be shown. Consequently it will be presented the correlogram of the logged levels and the growth rates. Lastly, it will be tested the stationarity of these time series running an augmented Dickey-Fuller test on the logged levels and on the first differences of the logs.
In the end, the focus will be shifted toward inflation. Firstly, previous results of inflation computed by using NGDP_R and PCPI will be compared, explaining the differences between them. Secondly,, a "Philips curve" will be estimated. Specifically, it would be considered the relation between the first difference of the logged inflation (dependent variable) and their past history along with the past level of unemployment rate (independent variable). For this purpose, a suitable number of lag will be found.

A preliminary specification

As an introduction, it could be useful to define the variables taken into consideration.
On one hand, NGDP_R stands for the gross domestic product with constant prices, it is expressed in billions of national currency units and the base year considered is 2010. On the other hand, NGDP_D indicates the deflator of the gross domestic product, it is derived by dividing current price GDP by constant price GDP and is considered to be an alternate measure of inflation. Regarding this variable, data are expressed in the same year as before (2010). This variable is an index.
The variables PCPI stands for the inflation measured due to the average consumer prices. It is an index expressed in average per year. Note that for Euro countries (as Austria is) consumer prices are computed based on harmonized prices.
Finally, LUR is the unemployment rate. It is expressed as percentage of total labor force. Unemployment can have two different definition: according to OECD the harmonized unemployment rate indicates the number of unemployed people as a percentage of the labor force (which include the total number of people employed plus unemployed) (OECD Main Economic Indicators, OECD, monthly); according to ILO unemployment workers are people that are not working but are willing and able to do it and have actively searched for work (ILO, http://www.ilo.org/public/english/bureau/stat/res/index.htm).
Note that all these specification of the variables come from the Excel file: *in_data/WEOApr2019all.csv*. It is Important to keep in mind that these data ends in 2018, and so data regarding 2019 and 2020 are estimated. In this sense, these data can be misleading due to the COVID-19 pandemic that we are facing, which led the world in one of the worst crises it has ever experienced.
Speaking of the general global situation from 1980 to 2020, there were 3 big crises: the first was in 1982 and was caused by the oil crisis in 1979; the second one was in 1991 with the early 90s recession; and lastly, the harshest one, the Global financial crisis in 2008. Furthermore, this is the period where the Globalization phenomena is spreading around the world.
Some general information about Austria may be useful as well. Austria's economy is the 11th of the European Union regarding the GDP and the 4th speaking about GDP per capita. In any case, it is a relatively small economy (and relatively small it is its territory). In 1999 Austria joined the monetary union and in 2002 adopted the Euro. As such, its monetary policy is managed by the European central bank (Source: Wikipedia).

Analysis

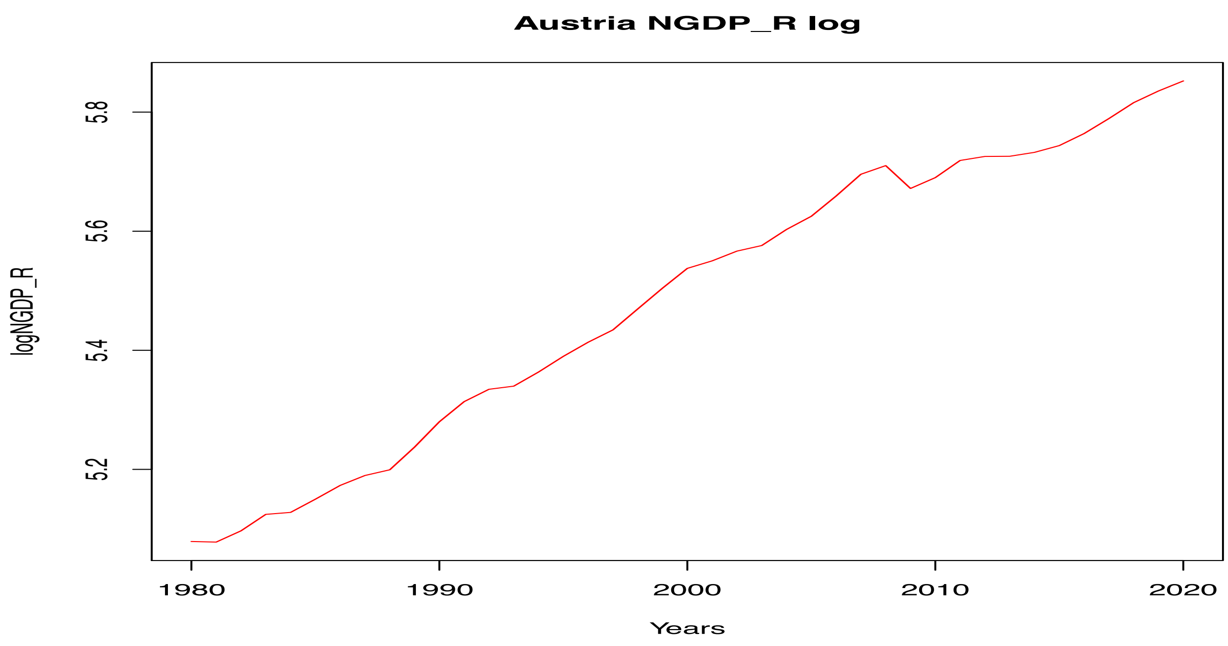
Figure 1. NGDP_R (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. NGDP_R is expressed in Billions of the national currency. Base year: 2010*

Figure 1 shows Austria's NGDP_R from year 1980 to year 2020. Overall, the gross domestic product at constant prices grew during the years. It is evident that between 2008 and 2009 there was a moment where the NGDP_R shrunk. This does not come as a surprise since this period coincides with the Financial crisis. However, after this break, NGDP_R started to increase again. In the long run, NGDP_R increase from 160 in 1980 to 348 in 2020.

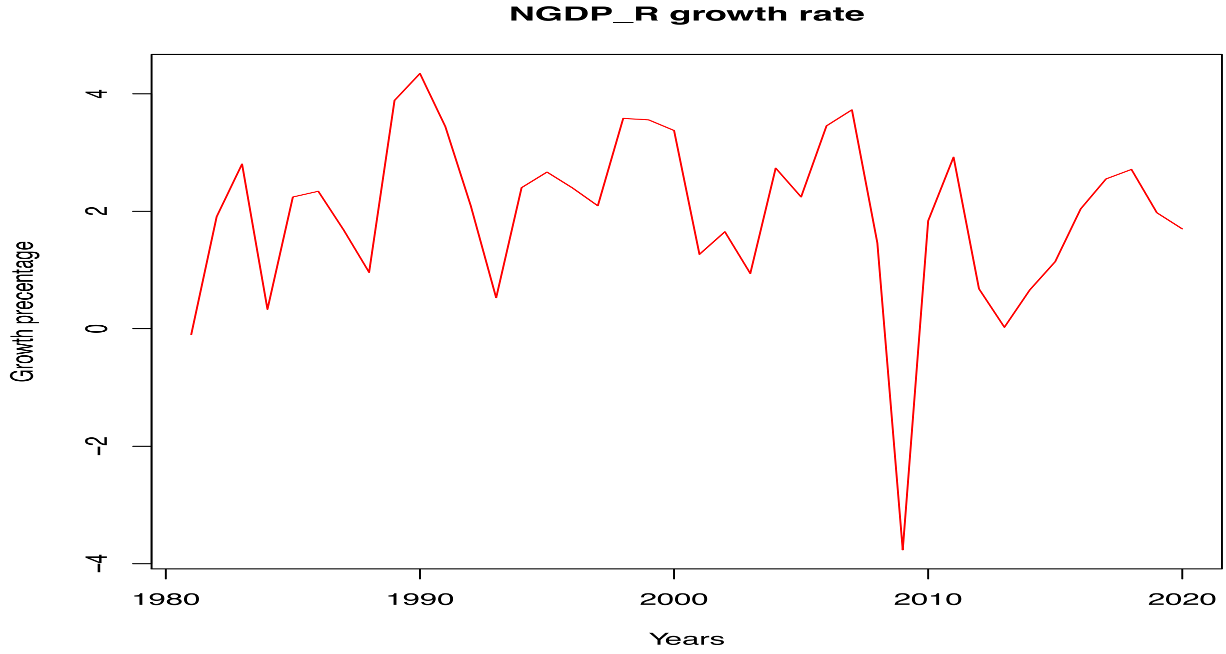
Figure 2. Logarithm of NGDP_R (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. Base year: 2010*

This chart illustrates the logarithm of NGDP_R. It is possible to note that its shape is very similar to *Figure 1*.

