VECM_TxPropria

November 30, 2019

1 TODO

- [ ] Checar importância da significância estatística dos coeficientes da regressão
- [ ] Checar quebra estrutural em 1991

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

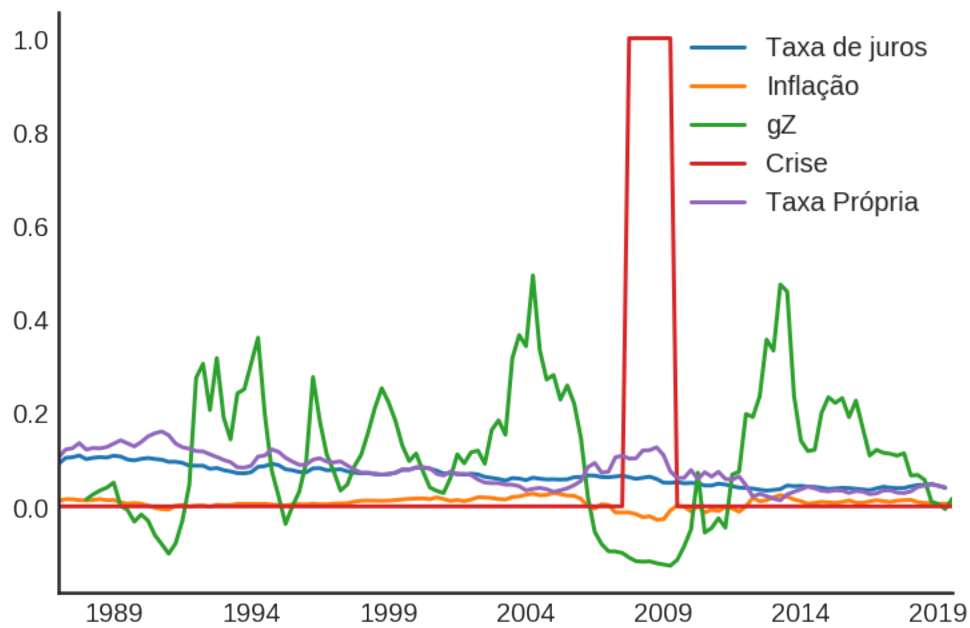
[2]:
```
%config InlineBackend.figure_format = 'retina'
%load_ext rpy2.ipython

# 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()
```

```python
    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]:
```python
# 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           78
m = 2           67 85
m = 3   18      67 85
m = 4   18 36   67 85
m = 5   18 36 54 73 91

Corresponding to breakdates:

m = 1                           2006(2)
m = 2                           2003(3) 2008(1)
m = 3   1991(2)                 2003(3) 2008(1)
m = 4   1991(2) 1995(4)         2003(3) 2008(1)
m = 5   1991(2) 1995(4) 2000(2) 2005(1) 2009(3)

Fit:

m   0       1       2       3       4       5
RSS   6.608   5.957   4.278   4.278   4.278   4.278
BIC  -3.113  -6.411 -38.155 -28.499 -18.842  -9.186
[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               101
m = 2            83 101
m = 3         65 83 101
m = 4      47 65 83 101
m = 5   19 37 65 83 101

Corresponding to breakdates:

m = 1                                   2012(1)
m = 2                           2007(3) 2012(1)
m = 3                   2003(1) 2007(3) 2012(1)
m = 4           1998(3) 2003(1) 2007(3) 2012(1)
m = 5   1991(3) 1996(1) 2003(1) 2007(3) 2012(1)

Fit:

m   0         1         2         3         4         5
RSS    0.5554    0.5437    0.5259    0.5016    0.4962    0.4883
BIC -312.6553 -305.6544 -300.1655 -296.4234 -288.1095 -280.4622
[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            83
m = 2         64 83
m = 3         64 83 101
m = 4   27    64 83 101
m = 5   27 45 64 83 101

Corresponding to breakdates:

m = 1                           2007(3)
m = 2                   2002(4) 2007(3)
m = 3                   2002(4) 2007(3) 2012(1)
m = 4   1993(3)         2002(4) 2007(3) 2012(1)
m = 5   1993(3) 1998(1) 2002(4) 2007(3) 2012(1)

Fit:
```

```
m   0           1           2           3           4           5
RSS  1.053e-02  1.040e-02  9.840e-03  9.280e-03  9.192e-03  9.186e-03
BIC -8.084e+02 -8.002e+02 -7.975e+02 -7.952e+02 -7.867e+02 -7.771e+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      38
m = 2      37        95
m = 3   18 38        95
m = 4   18     54 72 92
m = 5   18 36 54 72 92

Corresponding to breakdates:

m = 1           1996(2)
m = 2           1996(1)                 2010(3)
m = 3   1991(2) 1996(2)                 2010(3)
m = 4   1991(2)         2000(2) 2004(4) 2009(4)
m = 5   1991(2) 1995(4) 2000(2) 2004(4) 2009(4)

Fit:

m   0           1           2           3           4           5
RSS    0.16407     0.07499     0.04769     0.03629     0.02622     0.02163
BIC -465.08428 -553.28347 -600.20623 -624.71636 -655.68546 -670.09831
```

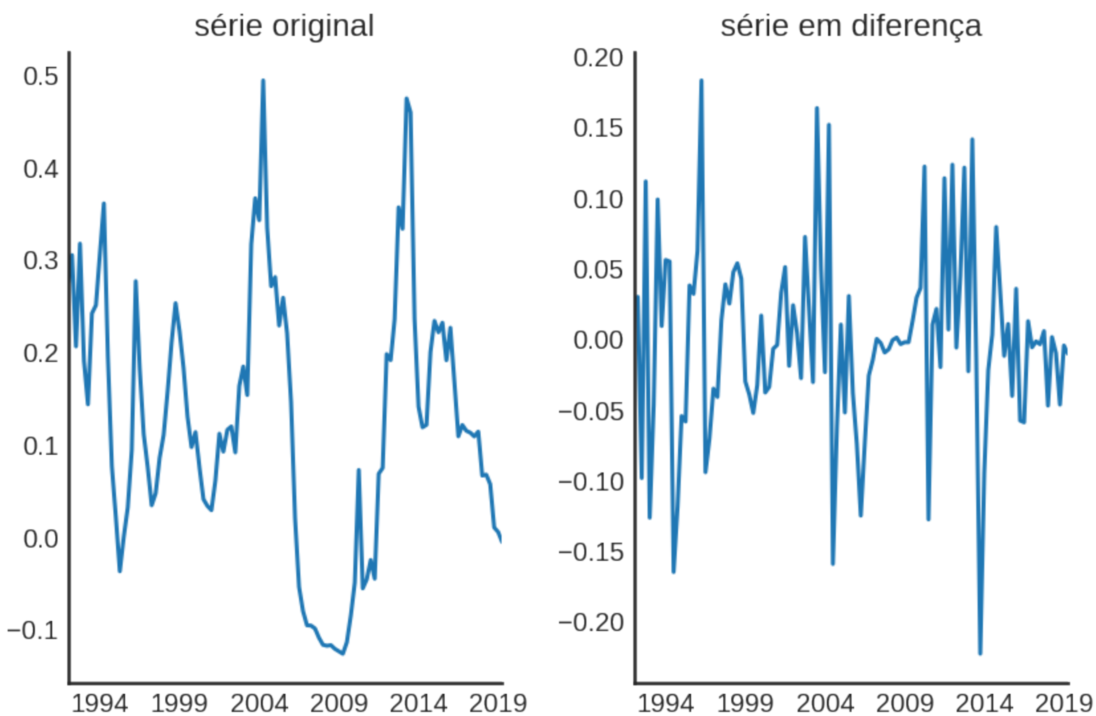
Selecionando série para depois de 1991

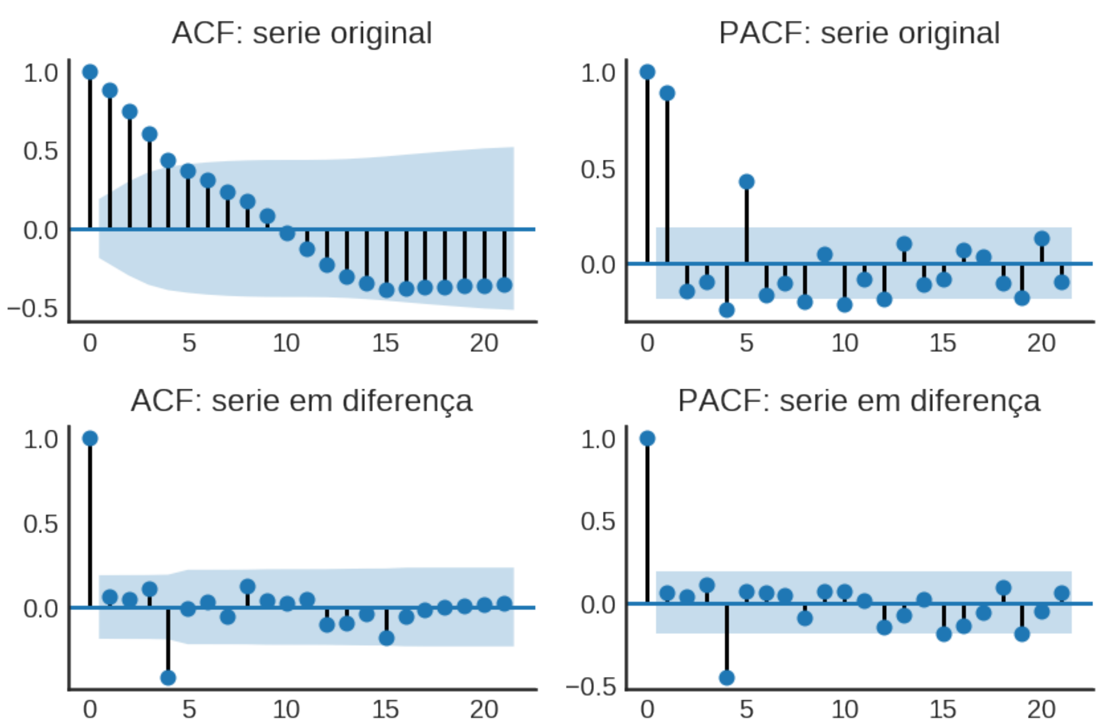
[9]:
```
df = df["1992-01-01":]
```

8 Teste de raíz unitária

8.1 Investimento residencial (g_Z)

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


série original
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
1994 1999 2004 2009 2014 2019
série em diferença
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
1994 1999 2004 2009 2014 2019


ACF: serie original
1.0
0.5
0.0
−0.5
0 5 10 15 20
PACF: serie original
1.0
0.5
0.0
0 5 10 15 20
ACF: serie em diferença
1.0
0.5
0.0
0 5 10 15 20
PACF: serie em diferença
1.0
0.5
0.0
−0.5
0 5 10 15 20

```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -3.206
P-value                         0.838
Lags                                5
-------------------------------------

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                 -7.727
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                 -2.406
P-value                         0.140
Lags                                5
-------------------------------------

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.


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

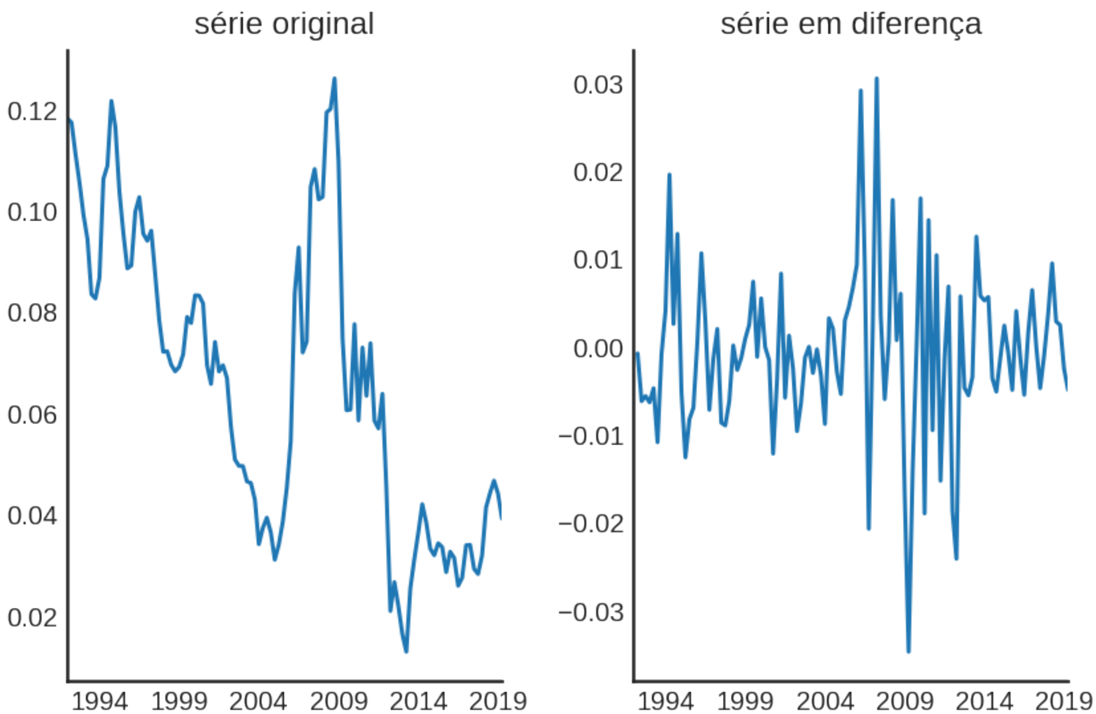
```
Test Statistic                 -7.298
P-value                         0.000
Lags                                3
-------------------------------------

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.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -1.683
P-value                         0.091
Lags                                5
-------------------------------------

Trend: Constant
Critical Values: -2.75 (1%), -2.13 (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                 -4.216
P-value                         0.000
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -2.75 (1%), -2.13 (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                  0.140
P-value                         0.423
Lags                                5
-------------------------------------

Trend: Constant
```

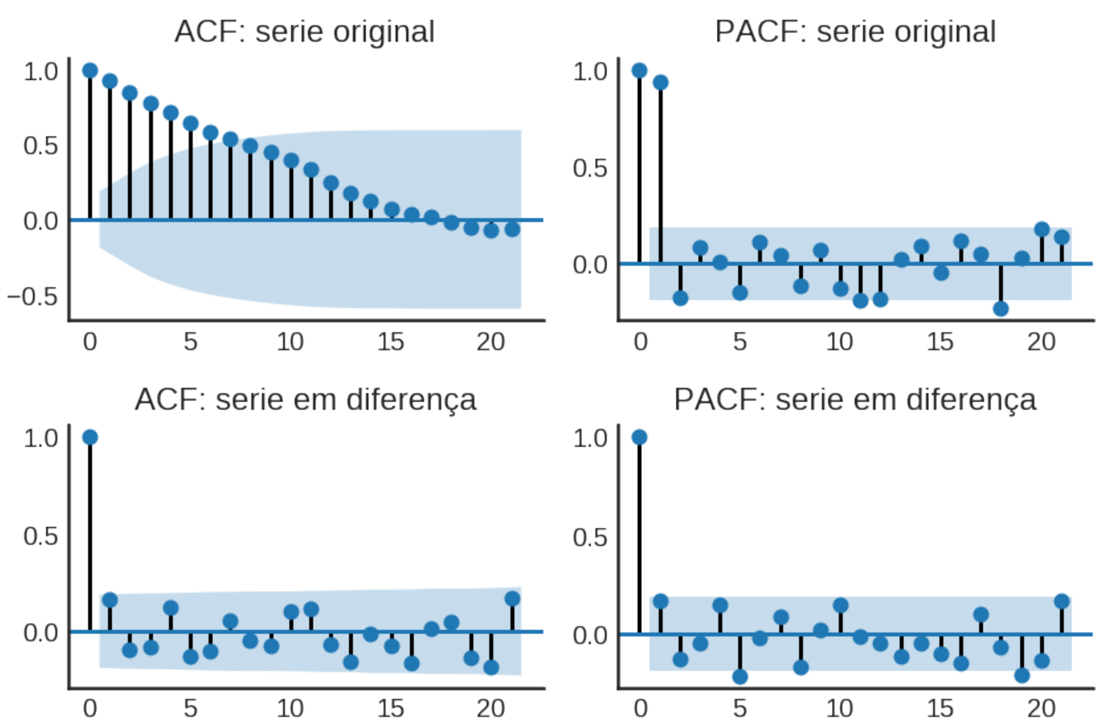
```
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


KPSS em primeira diferença
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.043
P-value                         0.915
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                 -2.747
P-value                         0.066
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                 -9.694
P-value                         0.000
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.
```

