VECM_Infla

November 30, 2019

1 TODO

- [ ] Checar importância da significância estatística dos coeficientes da regressão

2 Setup

[1]:
```
!rm *.csv # Removendo dados anteriores
!rm -R figs # Removendo pasta de figuras
!rm -R tabs # Removendo pasta de tabelas
!mkdir figs # Criando pasta para salvar figuras
!mkdir tabs # Criando pasta para salvar tabelas
!ls
```

```
Benchmark.html   Clean-checkpoint.ipynb  tabs
Benchmark.ipynb  Clean.ipynb             Teste.ipynb
Benchmark.pdf    figs                    VECM_Infla.ipynb
Benchmark.Rmd    SeriesTemporais.Rproj   VECM_TxPropria.ipynb
```

3 Introdução

Esta rotina ajusta um modelo de séries temporais. Será testado se o investimento residencial (I_h) depende da taxa própria de juros dos imóveis, ou seja,

$$I_h = f(r_{mo}, p_h)$$

em que

- I_h Investimento residencial
  - **Série:** PRFI
  - Com ajuste sazonal
  - Trimestral
- r_{mo} taxa de juros das hipotecas
  - **Série:** MORTGAGE30US

- Sem ajuste sazonal
- Semanal (encerrado às quintas feiras)

- p_h Inflação de imóveis: Índice Case-Shiller
  - **Série:** CSUSHPISA
  - Com ajuste sazonal, Jan 2000 = 100
  - Mensal

Nota: Uma vez que pretende-se utilizar os resultados obtidos deste modelo em um trabalho futuro, os resultados serão checados tanto em python quanto em gretl, ambos softwares livres.

4 Carregando pacotes

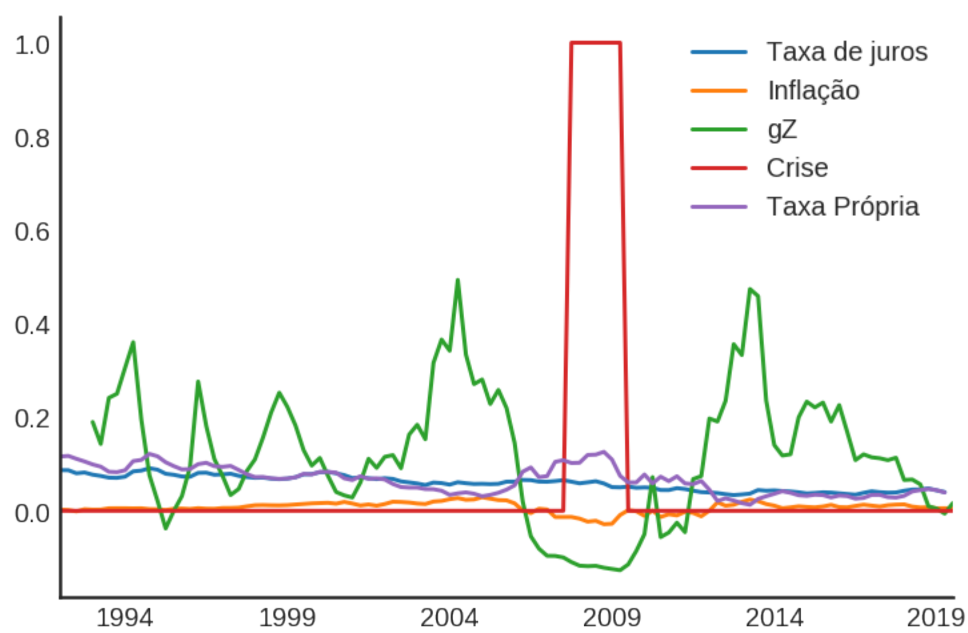
[2]:
```
%config InlineBackend.figure_format = 'retina'
%load_ext rpy2.ipython

# Pacotes gerais

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import datetime
import warnings
warnings.filterwarnings('ignore')
# Pacotes estatísticos

from statsmodels.tsa.vector_ar.var_model import VAR
from statsmodels.tsa.api import SVAR
from statsmodels.tsa.vector_ar.vecm import coint_johansen, CointRankResults,␣
 ↪VECM, select_coint_rank

from statsmodels.stats.diagnostic import acorr_breusch_godfrey, acorr_ljungbox,␣
 ↪het_arch, het_breuschpagan, het_white
from statsmodels.tsa.stattools import adfuller, kpss, grangercausalitytests,␣
 ↪q_stat, coint
from arch.unitroot import PhillipsPerron, ZivotAndrews, DFGLS, KPSS, ADF

from statsmodels.graphics.tsaplots import plot_acf, plot_pacf

# Pacotes para importação de dados

import pandas_datareader.data as web
from scipy.stats import yeojohnson

# Configurações do notebook
```

```
plt.style.use('seaborn-white')
#start = datetime.datetime(1987, 1, 1)
start = datetime.datetime(1992, 1, 1)
end = datetime.datetime(2019, 7, 1)
```

5 Importando dados

[3]:
```
df = web.DataReader(
    [
        "PRFI",
        "CSUSHPISA",
        "MORTGAGE30US",
    ],
    'fred',
    start,
    end
)

df.columns = [
    "Investimento residencial",
    "Preço dos imóveis",
    "Taxa de juros",
]
df.index.name = ""

df['Taxa de juros'] = df['Taxa de juros'].divide(100)
df['Preço dos imóveis'] = df['Preço dos imóveis']/df['Preço dos imóveis'][0]
df["Inflação"] = df["Preço dos imóveis"].pct_change(12)
df = df.resample('Q').mean()

df["Taxa Própria"] = ((1+df["Taxa de juros"])/(1+df["Inflação"])) -1
df['Taxa Própria'], *_ = yeojohnson(df['Taxa Própria'])

df['gZ'], *_ = yeojohnson(df["Investimento residencial"].pct_change(4))

df["Crise"] = [0 for i in range(len(df["gZ"]))]
for i in range(len(df["Crise"])):
    if df.index[i] > datetime.datetime(2007,12,1) and df.index[i] < datetime.
↪datetime(2009,7,1):
        df["Crise"][i] = 1

df.to_csv("Dados_yeojohnson.csv")


df.to_csv(
```

```
    "Dados_yeojohnson_ascii.csv",
    encoding='ascii',
    header = [
        #'data',
        'invRes',
        'preco',
        'juros',
        'infla',
        'taxap',
        'gz',
        'crise',
          ],
         )

df = df[["Taxa de juros", "Inflação", "gZ", "Crise", "Taxa Própria"]]
df.plot()
sns.despine()
plt.show()

df["d_Taxa Própria"] = df["Taxa Própria"].diff()
df["d_gZ"] = df["gZ"].diff()
df["d_Inflação"] = df["Inflação"].diff()
df["d_Taxa de juros"] = df['Taxa de juros'].diff()
df = df.dropna()
df.tail()
```



[3]:
```
            Taxa de juros  Inflação        gZ  Crise  Taxa Própria  \

2018-06-30       0.045446  0.009007  0.066893      0      0.041386
2018-09-30       0.045669  0.007121  0.056555      0      0.044225
2018-12-31       0.047846  0.007440  0.009721      0      0.046668
2019-03-31       0.043738  0.005347  0.004754      0      0.044109
2019-06-30       0.040108  0.005519 -0.006007      0      0.039164

            d_Taxa Própria      d_gZ  d_Inflação  d_Taxa de juros

2018-06-30        0.009454  0.001012   -0.004757         0.002623
2018-09-30        0.002839 -0.010338   -0.001885         0.000223
2018-12-31        0.002443 -0.046833    0.000318         0.002177
2019-03-31       -0.002559 -0.004968   -0.002093        -0.004108
2019-06-30       -0.004945 -0.010761    0.000172        -0.003631
```

6 Funções

6.1 Teste de raíz unitária

[4]:
```python
def testes_raiz(df=df["gZ"], original_trend='c', diff_trend='c'):
    """
    serie: Nome da coluna do df
    orignal_trend: 'c', 'ct', 'ctt'
    diff_trend: 'c', 'ct', 'ctt'

    Plota série o original e em diferenta e retorna testes de raíz unitária
    """
    fig, ax = plt.subplots(1,2)

    df.plot(ax=ax[0], title='série original')
    df.diff().plot(ax=ax[1], title='série em diferença')

    plt.tight_layout()
    sns.despine()
    plt.show()

    fig, ax = plt.subplots(2,2)

    plot_acf(df, ax=ax[0,0], title='ACF: serie original')
    plot_pacf(df, ax=ax[0,1], title='PACF: serie original')

    plot_acf(df.diff().dropna(), ax=ax[1,0], title='ACF: serie em diferença')
    plot_pacf(df.diff().dropna(), ax=ax[1,1], title='PACF: serie em diferença')

    plt.tight_layout()
```

```
    sns.despine()
    plt.show()


    # Zivot Andrews
    print('\nZIVOT ANDREWS série em nível')
    print(ZivotAndrews(df, trend = original_trend).summary(),"\n")
    print('\nZIVOT ANDREWS série em primeira difenrença')
    print(ZivotAndrews(df.diff().dropna(), trend = diff_trend).summary(),"\n")

    print('\nADF série em nível')
    print(ADF(df, trend=original_trend).summary(),"\n")
    print('\nADF série em primeira diferença')
    print(ADF(df.diff().dropna(), trend=diff_trend).summary(),"\n")

    print('\nDFGLS série em nível')
    print(DFGLS(df, trend=original_trend).summary(),"\n")
    print('\nDFGLS série em primeira diferença')
    print(DFGLS(df.diff().dropna(), trend=diff_trend).summary(),"\n")

    print('\nKPSS em nível')
    print(KPSS(df, trend = original_trend).summary(),"\n")
    print('\nKPSS em primeira diferença')
    print(KPSS(df.diff().dropna(), trend = diff_trend).summary(),"\n")

    print('\nPhillips Perron em nível')
    print(PhillipsPerron(df, trend=original_trend).summary(),"\n")
    print('\nPhillips Perron em primeira diferença')
    print(PhillipsPerron(df.diff().dropna(), trend=diff_trend).summary(),"\n")
```

6.2 Teste de Cointegração Engel-Granger e de Johansen

[5]:
```
# Teste de cointegração

def cointegracao(ts0, ts1, signif = 0.05, lag=1):
  trends = ['nc', 'c', 'ct', 'ctt']
  for trend in trends:
    print(f"\nTestando para lag = {lag} e trend = {trend}")
    result = coint(ts0, ts1, trend = trend, maxlag=lag)
    print('Null Hypothesis: there is NO cointegration')
    print('Alternative Hypothesis: there IS cointegration')
    print('t Statistic: %f' % result[0])
    print('p-value: %f' % result[1])
    if result[1] < signif:
      print('CONCLUSION: REJECT null Hypothesis: there IS cointegration\n')
    else:
```

```
    print('CONCLUSION: FAIL to reject Null Hypothesis: there is NO␣
↪cointegration\n')

def testes_coint(series, maxlag=8):
    for i in range(1, maxlag):
        print(50*'=')
        cointegracao(
            ts0=series.iloc[:, 0],
            ts1=series.iloc[:, 1:],
            signif=0.05,
            lag=i
        )
        print("\nTESTE DE JOHANSEN\n")
        rank_sel = select_coint_rank(endog=series, k_ar_diff=i, det_order=1).
↪rank
        print(f'Para lag = {i}, Rank = {rank_sel}')
        print(10*'=')
```

6.3 Análise de resíduos: Ljung-Box e Box-Pierce

[6]:
```
### Resíduos

def LjungBox_Pierce(resid, signif = 0.05, boxpierce = False, k = 4):
  """
  resid = residuals df
  signif = signif. level
  """
  var = len(resid.columns)
  print("H0: autocorrelations up to lag k equal zero")
  print('H1: autocorrelations up to lag k not zero')
  print("Box-Pierce: ", boxpierce)

  for i in range(var):
    print("Testing for ", resid.columns[i].upper(), ". Considering a␣
↪significance level of",  signif*100,"%")
    result = acorr_ljungbox(x = resid.iloc[:,i-1], lags = k, boxpierce =␣
↪boxpierce)[i-1] < signif
    for j in range(k):
      print("Reject H0 on lag " ,j+1,"? ", result[j])
    print("\n")

def ARCH_LM(resid, signif = 0.05, autolag = 'bic'):
  """
  df = residuals df
  signif = signif. level
  """
```

```
  var = len(resid.columns)
  print("H0: Residuals are homoscedastic")
  print('H1: Residuals are heteroskedastic')

  for i in range(var):
    print("Testing for ", resid.columns[i].upper())
    result = het_arch(resid = resid.iloc[:,i], autolag = autolag)
    print('LM p-value: ', result[1])
    print("Reject H0? ", result[1] < signif)
    print('F p-value: ', result[3])
    print("Reject H0? ", result[3] < signif)
    print('\n')


def analise_residuos(results, nmax=15):

    residuals = pd.DataFrame(results.resid, columns = results.names)

    residuals.plot()
    sns.despine()
    plt.show()

    for serie in residuals.columns:
        sns.set_context('paper')
        fig, ax = plt.subplots(1,2, figsize=(10,8))

        plot_acf(residuals[serie], ax=ax[0], title=f'ACF Resíduo de {serie}',␣
 ↪zero=False)
        plot_pacf(residuals[serie], ax=ax[1], title=f'PACF Resíduo de {serie}',␣
 ↪zero=False)

        plt.tight_layout()
        sns.despine()
        plt.show()

    print('AUTOCORRELAÇÃO RESIDUAL: PORTMANTEAU\n')
    print(results.test_whiteness(nlags=nmax).summary())
    print('\nAUTOCORRELAÇÃO RESIDUAL: PORTMANTEAU AJUSTADO\n')
    print(results.test_whiteness(nlags=nmax, adjusted=True).summary())
    print('\nLJUNGBOX\n')
    LjungBox_Pierce(residuals, k = 12, boxpierce=False)
    print('\nBOXPIERCE\n')
    LjungBox_Pierce(residuals, k = 12, boxpierce=True)
    print('\nNORMALIDADE\n')
    print(results.test_normality().summary())
    print('\nHOMOCEDASTICIDADE\n')
    ARCH_LM(residuals)
```

```
    return residuals
```

[7]:
```
results = []
def plot_lags(results = results, trimestres=[2, 5]):
    series = results.names
    fig, ax = plt.subplots(len(trimestres),2, figsize = (16,10))

    for i in range(len(trimestres)):
        sns.regplot(y = df[series[0]], x = df[series[1]].shift(-trimestres[i]),␣
 ↪color = 'black', ax = ax[i,0], order = 2)
        ax[i,0].set_xlabel(f'{series[1]} defasada em {trimestres[i]}␣
 ↪trimestres')

        sns.regplot(x = df[series[0]].shift(-trimestres[i]), y = df[series[1]],␣
 ↪color = 'black', ax = ax[i,1], order = 2)
        ax[i,1].set_xlabel(f'{series[0]} defasada em {trimestres[i]}␣
 ↪trimestres')
```

7 Teste de quebra estrutural

[8]:
```
%%R -i df
library(strucchange)
library(urca)
df <- df[,c(4:7)]
names(df) <- c("Juros", "Infla", "TaxaP", "gZ")
df <- ts(data = df, start = c(1987,01), frequency = 4)
bp_ts <- breakpoints(Juros ~ 1, data=df)
print("Testando quebra estrutural para Taxa de juros das hipotecas")
print(summary(bp_ts))

bp_ts <- breakpoints(gZ ~ 1, data=df)
print("=========================")
print("Testando quebra estrutural para Taxa de crescimento dos imóveis")
print(summary(bp_ts))

bp_ts <- breakpoints(TaxaP ~ 1, data=df)
print("=========================")
print("Testando quebra estrutural para Taxa Própria")
print(summary(bp_ts))

bp_ts <- breakpoints(Infla ~ 1, data=df)
print("=========================")
print("Testando quebra estrutural para Inflação")
print(summary(bp_ts))
```

```
R[write to console]: Carregando pacotes exigidos: zoo

R[write to console]:
Attaching package: zoo


R[write to console]: The following objects are masked from package:base:

    as.Date, as.Date.numeric


R[write to console]: Carregando pacotes exigidos: sandwich


[1] "Testando quebra estrutural para Taxa de juros das hipotecas"

         Optimal (m+1)-segment partition:

Call:
breakpoints.formula(formula = Juros ~ 1, data = df)

Breakpoints at observation number:

m = 1            58
m = 2         50 65
m = 3   15    50 65
m = 4   15 30 50 65
m = 5   15 30 50 65 80

Corresponding to breakdates:

m = 1                           2001(2)
m = 2                   1999(2) 2003(1)
m = 3   1990(3)         1999(2) 2003(1)
m = 4   1990(3) 1994(2) 1999(2) 2003(1)
m = 5   1990(3) 1994(2) 1999(2) 2003(1) 2006(4)

Fit:

m   0       1       2       3       4       5
RSS   6.533   5.957   3.733   3.733   3.733   3.733
BIC  15.695  15.315 -24.448 -15.140  -5.832   3.475
[1] "========================"
[1] "Testando quebra estrutural para Taxa de crescimento dos imÃşveis"

         Optimal (m+1)-segment partition:

Call:
```

```
breakpoints.formula(formula = gZ ~ 1, data = df)

Breakpoints at observation number:

m = 1             81
m = 2          66 81
m = 3       45 65 81
m = 4    30 45 65 81
m = 5 15 30 45 65 81

Corresponding to breakdates:

m = 1                                         2007(1)
m = 2                                 2003(2) 2007(1)
m = 3                         1998(1) 2003(1) 2007(1)
m = 4                 1994(2) 1998(1) 2003(1) 2007(1)
m = 5         1990(3) 1994(2) 1998(1) 2003(1) 2007(1)

Fit:

m   0         1         2         3         4         5
RSS    0.4492    0.4390    0.4155    0.3962    0.3838    0.3838
BIC -265.4028 -258.5118 -254.9753 -250.6748 -244.7006 -235.3934
[1] "========================"
[1] "Testando quebra estrutural para Taxa PrÃşpria"

         Optimal (m+1)-segment partition:

Call:
breakpoints.formula(formula = TaxaP ~ 1, data = df)

Breakpoints at observation number:

m = 1          63
m = 2       48 63
m = 3       48 63 81
m = 4    30 48 63 81
m = 5 15 30 48 63 81

Corresponding to breakdates:

m = 1                                 2002(3)
m = 2                         1998(4) 2002(3)
m = 3                         1998(4) 2002(3) 2007(1)
m = 4                 1994(2) 1998(4) 2002(3) 2007(1)
m = 5         1990(3) 1994(2) 1998(4) 2002(3) 2007(1)

Fit:
```

```
m    0           1           2           3           4           5
RSS  9.460e-03  9.303e-03  8.617e-03  8.057e-03  8.002e-03  7.998e-03
BIC -6.708e+02 -6.632e+02 -6.619e+02 -6.597e+02 -6.511e+02 -6.418e+02
[1] "========================="
[1] "Testando quebra estrutural para InflaÃğÃčo"

         Optimal (m+1)-segment partition:

Call:
breakpoints.formula(formula = Infla ~ 1, data = df)

Breakpoints at observation number:

m = 1             75
m = 2   18        75
m = 3      36 52 72
m = 4   18 36 52 72
m = 5   18 36 52 75 90

Corresponding to breakdates:

m = 1                               2005(3)
m = 2   1991(2)                     2005(3)
m = 3           1995(4) 1999(4) 2004(4)
m = 4   1991(2) 1995(4) 1999(4) 2004(4)
m = 5   1991(2) 1995(4) 1999(4) 2005(3) 2009(2)

Fit:

m    0           1           2           3           4           5
RSS    0.08460     0.04369     0.03293     0.02196     0.01677     0.01661
BIC -440.71461 -500.79446 -521.15497 -554.41950 -573.42798 -565.08228
```

