population

April 18, 2023

[1]:

```
import matplotlib
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
import statsmodels.api as sm
import scipy.stats as st
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.model_selection import train_test_split
from datetime import date, datetime

%matplotlib inline
```

[2]:

```
df_out = pd.read_pickle('df_out.pkl')
df_out_with_breeds_info = pd.read_pickle('df_out_with_breeks_info.pkl')
df_out.info()
df_out_with_breeds_info.info()
df_out.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 149511 entries, 0 to 149510
Data columns (total 41 columns):
 #   Column                   Non-Null Count   Dtype
---  ------                   --------------   -----
 0   index                    149511 non-null  Int64
 1   Animal ID                149511 non-null  string
 2   Name                     106260 non-null  string
 3   Outcome DateTime         149511 non-null  datetime64[ns]
 4   Outcome MonthYear        149511 non-null  string
 5   Date of Birth            149511 non-null  datetime64[ns]
 6   Outcome Type             149485 non-null  string
 7   Outcome Subtype          68443 non-null   string
 8   Animal Type              149511 non-null  string
 9   Sex upon Outcome         149509 non-null  string
 10  Age upon Outcome         149465 non-null  string
 11  Breed                    149511 non-null  string
 12  Color                    149511 non-null  string
 13  Intake MonthYear          147980 non-null  string
 14  Intake DateTime           147980 non-null  datetime64[ns]
 15  Found Location            147980 non-null  string
 16  Intake Type               147980 non-null  string
 17  Intake Condition          147980 non-null  string
 18  Sex upon Intake           147978 non-null  string
 19  Age upon Intake           147979 non-null  string
 20  Years in animal center    147980 non-null  Float64
 21  Colors (count)            149511 non-null  Int64
 22  Color 0                   149511 non-null  string
 23  Color 1                   79869 non-null   string
 24  Color 0 R                 135638 non-null  Float64
 25  Color 0 G                 135638 non-null  Float64
 26  Color 0 B                 135638 non-null  Float64
 27  Color 0 H                 135638 non-null  Float64
 28  Color 0 S                 135638 non-null  Float64
 29  Color 0 V                 135638 non-null  Float64
 30  Color 1 R                 78596 non-null   Float64
 31  Color 1 G                 78596 non-null   Float64
 32  Color 1 B                 78596 non-null   Float64
 33  Color 1 H                 78596 non-null   Float64
 34  Color 1 S                 78596 non-null   Float64
 35  Color 1 V                 78596 non-null   Float64
 36  Age upon Outcome (years)  149465 non-null  Float64
 37  Male                      149509 non-null  boolean
 38  Female                    149509 non-null  boolean
 39  NeuteredOrSpayed          149509 non-null  boolean
 40  Adopted                   149485 non-null  boolean
dtypes: Float64(14), Int64(2), boolean(4), datetime64[ns](3), string(18)
memory usage: 45.6 MB
<class 'pandas.core.frame.DataFrame'>
Int64Index: 149511 entries, 0 to 149510
Data columns (total 57 columns):
 #   Column                    Non-Null Count   Dtype
---  ------                    --------------   -----
 0   index                     149511 non-null  Int64
 1   Animal ID                 149511 non-null  string
 2   Name                      106260 non-null  string
 3   Outcome DateTime          149511 non-null  datetime64[ns]
 4   Outcome MonthYear         149511 non-null  string
 5   Date of Birth             149511 non-null  datetime64[ns]
 6   Outcome Type              149485 non-null  string
 7   Outcome Subtype           68443 non-null   string
 8   Animal Type               149511 non-null  string
 9   Sex upon Outcome          149509 non-null  string
 10  Age upon Outcome          149465 non-null  string
 11  Breed                     149511 non-null  string
 12  Color                     149511 non-null  string
 13  Intake MonthYear          147980 non-null  string
 14  Intake DateTime           147980 non-null  datetime64[ns]
 15  Found Location            147980 non-null  string
 16  Intake Type               147980 non-null  string
 17  Intake Condition          147980 non-null  string
 18  Sex upon Intake           147978 non-null  string
 19  Age upon Intake           147979 non-null  string
 20  Years in animal center    147980 non-null  Float64
 21  Colors (count)            149511 non-null  Int64
 22  Color 0                   149511 non-null  string
 23  Color 1                   79869 non-null   string
 24  Color 0 R                 135638 non-null  Float64
 25  Color 0 G                 135638 non-null  Float64
 26  Color 0 B                 135638 non-null  Float64
 27  Color 0 H                 135638 non-null  Float64
 28  Color 0 S                 135638 non-null  Float64
 29  Color 0 V                 135638 non-null  Float64
 30  Color 1 R                 78596 non-null   Float64
 31  Color 1 G                 78596 non-null   Float64
 32  Color 1 B                 78596 non-null   Float64
 33  Color 1 H                 78596 non-null   Float64
 34  Color 1 S                 78596 non-null   Float64
 35  Color 1 V                 78596 non-null   Float64
 36  Age upon Outcome (years)  149465 non-null  Float64
 37  Male                      149509 non-null  boolean
 38  Female                    149509 non-null  boolean
 39  NeuteredOrSpayed          149509 non-null  boolean
 40  Adopted                   149485 non-null  boolean
 41  BreedsInfoName            138419 non-null  object
 42  Breed (catalog)           138419 non-null  string
 43  Breed Group AKC           138419 non-null  string
 44  Breed Group CKC           138419 non-null  string
 45  Breed Group UKC           138419 non-null  string
 46  CKC Subgroup              138414 non-null  string
 47  height_low_inches         138419 non-null  Float64
 48  height_high_inches        138419 non-null  Float64
 49  average height            138419 non-null  Float64
 50  weight_low_lbs            138419 non-null  Float64
 51  weight_high_lbs           138419 non-null  Int64
 52  average weight            138419 non-null  Float64
 53  Lifespan Low              138415 non-null  Int64
 54  Lifespan High             138415 non-null  Int64
 55  average lifespan          138419 non-null  Float64
 56  Est. lifespan remaining   138408 non-null  float64
dtypes: Float64(20), Int64(5), boolean(4), datetime64[ns](3), float64(1),
object(1), string(23)
memory usage: 66.3+ MB
```

