Computer Lab in Economics
Master in International Economics
Time series analysis with Stata

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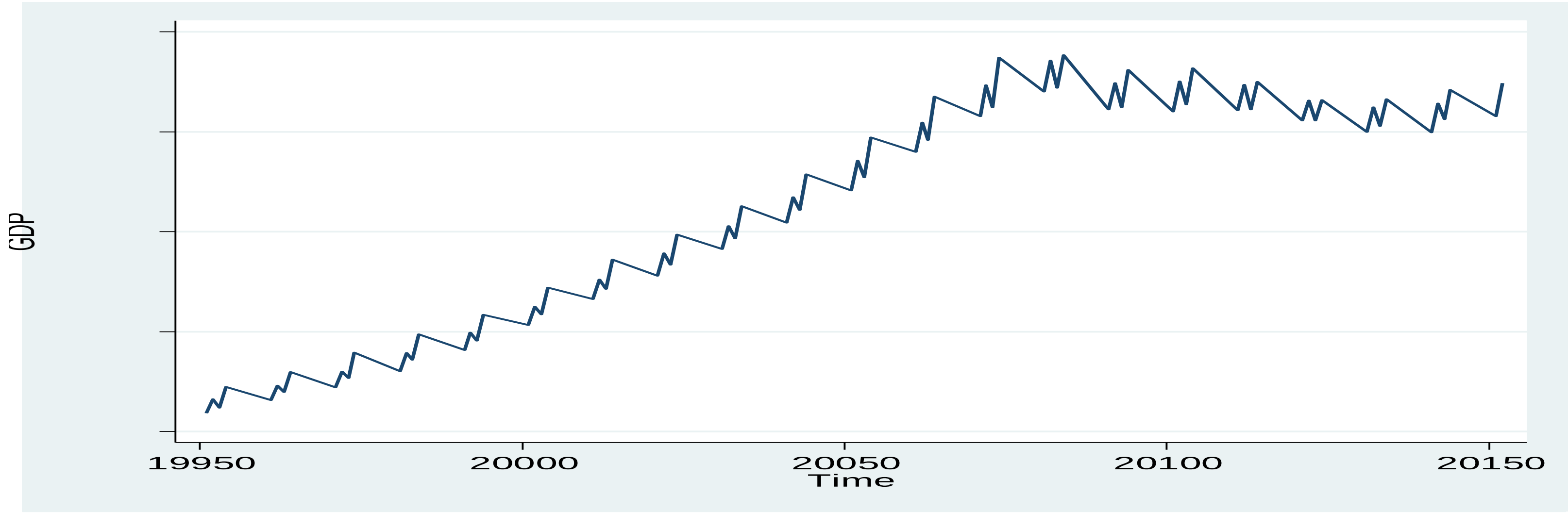
Time series analysis with Stata

What is a time serie?
Some observations along time, discrete or continuous.

Example: national GDP in Spain:

```
. tsset time
  time variable: time, 19951 to 20152, but with gaps  delta: 1 unit
. twoway (tsline gdp)
```



Time series analysis with Stata

Classification:

- **Stationarity**: constant average and variance. To obtain starionary series we can apply two transformations:

First differences: to eliminate trends
Box-cox: to eliminate different variances

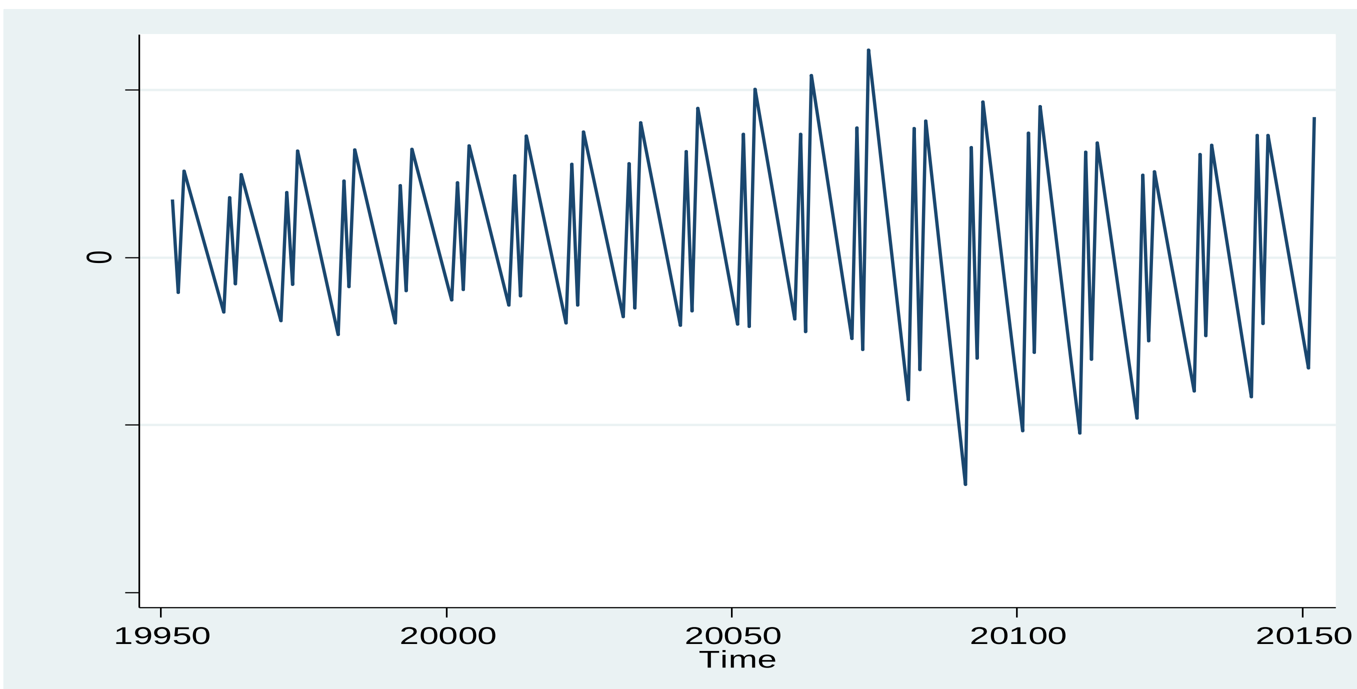
$$w_t = \begin{cases} (z_t^\lambda - 1)/\lambda & \lambda \neq 0 \\ \log z_t & \lambda = 0 \end{cases}$$

- **Seasonality**: seasonal trend

Time series analysis with Stata

Example: first differences in GDP

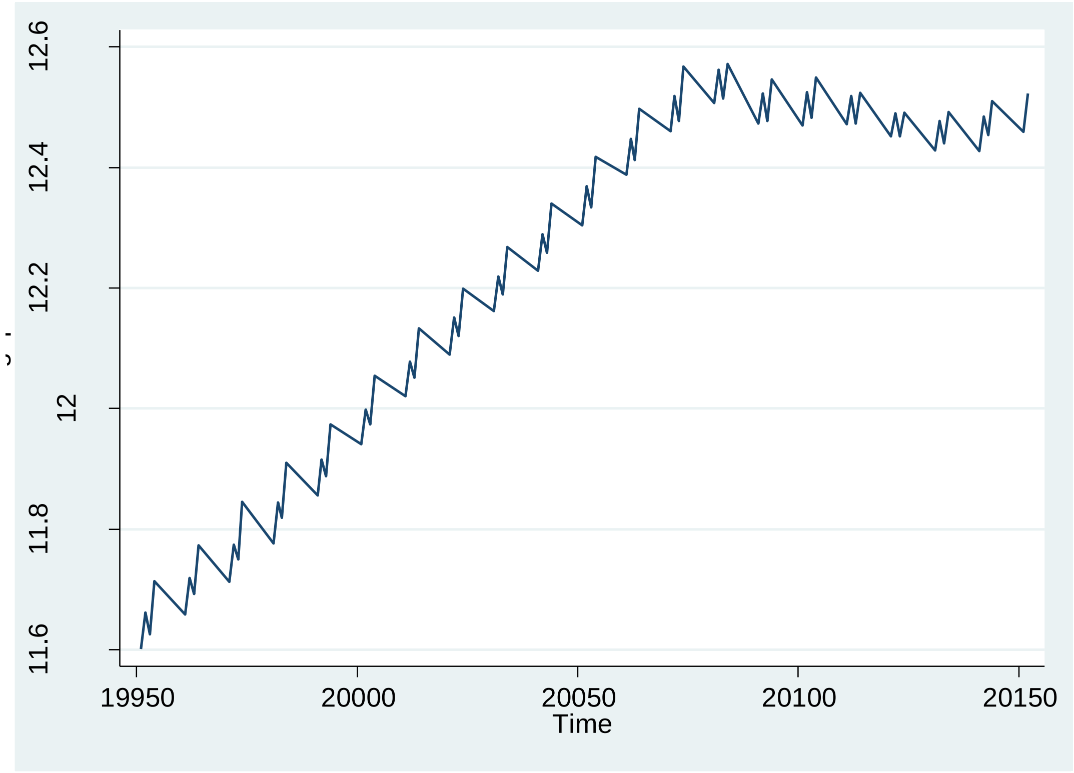
```
. generate gdp_1=gdp[_n-1]
(1 missing value generated)

. generate dgdp=gdp-gdp_1
(1 missing value generated)
```