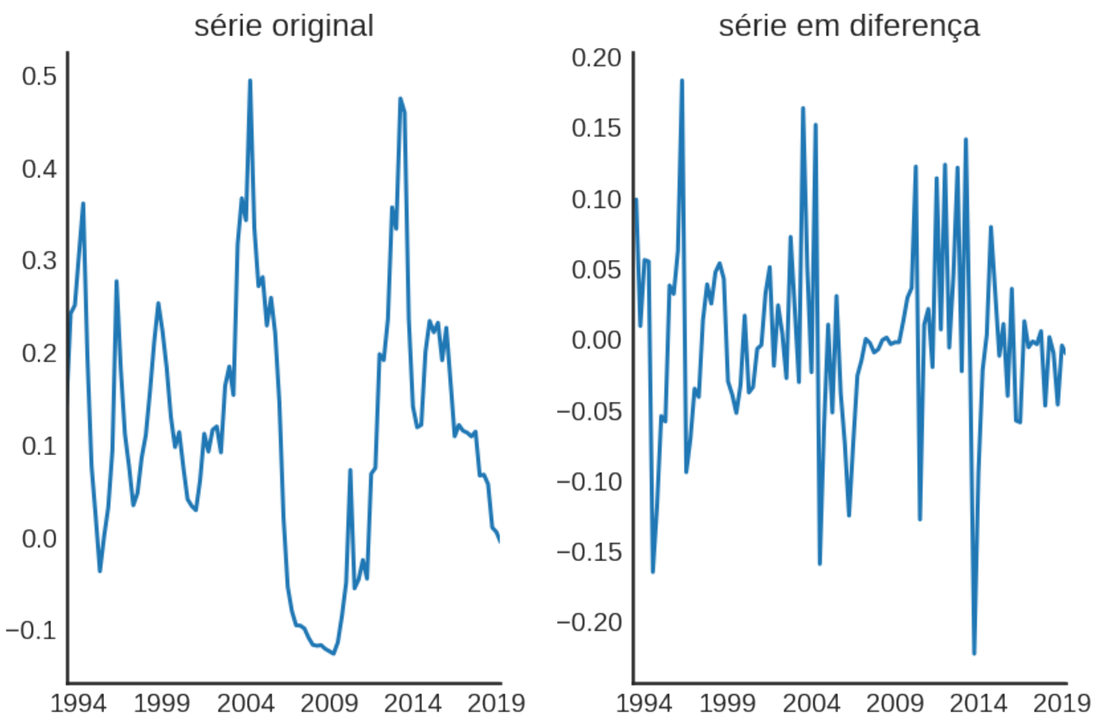
Selecionando série para depois de 1991

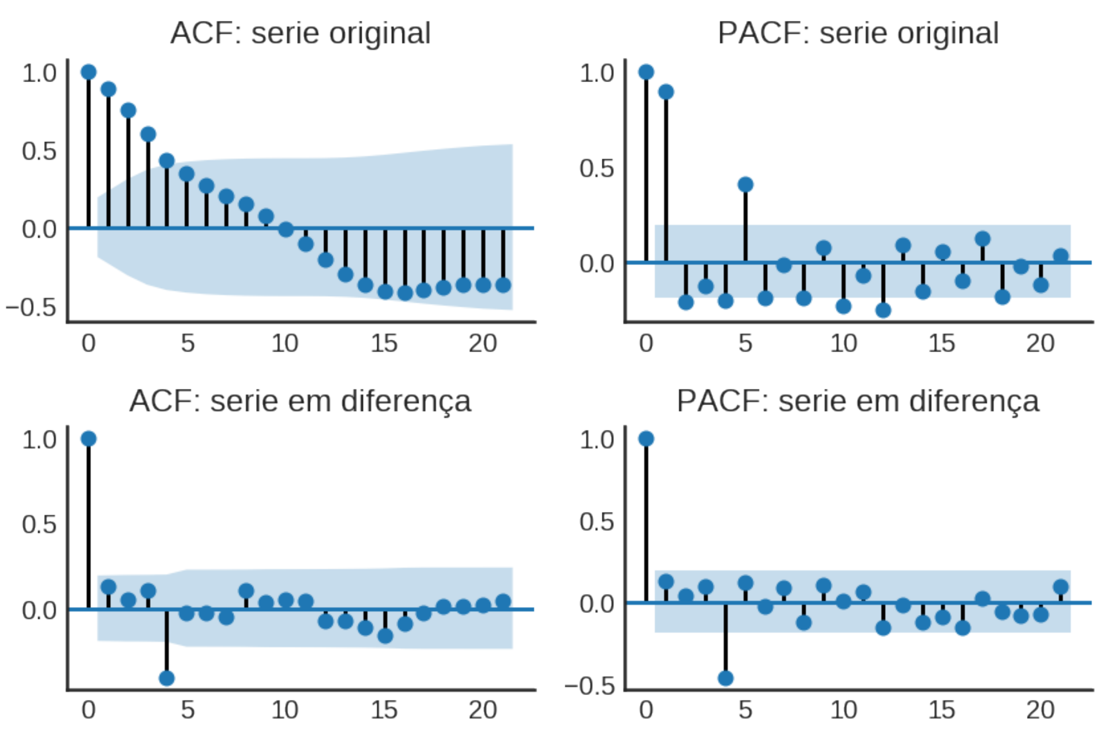
[9]:
```
df = df["1992-01-01":]
```

8 Teste de raíz unitária

8.1 Investimento residencial (g_Z)

[10]:
```
testes_raiz(df=df['gZ'])
```


série original
série em diferença
1994
1999
2004
2009
2014
2019


ACF: serie original
PACF: serie original
ACF: serie em diferença
PACF: serie em diferença

```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -3.670
P-value                         0.568
Lags                                9
-------------------------------------

Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ZIVOT ANDREWS série em primeira difenrença
        Zivot-Andrews Results
=====================================
Test Statistic                 -7.628
P-value                         0.000
Lags                                3
-------------------------------------

Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ADF série em nível
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -2.849
P-value                         0.052
Lags                                9
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
```

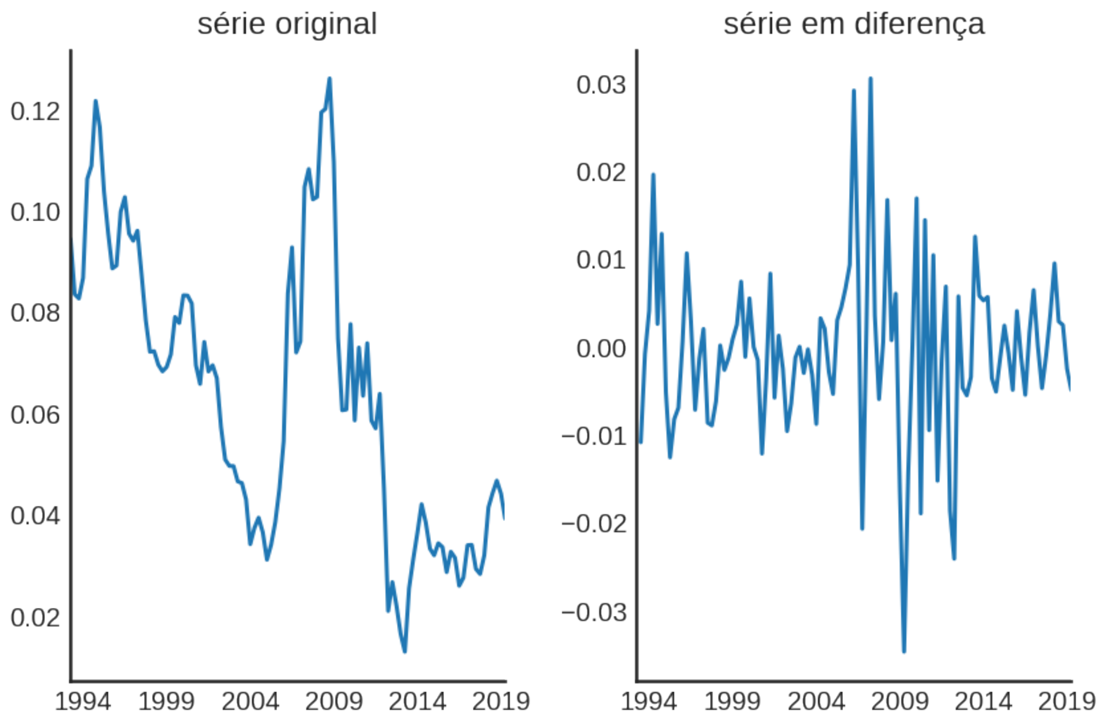
```
Test Statistic                 -4.936
P-value                         0.000
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -2.841
P-value                         0.005
Lags                                9
-------------------------------------

Trend: Constant
Critical Values: -2.77 (1%), -2.15 (5%), -1.83 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


DFGLS série em primeira diferença
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -0.942
P-value                         0.317
Lags                                9
-------------------------------------

Trend: Constant
Critical Values: -2.77 (1%), -2.15 (5%), -1.84 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


KPSS em nível
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.101
P-value                         0.581
Lags                                5
-------------------------------------

Trend: Constant
```

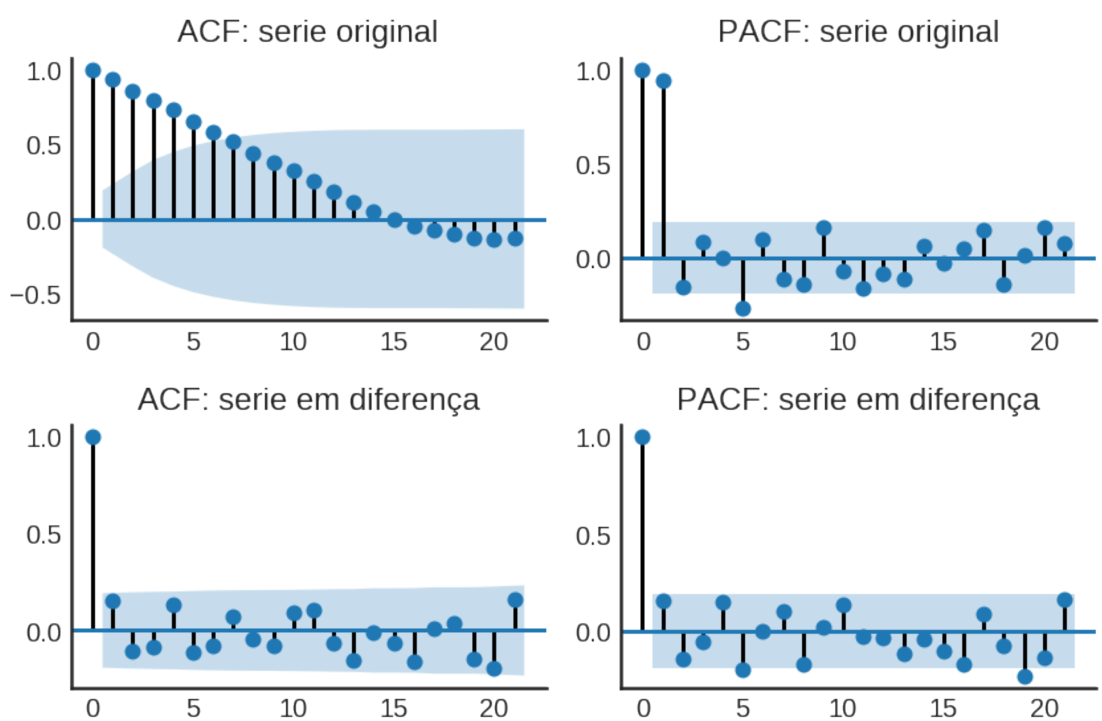
```
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


KPSS em primeira diferença
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.043
P-value                         0.916
Lags                                2
-------------------------------------

Trend: Constant
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


Phillips Perron em nível
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                 -2.579
P-value                         0.097
Lags                               13
-------------------------------------

Trend: Constant
Critical Values: -3.49 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


Phillips Perron em primeira diferença
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                 -8.900
P-value                         0.000
Lags                               13
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

Conclusão: Série não é fracamente estacionária.

8.2 Taxa própria

[11]:
```
testes_raiz(df['Taxa Própria'])
```





```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -4.382
P-value                         0.159
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ZIVOT ANDREWS série em primeira difenrença
        Zivot-Andrews Results
=====================================
Test Statistic                 -6.340
P-value                         0.000
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ADF série em nível
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -2.268
P-value                         0.182
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

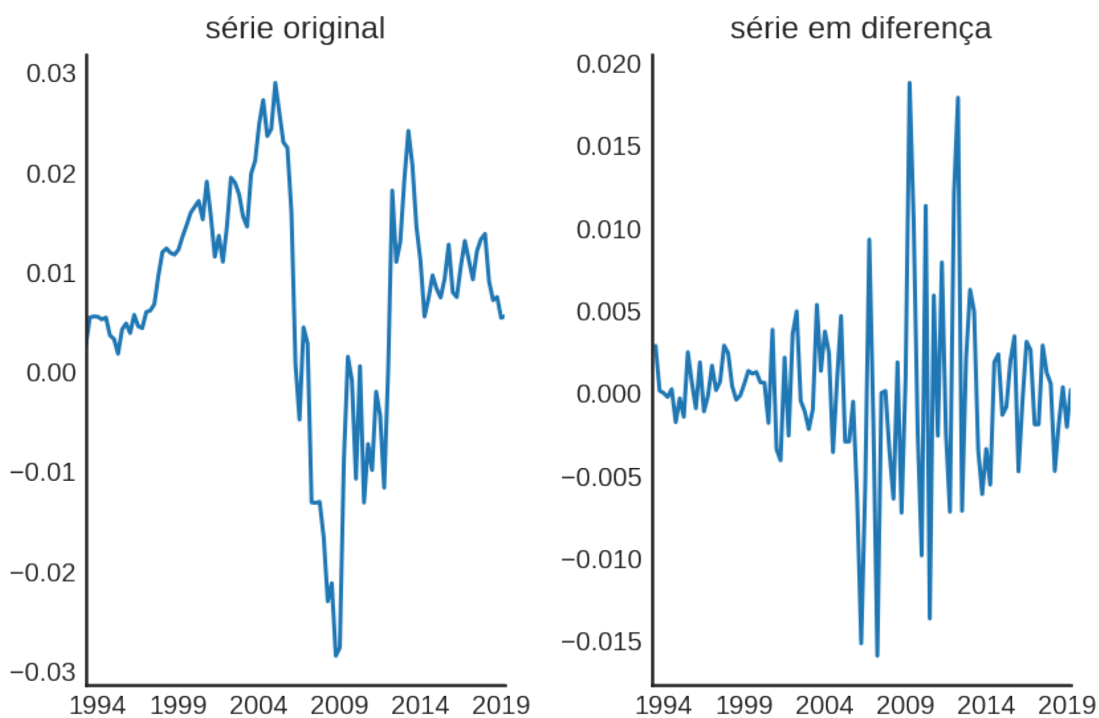
```
ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -4.902
P-value                         0.000
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -1.496
P-value                         0.131
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -2.76 (1%), -2.14 (5%), -1.82 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


DFGLS série em primeira diferença
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -2.675
P-value                         0.008
Lags                                3
-------------------------------------

Trend: Constant
Critical Values: -2.76 (1%), -2.14 (5%), -1.82 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


KPSS em nível
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.878
P-value                         0.005
Lags                                5
```

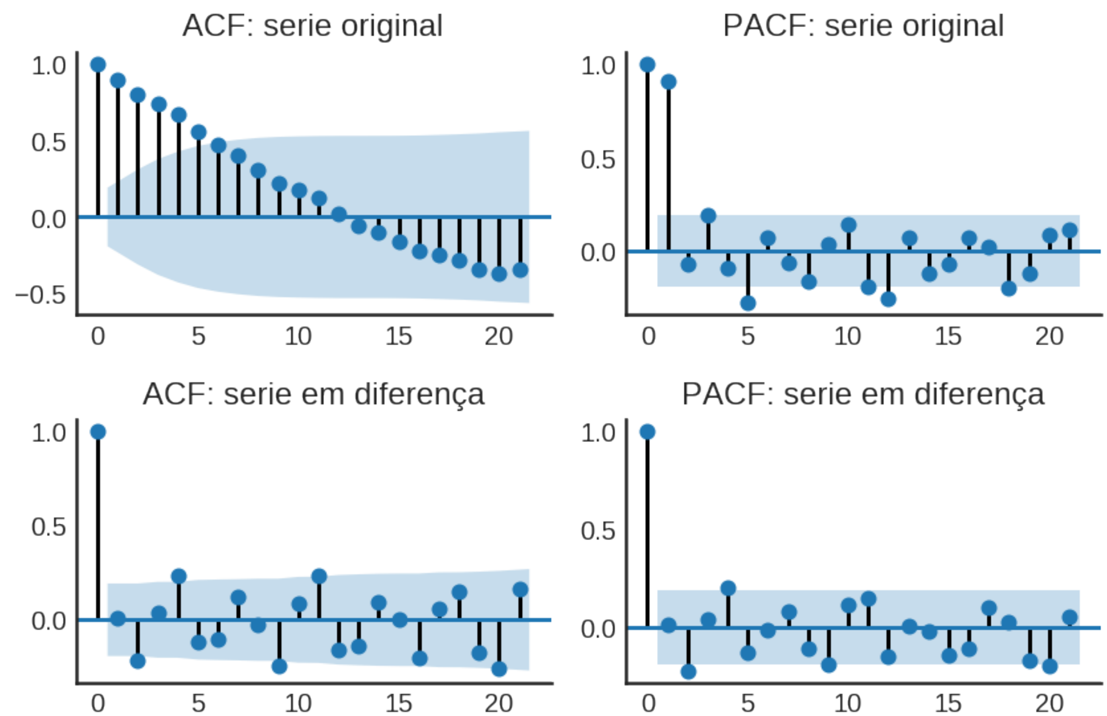
```
-------------------------------------

Trend: Constant
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


KPSS em primeira diferença
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.044
P-value                         0.912
Lags                                1
-------------------------------------

Trend: Constant
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


Phillips Perron em nível
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                 -1.923
P-value                         0.321
Lags                               13
-------------------------------------

Trend: Constant
Critical Values: -3.49 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


Phillips Perron em primeira diferença
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                 -8.543
P-value                         0.000
Lags                               13
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

Conclusão: Será tomada em primeira diferença.

8.3 Inflação

[12]:
```
testes_raiz(df['Inflação'])
```






```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -4.958
P-value                         0.033
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ZIVOT ANDREWS série em primeira difenrença
        Zivot-Andrews Results
=====================================
Test Statistic                 -9.841
P-value                         0.000
Lags                                1
-------------------------------------
```