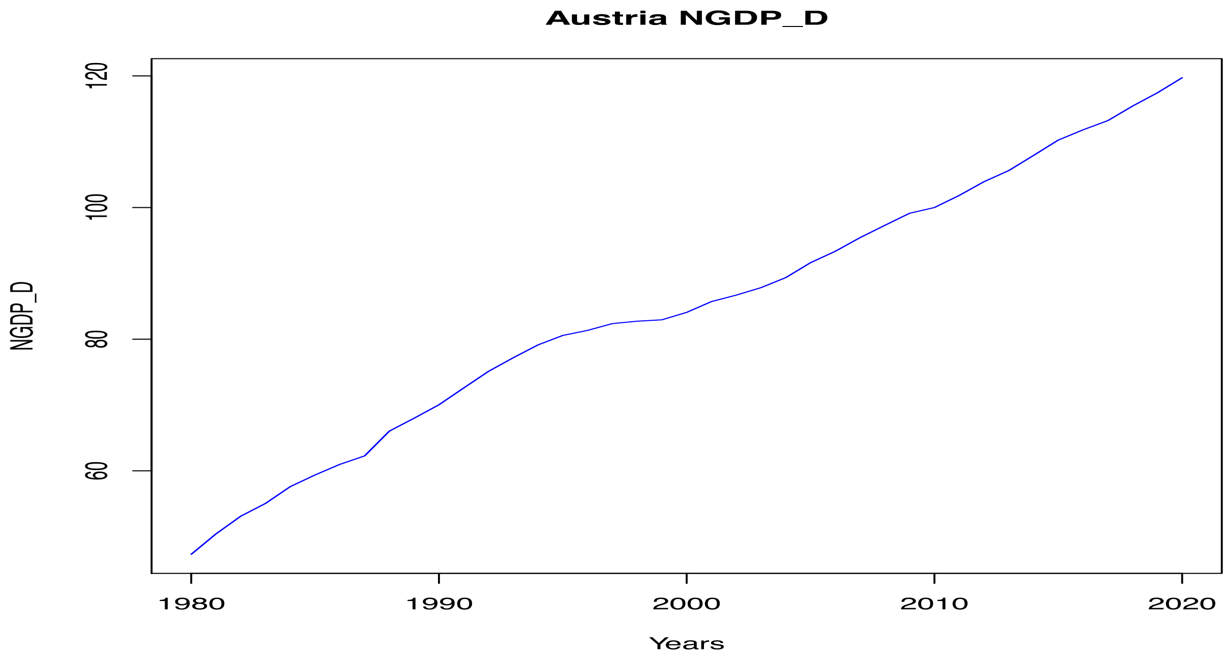
Figure 3. Growth rate of NGDP_R (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. Expressed as percentage.*

The NGDP_R growth rate shape is not as linear as the previous charts. At a first glance, it is evident that the growth rate sharply decreases from year 2008 to year 2009. From 2009, the NGDP_R growth rate starts to increase again, but only in the last period of 2009 goes above 0. As said before, these are the years of the financial crisis. Moreover, this is the only period where the growth rate is negative. In other words, in these years the NGDP_R decreases instead of increasing. Furthermore, from 2010 the growth rate of the GDP was less strong than before, due to austerity policies undertaken by Austria to react to the crisis. The highest peak is in 1990, where the growth rate was bigger than the 4%.

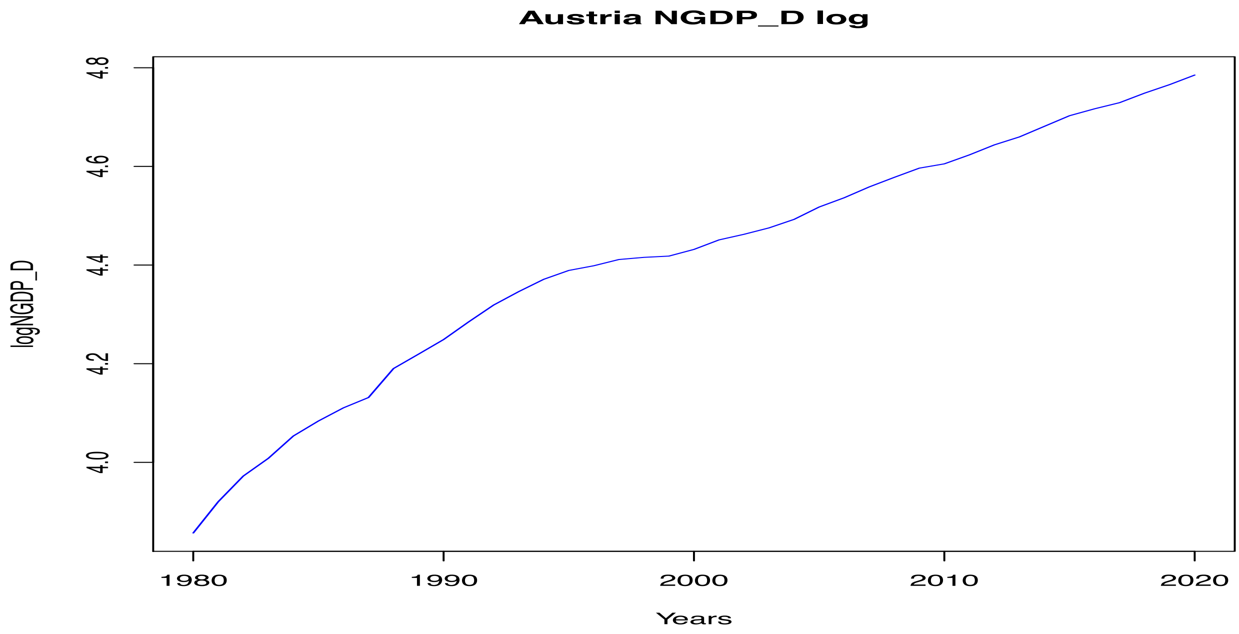
Figure 4. NGDP_D (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv.*

The deflator of Austria during the years tend to increase. This means that prices during the overall period tend to increase from year to year. The only time where the deflator seems not to increase too much is between 1998 and 1999. Note that the chart does not display (higher or lower) peaks. This means that through consequent years the deflator has changed, but not drastically. The general tendency is aligned to the general tendency in the European countries.

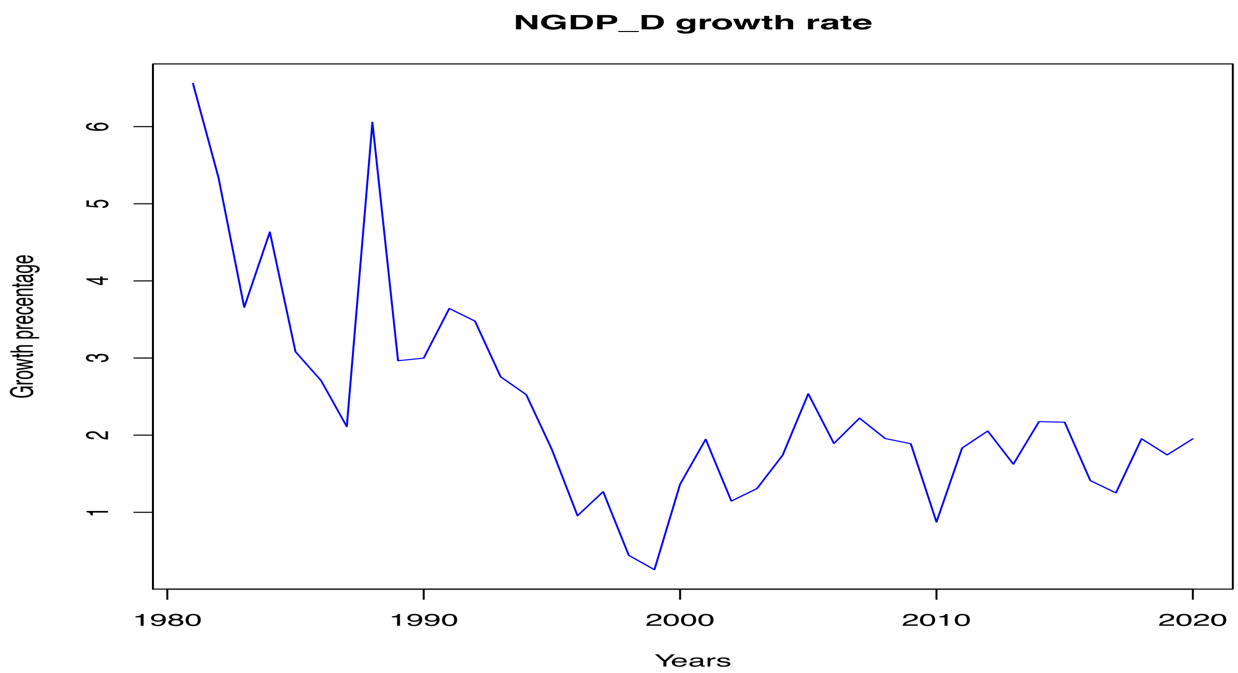
Figure 5. Logarithm of NGDP_D (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv.*

This chart illustrates the logarithm of the deflator. It is possible to note that has a shape very similar to *figure 4*.

