Appendix

In [ ]:

In [312…
```
from matplotlib import pyplot as plt
from sklearn import datasets
from sklearn.tree import DecisionTreeClassifier
from sklearn import tree
```

In [313…
```
import statsmodels.api as sm
import patsy
```

Read in the data

In [349…
```
import pandas as pd
df = pd.read_csv('https://query.data.world/s/lxnrwj5w73bsigranne42td54f54sm', in
```

```
/opt/anaconda3/lib/python3.8/site-packages/IPython/core/interactiveshell.py:316
5: DtypeWarning: Columns (29,30,31,32) have mixed types.Specify dtype option on
import or set low_memory=False.
  has_raised = await self.run_ast_nodes(code_ast.body, cell_name,
```

In [350…
```
df["state"].value_counts(normalize=True)
```

Out[350…
```
failed        0.553315
successful    0.291683
canceled      0.119232
live          0.024622
suspended     0.011148
Name: state, dtype: float64
```

Drop Unnecessary Columns

In [351…
```
# drop columns that we don't think will be useful
df["goal"] = df["goal"] * df["static_usd_rate"]
df["isUS"] = df["country"].apply(lambda c: 1 if c == "US" else 0).astype("catego
df["pledge_per_backer"] = df["usd_pledged"] / df["backers_count"]
df = df[df["state"] != "live"]
df = df.drop(
    [
        "id",
        "photo",
        "name",
        "blurb",
        "pledged",
        "slug",
        "state_changed_at",
        "creator",
        "location",
```

```
        "profile",
        "urls",
        "source_url",
        "friends",
        "is_starred",
        "is_backing",
        "permissions",
        "name_len",
        "name_len_clean",
        "state_changed_at_weekday",
        "created_at_weekday",
        "state_changed_at_day",
        "state_changed_at_yr",
        "state_changed_at_hr",
        "created_at_weekday",
        "created_at_yr",
        "created_at_hr",
        "create_to_launch",
        "created_at_month",
        "blurb_len_clean",
        "blurb_len",
        "currency_symbol",
        "currency_trailing_code",
        "created_at",
        "create_to_launch_days",
        "staff_pick",
        "spotlight",
        "usd_pledged",
        "state_changed_at_month",
        "created_at_day",
        "launch_to_state_change",
        "launch_to_state_change_days",
        "launched_at",
        "launch_to_deadline",
        "static_usd_rate",
        "country",
        "currency",
        "deadline",
        "state",
        "USorGB",
        "TOPCOUNTRY",
    ], axis=1)
```

Investigate average pledge amount per backer

In [352…

```
df["pledge_per_backer"].describe()
```

Out[352…

```
count    17318.000000
mean       108.380333
std        197.749285
min          0.471178
25%         25.135714
50%         57.142857
75%        116.355251
max       5000.500000
Name: pledge_per_backer, dtype: float64
```

In [353…

```
df.columns
```

Out[353…
```
Index(['goal', 'disable_communication', 'backers_count', 'category',
       'deadline_weekday', 'launched_at_weekday', 'deadline_month',
       'deadline_day', 'deadline_yr', 'deadline_hr', 'launched_at_month',
       'launched_at_day', 'launched_at_yr', 'launched_at_hr',
       'launch_to_deadline_days', 'SuccessfulBool', 'LaunchedTuesday',
       'DeadlineWeekend', 'isUS', 'pledge_per_backer'],
      dtype='object')
```

In [354…
```
df["category"] = df["category"].astype("category")
```

EDA

In [355…
```
df.head()
```

Out[355…

	goal	disable_communication	backers_count	category	deadline_weekday	launched_a
0	1500.0000	False	0	Academic	Friday	
1	500.0000	False	0	Academic	Friday	
2	100000.0000	False	5	Academic	Thursday	
3	5000.0000	False	0	Academic	Monday	
4	3591.2846	False	17	Academic	Monday	

