

6. We continue to consider the use of a logistic regression model to predict the probability of default using income and balance on the Default data set. In particular, we will now compute estimates for the standard errors of the income and balance logistic regression coefficients in two different ways: (1) using the bootstrap, and (2) using the standard formula for computing the standard errors in the `glm()` function. Do not forget to set a random seed before beginning your analysis.

```
In [13]: import numpy as np
import pandas as pd
import statsmodels.api as sm
from sklearn.utils import resample
```

```
In [2]: df = pd.read_csv('/Volumes/work/sem_1/MTH522/data/Default.csv')
df.head()
```

```
Out[2]:
```

| | default | student | balance | income |
|---|---------|---------|-------------|--------------|
| 0 | No | No | 729.526495 | 44361.625074 |
| 1 | No | Yes | 817.180407 | 12106.134700 |
| 2 | No | No | 1073.549164 | 31767.138947 |
| 3 | No | No | 529.250605 | 35704.493935 |
| 4 | No | No | 785.655883 | 38463.495879 |

```
In [4]: df['default'] = np.where(df['default'] == 'Yes', 1, 0)
df
```

Out[4]:

| | default | student | balance | income |
|------|---------|---------|-------------|--------------|
| 0 | 0 | No | 729.526495 | 44361.625074 |
| 1 | 0 | Yes | 817.180407 | 12106.134700 |
| 2 | 0 | No | 1073.549164 | 31767.138947 |
| 3 | 0 | No | 529.250605 | 35704.493935 |
| 4 | 0 | No | 785.655883 | 38463.495879 |
| ... | ... | ... | ... | ... |
| 9995 | 0 | No | 711.555020 | 52992.378914 |
| 9996 | 0 | No | 757.962918 | 19660.721768 |
| 9997 | 0 | No | 845.411989 | 58636.156984 |
| 9998 | 0 | No | 1569.009053 | 36669.112365 |
| 9999 | 0 | Yes | 200.922183 | 16862.952321 |

10000 rows × 4 columns

(a) Using the `summary()` and `glm()` functions, determine the estimated standard errors for the coefficients associated with income and balance in a multiple logistic regression model that uses both predictors.

```
In [7]: np.random.seed(17)
x = df.iloc[:, 2:]
X = sm.add_constant(x)
Y = df.iloc[:, :1]

model = sm.Logit(Y, X).fit()
model.summary()
```

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```

Out[7]:

Logit Regression Results

| | | | | | | |
|------------------|-----------|------------------|-------------------|-------|------------|----------|
| Dep. Variable: | | default | No. Observations: | | 10000 | |
| Model: | | Logit | Df Residuals: | | 9997 | |
| Method: | | MLE | Df Model: | | 2 | |
| Date: | | Sun, 30 Oct 2022 | Pseudo R-squ.: | | 0.4594 | |
| Time: | | 07:52:46 | Log-Likelihood: | | -789.48 | |
| converged: | | True | LL-Null: | | -1460.3 | |
| Covariance Type: | | nonrobust | LLR p-value: | | 4.541e-292 | |
| | coef | std err | z | P> z | [0.025 | 0.975] |
| const | -11.5405 | 0.435 | -26.544 | 0.000 | -12.393 | -10.688 |
| balance | 0.0056 | 0.000 | 24.835 | 0.000 | 0.005 | 0.006 |
| income | 2.081e-05 | 4.99e-06 | 4.174 | 0.000 | 1.1e-05 | 3.06e-05 |

Possibly complete quasi-separation: A fraction 0.14 of observations can be perfectly predicted. This might indicate that there is complete quasi-separation. In this case some parameters will not be identified.

In [8]: `model.bse['income']`Out[8]: `4.985245461753038e-06`In [9]: `model.bse['balance']`Out[9]: `0.00022738138476844578`In [10]: `print('Coefficient of income and balance is', model.params.values[[1, 2]])`Coefficient of income and balance is `[5.64710295e-03 2.08089755e-05]`**Observation:**

1. The standard error from the model that is generated is 2.27×10^{-4} for "balance" and 4.985×10^{-6} for "income".

(b) Write a function, `boot.fn()`, that takes as input the Default data set as well as an index of the observations, and that outputs the coefficient estimates for income and balance in the multiple logistic regression model.

```
In [11]: def boot_fn(data, obs):
          X = sm.add_constant(data.iloc[:obs, 2:])
          Y = data.iloc[:obs, :1]

          model = sm.Logit(Y, X).fit()

          return model.bse['income'], model.bse['balance']
```

(c) Use the `boot()` function together with your `boot_fn()` function to estimate the standard errors of the logistic regression coefficients for income and balance.

```
In [14]: np.random.seed(312)
income = []
balance = []
for i in range(1000):
    sample = resample(df)
    inc, bal = boot_fn(sample, 7000)
    income.append(inc)
    balance.append(bal)
```

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In [15]: df_error = pd.DataFrame(income, columns=['Income'])
df_error['Balance'] = balance
df_error

```

```

Out[15]:

```

| | Income | Balance |
|-----|----------|----------|
| 0 | 0.000006 | 0.000294 |
| 1 | 0.000005 | 0.000238 |
| 2 | 0.000006 | 0.000252 |
| 3 | 0.000006 | 0.000251 |
| 4 | 0.000006 | 0.000270 |
| ... | ... | ... |
| 995 | 0.000006 | 0.000276 |
| 996 | 0.000006 | 0.000267 |
| 997 | 0.000006 | 0.000255 |
| 998 | 0.000006 | 0.000261 |
| 999 | 0.000006 | 0.000263 |

1000 rows × 2 columns

```

In [17]: print('Standard error of mean for income: ', np.mean(df_error['Income']))
print('Standard error of mean for balance: ', np.mean(df_error['Balance']))

```

```

Standard error of mean for income:  5.986813530229936e-06
Standard error of mean for balance:  0.00027423674240413466

```

(d) Comment on the estimated standard errors obtained using the glm() function and using your bootstrap function.

Observation:

1. Standard error mean after doing bootstrap is almost similar to result what we have got earlier.

```

In [ ]:

```