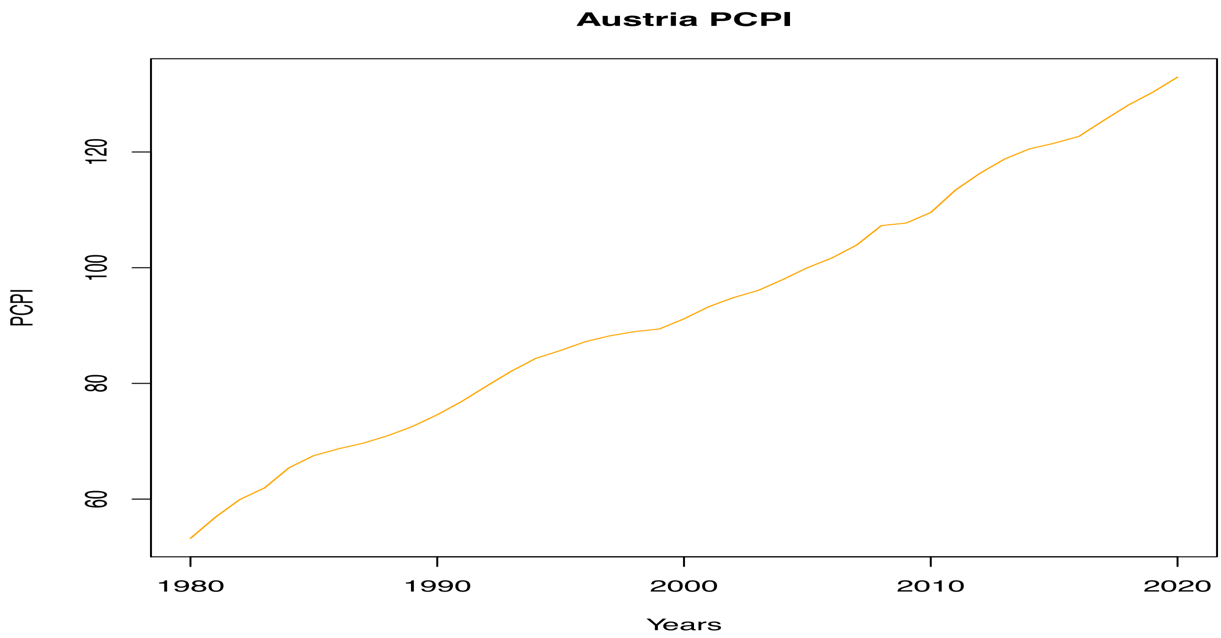
Figure 6. Growth rate of NGDP_D (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. Expressed as percentage.*

The growth rate of NGDP_D is not constant and it varies considerably from year 1980 to year 2000. Since 2000, growth rate changes become smaller in size than before. Indeed, in 1999 Austria became a member of the economic and monetary union and in 2002 it adopted the Euro. This lead to more slightly changes in the growth rate of the deflator.
It is fundamental to note is that the growth rate of the deflator never goes below 0. It is possible to see that the lowest level is reached in 1999 (less than 1%). On the other hand, there is a peak in 1988, where the growth rate is about 6%.

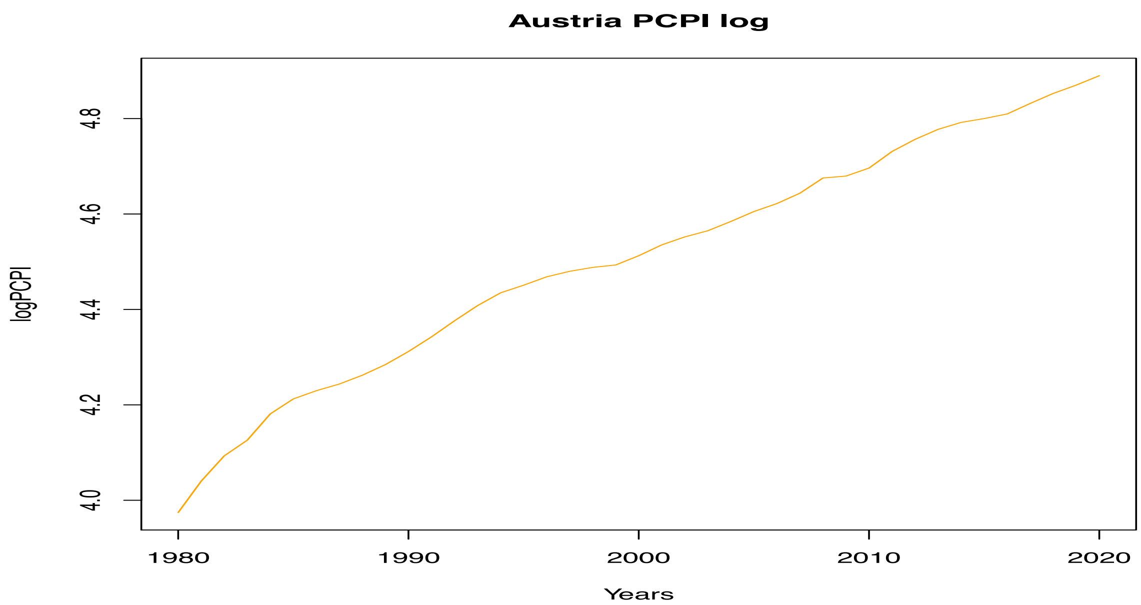
Figure 7. PCPI (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv.*

The PCPI of Austria tends to increase during the years. Especially it increases from about 53 in 1980 to 133 in 2020. There are not neither peaks nor sharp up-and-down. It is possible to note that the PCPI never decreases during this years, and the period where increases less is from 2009 to 2010.

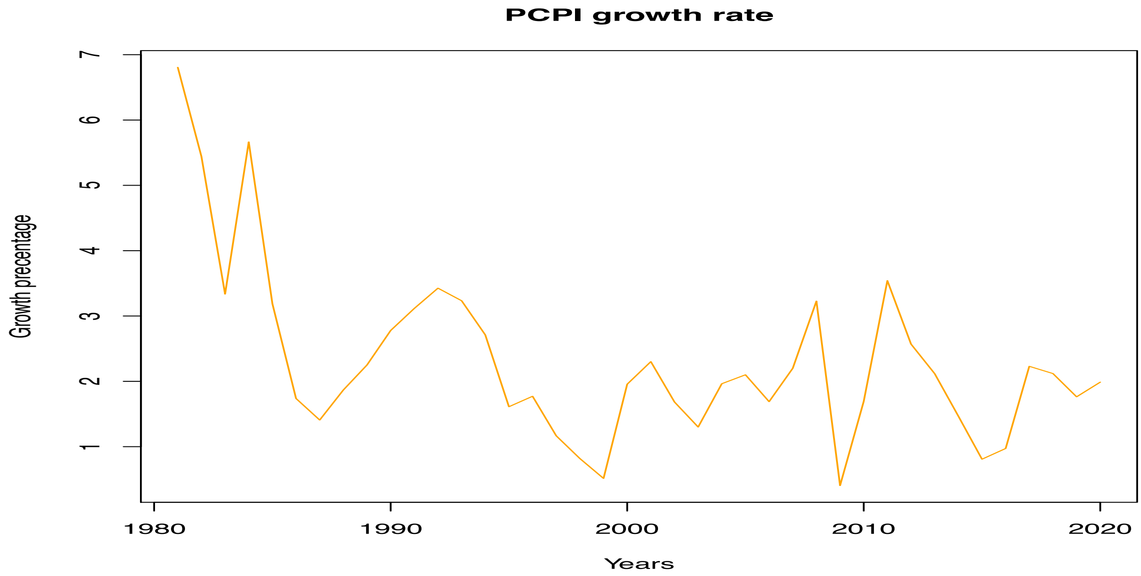
Figure 8. Logarithm of PCPI (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv.*

This chart illustrates the logarithm of the PCPI . It is possible to note that has a shape very similar to *figure 7*.