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                 -4.517
P-value                         0.114
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                 -8.320
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                 -2.323
P-value                         0.165
Lags                                1
-------------------------------------

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.
```

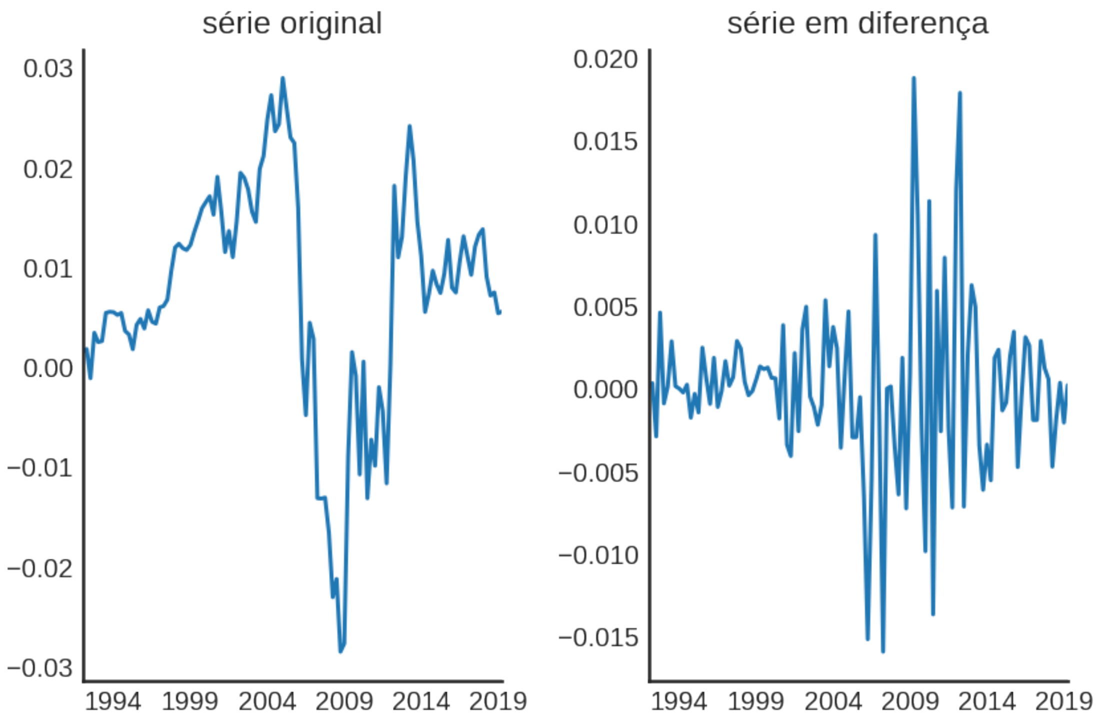
```
ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -7.480
P-value                         0.000
Lags                                1
-------------------------------------

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.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -0.999
P-value                         0.293
Lags                                1
-------------------------------------

Trend: Constant
Critical Values: -2.74 (1%), -2.12 (5%), -1.81 (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                 -7.508
P-value                         0.000
Lags                                1
-------------------------------------

Trend: Constant
Critical Values: -2.75 (1%), -2.13 (5%), -1.81 (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                  0.908
P-value                         0.004
Lags                                6
```

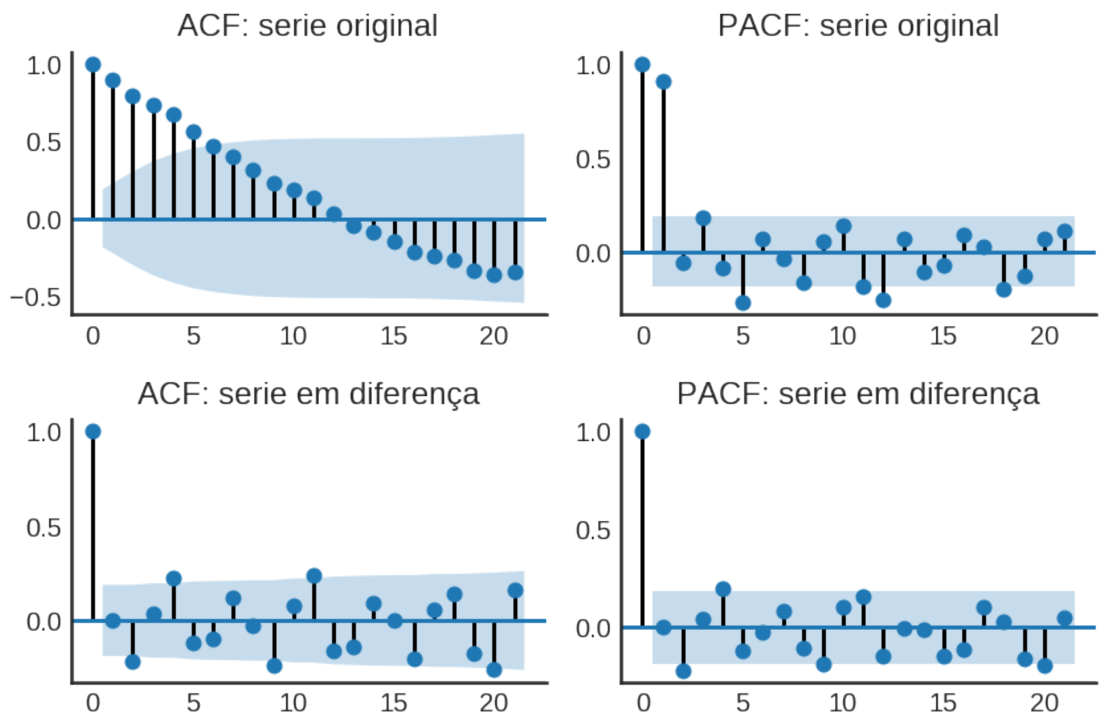
```
-------------------------------------

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.


KPSS em primeira diferença
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.066
P-value                         0.780
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                 -2.147
P-value                         0.226
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                 -8.563
P-value                         0.000
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.
```

Conclusão: Será tomada em primeira diferença.

8.3 Inflação

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






```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -5.056
P-value                         0.024
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                -10.104
P-value                         0.000
Lags                                1
-------------------------------------
```

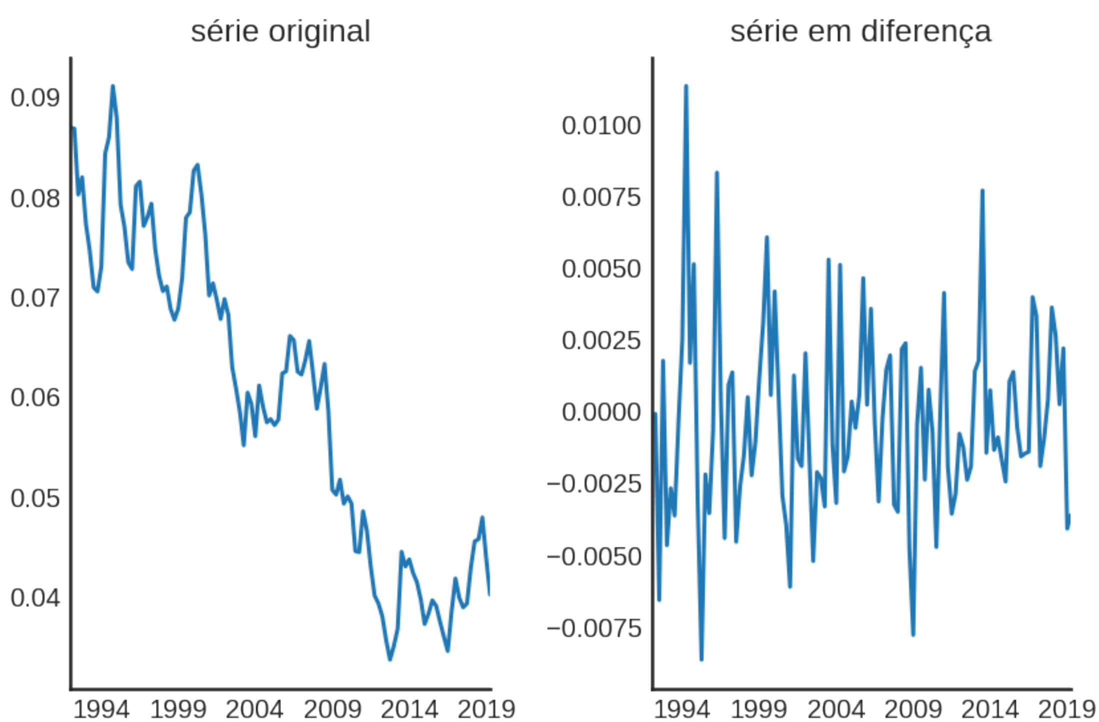
```
Trend: Constant
Critical Values: -5.28 (1%), -4.81 (5%), -4.57 (10%)
Null Hypothesis: The process contains a unit root with a single structural
break.
Alternative Hypothesis: The process is trend and break stationary.


ADF série em nível
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -2.617
P-value                         0.090
Lags                                4
-------------------------------------

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.


ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -8.950
P-value                         0.000
Lags                                1
-------------------------------------

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.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -2.440
P-value                         0.015
Lags                                4
-------------------------------------

Trend: Constant
Critical Values: -2.75 (1%), -2.13 (5%), -1.82 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

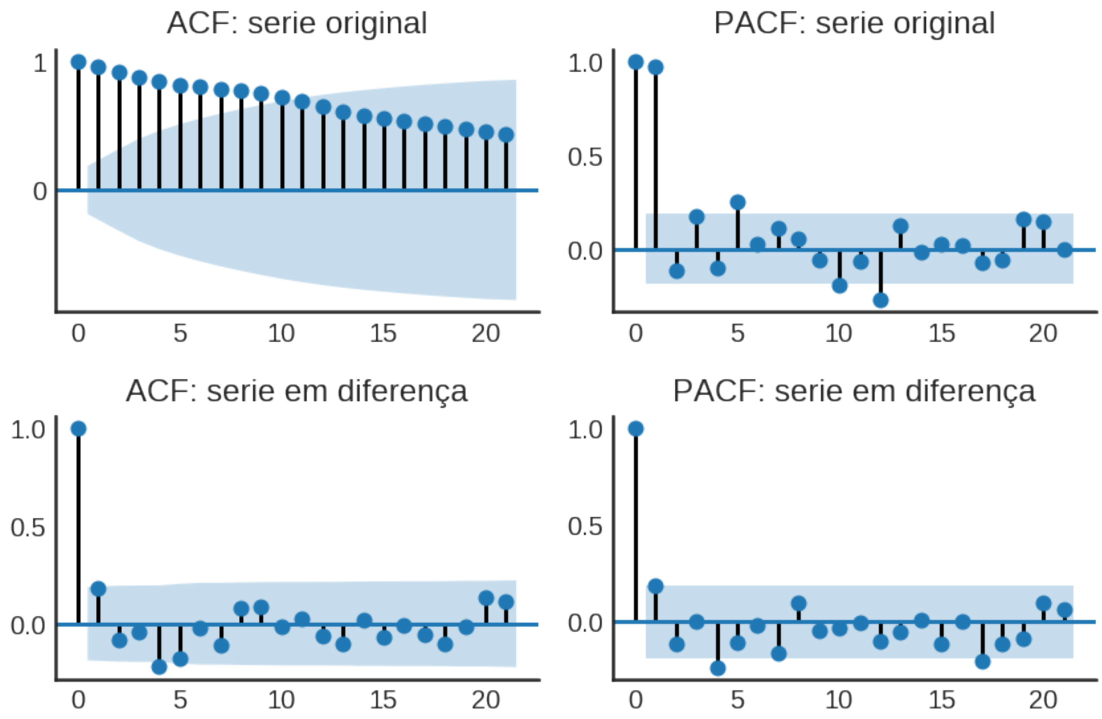
```
DFGLS série em primeira diferença
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -8.980
P-value                         0.000
Lags                                1
-------------------------------------

Trend: Constant
Critical Values: -2.75 (1%), -2.13 (5%), -1.81 (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                  0.148
P-value                         0.395
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                  0.060
P-value                         0.814
Lags                                7
-------------------------------------

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                 -2.582
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                -10.326
P-value                         0.000
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.
```

8.4 Taxa de juros das hipotecas

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






```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -4.941
P-value                         0.073
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                 -6.814
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                 -3.701
P-value                         0.022
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                 -6.546
P-value                         0.000
Lags                                3
-------------------------------------

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.
```

DFGLS série em nível

```
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -3.701
P-value                         0.004
Lags                                3
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: -3.61 (1%), -3.03 (5%), -2.73 (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                 -6.578
P-value                         0.000
Lags                                3
-------------------------------------

Trend: Constant
Critical Values: -2.75 (1%), -2.13 (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                  0.088
P-value                         0.219
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                  0.045
P-value                         0.908
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                 -2.872
P-value                         0.172
Lags                               13
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: -4.04 (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                 -8.516
P-value                         0.000
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.
```

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: -2.619887
p-value: 0.070102
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: -3.004305
p-value: 0.109186
```

```
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: -5.315541
p-value: 0.000231
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: -5.447755
p-value: 0.000586
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: -2.797282
p-value: 0.045811
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: -3.004305
p-value: 0.109186
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: -5.315541
p-value: 0.000231
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: -5.447755
p-value: 0.000586
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: -3.393339
p-value: 0.008597
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: -3.004305
p-value: 0.109186
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: -5.315541
p-value: 0.000231
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: -5.628671
p-value: 0.000271
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: -2.105898
p-value: 0.198053
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: -2.029164
p-value: 0.513389
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: -3.472220
p-value: 0.105689
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 4 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.612809
p-value: 0.174231
CONCLUSION: FAIL to reject Null Hypothesis: there is NO 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: -2.451295
p-value: 0.101755
```

```
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: -2.029164
p-value: 0.513389
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: -3.472220
p-value: 0.105689
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 5 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.612809
p-value: 0.174231
CONCLUSION: FAIL to reject Null Hypothesis: there is NO 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: -2.451295
p-value: 0.101755
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: -2.029164
p-value: 0.513389
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: -3.472220
p-value: 0.105689
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 6 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.612809
p-value: 0.174231
CONCLUSION: FAIL to reject Null Hypothesis: there is NO 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: -2.451295
p-value: 0.101755
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: -2.029164
p-value: 0.513389
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: -3.472220
p-value: 0.105689
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


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

```
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.612809
p-value: 0.174231
CONCLUSION: FAIL to reject Null Hypothesis: there is NO 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: -2.451295
p-value: 0.101755
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: -2.029164
p-value: 0.513389
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: -3.472220
p-value: 0.105689
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 8 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.612809
p-value: 0.174231
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Para lag = 8, Rank = 0
```