[2]:

```
    index Animal ID    Name     Outcome DateTime Outcome MonthYear  \
0   61546   A659834  Dudley 2013-10-01 09:31:00           Oct 2013
1   50833   A664235    <NA> 2013-10-01 10:39:00           Oct 2013
2   93227   A664236    <NA> 2013-10-01 10:44:00           Oct 2013
3  109856   A664237    <NA> 2013-10-01 10:44:00           Oct 2013
4   12697   A664223    Moby 2013-10-01 11:03:00           Oct 2013

  Date of Birth     Outcome Type Outcome Subtype Animal Type Sex upon Outcome  \
0    2013-07-23         Adoption          Foster         Dog    Neutered Male
1    2013-09-24         Transfer         Partner         Cat          Unknown
2    2013-09-24         Transfer         Partner         Cat          Unknown
3    2013-09-24         Transfer         Partner         Cat          Unknown
4    2009-09-30  Return to Owner            <NA>         Dog    Neutered Male

   … Color 1 G Color 1 B Color 1 H Color 1 S Color 1 V  \
0  …      <NA>      <NA>      <NA>      <NA>      <NA>
1  …       1.0       1.0       0.0       0.0       1.0
2  …       1.0       1.0       0.0       0.0       1.0
3  …       1.0       1.0       0.0       0.0       1.0
4  …      <NA>      <NA>      <NA>      <NA>      <NA>

  Age upon Outcome (years)   Male Female NeuteredOrSpayed Adopted
0                 0.166667   True  False             True    True
1                 0.019231  False  False            False   False
2                 0.019231  False  False            False   False
3                 0.019231  False  False            False   False
4                      4.0   True  False             True   False

[5 rows x 41 columns]
```

[3]:

```
def population(start, end):
    loc_intake = (df_out['Intake DateTime'].isna() | (df_out['Intake DateTime']␣
 ↪< end))
    loc_outcome = (df_out['Outcome DateTime'].isna() | (df_out['Outcome␣
 ↪DateTime'] >= start))
    loc_length_in_shelter = df_out["Years in animal center"] > (5 / 365.25)
    return df_out.loc[loc_intake & loc_outcome & loc_length_in_shelter]
```

[4]:

```
start = datetime(2014, 1, 1)
end = datetime(2023, 4, 1)
offset = datetime(start.year, start.month, start.day)

window_start = 'Window start'
window_end = 'Window end'
feature_1 = 'Intakes'
feature_1x_classes = df_out['Intake Type'].unique()
feature_1y_classes = df_out['Intake Condition'].unique()
```