Time series analysis with Stata

Example: logarithmic transformation of GDP

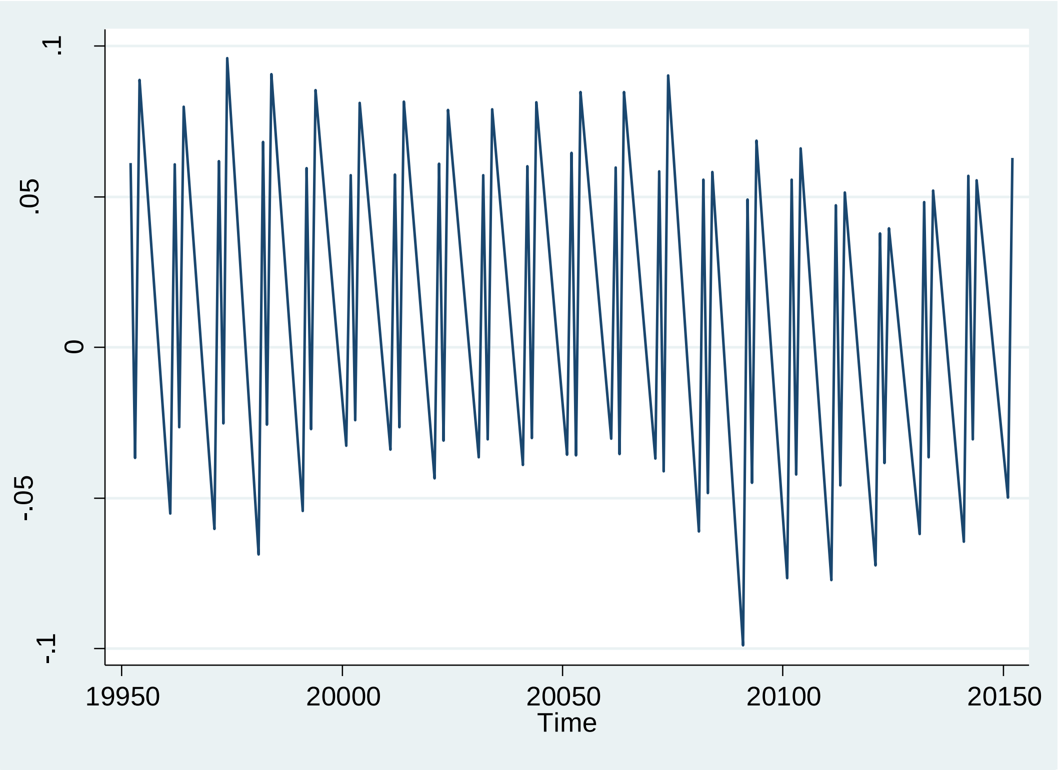
```
. generate lgdp=ln( gdp)
. twoway (tsline lgdp)
```



Time series analysis with Stata

Example: first differences in logarithmic transformation of GDP

```
. generate dlgdp=lgdp-lgdp[_n-1]
(1 missing value generated)
 twoway (tsline dlgdp)
```



Time series analysis with Stata

Unit root tests: Dickey-Fuller

The Dickey–Fuller test involves fitting the model

$$y_t = \alpha + \rho y_{t-1} + \delta t + u_t$$

by ordinary least squares (OLS), perhaps setting $\alpha = 0$ or $\delta = 0$. However, such a regression is likely to be plagued by serial correlation. To control for that, the augmented Dickey–Fuller test instead fits a model of the form

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta t + \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + \cdots + \zeta_k \Delta y_{t-k} + \epsilon_t \qquad (1)$$

where k is the number of lags specified in the `lags()` option. The `noconstant` option removes the constant term α from this regression, and the `trend` option includes the time trend δt, which by default is not included. Testing $\beta = 0$ is equivalent to testing $\rho = 1$, or, equivalently, that y_t follows a unit root process.