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

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: -4.203346
p-value: 0.003197
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: -4.303434
p-value: 0.009711
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: -5.720985
p-value: 0.000157
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: -5.936312
p-value: 0.000247
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: -4.203346
p-value: 0.003197
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: -4.303434
p-value: 0.009711
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: -5.720985
p-value: 0.000157
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: -5.936312
p-value: 0.000247
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: -4.203346
p-value: 0.003197
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: -4.303434
p-value: 0.009711
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: -5.964958
p-value: 0.000050
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: -6.327001
p-value: 0.000040
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: -4.203346
p-value: 0.003197
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: -2.997593
p-value: 0.242512
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: -3.868819
p-value: 0.092693
```

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


Testando para lag = 4 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.171197
p-value: 0.100415
CONCLUSION: FAIL to reject Null Hypothesis: there is NO 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: -4.203346
p-value: 0.003197
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: -2.997593
p-value: 0.242512
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: -3.868819
p-value: 0.092693
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 5 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.171197
p-value: 0.100415
CONCLUSION: FAIL to reject Null Hypothesis: there is NO 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: -4.203346
p-value: 0.003197
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: -4.303434
p-value: 0.009711
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: -3.868819
p-value: 0.092693
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 6 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.171197
p-value: 0.100415
CONCLUSION: FAIL to reject Null Hypothesis: there is NO 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: -4.203346
p-value: 0.003197
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: -4.303434
p-value: 0.009711
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: -3.868819
p-value: 0.092693
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 7 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.171197
p-value: 0.100415
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

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

9.3 g_Z e Inflação

[16]:
```python
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: -3.836432
p-value: 0.001967
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: -4.290165
p-value: 0.002652
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: -4.263676
p-value: 0.012321
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: -4.205067
p-value: 0.043593
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: -3.836432
p-value: 0.001967
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: -4.290165
p-value: 0.002652
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: -4.263676
p-value: 0.012321
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: -4.205067
p-value: 0.043593
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: -3.453133
p-value: 0.007125
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: -4.290165
p-value: 0.002652
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: -4.263676
p-value: 0.012321
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: -4.205067
p-value: 0.043593
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: -3.453133
p-value: 0.007125
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: -2.993343
p-value: 0.111796
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: -2.947616
p-value: 0.287077
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 4 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.205067
p-value: 0.043593
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Para lag = 4, Rank = 0
==========
==================================================
```

```
Testando para lag = 5 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.453133
p-value: 0.007125
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: -2.993343
p-value: 0.111796
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: -2.947616
p-value: 0.287077
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 5 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -4.205067
p-value: 0.043593
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: -4.232723
p-value: 0.000451
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: -4.290165
p-value: 0.002652
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: -4.263676
p-value: 0.012321
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: -4.205067
p-value: 0.043593
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: -4.232723
p-value: 0.000451
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: -4.290165
p-value: 0.002652
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: -4.263676
p-value: 0.012321
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: -4.205067
p-value: 0.043593
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=8,
    deterministic=det,
)
results = model.fit()

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

print(results.summary())
```

```
Det. terms outside the coint. relation & lagged endog. parameters for equation
Taxa Própria
================================================================================
===
                       coef    std err          z      P>|z|      [0.025
0.975]
--------------------------------------------------------------------------------
---
L1.Taxa Própria      0.2653      0.122      2.180      0.029       0.027
0.504
L1.gZ               -0.0135      0.019     -0.697      0.486      -0.052
0.025
L2.Taxa Própria     -0.0614      0.121     -0.509      0.610      -0.298
0.175
L2.gZ                0.0128      0.020      0.656      0.512      -0.025
0.051
L3.Taxa Própria     -0.1763      0.119     -1.476      0.140      -0.410
0.058
L3.gZ               -0.0065      0.019     -0.351      0.725      -0.043
0.030
L4.Taxa Própria      0.2522      0.115      2.189      0.029       0.026
0.478
L4.gZ                0.0052      0.018      0.285      0.776      -0.030
0.041
L5.Taxa Própria     -0.2778      0.110     -2.534      0.011      -0.493
-0.063
L5.gZ               -0.0393      0.016     -2.435      0.015      -0.071
-0.008
L6.Taxa Própria     -0.1173      0.111     -1.060      0.289      -0.334
```

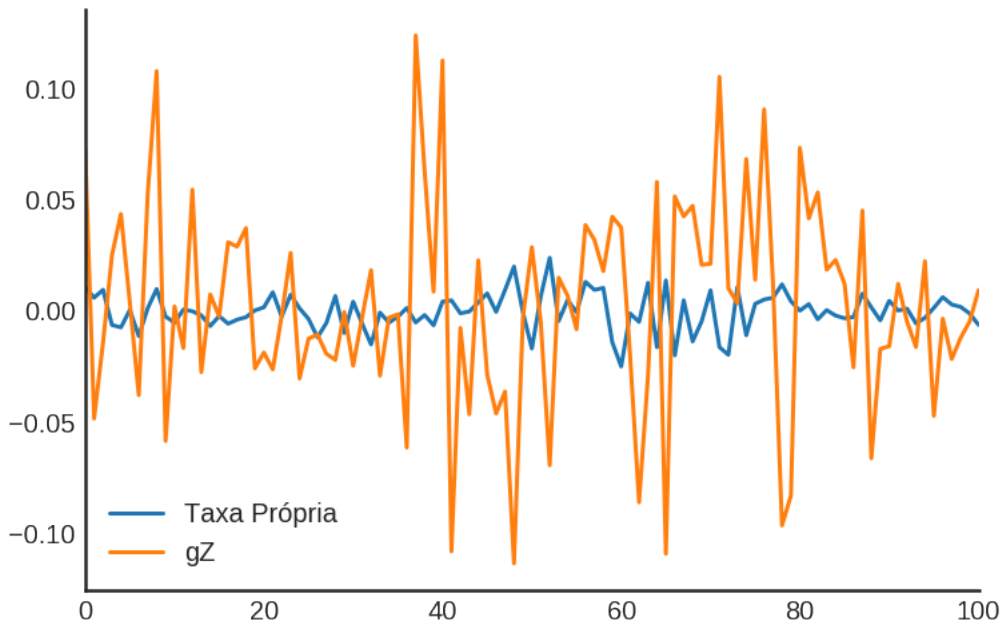
```
0.100
L6.gZ                 0.0042      0.016      0.262      0.793      -0.027
0.035
L7.Taxa Própria      0.0614      0.110      0.560      0.575      -0.154
0.276
L7.gZ                -0.0365      0.015     -2.355      0.019      -0.067
-0.006
L8.Taxa Própria     -0.2601      0.109     -2.392      0.017      -0.473
-0.047
L8.gZ                 0.0053      0.015      0.361      0.718      -0.024
0.034
 Det. terms outside the coint. relation & lagged endog. parameters for equation
gZ
================================================================================
===
                       coef    std err          z      P>|z|      [0.025
0.975]
--------------------------------------------------------------------------------
---
L1.Taxa Própria      0.4260      0.673      0.633      0.527      -0.893
1.746
L1.gZ                 0.2175      0.107      2.026      0.043       0.007
0.428
L2.Taxa Própria     -1.3957      0.667     -2.093      0.036      -2.703
-0.088
L2.gZ                -0.0170      0.108     -0.158      0.875      -0.228
0.194
L3.Taxa Própria      0.0873      0.661      0.132      0.895      -1.208
1.382
L3.gZ                 0.2448      0.103      2.386      0.017       0.044
0.446
L4.Taxa Própria     -0.4627      0.637     -0.726      0.468      -1.712
0.787
L4.gZ                -0.3486      0.100     -3.480      0.001      -0.545
-0.152
L5.Taxa Própria     -0.3381      0.606     -0.558      0.577      -1.527
0.850
L5.gZ                 0.2029      0.089      2.271      0.023       0.028
0.378
L6.Taxa Própria      1.9287      0.613      3.148      0.002       0.728
3.129
L6.gZ                 0.0437      0.088      0.495      0.621      -0.129
0.217
L7.Taxa Própria     -0.1648      0.607     -0.272      0.786      -1.354
1.024
L7.gZ                 0.0474      0.086      0.553      0.580      -0.121
0.215
L8.Taxa Própria      0.8188      0.601      1.361      0.173      -0.360
```

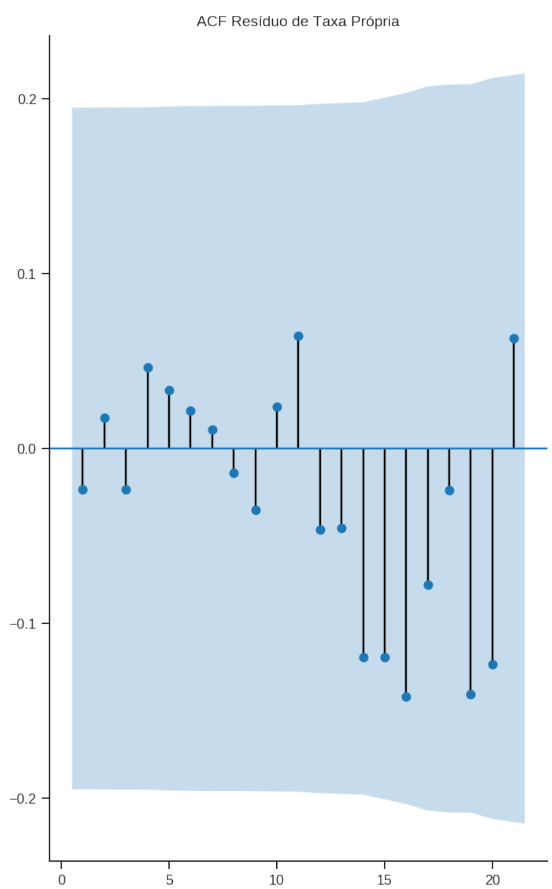
```
1.998
L8.gZ              -0.0663      0.082     -0.809      0.419      -0.227
0.094
            Loading coefficients (alpha) for equation Taxa Própria
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.1110      0.091     -1.218      0.223      -0.289       0.068
                 Loading coefficients (alpha) for equation gZ
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -1.6008      0.504     -3.177      0.001      -2.588      -0.613
          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         0.1583      0.023      6.932      0.000       0.114       0.203
const         -0.1166      0.006    -18.617      0.000      -0.129      -0.104
lin_trend      0.0006   8.01e-05      7.948      0.000       0.000       0.001
==============================================================================
```

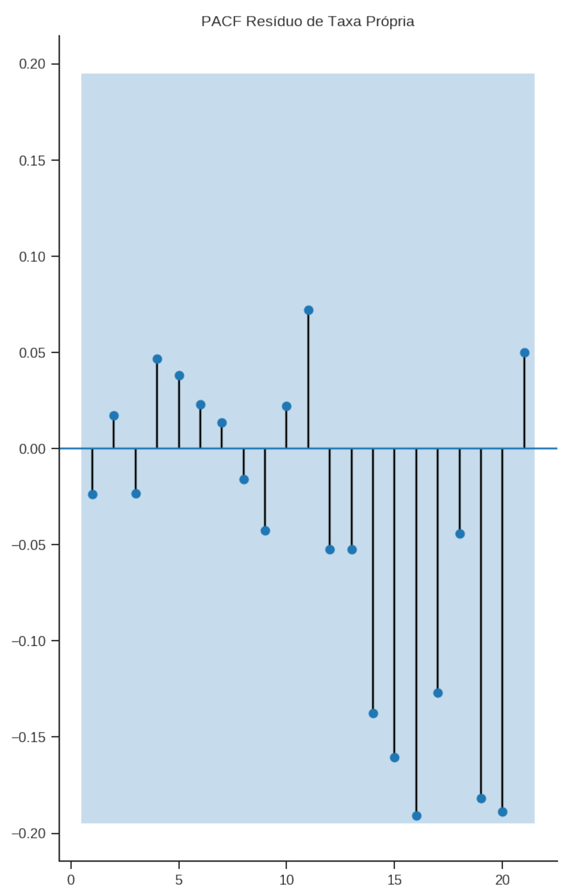
10.3 Análise dos resíduos

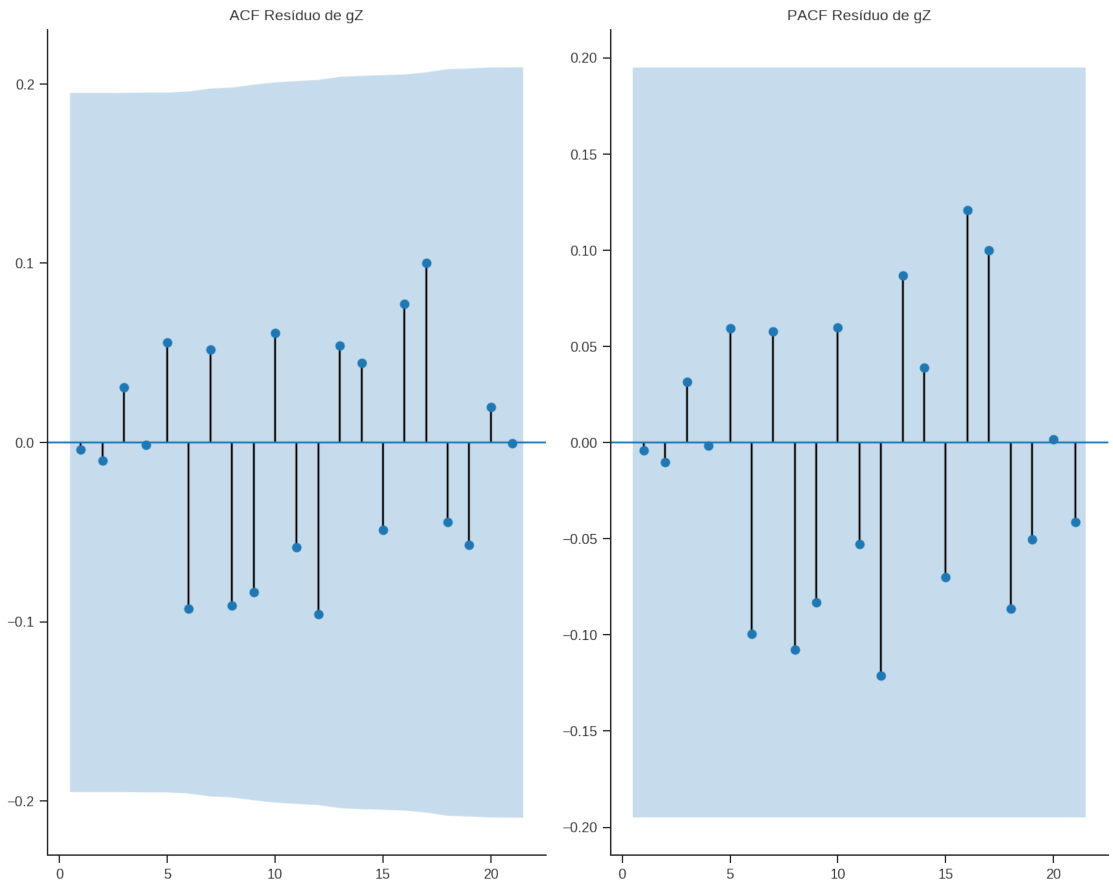
[19]:
```python
print(60*"=")
print("\nPÓS ESTIMAÇÃO\n")
residuals = analise_residuos(results=results)
print(60*"=")
```

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

PÓS ESTIMAÇÃO
```


0.10
0.05
0.00
−0.05
−0.10
Taxa Própria
gZ
0
20
40
60
80
100


ACF Resíduo de Taxa Própria
0.2
0.1
0.0
−0.1
−0.2
0
5
10
15
20


PACF Resíduo de Taxa Própria
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
0
5
10
15
20




```
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
----------------------------------------
         24.77          38.89   0.532 26
----------------------------------------

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
```

