Assigment 3

This assigment focuses on getting comfortable with working with multidimensional data and linear regression. Key items include:

- Creating random n-dimensional data
- Creating a Model that can handle the data
- Plot a subset of the data along with the prediction
- Using a Dataset to read in and choose certain columns to produce a model
- Create several models from various combinations of columns
- Plot a few of the results

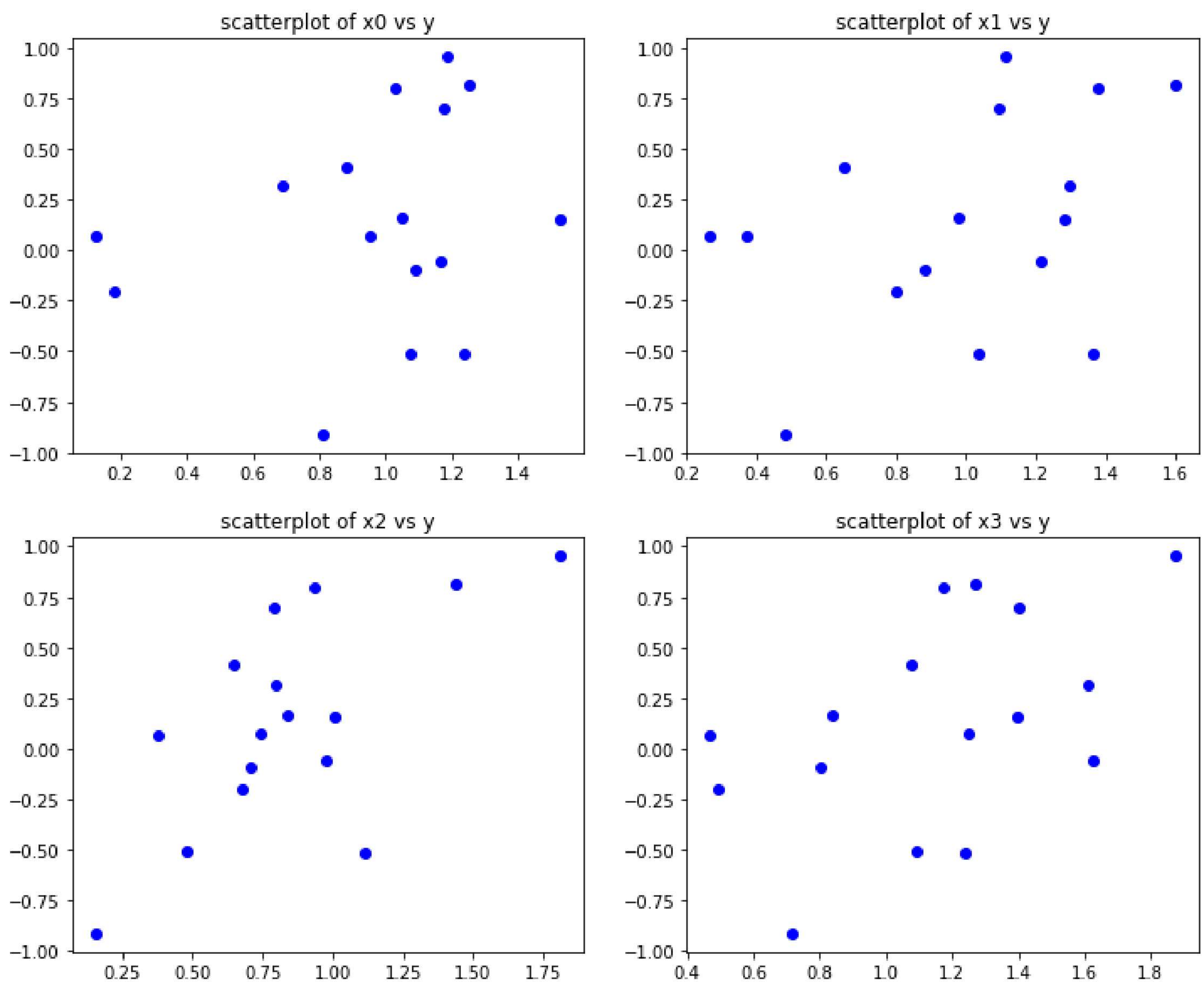
1. Create a 4 dimensional data set with 64 elements and show all 4 scatter 2D plots of the data x_1 vs. y, x_2 vs. y, x_3 vs. y, x_4 vs. y

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

In [15]:
```
n = 16
x = np.linspace(0,1,n) + np.random.rand(4,n)
x = np.vstack([x, np.ones(len(x.T))]).T
y = np.linspace(0,1,n) + np.random.rand(n) - 1
```

In [16]:

```
size_dict = {0: [(0,0)], 1:[(0,1)], 2:[(1,0)], 3:[(1,1)]}
fix, axs = plt.subplots(2,2, figsize = (12,10))
for key, place in size_dict.items():
    axs[place[0]].scatter(x.T[key],y,c="b")
    axs[place[0]].set_title(f"scatterplot of x{key} vs y")
```



2. Create a Linear Regression model (like we did in class) to fit the data. *Use the example from Lesson 3 and do not use a library that calculates automatically*. We are expecting 5 coefficients to describe the linear model.

After creating the model (finding the coefficients), create a new column $y_p = \Sigma\beta_n \cdot x_n$

In [17]:

```
# beta = (left) * (right)
# left = (x.Tx)**-1, right = y.Tx
left = np.linalg.inv(np.dot(x.T,x))
right = np.dot(y.T,x)
beta = np.dot(left, right)
print(f"Derived: {beta}")
beta = np.linalg.lstsq(x,y)[0]
print(f"Solver: {beta}")
```

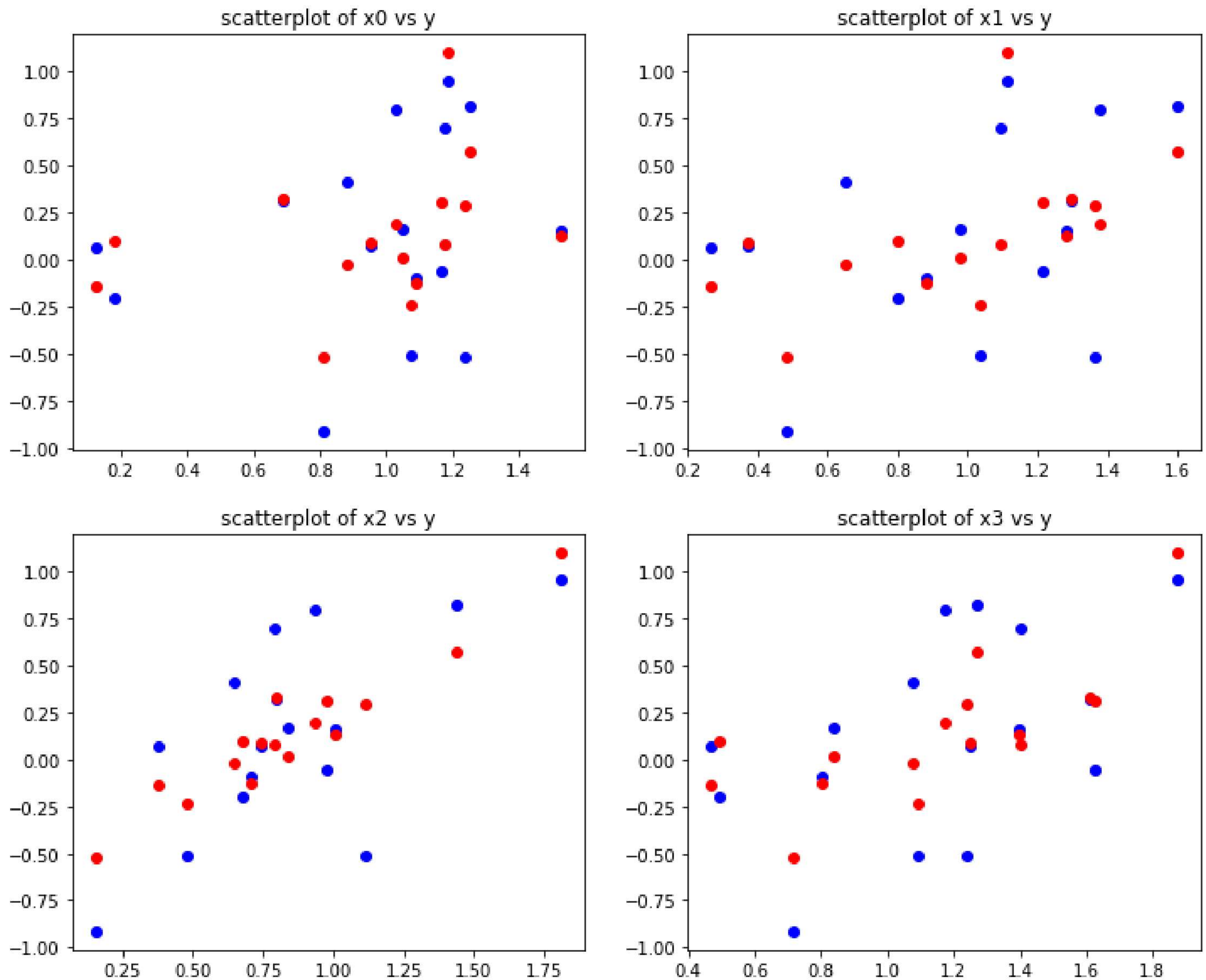
```
Derived: [-0.37275214 -0.01380851  0.86877716  0.28422048 -0.55106865]
Solver: [-0.37275214 -0.01380851  0.86877716  0.28422048 -0.55106865]

C:\Users\gdlev\AppData\Local\Temp\ipykernel_9128\250170633.py:7: FutureWarning: `rcond` parameter will chan
ge to the default of machine precision times ``max(M, N)`` where M and N are the input matrix dimensions.
To use the future default and silence this warning we advise to pass `rcond=None`, to keep using the old, e
xplicitly pass `rcond=-1`.
  beta = np.linalg.lstsq(x,y)[0]
```