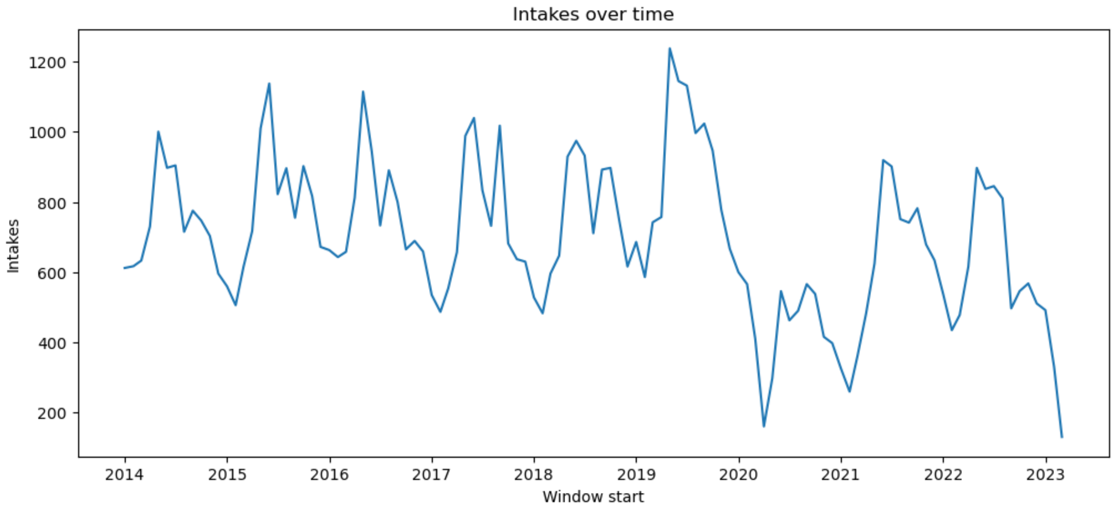
```
feature_1x = [f'Intakes Types ({feature_class})' for feature_class in feature_1x_classes]
feature_1y = [f'Intakes Conditions ({feature_class})' for feature_class in feature_1y_classes]
feature_2 = 'Outcomes'
feature_2x_classes = df_out['Outcome Type'].unique()
feature_2x = [f'Outcomes ({feature_class})' for feature_class in feature_2x_classes]
feature_3 = 'Breeds (unique)'
feature_4 = 'Animals (count)'
feature_5a = 'Years in animal center (mean)'
feature_5b = 'Years in animal center (std dev)'

df_populations = pd.DataFrame()

df_populations[window_start] = pd.Series(dtype=df_out["Outcome DateTime"].dtype)
df_populations[window_end] = pd.Series(dtype=df_out["Outcome DateTime"].dtype)

df_populations.set_index(window_start)

df_populations[feature_1] = pd.Series(dtype=int)
for feature in feature_1x:
    df_populations[f'{feature} (Absolute)'] = pd.Series(dtype=int)
    df_populations[f'{feature} (Relative)'] = pd.Series(dtype=float)
df_populations = df_populations.copy()
for feature in feature_1y:
    df_populations[feature] = pd.Series(dtype=int)
    df_populations[f'{feature} (Absolute)'] = pd.Series(dtype=int)
    df_populations[f'{feature} (Relative)'] = pd.Series(dtype=float)
df_populations = df_populations.copy()

df_populations[feature_2] = pd.Series(dtype=int)
for feature in feature_2x:
    df_populations[feature] = pd.Series(dtype=int)
    df_populations[f'{feature} (Absolute)'] = pd.Series(dtype=int)
    df_populations[f'{feature} (Relative)'] = pd.Series(dtype=float)
df_populations = df_populations.copy()

df_populations[feature_3] = pd.Series(dtype=int)

df_populations = df_populations.copy()

while offset != end:
    offset_next = datetime(offset.year + (1 if offset.month == 12 else 0), (offset.month % 12) + 1, offset.day)

    df_populations.at[offset, window_start] = offset
    df_populations.at[offset, window_end] = offset_next

    animals = population(offset, offset_next)

    intakes = animals.loc[(animals['Intake DateTime'] >= offset) &␣
  ↪(animals['Intake DateTime'] < offset_next)]
    df_populations.at[offset, feature_1] = intakes.shape[0]
    for feature_class, count in intakes['Intake Type'].value_counts().items():
        df_populations.at[offset, f'Intakes Types ({feature_class})␣
  ↪(Absolute)'] = count
        df_populations.at[offset, f'Intakes Types ({feature_class})␣
  ↪(Relative)'] = count / intakes.shape[0]
    for feature_class, count in intakes['Intake Condition'].value_counts().
  ↪items():
        df_populations.at[offset, f'Intakes Conditions ({feature_class})␣
  ↪(Absolute)'] = count
        df_populations.at[offset, f'Intakes Conditions ({feature_class})␣
  ↪(Relative)'] = count / intakes.shape[0]

    outcomes = animals.loc[(animals['Outcome DateTime'] >= offset) &␣
  ↪(animals['Outcome DateTime'] < offset_next)]
    df_populations.at[offset, feature_2] = outcomes.shape[0]
    for feature_class, count in outcomes['Outcome Type'].value_counts().items():
        df_populations.at[offset, f'Outcome Types ({feature_class})␣
  ↪(Absolute)'] = count
        df_populations.at[offset, f'Outcome Types ({feature_class})␣
  ↪(Relative)'] = count / outcomes.shape[0]

    df_populations.at[offset, feature_3] = len(animals['Breed'].unique())
    df_populations.at[offset, feature_4] = animals.shape[0]

    df_populations.at[offset, feature_5a] = animals["Years in animal center"].
  ↪mean()
    df_populations.at[offset, feature_5b] = animals["Years in animal center"].
  ↪std()

    offset = offset_next
```