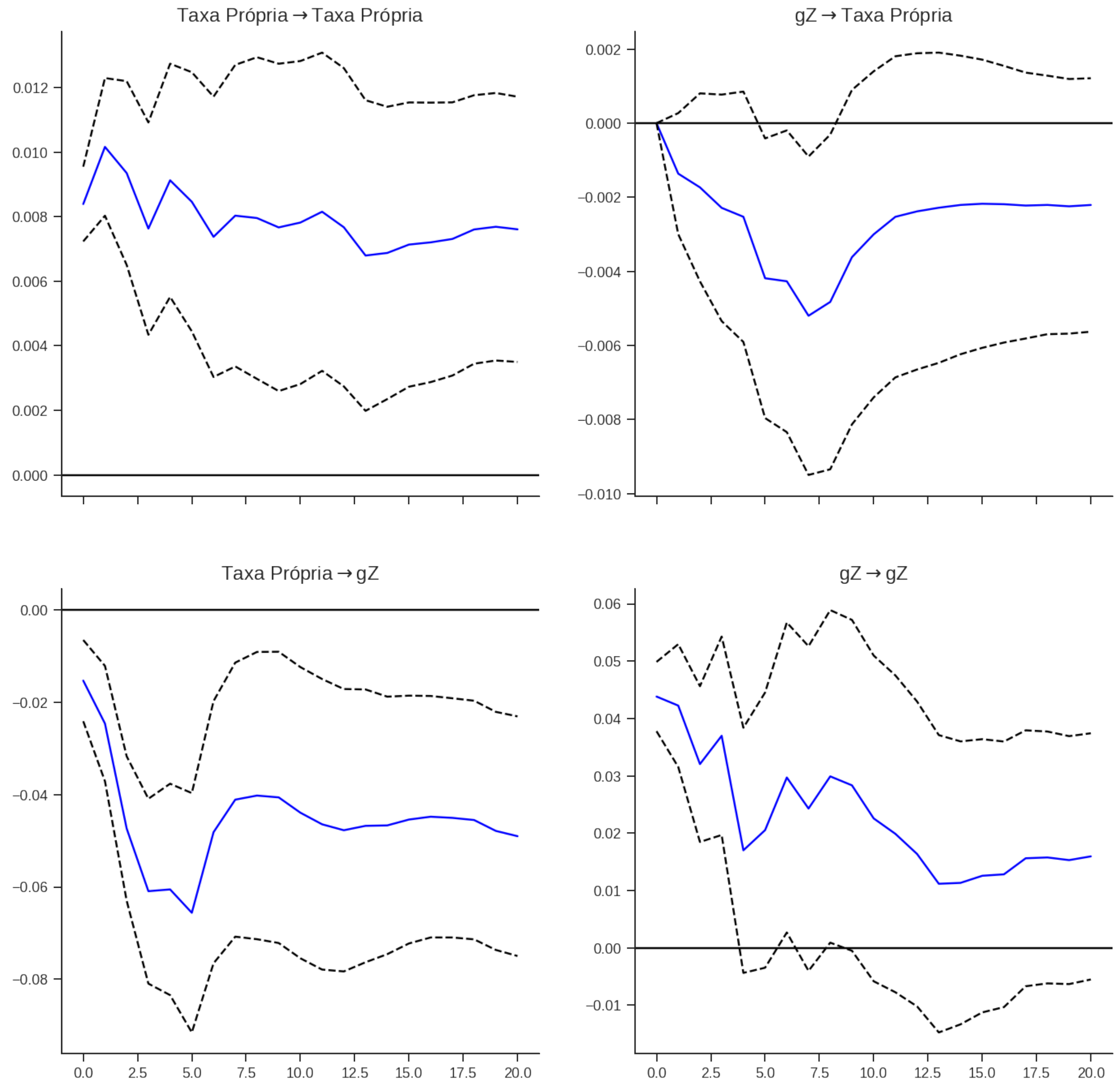
```
----------------------------------------
        27.51          38.89   0.383 26
----------------------------------------

LJUNGBOX

H0: autocorrelations up to lag k equal zero
H1: autocorrelations up to lag k not zero
Box-Pierce:  False
Testing for  TAXA PRÓPRIA . 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  TAXA PRÓPRIA . 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: fail to reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         6.612          9.488   0.158  4
----------------------------------------

HOMOCEDASTICIDADE

H0: Residuals are homoscedastic
H1: Residuals are heteroskedastic
Testing for  TAXA PRÓPRIA
LM p-value:  0.013011722599460384
Reject H0?  True
F p-value:  0.012197197569193966
Reject H0?  True
```

```
Testing for  GZ
LM p-value:  0.13739405589388878
Reject H0?  False
F p-value:  0.14018926170258675
Reject H0?  False


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

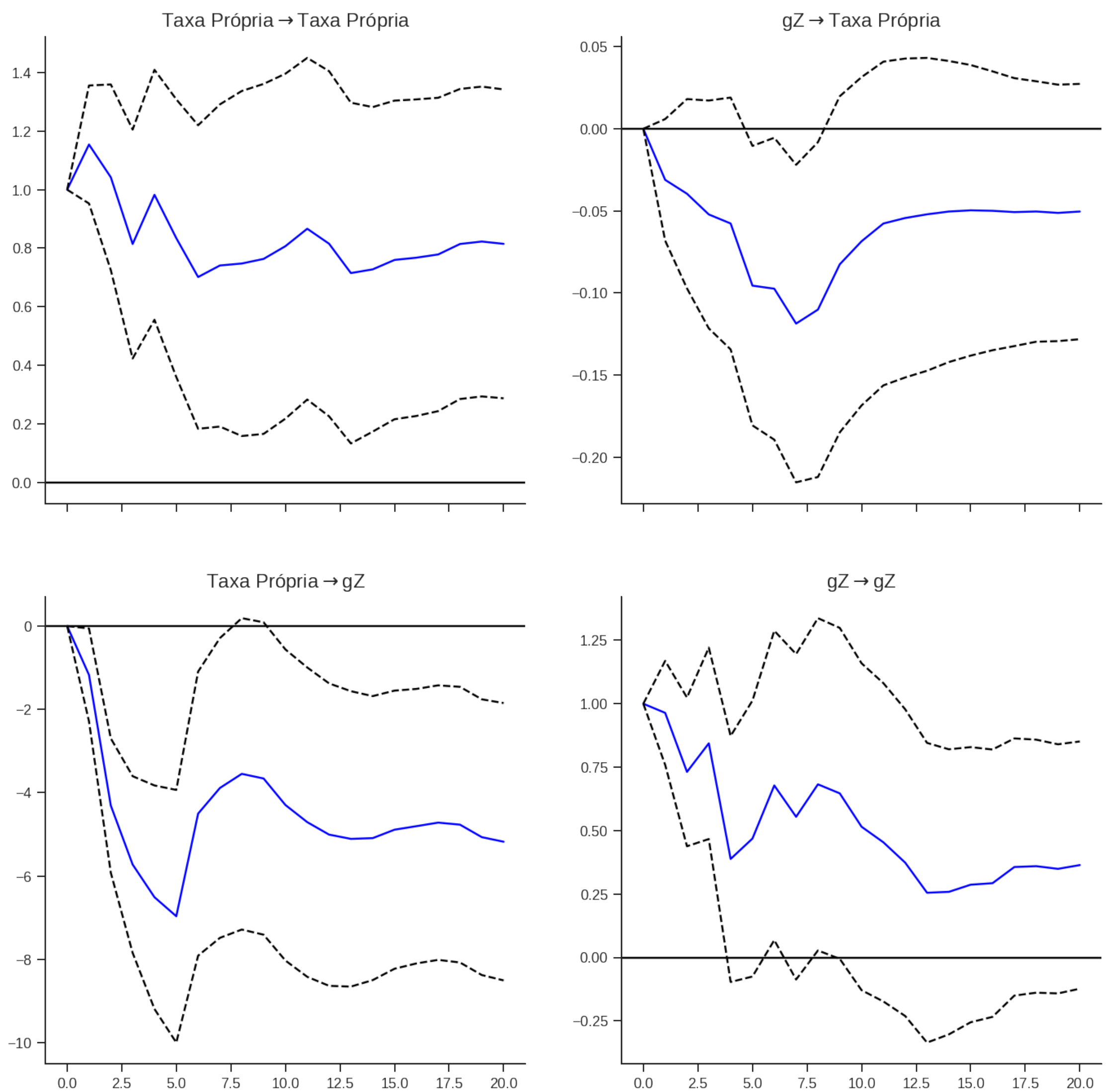
10.4 Função impulso resposta ortogonalizada

[20]:
```
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,)
```



10.6 Teste de causalidade de granger

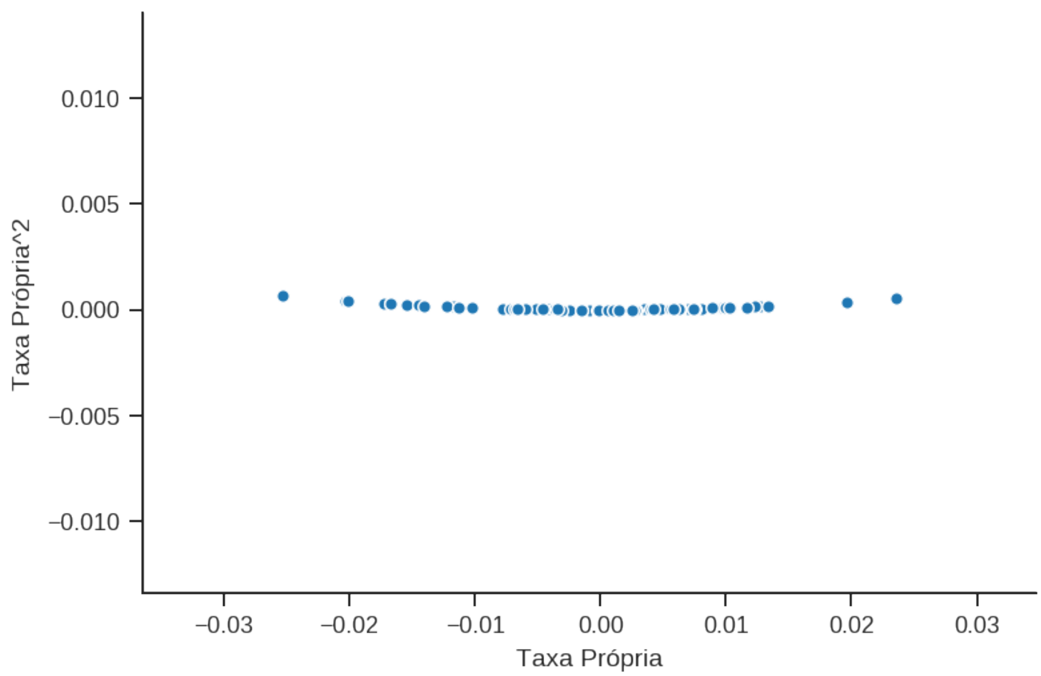
[22]:
```
series = residuals.columns
print(results.test_granger_causality(causing=series[0], caused=series[1]).
 ↪summary())
print(results.test_inst_causality(causing=series[0]).summary())
```

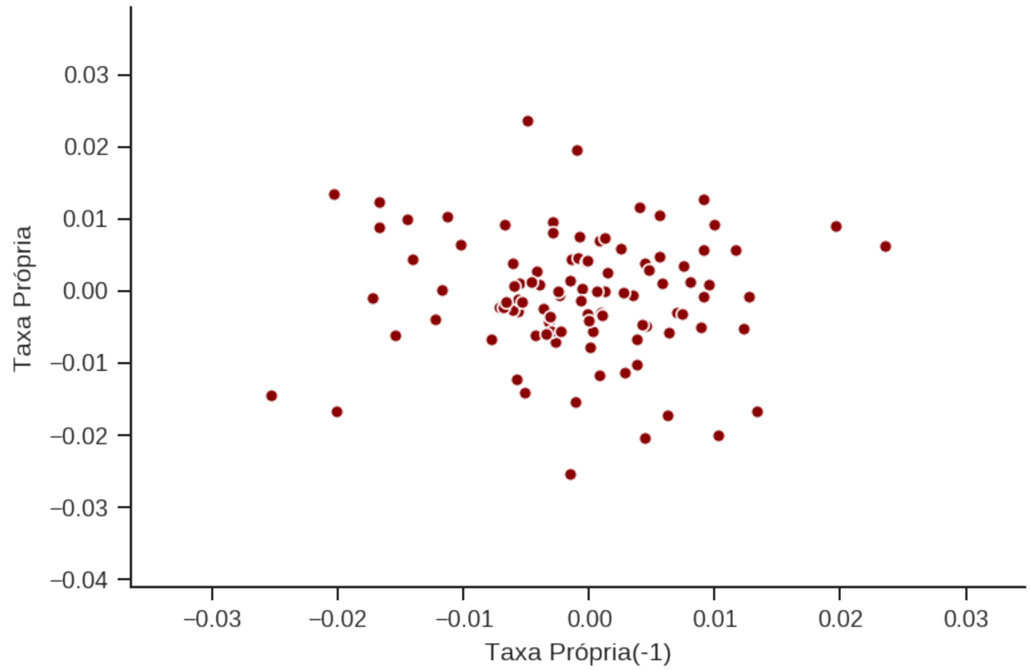
```
Granger causality F-test. H_0: Taxa Própria does not Granger-cause gZ.
Conclusion: reject H_0 at 5% significance level.
==============================================
Test statistic Critical value p-value    df
----------------------------------------------
         4.547          1.940   0.000 (9, 156)
```

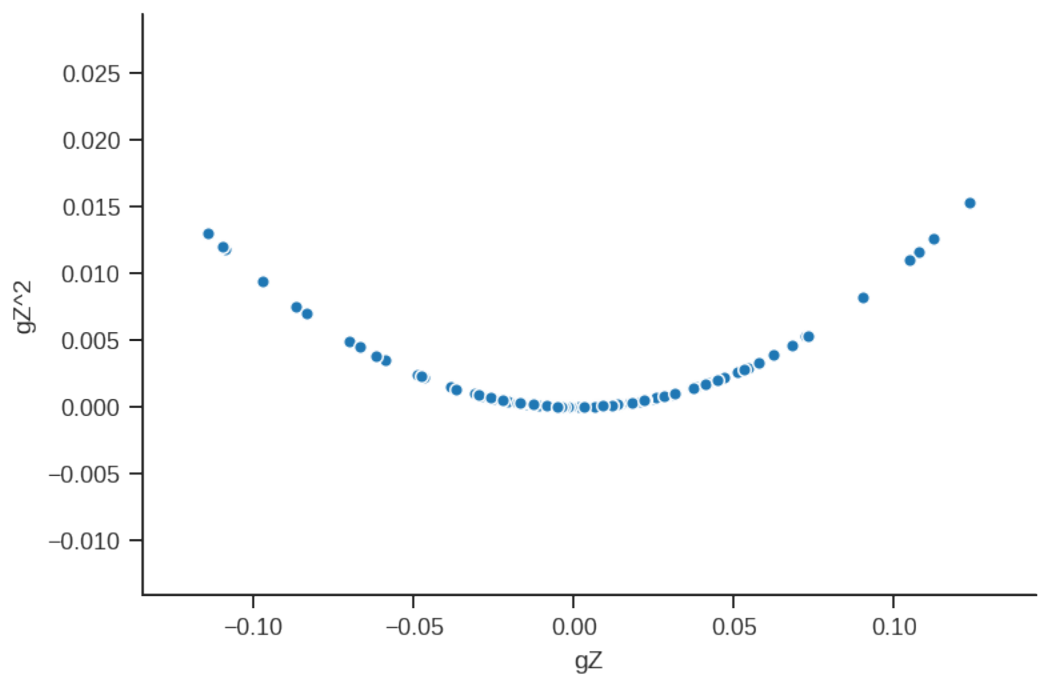
```
--------------------------------------------------
Instantaneous causality Wald-test. H_0: Taxa Própria does not instantaneously
cause gZ. Conclusion: reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         8.067          3.841   0.005  1
----------------------------------------
```

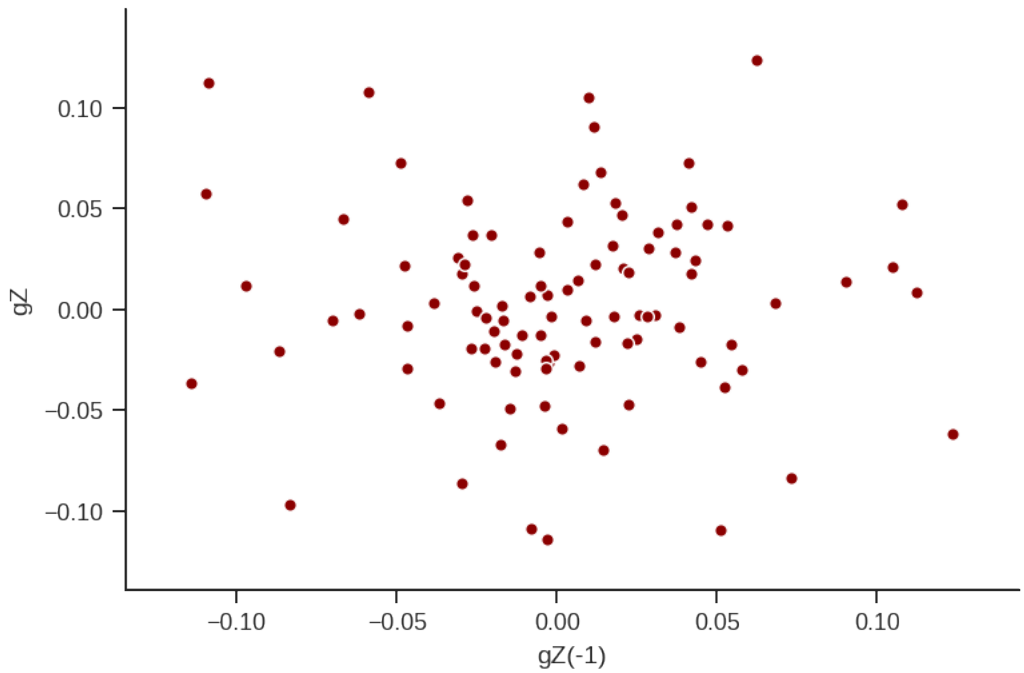
10.7 Inspeção gráfica dos resíduos

[23]:
```python
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()
```

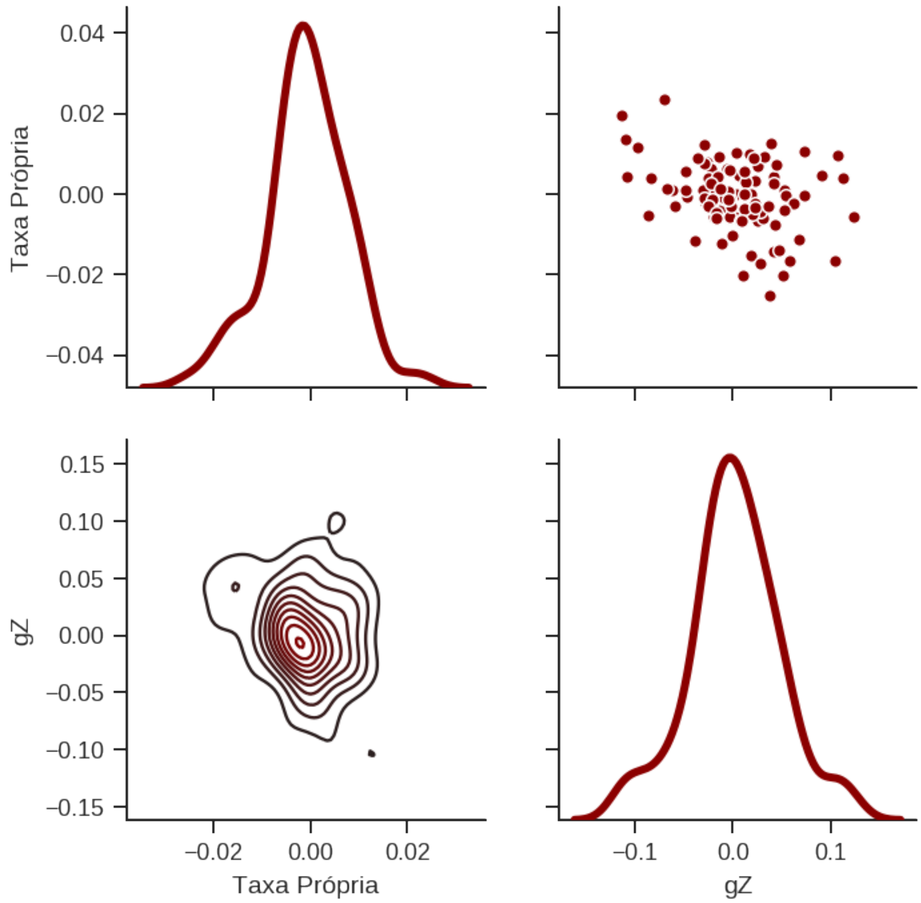



0.03
0.02
0.01
0.00
−0.01
−0.02
−0.03
−0.04
Taxa Própria
−0.03
−0.02
−0.01
0.00
0.01
0.02
0.03
Taxa Própria(-1)

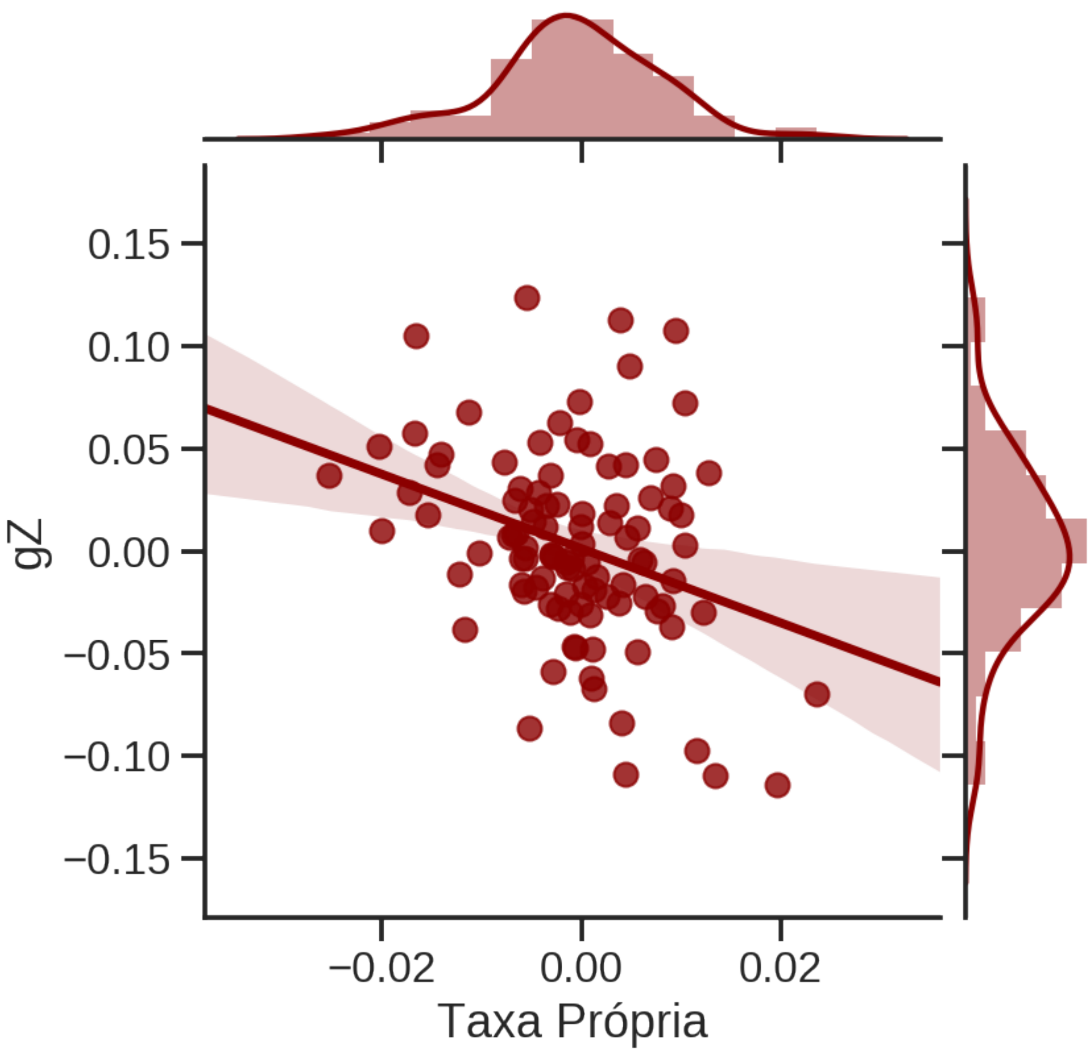

0.025
0.020
0.015
0.010
0.005
0.000
−0.005
−0.010
gZ^2
−0.10
−0.05
0.00
0.05
0.10
gZ



[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()
```



