causal_python_pycon2021

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1 Causal Python - PyCon2021 IL

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2.1 Sex Bias in Graduate Admissions: Data From Berkeley

Simpson's Paradox (Confounder Bias) Effect Estimation in 4 Ways: 1. Naive 2. Standarization 3. Regression 4. IPTW

Inspired by a Science paper: P.J. Bickel, E.A. Hammel and J.W. O'Connell (1975). "Sex Bias in Graduate Admissions: Data From Berkeley" (PDF). Science. 187 (4175): 398–404. doi:10.1126/science.187.4175.398. PMID 17835295.

[253]:
```
import pandas as pd
import numpy as np
from io import StringIO
```

[190]:
```
dataset = """Department,Male-Admitted,Male-Denied,Female-Admitted,Female-Denied
A,512,313,89,19
B,313,207,17,8
C,101,205,202,391
D,138,279,131,244
E,40,138,94,299
F,22,351,24,317"""
# from https://raw.githubusercontent.com/hupili/
 ↪python-for-data-and-media-communication-gitbook/master/assets/
 ↪1973-UC-Berkeley-Admission-Data-Synthesis-Data.csv
df = pd.read_csv(StringIO(dataset))
df
```

[190]:

	Department	Male-Admitted	Male-Denied	Female-Admitted	Female-Denied
0	A	512	313	89	19
1	B	313	207	17	8
2	C	101	205	202	391
3	D	138	279	131	244
4	E	40	138	94	299
5	F	22	351	24	317

[195]:
```
def melt_and_duplicate(df):
    """convert the summary stats to raw data where every row is a student"""
    df_melt = df.melt(id_vars='Department',var_name='group', value_name='count')
    df_melt['male'] = df_melt['group'].str.contains('Male')
    df_melt['admitted'] = df_melt['group'].str.contains('Admitted')
    df_list = []
    for i in range(len(df_melt)):
        df_list.append(pd.concat([df_melt.iloc[[i]]] * df_melt.
 ↪iloc[i]['count'], axis=0))
    df_raw = pd.concat(df_list, axis=0)
    df_raw = df_raw.drop(['group', 'count'], axis=1)
    return df_raw
df_raw = melt_and_duplicate(df)
df_raw
```

[195]:

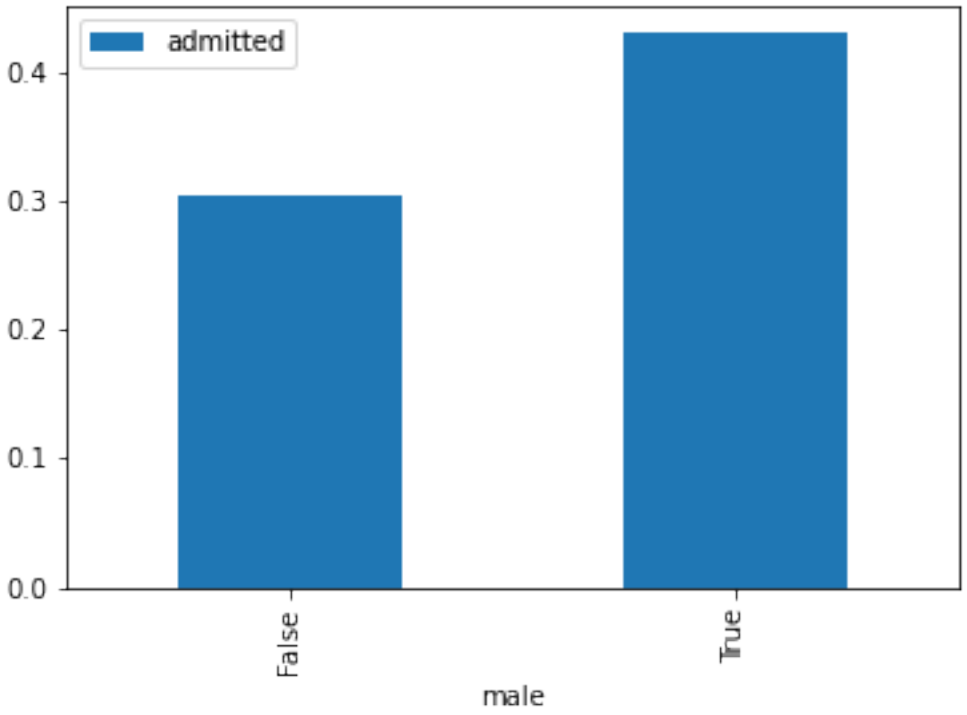
	Department	male	admitted
0	A	True	True
0	A	True	True
0	A	True	True
0	A	True	True
0	A	True	True
..	…	…	…
23	F	False	False
23	F	False	False
23	F	False	False
23	F	False	False
23	F	False	False

[4454 rows x 3 columns]

2.2 Native Approach

[249]:
```
naive_est = df_raw.groupby('male')['admitted'].mean()
naive_est.plot(kind='bar', legend=True)
naive_ate = naive_effect.diff()[1]
print(naive_ate)
```

```
0.1263928553964791
```



2.3 Wrong conclusion: Bias in admission to favour males over females

2.4 Stantarization

[152]:
```
p_x = df_raw.Department.value_counts(normalize=True)
p_x.to_frame()
```

[152]:

	Department
A	0.209475
C	0.201841
D	0.177818
F	0.160305
E	0.128199
B	0.122362

[153]:
```
p_y_x = df_raw.groupby(['Department','male'])['admitted'].mean()
p_y_x = p_y_x.reset_index(level=1)
p_y_x
```

[153]:

Department	male	admitted
A	False	0.824074
A	True	0.620606
B	False	0.680000

```
B            True  0.601923
C           False  0.340641
C            True  0.330065
D           False  0.349333
D            True  0.330935
E           False  0.239186
E            True  0.224719
F           False  0.070381
F            True  0.058981
```

[157]:
```
p_y_x['weighted'] = p_y_x['admitted'] * p_x
```

[247]:
```
stratified_ate = p_y_x.groupby('male').weighted.sum().diff()[1]
print(stratified_ate)
```

```
-0.06126318937738062
```

[165]:
```
stratified_effect.diff()
```

[165]:
```
male
False         NaN
True    -0.061263
Name: weighted, dtype: float64
```

2.5 Regression Adjustment

[171]:
```
from statsmodels.regression.linear_model import OLS
```

[198]:
```
import statsmodels.formula.api as smf
```

[243]:
```
df_raw['y'] = df_raw.admitted.astype('float')
reg_model = smf.ols(formula = 'y ~ male + C(Department)', data=df_raw.
 ↪reset_index()).fit()
reg_ate = reg_model.params['male[T.True]']
reg_model.summary()
```

[243]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.172
Model:                            OLS   Adj. R-squared:                  0.171
Method:                 Least Squares   F-statistic:                     153.9
Date:                Mon, 26 Apr 2021   Prob (F-statistic):          4.25e-178
Time:                        18:38:11   Log-Likelihood:                -2675.4
No. Observations:                4454   AIC:                             5365.
Df Residuals:                    4447   BIC:                             5410.
```

```
Df Model:                           6
Covariance Type:            nonrobust
==============================================================================
======
                           coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
------
Intercept               0.6775      0.020     34.086      0.000       0.639
0.716
male[T.True]           -0.0377      0.015     -2.442      0.015      -0.068
-0.007
C(Department)[T.B]     -0.0360      0.024     -1.512      0.131      -0.083
0.011
C(Department)[T.C]     -0.3276      0.022    -14.707      0.000      -0.371
-0.284
C(Department)[T.D]     -0.3180      0.022    -14.431      0.000      -0.361
-0.275
C(Department)[T.E]     -0.4310      0.025    -17.195      0.000      -0.480
-0.382
C(Department)[T.F]     -0.5934      0.023    -26.193      0.000      -0.638
-0.549
==============================================================================
Omnibus:                     2839.241   Durbin-Watson:                   0.007
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              330.503
Skew:                           0.328   Prob(JB):                     1.71e-72
Kurtosis:                       1.838   Cond. No.                         8.00
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
"""
```

2.6 IPTW

[206]:
```
df_raw['male_float'] = df_raw['male'].astype('float')
propensity_model = smf.ols(formula = 'male_float ~ C(Department)', data =␣
↪df_raw.reset_index()).fit()
```

[214]:
```
p = propensity_model.get_prediction().predicted_mean
```

[244]:
```
iptw_ate = (df_raw['admitted']*(df_raw['male'] -p)/(p*(1-p))).mean()
```

2.7 Summary

[255]:
```
pd.DataFrame({'method':['naive','standartization','regression','IPTW'],
              'ATE':[naive_ate, stratified_ate, reg_ate,iptw_ate]}).
↪set_index('method').plot(kind='barh');
```