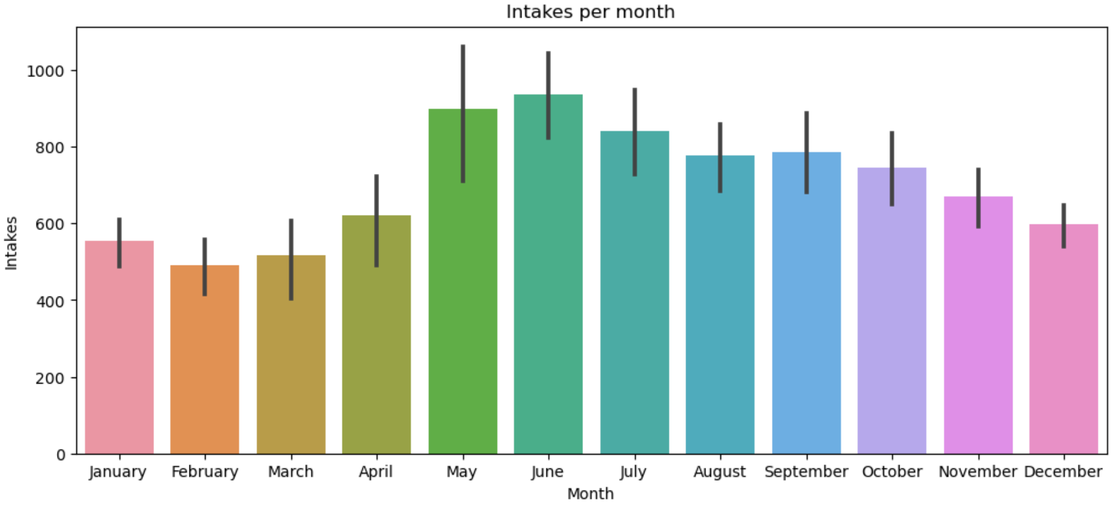
[5]:

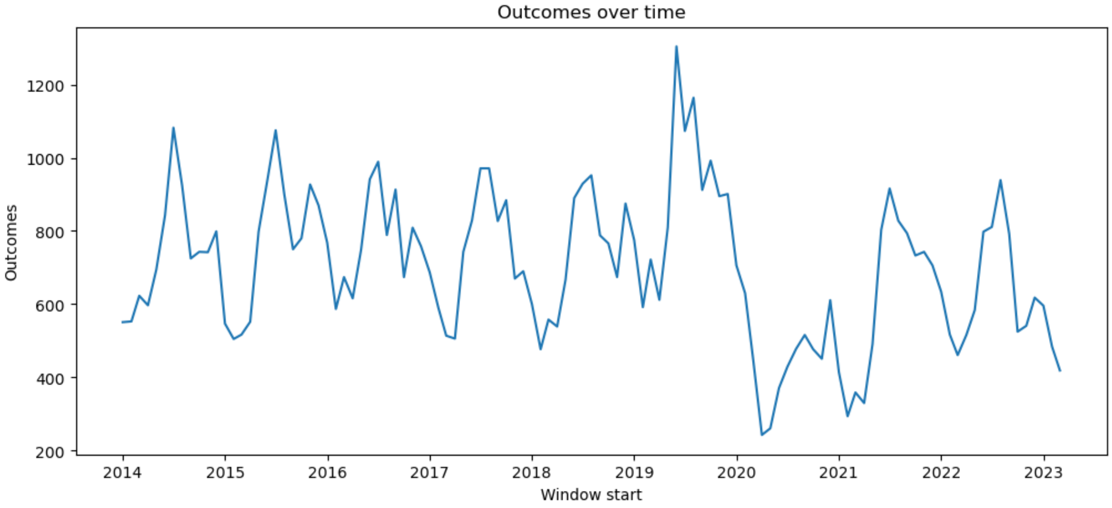
```
df_populations['Month'] = pd.Series(dtype=int)
df_populations['Year'] = pd.Series(dtype=int)
for index in df_populations.index:
    df_populations.at[index, 'Month'] = df_populations.at[index, window_start].
  ↪month
    df_populations.at[index, 'Year'] = df_populations.at[index, window_start].
  ↪year
```

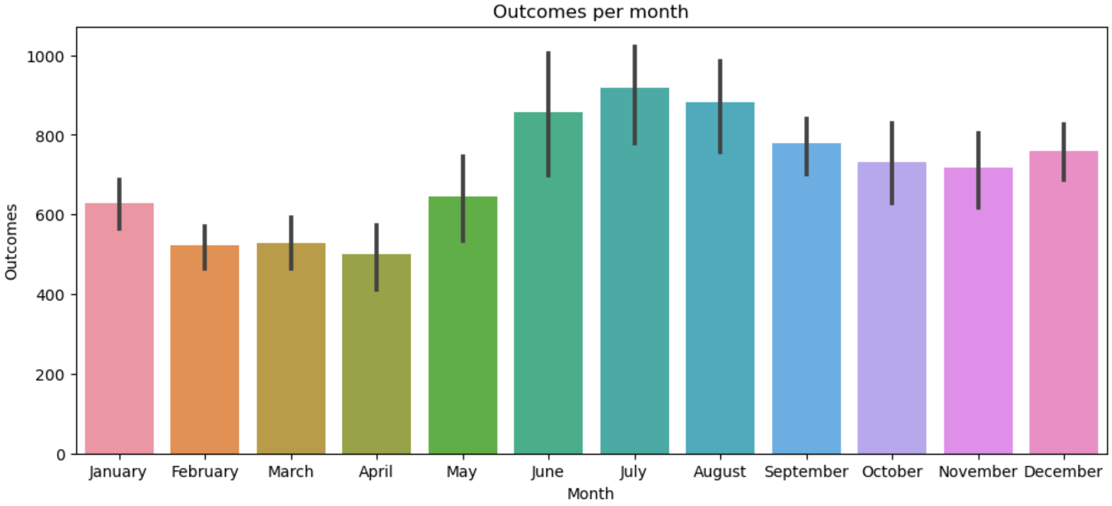
[6]:

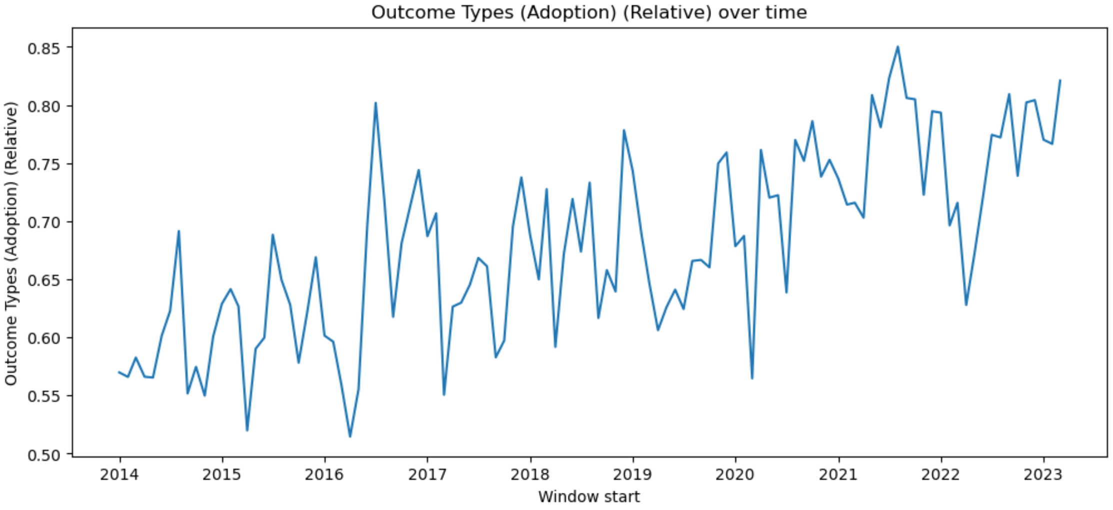
```python
def populationCharts(feature):
    plt.figure(figsize=(12, 5))
    sns.lineplot(
        data=df_populations,
        x=window_start,
        y=feature
    )
    plt.title(f'{feature} over time')
    plt.show()

    plt.figure(figsize=(12, 5))
    sns.barplot(
        data=df_populations,
        x='Month',
        y=feature,
    )
    plt.xticks(range(12), ["January", "February", "March", "April", "May", "June", "July", "August", "September", "October", "November", "December"])
    plt.title(f'{feature} per month')
    plt.show()

populationCharts('Intakes')
populationCharts('Outcomes')
populationCharts('Outcome Types (Adoption) (Relative)')
```

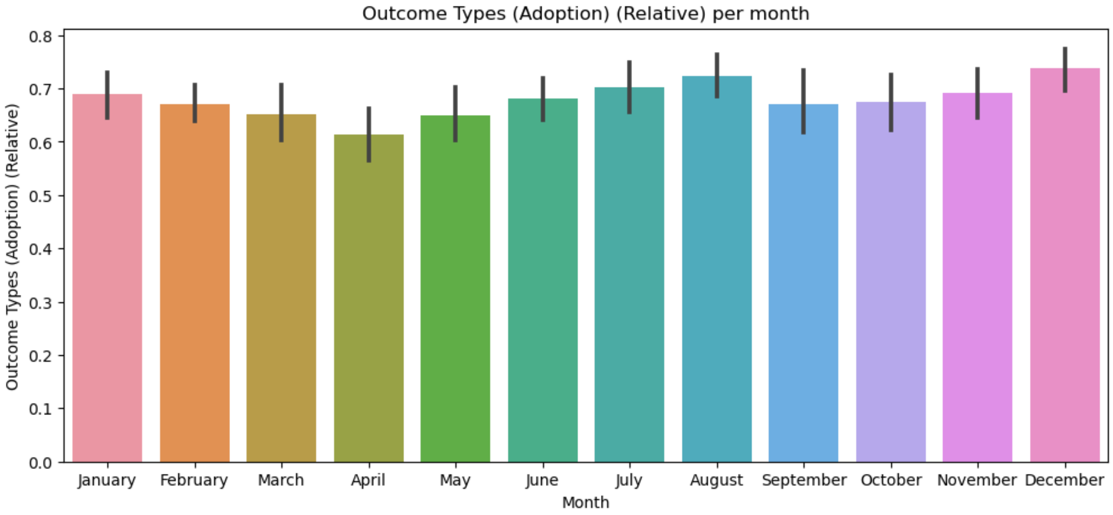



Intakes per month
Intakes
0
200
400
600
800
1000
January
February
March
April
May
June
July
August
September
October
November
December
Month


Outcomes over time
Outcomes
200
400
600
800
1000
1200
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Window start


Outcomes per month
Outcomes
0
200
400
600
800
1000
January
February
March
April
May
June
July
August
September
October
November
December
Month