10.8 FEVD

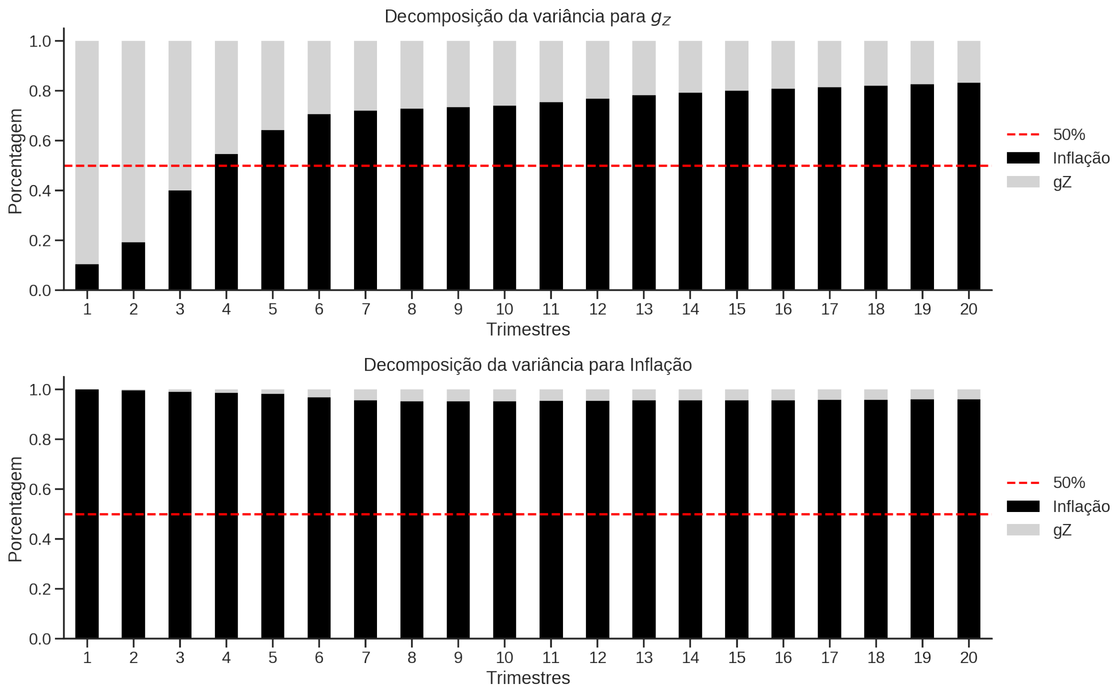
[26]:
```
%%R -o fevd_gz
library(tsDyn)
library(readr)
df <- read.csv("./Dados_yeojohnson.csv", encoding="UTF-8")
df <- df[,c(4:7)]
names(df) <- c("Juros", "Infla", "TaxaP", "gZ")
df <- na.omit(df[,c("Juros", "Infla","TaxaP", "gZ")])
df <- ts(data = df, start = c(1992,03), frequency = 4)
model <- tsDyn::VECM(data = df[,c("TaxaP","gZ")], lag = 6, r = 1, estim = "ML",␣
↪LRinclude="both", include="trend")
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)$TaxaP)
```

[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,)
```



11 VAR

Dúvida: Variável exógena do VAR deve ser estacionária também?

11.1 Ordem do modelo

[29]:
```
model = VAR(
    df[["d_Taxa Própria", 'd_gZ']],
)
print(model.select_order(maxlags=15, trend='ct').summary())
```

```
 VAR Order Selection (* highlights the minimums)
==================================================
       AIC         BIC         FPE         HQIC
--------------------------------------------------
0       -14.80      -14.69*    3.730e-07      -14.76
1       -14.77       -14.56    3.849e-07      -14.68
2       -14.82       -14.49    3.676e-07      -14.69
```

```
3       -14.79      -14.36   3.775e-07      -14.62
4       -15.00      -14.46   3.075e-07     -14.78*
5      -15.02*      -14.37  3.011e-07*      -14.76
6       -15.02      -14.27   3.017e-07      -14.71
7       -14.97      -14.11   3.187e-07      -14.62
8       -14.96      -13.99   3.222e-07      -14.57
9       -14.89      -13.81   3.462e-07      -14.45
10      -14.84      -13.65   3.660e-07      -14.36
11      -14.83      -13.54   3.723e-07      -14.30
12      -14.79      -13.39   3.881e-07      -14.23
13      -14.82      -13.31   3.802e-07      -14.21
14      -14.75      -13.14   4.103e-07      -14.10
15      -14.78      -13.06   4.019e-07      -14.09
--------------------------------------------------
```

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

11.2 Estimação

[30]:
```python
results = model.fit(maxlags=5)
print(results.summary())
```

```
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           sáb, 30, nov, 2019
Time:                     11:33:24
--------------------------------------------------------------------
No. of Equations:         2.00000    BIC:                   -14.5725
Nobs:                     105.000    HQIC:                  -14.9032
Log likelihood:           518.271    FPE:                2.69422e-07
AIC:                     -15.1285    Det(Omega_mle):     2.20748e-07
--------------------------------------------------------------------
Results for equation d_Taxa Própria
================================================================================
====
                       coefficient       std. error           t-stat
prob
--------------------------------------------------------------------------------
----
const                    -0.000777         0.000941           -0.826
0.409
L1.d_Taxa Própria         0.191503         0.103345            1.853
0.064
L1.d_gZ                  -0.016181         0.018338           -0.882
0.378
```

```
L2.d_Taxa Própria        -0.130476         0.103939           -1.255
0.209
L2.d_gZ                  -0.005100         0.015279           -0.334
0.739
L3.d_Taxa Própria        -0.133309         0.111579           -1.195
0.232
L3.d_gZ                   0.006938         0.014720            0.471
0.637
L4.d_Taxa Própria         0.159670         0.108469            1.472
0.141
L4.d_gZ                  -0.006026         0.014198           -0.424
0.671
L5.d_Taxa Própria        -0.246894         0.111629           -2.212
0.027
L5.d_gZ                  -0.027823         0.015643           -1.779
0.075
================================================================================
====

Results for equation d_gZ
================================================================================
====
                       coefficient       std. error           t-stat
prob
--------------------------------------------------------------------------------
----
const                    -0.007620         0.005386           -1.415
0.157
L1.d_Taxa Própria        -1.131758         0.591654           -1.913
0.056
L1.d_gZ                  -0.002499         0.104985           -0.024
0.981
L2.d_Taxa Própria        -2.285625         0.595055           -3.841
0.000
L2.d_gZ                  -0.157266         0.087474           -1.798
0.072
L3.d_Taxa Própria        -1.248212         0.638797           -1.954
0.051
L3.d_gZ                   0.043777         0.084270            0.519
0.603
L4.d_Taxa Própria        -1.209769         0.620991           -1.948
0.051
L4.d_gZ                  -0.464672         0.081285           -5.717
0.000
L5.d_Taxa Própria        -0.942436         0.639081           -1.475
0.140
L5.d_gZ                   0.015888         0.089555            0.177
0.859
```

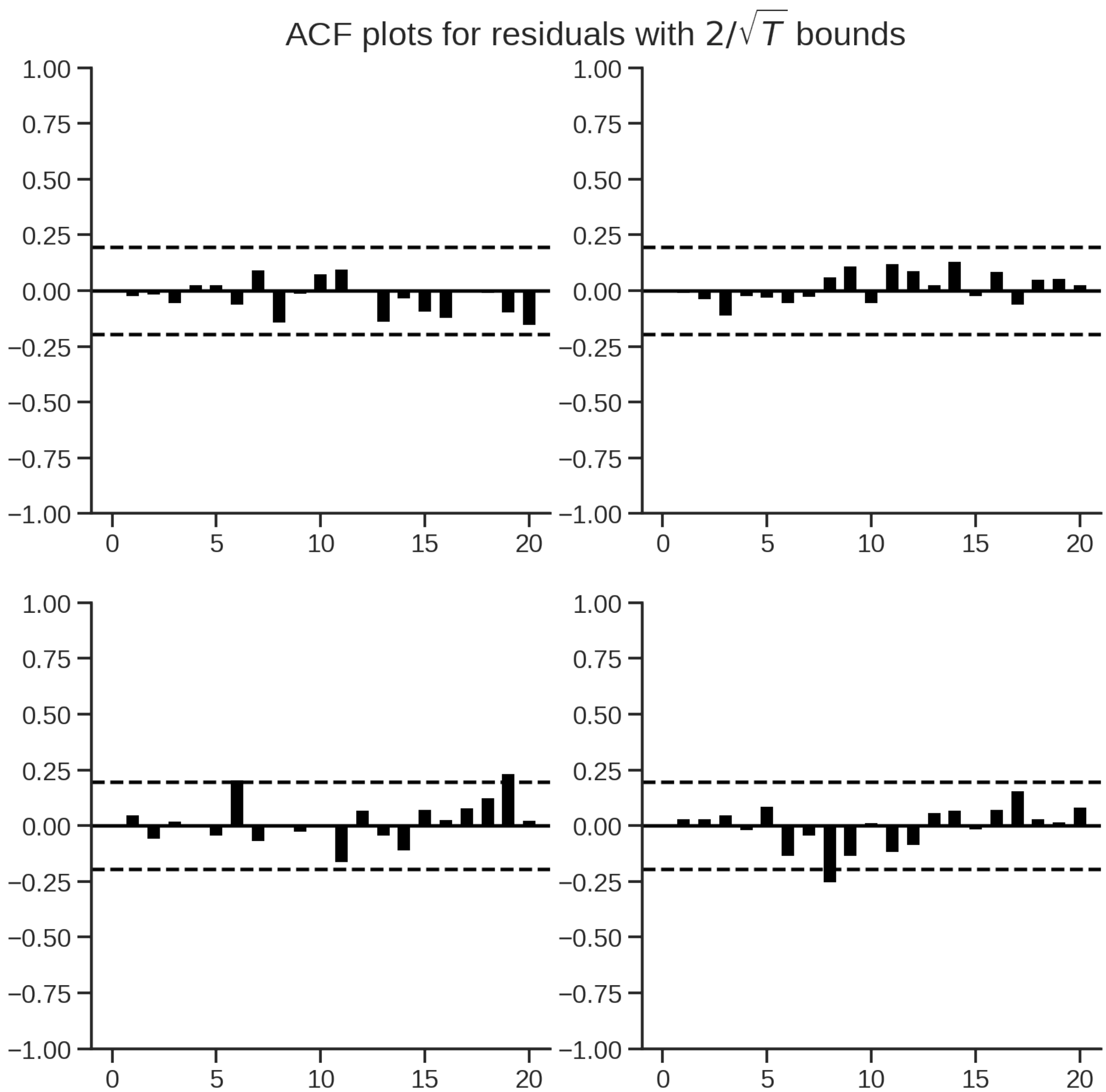
```
================================================================================
====

Correlation matrix of residuals
                  d_Taxa Própria      d_gZ
d_Taxa Própria          1.000000 -0.314068
d_gZ                   -0.314068  1.000000
```

11.3 Pós-estimação

11.3.1 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.

11.3.2 Estabilidade

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

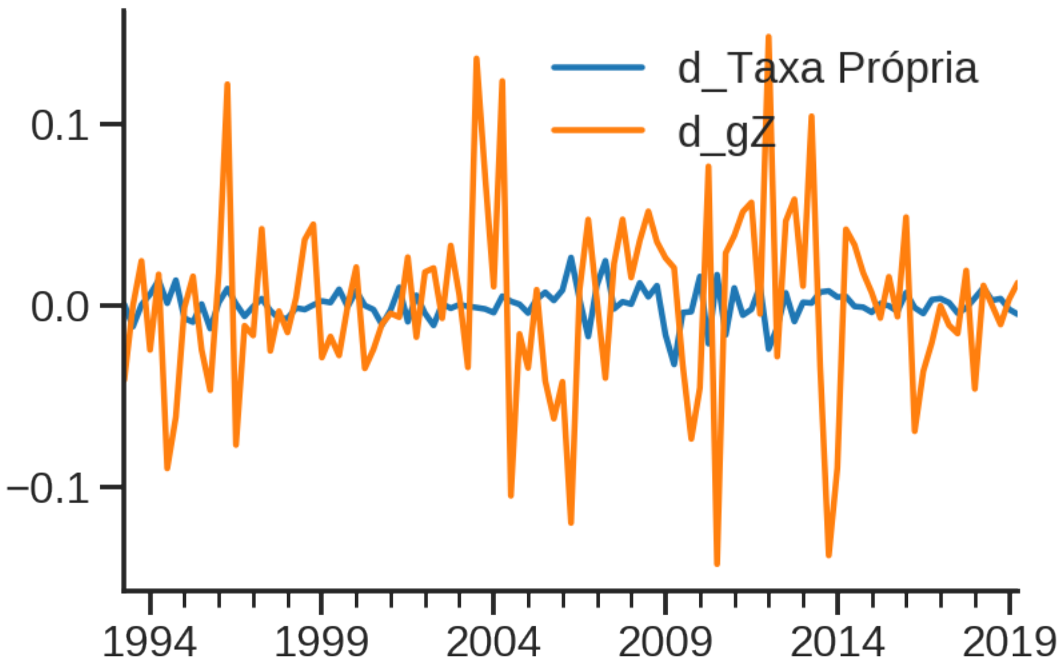
```
Eigenvalues of VAR(1) rep
0.7952196047128628
0.8274111916556438
0.8274111916556438
0.7575379610838274
0.7575379610838274
0.8737013141613541
0.8737013141613541
```

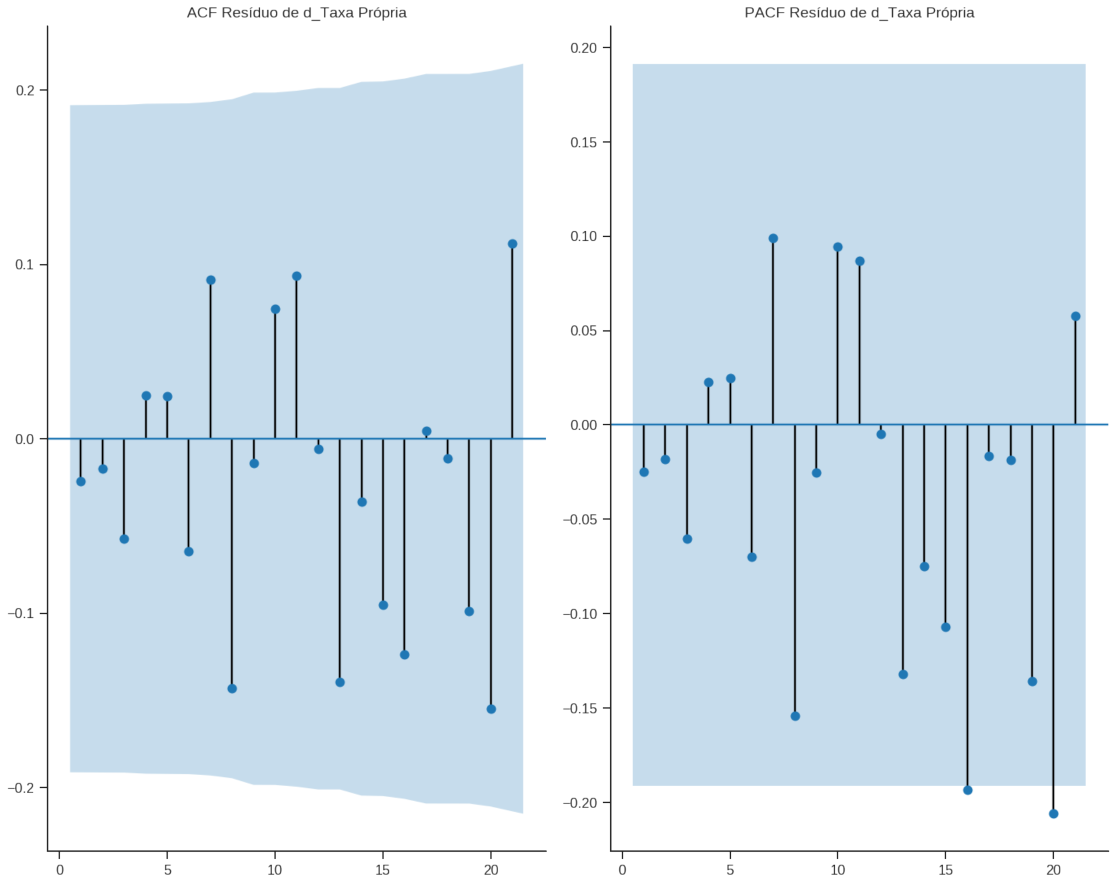
```
0.5525176483885951
0.47829483288915725
0.47829483288915725
Estável: True
```

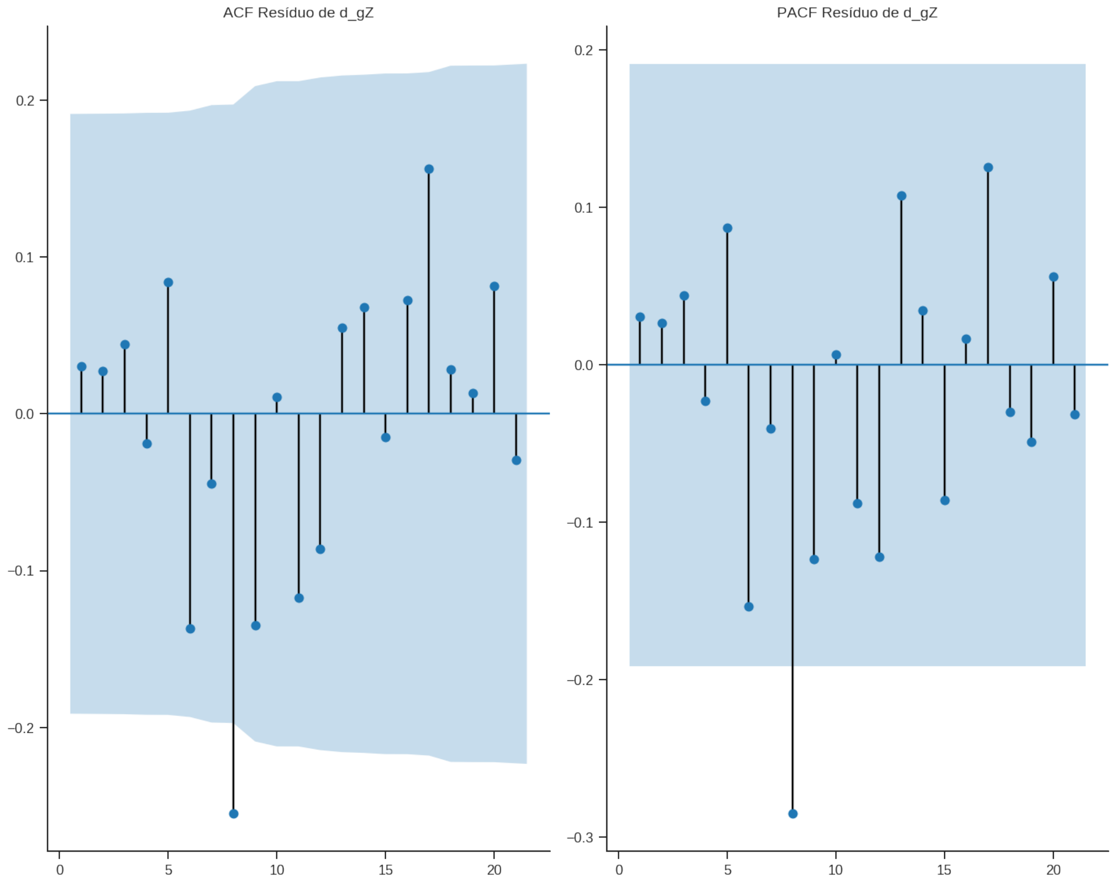
OBS: Apesar de estar escrito VAR(1), os resultados acima correspondem ao VAR(p)

11.4 Inspeção dos resíduos

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




ACF Resíduo de d_Taxa Própria
PACF Resíduo de d_Taxa Própria



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
----------------------------------------
         44.22          55.76   0.298 40
----------------------------------------
```

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
----------------------------------------
         48.46          55.76   0.169 40
```

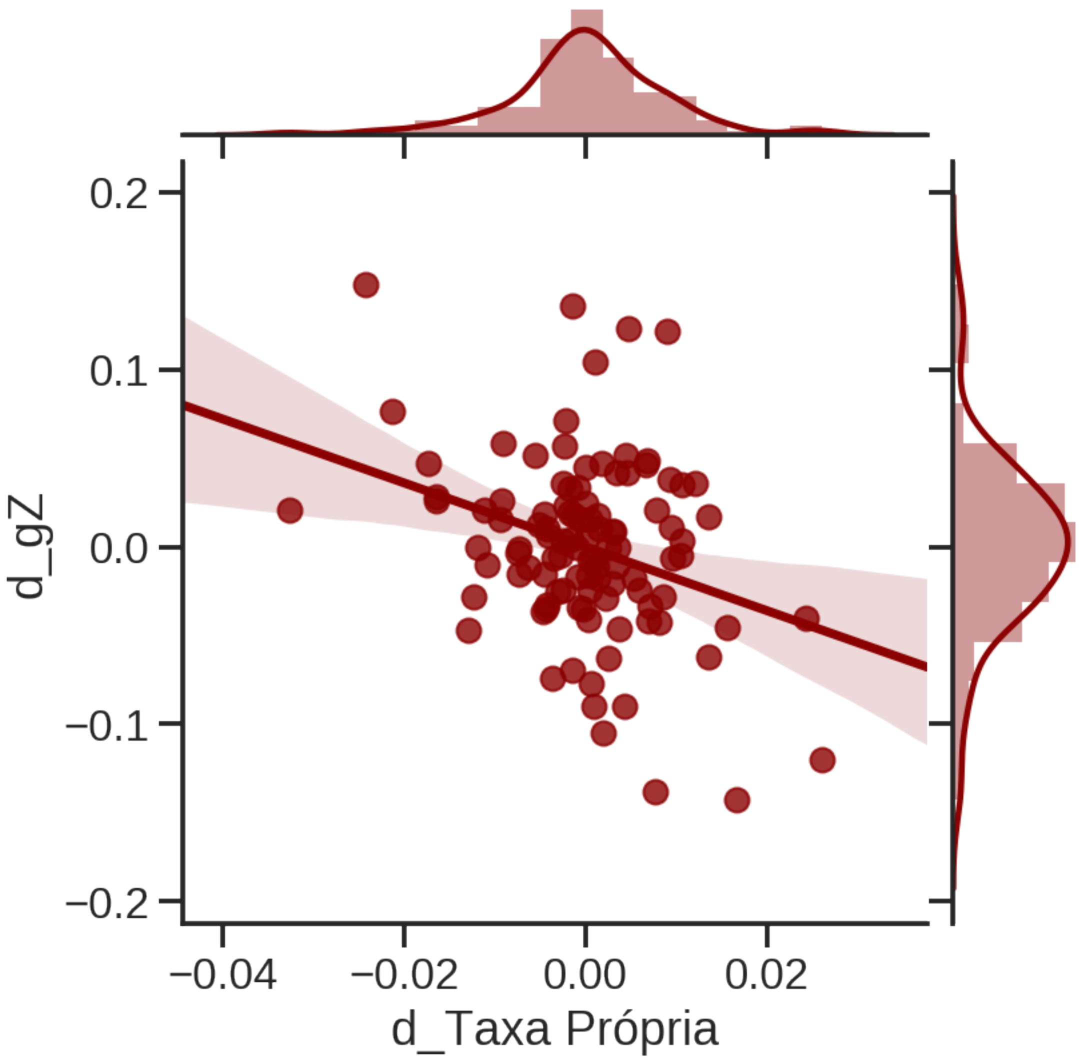
```
----------------------------------------