In [18]:
```
pred = np.dot(x,beta)
```

3. Plot the model's prediction as a different color on top of the scatter plot from Q1 in 2D for all 4 of the dimensions ($x_1 \rightarrow y_p, x_2 \rightarrow y_p, x_3 \rightarrow y_p, x_4 \rightarrow y_p$)

In [19]:

```
fix, axs = plt.subplots(2,2, figsize = (12,10))
for key, place in size_dict.items():
    axs[place[0]].scatter(x.T[key],y,c="b")
    axs[place[0]].scatter(x.T[key],pred,c="r")
    axs[place[0]].set_title(f"scatterplot of x{key} vs y")
```



4. Read in `mlnn/data/Credit.csv` with Pandas and build a Linear Regression model to predict Credit Rating (`Rating`). Use only the numeric columns in your model, but feel free to experiment which which columns you believe are better predicters of Credit Rating (Column `Rating`)

In [20]:

```
import pandas as pd
import numpy as np
credit = pd.read_csv('../data/Credit.csv')
credit.head()
```

Out[20]:

	Unnamed: 0	Income	Limit	Rating	Cards	Age	Education	Gender	Student	Married	Ethnicity	Balance
0	1	14.891	3606	283	2	34	11	Male	No	Yes	Caucasian	333
1	2	106.025	6645	483	3	82	15	Female	Yes	Yes	Asian	903
2	3	104.593	7075	514	4	71	11	Male	No	No	Asian	580
3	4	148.924	9504	681	3	36	11	Female	No	No	Asian	964
4	5	55.882	4897	357	2	68	16	Male	No	Yes	Caucasian	331

Choose multiple columns as inputs beyond `Income` and `Limit` but clearly, don't use `Rating`