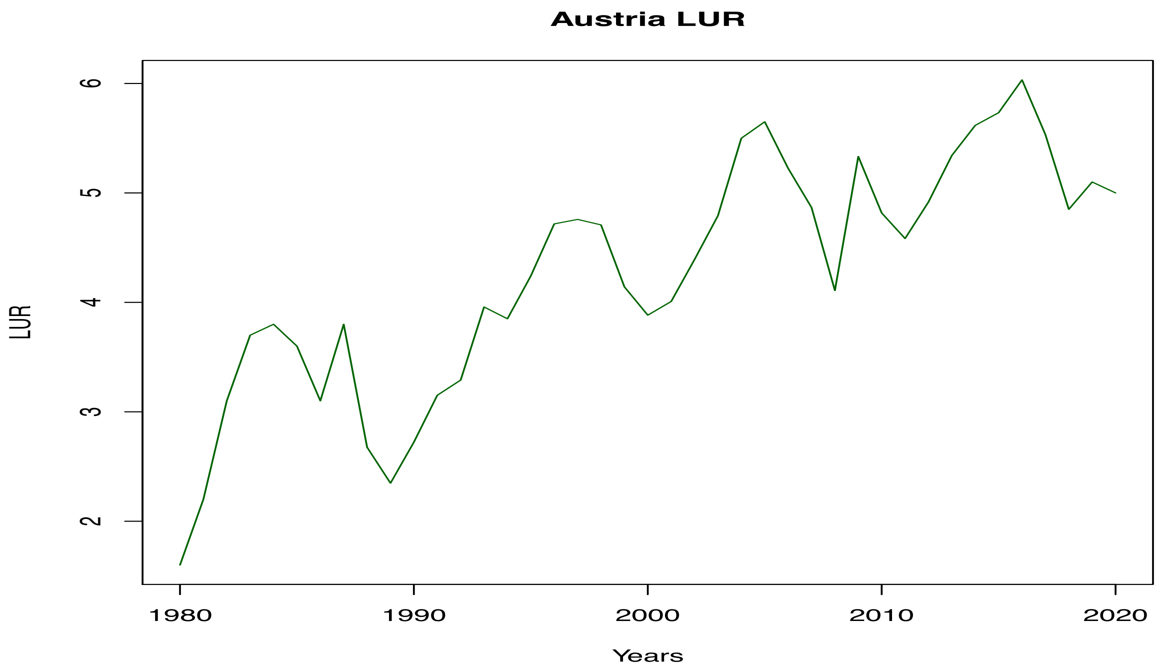
Figure 9. Growth rate of PCPI (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. Expressed as percentage.*

PCPI growth rate is not constant, and varied considerably from year to year. It is interesting that the growth rate decreases sharply from 1980 to 2000. In this period, the it passes from about 7% to less than 1%. The sudden drop in the early 80s can be seen as a consequence of the 1979 oil crisis. From 2000, the growth rate will never be higher than about 3,5% and has a low peak, as predictable, in 2008. That is a consequence of the Financial crisis. Moreover, from 1999 the growth rate variations are weaker than before. Probably, as seen before, this is a consequence of the Austrian participation in the common monetary policy. In any case, the growth rate never goes below 0.

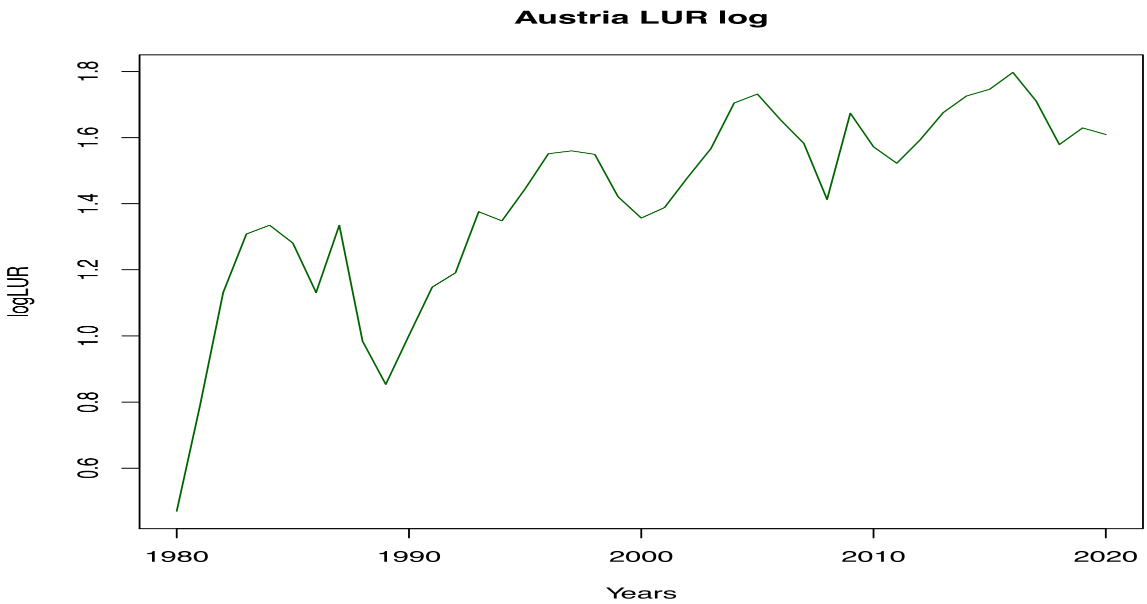
Figure 10. LUR (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. LUR Expressed as percentage of total labor force.*

At a first glance, it is evident how the unemployment rate increased from 1980 to 2020. The rate never goes below 1 (as expectable, because full employment is almost impossible to reach). Moreover, it is evident that from 1995 the unemployment has never gone below the 3,8%. The effect of the oil crisis is evident here: from 1980 to 1984 unemployment goes from 1.6% to 3.80%. The consequence of the 1990s recession is clear too: unemployment increase from 2,7% in 1990 to 4.7% in 1998. Anyway, the highest peak for unemployment is in 2016.

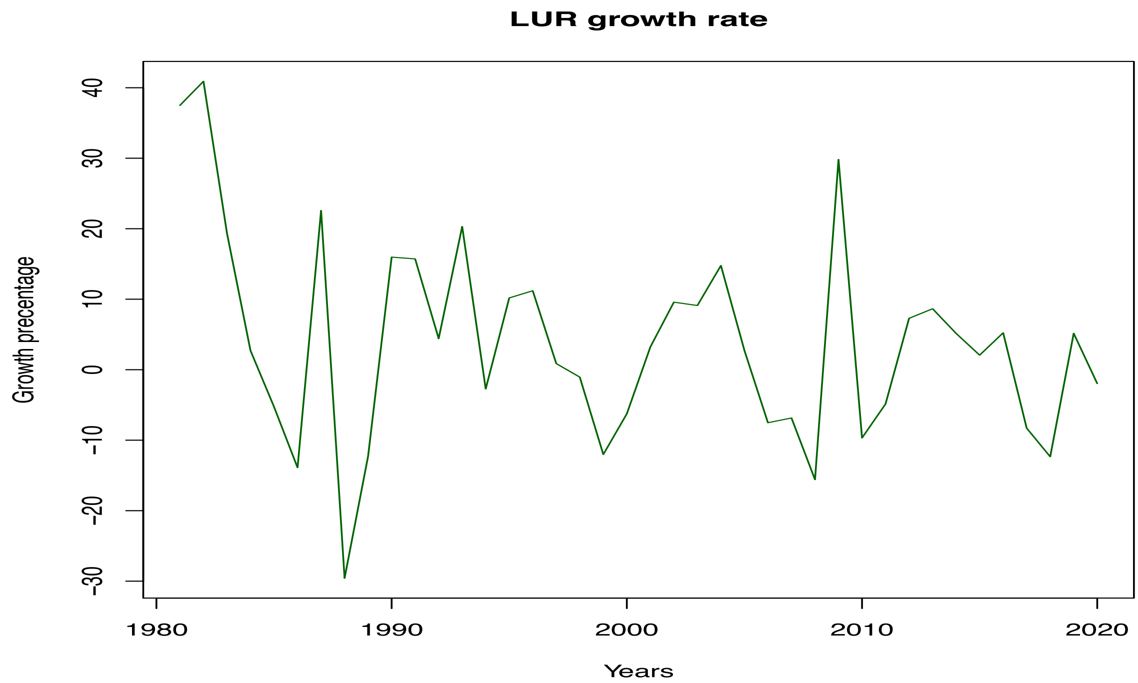
Figure 11. Logarithm of LUR (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. LUR Expressed as percentage of total labor force.*

This chart illustrates the logarithm of the LUR . It is possible to note that has a shape very similar to *figure 11*.