```
Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.
```

```
ADF série em nível
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -2.534
P-value                         0.107
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

```
ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -8.725
P-value                         0.000
Lags                                1
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

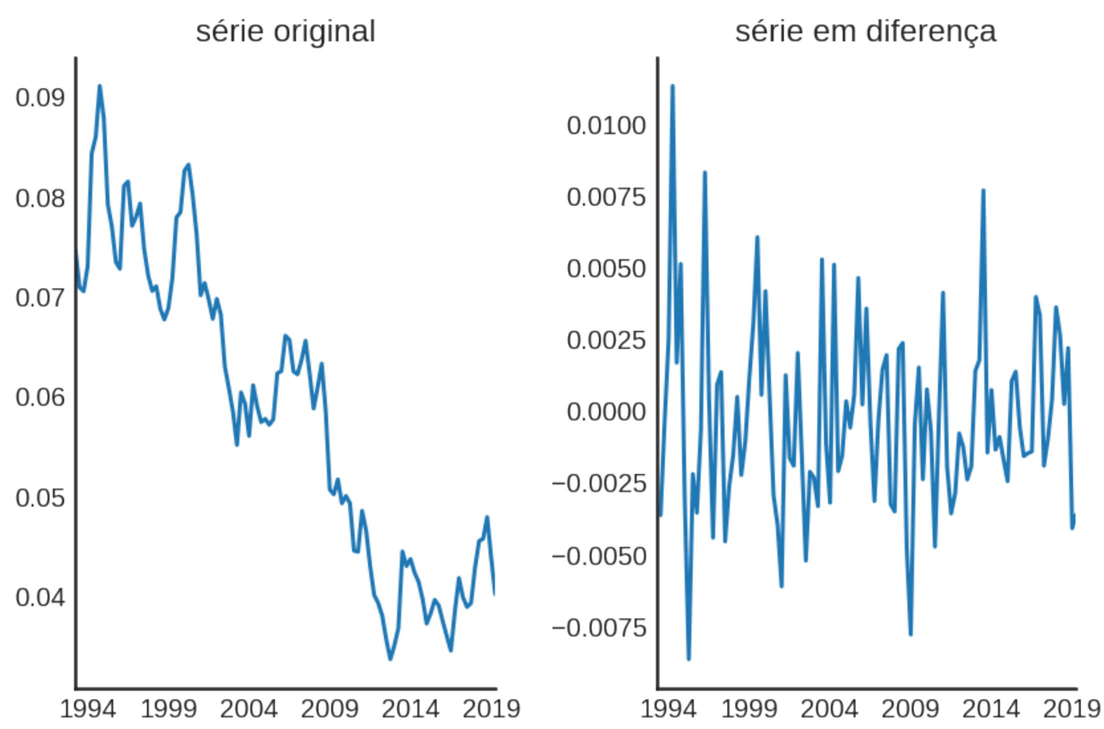
```
DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -2.437
P-value                         0.015
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -2.76 (1%), -2.14 (5%), -1.82 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

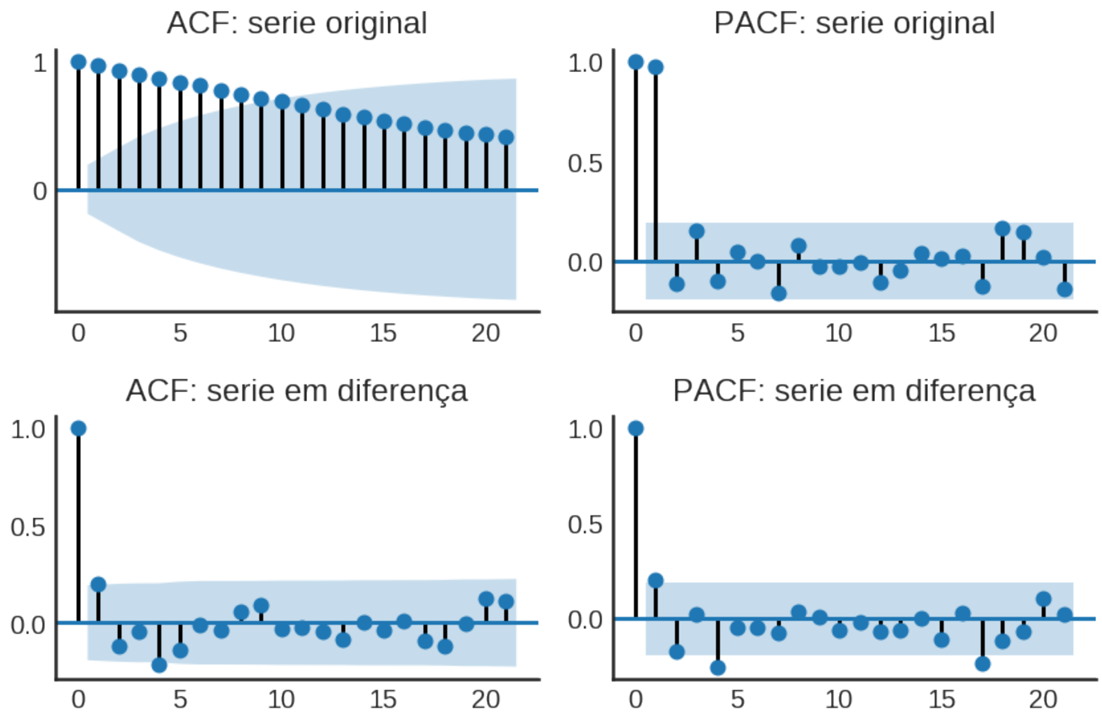
```
DFGLS série em primeira diferença
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -3.296
P-value                         0.001
Lags                                3
-------------------------------------

Trend: Constant
Critical Values: -2.76 (1%), -2.14 (5%), -1.82 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


KPSS em nível
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.168
P-value                         0.340
Lags                                5
-------------------------------------

Trend: Constant
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


KPSS em primeira diferença
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.062
P-value                         0.802
Lags                                6
-------------------------------------

Trend: Constant
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


Phillips Perron em nível
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                 -2.524
P-value                         0.110
```

```
Lags                                13
-------------------------------------

Trend: Constant
Critical Values: -3.49 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


Phillips Perron em primeira diferença
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                -10.023
P-value                         0.000
Lags                               13
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

8.4 Taxa de juros das hipotecas

[13]:
```python
testes_raiz(df['Taxa de juros'], original_trend='ct')
```






```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -5.298
P-value                         0.025
Lags                                3
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: -5.58 (1%), -5.07 (5%), -4.83 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ZIVOT ANDREWS série em primeira difenrença
        Zivot-Andrews Results
=====================================
Test Statistic                 -7.625
P-value                         0.000
```

```
Lags                                1
-------------------------------------

Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ADF série em nível
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -3.892
P-value                         0.012
Lags                                3
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: -4.05 (1%), -3.45 (5%), -3.15 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -7.368
P-value                         0.000
Lags                                1
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -3.023
P-value                         0.032
Lags                                3
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: -3.62 (1%), -3.03 (5%), -2.74 (10%)
```

```
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


DFGLS série em primeira diferença
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -3.584
P-value                         0.000
Lags                                2
-------------------------------------

Trend: Constant
Critical Values: -2.76 (1%), -2.14 (5%), -1.82 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


KPSS em nível
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.091
P-value                         0.204
Lags                                5
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: 0.22 (1%), 0.15 (5%), 0.12 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


KPSS em primeira diferença
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.050
P-value                         0.875
Lags                                0
-------------------------------------

Trend: Constant
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


Phillips Perron em nível
     Phillips-Perron Test (Z-tau)
```

```
=====================================
Test Statistic                 -2.938
P-value                         0.150
Lags                               13
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: -4.05 (1%), -3.45 (5%), -3.15 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.


Phillips Perron em primeira diferença
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                 -8.068
P-value                         0.000
Lags                               13
-------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

9 Cointegração

9.1 g_Z e Taxa Própria

[14]:
```
testes_coint(series=df[['gZ', 'Taxa Própria']], maxlag=9)
```

```
==================================================

Testando para lag = 1 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.616725
p-value: 0.070613
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 1 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.755865
p-value: 0.180132
```

```
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 1 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.268558
p-value: 0.000283
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 1 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.389378
p-value: 0.000746
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 1, Rank = 2
==========
==================================================

Testando para lag = 2 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.897999
p-value: 0.035443
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 2 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.755865
p-value: 0.180132
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 2 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.268558
p-value: 0.000283
CONCLUSION: REJECT null Hypothesis: there IS cointegration
```

```
Testando para lag = 2 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.389378
p-value: 0.000746
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 2, Rank = 2
==========
==================================================

Testando para lag = 3 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.335534
p-value: 0.010275
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.169286
p-value: 0.075216
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 3 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.302923
p-value: 0.000244
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.416621
p-value: 0.000667
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN
```

```
Para lag = 3, Rank = 2
==========
==================================================

Testando para lag = 4 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.242563
p-value: 0.154581
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 4 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.816819
p-value: 0.160392
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 4 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.403467
p-value: 0.007795
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 4 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.255604
p-value: 0.037937
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 4, Rank = 2
==========
==================================================

Testando para lag = 5 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.412466
p-value: 0.110385
```

```
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 5 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.816819
p-value: 0.160392
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 5 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.403467
p-value: 0.007795
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 5 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.255604
p-value: 0.037937
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 5, Rank = 2
==========
==================================================

Testando para lag = 6 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.412466
p-value: 0.110385
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 6 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.816819
p-value: 0.160392
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration
```

```
Testando para lag = 6 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.403467
p-value: 0.007795
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 6 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.255604
p-value: 0.037937
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 6, Rank = 2
==========
==================================================

Testando para lag = 7 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.412466
p-value: 0.110385
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 7 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.816819
p-value: 0.160392
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 7 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.403467
p-value: 0.007795
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 7 e trend = ctt
```

```
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.255604
p-value: 0.037937
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 7, Rank = 2
==========
==================================================

Testando para lag = 8 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.412466
p-value: 0.110385
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 8 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.816819
p-value: 0.160392
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 8 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.403467
p-value: 0.007795
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 8 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.255604
p-value: 0.037937
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 8, Rank = 2
```

```
==========
```

9.2 g_Z, Inflação e taxa de juros

[15]:
```
testes_coint(series=df[['gZ', 'Inflação', 'Taxa de juros']])
```

```
==================================================

Testando para lag = 1 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.307978
p-value: 0.002198
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 1 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.476549
p-value: 0.005442
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 1 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.636831
p-value: 0.000229
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 1 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.827974
p-value: 0.000397
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 1, Rank = 3
==========
==================================================

Testando para lag = 2 e trend = nc
```

```
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.307978
p-value: 0.002198
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 2 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.476549
p-value: 0.005442
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 2 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.636831
p-value: 0.000229
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 2 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.827974
p-value: 0.000397
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 2, Rank = 3
==========
==================================================

Testando para lag = 3 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.307978
p-value: 0.002198
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
```

```
t Statistic: -4.476549
p-value: 0.005442
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.762971
p-value: 0.000130
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.997677
p-value: 0.000187
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 3, Rank = 1
==========
==================================================

Testando para lag = 4 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.307978
p-value: 0.002198
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 4 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.476549
p-value: 0.005442
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 4 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.762971
p-value: 0.000130
```

```
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 4 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.997677
p-value: 0.000187
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 4, Rank = 1
==========
==================================================

Testando para lag = 5 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.307978
p-value: 0.002198
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 5 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.476549
p-value: 0.005442
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 5 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.762971
p-value: 0.000130
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 5 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.997677
p-value: 0.000187
CONCLUSION: REJECT null Hypothesis: there IS cointegration
```

```
TESTE DE JOHANSEN

Para lag = 5, Rank = 0
==========
==================================================

Testando para lag = 6 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.307978
p-value: 0.002198
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 6 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.476549
p-value: 0.005442
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 6 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.762971
p-value: 0.000130
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 6 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.997677
p-value: 0.000187
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 6, Rank = 0
==========
==================================================

Testando para lag = 7 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
```

```
t Statistic: -4.307978
p-value: 0.002198
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 7 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.476549
p-value: 0.005442
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 7 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.762971
p-value: 0.000130
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 7 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -5.997677
p-value: 0.000187
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 7, Rank = 0
==========
```

9.3 g_Z e Inflação

[16]:
```
testes_coint(series=df[['gZ', 'Inflação']])
```

```
==================================================

Testando para lag = 1 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.294970
p-value: 0.000353
CONCLUSION: REJECT null Hypothesis: there IS cointegration
```

```
Testando para lag = 1 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.385287
p-value: 0.001878
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 1 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.376467
p-value: 0.008531
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 1 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.315458
p-value: 0.032046
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 1, Rank = 2
==========
==================================================

Testando para lag = 2 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.294970
p-value: 0.000353
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 2 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.385287
p-value: 0.001878
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 2 e trend = ct
```

```
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.376467
p-value: 0.008531
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 2 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.315458
p-value: 0.032046
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 2, Rank = 2
==========
==================================================

Testando para lag = 3 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.294970
p-value: 0.000353
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.385287
p-value: 0.001878
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.376467
p-value: 0.008531
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 3 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
```

```
t Statistic: -4.315458
p-value: 0.032046
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 3, Rank = 2
==========
==================================================

Testando para lag = 4 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.294970
p-value: 0.000353
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 4 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.385287
p-value: 0.001878
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 4 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.376467
p-value: 0.008531
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 4 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.315458
p-value: 0.032046
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 4, Rank = 2
==========
==================================================
```

```
Testando para lag = 5 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.294970
p-value: 0.000353
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 5 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.385287
p-value: 0.001878
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 5 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.376467
p-value: 0.008531
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 5 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.315458
p-value: 0.032046
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 5, Rank = 0
==========
==================================================

Testando para lag = 6 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.294970
p-value: 0.000353
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 6 e trend = c
```

```
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.385287
p-value: 0.001878
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 6 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.376467
p-value: 0.008531
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 6 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.315458
p-value: 0.032046
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 6, Rank = 0
==========
==================================================

Testando para lag = 7 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.294970
p-value: 0.000353
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 7 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.385287
p-value: 0.001878
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 7 e trend = ct
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
```

```
t Statistic: -4.376467
p-value: 0.008531
CONCLUSION: REJECT null Hypothesis: there IS cointegration


Testando para lag = 7 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.315458
p-value: 0.032046
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 7, Rank = 0
==========
```

10 VECM

VECM: g_Z, Inflação e Juros exógeno

10.1 Ordem do modelo

[17]:
```
from statsmodels.tsa.vector_ar.vecm import select_order

det = 'cili'
order_vec = select_order(
    df[[
        "Inflação",
        #"Taxa Própria",
        "gZ"
    ]],
    exog=df[["Taxa de juros"]],
    maxlags=15, deterministic=det)

with open('./tabs/VECM_lag_order.tex','w') as fh:
    fh.write(order_vec.summary().as_latex_tabular(tile = "Selação ordem do␣
 ↪VECM"))

order_vec.summary()
```

[17]:
```
<class 'statsmodels.iolib.table.SimpleTable'>
```

10.2 Estimação

[18]:
```
model = VECM(
    endog = df[[
        "Inflação",
        #"Taxa Própria",
        "gZ"
    ]],
    exog=df[["Taxa de juros"]],
    k_ar_diff=4,
    deterministic=det
)
results = model.fit()

with open('./tabs/VECM_ajuste.tex','w') as fh:
    fh.write(results.summary().as_latex())
```

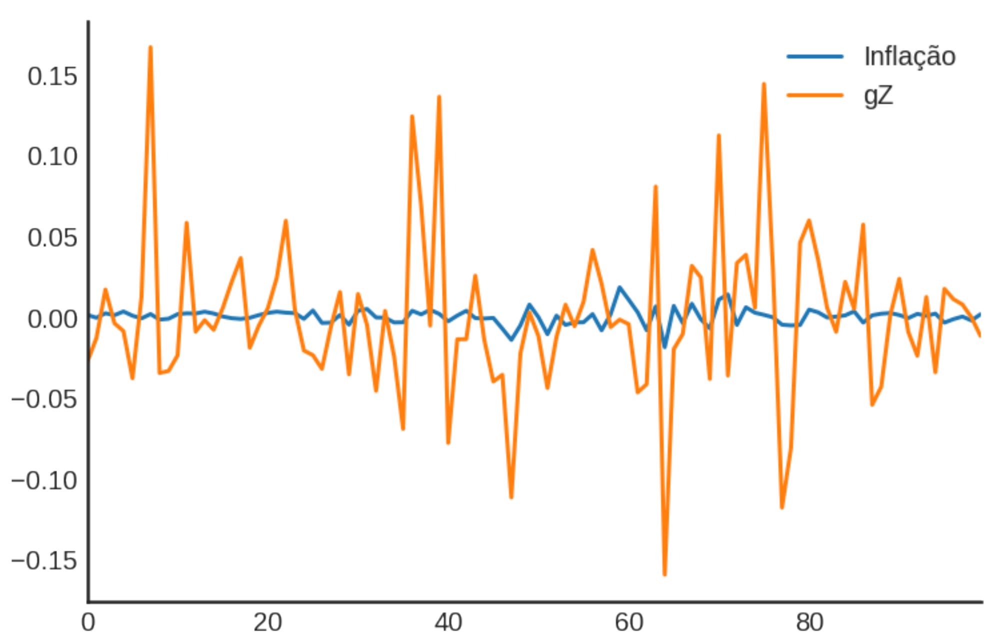
10.3 Análise dos resíduos

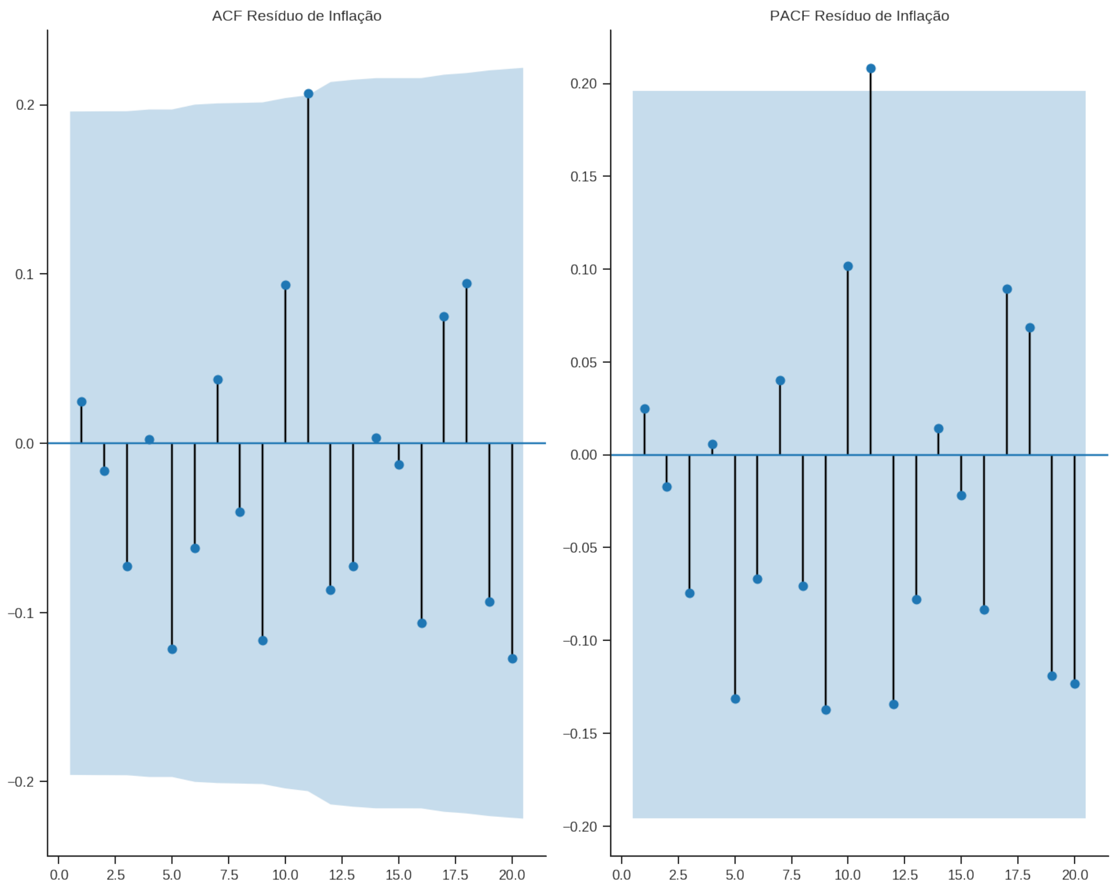
[19]:
```
print(results.summary())
print(60*"=")
print("\nPÓS ESTIMAÇÃO\n")
residuals = analise_residuos(results=results)
print(60*"=")
```