In [356…
```
df.corr()
```

Out[356…

	goal	disable_communication	backers_count	deadline_month	dea
goal	1.000000	-0.003383	0.006229	0.000255	
disable_communication	-0.003383	1.000000	0.004403	-0.003880	
backers_count	0.006229	0.004403	1.000000	0.004340	
deadline_month	0.000255	-0.003880	0.004340	1.000000	
deadline_day	-0.013641	0.015332	-0.009020	0.016969	
deadline_yr	0.002396	0.035147	-0.018983	-0.213964	
deadline_hr	0.001606	-0.007863	-0.025546	-0.019458	
launched_at_month	0.001955	-0.006452	0.008554	0.532651	
launched_at_day	0.003042	0.015060	0.007889	0.027054	
launched_at_yr	0.000516	0.035762	-0.020998	-0.105063	
launched_at_hr	0.006108	0.005346	-0.049709	-0.027702	
launch_to_deadline_days	0.045165	0.010702	0.021530	-0.026715	
SuccessfulBool	-0.033666	-0.070231	0.194228	0.006702	
LaunchedTuesday	-0.000616	0.009506	0.028621	0.022543	
DeadlineWeekend	-0.007380	0.003879	-0.006962	-0.020890	

	goal	disable_communication	backers_count	deadline_month	dea
pledge_per_backer	0.013624	-0.003644	0.004482	0.020873	

Logistic Regression Model fitting

In [357…

```
y, X = patsy.dmatrices("SuccessfulBool ~  goal  + backers_count   + \
        launch_to_deadline_days + isUS", df, return_type="dataframe")
model0 = sm.Logit(y, X).fit()
print(model0.summary())
print(model0.aic)
```

```
Optimization terminated successfully.
         Current function value: 0.378532
         Iterations 11
                           Logit Regression Results
==============================================================================
Dep. Variable:         SuccessfulBool   No. Observations:                20124
Model:                          Logit   Df Residuals:                    20119
Method:                           MLE   Df Model:                            4
Date:                Fri, 07 Oct 2022   Pseudo R-squ.:                  0.3795
Time:                        21:11:21   Log-Likelihood:                -7617.6
converged:                       True   LL-Null:                       -12277.
Covariance Type:            nonrobust   LLR p-value:                     0.000
==============================================================================
                                 coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
Intercept                  -0.3142      0.068     -4.610      0.000      -0.448
-0.181
isUS[T.1]                   0.0494      0.043      1.145      0.252      -0.035
0.134
goal                    -6.237e-05   1.64e-06    -38.111      0.000   -6.56e-05
-5.92e-05
backers_count               0.0161      0.000     47.262      0.000       0.015
0.017
launch_to_deadline_days    -0.0181      0.002    -10.000      0.000      -0.022
-0.015
==============================================================================

Possibly complete quasi-separation: A fraction 0.11 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
15245.14489293655
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
```

In [358…

```
y, X = patsy.dmatrices("SuccessfulBool ~  goal  + backers_count   + \
       launch_to_deadline_days + isUS  \
         ", df, return_type="dataframe")
model1 = sm.Logit(y, X).fit()
print(model1.summary())
print(model1.aic)
```

```
Optimization terminated successfully.
         Current function value: 0.378532
         Iterations 11
                           Logit Regression Results
==============================================================================
Dep. Variable:         SuccessfulBool   No. Observations:                20124
Model:                          Logit   Df Residuals:                    20119
Method:                           MLE   Df Model:                            4
Date:                Fri, 07 Oct 2022   Pseudo R-squ.:                  0.3795
Time:                        21:11:28   Log-Likelihood:                -7617.6
converged:                       True   LL-Null:                       -12277.
Covariance Type:            nonrobust   LLR p-value:                     0.000
==============================================================================
                                 coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
Intercept                  -0.3142      0.068     -4.610      0.000      -0.448
-0.181
isUS[T.1]                   0.0494      0.043      1.145      0.252      -0.035
0.134
goal                    -6.237e-05   1.64e-06    -38.111      0.000   -6.56e-05
-5.92e-05
backers_count               0.0161      0.000     47.262      0.000       0.015
0.017
launch_to_deadline_days    -0.0181      0.002    -10.000      0.000      -0.022
-0.015
==============================================================================

Possibly complete quasi-separation: A fraction 0.11 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
15245.14489293655
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
```

In [ ]:

In [359…

```
y, X = patsy.dmatrices("SuccessfulBool ~  goal + backers_count + isUS", df, retu
model2 = sm.Logit(y, X).fit()
print(model2.summary())
print(model2.aic)
```

```
Optimization terminated successfully.
         Current function value: 0.381138
         Iterations 11
                           Logit Regression Results
==============================================================================
Dep. Variable:         SuccessfulBool   No. Observations:                20124
Model:                          Logit   Df Residuals:                    20120
Method:                           MLE   Df Model:                            3
Date:                Fri, 07 Oct 2022   Pseudo R-squ.:                  0.3752
Time:                        21:11:31   Log-Likelihood:                -7670.0
converged:                       True   LL-Null:                       -12277.
Covariance Type:            nonrobust   LLR p-value:                     0.000
```

```
==============================================================================
=
                 coef    std err          z      P>|z|      [0.025      0.97
5]
------------------------------------------------------------------------------
-
Intercept        -0.8921      0.038    -23.760      0.000      -0.966      -0.81
9
isUS[T.1]         0.0467      0.043      1.087      0.277      -0.038       0.13
1
goal          -6.403e-05   1.64e-06    -38.970      0.000   -6.72e-05   -6.08e-0
5
backers_count     0.0162      0.000     47.366      0.000       0.015       0.01
7
==============================================================================
=

Possibly complete quasi-separation: A fraction 0.11 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
15348.025740553094
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
```

In [360…

```
y, X = patsy.dmatrices("SuccessfulBool ~ goal  + backers_count", df[df["isUS"] =
model3 = sm.Logit(y, X).fit()
print(model3.summary())
print(model3.aic)
```

```
Optimization terminated successfully.
         Current function value: 0.380060
         Iterations 11
                           Logit Regression Results
==============================================================================
Dep. Variable:         SuccessfulBool   No. Observations:                13835
Model:                          Logit   Df Residuals:                    13832
Method:                           MLE   Df Model:                            2
Date:                Fri, 07 Oct 2022   Pseudo R-squ.:                  0.3902
Time:                        21:11:31   Log-Likelihood:                -5258.1
converged:                       True   LL-Null:                       -8622.9
Covariance Type:            nonrobust   LLR p-value:                     0.000
==============================================================================
=
                 coef    std err          z      P>|z|      [0.025      0.97
5]
------------------------------------------------------------------------------
-
Intercept        -0.8735      0.029    -29.641      0.000      -0.931      -0.81
6
goal          -6.155e-05   1.88e-06    -32.677      0.000   -6.52e-05   -5.79e-0
5
backers_count     0.0162      0.000     40.475      0.000       0.015       0.01
7
==============================================================================
=

Possibly complete quasi-separation: A fraction 0.11 of observations can be
perfectly predicted. This might indicate that there is complete
```

```
quasi-separation. In this case some parameters will not be identified.
10522.26702526179
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
```

In [361…

```
y, X = patsy.dmatrices("SuccessfulBool ~  goal + backers_count    + \
       launch_to_deadline_days + LaunchedTuesday \
         ", df, return_type="dataframe")
model4 = sm.Logit(y, X).fit(maxiter=1000)
print(model4.summary())
print(model4.aic)
```

```
Optimization terminated successfully.
         Current function value: 0.378557
         Iterations 11
                           Logit Regression Results
==============================================================================
Dep. Variable:         SuccessfulBool   No. Observations:                20124
Model:                          Logit   Df Residuals:                    20119
Method:                           MLE   Df Model:                            4
Date:                Fri, 07 Oct 2022   Pseudo R-squ.:                  0.3795
Time:                        21:11:32   Log-Likelihood:                -7618.1
converged:                       True   LL-Null:                       -12277.
Covariance Type:            nonrobust   LLR p-value:                     0.000
==============================================================================
===========
                               coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
-----------
Intercept                   -0.2871      0.063     -4.573      0.000      -0.410
-0.164
goal                     -6.239e-05   1.64e-06    -38.113      0.000   -6.56e-05
-5.92e-05
backers_count                0.0161      0.000     47.338      0.000       0.015
0.017
launch_to_deadline_days     -0.0181      0.002     -9.990      0.000      -0.022
-0.015
LaunchedTuesday              0.0256      0.048      0.527      0.598      -0.069
0.121
==============================================================================
===========

Possibly complete quasi-separation: A fraction 0.11 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
15246.181237684226
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
```