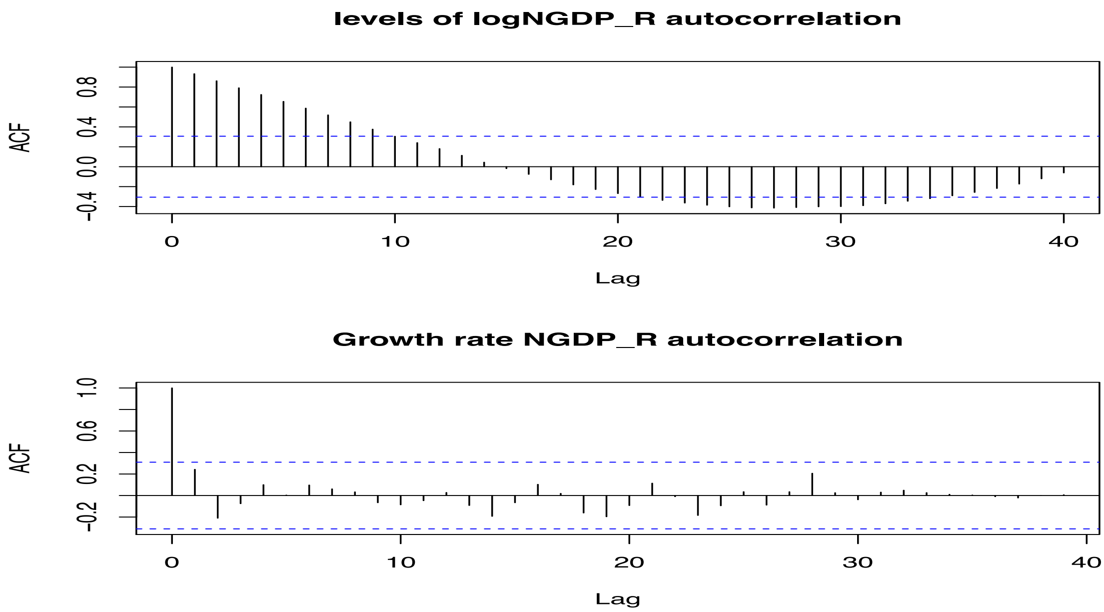
Figure 12. Growth rate of LUR (Austria) from 1980 to 2020



Note: Source of data: *WEOApr2019all.csv. LUR Expressed as percentage.*

The growth rate of the unemployment rate is quite volatile. It is possible to observe that the growth rate goes suddendly above and below the threshold of 0. This is a demonstration that unemployment rate increases and decreases over the years.
In the long run, from a peak of the 40% in 1980 it decreases of about the (-)10% in 2018. There is a drop from 1988 which ends in the lowest peak in 1989. On the other hand, the highest peak is in 2009. As well known, this coincide with the Global financial crisis. In conclusion, a brief comment on 2020: due to the COVID pandemic these data seems to be a little bit optimistic. It is probably that growth rate will be positive and big, seeing that unemployment rate will probably raise.

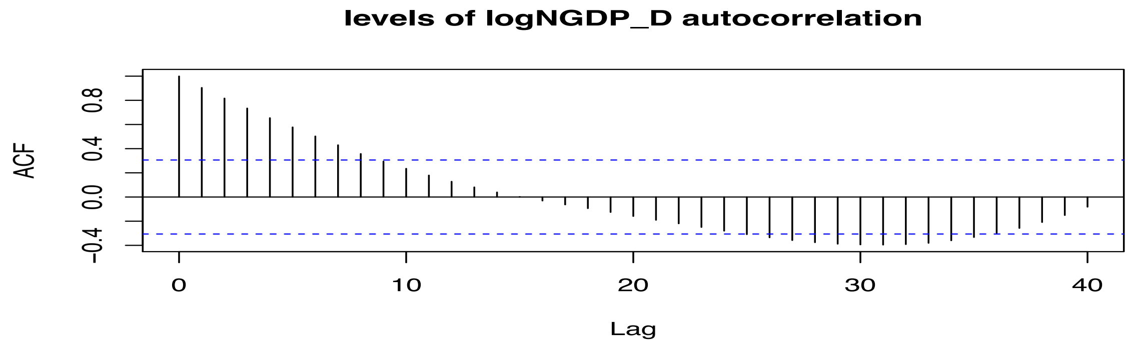
Figure 13. Correlogram of the (logged) levels and the growth rates of NGDP_R

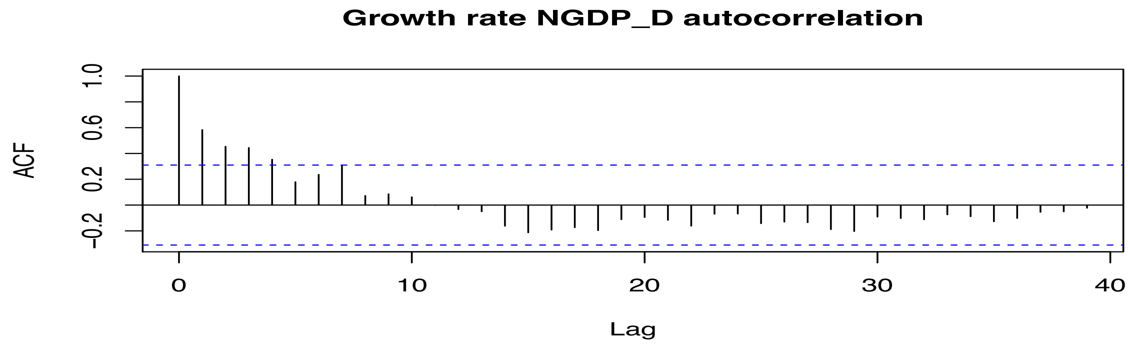


Note: Source of data: *WEOApr2019all.csv.*

Speaking about the log levels of NGDP_R it is evident that a strong autocorrelation exists between one period-lagged data. The autocorrelation is significant until lag 10. On the other hand, from lag 10 to lag 20 it is not so significant. Moreover, from lag 15 (1995) the autocorrelation changes from positive to negative and start to increase, in absolute term, until lag 30 (2010) . From this lag the autocorrelation goes backward but never become positive again. In this sense, it is possible to affirm that the first lag is not correlated with the last lag. This considerations shows us that, at least considering data until the 40th lag, the second least assumption for time series is respected.
Regarding the growth rate of NGDP_R one thing must be noticed: autocorrelation never goes above or below the dotted blue row. That is, no one of the lag is significantly correlated with the previous one. In this sense, NGDP_R's growth rate over the years is not significantly correlated among itself. That is, the previous growth rate does not explain the next one.