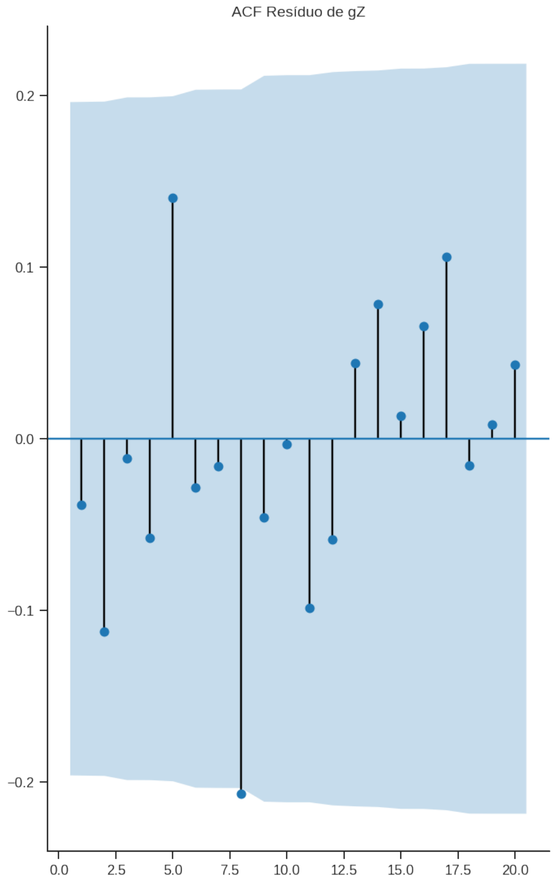
```
Det. terms outside the coint. relation & lagged endog. parameters for equation
Inflação
===============================================================================
                  coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------
exog1          -0.0822      0.082     -0.998      0.318      -0.244       0.079
L1.Inflação    -0.0524      0.112     -0.469      0.639      -0.271       0.167
L1.gZ           0.0042      0.008      0.504      0.614      -0.012       0.021
L2.Inflação    -0.2471      0.110     -2.241      0.025      -0.463      -0.031
L2.gZ           0.0105      0.008      1.238      0.216      -0.006       0.027
L3.Inflação    -0.0163      0.106     -0.154      0.878      -0.225       0.192
L3.gZ           0.0094      0.009      1.102      0.270      -0.007       0.026
L4.Inflação     0.1699      0.107      1.593      0.111      -0.039       0.379
L4.gZ          -0.0013      0.009     -0.148      0.882      -0.019       0.016
Det. terms outside the coint. relation & lagged endog. parameters for equation
gZ
===============================================================================
                  coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------
exog1          -4.7445      0.804     -5.904      0.000      -6.320      -3.169
L1.Inflação    -1.0973      1.090     -1.007      0.314      -3.234       1.039
L1.gZ           0.1702      0.082      2.070      0.038       0.009       0.331
```

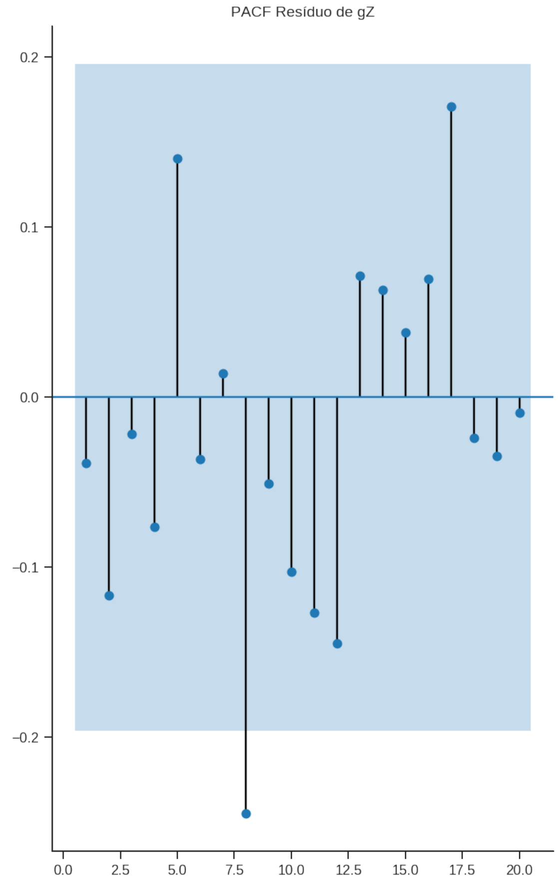
```
L2.Inflação      0.3287      1.076      0.306      0.760     -1.780      2.437
L2.gZ            0.0622      0.083      0.752      0.452     -0.100      0.224
L3.Inflação      0.6038      1.037      0.582      0.560     -1.429      2.636
L3.gZ            0.2408      0.084      2.879      0.004      0.077      0.405
L4.Inflação     -0.1417      1.041     -0.136      0.892     -2.182      1.898
L4.gZ           -0.2771      0.086     -3.232      0.001     -0.445     -0.109
              Loading coefficients (alpha) for equation Inflação
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1            0.0480      0.048      0.995      0.320     -0.047       0.143
                 Loading coefficients (alpha) for equation gZ
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1            2.7400      0.471      5.816      0.000      1.817       3.663
          Cointegration relations for loading-coefficients-column 1
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
beta.1         1.0000          0          0      0.000      1.000       1.000
beta.2        -0.1311      0.015     -8.853      0.000     -0.160      -0.102
const          0.1492      0.030      4.970      0.000      0.090       0.208
lin_trend     -0.0008      0.000     -4.347      0.000     -0.001      -0.000
==============================================================================
============================================================
```

PÓS ESTIMAÇÃO




ACF Resíduo de Inflação
PACF Resíduo de Inflação
0.2
0.1
0.0
−0.1
−0.2
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0






```
AUTOCORRELAÇÃO RESIDUAL: PORTMANTEAU

Portmanteau-test for residual autocorrelation. H_0: residual autocorrelation up
to lag 15 is zero. Conclusion: fail to reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         50.54          58.12   0.172 42
----------------------------------------

AUTOCORRELAÇÃO RESIDUAL: PORTMANTEAU AJUSTADO

Adjusted Portmanteau-test for residual autocorrelation. H_0: residual
autocorrelation up to lag 15 is zero. Conclusion: fail to reject H_0 at 5%
significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         55.44          58.12   0.080 42
```

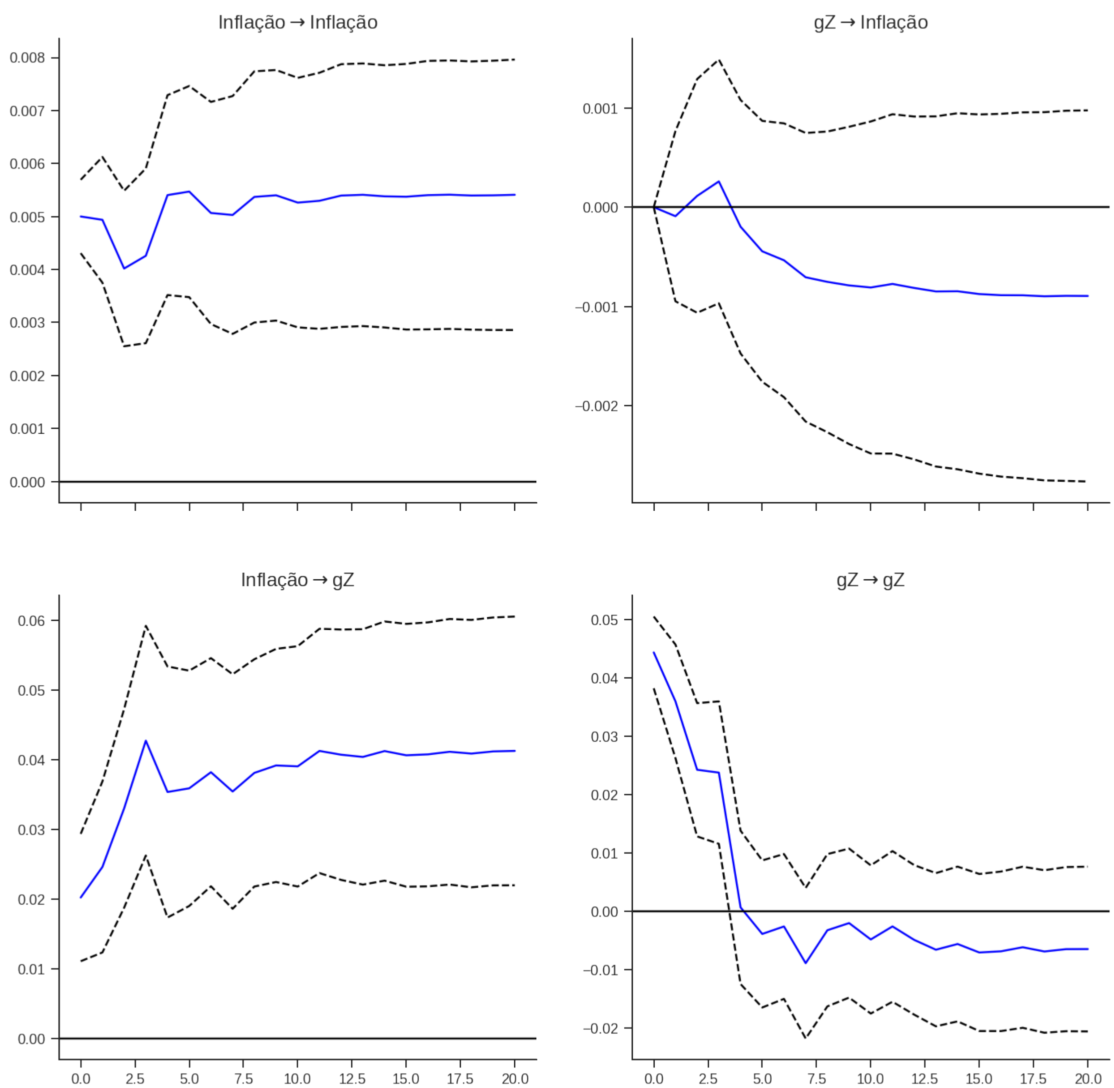
```
----------------------------------------

LJUNGBOX

H0: autocorrelations up to lag k equal zero
H1: autocorrelations up to lag k not zero
Box-Pierce:  False
Testing for  INFLAÇÃO . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False


Testing for  GZ . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False



BOXPIERCE

H0: autocorrelations up to lag k equal zero
H1: autocorrelations up to lag k not zero
Box-Pierce:  True
Testing for  INFLAÇÃO . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
```

```
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False


Testing for  GZ . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False



NORMALIDADE

normality (skew and kurtosis) test. H_0: data generated by normally-distributed
process. Conclusion: reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         75.46          9.488   0.000  4
----------------------------------------

HOMOCEDASTICIDADE

H0: Residuals are homoscedastic
H1: Residuals are heteroskedastic
Testing for  INFLAÇÃO
LM p-value:  0.04278447613306706
Reject H0?  True
F p-value:  0.04324828075067398
Reject H0?  True


Testing for  GZ
```

```
LM p-value:  0.5464862013789487
Reject H0?  False
F p-value:  0.5512264318586336
Reject H0?  False


============================================================
```

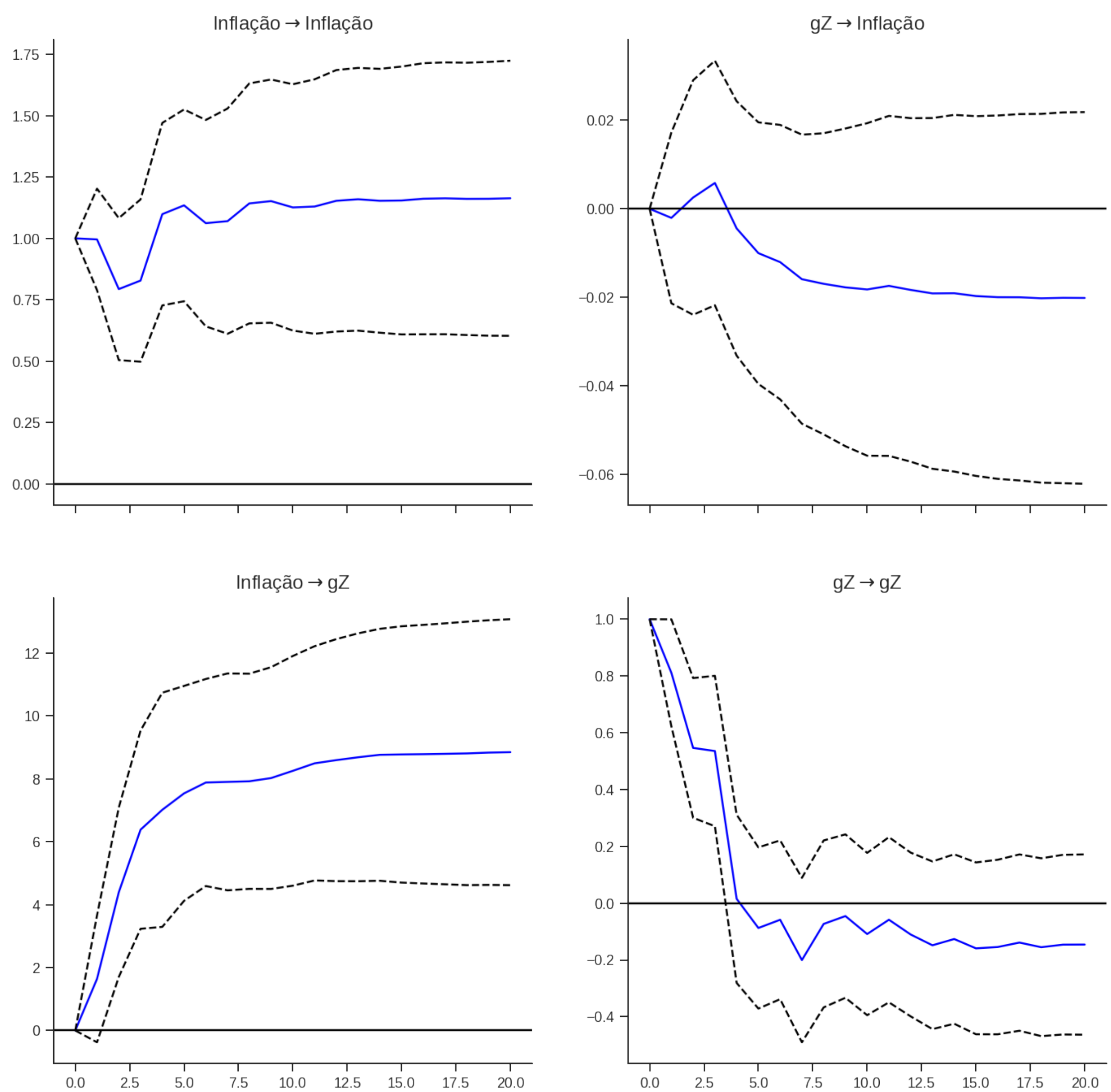
10.4 Função impulso resposta ortogonalizada

[20]:
```python
p = results.irf(20).plot(orth=True)
p.suptitle("")
sns.despine()
plt.show()
p.savefig("./figs/Impulso_VECMOrth.png", dpi = 300, bbox_inches = 'tight',
    pad_inches = 0.2, transparent = True,)
```



10.5 Função impulso resposta não-ortogonalizada

[21]:
```
p = results.irf(20).plot(orth=False)
p.suptitle("")
sns.despine()
plt.show()
p.savefig("./figs/Impulso_VECM.png", dpi = 300, bbox_inches = 'tight',
    pad_inches = 0.2, transparent = True,)
```



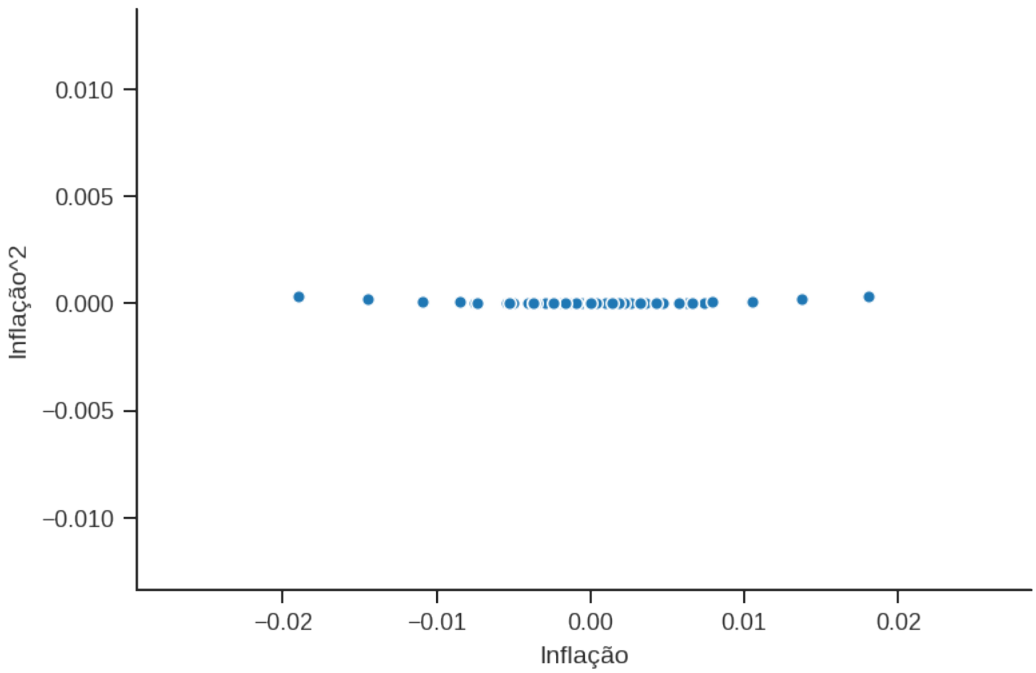
11 Teste de causalidade de granger

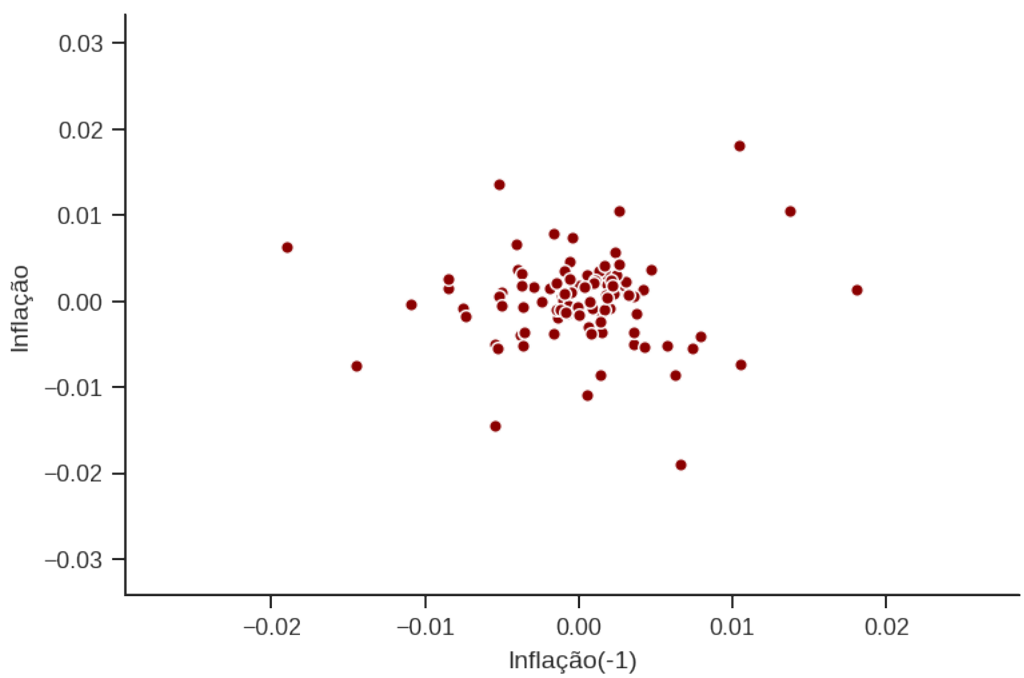
[22]:
```
series = residuals.columns
print(results.test_granger_causality(causing=series[0], caused=series[1]).
 ↪summary())
print(results.test_inst_causality(causing=series[0]).summary())
```

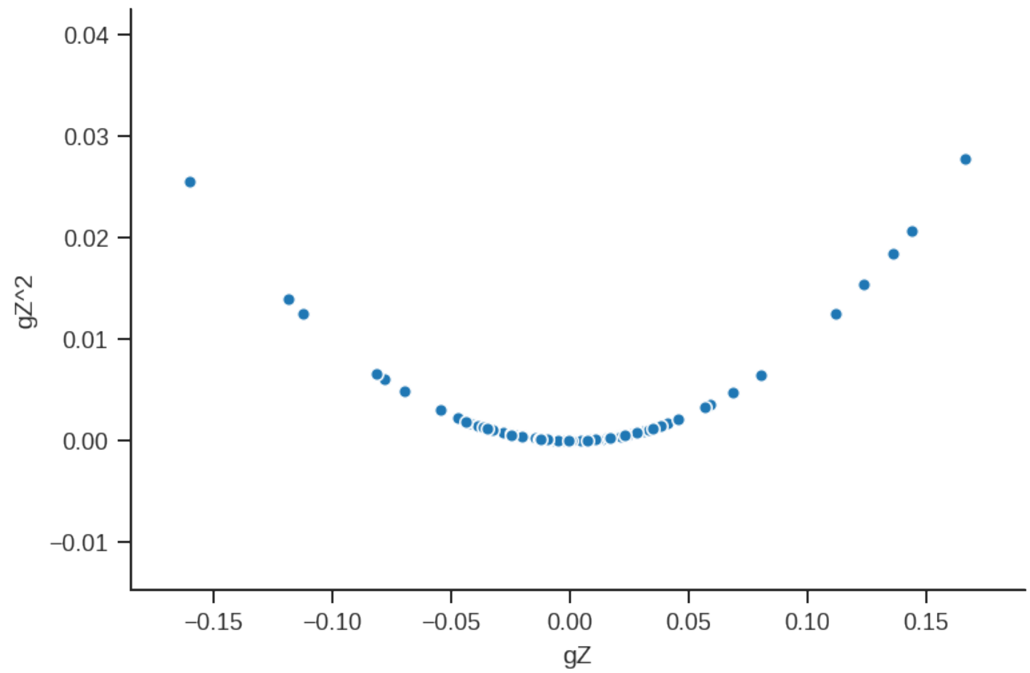
```
Granger causality F-test. H_0: Inflação does not Granger-cause gZ. Conclusion:
fail to reject H_0 at 5% significance level.
==============================================
Test statistic Critical value p-value    df
----------------------------------------------
         1.777          2.268   0.120 (5, 168)
----------------------------------------------
Instantaneous causality Wald-test. H_0: Inflação does not instantaneously cause
gZ. Conclusion: reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         14.42          3.841   0.000  1
----------------------------------------
```

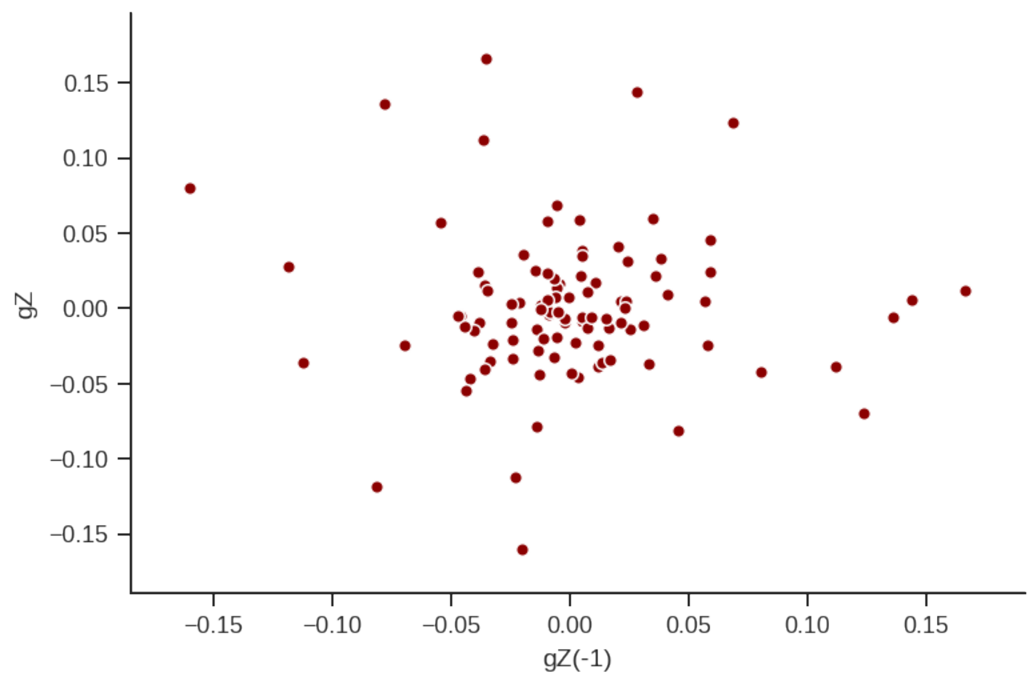
11.1 Inspeção gráfica dos resíduos

[23]:
```
series = results.names
for serie in series:
    sns.scatterplot(x = residuals[serie], y = residuals[serie]**2)
    plt.ylabel(f"{serie}^2")
    sns.despine()
    plt.show()

    sns.scatterplot(
    y = residuals[serie],
    x = residuals[serie].shift(-1),
    color = 'darkred'
    )
    sns.despine()
    plt.xlabel(f"{serie}(-1)")
    plt.show()
```


0.010
0.005
0.000
−0.005
−0.010
Inflação^2
−0.02
−0.01
0.00
0.01
0.02
Inflação

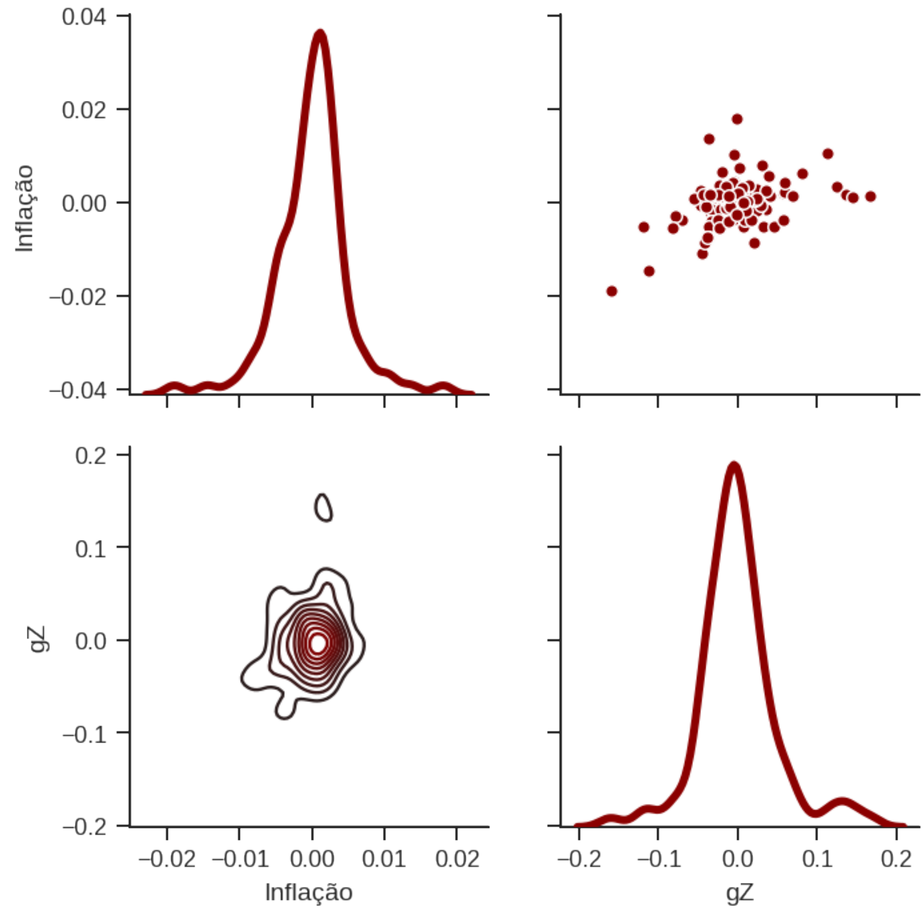

0.03
0.02
0.01
0.00
−0.01
−0.02
−0.03
Inflação
−0.02
−0.01
0.00
0.01
0.02
Inflação(-1)



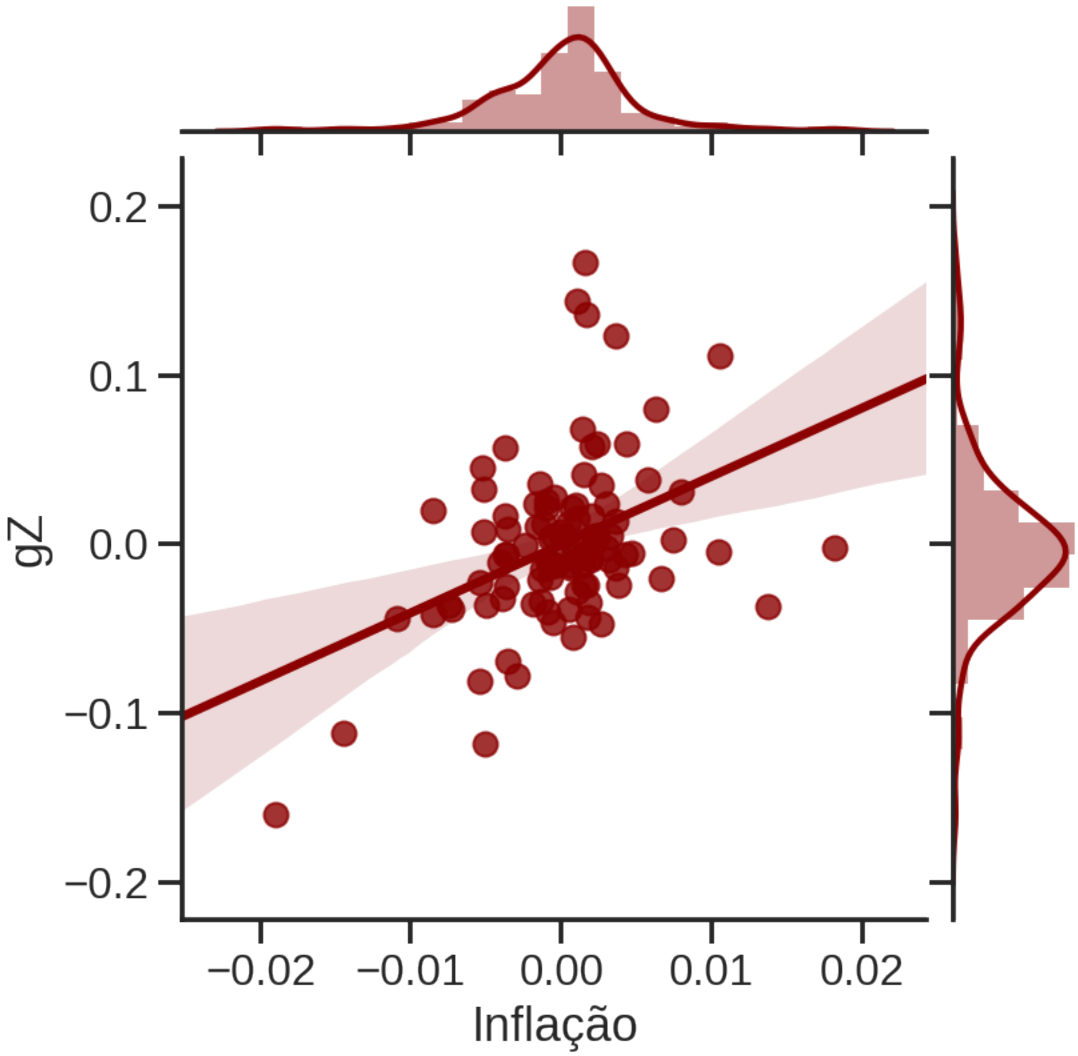


[24]:
```
sns.set_context('paper')
g = sns.PairGrid(residuals, diag_sharey=False)
g.map_lower(sns.kdeplot, color = 'darkred')
```

```
g.map_upper(sns.scatterplot, color = 'darkred')
g.map_diag(sns.kdeplot, lw=3, color = 'darkred')
plt.show()
g.savefig("./figs/Residuos_4VECM.png", dpi = 300, bbox_inches = 'tight',
    pad_inches = 0.2, transparent = True,)
```



[25]:
```
series = results.names
sns.set_context('talk')
ax = sns.jointplot(
    x = series[0],
    y = series[1],
    data = residuals, color = 'darkred', kind="reg",
)
plt.show()
```



11.2 FEVD

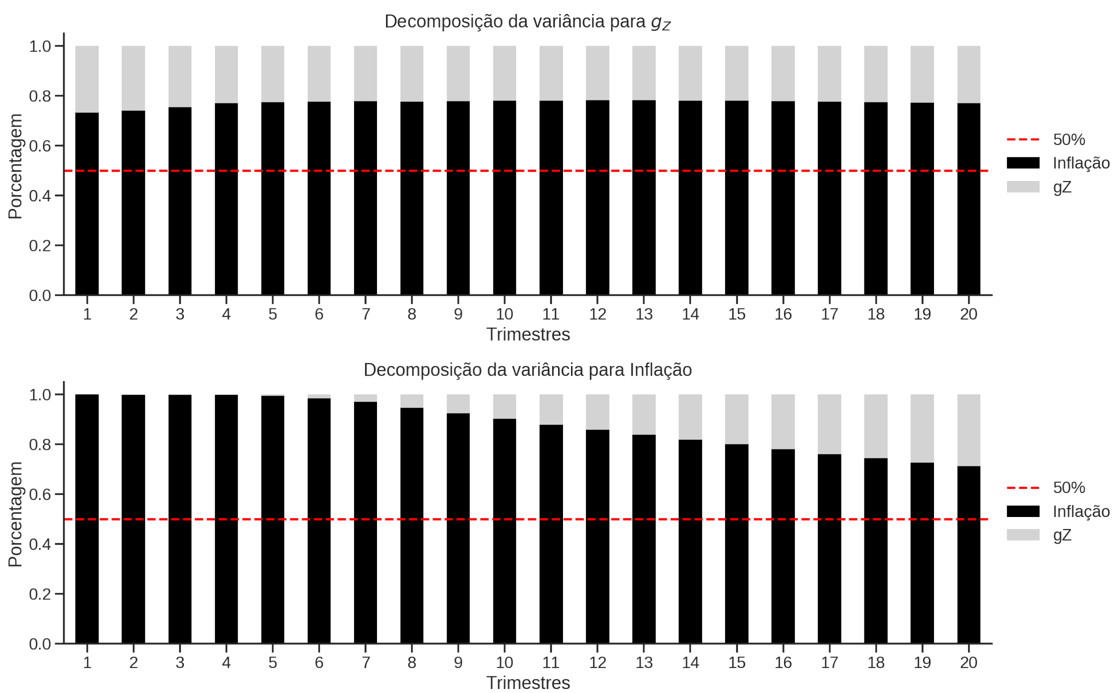
[26]:
```
%%R -o fevd_gz
library(tsDyn)
library(readr)
df <- read.csv("./Dados_yeojohnson.csv", encoding="UTF-8")
df <- df[,c(4:7)]
names(df) <- c("Juros", "Infla", "TaxaP", "gZ")
df <- na.omit(df[,c("Juros", "Infla","TaxaP", "gZ")])
df <- ts(data = df, start = c(1992,03), frequency = 4)
model <- tsDyn::VECM(data = df[,c("Infla","gZ")], lag = 4, r = 1, estim = "ML",
 ↪LRinclude="both", include="trend", exogen = coredata(df[,"Juros"]))
fevd_gz = data.frame(tsDyn::fevd(model, 20)$gZ)
```

```
R[write to console]: Registered S3 method overwritten by 'xts':
  method     from
  as.zoo.xts zoo

R[write to console]: Registered S3 method overwritten by 'quantmod':
  method            from
  as.zoo.data.frame zoo

R[write to console]: Registered S3 methods overwritten by 'forecast':
  method             from
  fitted.fracdiff    fracdiff
  residuals.fracdiff fracdiff
```

[27]:
```
%%R -o fevd_tx
fevd_tx = data.frame(tsDyn::fevd(model, 20)$Infla)
```

[28]:
```
sns.set_context('talk')
fig, ax = plt.subplots(2,1, figsize = (16,10))

fevd_gz.plot(
    ax=ax[0],
    title = "Decomposição da variância para $g_Z$",
    color = ("black", "lightgray"),
    kind = 'bar', stacked = True
)
ax[0].set_xlabel('Trimestres')
ax[0].set_ylabel('Porcentagem')
ax[0].axhline(y=0.5, color = 'red', ls = '--')
ax[0].legend(loc='center left', bbox_to_anchor=(1, 0.5), labels = ("50%",␣
 ↪"Inflação", "gZ"))
ax[0].set_xticklabels(ax[0].get_xticklabels(), rotation=0)


fevd_tx.plot(
    ax=ax[1],
    title = "Decomposição da variância para Inflação",
    color = ("black", "lightgray"),
    kind = 'bar', stacked = True,
)
ax[1].axhline(y=0.5, color = 'red', ls = '--')
ax[1].legend(loc='center left', bbox_to_anchor=(1, 0.5), labels = ("50%",␣
 ↪"Inflação", "gZ"))
ax[1].set_xlabel('Trimestres')
ax[1].set_ylabel('Porcentagem')
ax[1].set_xticklabels(ax[1].get_xticklabels(), rotation=0)

sns.despine()
```

```
plt.tight_layout()
plt.show()
fig.savefig("./figs/FEVD_VECM.png", dpi = 300, bbox_inches = 'tight',
    pad_inches = 0.2, transparent = True,)
```



12 VAR

Dúvida: Variável exógena do VAR deve ser estacionária também?

12.1 Ordem do modelo

[29]:
```
model = VAR(
    df[["d_Inflação", 'd_gZ']],
    exog=df['Taxa de juros']
)
print(model.select_order(maxlags=15, trend='ct').summary())
```

```
 VAR Order Selection (* highlights the minimums)
==================================================
       AIC         BIC         FPE         HQIC
--------------------------------------------------
0       -16.08      -15.92*    1.037e-07     -16.01*
1       -16.00       -15.72    1.130e-07      -15.88
```

```
2        -16.04      -15.66   1.078e-07      -15.89
3        -15.97      -15.47   1.157e-07      -15.77
4        -16.18      -15.57   9.383e-08      -15.94
5        -16.20      -15.47   9.282e-08      -15.91
6        -16.19      -15.36   9.375e-08      -15.85
7        -16.11      -15.16   1.020e-07      -15.73
8       -16.23*      -15.17  9.096e-08*      -15.80
9        -16.17      -15.01   9.631e-08      -15.70
10       -16.10      -14.82   1.046e-07      -15.58
11       -16.05      -14.67   1.099e-07      -15.49
12       -16.02      -14.52   1.144e-07      -15.42
13       -15.98      -14.37   1.204e-07      -15.33
14       -15.91      -14.18   1.311e-07      -15.21
15       -15.87      -14.03   1.380e-07      -15.13
--------------------------------------------------
```

Adotando o BIC como critério de seleção dada a parciomônia, estima-se uma VAR de ordem 5.

12.2 Estimação

[30]:
```python
results = model.fit(maxlags=8)
print(results.summary())
```

```
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           sáb, 30, nov, 2019
Time:                     11:34:32
--------------------------------------------------------------------
No. of Equations:         2.00000    BIC:                   -15.1525
Nobs:                     97.0000    HQIC:                  -15.7217
Log likelihood:           541.966    FPE:                1.01893e-07
AIC:                     -16.1080    Det(Omega_mle):     7.24925e-08
--------------------------------------------------------------------
Results for equation d_Inflação
================================================================================
                   coefficient       std. error           t-stat            prob
--------------------------------------------------------------------------------
const                 0.000604         0.002193            0.275           0.783
exog0                -0.006561         0.037735           -0.174           0.862
L1.d_Inflação        -0.049969         0.120911           -0.413           0.679
L1.d_gZ               0.013133         0.011048            1.189           0.235
L2.d_Inflação        -0.255377         0.120723           -2.115           0.034
L2.d_gZ               0.008257         0.011079            0.745           0.456
L3.d_Inflação        -0.235742         0.129135           -1.826           0.068
L3.d_gZ               0.019560         0.010679            1.832           0.067
```

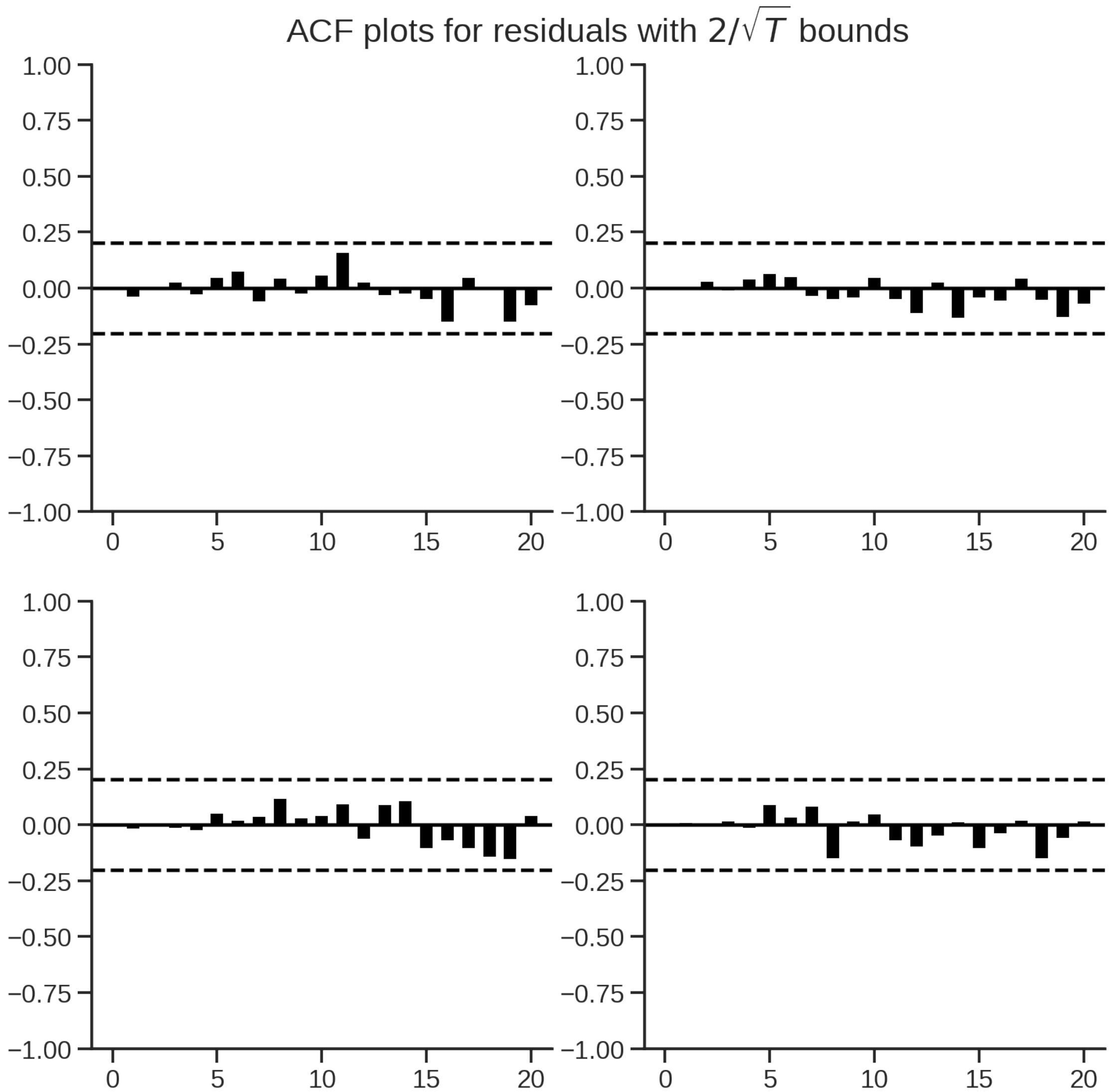
```
L4.d_Inflação         0.129583         0.126430            1.025           0.305
L4.d_gZ              -0.000263         0.010578           -0.025           0.980
L5.d_Inflação        -0.273118         0.121557           -2.247           0.025
L5.d_gZ               0.022079         0.009953            2.218           0.027
L6.d_Inflação        -0.154127         0.124652           -1.236           0.216
L6.d_gZ               0.008064         0.010094            0.799           0.424
L7.d_Inflação         0.060527         0.120576            0.502           0.616
L7.d_gZ               0.006172         0.010046            0.614           0.539
L8.d_Inflação        -0.234698         0.120862           -1.942           0.052
================================================================================

Results for equation d_gZ
================================================================================
                   coefficient       std. error           t-stat            prob
--------------------------------------------------------------------------------
const                 0.018961         0.009937            1.908           0.056
exog0                 0.012580         0.024702            0.509           0.611
L1.d_Inflação        -0.239051         0.425083           -0.562           0.574
L1.d_gZ               0.269364         1.362053            0.198           0.843
L2.d_Inflação         0.165980         0.124450            1.334           0.182
L2.d_gZ               2.753155         1.359930            2.024           0.043
L3.d_Inflação        -0.098767         0.124808           -0.791           0.429
L3.d_gZ               1.074427         1.454692            0.739           0.460
L4.d_Inflação         0.157787         0.120293            1.312           0.190
L4.d_gZ               0.178308         1.424223            0.125           0.900
L5.d_Inflação        -0.476704         0.119163           -4.000           0.000
L5.d_gZ               1.070723         1.369334            0.782           0.434
L6.d_Inflação         0.086514         0.112123            0.772           0.440
L6.d_gZ              -2.391542         1.404195           -1.703           0.089
L7.d_Inflação        -0.019635         0.113711           -0.173           0.863
L7.d_gZ               0.451476         1.358282            0.332           0.740
L8.d_Inflação         0.030168         0.113164            0.267           0.790
================================================================================

Correlation matrix of residuals
              d_Inflação      d_gZ
d_Inflação      1.000000  0.471363
d_gZ            0.471363  1.000000
```

12.3 Pós-estimação

12.3.1 Autocorrelação dos resíduos

OBS: série consigo mesma na diagonal principal.

[31]:
```
results.plot_acorr(nlags = 20)
sns.despine()
plt.show()
```



Conclusão: Pela inspeção gráfica, o modelo não apresenta autocorrelação serial dos resíduos.

12.3.2 Estabilidade

[32]:
```
print("Estável:", results.is_stable(verbose=True))
```

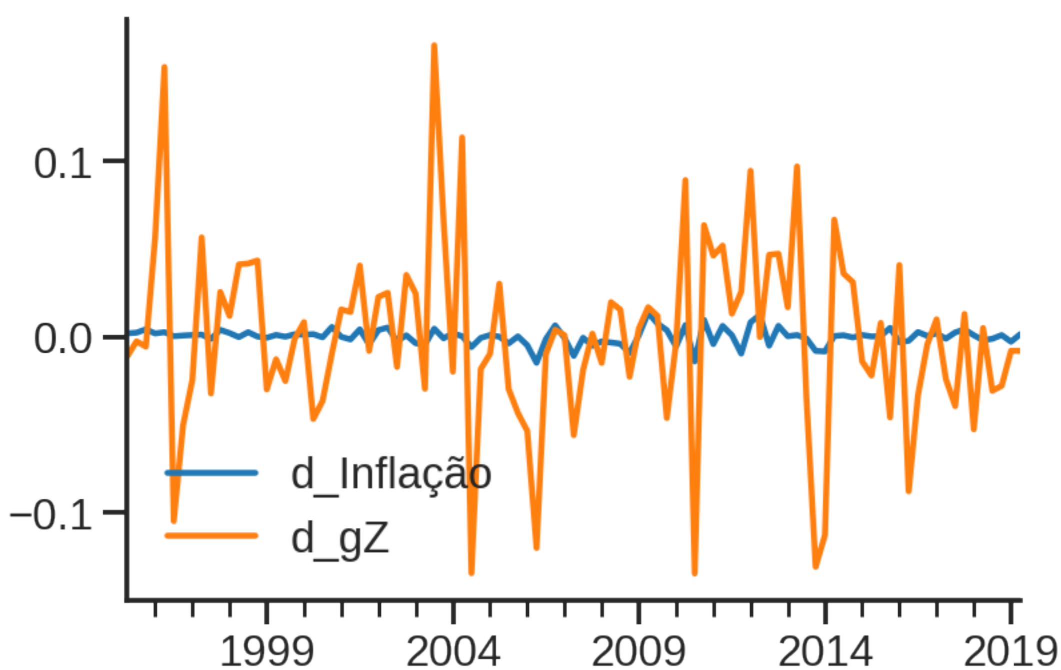
```
Eigenvalues of VAR(1) rep
0.8481367950611535
0.8481367950611535
```

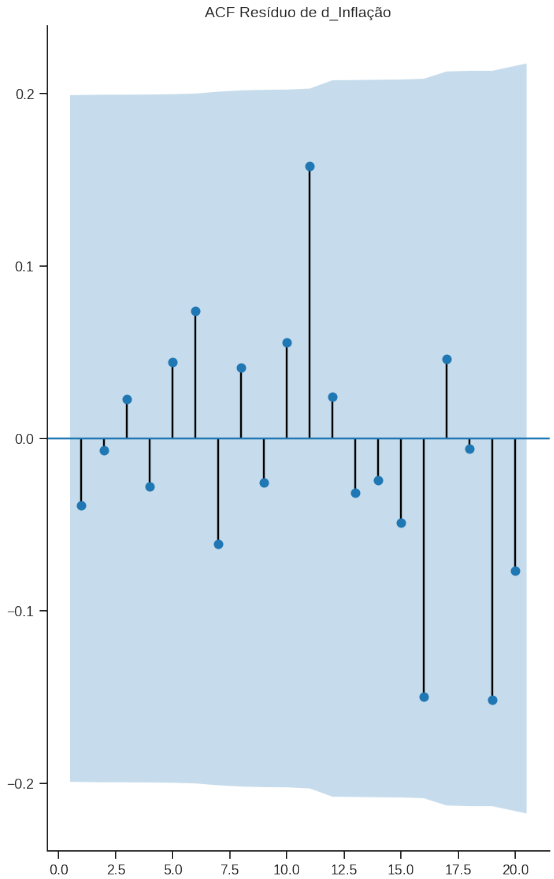
```
0.8526626331782824
0.8526626331782824
0.8826421518181559
0.8826421518181559
0.7166823754015214
0.7166823754015214
0.8184583243876727
0.8184583243876727
0.8478835234021194
0.8478835234021194
0.8236338710222055
0.8236338710222055
0.6208975680752609
0.6208975680752609
Estável: True
```

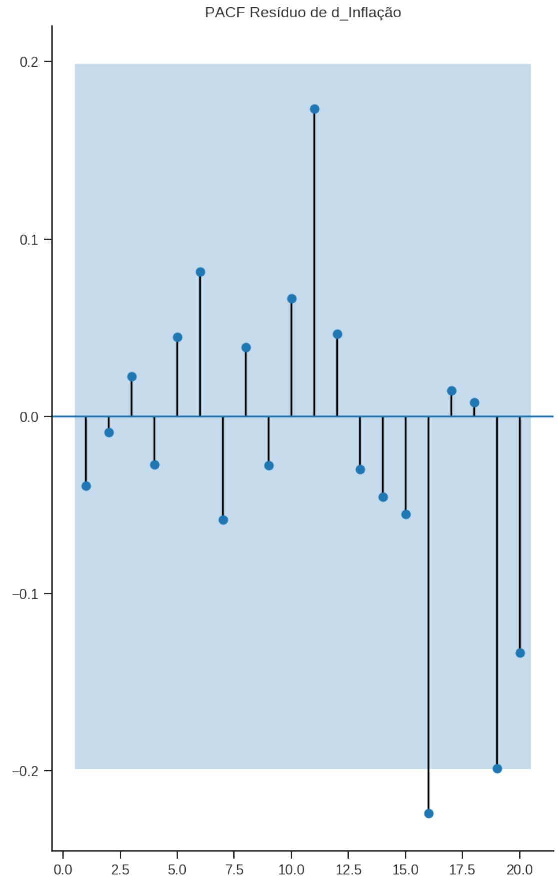
OBS: Apesar de estar escrito VAR(1), os resultados acima correspondem ao VAR(p)

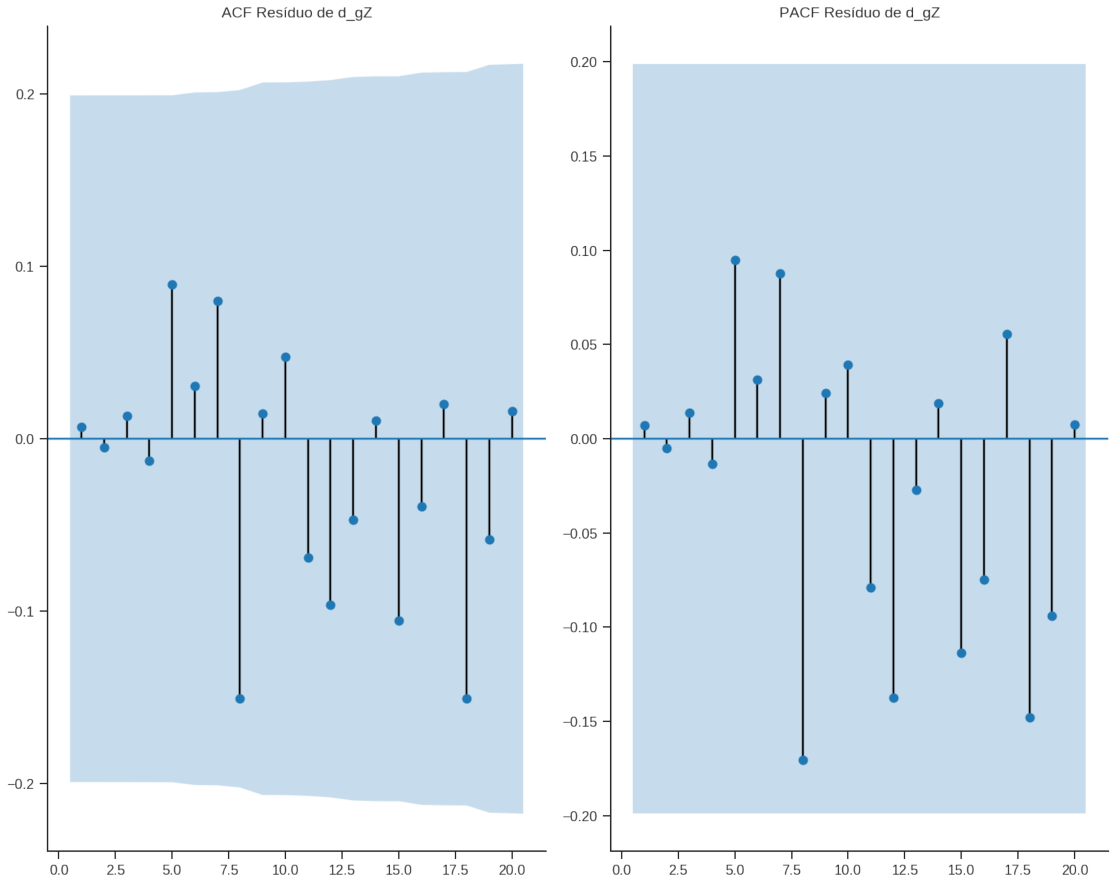
12.4 Inspeção dos resíduos

[33]:
```
residuals = analise_residuos(results=results)
```




ACF Resíduo de d_Inflação
0.2
0.1
0.0
−0.1
−0.2
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0