In [362…

```
y, X = patsy.dmatrices("SuccessfulBool ~  goal  + backers_count   + \
       launch_to_deadline_days + isUS  \
         ", df, return_type="dataframe")
model = sm.Logit(y, X).fit()
print(model.summary())
print(model.aic)
```

```
Optimization terminated successfully.
         Current function value: 0.378532
         Iterations 11
```

```
                           Logit Regression Results
==============================================================================
Dep. Variable:         SuccessfulBool   No. Observations:                20124
Model:                          Logit   Df Residuals:                    20119
Method:                           MLE   Df Model:                            4
Date:                Fri, 07 Oct 2022   Pseudo R-squ.:                  0.3795
Time:                        21:11:33   Log-Likelihood:                -7617.6
converged:                       True   LL-Null:                       -12277.
Covariance Type:            nonrobust   LLR p-value:                     0.000
==============================================================================
                                 coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
Intercept                  -0.3142      0.068     -4.610      0.000      -0.448
-0.181
isUS[T.1]                   0.0494      0.043      1.145      0.252      -0.035
0.134
goal                    -6.237e-05   1.64e-06    -38.111      0.000   -6.56e-05
-5.92e-05
backers_count               0.0161      0.000     47.262      0.000       0.015
0.017
launch_to_deadline_days    -0.0181      0.002    -10.000      0.000      -0.022
-0.015
==============================================================================

Possibly complete quasi-separation: A fraction 0.11 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
15245.14489293655
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
```

In [ ]:

In [396…

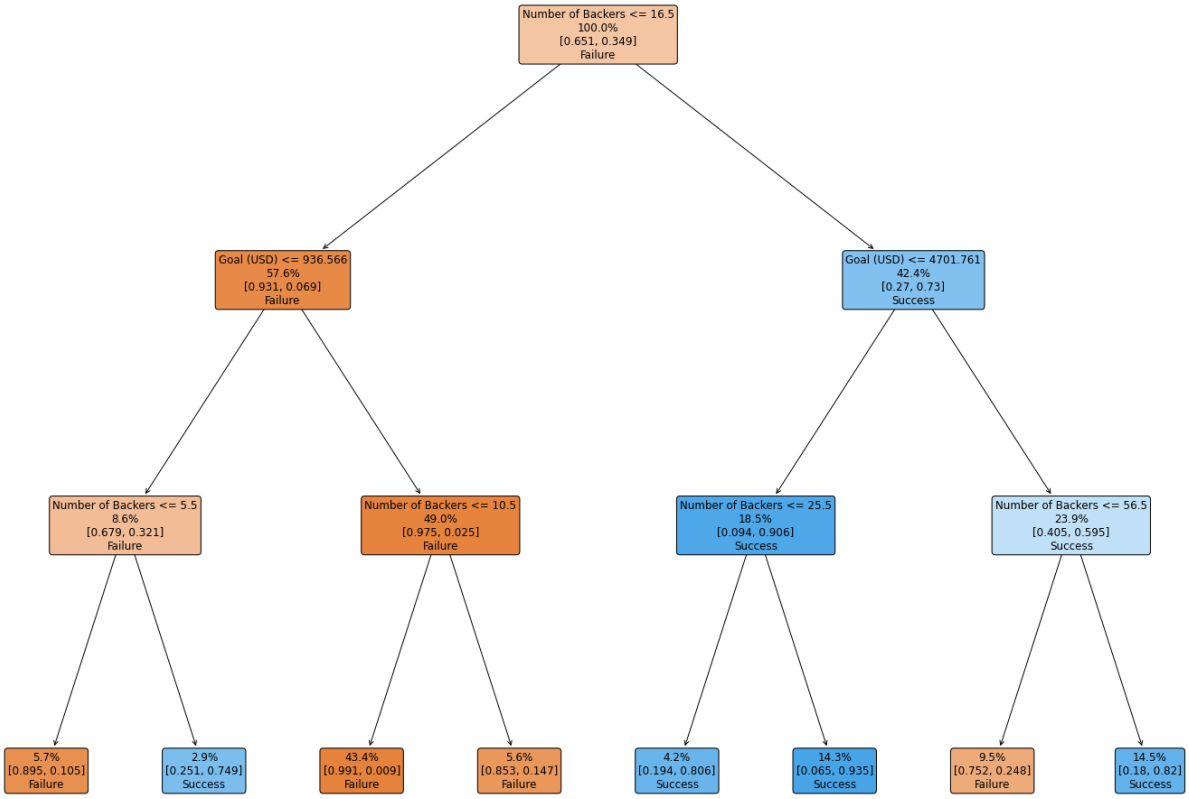
```
y, X = patsy.dmatrices("SuccessfulBool ~  goal    + \
       + backers_count + launch_to_deadline_days + isUS  \
         ", df[(df["backers_count"] < 100) & (df["goal"] < 25000)], return_type=
clf = DecisionTreeClassifier(random_state=1234, max_depth=3)
dt_model = clf.fit(X, y)
```