In [21]:
```
columns = ['Income', 'Limit', 'Cards', 'Age', 'Education','Balance']
X = credit[columns].values

X = np.vstack([X.T, np.ones(len(X))]).T
X
```

Out[21]:
```
array([[1.48910e+01, 3.60600e+03, 2.00000e+00, ..., 1.10000e+01,
         3.33000e+02, 1.00000e+00],
        [1.06025e+02, 6.64500e+03, 3.00000e+00, ..., 1.50000e+01,
         9.03000e+02, 1.00000e+00],
        [1.04593e+02, 7.07500e+03, 4.00000e+00, ..., 1.10000e+01,
         5.80000e+02, 1.00000e+00],
        ...,
        [5.78720e+01, 4.17100e+03, 5.00000e+00, ..., 1.20000e+01,
         1.38000e+02, 1.00000e+00],
        [3.77280e+01, 2.52500e+03, 1.00000e+00, ..., 1.30000e+01,
         0.00000e+00, 1.00000e+00],
        [1.87010e+01, 5.52400e+03, 5.00000e+00, ..., 7.00000e+00,
         9.66000e+02, 1.00000e+00]])
```

In [22]:
```
y = credit['Rating']
y
```

Out[22]:
```
0      283
1      483
2      514
3      681
4      357
      ...
395    307
396    296
397    321
398    192
399    415
Name: Rating, Length: 400, dtype: int64
```

5. Plot your results using scatter plots (just like in class). Show as many of your columns vs. credit rating that you can.

In [23]:
```
new_dict = {0: [(0,0)], 1:[(0,1)], 2:[(1,0)], 3:[(1,1)], 4:[(2,0)], 5:[(2,1)]}
for key, value in new_dict.items():
    new_dict[key].append(columns[key])
new_dict
```

Out[23]:
```
{0: [(0, 0), 'Income'],
 1: [(0, 1), 'Limit'],
 2: [(1, 0), 'Cards'],
 3: [(1, 1), 'Age'],
 4: [(2, 0), 'Education'],
 5: [(2, 1), 'Balance']}
```