Figure 14. Correlogram of the (logged) levels and the growth rates of NGDP_D



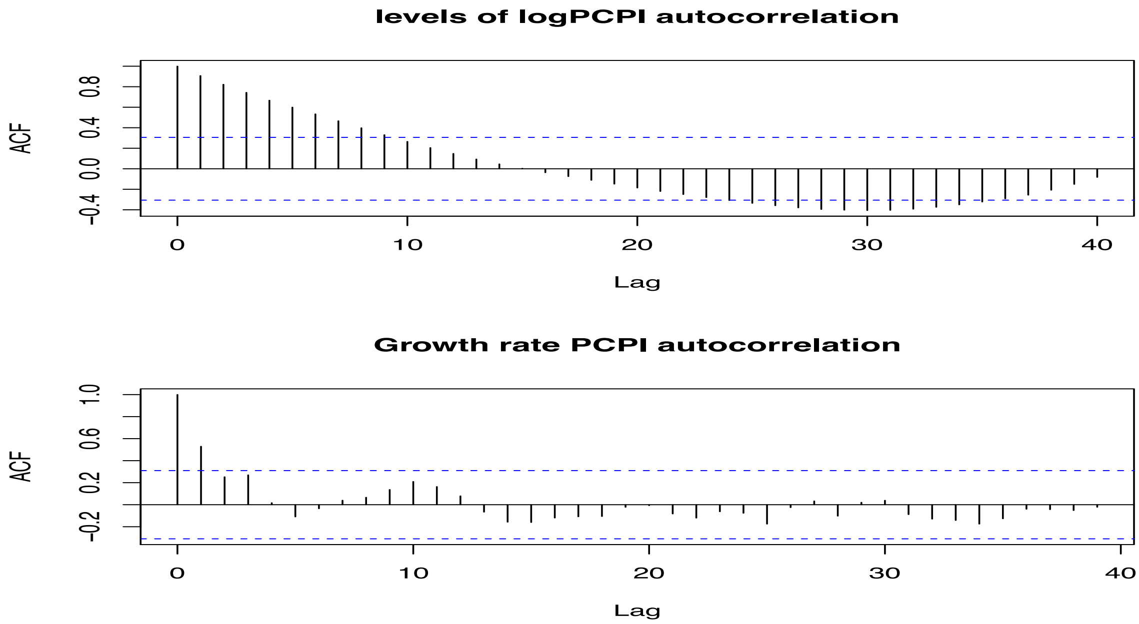


Note: Source of data: *WEOApr2019all.csv.*

The correlogram of NGDP_D logged levels is quite similar to the correlogram of the NGDP_R. Even in this case, the correlation is significant until lag 10 and become negative from lag 15. As before, from lag 30 (2010) correlation starts to go backward but never reaches the 0. It is possible to state that the first lag is not correlated with the last one. These insights shows us that, at least considering data until the 40th lag, the second least assumption for time series is respected.

The NGDP_D growth rate, on the other side, shows a more uncertain autocorrelation. First of all, most of the lags have not a significant correlation with the lag before. From lag 11 (1991), where the autocorrelation is 0, the correlation starts to become negative, even if shows a wavy shape. In lag 40 (2020) the correlation become 0 again. Even in this case, it is possible to affirm that lags are not significantly correlated among itself.

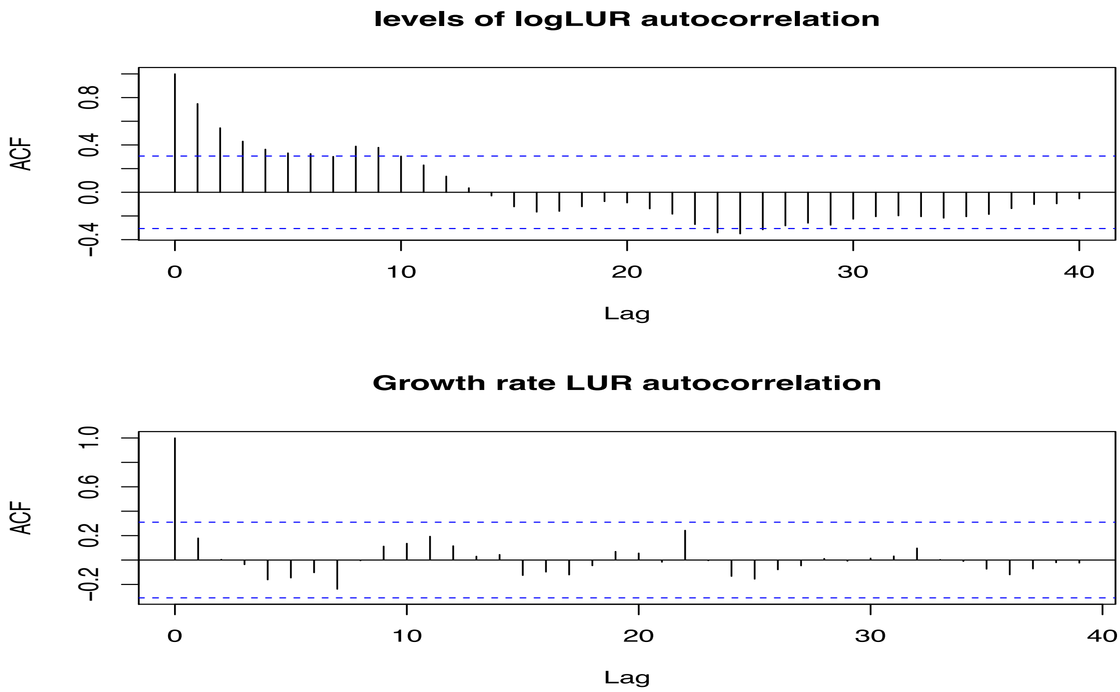
Figure 15. Correlogram of the (logged) levels and the growth rates of PCPI



Note: Source of data: *WEOApr2019all.csv.*

The levels of the logPCPI shows a situation similar to the previous ones. Even for the PCPI, its autocorrelation during time is positive until lag 15 (1995), where it is precisely 0. Since this time, the autocorrelation starts to be negative and, as before, increases in absolute term until lag 30, where begins to decrease. As well as for the above variables, the first lag is not correlated with the last one. These considerations shows us that, at least considering data until the 40th lag, the second least assumption for time series is respected.
Looking to the growth rate, the autocorrelation is not so clear. Indeed, it seems not to exist a significant correlation between a lag and the previous one. Overall, just the second lag is significantly correlated with the first one. It is possible to see that there are many ups and downs and many lags that have very low correlations with the previous one. Seeing that, the lags are not significantly correlated among itself.

Figure 16. Correlogram of the (logged) levels and the growth rates of LUR



Note: Source of data: *WEOApr2019all.csv.*

The levels of the logLUR autocorrelation presents many ups and downs. The autocorrelation remains positive until lag 13 (1993), but during this period it assumes a undulating shape. Starting from lag 14 the autocorrelation becomes negative but maintain its wavy shape. Moreover, from the 10^{th} lag the correlation between contiguous lags isn't so much significant (only in lags 24, 25 and 26 is significant). That is, the autocorrelation of the LUR first logged levels and the last one is not significant. This considerations shows us that, at least considering data until the 40^{th} lag, the second least assumption for time series is respected.
Regarding the LUR growth rate autocorrelation over time, it is not significant at all. Indeed, no one of contiguous lags has a significant correlation. This means that values observed today do not depend on what has been observed in the past. In this case, not even the second lag is correlated with the first one. Moreover, it is possible to observe that there are lots of lags that have a correlation very close to 0. That is, LUR growth rate lags are not significantly correlated among itself.

[i] Stationarity

A time-series is stationary if its probability distribution doesn't change over time. If this condition is not met, so the series is nonstationary and conventional hypothesis test and confidence intervals are unreliable. An Augmented Dickey-Fuller test exactly test the presence of a unit root. For this reason, the null-hypothesis of the Dickey-Fuller test is the presence of a stochastic trend.

Table 1. Augmented Dickey-Fuller test for the logged levels of NGDP_R

```
==========================================================================================
Test regression trend
------------------------------------------------------------------------------------------

Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
      Min        1Q    Median        3Q       Max
-0.046446 -0.007843  0.000626  0.008430  0.018764

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.366281   0.366765   0.999    0.325
z.lag.1     -0.067797   0.072911  -0.930    0.359
tt           0.001156   0.001520   0.760    0.453
z.diff.lag1  0.314556   0.166052   1.894    0.067 .
z.diff.lag2 -0.250039   0.166343  -1.503    0.142
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01353 on 33 degrees of freedom
Multiple R-squared:  0.1985,     Adjusted R-squared:  0.1013
F-statistic: 2.043 on 4 and 33 DF,  p-value: 0.1111
------------------------------------------------------------------------------------------
Value of test-statistic is: -0.9299 6.9606 1.1492

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61
==========================================================================================
```

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is not possible to reject the null-hypothesis for every alpha. That is, this time series has a unit root.