Decision Tree

In [388…

```
fig = plt.figure(figsize=(25,20))
_ = tree.plot_tree(clf,
                   feature_names=["", "Is USA?", "Goal (USD)", "Number of Backer
                   class_names=["Failure", "Success"],
                   label="none",
                   impurity=False,
                   proportion=True,
```

```
                rounded=True,
                filled=True)
```

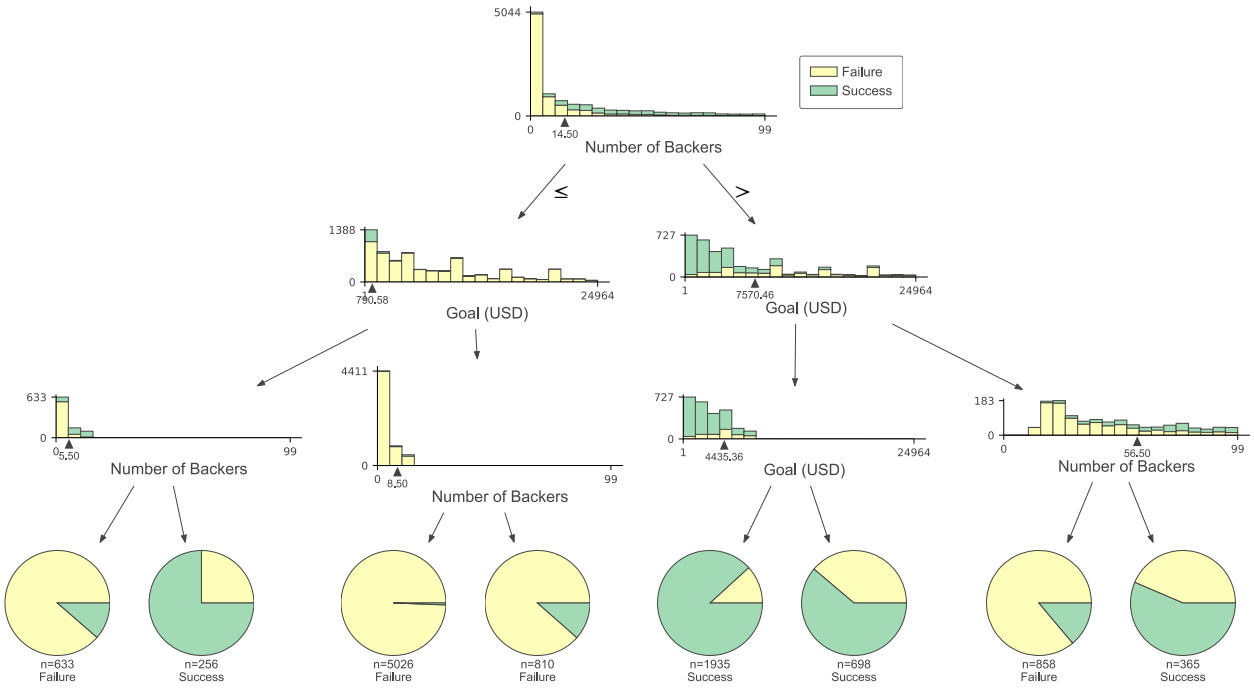


In [402…

```
from dtreeviz.trees import dtreeviz # remember to load the package
viz = dtreeviz(clf, X, y["SuccessfulBool"],
               target_name="",
                  feature_names=["", "Is USA?", "Goal (USD)", "Number of Backer
                  class_names=["Failure", "Success"],)

viz
```

Out[402…




```
<Figure size 3960x1440 with 0 Axes>
```

In [331…

```
model.summary()
```

```
/opt/anaconda3/lib/python3.8/site-packages/statsmodels/discrete/discrete_model.p
y:1810: RuntimeWarning: overflow encountered in exp
  return 1/(1+np.exp(-X))
```