LJUNGBOX

H0: autocorrelations up to lag k equal zero
H1: autocorrelations up to lag k not zero
Box-Pierce:  False
Testing for  D_TAXA PRÓPRIA . 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_TAXA PRÓPRIA . 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
----------------------------------------
         27.67          9.488   0.000  4
----------------------------------------

HOMOCEDASTICIDADE

H0: Residuals are homoscedastic
H1: Residuals are heteroskedastic
Testing for  D_TAXA PRÓPRIA
LM p-value:  0.08726668673593076
Reject H0?  False
F p-value:  0.0888685276922382
Reject H0?  False


Testing for  D_GZ
```

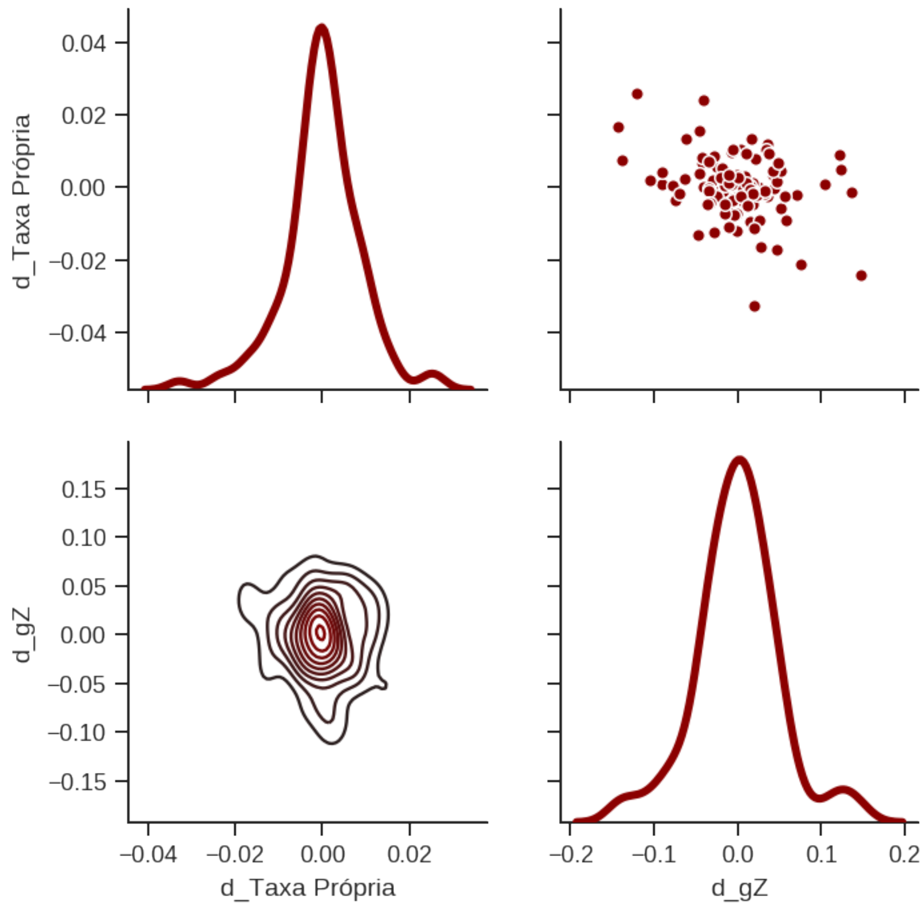
```
LM p-value:  0.29303716237189587
Reject H0?  False
F p-value:  0.2976190932509506
Reject H0?  False
```

11.5 Inspeção gráfica dos resíduos

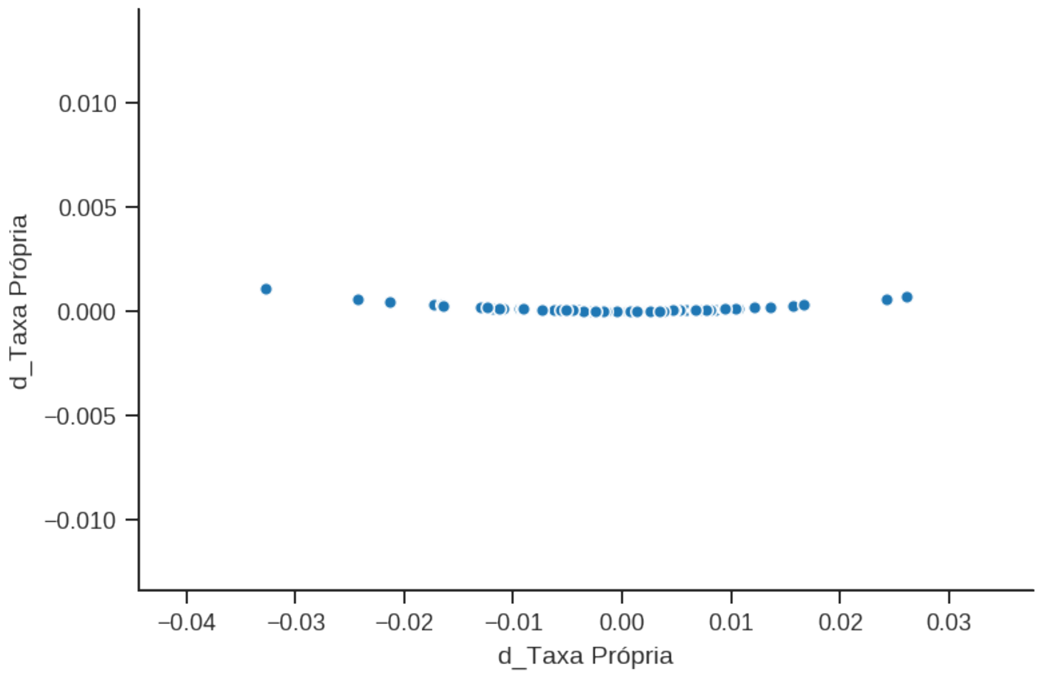
[34]:
```python
series = results.names
sns.set_context('talk')
ax = sns.jointplot(
    x = series[0],
    y = series[1],
    data = residuals, color = 'darkred', kind="reg",
)
plt.show()
```

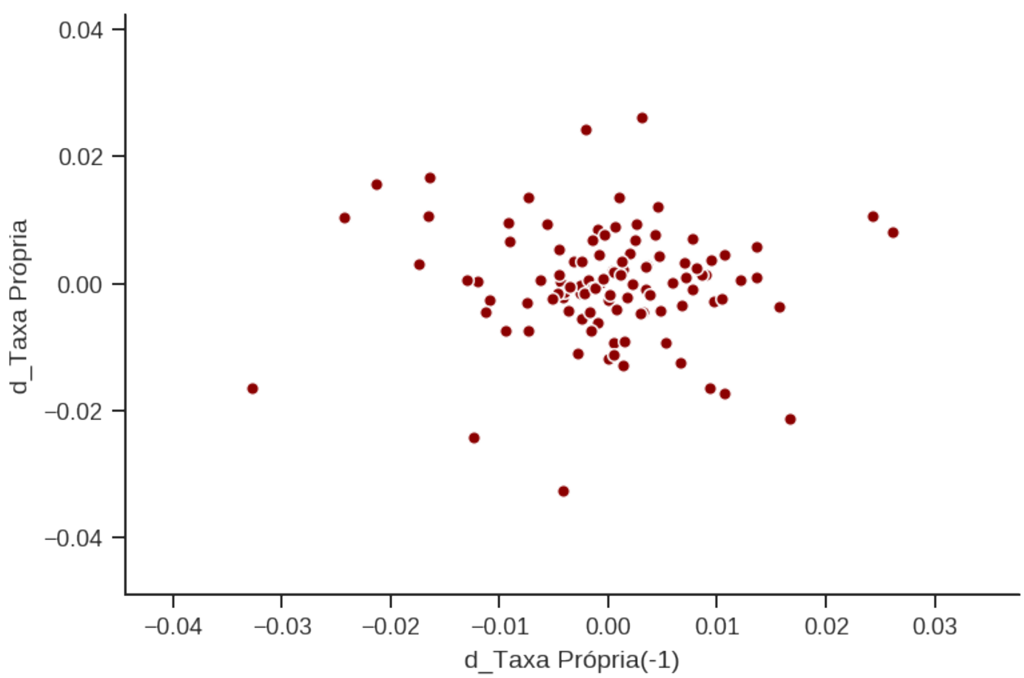


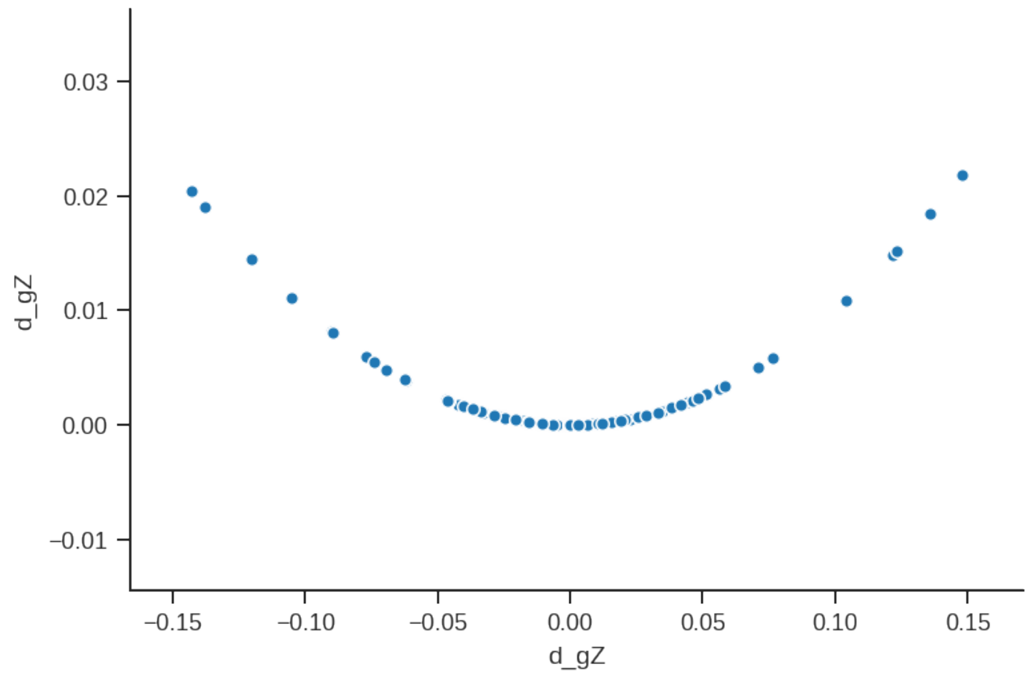
[35]:
```
sns.set_context('paper')
g = sns.PairGrid(residuals, diag_sharey=False)
g.map_lower(sns.kdeplot, color = 'darkred')
g.map_upper(sns.scatterplot, color = 'darkred')
g.map_diag(sns.kdeplot, lw=3, color = 'darkred')
plt.show()
g.savefig("./figs/Residuos_4.png", dpi=300)
```

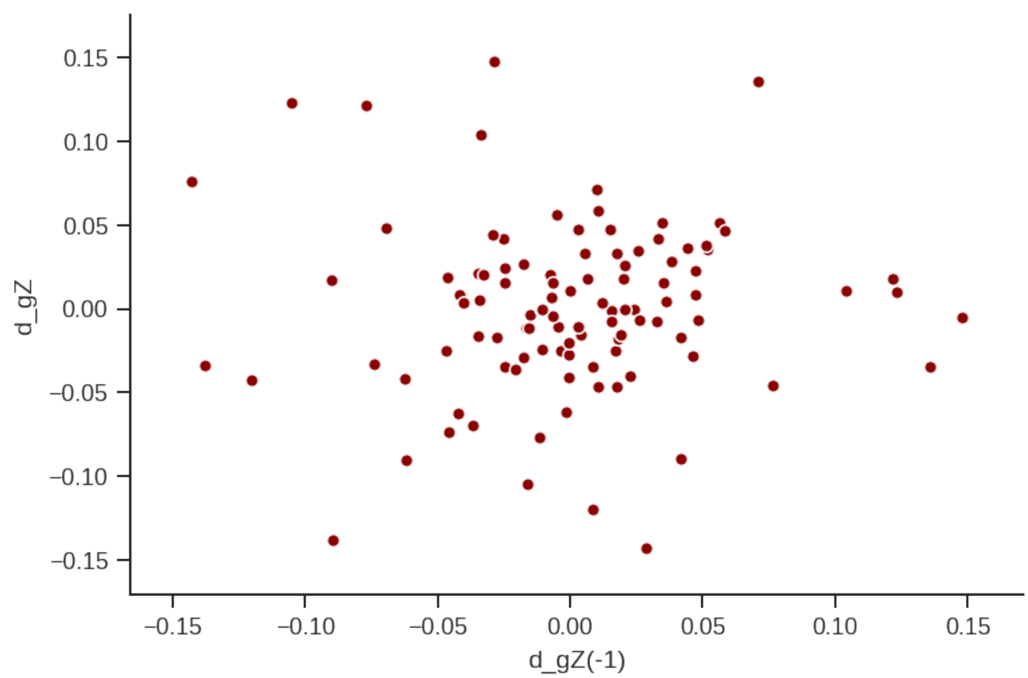


[36]:
```
series = results.names
for serie in series:
    sns.scatterplot(x = residuals[serie], y = residuals[serie]**2)
    sns.despine()
    plt.show()

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

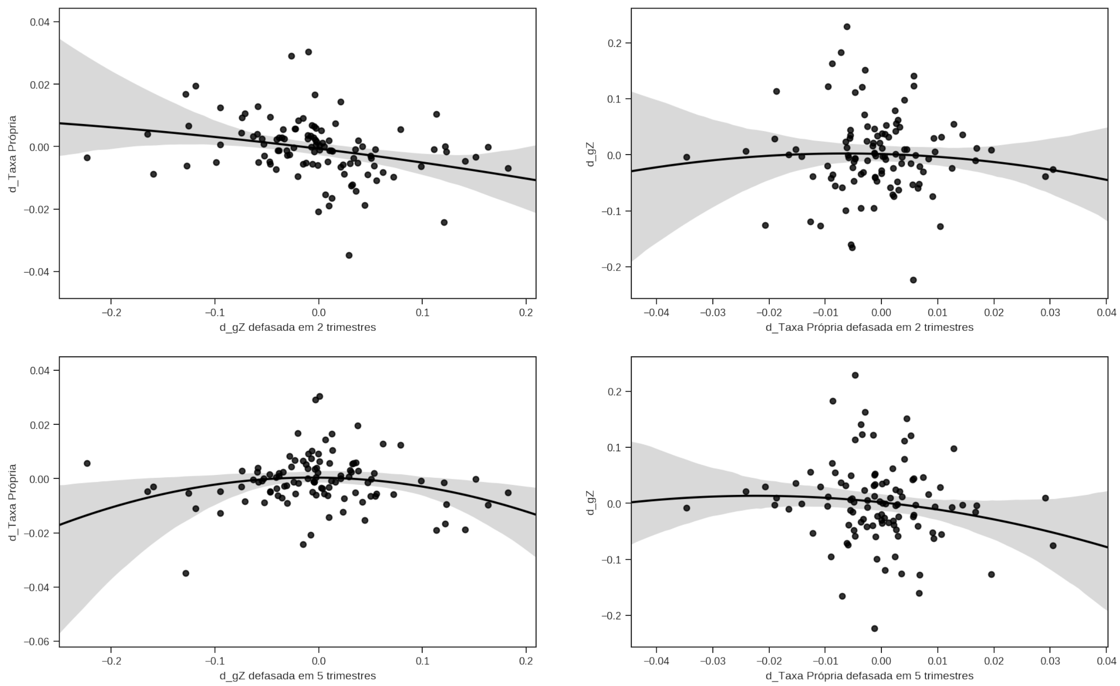

0.010
0.005
0.000
−0.005
−0.010
d_Taxa Própria
−0.04
−0.03
−0.02
−0.01
0.00
0.01
0.02
0.03
d_Taxa Própria


0.04
0.02
0.00
−0.02
−0.04
d_Taxa Própria
−0.04
−0.03
−0.02
−0.01
0.00
0.01
0.02
0.03
d_Taxa Própria(-1)



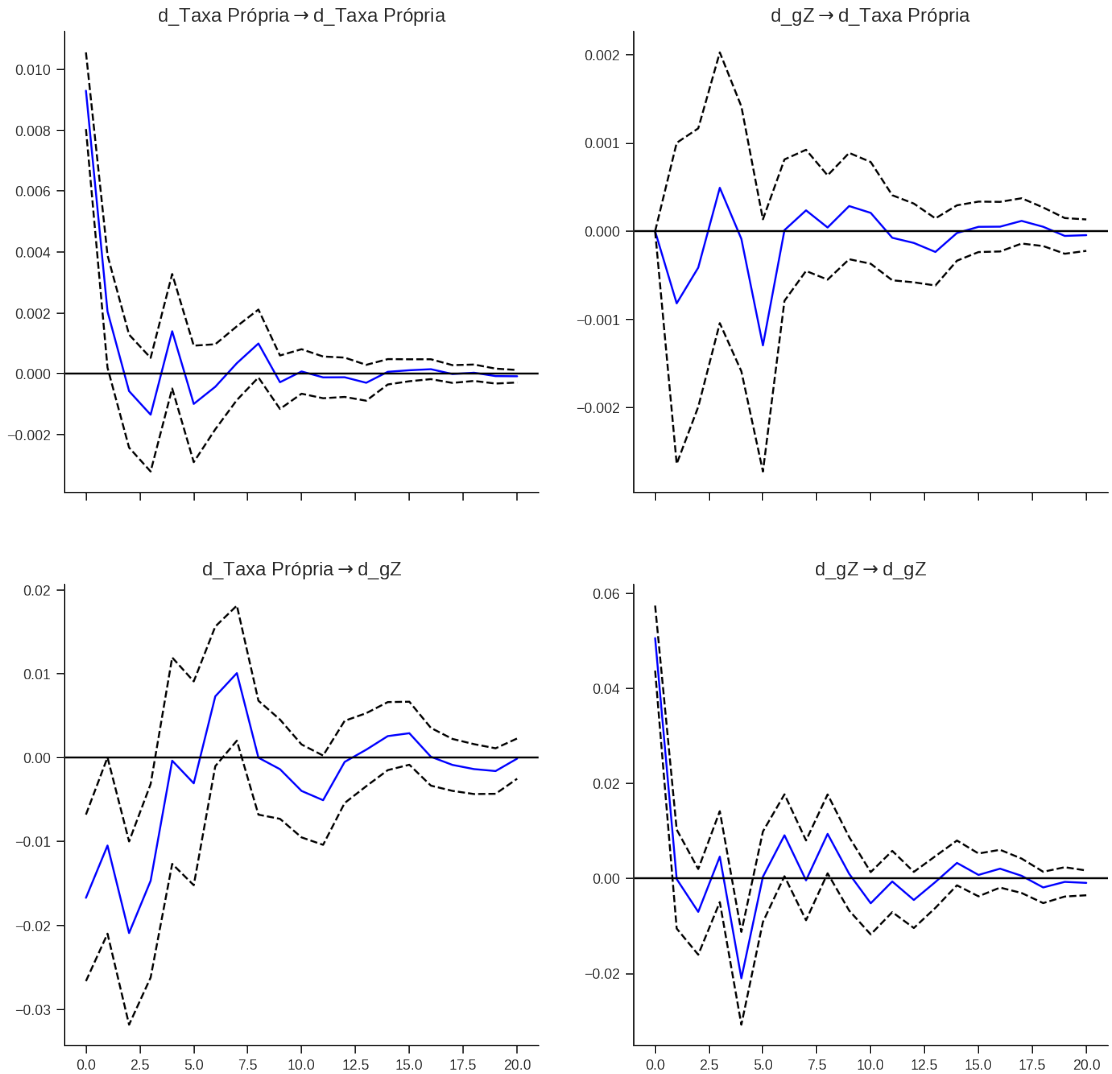


[37]:
```
plot_lags(results=results)
```



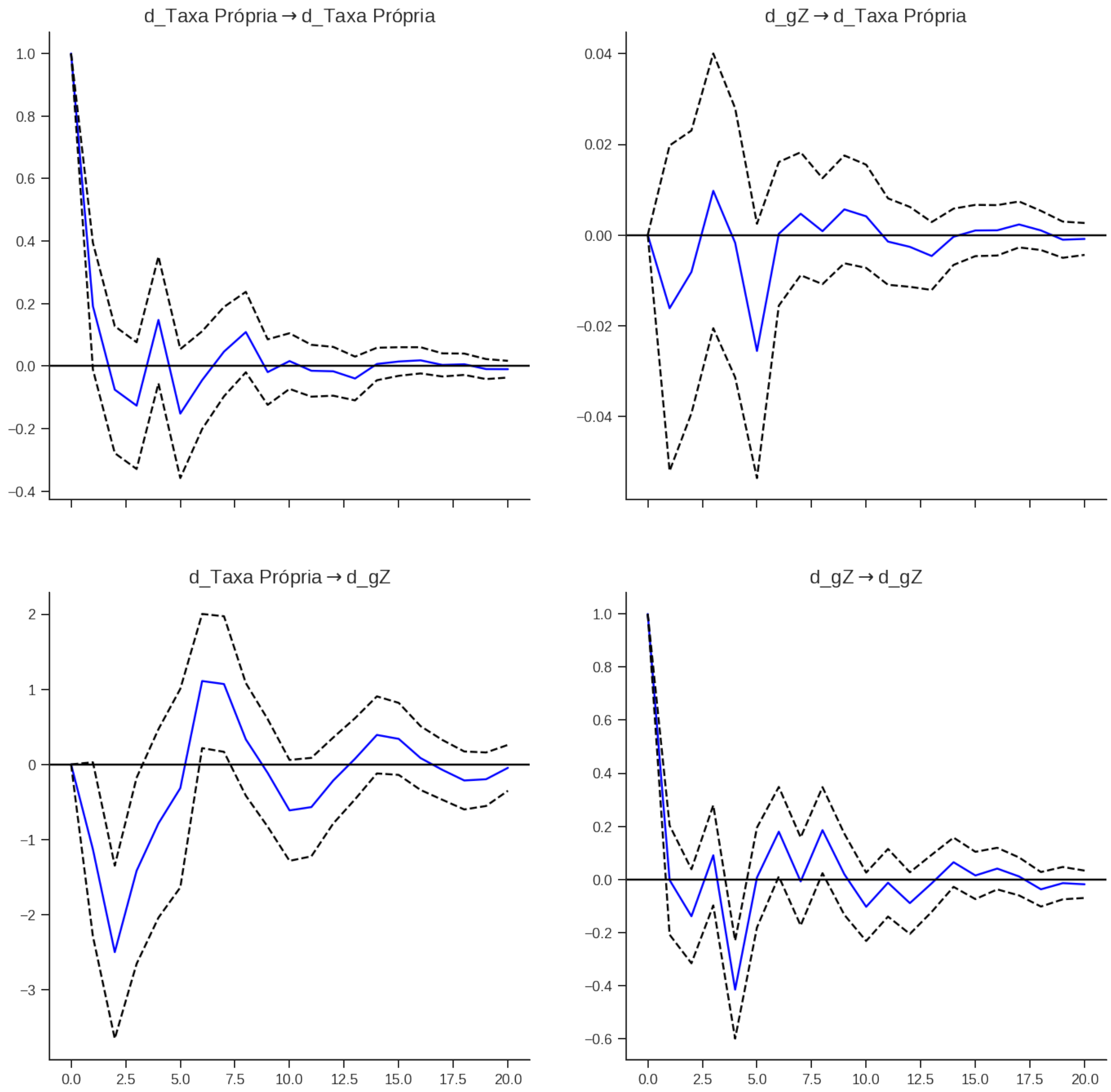
11.6 Função resposta ao impulso ortogonalizada

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



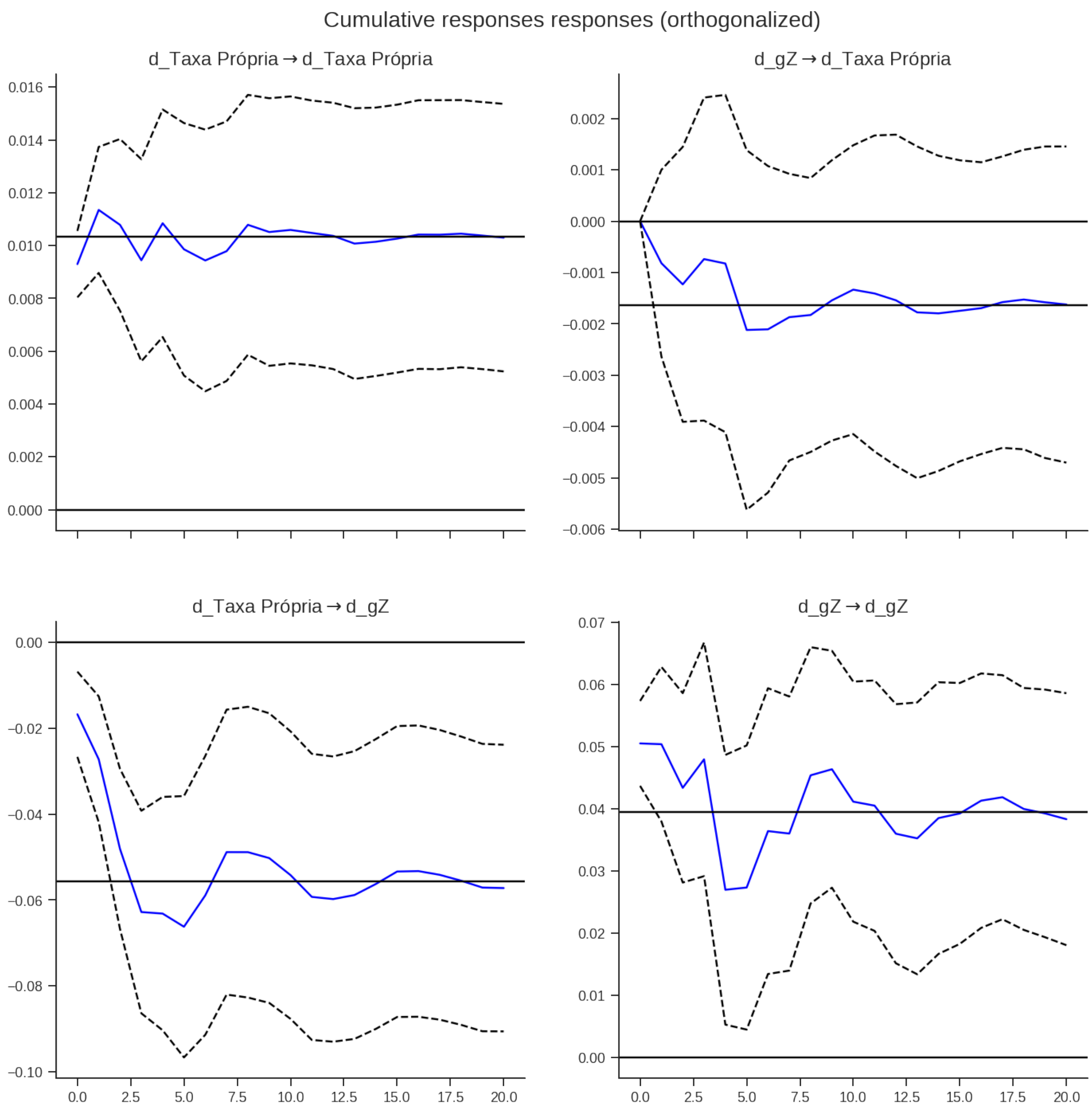
11.7 Função resposta ao impulso não-ortogonalizada

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



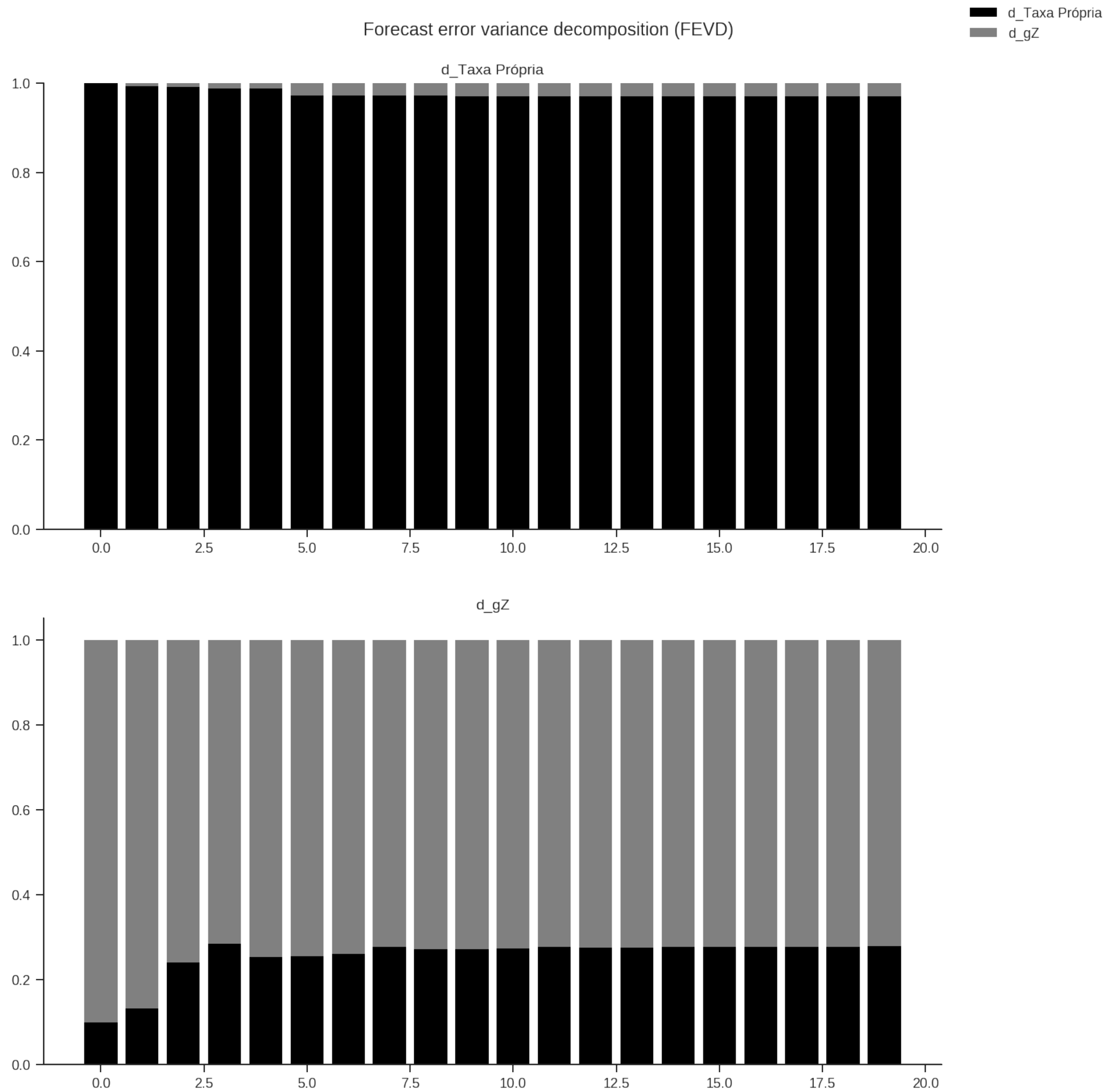
11.8 Efeito cumulativo

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



11.9 Decomposição da variância

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


Forecast error variance decomposition (FEVD)
d_Taxa Própria
d_gZ
d_Taxa Própria
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