Time series analysis with Stata

Unit root tests: Dickey-Fuller

Example: GDP

. dfuller gdp, lags(0)

Dickey-Fuller test for unit root Number of obs = 61

	---------- Interpolated Dickey-Fuller ---------			
	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-0.109	-3.565	-2.921	-2.596

MacKinnon approximate p-value for Z(t) = 0.9485

we cannot reject the null hypothesis that GDP exhibits a unit root

Time series analysis with Stata

Unit root tests: Dickey-Fuller

Example: logarithmic transformation of GDP

```
. dfuller lgdp, lags(0)

Dickey-Fuller test for unit root                   Number of obs   =        61

                          ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
                Statistic          Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.433            -3.565            -2.921            -2.596
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.5665
```

we cannot reject the null hypothesis that log GDP exhibits a unit root

Time series analysis with Stata

Unit root tests: Dickey-Fuller

Example: first differences of logarithmic transformation of GDP

```
. dfuller dlgdp , lags(0)

Dickey-Fuller test for unit root                   Number of obs   =        60

                         ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)          -30.265            -3.566            -2.922            -2.596
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Here we can overwhelmingly reject the null hypothesis of a unit root at all common Significance levels

Time series analysis with Stata

Decomposition of a time series

A time series can be decomposed into:

$$z_t = T_t + S_t + a_t$$

- Tendency (T)
- Seasonality (S)
- Irregular term (a)

We can use a filter to obtain these components.

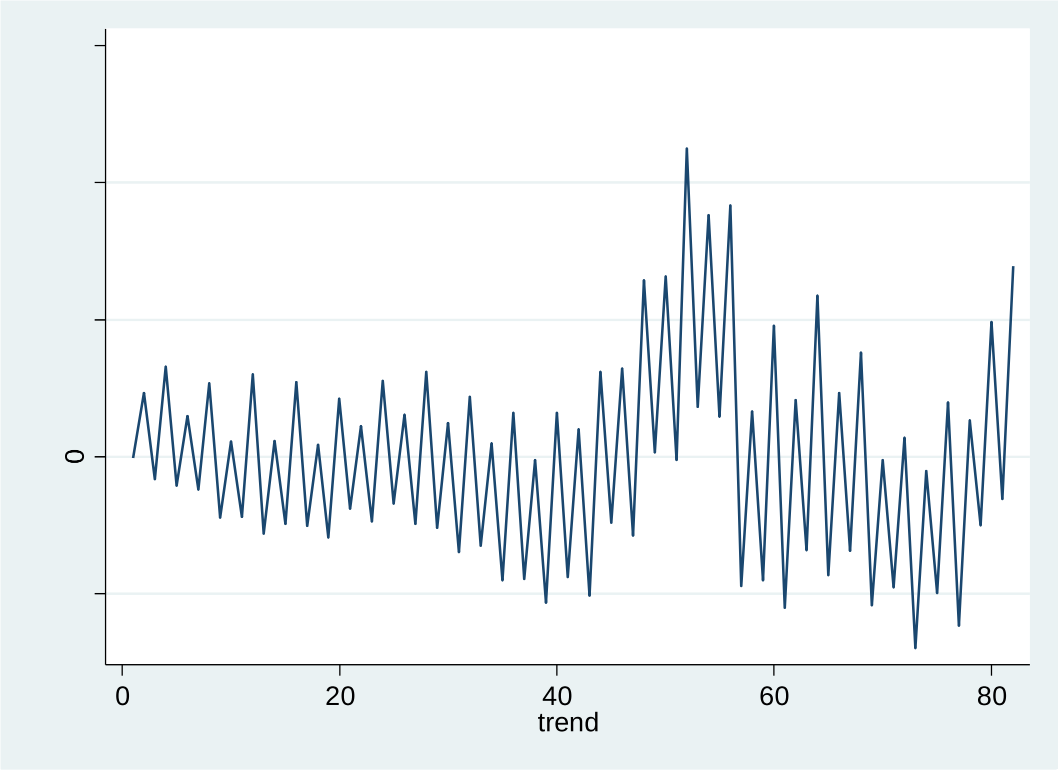
Time series analysis with Stata

Decomposition of a time series

Example: decomposition of GDP.

tsset trend
    time variable: trend, 1 to 82
        delta: 1 unit

hprescott gdp, stub(hp)
twoway (tsline hp_gdp_1)

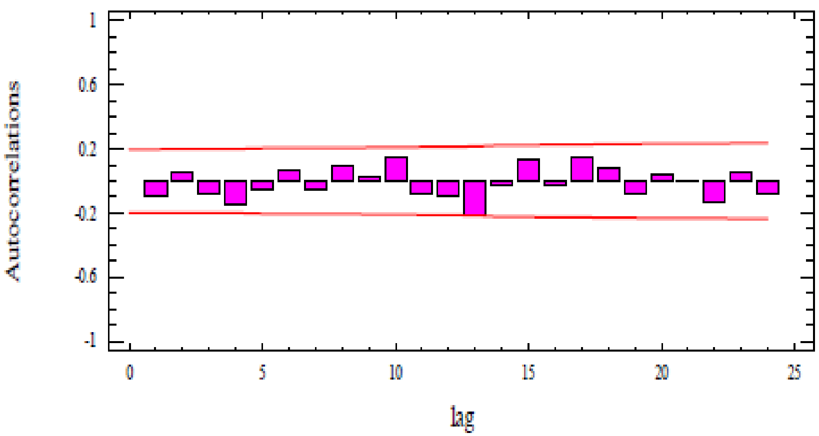


