MSP projekt Matej Mištík - xmisti00 - streda 8:00

```python
import pandas as pd
from scipy import stats

pd.set_option('display.max_columns', 500)
pd.set_option('display.width', 1000)

df = pd.read_excel('./MSP_Projekt_2022-23_Zadani_St_8 (1).xlsx', sheet_name='Úkol 1')
df = df.dropna()
df = df.rename(columns={'Unnamed: 0': ''})
df2 = df.copy()
#
# merge columns of Praha and Brno

df2['Praha'] = df2['Praha'].astype(int)
df2['Brno'] = df2['Brno'].astype(int)
df2['Praha'] = df2['Praha'] + df2['Brno']
df2 = df2.drop(columns=['Brno'])
df2 = df2.rename(columns={'Praha': 'Vetsi_mesta'})

# merge columns of Znojmo Tišnov

df2['Znojmo'] = df2['Znojmo'].astype(int)
df2['Tišnov'] = df2['Tišnov'].astype(int)
df2['Znojmo'] = df2['Znojmo'] + df2['Tišnov']
df2 = df2.drop(columns=['Tišnov'])
df2 = df2.rename(columns={'Znojmo': 'Mala_mesta'})

# merge forth, fifth, sixth column

df2['Rokytnice nad Jizerou'] = df2['Rokytnice nad Jizerou'].astype(int)
df2['Jablunkov'] = df2['Jablunkov'].astype(int)
df2['Dolní Věstonice'] = df2['Dolní Věstonice'].astype(int)
df2['Rokytnice nad Jizerou'] = df2['Rokytnice nad Jizerou'] + df2['Jablunkov'] + df2['Dolní Věstonice']
df2 = df2.drop(columns=['Jablunkov', 'Dolní Věstonice'])
df2 = df2.rename(columns={'Rokytnice nad Jizerou': 'obce'})
```

```python
print('Datova sada, s ktorou budeme pracovať v ulohách 1a až 1c:')
df
```

```
Datova sada, s ktorou budeme pracovať v ulohách 1a až 1c:
```

		Praha	Brno	Znojmo	Tišnov	Rokytnice nad Jizerou	Jablunkov	Dolní Věstonice	okolí studenta
0	počet respondentů	1327.0	915.0	681.0	587.0	284.0	176.0	215.0	20.0
1	zimní čas	510.0	324.0	302.0	257.0	147.0	66.0	87.0	4.0
2	letní čas	352.0	284.0	185.0	178.0	87.0	58.0	65.0	9.0
3	střídání časů	257.0	178.0	124.0	78.0	44.0	33.0	31.0	4.0
4	nemá názor	208.0	129.0	70.0	74.0	6.0	19.0	32.0	2.0

```python
print('Datova sada, s ktorou budeme pracovať v ulohách 1d až 1f:')
df2
```

```
Datova sada, s ktorou budeme pracovať v ulohách 1d až 1f:
```

		Vetsi_mesta	Mala_mesta	obce	okolí studenta
0	počet respondentů	2242	1268	675	20.0
1	zimní čas	834	559	300	4.0
2	letní čas	636	363	210	9.0
3	střídání časů	435	202	108	4.0
4	nemá názor	337	144	57	2.0

BOD 1

Hypotézy

1.a

H0 : percentuálne zastúpenie obyvateľov pre zimný čas je rovnaký pre všetky mesta

H1 : percentuálne zastúpenie obyvateľov pre zimný čas je rôzny pre všetky mesta

1.b

H0 : percentuálne zastúpenie obyvateľov pre letný čas je rovnaký pre všetky mestá

H1 : percentuálne zastúpenie obyvateľov pre letný čas je rôzny pre všetky mestá

1.c

H0 : percentuálne zastúpenie obyvateľov pre striedanie časov je rovnaký pre všetky mestá

H1 : percentuálne zastúpenie obyvateľov pre striedanie časov je rôzny pre všetky mestá

```python
# A - zimny, B - letny , C - striedanie casov
alpha = 0.05
# sum of first row
sumForEveryRow = df.sum(axis=1,numeric_only=True)
print('SUM of every row:')
print(sumForEveryRow)
print('-----------------------------------')

# cycle trough list of sumForEveryRow
optionsList = ['A','B','C']
for i in range(1,4):
    print('Option:',optionsList[i-1])
    p = sumForEveryRow[i]/ sumForEveryRow[0]
    print('probability:',p)
    values = df.iloc[0,1:].values

    print('Observed frequencies in each category:',values)
    # create list of expected values for every column

    expectedValues = []
    for j in range(0,8):
        expectedValues.append(values[j] * p)
    print('Expected frequencies in each category:',expectedValues)

    T, p = stats.chisquare(f_obs = df.iloc[i].values[1:,], f_exp = expectedValues,ddof=1)

    print('chisq:',T)
    print('The p-value of the test:',p)
    print('H0 is rejected' if p < alpha else 'H0 is not rejected')
    print('-----------------------------------')
```

```
SUM of every row:
0    4205.0
1    1697.0
2    1218.0
3     749.0
4     540.0
dtype: float64
-----------------------------------
Option: A
probability: 0.4035671819262782
Observed frequencies in each category: [1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
Expected frequencies in each category: [535.5336504161712, 369.2639714625446, 274.8292508917955, 236.89393579072532, 114.61307966706302, 71.02782401902496, 86.76694411414982, 8.071343638525564]
chisq: 22.720476798835556
The p-value of the test: 0.0008957117744714648
H0 is rejected
-----------------------------------
Option: B
probability: 0.2896551724137931
Observed frequencies in each category: [1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
Expected frequencies in each category: [384.3724137931035, 265.0344827586207, 197.25517241379313, 170.02758620689656, 82.26206896551724, 50.97931034482759, 62.27586206896552, 5.793103448275863]
chisq: 8.3529705718337
The p-value of the test: 0.2133672661064076
H0 is not rejected
-----------------------------------
Option: C
probability: 0.17812128418549347
Observed frequencies in each category: [1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
Expected frequencies in each category: [236.36694411414985, 162.98097502972652, 121.30059453032105, 104.55719381688466, 50.58644470868015, 31.34934601664685, 38.2960760998811, 3.5624256837098693]
chisq: 12.378916461699824
The p-value of the test: 0.05403021733299772
H0 is not rejected
-----------------------------------
```

Vyhodnotenie Hypotéz

1.a

H0 : percentuálne zastúpenie obyvateľov pre zimný čas je rovnaký pre všetky mestá - **zamieta sa**

1.b

H0 : percentuálne zastúpenie obyvateľov pre letný čas je rovnaký pre všetky mestá - **nezamieta sa**

1.c

H0 : percentuálne zastúpenie obyvateľov pre striedanie časov je rovnaký pre všetky mestá - **nezamieta sa**

Tabuľka hodnôt pre úlohy 1.d až 1.f

```python
# Tabulka pre ulohy 1d až 1f
df2
```

		Vetsi_mesta	Mala_mesta	obce	okolí studenta
0	počet respondentů	2242	1268	675	20.0
1	zimní čas	834	559	300	4.0
2	letní čas	636	363	210	9.0
3	střídání časů	435	202	108	4.0
4	nemá názor	337	144	57	2.0

Hypotézy D, E

1.d

H0 : percentuálne zastúpenie obyvateľov pre zimný čas je rovnaký pre vsetky zastúpenie miest

H1 : percentuálne zastúpenie obyvateľov pre zimný čas je rôzny pre vsetky zastúpenie miest

1.e

H0 : percentuálne zastúpenie nerozhodnutných obyvateľov je rovnaký pre všetky zastúpenie miest

H1 : percentuálne zastúpenie nerozhodnutných obyvateľov je rôzny pre všetky zastúpenie miest

```python
#D, E nova tabula bez okolia studenta , len 3 hodnoty
sumForEveryRow = df2.sum(axis=1,numeric_only=True)
print('SUM of every row:')
print(sumForEveryRow)
print('-----------------------------------')
# cycle trough list of sumForEveryRow
x = [1,4] # zimny cas a nema nazor
optionsList = ['D','','','E']
for i in x:
    print('Option:',optionsList[i-1])
    p = sumForEveryRow[i]/ sumForEveryRow[0]
    print('probability:',p)
    values = df.iloc[0,1:].values

    print('Observed frequencies in each category:',values)
    # create list of expected values for every column

    expectedValues = []
    for j in range(0,8):
        expectedValues.append(values[j] * p)
    print('Expected frequencies in each category:',expectedValues)

    T, p = stats.chisquare(f_obs = df.iloc[i].values[1:,], f_exp = expectedValues,ddof=1)

    print('chisq:',T)
    print('The p-value of the test:',p)
    print('H0 is rejected' if p < alpha else 'H0 is not rejected')
    print('-----------------------------------')
```

```
SUM of every row:
0    4205.0
1    1697.0
2    1218.0
3     749.0
4     540.0
dtype: float64
-----------------------------------
Option: D
probability: 0.4035671819262782
Observed frequencies in each category: [1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
Expected frequencies in each category: [535.5336504161712, 369.2639714625446, 274.8292508917955, 236.89393579072532, 114.61307966706302, 71.02782401902496, 86.76694411414982, 8.071343638525564]
chisq: 22.720476798835556
The p-value of the test: 0.0008957117744714648
H0 is rejected
-----------------------------------
Option: E
probability: 0.12841854934601665
Observed frequencies in each category: [1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
Expected frequencies in each category: [170.4114149821641, 117.50297265160523, 87.45303210463734, 75.38168846611177, 36.47086801426873, 22.60166468489893, 27.60998810939358, 2.568370986920333]
chisq: 39.78016680405891
The p-value of the test: 5.031424182862881e-07
H0 is rejected
-----------------------------------
```

Vyhodnotenie Hypotéz

1.d

H0 : percentuálne zastúpenie obyvateľov pre zimný čas je rovnaký pre vsetky zastúpenie miest - **zamieta sa**

1.e

H0 : percentuálne zastúpenie nerozhodnutných obyvateľov je rovnaký pre všetky zastúpenie miest - **zamieta sa**

Hypotéza F pre alfa = 0.1

1.f

H0 : Okolie študenta je podobné veľkým mestám

H1 : Okolie študenta je podobné malým mestám

H2 : Okolie študenta je podobné obciam

```python
sumForEveryRow = df2.sum(axis=1,numeric_only=True)
print('SUM of every row:')
print(sumForEveryRow)
print('-----------------------------------')

# create variable for p1, p2 in cycle

# cycle trough list of sumForEveryRow
alpha = 0.1
for i in range(1,4):
    p = sumForEveryRow[i]/ sumForEveryRow[0]
    print('probability:',p)
    values = df.iloc[0,1:].values

    print(values)
    # create list of expected values for every column

    expectedValues = []
    for j in range(0,8):
        expectedValues.append(values[j] * p)
    print(expectedValues)


    T, p = stats.chisquare(f_obs = df.iloc[i].values[1:,], f_exp = expectedValues,ddof=1)

    print('chisq:',T)
    print('The p-value of the test:',p)
    print('H{} is rejected'.format(i) if p < alpha else 'H{} is not rejected'.format(i))
    print('-----------------------------------')
```

```
SUM of every row:
0    4205.0
1    1697.0
2    1218.0
3     749.0
4     540.0
dtype: float64
-----------------------------------
probability: 0.4035671819262782
[1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
[535.5336504161712, 369.2639714625446, 274.8292508917955, 236.89393579072532, 114.61307966706302, 71.02782401902496, 86.76694411414982, 8.071343638525564]
chisq: 22.720476798835556
The p-value of the test: 0.0008957117744714648
H1 is rejected
-----------------------------------
probability: 0.2896551724137931
[1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
[384.3724137931035, 265.0344827586207, 197.25517241379313, 170.02758620689656, 82.26206896551724, 50.97931034482759, 62.27586206896552, 5.793103448275863]
chisq: 8.3529705718337
The p-value of the test: 0.2133672661064076
H2 is not rejected
-----------------------------------
probability: 0.17812128418549347
[1327.0 915.0 681.0 587.0 284.0 176.0 215.0 20.0]
[236.36694411414985, 162.98097502972652, 121.30059453032105, 104.55719381688466, 50.58644470868015, 31.34934601664685, 38.2960760998811, 3.5624256837098693]
chisq: 12.378916461699824
The p-value of the test: 0.05403021733299772
H3 is rejected
-----------------------------------
```

Vyhodnotenie Hypotézy F

1.f

H0 : Okolie študenta je podobné veľkým mestám - zamieta sa

H1 : Okolie študenta je podobné malým mestám - nezamieta sa

H2 : Okolie študenta je podobné obciam - zamieta sa

Okolie študenta je **podobné malým mestám**

BOD 2

```python
import numpy as np
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D
import statsmodels.api as sm
import scipy.stats as stats
from statsmodels.formula.api import ols

data = pd.read_excel('./MSP_Projekt_2022-23_Zadani_St_8 (1).xlsx', sheet_name='Úkol 2 - Data')
xi = np.array(pd.DataFrame(data, columns=['xi']))
yi = np.array(pd.DataFrame(data,columns=['yi']))
zi = np.array(pd.DataFrame(data,columns=['zi']))
xi = xi.ravel()
yi = yi.ravel()
zi = zi.ravel()
```

2.a

Určenie vhodného modelu

```python
#ANOVA
model = ols('zi ~ yi + I(yi**2) + xi + I(xi**2) + (xi*yi)',data = data).fit()
at = sm.stats.anova_lm(model,typ=2)
print(at)
print(model.summary())
model.pvalues
for i in range(0,6):
    print('H{} is rejected'.format(i) if model.pvalues[i] < 0.05 else 'H{} is not rejected'.format(i))
```

```
                 sum_sq    df         F    PR(>F)
yi           7055.714163   1.0  0.717120  0.400246
I(yi ** 2)  25369.316298   1.0  2.578454  0.113251
xi          10197.367669   1.0  1.036427  0.312487
I(xi ** 2)  32371.389818   1.0  3.290122  0.074386
xi:yi        8469.528042   1.0  0.860815  0.356997
Residual   629693.666965  64.0       NaN       NaN
                            OLS Regression Results
==============================================================================
Dep. Variable:                     zi   R-squared:                       0.580
Model:                            OLS   Adj. R-squared:                  0.547
Method:                 Least Squares   F-statistic:                     17.64
Date:                Sun, 11 Dec 2022   Prob (F-statistic):           6.00e-11
Time:                        18:20:36   Log-Likelihood:                -417.98
No. Observations:                  70   AIC:                             848.0
Df Residuals:                      64   BIC:                             861.5
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept     32.7964     47.479      0.691      0.492     -62.053     127.646
yi           -16.0296     13.982     -1.146      0.256     -43.962      11.903
I(yi ** 2)    -1.9784      1.232     -1.606      0.113      -4.440       0.483
xi            -9.5729      7.408     -1.292      0.201     -24.372       5.226
I(xi ** 2)     0.5993      0.330      1.814      0.074      -0.061       1.259
xi:yi          0.5170      0.557      0.928      0.357      -0.596       1.630
==============================================================================
Omnibus:                        1.449   Durbin-Watson:                   2.122
Prob(Omnibus):                  0.485   Jarque-Bera (JB):                1.473
Skew:                          -0.283   Prob(JB):                        0.479
Kurtosis:                       2.571   Cond. No.                         839.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
H0 is not rejected
H1 is not rejected
H2 is not rejected
H3 is not rejected
H4 is not rejected
H5 is not rejected
```

Zjednodušenie na submodel odobratím dvoch najväčších hodnôt na základe hypotéz

```python
# odhad regresnich parametru je u koeficinetu posledni dva sloupce.
F = np.column_stack((xi**2, yi**2,xi))
F = sm.add_constant(F)
y = zi
model = sm.OLS(y, F).fit()
print(model.summary())
chosen_model = model
koefs = model.params
for i in range(0,4):
    print('H{} is rejected'.format(i) if model.pvalues[i] < 0.05 else 'H{} is not rejected'.format(i))
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.569
Model:                            OLS   Adj. R-squared:                  0.550
Method:                 Least Squares   F-statistic:                     29.06
Date:                Sun, 11 Dec 2022   Prob (F-statistic):           4.29e-12
Time:                        18:20:36   Log-Likelihood:                -418.84
No. Observations:                  70   AIC:                             845.7
Df Residuals:                      66   BIC:                             854.7
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -11.1528     31.853     -0.350      0.727     -74.750      52.444
x1             0.5993      0.329      1.820      0.073      -0.058       1.257
x2            -2.9808      0.341     -8.751      0.000      -3.661      -2.301
x3            -6.9879      6.842     -1.021      0.311     -20.648       6.673
==============================================================================
Omnibus:                        1.526   Durbin-Watson:                   2.109
Prob(Omnibus):                  0.466   Jarque-Bera (JB):                1.526
Skew:                          -0.334   Prob(JB):                        0.466
Kurtosis:                       2.720   Cond. No.                         534.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
H0 is not rejected
H1 is not rejected
H2 is rejected
H3 is not rejected
```

Pre nasledovný submodel vyšiel R-squared a hodnoty p-value najlepšie a bol vybraný ako submodel pre nasledovné úlohy.

```python
# odhad regresnich parametru je u koeficinetu posledni dva sloupce.
F = np.column_stack((xi**2, yi**2))
F = sm.add_constant(F)
y = zi
model = sm.OLS(y, F).fit()
print(model.summary())
chosen_model = model
koefs = model.params
for i in range(0,3):
    print('H{} is rejected'.format(i) if model.pvalues[i] < 0.05 else 'H{} is not rejected'.format(i))
```

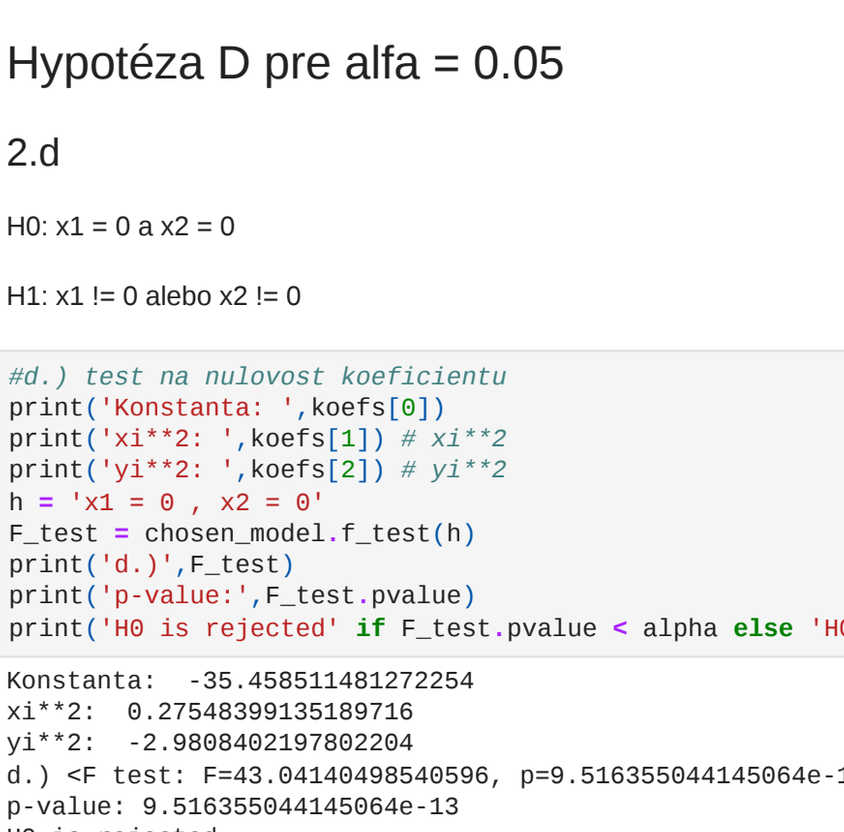
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.562
Model:                            OLS   Adj. R-squared:                  0.549
Method:                 Least Squares   F-statistic:                     43.04
Date:                Sun, 11 Dec 2022   Prob (F-statistic):           9.52e-13
Time:                        18:20:36   Log-Likelihood:                -419.38
No. Observations:                  70   AIC:                             844.8
Df Residuals:                      67   BIC:                             851.5
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -35.4585     21.179     -1.674      0.099     -77.733       6.816
x1             0.2755      0.089      3.090      0.003       0.098       0.453
x2            -2.9808      0.341     -8.748      0.000      -3.661      -2.301
==============================================================================
Omnibus:                        1.531   Durbin-Watson:                   2.074
Prob(Omnibus):                  0.465   Jarque-Bera (JB):                1.553
Skew:                          -0.299   Prob(JB):                        0.460
Kurtosis:                       2.582   Cond. No.                         350.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
H0 is not rejected
H1 is rejected
H2 is rejected
```

2.b

Intervalové odhady

[0.025	0.975]
-77.733	6.816
0.098	0.453
-3.661	-2.301

```python
XY = np.vstack((xi, yi)).T
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.scatter(xi, yi, zi, marker='.', color='red')
ax.set_xlabel("x")
ax.set_ylabel("y")
ax.set_zlabel("z")
poly = PolynomialFeatures(degree=2, include_bias=False)
X_poly = poly.fit_transform(XY)
model = LinearRegression()
model.fit(X_poly, zi)
xs = np.tile(np.arange(20), (20,1))
ys = np.tile(np.arange(20), (20,1)).T
zs = xs**2*koefs[1]+ys**2*koefs[2]+koefs[0]
ax.plot_surface(xs,ys,zs, alpha=0.5)
plt.show()
```



Nestranne odhadovaný rozptyl závislej premennej

2.c

```python
print('nestranny odhadovany rozptyl:',chosen_model.mse_resid)
```

```
nestranny odhadovany rozptyl: 9782.33249013458
```

Hypotéza D pre alfa = 0.05

2.d

H0: x1 = 0 a x2 = 0

H1: x1 != 0 alebo x2 != 0

```python
#d.) test na nulovost koeficientu
print('Konstanta: ',koefs[0])
print('xi**2: ',koefs[1]) # xi**2
print('yi**2: ',koefs[2]) # yi**2
h = 'x1 = 0 , x2 = 0'
F_test = chosen_model.f_test(h)
print('d.)',F_test)
print('p-value:',F_test.pvalue)
print('H0 is rejected' if F_test.pvalue < alpha else 'H0 is not rejected')
```

```
Konstanta:  -35.458511481272254
xi**2:  0.27548399135189716
yi**2:  -2.9808402197802204
d.) <F test: F=43.04140498540596, p=9.516355044145064e-13, df_denom=67, df_num=2>
p-value: 9.516355044145064e-13
H0 is rejected
```

Vyhodnotenie Hypotézy D pre alfa = 0.05

2.d

H0: x1 = 0 a x2 = 0 - **zamieta sa**

Hypotéza E pre alfa = 0.05

2.e

H0: x1 = x2

H1: x1 != x2

```python
#e.) test na rovnost koeficientu
h2 = 'x1 = x2'
T_test = chosen_model.t_test(h2,use_t=True)
print('e.)',T_test)
T_test.pvalue
print('p-value: ',T_test.pvalue)
print('H0 is rejected' if T_test.pvalue < 0.05 else 'H0 is not rejected')
```

```
e.)                              Test for Constraints
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
c0             3.2563      0.352      9.246      0.000       2.553       3.959
==============================================================================
p-value:  1.3926433334245964e-13
H0 is rejected
```

Vyhodnotenie Hypotézy E pre alfa = 0.05

2.e

H0: x1 = x2 - **zamieta sa**