Table 2. Augmented Dickey-Fuller test for the first differences of the logarithm of NGDP_R

```
###############################################################################
Test regression trend
-------------------------------------------------------------------------------
Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.049867 -0.006919  0.002390  0.010050  0.017277 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)   
(Intercept)  0.0246636  0.0084828   2.907  0.00657 **
z.lag.1     -0.9848066  0.2739745  -3.595  0.00108 **
tt          -0.0002509  0.0002248  -1.116  0.27260   
z.diff.lag1  0.2833318  0.2060137   1.375  0.17859   
z.diff.lag2 -0.0389801  0.1710992  -0.228  0.82123   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0139 on 32 degrees of freedom
Multiple R-squared:  0.4508,     Adjusted R-squared:  0.3821 
F-statistic: 6.566 on 4 and 32 DF,  p-value: 0.0005629
-------------------------------------------------------------------------------
Value of test-statistic is: -3.5945 4.3072 6.4607 

Critical values for test statistics: 
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61

###############################################################################
```

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is possible to reject the null-hypothesis only for alpha = 0.05. That is, this time series doesn't have a unit root.

Table 3. Augmented Dickey-Fuller test for the logged levels of NGDP_D

```
###############################################################################
Test regression trend
-------------------------------------------------------------------------------
Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
       Min         1Q     Median         3Q        Max 
-0.0116693 -0.0047016  0.0002063  0.0036713  0.0300040 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.3922519  0.1638232   2.394   0.0225 *
z.lag.1     -0.0925527  0.0400592  -2.310   0.0273 *
tt           0.0015017  0.0007442   2.018   0.0518 .
z.diff.lag1  0.2090165  0.1603059   1.304   0.2013  
z.diff.lag2  0.0950600  0.1500833   0.633   0.5309  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.008022 on 33 degrees of freedom
Multiple R-squared:  0.5124,     Adjusted R-squared:  0.4533 
F-statistic: 8.669 on 4 and 33 DF,  p-value: 6.745e-05
```

```
--------------------------------------------------------------------------------------------
Value of test-statistic is: -2.3104 4.5137 3.2852

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61
============================================================================================
```

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is not possible to reject the null-hypothesis for every alpha. That is, this time series has a unit root.

Table 4. Augmented Dickey-Fuller test for the first differences of the logarithm of NGDP_D

```
============================================================================================
Test regression trend
--------------------------------------------------------------------------------------------
Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
      Min        1Q    Median        3Q       Max
-0.012197 -0.004190 -0.000026  0.003554  0.034763

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.888e-03  7.441e-03   1.194   0.2411
z.lag.1     -3.822e-01  1.864e-01  -2.051   0.0486 *
tt          -8.172e-05  1.818e-04  -0.450   0.6560
z.diff.lag1 -3.565e-01  1.830e-01  -1.948   0.0602 .
z.diff.lag2 -2.033e-01  1.559e-01  -1.304   0.2015
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.008485 on 32 degrees of freedom
Multiple R-squared:  0.3722,     Adjusted R-squared:  0.2937
F-statistic: 4.742 on 4 and 32 DF,  p-value: 0.004052
--------------------------------------------------------------------------------------------
Value of test-statistic is: -2.0506 2.1719 2.8704

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61
============================================================================================
```

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is not possible to reject the null-hypothesis for every alpha. That is, this time series has a unit root.

Table 5. Augmented Dickey-Fuller test for the logged levels of PCPI

```
============================================================================================
Test regression trend
--------------------------------------------------------------------------------------------
Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0174608 -0.0053997 -0.0001187  0.0036515  0.0201622

Coefficients:
```

```
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.821652   0.266310   3.085  0.00410 **
z.lag.1     -0.195491   0.064647  -3.024  0.00480 **
tt           0.003633   0.001264   2.875  0.00702 **
z.diff.lag1  0.345056   0.152329   2.265  0.03019 *
z.diff.lag2 -0.112830   0.135646  -0.832  0.41150
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.007769 on 33 degrees of freedom
Multiple R-squared:  0.4412,     Adjusted R-squared:  0.3735
F-statistic: 6.514 on 4 and 33 DF,  p-value: 0.000559
-----------------------------------------------------------------------------------------
Value of test-statistic is: -3.024 8.1667 5.3083

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61
=========================================================================================
```

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is not possible to reject the null-hypothesis for every alpha. That is, this time series has a unit root.

Table 6. Augmented Dickey-Fuller test for the first differences of the logarithm of PCPI

```
=========================================================================================
Test regression trend
-----------------------------------------------------------------------------------------
Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
      Min        1Q    Median        3Q       Max
-0.019276 -0.006802  0.001158  0.005361  0.023550

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.198e-02  6.858e-03   1.747   0.0903 .
z.lag.1     -5.136e-01  1.918e-01  -2.678   0.0116 *
tt          -8.809e-05  1.632e-04  -0.540   0.5932
z.diff.lag1 -6.697e-02  1.690e-01  -0.396   0.6945
z.diff.lag2 -1.962e-01  1.495e-01  -1.312   0.1987
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.008671 on 32 degrees of freedom
Multiple R-squared:  0.3361,     Adjusted R-squared:  0.2531
F-statistic:  4.05 on 4 and 32 DF,  p-value: 0.009085
-----------------------------------------------------------------------------------------
Value of test-statistic is: -2.6781 2.9307 4.1552

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61
=========================================================================================
```

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is not possible to reject the null-hypothesis for every alpha. That is, this time series has an unit root.

Table 7. Augmented Dickey-Fuller test for the logged levels of LUR

```
###############################################
# 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
-0.298943 -0.059780  0.008104  0.058860  0.221319

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.588826   0.167893   3.507  0.00133 **
z.lag.1     -0.550252   0.159133  -3.458  0.00152 **
tt           0.009750   0.003469   2.811  0.00825 **
z.diff.lag1  0.233162   0.152694   1.527  0.13629
z.diff.lag2  0.210317   0.147642   1.425  0.16369
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1111 on 33 degrees of freedom
Multiple R-squared:  0.2692,     Adjusted R-squared:  0.1806
F-statistic: 3.039 on 4 and 33 DF,  p-value: 0.03078
-------------------------------------------------------------------------------
Value of test-statistic is: -3.4578 4.1739 6.0585

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61
===============================================================================
```

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is not possible to reject the null-hypothesis for alpha = 0.05 but It is possible to reject it for alpha= 0.1 . That is, this time series has an unit root with a confidence level of 0.95.

Table 7. Augmented Dickey-Fuller test for the first differences of the logarithm of LUR

```
===============================================================================
test regression trend
-------------------------------------------------------------------------------
Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
     Min       1Q   Median       3Q      Max
-0.36239 -0.08058  0.02277  0.07507  0.23421

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.0167891  0.0495161   0.339 0.736777
z.lag.1     -1.1515202  0.2686113  -4.287 0.000155 ***
tt          -0.0002664  0.0020393  -0.131 0.896885
z.diff.lag1  0.0857988  0.2081293   0.412 0.682914
z.diff.lag2  0.0278854  0.1557866   0.179 0.859068
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1279 on 32 degrees of freedom
Multiple R-squared:  0.5481,     Adjusted R-squared:  0.4916
F-statistic: 9.704 on 4 and 32 DF,  p-value: 2.953e-05
-------------------------------------------------------------------------------
Value of test-statistic is: -4.2869 6.5115 9.5617
```

```
Critical values for test statistics:
      1pct  5pct 10pct
tau3 -4.15 -3.50 -3.18
phi2  7.02  5.13  4.31
phi3  9.31  6.73  5.61
==========================================================================================
```
*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

It is possible to reject the null-hypothesis for every alpha. That is, this time series is stationary.