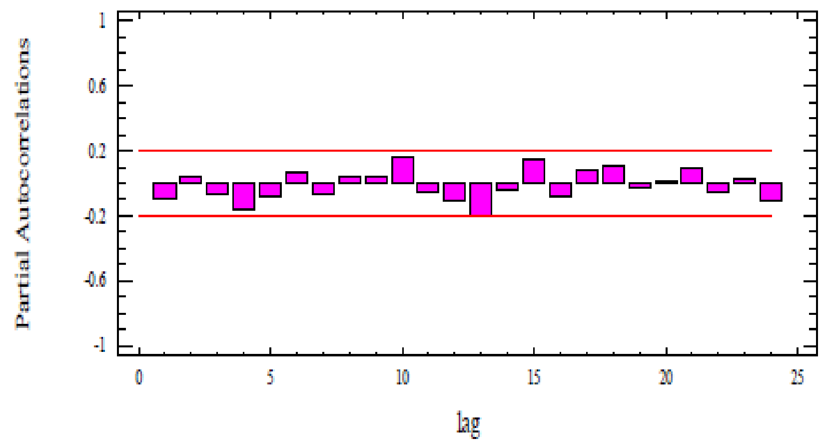
Time series analysis with Stata

Analysis of a time series

Simple Autocorrelation Function: autocorrelation between one observation and the followers.
Partial Autocorrelation Function: only direct correlation between one observation and those separated k lags.

White noise aucotorrelation





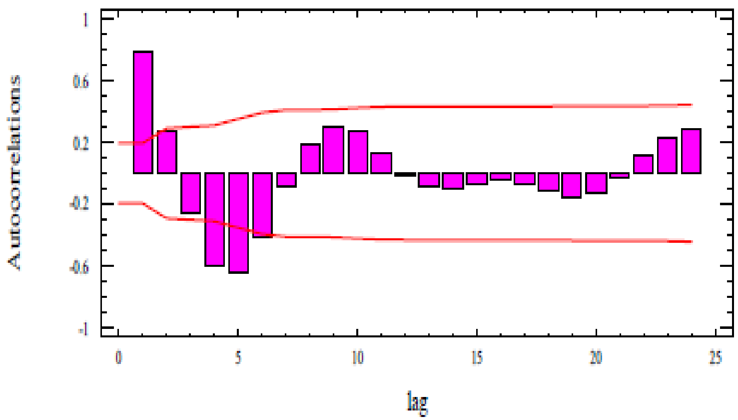
Time series analysis with Stata

Analysis of a time series
Autorregresive process, AR(p)

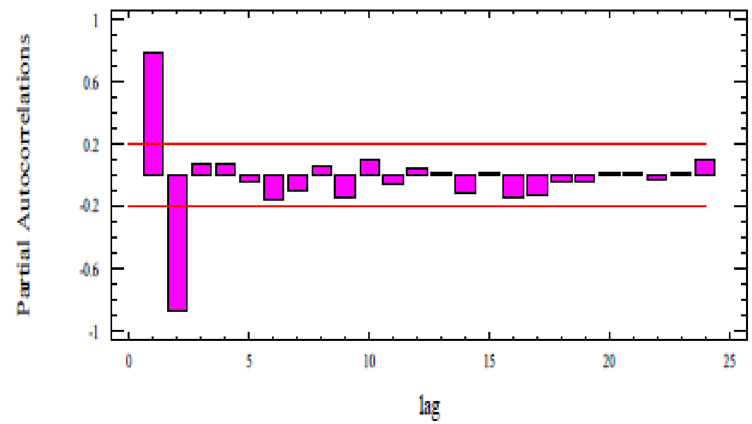
$$z_t = c + \phi_1 z_{t-1} + \phi_2 z_{t-2} + \cdots + \phi_p z_{t-p} + a_t$$

AR(2)

Simple Autocorrelation Function (more complex)



Partial Autocorrelation Function (P significant elements)



Time series analysis with Stata

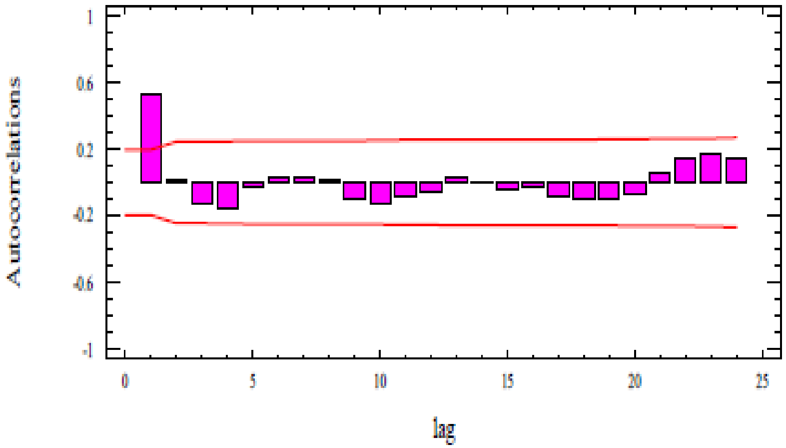
Analysis of a time series
Moving average process, MA(q)

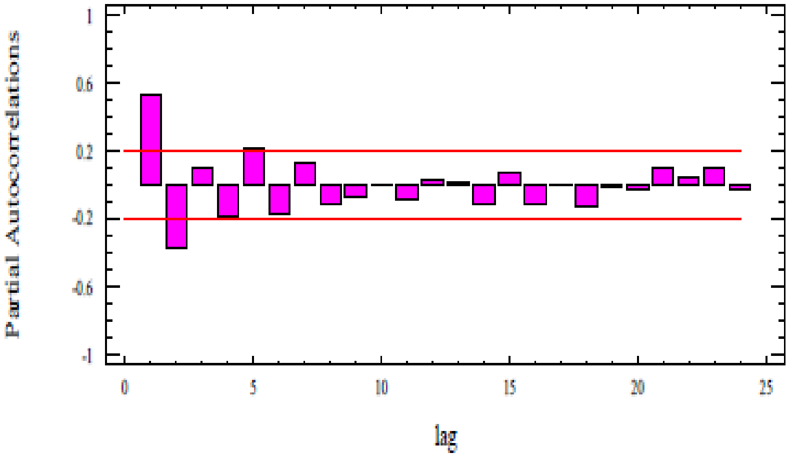
$$z_t = a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \cdots - \theta_q a_{t-q}$$

MA(1)

Simple Autocorrelation Function
(q significant elements)

Partial Autocorrelation Function
(decreasing)



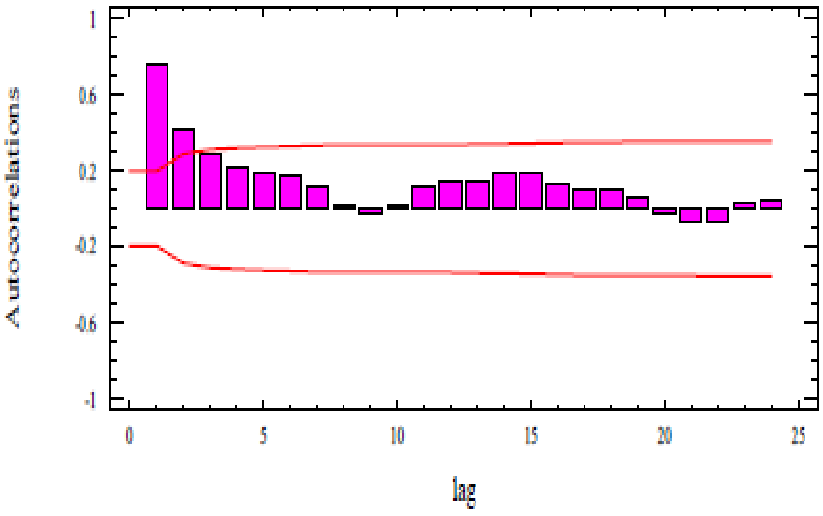


Time series analysis with Stata

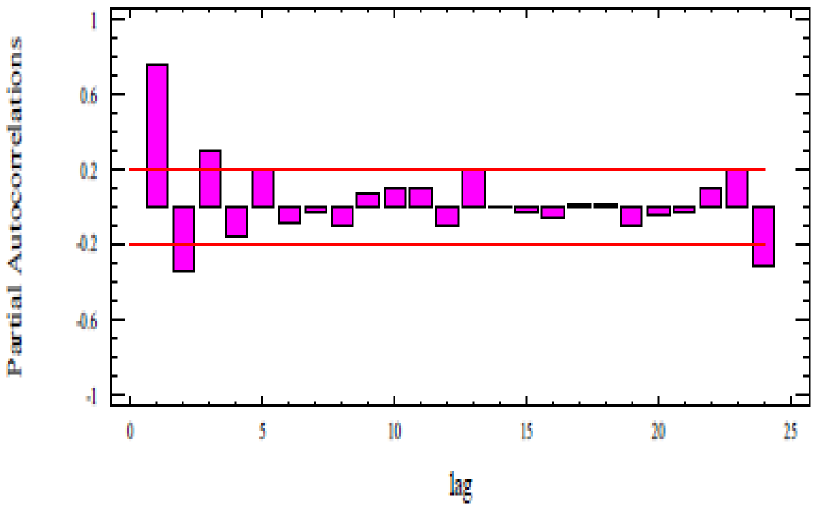
Analysis of a time series ARMA(p,q)

ARMA(1,1)

Simple Autocorrelation Function
(q significant elements)



Partial Autocorrelation Function
(p significant elements)



Time series analysis with Stata

Analysis of a time series
ARIMA(p,d,q)

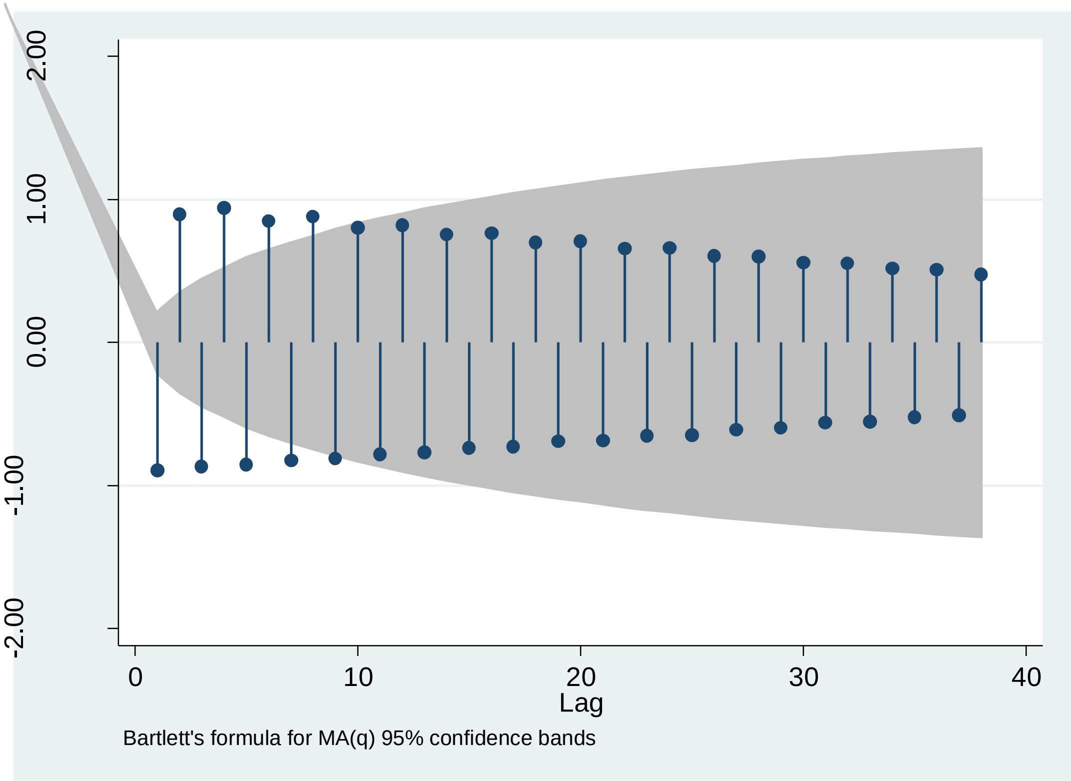
$$Y_t = -(\Delta^d Y_t - Y_t) + \phi_0 + \sum_{i=1}^{p} \phi_i \Delta^d Y_{t-i} - \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \varepsilon_t$$

p: autorregresive order
d: diferenciation to became an stationary serie
q: moving average order

Time series analysis with Stata

Analysis of a time series

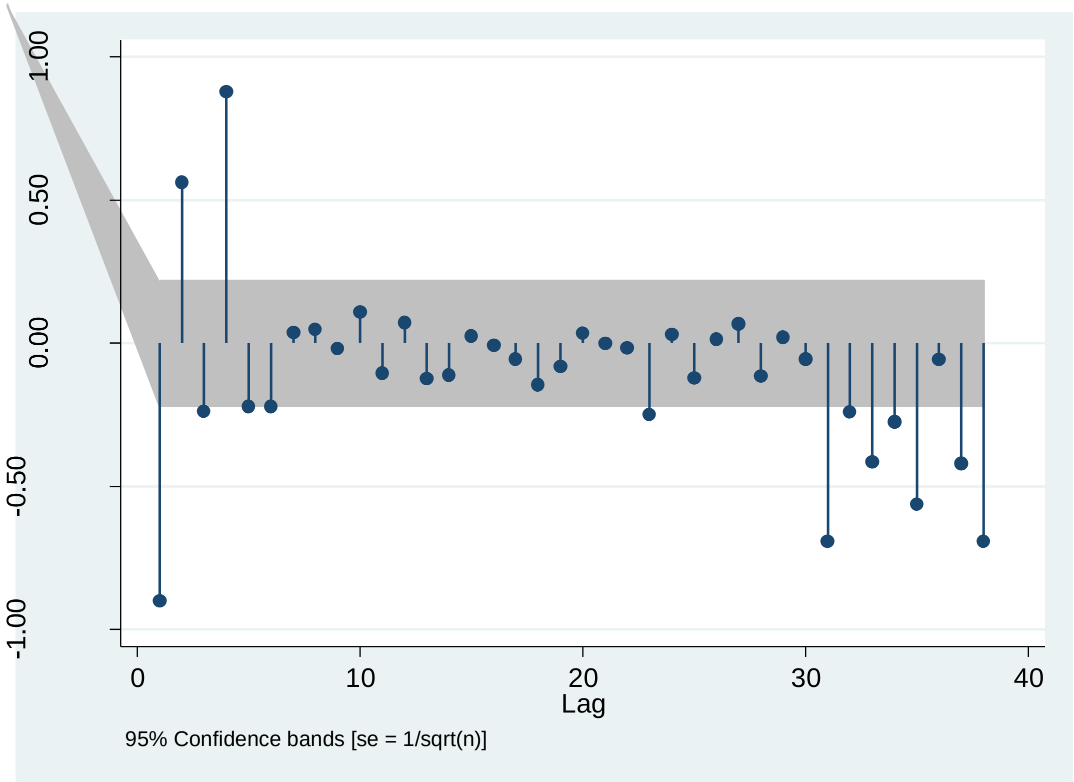
Example: analysis of GDP
ac dlgdp



Time series analysis with Stata

Analysis of a time series

pac dlgdp



Time series analysis with Stata

```
. arima lgdp, arima(2,1,0)

(setting optimization to BHHH)
Iteration 0:   log likelihood =  198.37159
Iteration 1:   log likelihood =  198.41042
Iteration 2:   log likelihood =  198.41266
Iteration 3:   log likelihood =  198.41298
Iteration 4:   log likelihood =  198.41305
(switching optimization to BFGS)
Iteration 5:   log likelihood =  198.41307
Iteration 6:   log likelihood =  198.41307

ARIMA regression

Sample:  2 - 82                                 Number of obs      =        81
                                                Wald chi2(2)       =    395.63
Log likelihood =  198.4131                      Prob > chi2        =    0.0000
```

D.lgdp	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
lgdp						
_cons	.010739	.0028034	3.83	0.000	.0052445	.0162336
ARMA						
ar						
L1.	-.4003017	.1097632	-3.65	0.000	-.6154337	-.1851698
L2.	.5544669	.1151749	4.81	0.000	.3287282	.7802056
/sigma	.0205855	.0022768	9.04	0.000	.016123	.0250481

```
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.
```

Time series analysis with Stata

$$GDP_t = -(\Delta GDP_t - GDP_t) + 0.01 - 0.40\Delta GDP_{t-1} + 0.55\Delta GDP_{t-2}$$