Out[331…

Logit Regression Results

Dep. Variable:	SuccessfulBool	**No. Observations:**	20124
Model:	Logit	**Df Residuals:**	20119
Method:	MLE	**Df Model:**	4
Date:	Fri, 07 Oct 2022	**Pseudo R-squ.:**	0.3795
Time:	19:16:02	**Log-Likelihood:**	-7617.6
converged:	True	**LL-Null:**	-12277.
Covariance Type:	nonrobust	**LLR p-value:**	0.000

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-0.3142	0.068	-4.610	0.000	-0.448	-0.181
goal	-6.237e-05	1.64e-06	-38.111	0.000	-6.56e-05	-5.92e-05
backers_count	0.0161	0.000	47.262	0.000	0.015	0.017
launch_to_deadline_days	-0.0181	0.002	-10.000	0.000	-0.022	-0.015
isUS	0.0494	0.043	1.145	0.252	-0.035	0.134

Possibly complete quasi-separation: A fraction 0.11 of observations can be

perfectly predicted. This might indicate that there is complete quasi-separation. In this case some parameters will not be identified.

Prediction

In [345…
```
model.predict(
    [
        [1, 25000, 50, 7, 1],
        [1, 25000, 100, 14, 1],
        [1, 25000, 200, 30, 1],
        [1, 25000, 300, 60, 1],
        [1, 25000, 1000, 90, 1],
    ]
)
```

Out[345…
```
array([0.24093951, 0.38438148, 0.69969011, 0.87087644, 0.99999667])
```

In [333…
```
import math
```

In [342…
```
 math.e ** (-6.237e-05)
```

Out[342…
```
0.999937631944968
```

In [335…
```
math.e ** (0.0161)
```

Out[335…
```
1.0162303033554483
```

In [336…
```
1 - math.e ** -0.0181
```

Out[336…
```
0.017937178834293688
```

In [340…
```
math.e ** 0.0494
```

Out[340…
```
1.0506405229091558
```

In [338…
```
df.shape
```

Out[338…
```
(20124, 20)
```

In [248…
```
df.columns
```

Out[248…
```
Index(['goal', 'disable_communication', 'backers_count', 'category',
       'deadline_weekday', 'launched_at_weekday', 'deadline_month',
       'deadline_day', 'deadline_yr', 'deadline_hr', 'launched_at_month',
       'launched_at_day', 'launched_at_yr', 'launched_at_hr',
       'launch_to_deadline_days', 'SuccessfulBool', 'LaunchedTuesday',
       'DeadlineWeekend', 'isUS', 'pledge_per_backer'],
      dtype='object')
```

In [270…
```
baseline = ["goal", "backers_count", "category", "launch_to_deadline_days", "Suc
```

In [272…
```
df[baseline].describe()
```

Out[272…

	goal	backers_count	launch_to_deadline_days	SuccessfulBool	isUS
count	2.012400e+04	20124.000000	20124.000000	20124.000000	20124.000000
mean	8.806323e+04	185.865335	34.617472	0.299046	0.312512
std	1.299946e+06	1235.778801	11.836983	0.457851	0.463529
min	7.022768e-01	0.000000	1.000000	0.000000	0.000000
25%	4.000000e+03	2.000000	30.000000	0.000000	0.000000
50%	1.348892e+04	12.000000	30.000000	0.000000	0.000000
75%	4.500000e+04	64.000000	40.000000	1.000000	1.000000
max	1.000000e+08	105857.000000	91.000000	1.000000	1.000000

In [285…
```
df["SuccessfulBool"].value_counts()
```

Out[285…
```
0    14106
1     6018
Name: SuccessfulBool, dtype: int64
```

In [288…
```
df[df["SuccessfulBool"] == 1]["backers_count"].describe()
```

Out[288…
```
count      6018.000000
mean        553.332669
std        2200.792317
min           1.000000
25%          39.000000
50%         105.000000
75%         380.000000
max      105857.000000
Name: backers_count, dtype: float64
```

In [296…
```
df["isUS"].value_counts(normalize=True)
```

Out[296…
```
0    0.687488
1    0.312512
Name: isUS, dtype: float64
```

In [ ]: