VECM_TxPropria

December 11, 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            SeriesTemporais.Rproj   VECM_Infla.pdf
Benchmark.ipynb           tabs                    VECM_Infla.py
Benchmark.pdf             tese_Lucas.xls          VECM_TxPropria.html
Benchmark.Rmd             Teste.ipynb             VECM_TxPropria.ipynb
Clean-checkpoint.ipynb    VECM_Infla.html         VECM_TxPropria_media.ipynb
Clean.ipynb               VECM_Infla.ipynb        VECM_TxPropria.pdf
figs                      VECM_Infla_media.ipynb  VECM_TxPropria.py
```

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

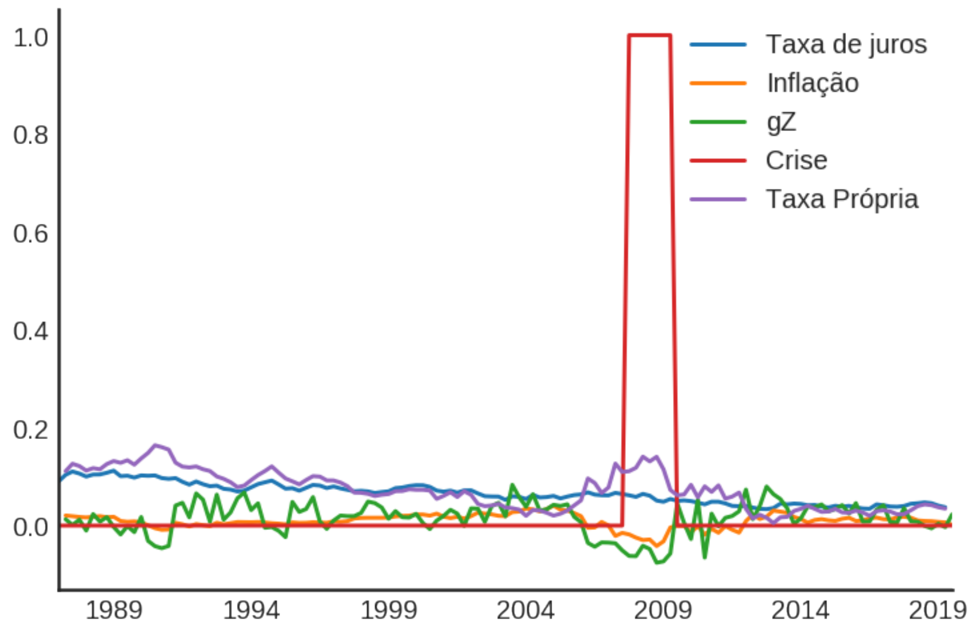
[2]:
```
%config InlineBackend.figure_format = 'retina'
%load_ext rpy2.ipython

# 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
```

```python
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]:
```python
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 = df.resample('M').last()
df['Preço dos imóveis'] = df['Preço dos imóveis']/df['Preço dos imóveis'][0]
df = df.resample('Q').last()

df["Inflação"] = df["Preço dos imóveis"].pct_change() # Warning: 4
df['gZ'] = df["Investimento residencial"].pct_change() # Warning: 4
df["Taxa Própria"] = ((1+df["Taxa de juros"])/(1+df["Inflação"])) -1

df['Taxa Própria'], *_ = yeojohnson(df['Taxa Própria'])
#df['Inflação'], *_ = yeojohnson(df['Inflação'])
df['gZ'], *_ = yeojohnson(df['gZ'])

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 = 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.head()
```



[3]:

```
            Taxa de juros  Inflação        gZ  Crise  Taxa Própria  \

1987-09-30         0.1102  0.018975  0.001110      0      0.126023
1987-12-31         0.1061  0.017537  0.011925      0      0.121337
1988-03-31         0.0999  0.016549 -0.010302      0      0.112091
1988-06-30         0.1040  0.017773  0.023392      0      0.117053
1988-09-30         0.1042  0.019099  0.007998      0      0.114831

            d_Taxa Própria      d_gZ  d_Inflação  d_Taxa de juros

1987-09-30        0.015103 -0.011713   -0.001516           0.0067
1987-12-31       -0.004686  0.010815   -0.001437          -0.0041
```

```
1988-03-31        -0.009246 -0.022228   -0.000988           -0.0062
1988-06-30         0.004961  0.033694    0.001224            0.0041
1988-09-30        -0.002222 -0.015394    0.001326            0.0002
```

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=6, signif = 0.05,):
    for i in range(1, maxlag):
        print(50*'=')
        cointegracao(
            ts0=series.iloc[:, 0],
            ts1=series.iloc[:, 1:],
            signif=signif,
            lag=i
        )
```

```
        print("\nTESTE DE JOHANSEN\n")
        print("Teste SEM constante")
        result = select_coint_rank(endog=series, k_ar_diff=i, det_order=-1,␣
↪signif=signif) ## Warning: 1
        print(result.summary())
        print(f'Para lag = {i} e significância = {signif*100}%, Rank = {result.
↪rank}')
        print("\nTeste COM constante\n")
        result = select_coint_rank(endog=series, k_ar_diff=i, det_order=0,␣
↪signif=signif) ## Warning: 1
        print(result.summary())
        print(f'Para lag = {i} e significância = {signif*100}%, Rank = {result.
↪rank}')
        print("\nTeste COM constante E tendência\n")
        result = select_coint_rank(endog=series, k_ar_diff=i, det_order=1,␣
↪signif=signif) ## Warning: 1
        print(result.summary())
        print(f'Para lag = {i} e significância = {signif*100}%, Rank = {result.
↪rank}')
        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]
    conclusion = result < signif
    for j in range(k):
      print(f'p-value = {result[j]}')
      print("Reject H0 on lag " ,j+1,"? ", conclusion[j], "\n")
    print("\n")
```

```python
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            81
m = 2         70 89
m = 3   19    70 89
m = 4   19 38 70 89
m = 5   19 38 70 89 108

Corresponding to breakdates:

m = 1                           2007(1)
m = 2                   2004(2) 2009(1)
m = 3   1991(3)         2004(2) 2009(1)
m = 4   1991(3) 1996(2) 2004(2) 2009(1)
m = 5   1991(3) 1996(2) 2004(2) 2009(1) 2013(4)

Fit:

m   0       1       2       3       4       5
RSS   6.617   5.957   4.421   4.421   4.421   4.421
BIC  -6.230  -9.969 -38.443 -28.739 -19.035  -9.331
```

```
[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               102
m = 2         65 86
m = 3         65 86 105
m = 4      32 65 86 105
m = 5   19 38 65 86 105

Corresponding to breakdates:

m = 1                                   2012(2)
m = 2                   2003(1) 2008(2)
m = 3                   2003(1) 2008(2) 2013(1)
m = 4           1994(4) 2003(1) 2008(2) 2013(1)
m = 5   1991(3) 1996(2) 2003(1) 2008(2) 2013(1)

Fit:

m   0         1         2         3         4         5
RSS    0.1173    0.1170    0.1159    0.1153    0.1150    0.1147
BIC -522.4339 -513.0640 -504.5624 -495.5101 -486.1506 -476.8180
[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            86
m = 2         67 86
m = 3         67 86 105
m = 4      30 67 86 105
m = 5   19 39 67 86 105

Corresponding to breakdates:

m = 1                           2008(2)
```

```
m = 2                   2003(3) 2008(2)
m = 3                   2003(3) 2008(2) 2013(1)
m = 4           1994(2) 2003(3) 2008(2) 2013(1)
m = 5   1991(3) 1996(3) 2003(3) 2008(2) 2013(1)

Fit:

m   0          1          2          3          4          5
RSS    0.01915    0.01892    0.01804    0.01751    0.01736    0.01740
BIC -754.39978 -746.24362 -742.60616 -736.76070 -728.18661 -718.13874
[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      40
m = 2      39        98
m = 3      40    75 95
m = 4   20 41    75 95
m = 5   19 38 57 76 95

Corresponding to breakdates:

m = 1           1996(4)
m = 2           1996(3)                 2011(2)
m = 3           1996(4)         2005(3) 2010(3)
m = 4   1991(4) 1997(1)         2005(3) 2010(3)
m = 5   1991(3) 1996(2) 2001(1) 2005(4) 2010(3)

Fit:

m   0          1          2          3          4          5
RSS    0.19495    0.09831    0.06831    0.04851    0.03657    0.03385
BIC -457.39087 -535.31386 -572.20645 -606.32884 -632.76612 -632.98710
```

Selecionando série para depois de 1991

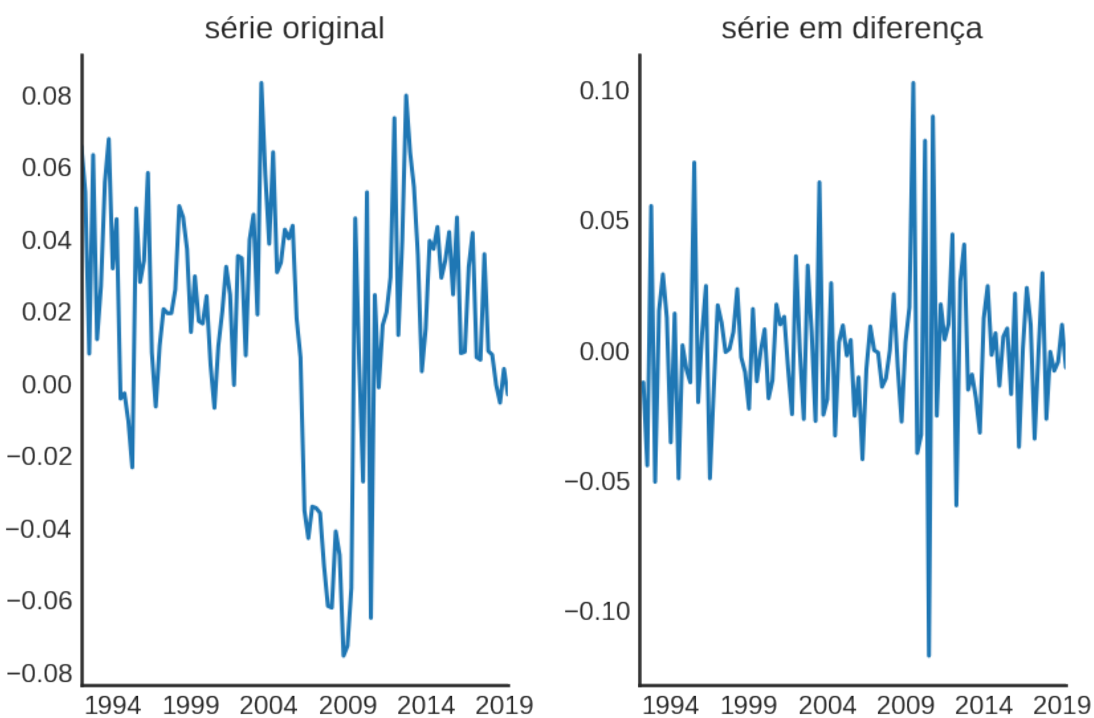
[9]:
```
df = df["1992-01-01":]
df[["Inflação", "gZ", "Taxa Própria", "Taxa de juros"]].
 ↪to_csv("Dados_yeojohnson.csv")


df[["Inflação", "gZ", "Taxa Própria", "Taxa de juros"]].to_csv(
```

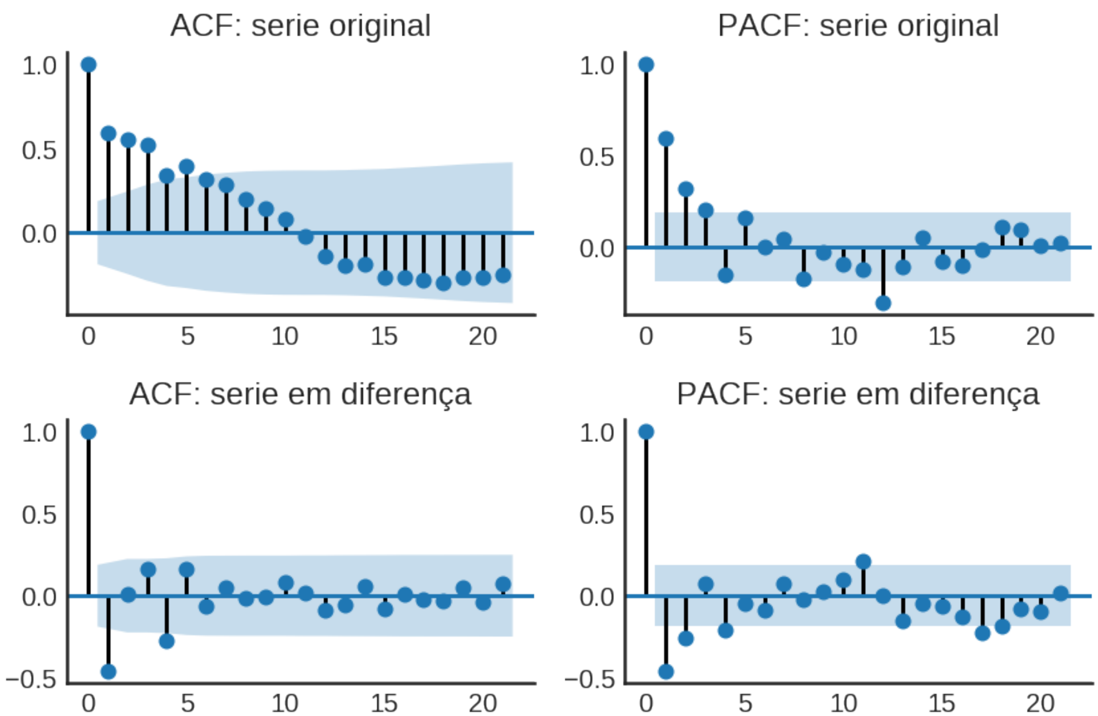
```
    "Dados_yeojohnson_ascii.csv",
    encoding='ascii',
    header = [
        'infla',
        'gz',
        'taxap',
        'juros',
         ],
        )
```

8 Teste de raíz unitária

8.1 Investimento residencial (g_Z)

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






```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -4.439
P-value                         0.139
Lags                               11
-------------------------------------

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                 -7.739
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                 -3.333
P-value                         0.013
Lags                               11
-------------------------------------

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                 -7.155
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                 -1.323
P-value                         0.178
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.
```

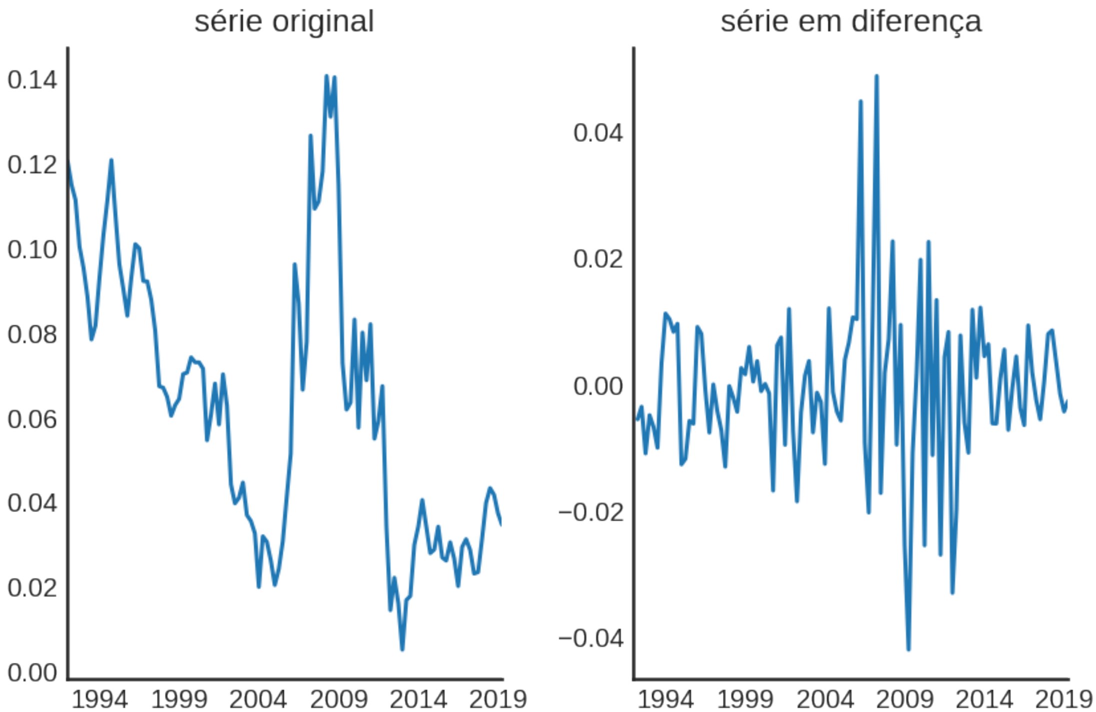
```
DFGLS série em primeira diferença
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -0.948
P-value                         0.315
Lags                               10
-------------------------------------

Trend: Constant
Critical Values: -2.76 (1%), -2.14 (5%), -1.83 (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                  0.181
P-value                         0.309
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                  0.106
P-value                         0.558
Lags                               22
-------------------------------------

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                 -6.165
P-value                         0.000
```

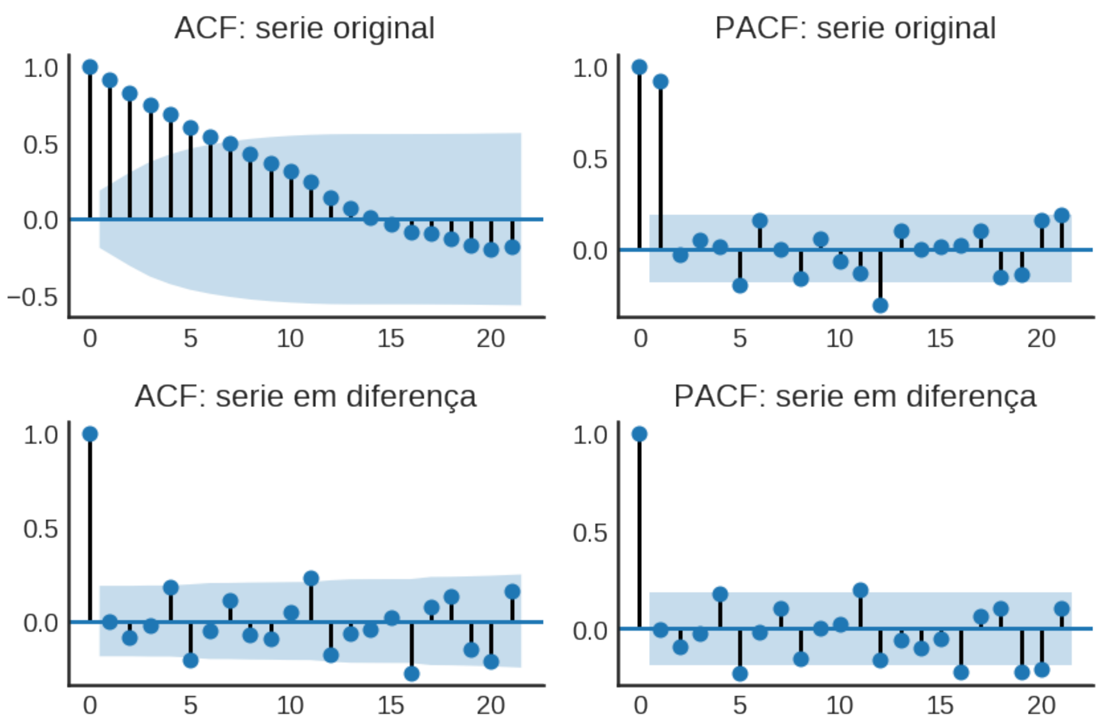
```
Lags                                 13
-------------------------------------

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.


Phillips Perron em primeira diferença
     Phillips-Perron Test (Z-tau)
=====================================
Test Statistic                  -20.346
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'])
```


série original
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1994
1999
2004
2009
2014
2019
série em diferença
0.04
0.02
0.00
−0.02
−0.04
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
10
15
20

```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -4.203
P-value                         0.237
Lags                                0
-------------------------------------

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                 -2.330
P-value                         0.162
Lags                                0
-------------------------------------

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

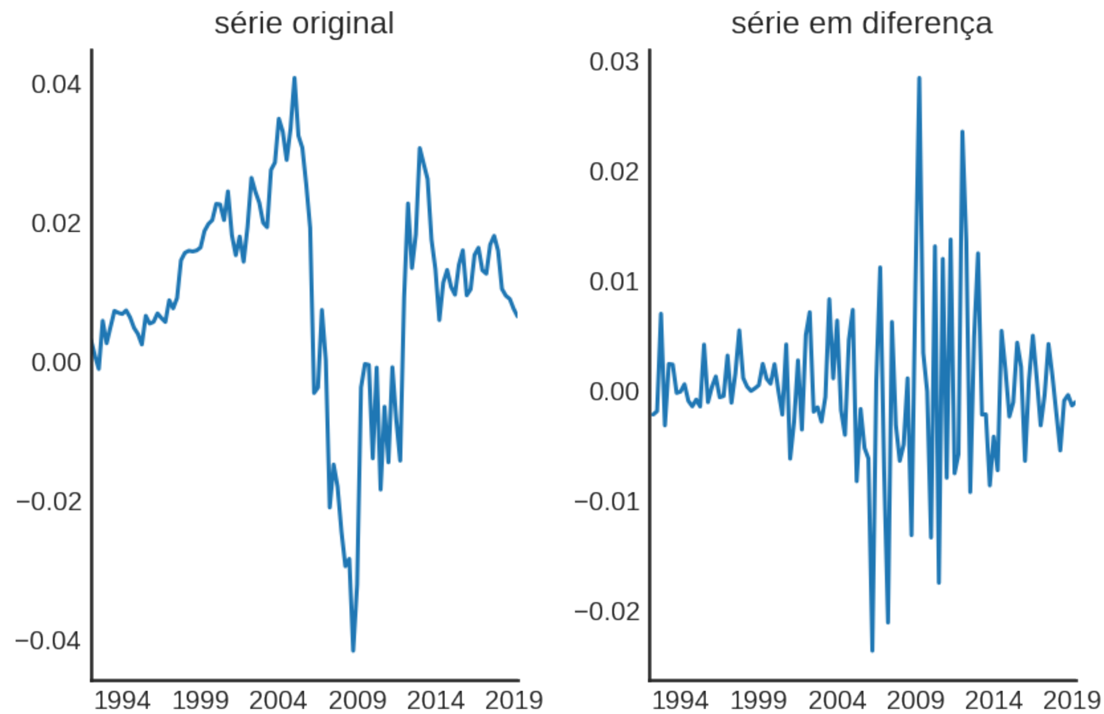
```
Test Statistic                 -5.087
P-value                         0.000
Lags                                4
-------------------------------------

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.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -1.056
P-value                         0.270
Lags                                0
-------------------------------------

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                 -3.829
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                  0.690
P-value                         0.014
Lags                                6
-------------------------------------

Trend: Constant
```

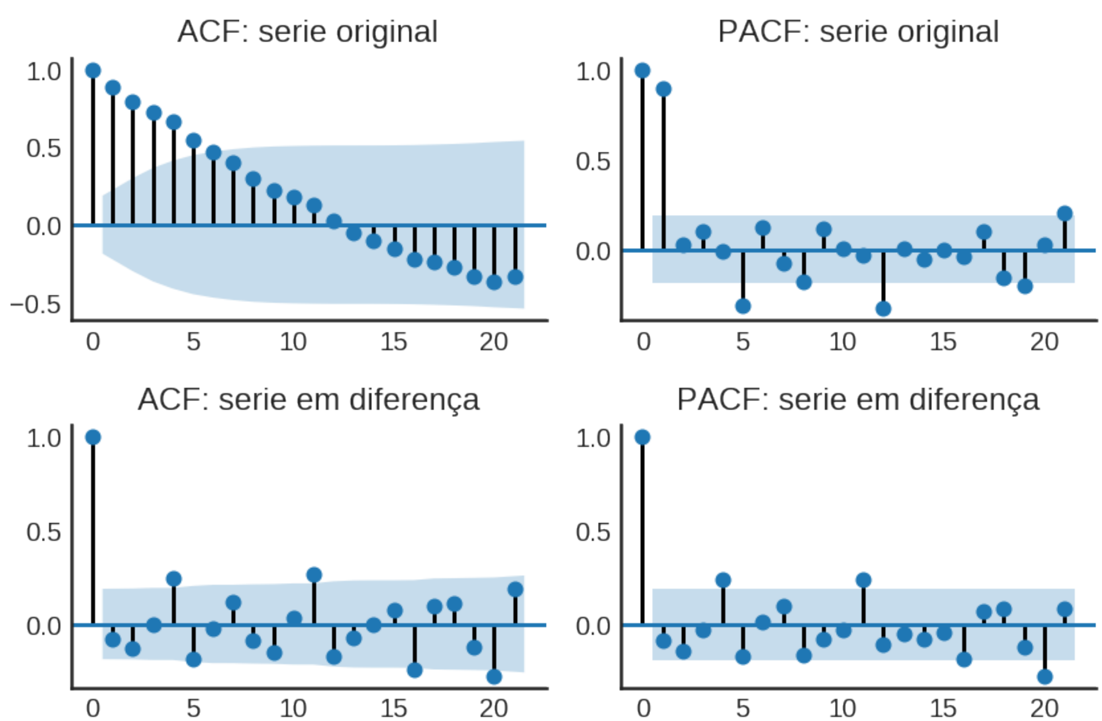
```
Critical Values: 0.74 (1%), 0.46 (5%), 0.35 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.


KPSS em primeira diferença
    KPSS Stationarity Test Results
=====================================
Test Statistic                  0.062
P-value                         0.804
Lags                                3
-------------------------------------

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                 -2.425
P-value                         0.135
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                -10.408
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'])
```





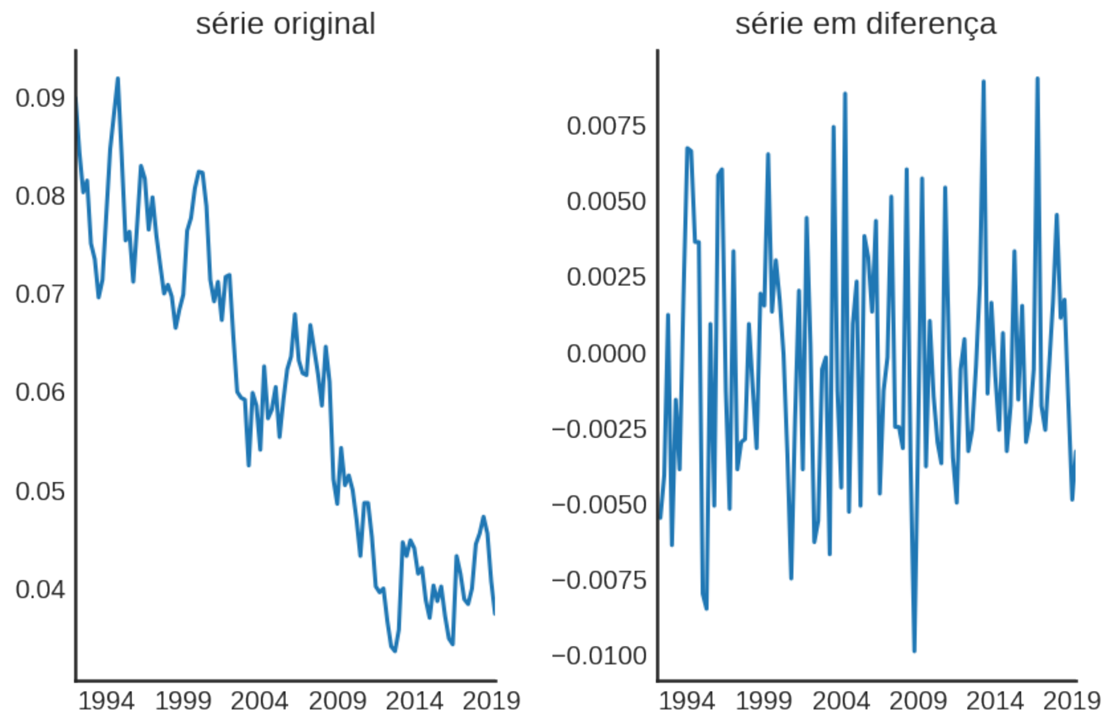
```
ZIVOT ANDREWS série em nível
        Zivot-Andrews Results
=====================================
Test Statistic                 -4.871
P-value                         0.043
Lags                                4
-------------------------------------

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                 -6.122
P-value                         0.001
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                 -2.671
P-value                         0.079
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.
```

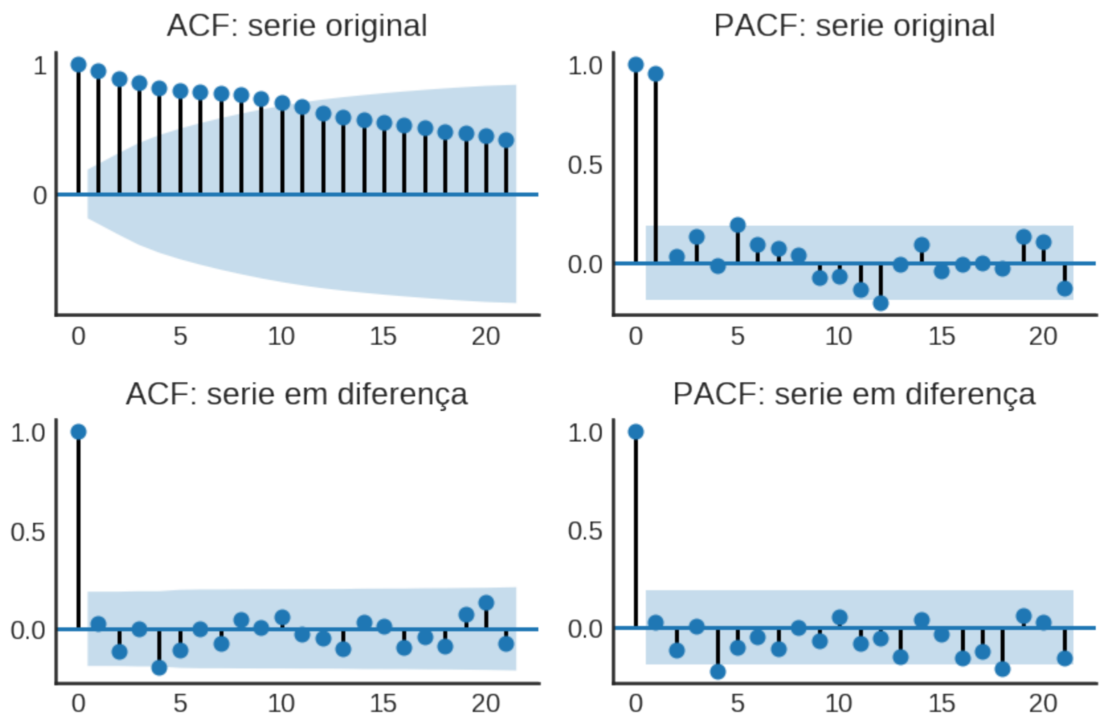
```
ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -4.680
P-value                         0.000
Lags                                4
-------------------------------------

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.


DFGLS série em nível
      Dickey-Fuller GLS Results
=====================================
Test Statistic                 -2.534
P-value                         0.011
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                 -3.881
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                  0.148
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                  0.059
P-value                         0.819
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                 -2.704
P-value                         0.073
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                -11.340
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                 -4.494
P-value                         0.215
Lags                                0
-------------------------------------

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                 -8.144
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                 -3.638
P-value                         0.027
Lags                                0
-------------------------------------

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.


ADF série em primeira diferença
   Augmented Dickey-Fuller Results
=====================================
Test Statistic                 -8.050
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                 -3.445
P-value                         0.009
Lags                                0
-------------------------------------

Trend: Constant and Linear Time Trend
Critical Values: -3.60 (1%), -3.02 (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                 -1.074
P-value                         0.264
Lags                                9
-------------------------------------

Trend: Constant
Critical Values: -2.76 (1%), -2.14 (5%), -1.83 (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                  0.081
P-value                         0.264
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                  0.034
P-value                         0.962
Lags                                3
-------------------------------------

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                 -3.604
P-value                         0.030
```

```
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                -11.127
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]:
```python
print("Ordem do VAR\n")

model = VAR(
    df[["gZ", 'Taxa Própria']],
)
print(model.select_order(maxlags=15, trend='ct').summary())

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

```
Ordem do VAR

 VAR Order Selection (* highlights the minimums)
==================================================
       AIC         BIC         FPE         HQIC
--------------------------------------------------
0       -14.83      -14.72   3.643e-07      -14.78
1       -16.33     -16.11*   8.126e-08      -16.24
2       -16.30      -15.97   8.361e-08      -16.17
3       -16.42      -15.99   7.392e-08      -16.25
4       -16.46      -15.92   7.097e-08      -16.25
```

```
5      -16.56*      -15.91  6.450e-08*     -16.30*
6       -16.49      -15.74   6.898e-08      -16.19
7       -16.45      -15.59   7.200e-08      -16.11
8       -16.39      -15.42   7.687e-08      -16.00
9       -16.39      -15.31   7.722e-08      -15.95
10      -16.32      -15.14   8.274e-08      -15.85
11      -16.31      -15.02   8.419e-08      -15.79
12      -16.53      -15.13   6.810e-08      -15.97
13      -16.47      -14.96   7.303e-08      -15.86
14      -16.45      -14.84   7.510e-08      -15.80
15      -16.40      -14.68   7.955e-08      -15.71
--------------------------------------------------
==================================================

Testando para lag = 1 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.173200
p-value: 0.016646
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: -4.347271
p-value: 0.002158
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: -9.155974
p-value: 0.000000
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: -9.988712
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN
```

```
Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          13.18          12.32
  1   2          2.992          4.130
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          23.48          15.49
  1   2          5.161          3.841
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 2

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          48.63          18.40
  1   2          6.006          3.841
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 2 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.420720
p-value: 0.108507
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 2 e trend = c
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
```

```
t Statistic: -2.800615
p-value: 0.165489
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: -4.396205
p-value: 0.007987
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: -9.988712
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          12.58          12.32
  1   2          2.988          4.130
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          15.52          15.49
  1   2          4.590          3.841
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 2

Teste COM constante E tendência
```

```
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          26.13          18.40
  1   2          6.674          3.841
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 3 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.824973
p-value: 0.042736
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: -2.800615
p-value: 0.165489
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: -4.396205
p-value: 0.007987
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: -9.988712
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
```

```
level
======================================
r_0 r_1 test statistic critical value
--------------------------------------
  0   2          17.12          12.32
  1   2          2.470          4.130
--------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
======================================
r_0 r_1 test statistic critical value
--------------------------------------
  0   2          20.78          15.49
  1   2          4.006          3.841
--------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 2

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
======================================
r_0 r_1 test statistic critical value
--------------------------------------
  0   2          33.43          18.40
  1   2          7.562          3.841
--------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 4 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.255263
p-value: 0.150904
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: -2.161915
p-value: 0.444081
```

```
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: -3.142748
p-value: 0.206301
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: -3.499544
p-value: 0.216038
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          18.65          12.32
  1   2          2.362          4.130
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          19.02          15.49
  1   2          3.774          3.841
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 1

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
```

```
======================================
r_0 r_1 test statistic critical value
--------------------------------------
  0   2          28.08          18.40
  1   2          13.33          3.841
--------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 5 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.255263
p-value: 0.150904
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: -2.161915
p-value: 0.444081
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: -3.142748
p-value: 0.206301
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: -3.499544
p-value: 0.216038
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
======================================
```

```
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          15.56          12.32
  1   2          2.636          4.130
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          14.77          15.49
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 0

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          21.37          18.40
  1   2          9.604          3.841
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 6 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.255263
p-value: 0.150904
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: -2.161915
p-value: 0.444081
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: -2.209932
p-value: 0.675199
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: -9.988712
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          13.75          12.32
  1   2          2.434          4.130
-------------------------------------
Para lag = 6 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          11.96          15.49
-------------------------------------
Para lag = 6 e significância = 5.0%, Rank = 0

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          17.55          18.40
```

```
-------------------------------------
Para lag = 6 e significância = 5.0%, Rank = 0
==========
==================================================

Testando para lag = 7 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.255263
p-value: 0.150904
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: -2.161915
p-value: 0.444081
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: -3.142748
p-value: 0.206301
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: -3.499544
p-value: 0.216038
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          15.45          12.32
  1   2          3.322          4.130
-------------------------------------
```

```
Para lag = 7 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          13.82          15.49
-------------------------------------
Para lag = 7 e significância = 5.0%, Rank = 0

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          17.63          18.40
-------------------------------------
Para lag = 7 e significância = 5.0%, Rank = 0
==========
==================================================

Testando para lag = 8 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.255263
p-value: 0.150904
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: -2.161915
p-value: 0.444081
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: -3.142748
p-value: 0.206301
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: -3.499544
p-value: 0.216038
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          18.33          12.32
  1   2          4.187          4.130
-------------------------------------
Para lag = 8 e significância = 5.0%, Rank = 2

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          14.29          15.49
-------------------------------------
Para lag = 8 e significância = 5.0%, Rank = 0

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          15.82          18.40
-------------------------------------
Para lag = 8 e significância = 5.0%, 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: -5.040755
p-value: 0.000118
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: -5.097520
p-value: 0.000518
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: -9.710937
p-value: 0.000000
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: -10.817112
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          39.49          24.28
  1   3          10.46          12.32
```

```
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          41.00          29.80
  1   3          11.49          15.49
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 1

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          93.11          35.01
  1   3          27.45          18.40
  2   3          8.180          3.841
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 3
==========
==================================================

Testando para lag = 2 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.379085
p-value: 0.040475
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: -3.395760
p-value: 0.113140
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: -4.692874
p-value: 0.009045
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: -10.817112
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          33.07          24.28
  1   3          10.25          12.32
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          31.65          29.80
  1   3          8.898          15.49
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 1

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          56.23          35.01
  1   3          28.19          18.40
```

```
  2   3          6.827          3.841
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 3
==========
==================================================

Testando para lag = 3 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.379085
p-value: 0.040475
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: -3.395760
p-value: 0.113140
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: -4.692874
p-value: 0.009045
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: -10.817112
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          38.59          24.28
  1   3          10.48          12.32
```

```
-------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 1

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          35.12          29.80
  1   3          7.795          15.49
-------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 1

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          52.24          35.01
  1   3          24.77          18.40
  2   3          5.107          3.841
-------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 3
==========
==================================================

Testando para lag = 4 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.851233
p-value: 0.137385
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: -2.841576
p-value: 0.310365
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: -3.342995
p-value: 0.261732
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: -10.817112
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          35.11          24.28
  1   3          19.18          12.32
  2   3          6.746          4.130
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 3

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          29.46          29.80
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 0

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          39.61          35.01
  1   3          22.20          18.40
```

```
  2   3          7.966          3.841
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 3
==========
==================================================

Testando para lag = 5 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.851233
p-value: 0.137385
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: -2.841576
p-value: 0.310365
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: -3.342995
p-value: 0.261732
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: -10.817112
p-value: 0.000000
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          30.81          24.28
  1   3          15.99          12.32
```

```
  2   3          7.402          4.130
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 3

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          24.15          29.80
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 0

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   3          32.18          35.01
-------------------------------------
Para lag = 5 e significância = 5.0%, 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: -5.107785
p-value: 0.000011
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: -5.064438
p-value: 0.000125
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: -5.034058
p-value: 0.000752
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: -5.186070
p-value: 0.001684
CONCLUSION: REJECT null Hypothesis: there IS cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          32.26          12.32
  1   2          4.441          4.130
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 2

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          33.71          15.49
  1   2          6.015          3.841
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 2

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
```

```
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          33.38          18.40
  1   2          6.072          3.841
-------------------------------------
Para lag = 1 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 2 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.423940
p-value: 0.007812
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: -3.383623
p-value: 0.044202
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: -3.359461
p-value: 0.134796
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 2 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.419919
p-value: 0.248270
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
```

```
-------------------------------------
  0   2          24.99          12.32
  1   2          5.231          4.130
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 2

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          26.75          15.49
  1   2          7.084          3.841
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 2

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          26.25          18.40
  1   2          7.143          3.841
-------------------------------------
Para lag = 2 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 3 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.423940
p-value: 0.007812
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: -3.383623
p-value: 0.044202
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: -3.359461
p-value: 0.134796
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


Testando para lag = 3 e trend = ctt
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -3.419919
p-value: 0.248270
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          29.94          12.32
  1   2          4.831          4.130
-------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 2

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          31.62          15.49
  1   2          6.479          3.841
-------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 2

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
```

```
  0   2          30.63          18.40
  1   2          6.509          3.841
-------------------------------------
Para lag = 3 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 4 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.893667
p-value: 0.035844
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: -2.842193
p-value: 0.152628
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: -2.794435
p-value: 0.361320
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: -2.820552
p-value: 0.560025
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          24.89          12.32
```

```
  1   2          8.454          4.130
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 2

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          27.65          15.49
  1   2          11.32          3.841
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 2

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          26.81          18.40
  1   2          11.38          3.841
-------------------------------------
Para lag = 4 e significância = 5.0%, Rank = 2
==========
==================================================

Testando para lag = 5 e trend = nc
Null Hypothesis: there is NO cointegration
Alternative Hypothesis: there IS cointegration
t Statistic: -2.893667
p-value: 0.035844
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: -2.842193
p-value: 0.152628
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: -2.794435
p-value: 0.361320
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: -2.820552
p-value: 0.560025
CONCLUSION: FAIL to reject Null Hypothesis: there is NO cointegration


TESTE DE JOHANSEN

Teste SEM constante
Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          19.03          12.32
  1   2          5.190          4.130
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 2

Teste COM constante

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          20.93          15.49
  1   2          7.246          3.841
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 2

Teste COM constante E tendência

Johansen cointegration test using trace test statistic with 5% significance
level
=====================================
r_0 r_1 test statistic critical value
-------------------------------------
  0   2          19.93          18.40
  1   2          7.277          3.841
```

```
-------------------------------------
Para lag = 5 e significância = 5.0%, Rank = 2
==========
```

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'
#det = 'coli'
#det = 'colo'
#det = 'cilo'
#det = 'ci'
#det = 'nc'
#det= 'co'

order_vec = select_order(
    df[[
        #"Inflação",
        "Taxa Própria",
        "gZ"
    ]],
    #exog=df[["Taxa de juros"]],
    #seasons=4,
    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'>
```

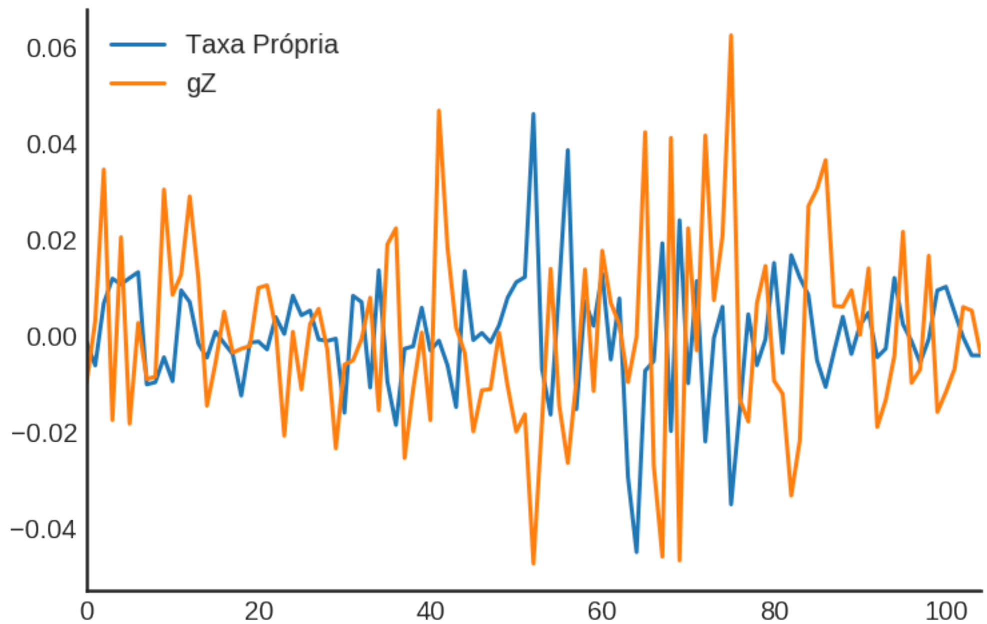
10.2 Estimação

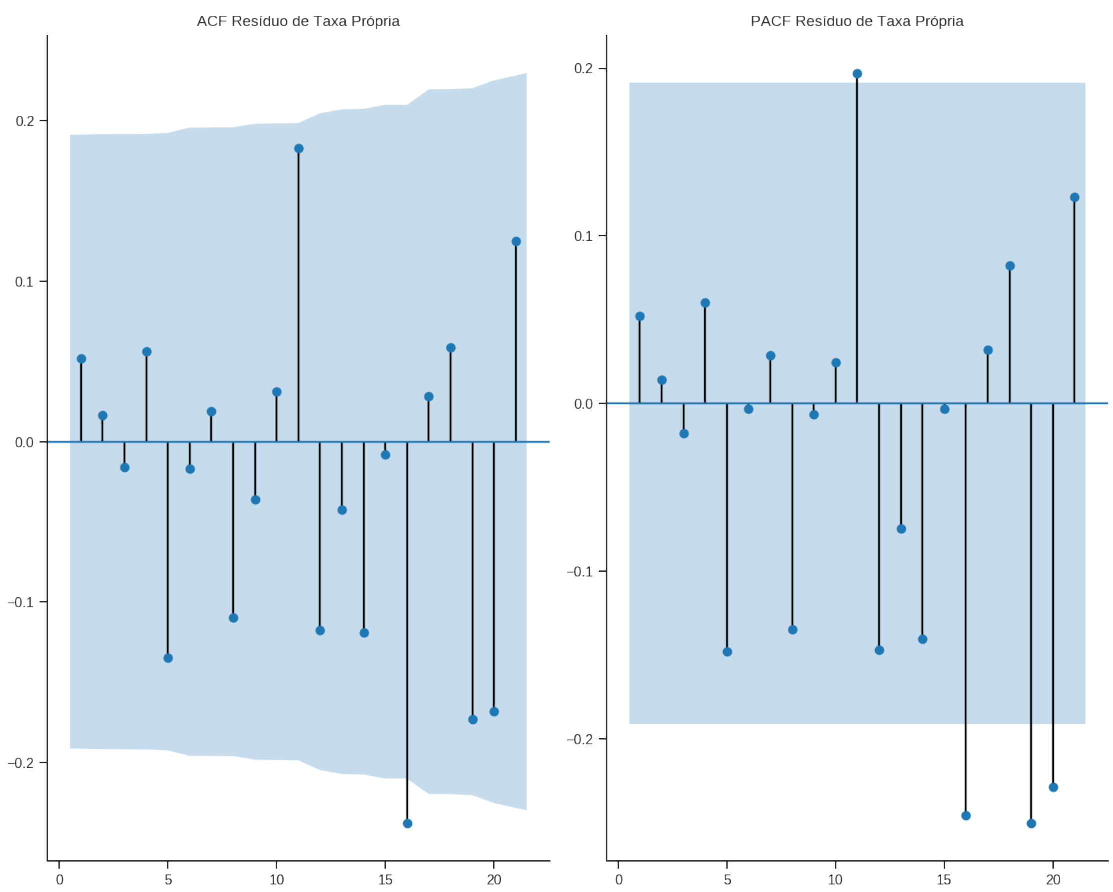
[18]:
```
model = VECM(
    endog = df[[
        #"Inflação",
        "Taxa Própria",
        "gZ"
    ]],
    #exog=df[["Taxa de juros"]],
```

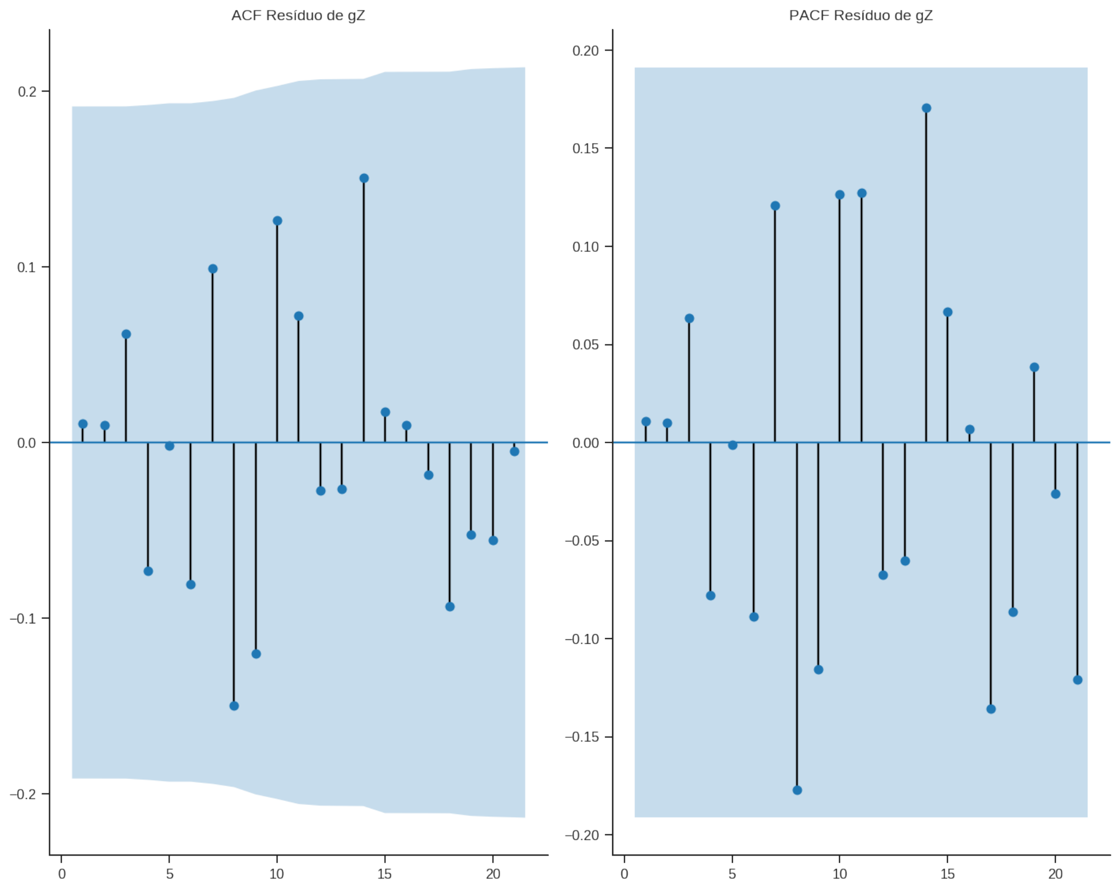
```python
    #k_ar_diff=0,
    #k_ar_diff=1,
    #k_ar_diff=2,
    #k_ar_diff=3,
    k_ar_diff=4,
    #k_ar_diff=5,
    #k_ar_diff=6,
    #k_ar_diff=7,
    #k_ar_diff=8,
    deterministic=det,
    #seasons=4,
)
results = model.fit()

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

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
Taxa Própria
================================================================================
===
                       coef    std err          z      P>|z|      [0.025
0.975]
--------------------------------------------------------------------------------
---
L1.Taxa Própria      0.0416      0.110      0.377      0.706      -0.175
0.258
L1.gZ                0.0784      0.081      0.967      0.333      -0.080
0.237
L2.Taxa Própria     -0.0004      0.109     -0.003      0.997      -0.214
0.213
L2.gZ                0.1149      0.080      1.437      0.151      -0.042
0.272
L3.Taxa Própria      0.0763      0.118      0.648      0.517      -0.154
0.307
L3.gZ                0.1101      0.068      1.616      0.106      -0.023
0.244
L4.Taxa Própria      0.2644      0.119      2.229      0.026       0.032
0.497
L4.gZ                0.0595      0.053      1.120      0.263      -0.045
```

```
0.164
 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    -0.1727      0.175     -0.987      0.323      -0.515
0.170
L1.gZ              -0.4209      0.128     -3.277      0.001      -0.673
-0.169
L2.Taxa Própria    -0.9973      0.173     -5.779      0.000      -1.336
-0.659
L2.gZ              -0.4596      0.127     -3.627      0.000      -0.708
-0.211
L3.Taxa Própria    -0.5835      0.187     -3.127      0.002      -0.949
-0.218
L3.gZ              -0.1992      0.108     -1.844      0.065      -0.411
0.013
L4.Taxa Própria    -0.5321      0.188     -2.830      0.005      -0.901
-0.164
L4.gZ              -0.2446      0.084     -2.904      0.004      -0.410
-0.080
            Loading coefficients (alpha) for equation Taxa Própria
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.0286      0.070     -0.412      0.681      -0.165       0.108
                 Loading coefficients (alpha) for equation gZ
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ec1           -0.4278      0.110     -3.882      0.000      -0.644      -0.212
          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         1.2694      0.147      8.652      0.000       0.982       1.557
const         -0.1124      0.009    -12.824      0.000      -0.130      -0.095
lin_trend      0.0006      0.000      5.014      0.000       0.000       0.001
==============================================================================
============================================================

PÓS ESTIMAÇÃO
```


Taxa Própria
gZ
0.06
0.04
0.02
0.00
−0.02
−0.04
0
20
40
60
80
100


ACF Resíduo de Taxa Própria
PACF Resíduo de 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
----------------------------------------
         49.50          58.12   0.199 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
```

```
----------------------------------------
         54.42          58.12   0.095 42
----------------------------------------

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 %
p-value = 0.9108621230490326
Reject H0 on lag  1 ?  False

p-value = 0.9883918763097149
Reject H0 on lag  2 ?  False

p-value = 0.9308058487923343
Reject H0 on lag  3 ?  False

p-value = 0.903318881269298
Reject H0 on lag  4 ?  False

p-value = 0.9590509584600702
Reject H0 on lag  5 ?  False

p-value = 0.9387725176342155
Reject H0 on lag  6 ?  False

p-value = 0.8931982365444867
Reject H0 on lag  7 ?  False

p-value = 0.7017393626104657
Reject H0 on lag  8 ?  False

p-value = 0.6159678050559062
Reject H0 on lag  9 ?  False

p-value = 0.5228632038947401
Reject H0 on lag  10 ?  False

p-value = 0.5553928742851937
Reject H0 on lag  11 ?  False

p-value = 0.6323301403932835
Reject H0 on lag  12 ?  False
```

```
Testing for  GZ . Considering a significance level of 5.0 %
p-value = 0.291641080616544
Reject H0 on lag  1 ?  False

p-value = 0.32186457575852456
Reject H0 on lag  2 ?  False

p-value = 0.34906177535797317
Reject H0 on lag  3 ?  False

p-value = 0.7019209542757862
Reject H0 on lag  4 ?  False

p-value = 2.7414947965852505
Reject H0 on lag  5 ?  False

p-value = 2.772896011411245
Reject H0 on lag  6 ?  False

p-value = 2.814710900243284
Reject H0 on lag  7 ?  False

p-value = 4.210870650689688
Reject H0 on lag  8 ?  False

p-value = 4.36096113475612
Reject H0 on lag  9 ?  False

p-value = 4.477963593985376
Reject H0 on lag  10 ?  False

p-value = 8.491163028329355
Reject H0 on lag  11 ?  False

p-value = 10.153450558578296
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 %
p-value = 0.9121154648950444
Reject H0 on lag  1 ?  False
```

```
p-value = 0.9887654810995691
Reject H0 on lag  2 ?  False

p-value = 0.9351354573578504
Reject H0 on lag  3 ?  False

p-value = 0.9115608537908553
Reject H0 on lag  4 ?  False

p-value = 0.9634723629547096
Reject H0 on lag  5 ?  False

p-value = 0.947339927230437
Reject H0 on lag  6 ?  False

p-value = 0.9108134222209635
Reject H0 on lag  7 ?  False

p-value = 0.7506677624912002
Reject H0 on lag  8 ?  False

p-value = 0.6805432917504961
Reject H0 on lag  9 ?  False

p-value = 0.6030683177019144
Reject H0 on lag  10 ?  False

p-value = 0.6390526906871496
Reject H0 on lag  11 ?  False

p-value = 0.7121333927113775
Reject H0 on lag  12 ?  False



Testing for  GZ . Considering a significance level of 5.0 %
p-value = 0.291641080616544
Reject H0 on lag  1 ?  False

p-value = 0.32186457575852456
Reject H0 on lag  2 ?  False

p-value = 0.34906177535797317
Reject H0 on lag  3 ?  False

p-value = 0.7019209542757862
Reject H0 on lag  4 ?  False
```

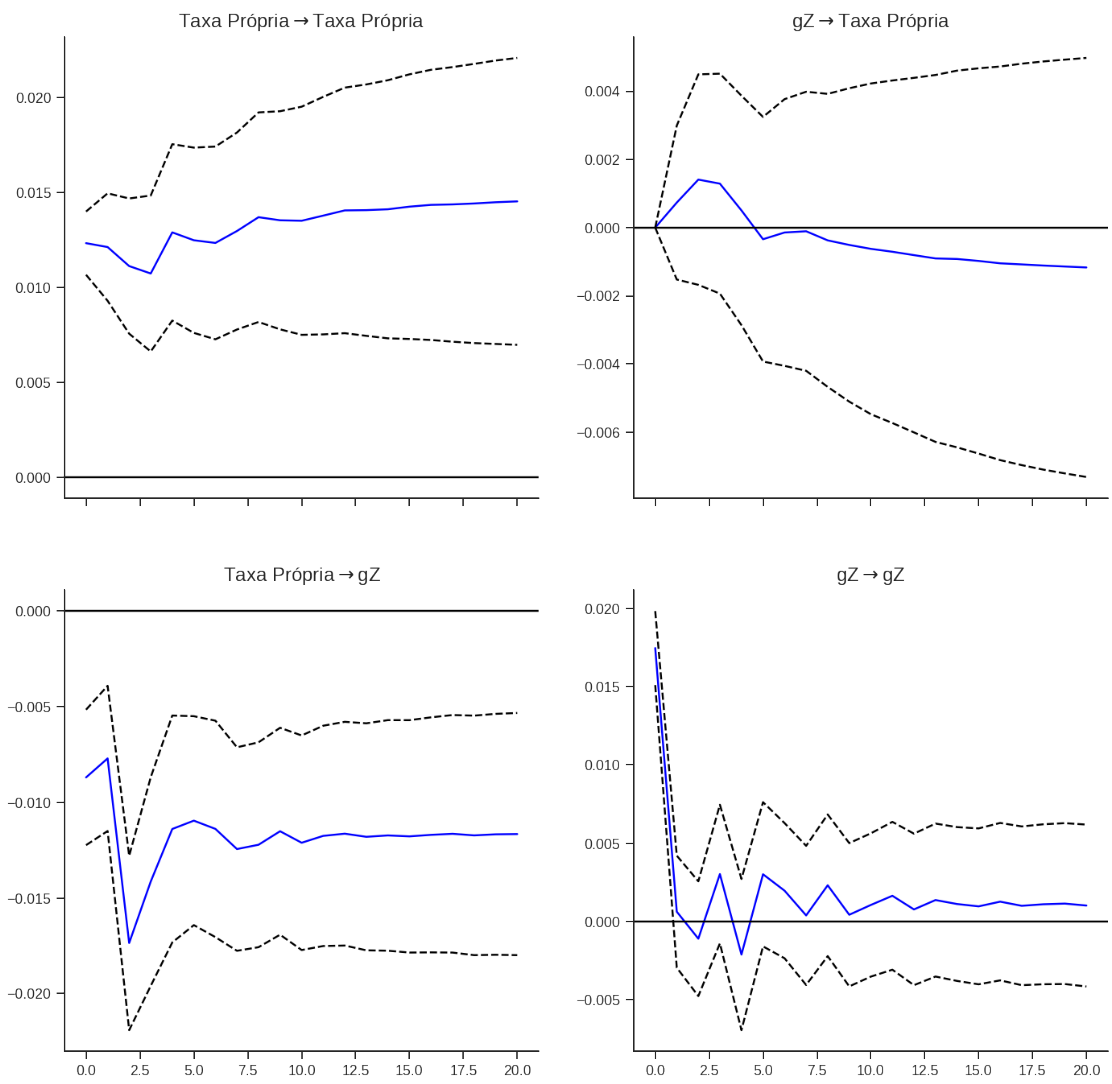
```
p-value = 2.7414947965852505
Reject H0 on lag  5 ?  False

p-value = 2.772896011411245
Reject H0 on lag  6 ?  False

p-value = 2.814710900243284
Reject H0 on lag  7 ?  False

p-value = 4.210870650689688
Reject H0 on lag  8 ?  False

p-value = 4.36096113475612
Reject H0 on lag  9 ?  False

p-value = 4.477963593985376
Reject H0 on lag  10 ?  False

p-value = 8.491163028329355
Reject H0 on lag  11 ?  False

p-value = 10.153450558578296
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
----------------------------------------
         46.69          9.488   0.000  4
----------------------------------------

HOMOCEDASTICIDADE

H0: Residuals are homoscedastic
H1: Residuals are heteroskedastic
Testing for  TAXA PRÓPRIA
LM p-value:  0.16299984459675676
Reject H0?  False
F p-value:  0.1661408241092586
Reject H0?  False
```

```
Testing for  GZ
LM p-value:  0.0827931621339786
Reject H0?  False
F p-value:  0.08428565465553892
Reject H0?  False


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

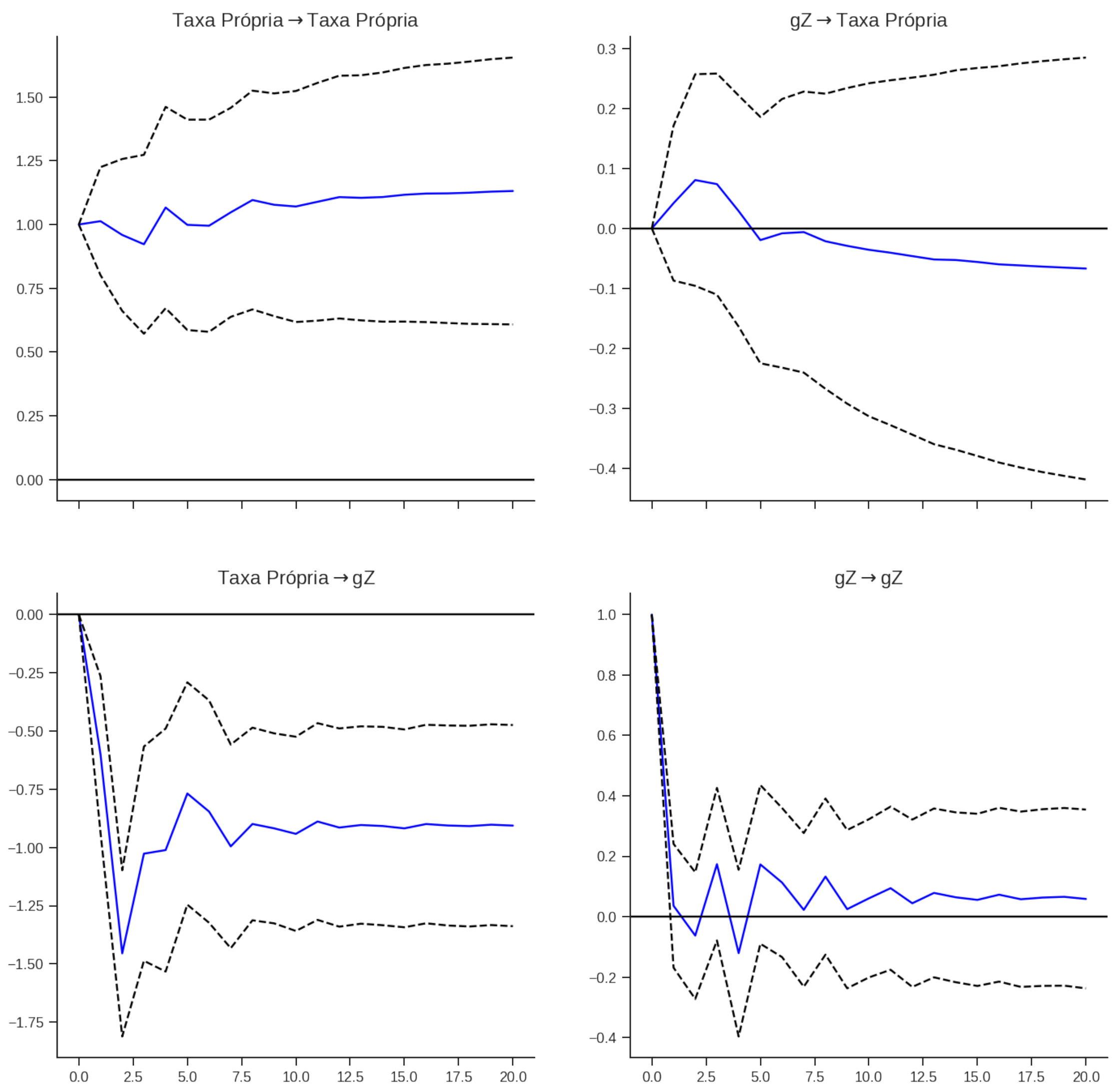
10.3 Função impulso resposta ortogonalizada

[19]:
```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,)
```



10.4 Função impulso resposta não-ortogonalizada

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



10.5 Teste de causalidade de granger

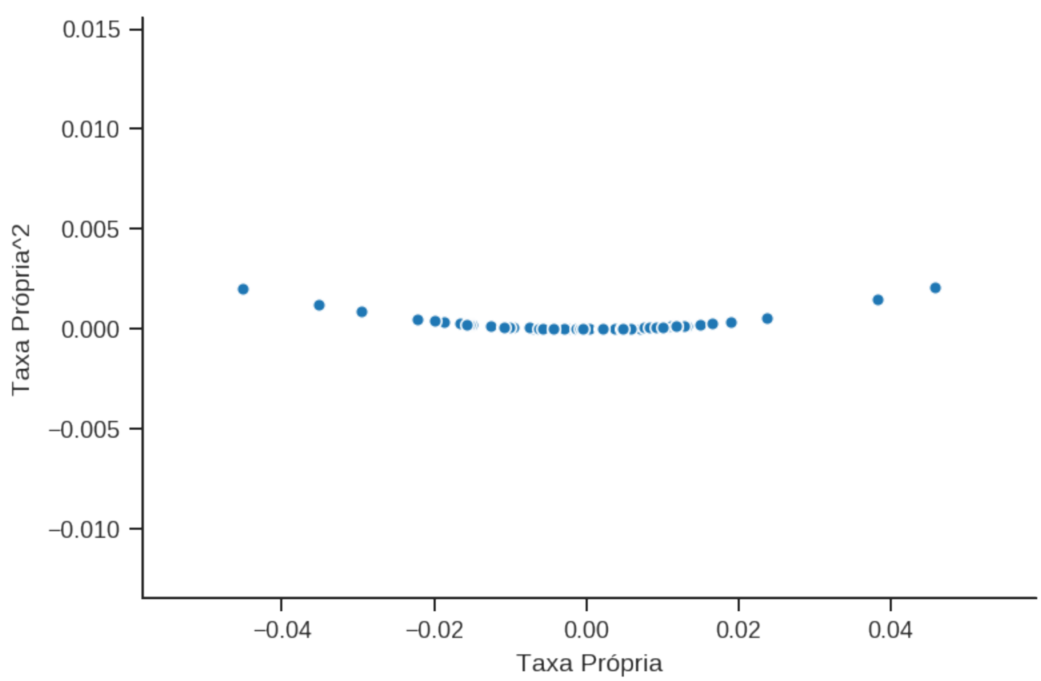
[21]:
```
series = residuals.columns
print(results.test_granger_causality(causing=series[0], caused=series[1]).
 ↪summary())
print(results.test_inst_causality(causing=series[0]).summary())
```

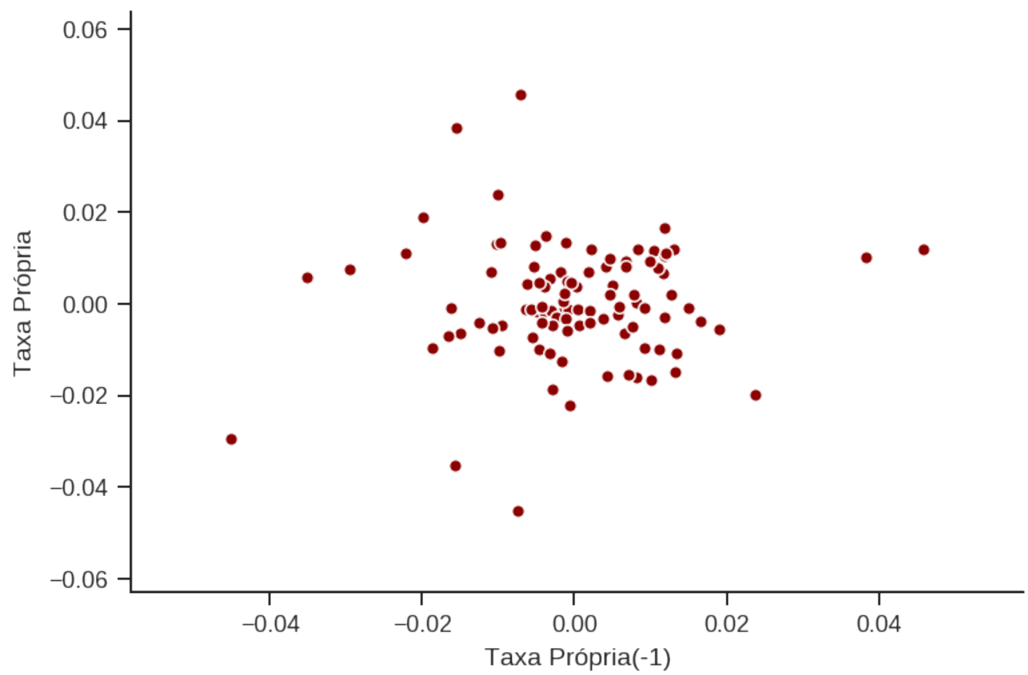
```
Granger causality F-test. H_0: Taxa Própria does not Granger-cause gZ.
Conclusion: reject H_0 at 5% significance level.
==============================================
Test statistic Critical value p-value    df
----------------------------------------------
         12.28          2.264   0.000 (5, 180)
```

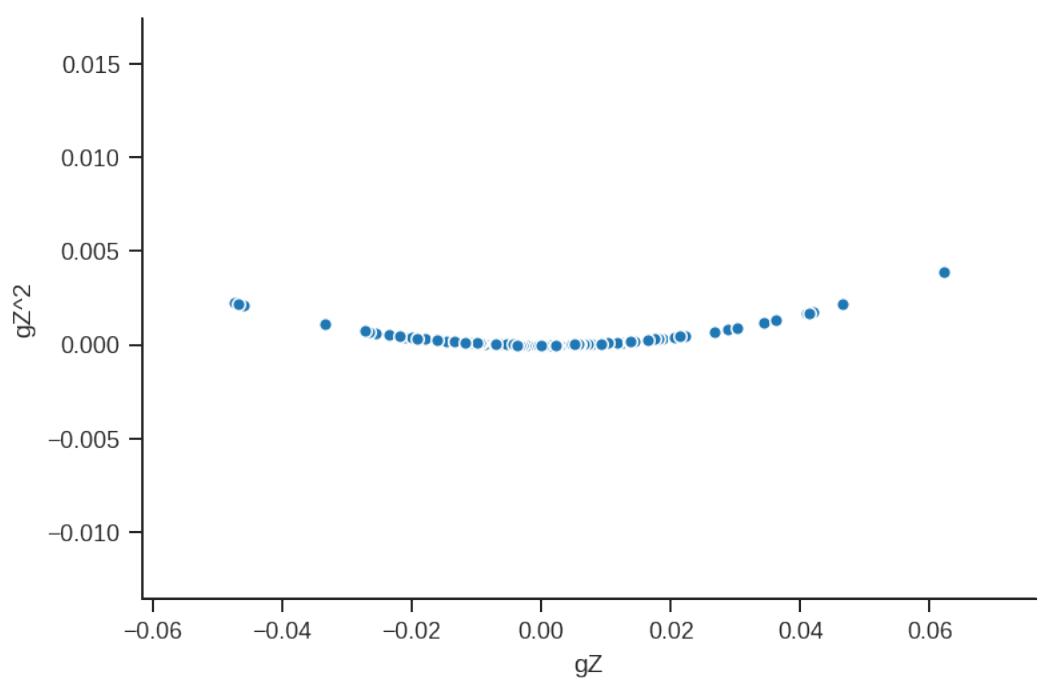
```
-----------------------------------------------
Instantaneous causality Wald-test. H_0: Taxa Própria does not instantaneously
cause gZ. Conclusion: reject H_0 at 5% significance level.
========================================
Test statistic Critical value p-value df
----------------------------------------
         15.44          3.841   0.000  1
----------------------------------------
```

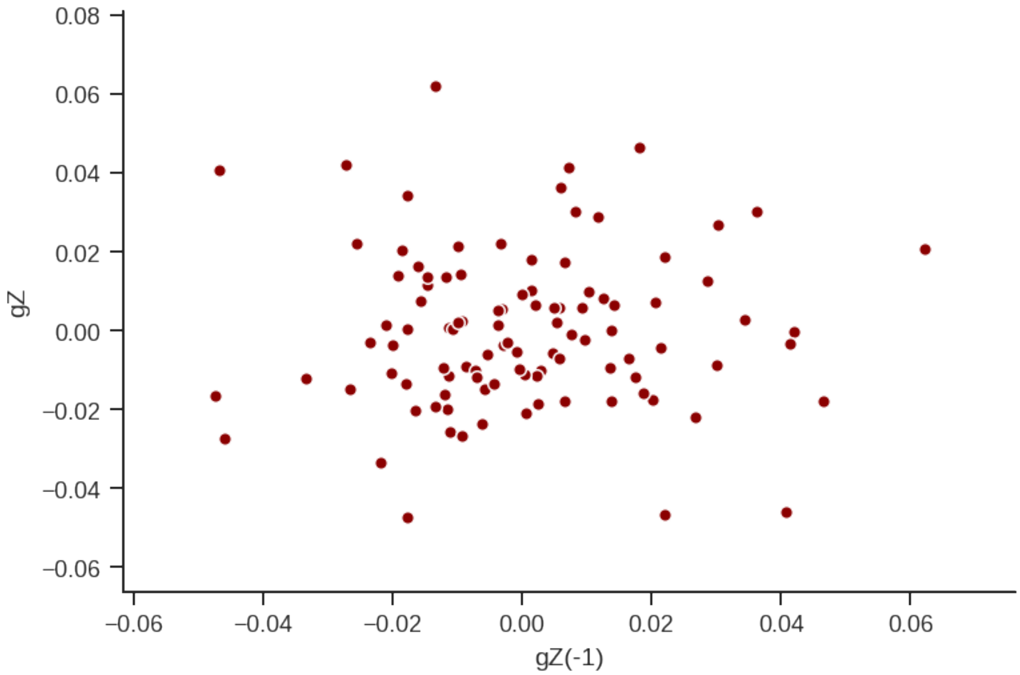
10.6 Inspeção gráfica dos resíduos

[22]:
```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()
```

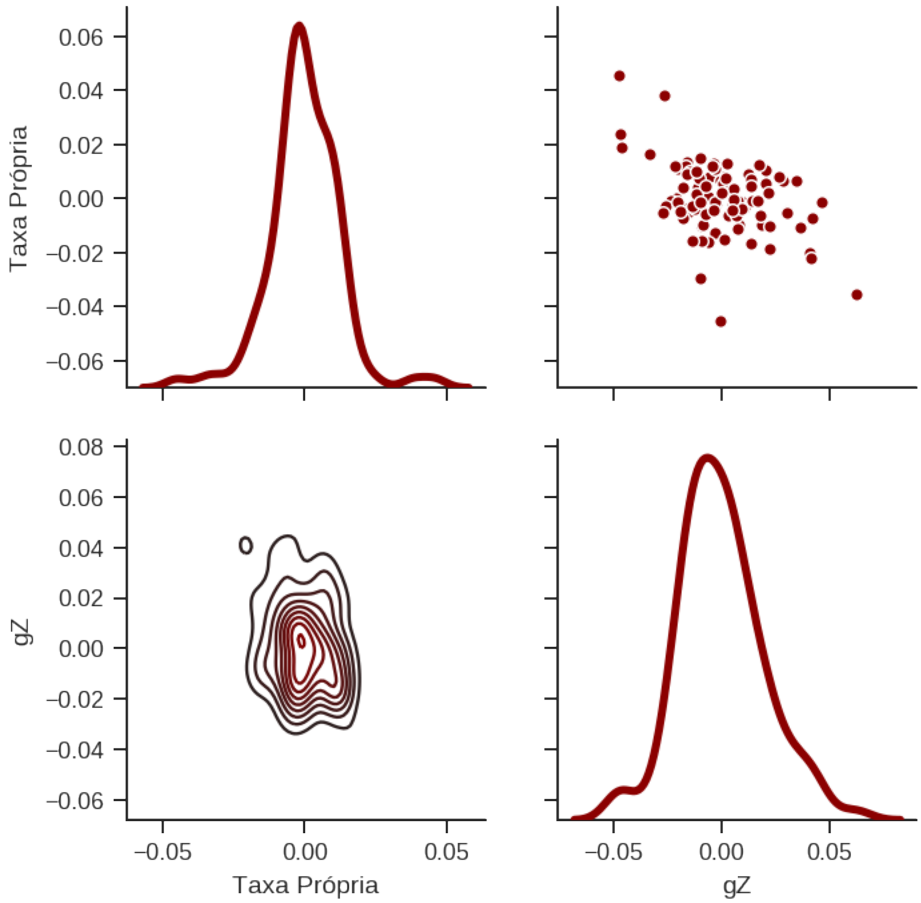



0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
Taxa Própria
−0.04
−0.02
0.00
0.02
0.04
Taxa Própria(-1)

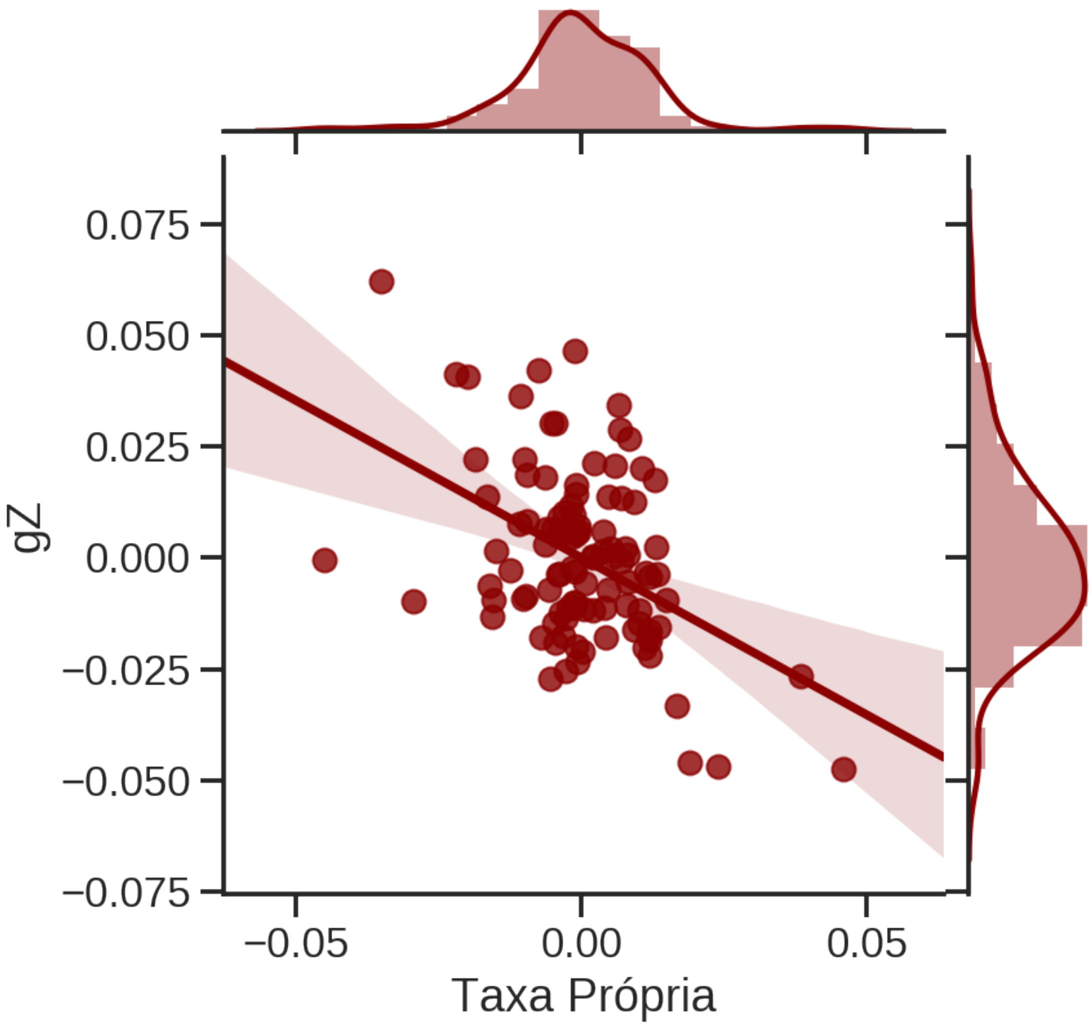

0.015
0.010
0.005
0.000
−0.005
−0.010
gZ^2
−0.06
−0.04
−0.02
0.00
0.02
0.04
0.06
gZ



[23]:
```
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,)
```



[24]:
```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()
```



10.7 FEVD

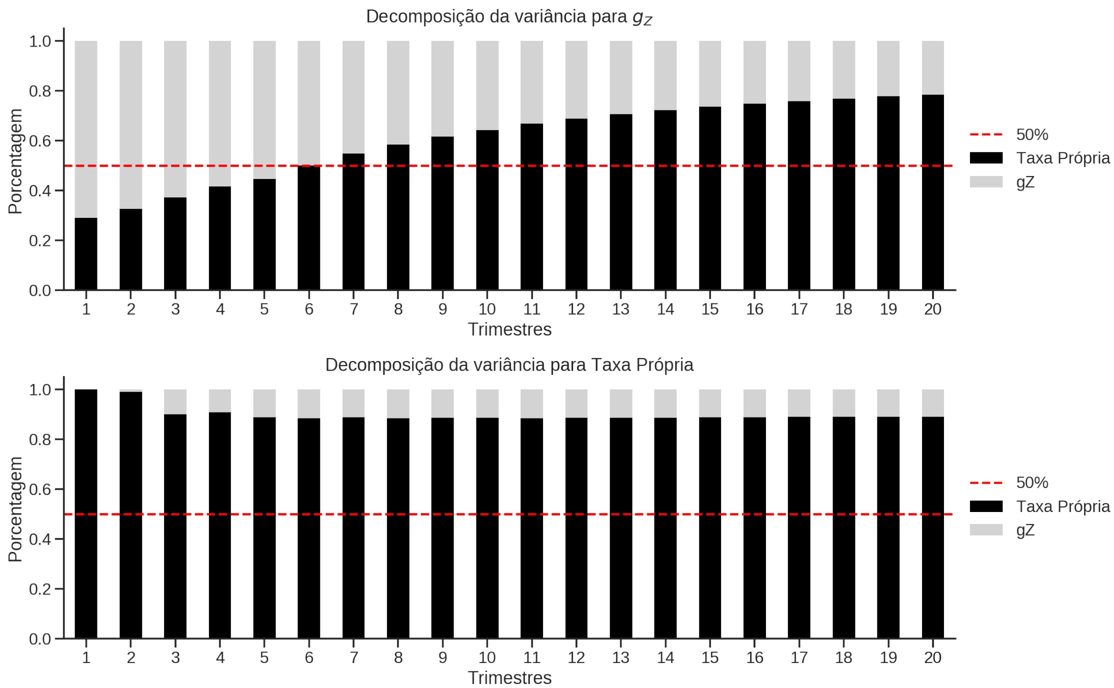
[25]:
```
%%R -o fevd_gz
library(tsDyn)
library(readr)
df <- read.csv("./Dados_yeojohnson.csv", encoding="UTF-8")
#df <- df[,c(4:7)]
names(df) <- c("Infla", "gZ", "TaxaP", "Juros")
df <- na.omit(df[,c("Infla", "gZ", "TaxaP", "Juros")])
df <- ts(data = df, start = c(1992,03), frequency = 4)
model <- tsDyn::VECM(data = df[,c("TaxaP","gZ")], lag = 4, r = 1, estim = "ML",
  LRinclude="both", include="none")
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
```

[26]:
```
%%R -o fevd_tx
fevd_tx = data.frame(tsDyn::fevd(model, 20)$TaxaP)
```

[27]:
```
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%", "Taxa␣
↪Própria", "gZ"))
ax[0].set_xticklabels(ax[0].get_xticklabels(), rotation=0)


fevd_tx.plot(
    ax=ax[1],
    title = "Decomposição da variância para Taxa Própria",
    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%", "Taxa␣
↪Própria", "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

[28]:
```
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       -15.74      -15.63   1.462e-07      -15.69
1       -15.90      -15.69   1.243e-07      -15.81
2       -16.24     -15.92*   8.869e-08      -16.11
```

```
3        -16.20      -15.77    9.223e-08      -16.03
4        -16.33      -15.80   8.070e-08*     -16.12*
5        -16.33      -15.68    8.128e-08      -16.07
6        -16.30      -15.55    8.337e-08      -16.00
7        -16.24      -15.38    8.896e-08      -15.89
8        -16.27      -15.31    8.646e-08      -15.88
9        -16.23      -15.16    9.025e-08      -15.80
10       -16.24      -15.06    9.018e-08      -15.76
11      -16.35*      -15.06    8.133e-08      -15.83
12       -16.32      -14.92    8.410e-08      -15.75
13       -16.30      -14.79    8.646e-08      -15.69
14       -16.22      -14.61    9.409e-08      -15.57
15       -16.16      -14.44    1.016e-07      -15.46
--------------------------------------------------
```

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

11.2 Estimação

[29]:
```python
results = model.fit(maxlags=4)
print(results.summary())
```

```
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           qua, 11, dez, 2019
Time:                     11:24:38
--------------------------------------------------------------------
No. of Equations:         2.00000    BIC:                  -15.9206
Nobs:                     106.000    HQIC:                 -16.1896
Log likelihood:           584.948    FPE:               7.75719e-08
AIC:                     -16.3729    Det(Omega_mle):    6.59053e-08
--------------------------------------------------------------------
Results for equation d_Taxa Própria
================================================================================
====
                       coefficient       std. error           t-stat
prob
--------------------------------------------------------------------------------
----
const                    -0.000225         0.001274           -0.177
0.860
L1.d_Taxa Própria         0.026791         0.108015            0.248
0.804
L1.d_gZ                   0.053280         0.060755            0.877
0.381
```

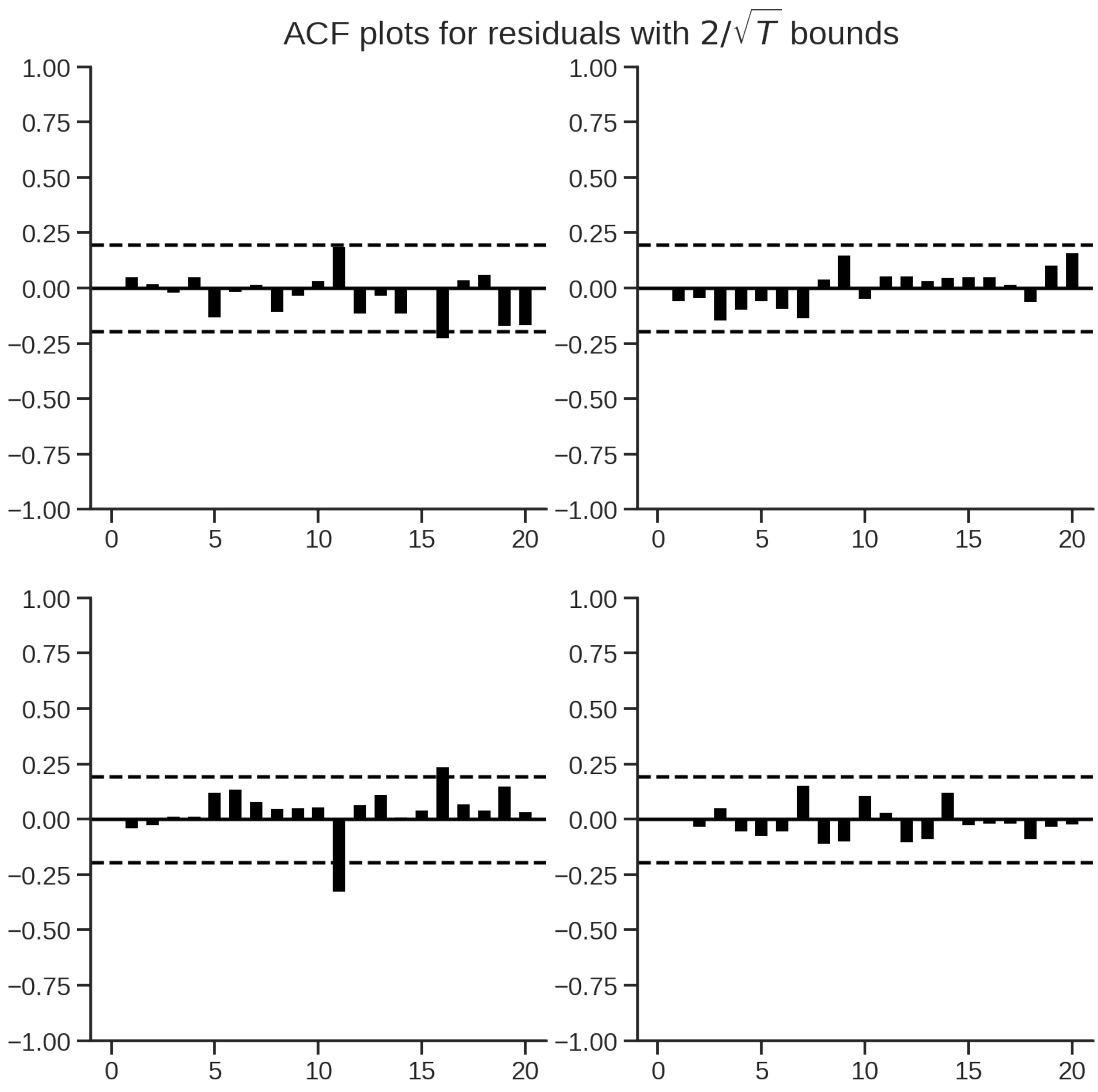
```
L2.d_Taxa Própria        -0.011045         0.110349           -0.100
0.920
L2.d_gZ                   0.100475         0.074389            1.351
0.177
L3.d_Taxa Própria         0.078140         0.123519            0.633
0.527
L3.d_gZ                   0.100932         0.067956            1.485
0.137
L4.d_Taxa Própria         0.270819         0.122912            2.203
0.028
L4.d_gZ                   0.051875         0.053754            0.965
0.335
================================================================================
====

Results for equation d_gZ
================================================================================
====
                       coefficient       std. error           t-stat
prob
--------------------------------------------------------------------------------
----
const                    -0.003123         0.002167           -1.441
0.150
L1.d_Taxa Própria        -0.411515         0.183729           -2.240
0.025
L1.d_gZ                  -0.791883         0.103341           -7.663
0.000
L2.d_Taxa Própria        -1.174157         0.187698           -6.256
0.000
L2.d_gZ                  -0.692852         0.126532           -5.476
0.000
L3.d_Taxa Própria        -0.567872         0.210101           -2.703
0.007
L3.d_gZ                  -0.345006         0.115590           -2.985
0.003
L4.d_Taxa Própria        -0.439555         0.209067           -2.102
0.036
L4.d_gZ                  -0.348317         0.091434           -3.810
0.000
================================================================================
====

Correlation matrix of residuals
                  d_Taxa Própria      d_gZ
d_Taxa Própria          1.000000 -0.396595
d_gZ                   -0.396595  1.000000
```

11.3 Pós-estimação

11.3.1 Autocorrelação dos resíduos

OBS: série consigo mesma na diagonal principal.

[30]:
```
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

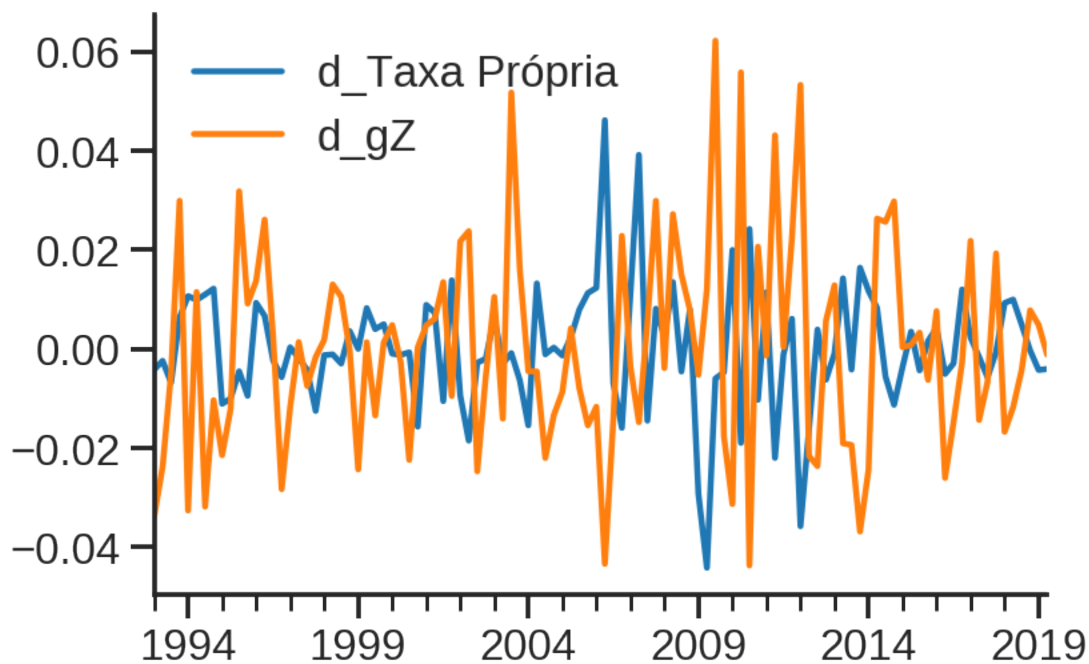
[31]:
```
print("Estável:", results.is_stable(verbose=True))
```

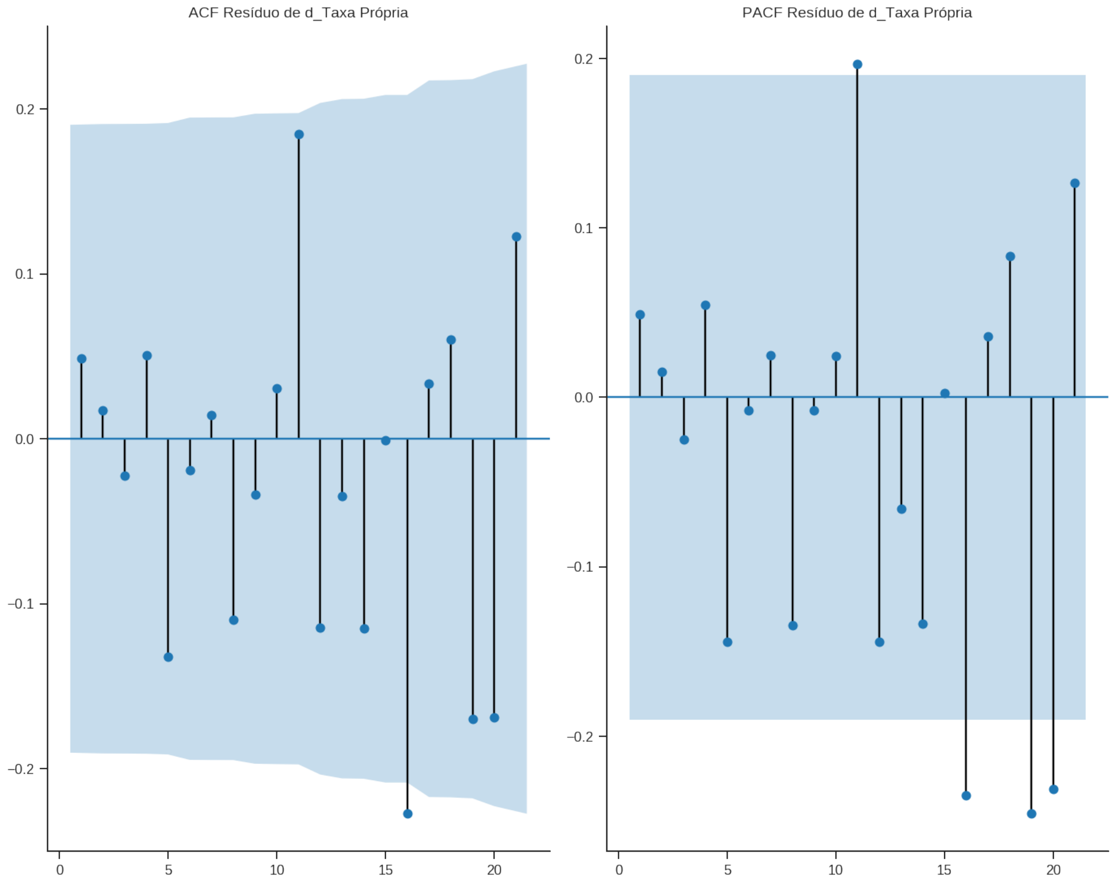
```
Eigenvalues of VAR(1) rep
0.6028981520089486
0.7019925401767092
0.7019925401767092
0.7432362599067193
0.7432362599067193
0.6605408378835657
0.8122883049550694
0.8122883049550694
Estável: True
```

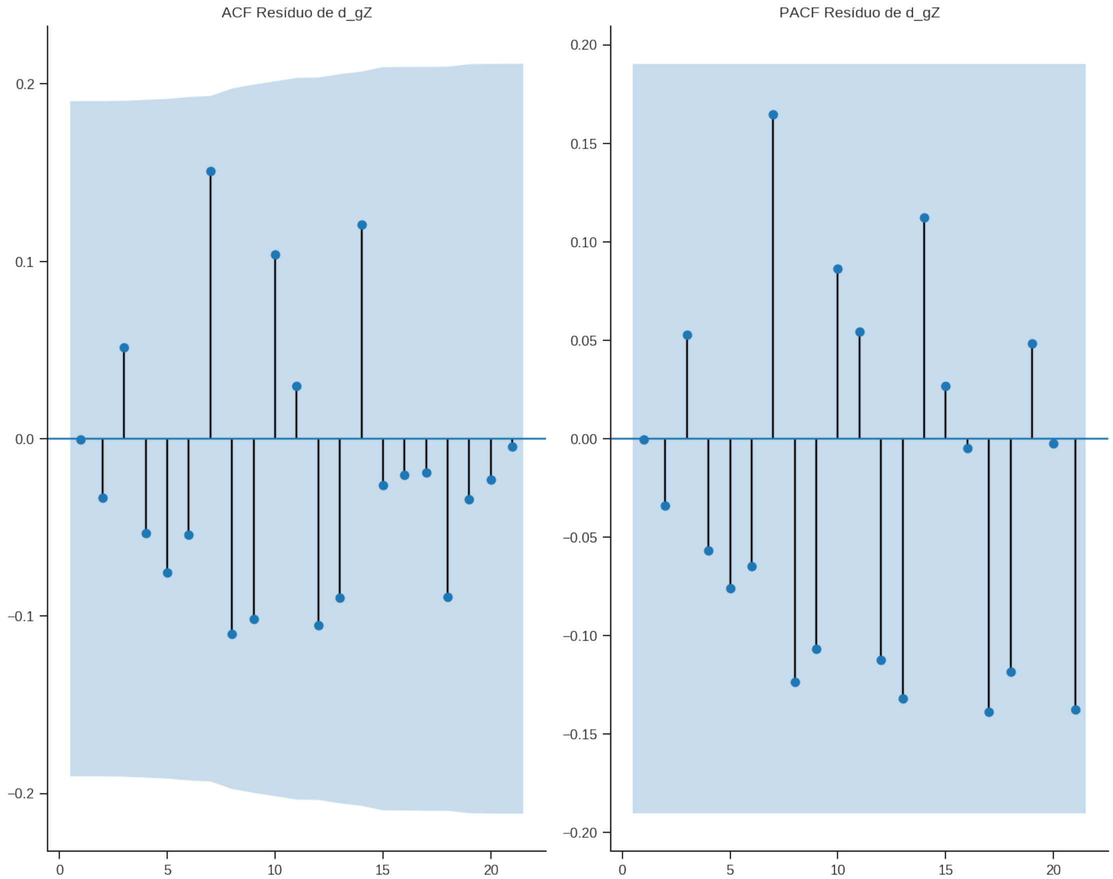
OBS: Apesar de estar escrito VAR(1), os resultados acima correspondem ao VAR(p)

11.4 Inspeção dos resíduos

[32]:
```
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
----------------------------------------
         50.83          60.48   0.222 44
----------------------------------------

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
----------------------------------------
         55.42          60.48   0.116 44
```

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

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 %
p-value = 0.996228493554174
Reject H0 on lag  1 ?  False

p-value = 0.9406298040776545
Reject H0 on lag  2 ?  False

p-value = 0.9370067805887892
Reject H0 on lag  3 ?  False

p-value = 0.9469791896038633
Reject H0 on lag  4 ?  False

p-value = 0.9261744701048196
Reject H0 on lag  5 ?  False

p-value = 0.9436822568459015
Reject H0 on lag  6 ?  False

p-value = 0.7387979774955189
Reject H0 on lag  7 ?  False

p-value = 0.6740446150554438
Reject H0 on lag  8 ?  False

p-value = 0.6390067042150279
Reject H0 on lag  9 ?  False

p-value = 0.6025561072846164
Reject H0 on lag  10 ?  False

p-value = 0.6793866476512512
Reject H0 on lag  11 ?  False

p-value = 0.6405995235159032
Reject H0 on lag  12 ?  False



Testing for  D_GZ . Considering a significance level of 5.0 %
p-value = 0.25680182993795736
```

```
Reject H0 on lag  1 ?  False

p-value = 0.2889199224614687
Reject H0 on lag  2 ?  False

p-value = 0.3453002484818514
Reject H0 on lag  3 ?  False

p-value = 0.6316045110497377
Reject H0 on lag  4 ?  False

p-value = 2.6126619132928375
Reject H0 on lag  5 ?  False

p-value = 2.6543149495452156
Reject H0 on lag  6 ?  False

p-value = 2.678535751106577
Reject H0 on lag  7 ?  False

p-value = 4.092231668343421
Reject H0 on lag  8 ?  False

p-value = 4.2266275487084055
Reject H0 on lag  9 ?  False

p-value = 4.338354449221555
Reject H0 on lag  10 ?  False

p-value = 8.446974813432979
Reject H0 on lag  11 ?  False

p-value = 10.042215402605208
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 %
p-value = 0.9962812441093268
Reject H0 on lag  1 ?  False

p-value = 0.9427644153435034
```

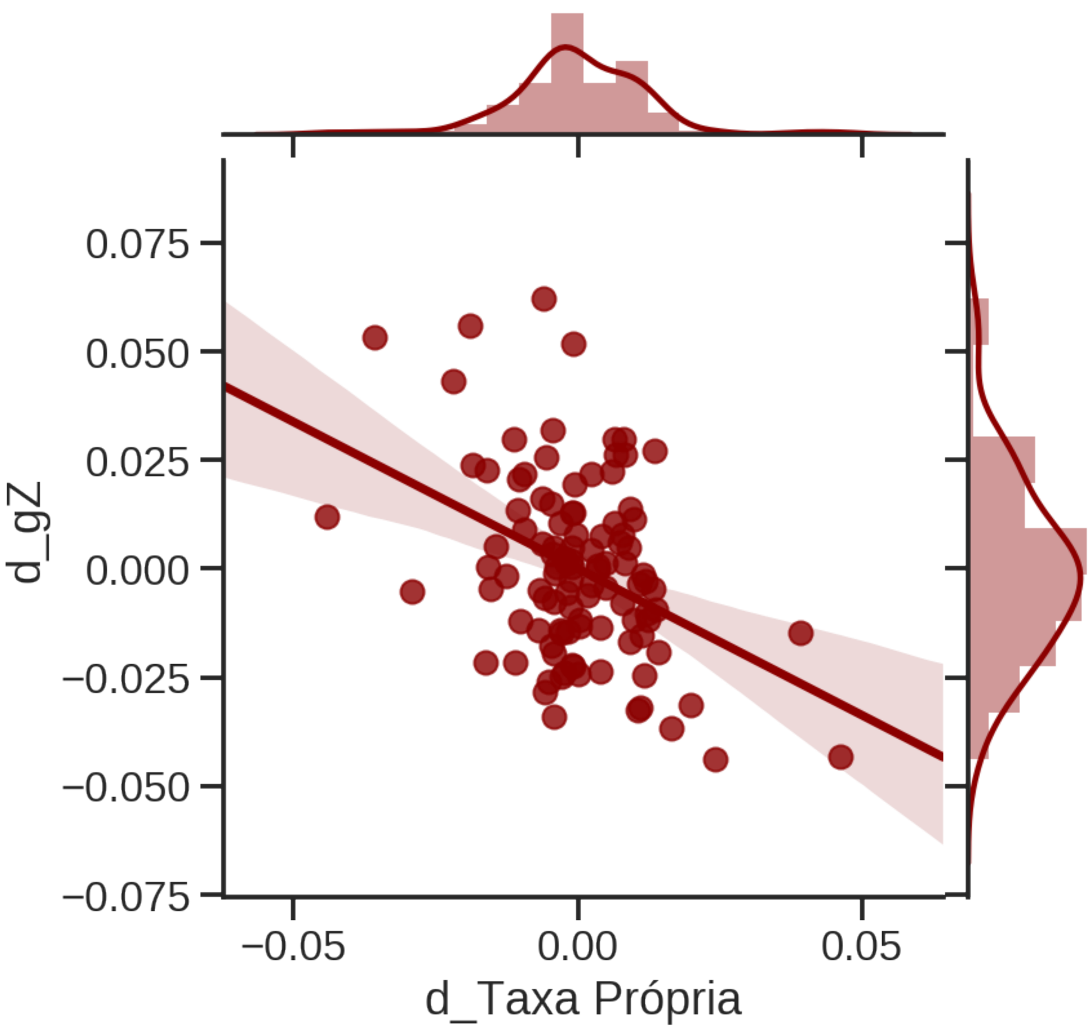
```
Reject H0 on lag  2 ?  False

p-value = 0.9407649989900082
Reject H0 on lag  3 ?  False

p-value = 0.9514664730870009
Reject H0 on lag  4 ?  False

p-value = 0.9344108021350422
Reject H0 on lag  5 ?  False

p-value = 0.9514336966350602
Reject H0 on lag  6 ?  False

p-value = 0.7766369229471246
Reject H0 on lag  7 ?  False

p-value = 0.7242231213618654
Reject H0 on lag  8 ?  False

p-value = 0.6988127568441576
Reject H0 on lag  9 ?  False

p-value = 0.6727776485755902
Reject H0 on lag  10 ?  False

p-value = 0.7449632651011944
Reject H0 on lag  11 ?  False

p-value = 0.7189007905800859
Reject H0 on lag  12 ?  False



Testing for  D_GZ . Considering a significance level of 5.0 %
p-value = 0.25680182993795736
Reject H0 on lag  1 ?  False

p-value = 0.2889199224614687
Reject H0 on lag  2 ?  False

p-value = 0.3453002484818514
Reject H0 on lag  3 ?  False

p-value = 0.6316045110497377
Reject H0 on lag  4 ?  False

p-value = 2.6126619132928375
```

```
Reject H0 on lag  5 ?  False

p-value = 2.6543149495452156
Reject H0 on lag  6 ?  False

p-value = 2.678535751106577
Reject H0 on lag  7 ?  False

p-value = 4.092231668343421
Reject H0 on lag  8 ?  False

p-value = 4.2266275487084055
Reject H0 on lag  9 ?  False

p-value = 4.338354449221555
Reject H0 on lag  10 ?  False

p-value = 8.446974813432979
Reject H0 on lag  11 ?  False

p-value = 10.042215402605208
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
----------------------------------------
         49.47          9.488   0.000  4
----------------------------------------

HOMOCEDASTICIDADE

H0: Residuals are homoscedastic
H1: Residuals are heteroskedastic
Testing for  D_TAXA PRÓPRIA
LM p-value:  0.18615610271075678
Reject H0?  False
F p-value:  0.18962127829043593
Reject H0?  False


Testing for  D_GZ
```

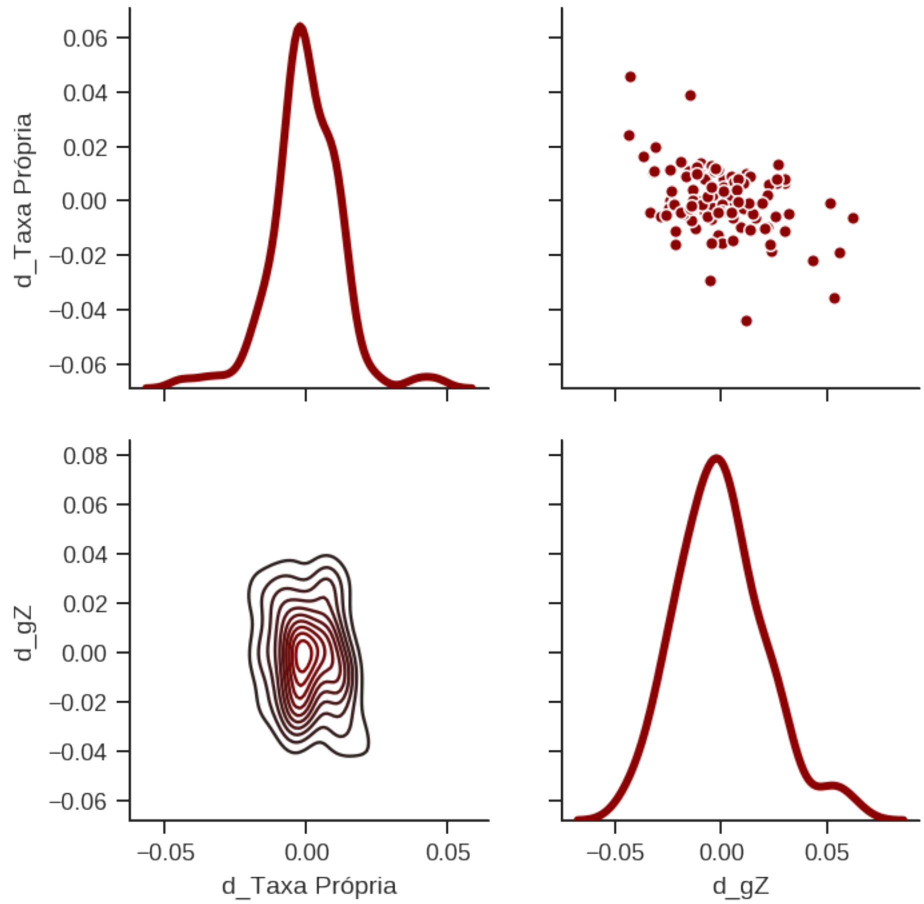
```
LM p-value:  0.3580339529225405
Reject H0?  False
F p-value:  0.36284810006830603
Reject H0?  False
```

11.5 Inspeção gráfica dos resíduos

[33]:
```
series = results.names
sns.set_context('talk')
ax = sns.jointplot(
    x = series[0],
    y = series[1],
    data = residuals, color = 'darkred', kind="reg",
)
plt.show()
```

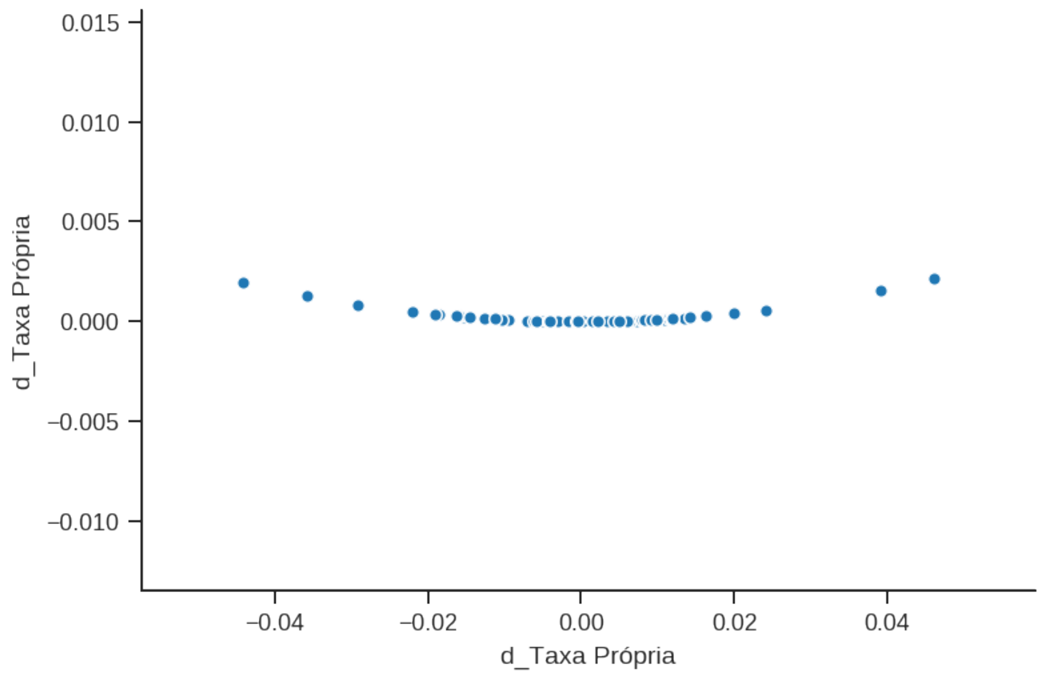


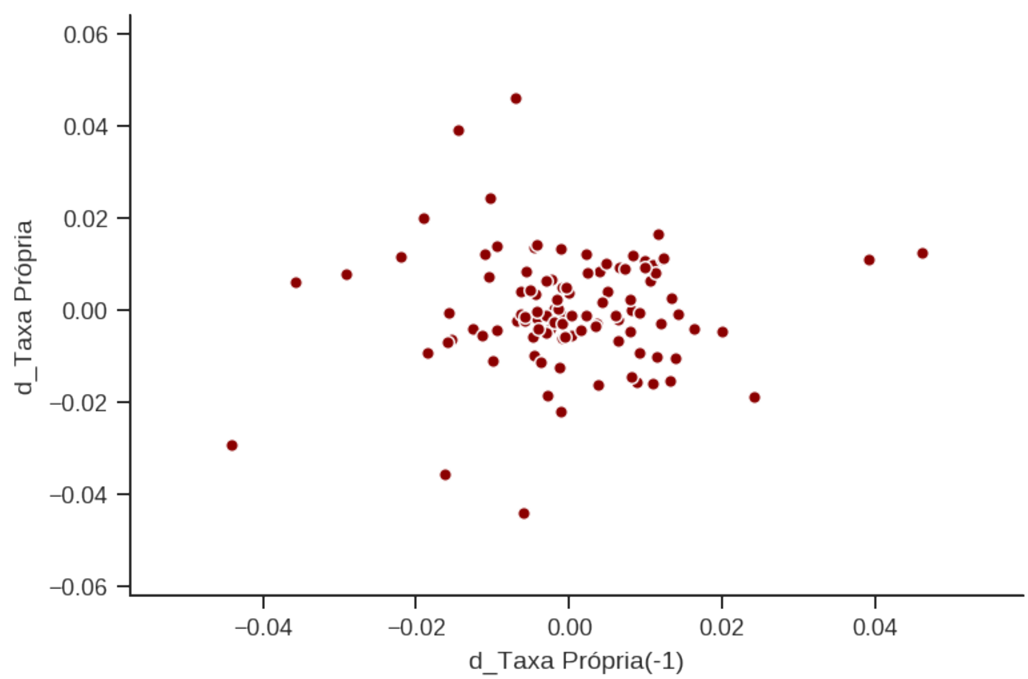
[34]:
```
sns.set_context('paper')
g = sns.PairGrid(residuals, diag_sharey=False)
g.map_lower(sns.kdeplot, color = 'darkred')
g.map_upper(sns.scatterplot, color = 'darkred')
g.map_diag(sns.kdeplot, lw=3, color = 'darkred')
plt.show()
g.savefig("./figs/Residuos_4.png", dpi=300)
```

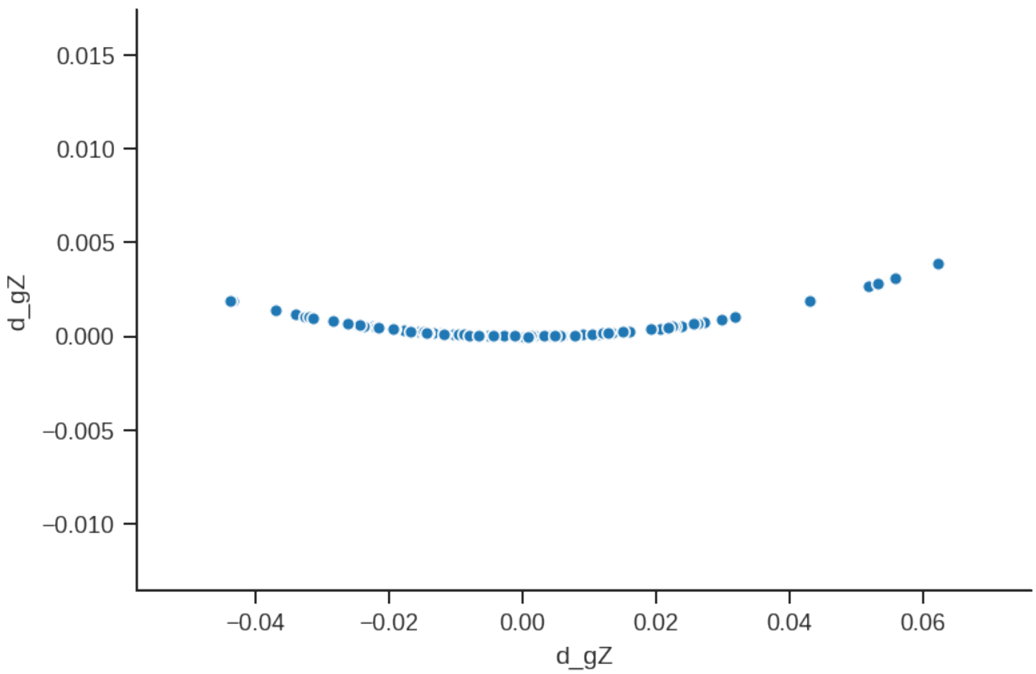


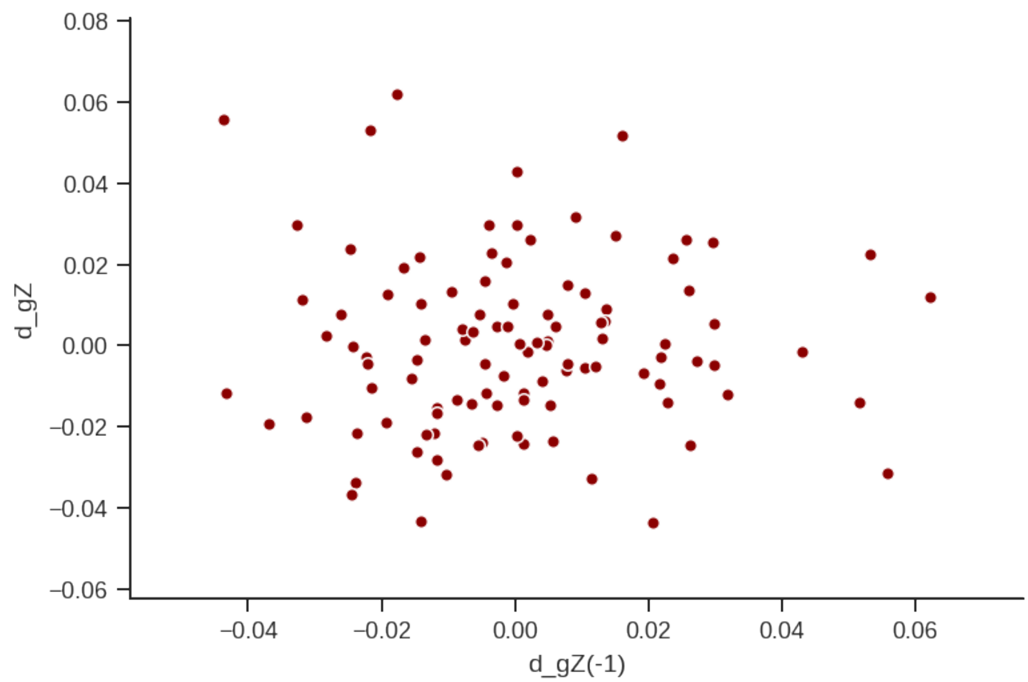
[35]:
```
series = results.names
for serie in series:
    sns.scatterplot(x = residuals[serie], y = residuals[serie]**2)
    sns.despine()
    plt.show()

    sns.scatterplot(
    y = residuals[serie],
    x = residuals[serie].shift(-1),
```

```python
    color = 'darkred'
    )
    sns.despine()
    plt.xlabel(f"{serie}(-1)")
    plt.show()
```

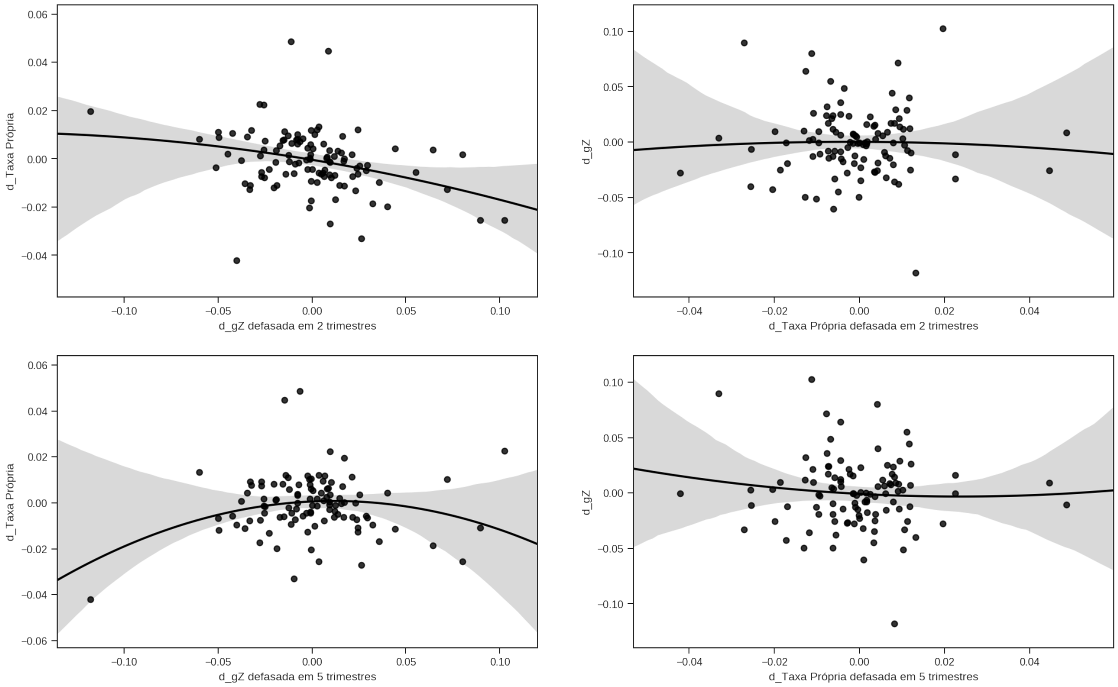





0.015
0.010
0.005
0.000
−0.005
−0.010
d_gZ
−0.04
−0.02
0.00
0.02
0.04
0.06
d_gZ

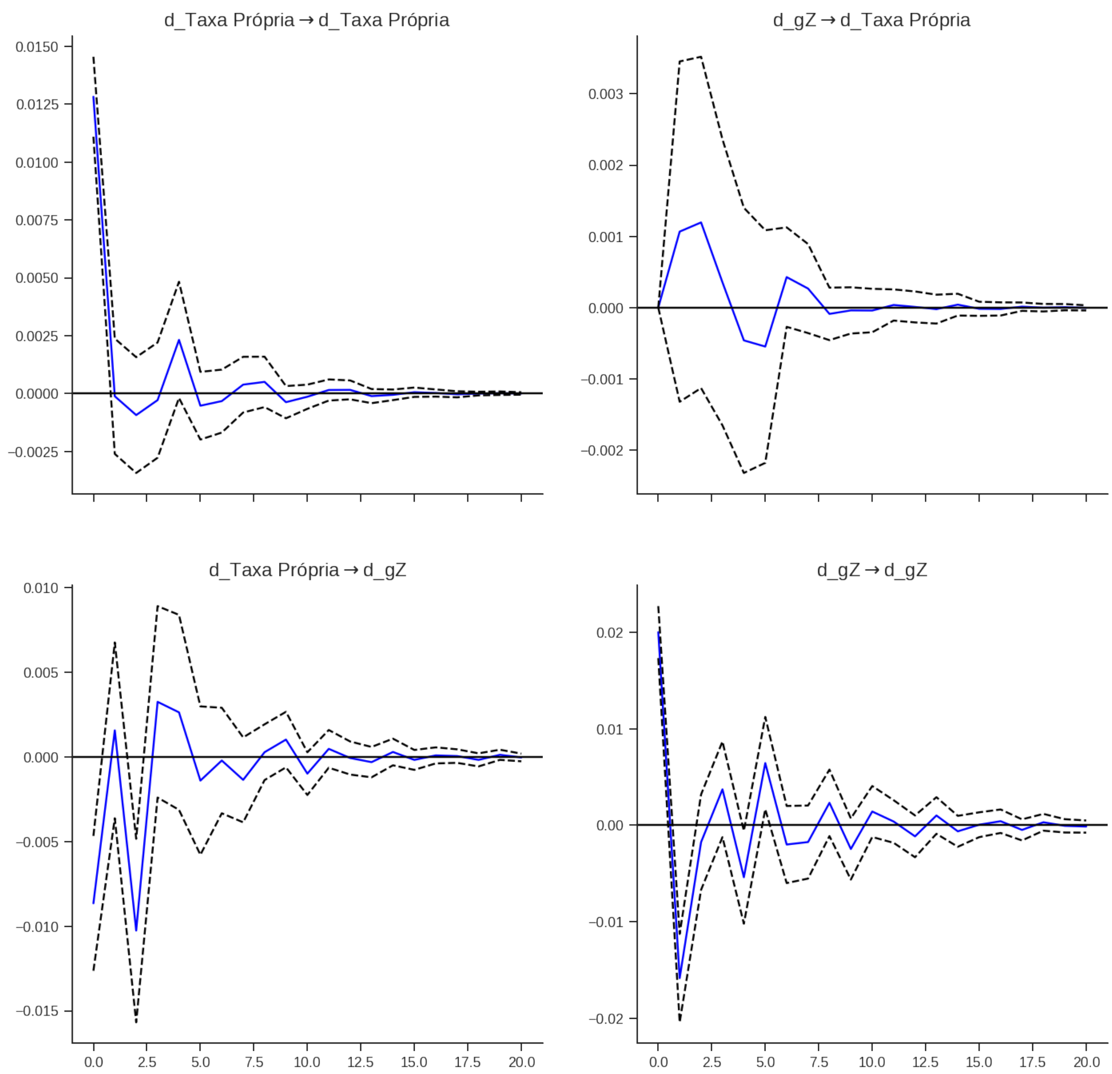

0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
d_gZ
−0.04
−0.02
0.00
0.02
0.04
0.06
d_gZ(-1)

[36]:
```
plot_lags(results=results)
```



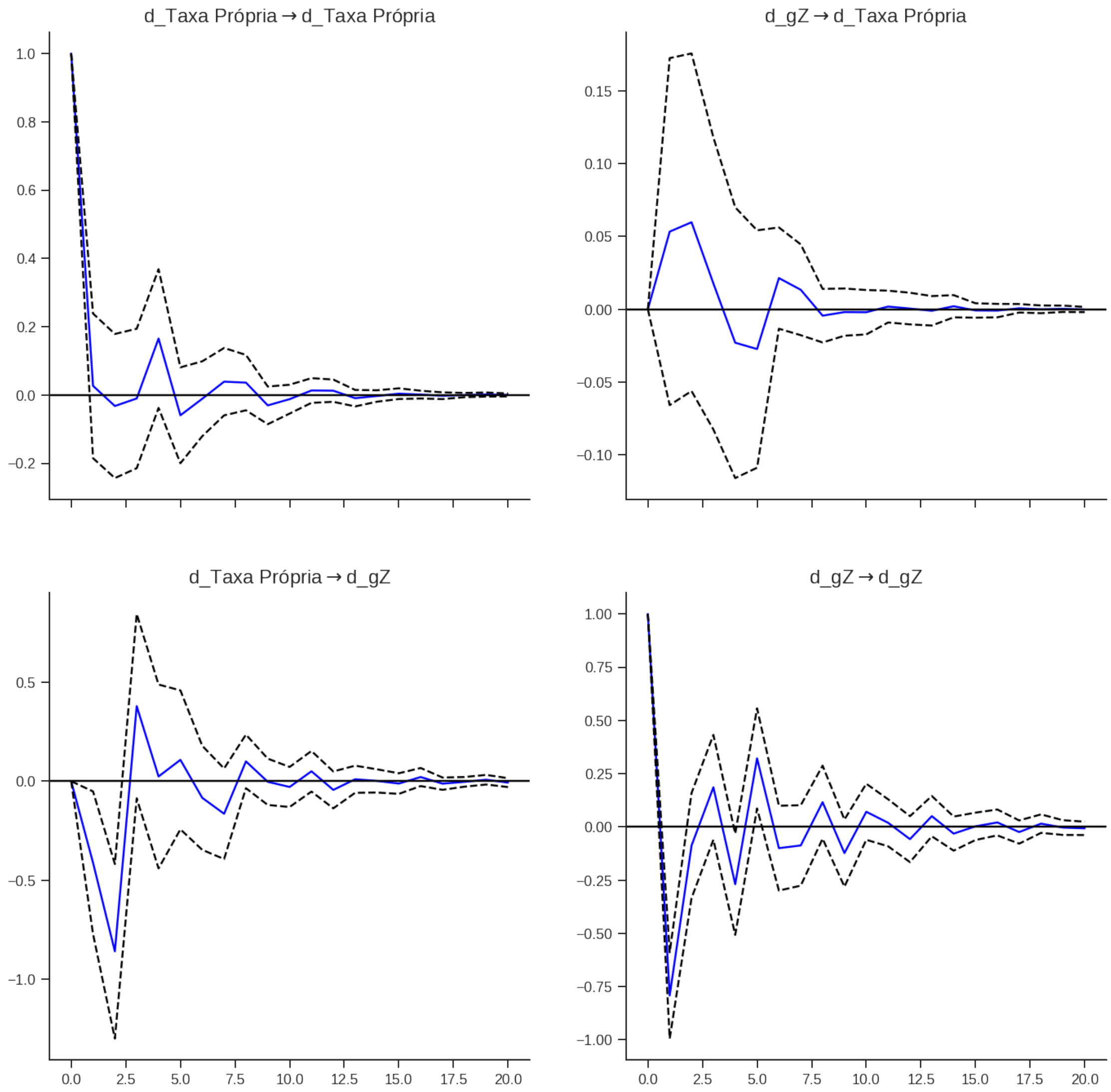
11.6 Função resposta ao impulso ortogonalizada

[37]:
```
p = results.irf(20).plot(orth=True)
p.suptitle("")
sns.despine()
plt.show()
p.savefig("./figs/Impulso_Orth.png", dpi = 300)
```



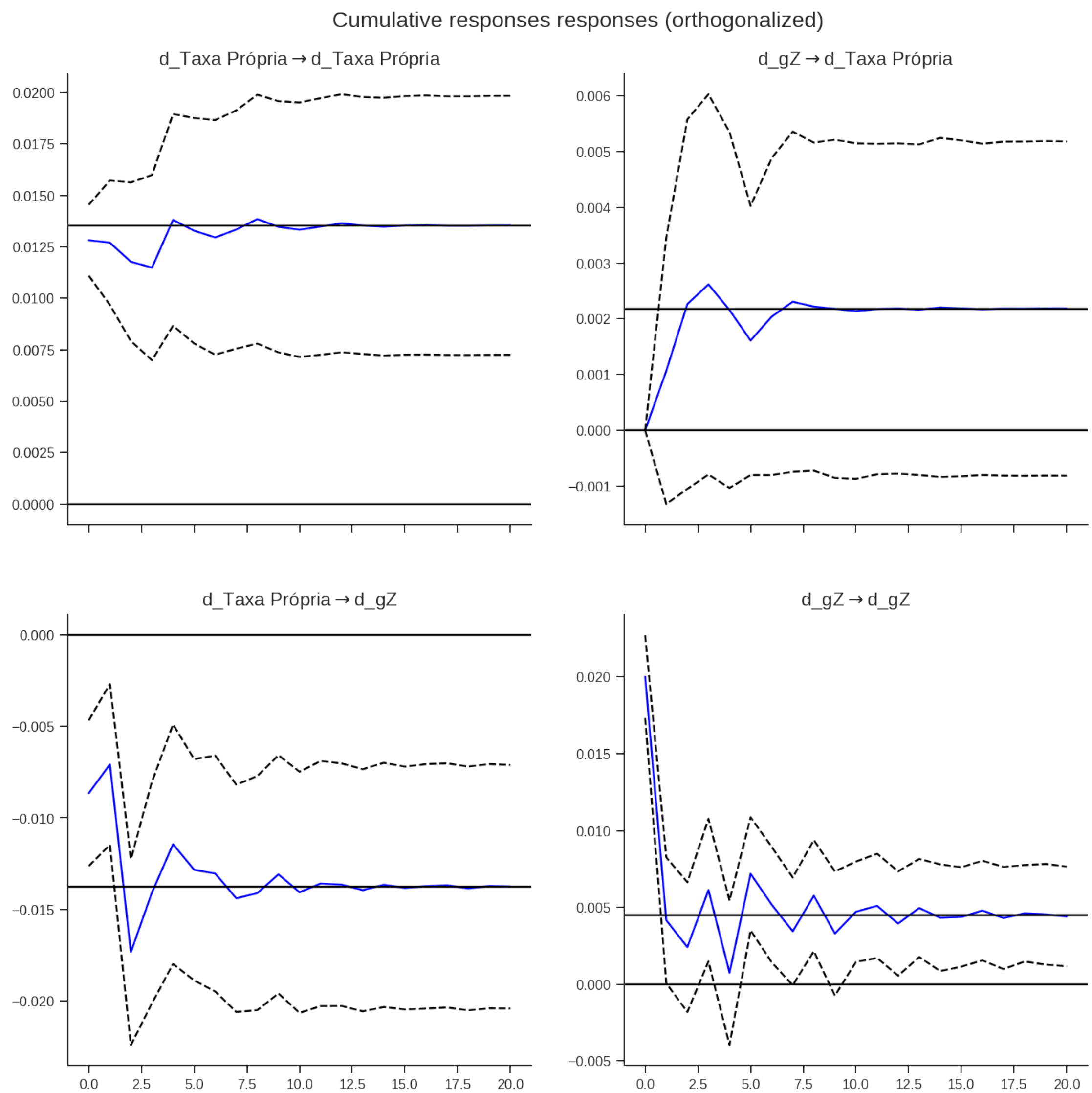
11.7 Função resposta ao impulso não-ortogonalizada

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



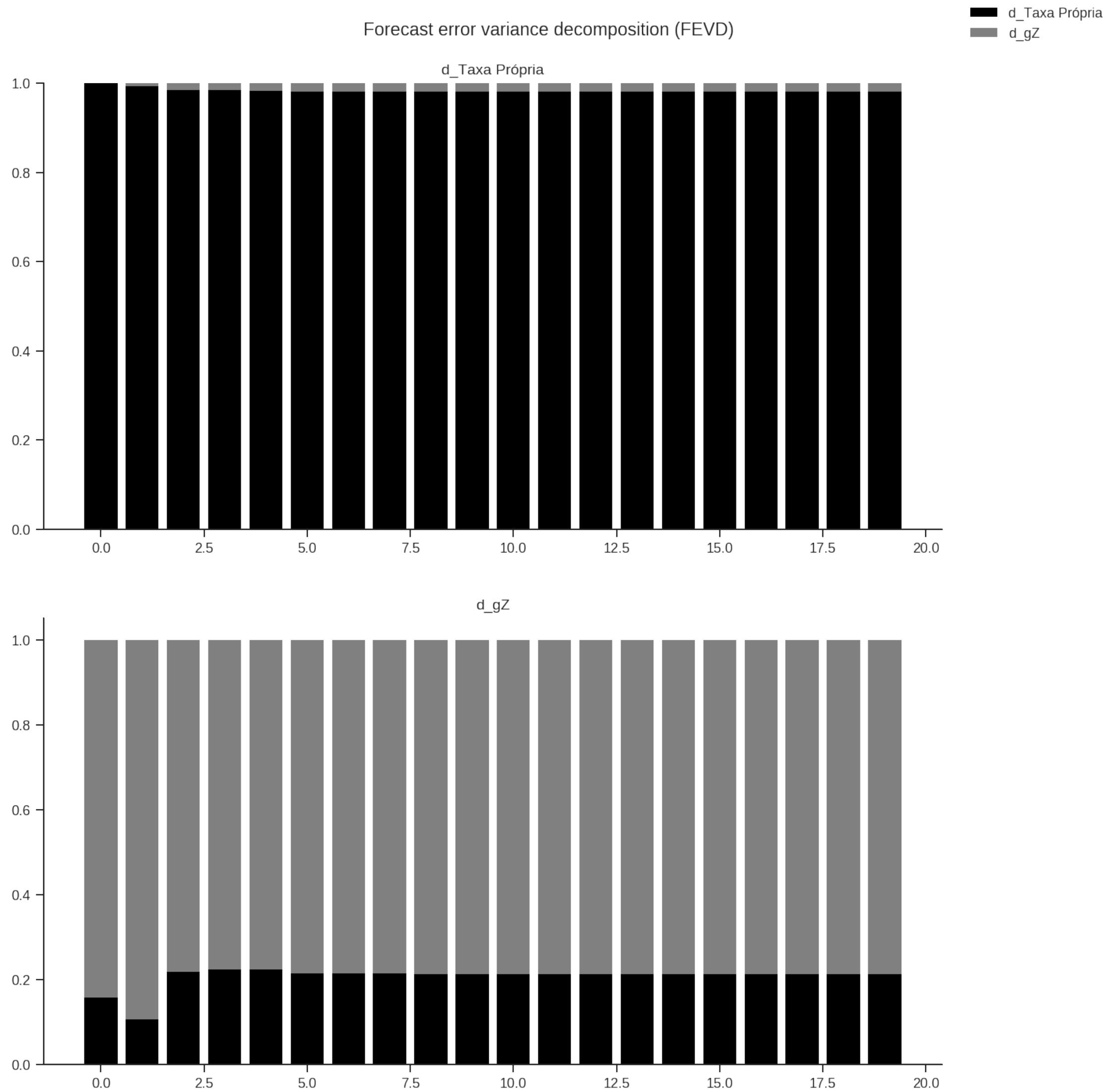
11.8 Efeito cumulativo

[39]:
```
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

[40]:
```
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
1.0
0.8
0.6
0.4
0.2
0.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
d_gZ
1.0
0.8
0.6
0.4
0.2
0.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0