PACF Resíduo de d_Inflação
0.2
0.1
0.0
−0.1
−0.2
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0




```
AUTOCORRELAÇÃO RESIDUAL: PORTMANTEAU

Portmanteau-test for residual autocorrelation. H_0: residual autocorrelation up
to lag 15 is zero. Conclusion: fail to reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         27.72          41.34   0.479 28
----------------------------------------

AUTOCORRELAÇÃO RESIDUAL: PORTMANTEAU AJUSTADO

Adjusted Portmanteau-test for residual autocorrelation. H_0: residual
autocorrelation up to lag 15 is zero. Conclusion: fail to reject H_0 at 5%
significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         31.05          41.34   0.315 28
```

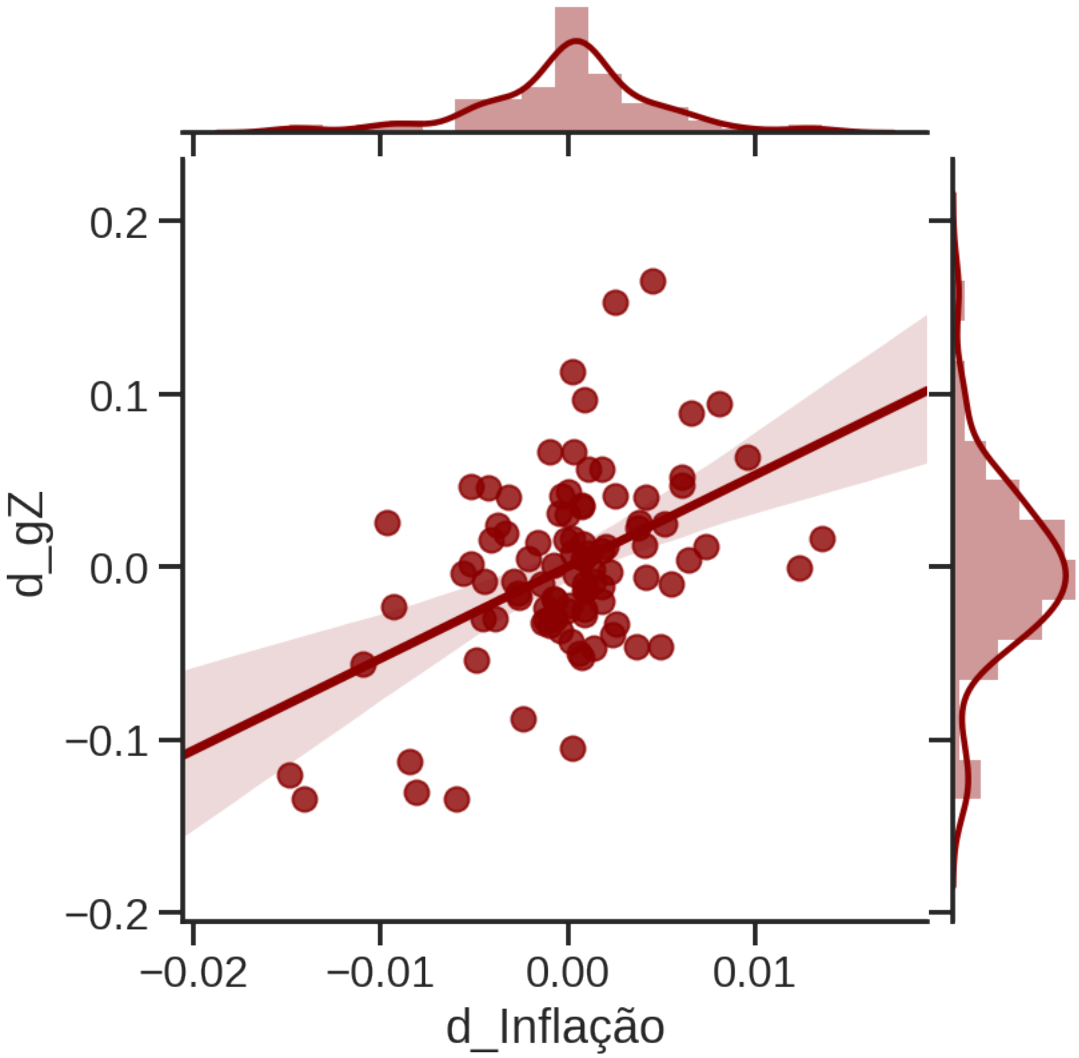
```
----------------------------------------

LJUNGBOX

H0: autocorrelations up to lag k equal zero
H1: autocorrelations up to lag k not zero
Box-Pierce:  False
Testing for  D_INFLAÇÃO . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False


Testing for  D_GZ . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False



BOXPIERCE

H0: autocorrelations up to lag k equal zero
H1: autocorrelations up to lag k not zero
Box-Pierce:  True
Testing for  D_INFLAÇÃO . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
```

```
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False


Testing for  D_GZ . Considering a significance level of 5.0 %
Reject H0 on lag  1 ?  False
Reject H0 on lag  2 ?  False
Reject H0 on lag  3 ?  False
Reject H0 on lag  4 ?  False
Reject H0 on lag  5 ?  False
Reject H0 on lag  6 ?  False
Reject H0 on lag  7 ?  False
Reject H0 on lag  8 ?  False
Reject H0 on lag  9 ?  False
Reject H0 on lag  10 ?  False
Reject H0 on lag  11 ?  False
Reject H0 on lag  12 ?  False



NORMALIDADE

normality (skew and kurtosis) test. H_0: data generated by normally-distributed
process. Conclusion: reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         18.09          9.488   0.001  4
----------------------------------------

HOMOCEDASTICIDADE

H0: Residuals are homoscedastic
H1: Residuals are heteroskedastic
Testing for  D_INFLAÇÃO
LM p-value:  0.07543360968159642
Reject H0?  False
F p-value:  0.07685252264954635
Reject H0?  False


Testing for  D_GZ
```

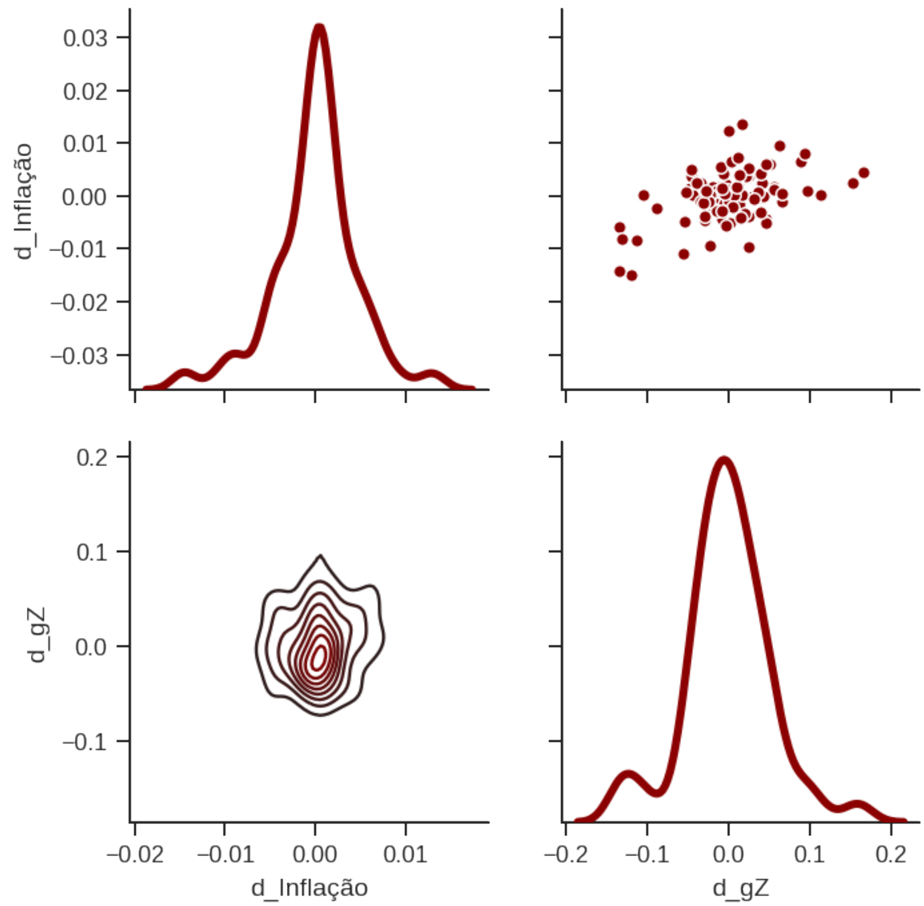
```
LM p-value:  0.016120040415036944
Reject H0?  True
F p-value:  0.01587735132787215
Reject H0?  True
```

12.5 Inspeção gráfica dos resíduos

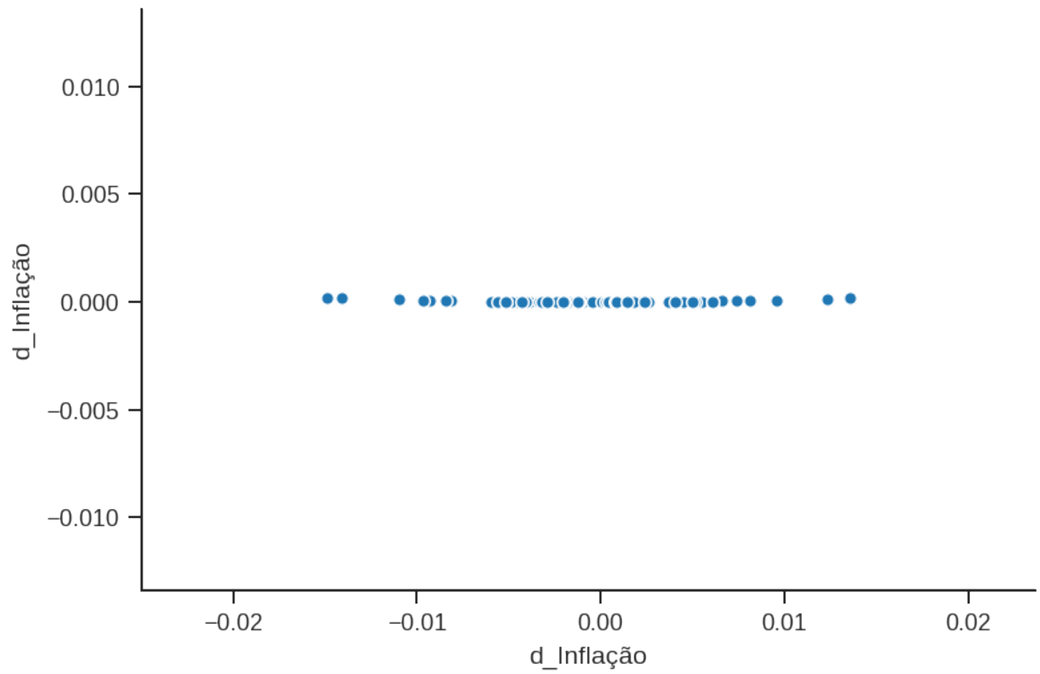
[34]:
```python
series = results.names
sns.set_context('talk')
ax = sns.jointplot(
    x = series[0],
    y = series[1],
    data = residuals, color = 'darkred', kind="reg",
)
plt.show()
```

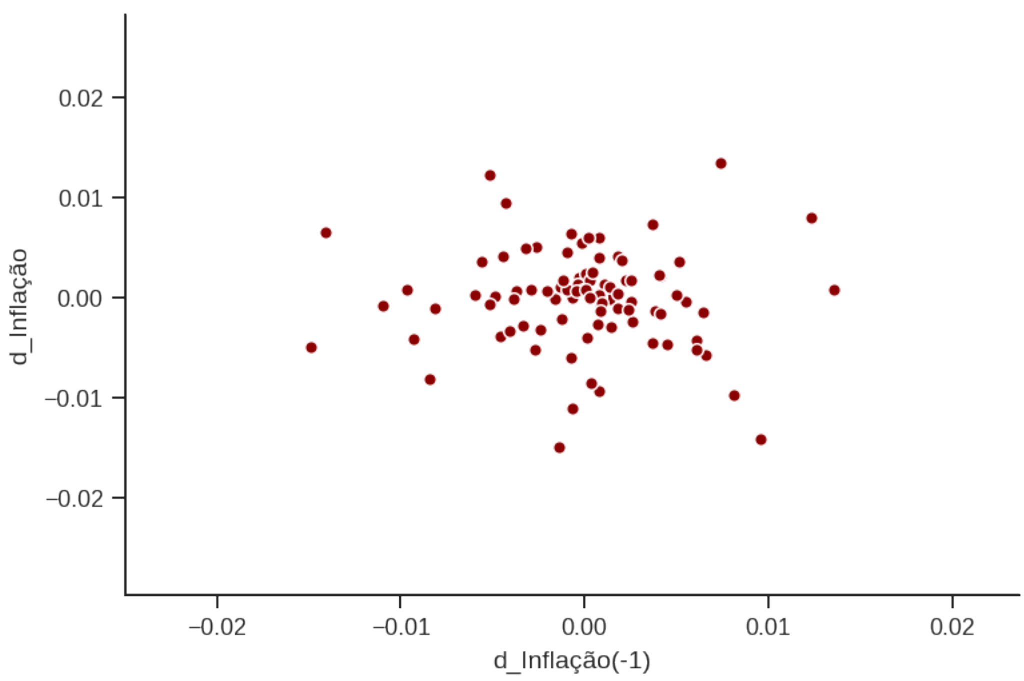


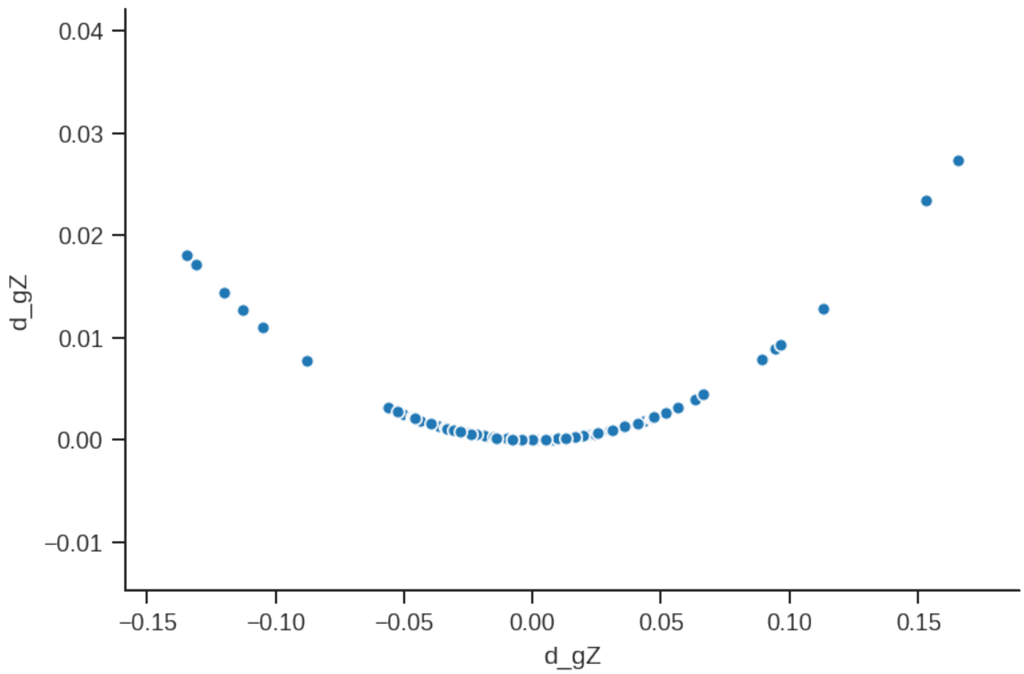
[35]:
```
sns.set_context('paper')
g = sns.PairGrid(residuals, diag_sharey=False)
g.map_lower(sns.kdeplot, color = 'darkred')
g.map_upper(sns.scatterplot, color = 'darkred')
g.map_diag(sns.kdeplot, lw=3, color = 'darkred')
plt.show()
g.savefig("./figs/Residuos_4.png", dpi=300)
```

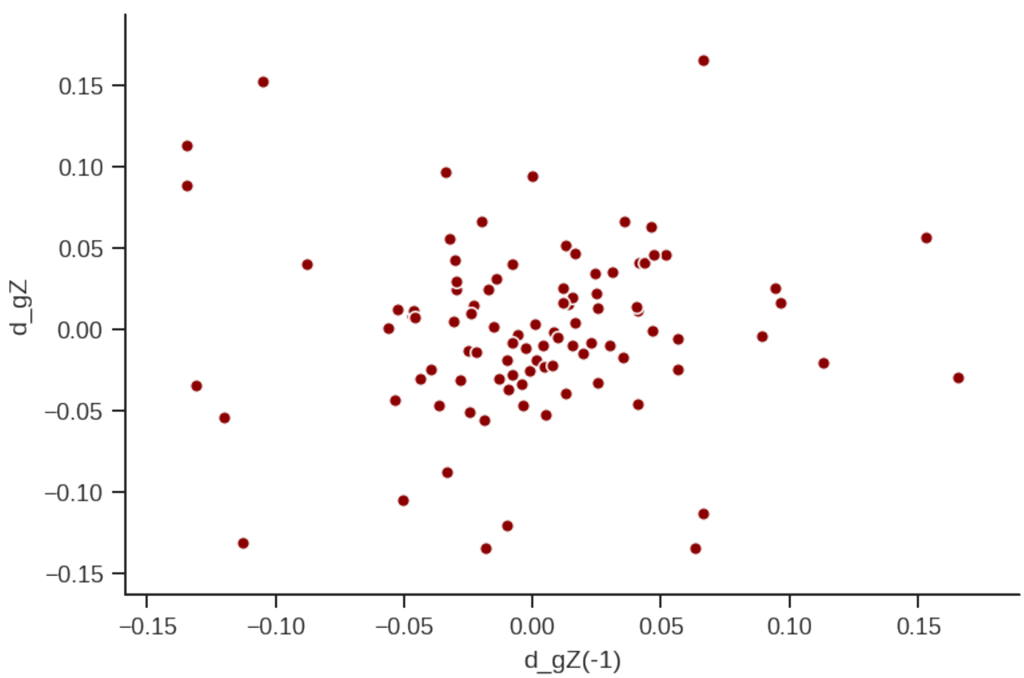


[36]:
```
series = results.names
for serie in series:
    sns.scatterplot(x = residuals[serie], y = residuals[serie]**2)
    sns.despine()
    plt.show()

    sns.scatterplot(
    y = residuals[serie],
    x = residuals[serie].shift(-1),
    color = 'darkred'
    )
    sns.despine()
    plt.xlabel(f"{serie}(-1)")
    plt.show()
```