[ii] Inflation

Figure 17. Measures of inflation (measured by logNGDP_D and logPCPI first differences) (Austria)

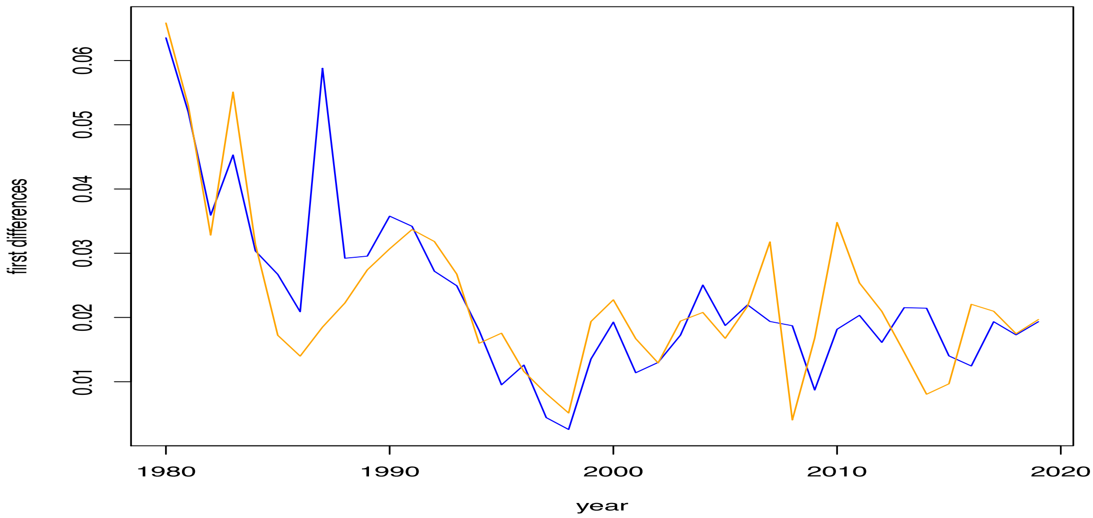
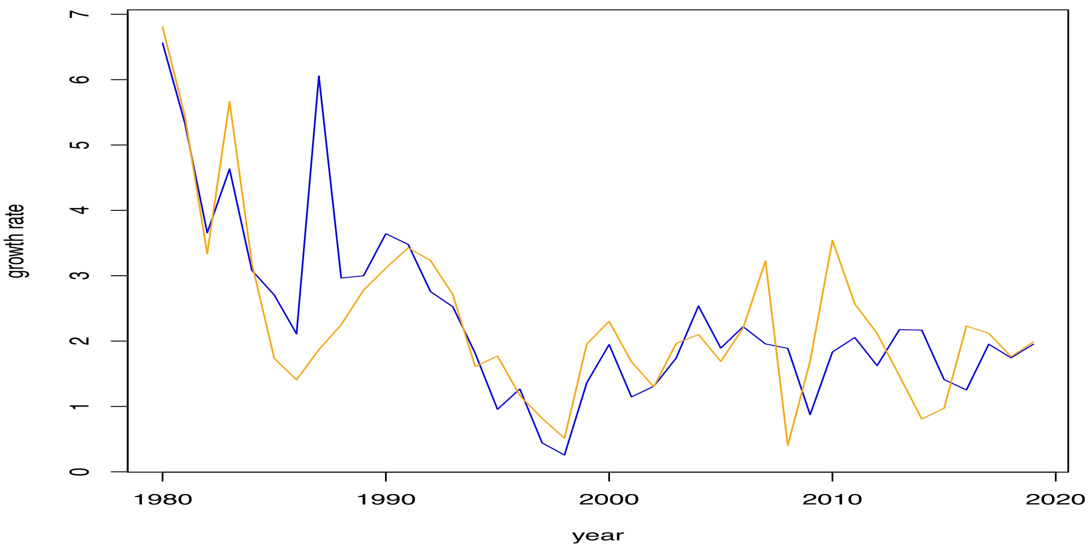


Figure 18. Inflation growth rate (measured by NGDP_D and PCPI growth rate) (Austria)



Note: Source of data: WEOApr2019all.csv. PCPI = orange line; NGDP: blue line.

First of all it could be useful to define these two measures: the PCPI measures inflation considering a representative bunch of goods. The deflator, instead, represents inflation by considering all the goods produced within a State

(excluding services). As it is possible to see, computations of the inflation (first differences and growth rate) are very similar. That is because both the first differences (with an approximation) and the growth rate can be used to compute inflation.
Comparing PCPI and NGDP_D index, the shapes of the lines are not completely similar. Especially, the Deflator has a sharp vertical growth in year 1986-1987 whereas the PCPI has a softer growth rate. Moreover, the PCPI growth rate never reach the 1997 peak of the deflator. Anyway, both the measures follow almost the same trend: a decrease from 1980 to 1998 and a slightly increase, with lots of ups and downs, from 1998 to 2020. It is Interesting the global financial crisis period: the PCPI growth rate faced a deeper depression than the NGDP_R but after that it grew up faster.
In conclusion, expectation are confirmed by these charts: deflator growth rate and PCPI growth rate are similar (and similar are, obviously, their first differences). For this reason, deflator is considered as an alternative measure of inflation.

[iii] Philips Curve Estimation

Table 8. Estimated Philips curve models

	Dependent variable:				
	fdiffPCPI				
	(1)	(2)	(3)	(4)	(5)
L(fdiffPCPI)	0.446***	0.371**	0.401**	0.414**	0.392**
	(0.129)	(0.175)	(0.176)	(0.179)	(0.185)
L(fdiffPCPI, 2)		0.005	-0.083	-0.195	-0.170
		(0.140)	(0.160)	(0.190)	(0.197)
L(fdiffPCPI, 3)				0.199	0.151
				(0.140)	(0.162)
L(LURts)	-0.002	-0.002	0.001	0.001	0.001
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
L(LURts, 2)			-0.004	-0.003	-0.002
			(0.003)	(0.003)	(0.004)
L(LURts, 3)					-0.002
					(0.003)
Constant	0.020**	0.021**	0.025**	0.021*	0.024**
	(0.009)	(0.010)	(0.010)	(0.010)	(0.011)
Observations	39	38	38	37	37
R2	0.424	0.287	0.314	0.334	0.341
Adjusted R2	0.391	0.224	0.231	0.226	0.210
Residual Std. Error	0.009 (df = 36)	0.009 (df = 34)	0.009 (df = 33)	0.009 (df = 31)	0.009 (df = 30)
F Statistic	13.224*** (df = 2; 36)	4.565*** (df = 3; 34)	3.778** (df = 4; 33)	3.106** (df = 5; 31)	2.593** (df = 6; 30)

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv. fdiffPCPI = first differences of logged inflation, LUR = unemployment*

These models try to explain the first differences of the logged inflation by using as regressor their past history and unemployment. *Ex-ante*, we expect that unemployment will be negatively correlated with inflation. This intuition is present just in *model (1)* and *(2)*. Moreover, *model (1)* has the biggest R-squared, this means that it is the best-fitted model for the observed data. Furthermore, adding one more lag for the first difference of the logged inflation (passing from 1 lag to 2) makes this regressor lose significance. On the other hand, regressor LUR seems not to be so significant in explaining inflation.
Anyway, to choose the suitable number of length the information criterion approach can help. The Bayesian Information Criterion (BIC) indicates that the best lag-length is 1 for both the regressor. That is, BIC suggests that the most fitted model for explaining our "Philips curve" is *model (1).* For further confirmation, even the F-test shows the joint significance of the regressors (P-value = 8.819e-06).

Table 9. BIC computation until order 1:12

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]	[,10]	[,11]	[,12]
p	2.0000	4.0000	6.0000	8.0000	10.0000	12.0000	14.0000	16.0000	18.0000	20.0000	22.0000	24.000
BIC	-9.3223	-9.1726	-9.0234	-9.2853	-9.0381	-8.9217	-8.7233	-8.4737	-8.2955	-8.1007	-7.7917	-8.118
R2	0.4235	0.3141	0.3415	0.3804	0.3397	0.4266	0.4587	0.4759	0.5322	0.5689	0.5437	0.732

Note. Source of data: WEOApr2019all.csv. Lowest BIC = [,2].

Table 10. Estimated Philips curve (robust standard errors)

	Dependent variable:
	PHC(1,1)
L(fdiffPCPI)	0.446***
	(0.097)
L(LURts)	-0.002**
	(0.001)
Constant	0.020***
	(0.005)
Observations	39
R2	0.424
Adjusted R2	0.391
Residual Std. Error	0.009 (df = 36)
F Statistic	13.224*** (df = 2; 36)

*Note. *p<0.1; **p<0.05; ***p<0.01. Source of data: WEOApr2019all.csv*

This model shows the estimated "Philips curve". It is exactly the *model (1)* above, except for the computation of the standard error. In this case, a robust formula has been used. It is possible to see that standard errors changes. This is an indication of the presence of heteroskedasticity. Moreover, in computing robust standard errors it becomes statistically significant even the unemployment level (whose coefficient is still negative).