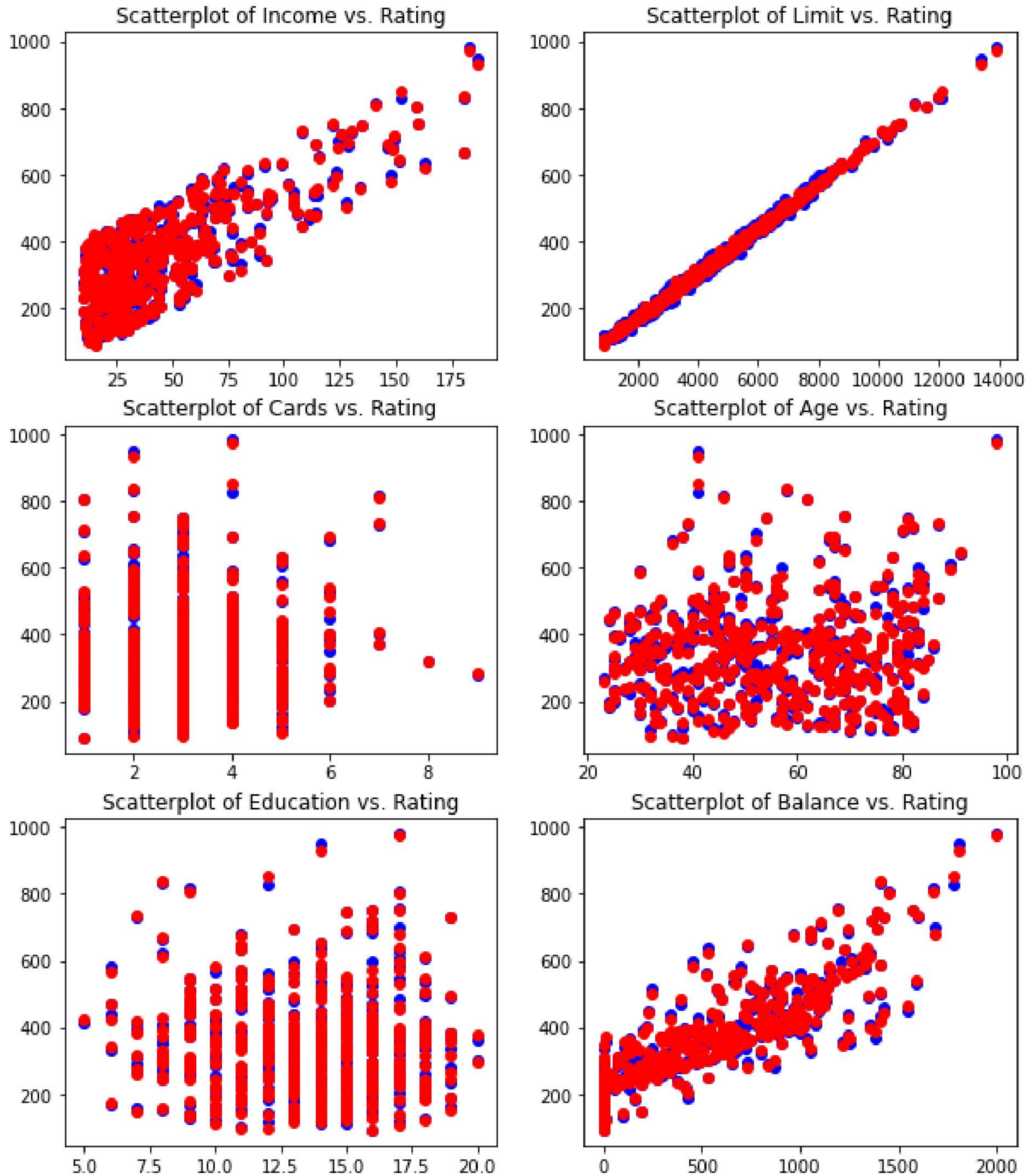
In [24]:
```
beta = np.linalg.lstsq(X,y)[0]
print(f"Solver: {beta}")
left = np.linalg.inv(np.dot(X.T,X))
right = np.dot(y.T,X)
beta = np.dot(left, right)
print(f"Derived: {beta}")
```

```
Solver: [ 9.48157743e-02  6.42304413e-02  4.67706085e+00  8.06617460e-03
 -2.30863025e-01  8.18115721e-03  3.10522106e+01]
Derived: [ 9.48157743e-02  6.42304413e-02  4.67706085e+00  8.06617460e-03
 -2.30863025e-01  8.18115721e-03  3.10522106e+01]

C:\Users\gdlev\AppData\Local\Temp\ipykernel_9128\426998610.py:1: FutureWarning: `rcond` parameter will chan
ge to the default of machine precision times ``max(M, N)`` where M and N are the input matrix dimensions.
To use the future default and silence this warning we advise to pass `rcond=None`, to keep using the old, e
xplicitly pass `rcond=-1`.
  beta = np.linalg.lstsq(X,y)[0]
```

In [25]:
```
pred = np.dot(X,beta)
```

In [26]:

```
fig, axs = plt.subplots(3,2, figsize = (10,12))
for key, value in new_dict.items():
    axs[value[0]].scatter(X[:,key],y, c="b")
    axs[value[0]].scatter(X[:,key],pred, c="r")
    axs[value[0]].set_title(f"Scatterplot of {value[1]} vs. Rating")
```


Scatterplot of Income vs. Rating
1000
800
600
400
200
25 50 75 100 125 150 175
Scatterplot of Limit vs. Rating
2000 4000 6000 8000 10000 12000 14000
Scatterplot of Cards vs. Rating
2 4 6 8
Scatterplot of Age vs. Rating
20 40 60 80 100
Scatterplot of Education vs. Rating
5.0 7.5 10.0 12.5 15.0 17.5 20.0
Scatterplot of Balance vs. Rating
0 500 1000 1500 2000