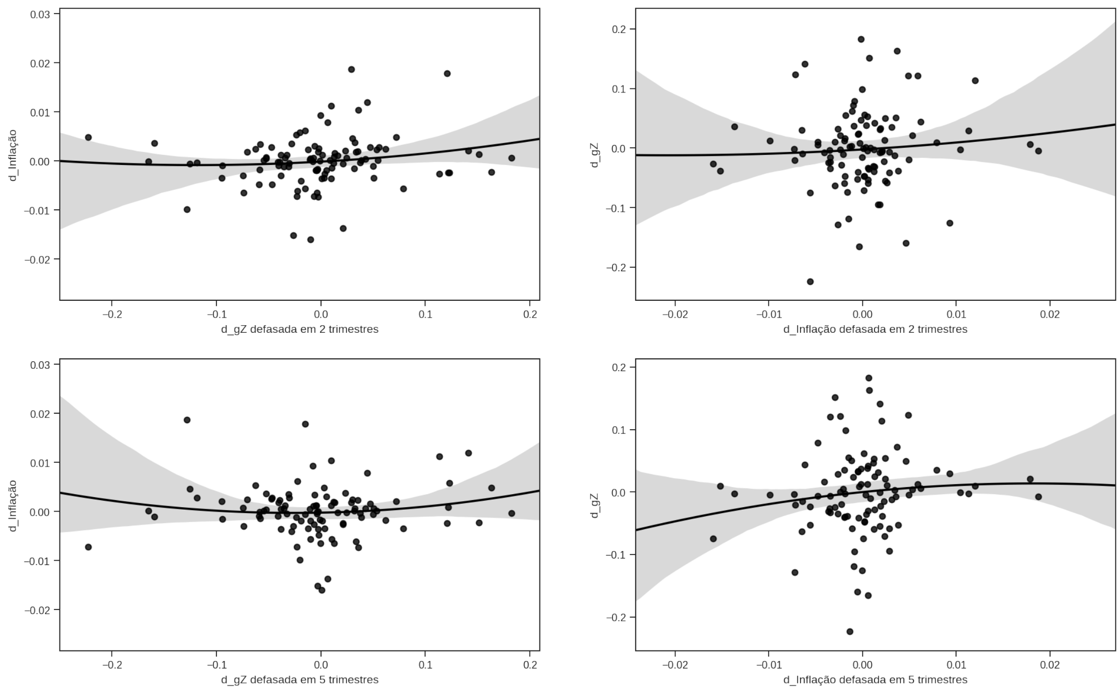

0.010
0.005
0.000
−0.005
−0.010
d_Inflação
−0.02
−0.01
0.00
0.01
0.02
d_Inflação


0.02
0.01
0.00
−0.01
−0.02
d_Inflação
−0.02
−0.01
0.00
0.01
0.02
d_Inflação(-1)



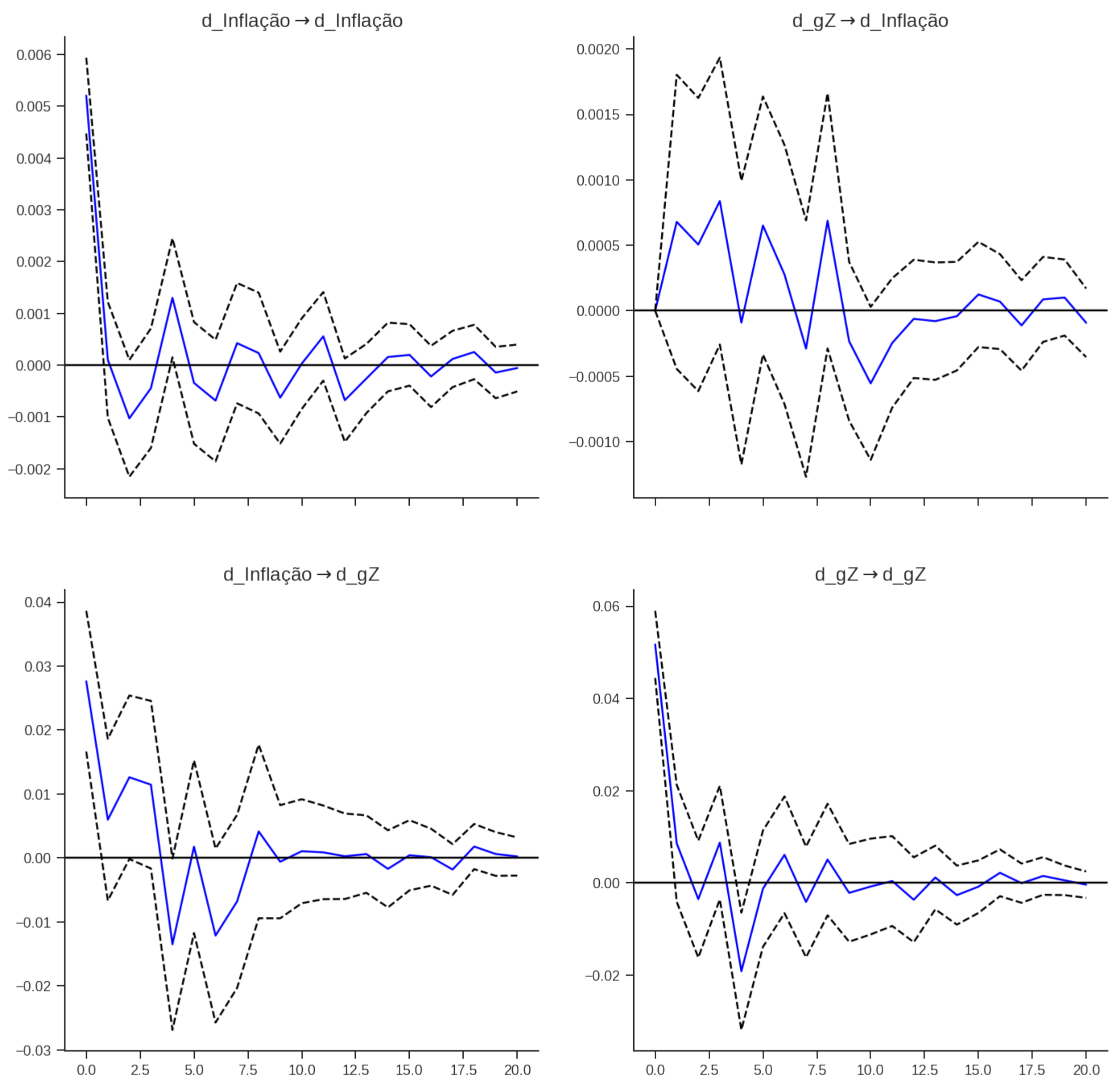


[37]:
```
plot_lags(results=results)
```



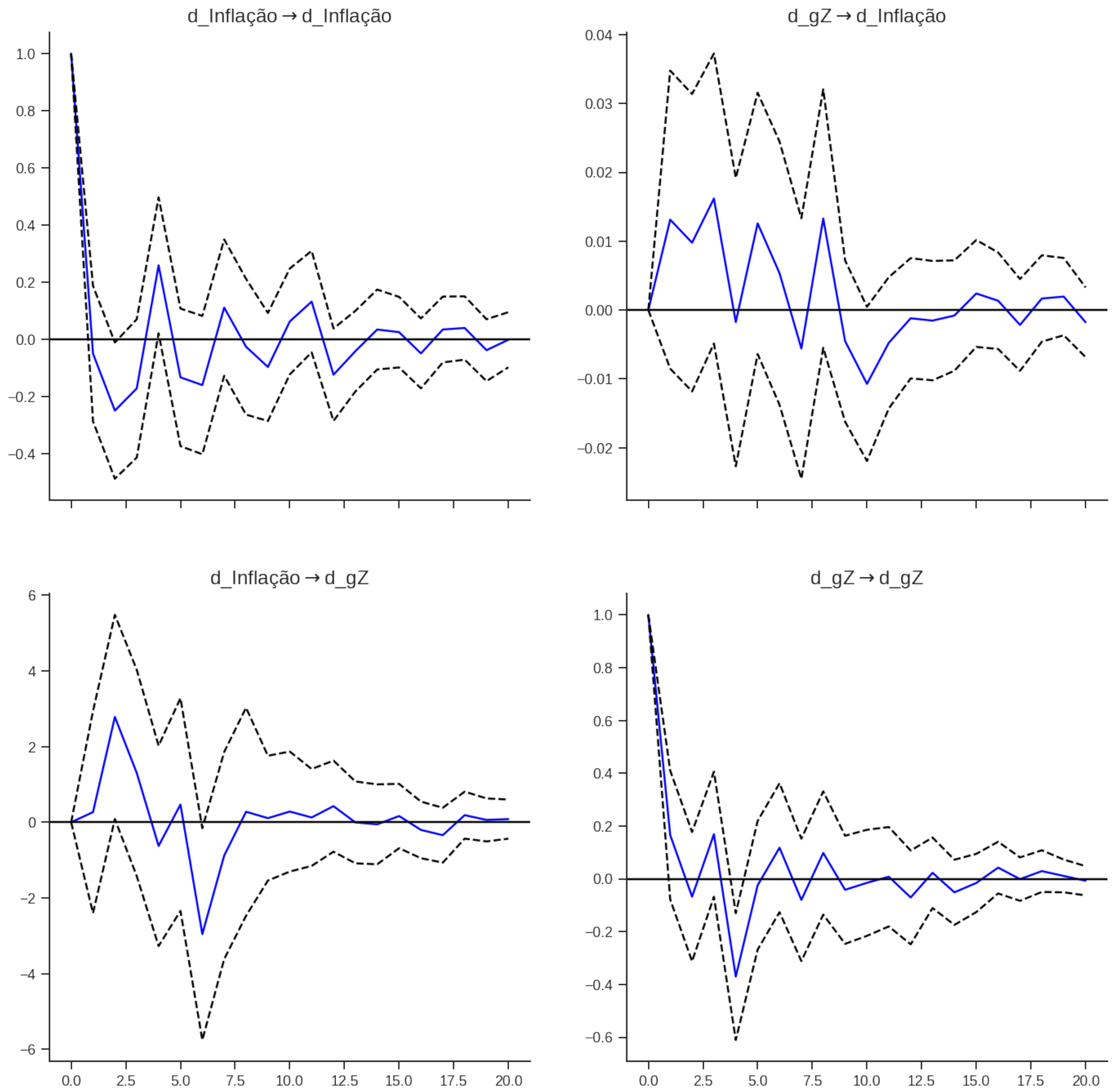
12.6 Função resposta ao impulso ortogonalizada

[38]:
```
p = results.irf(20).plot(orth=True)
p.suptitle("")
sns.despine()
plt.show()
p.savefig("./figs/Impulso_Orth.png", dpi = 300)
```



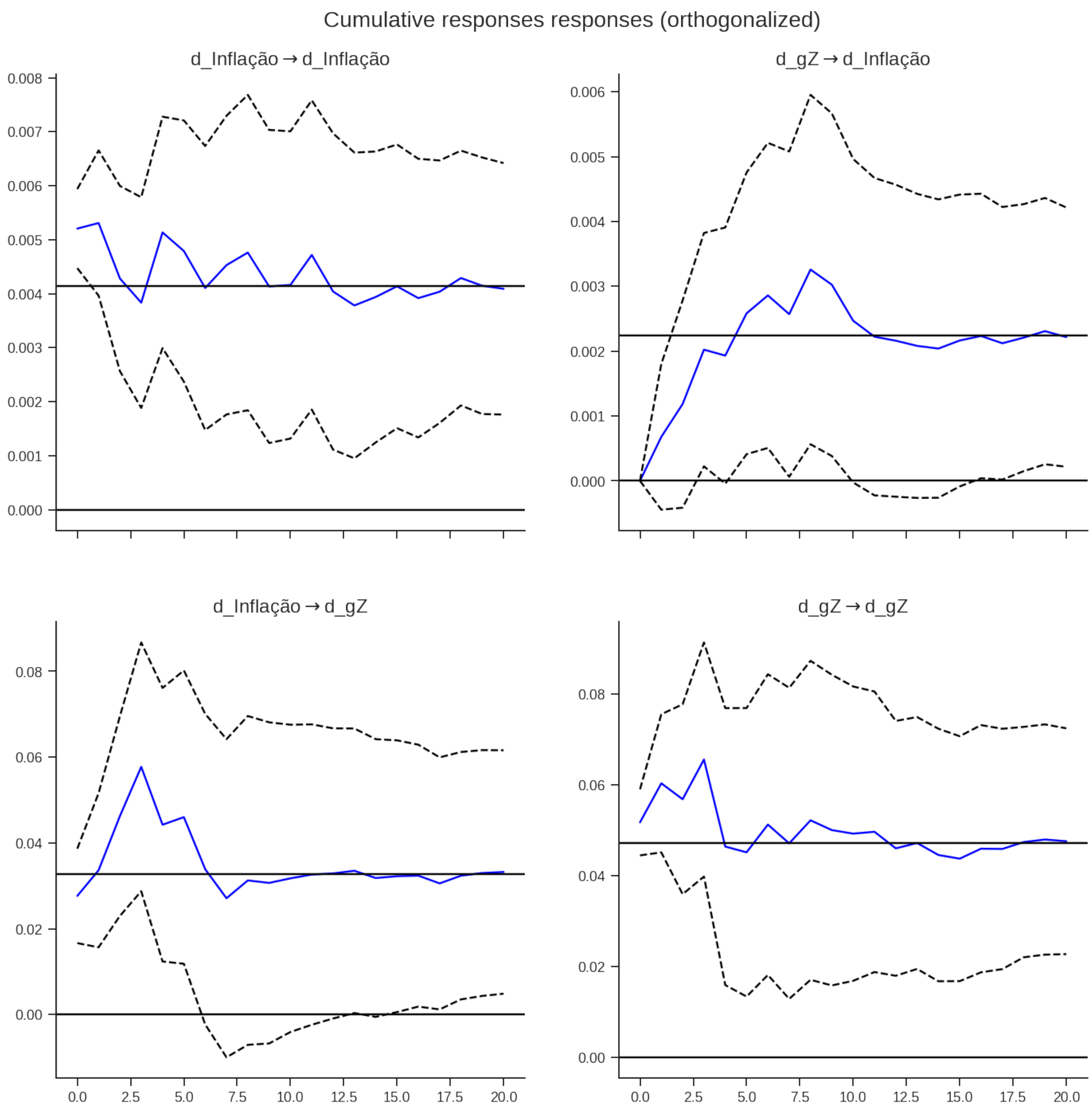
12.7 Função resposta ao impulso não-ortogonalizada

[39]:
```
p = results.irf(20).plot(orth=False)
p.suptitle("")
sns.despine()
plt.show()
p.savefig("./figs/Impulso.png", dpi = 300)
```



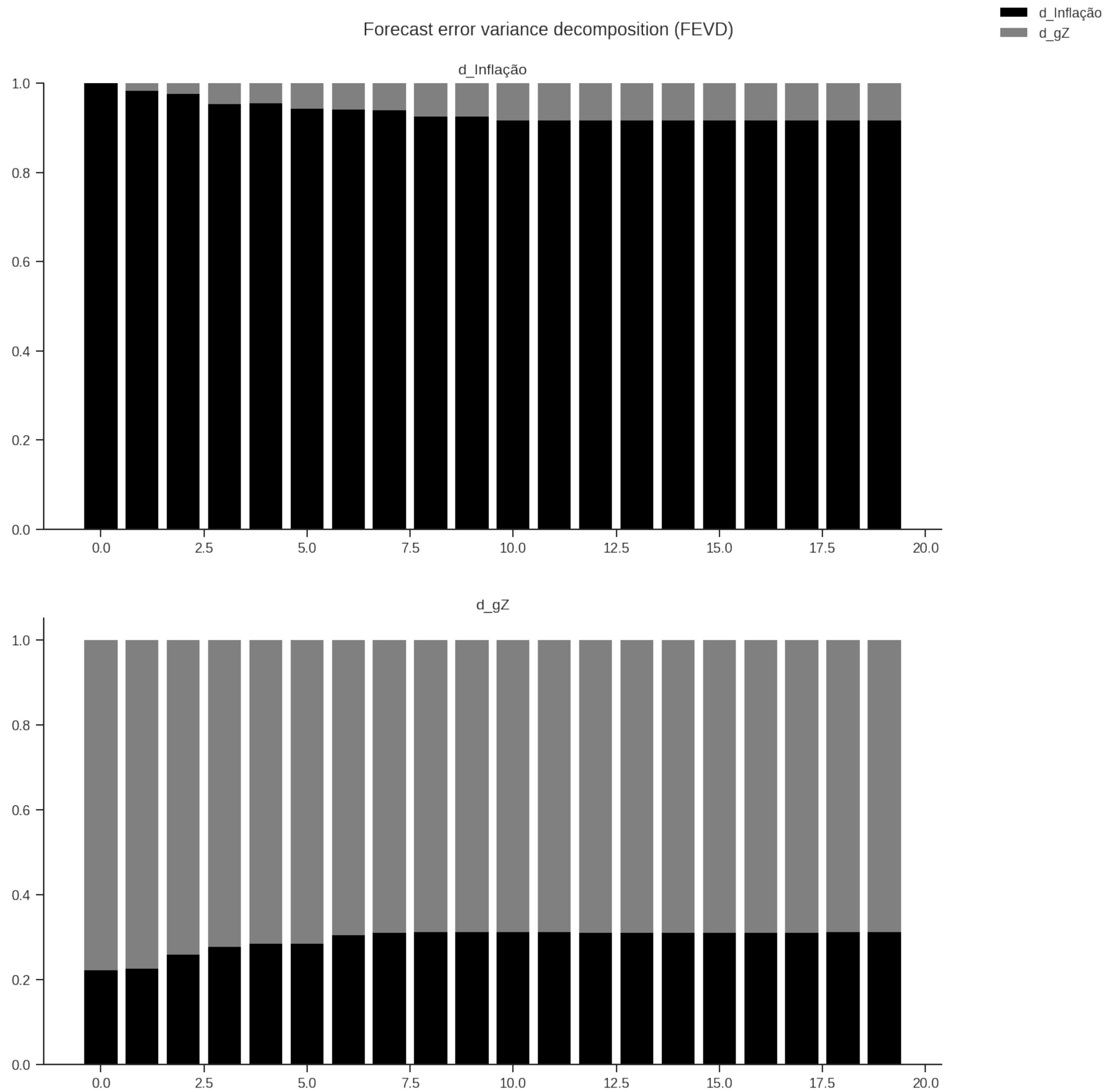
12.8 Efeito cumulativo

[40]:
```
p = results.irf(20).plot_cum_effects(orth=True)
sns.despine()
plt.show()
p.savefig("./figs/Impulso_Cum.png", dpi = 300)
```



12.9 Decomposição da variância

[41]:
```
p = results.fevd(20).plot()
sns.despine()
plt.show()
p.savefig("./figs/DecompVar.png", dpi = 300)
```


Forecast error variance decomposition (FEVD)
d_Inflação
d_gZ
d_Inflação
d_gZ
0.0
0.2
0.4
0.6
0.8
1.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0