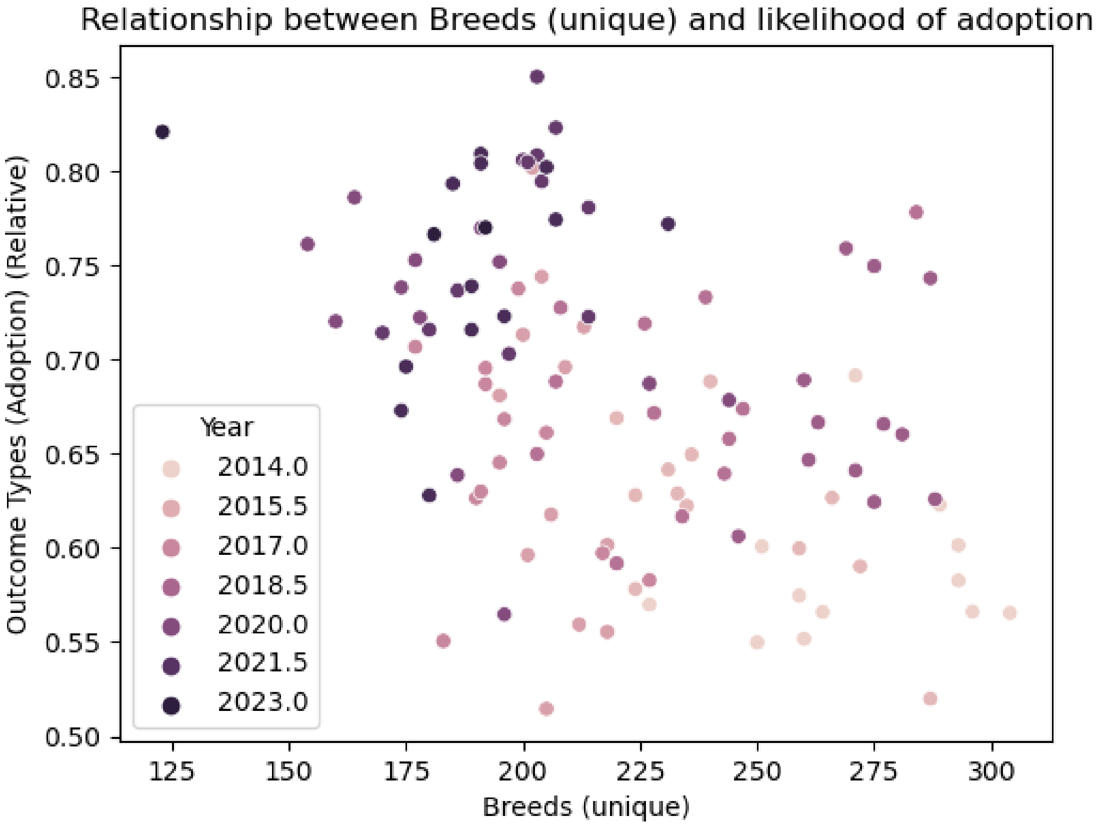

Outcome Types (Adoption) (Relative) over time
Outcome Types (Adoption) (Relative)
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Window start

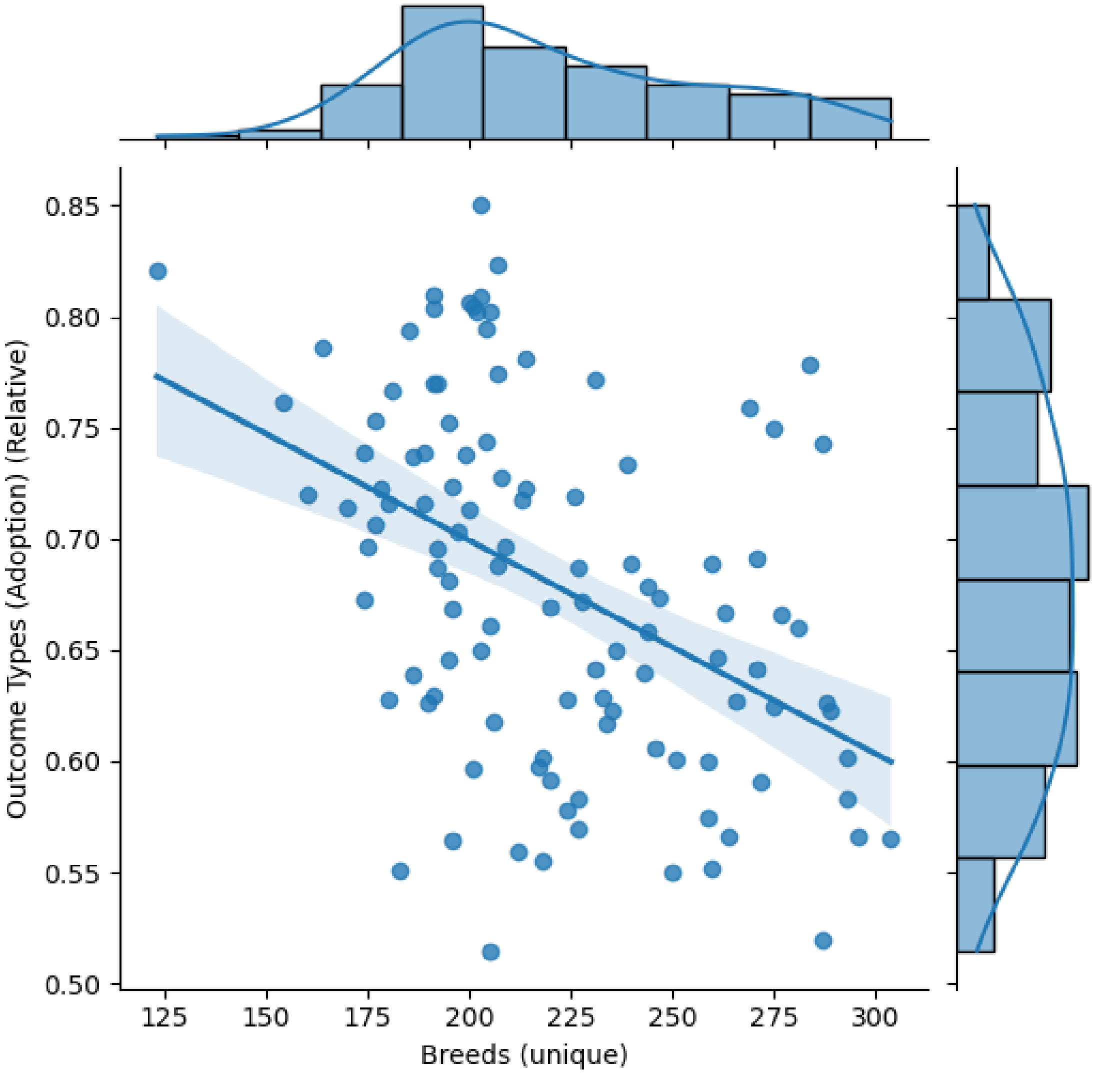


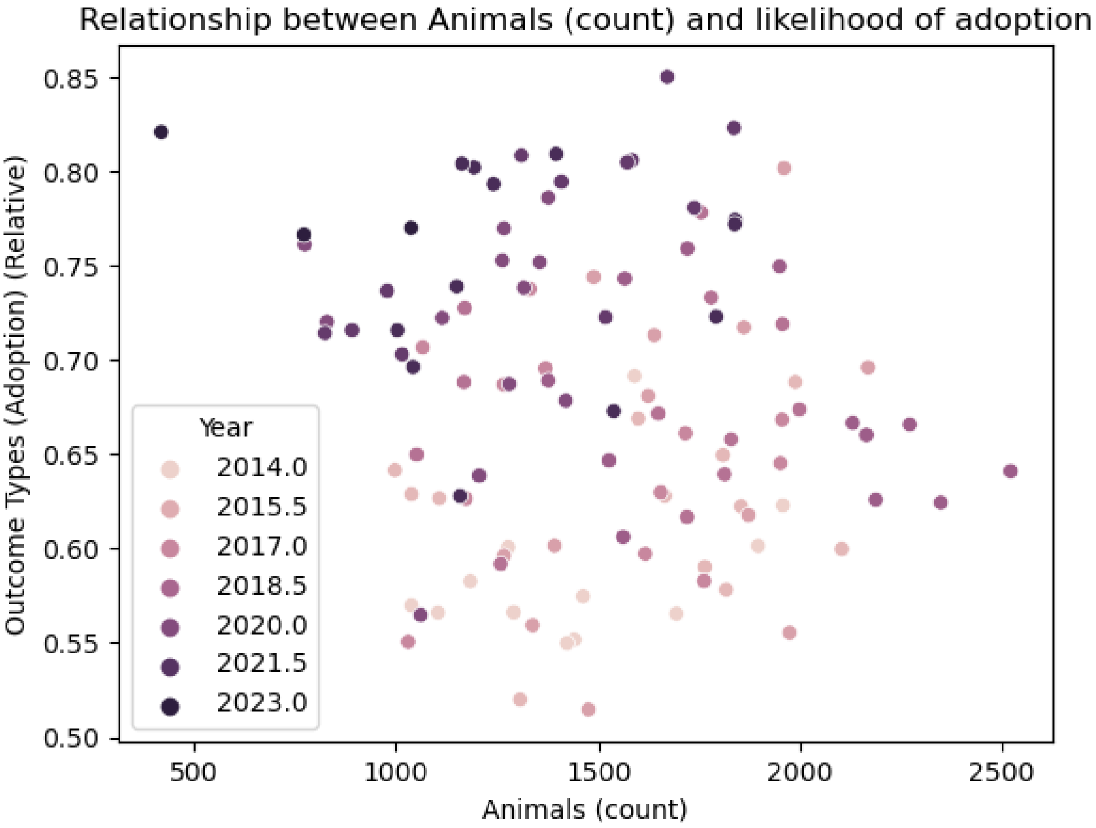
[7]:
```
df_populations.Year.head(20)
```

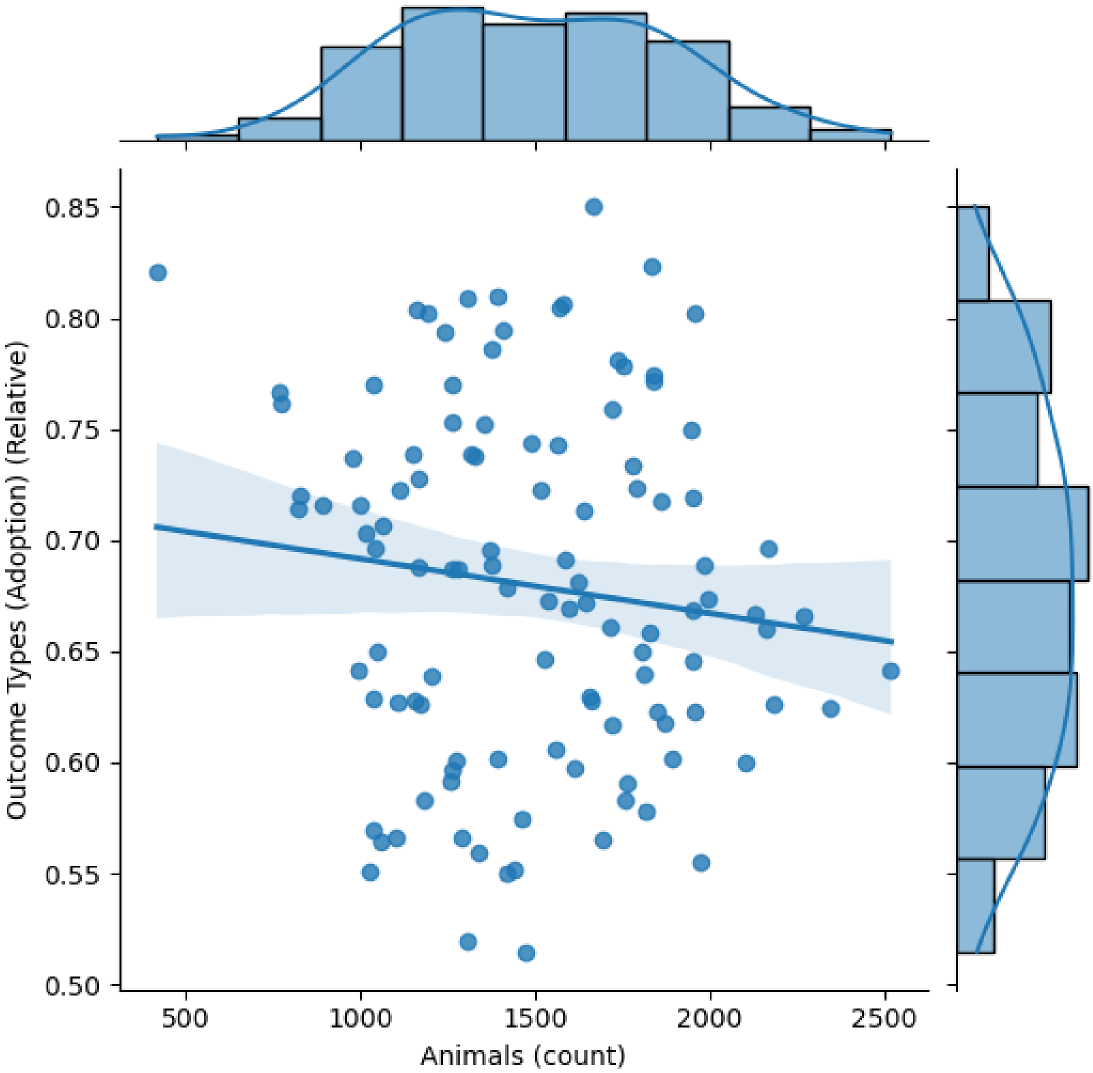
[7]:
```
2014-01-01    2014.0
2014-02-01    2014.0
2014-03-01    2014.0
2014-04-01    2014.0
2014-05-01    2014.0
2014-06-01    2014.0
2014-07-01    2014.0
2014-08-01    2014.0
2014-09-01    2014.0
2014-10-01    2014.0
2014-11-01    2014.0
2014-12-01    2014.0
2015-01-01    2015.0
2015-02-01    2015.0
2015-03-01    2015.0
2015-04-01    2015.0
2015-05-01    2015.0
2015-06-01    2015.0
2015-07-01    2015.0
2015-08-01    2015.0
Name: Year, dtype: float64
```

[8]:
```
def adoptionCorr(feature, hue):
    sns.scatterplot(
        data=df_populations,
        x=feature,
        y='Outcome Types (Adoption) (Relative)',
        hue=hue
    )
    plt.title(f"Relationship between {feature} and likelihood of adoption")
    plt.show()

    try:
        sns.jointplot(
            data=df_populations,
            x=feature,
            y='Outcome Types (Adoption) (Relative)',
            kind='reg'
        )
        plt.show()
    except: pass

adoptionCorr(feature_3, 'Year')
adoptionCorr(feature_4, 'Year')
adoptionCorr(feature_5a, 'Year')
adoptionCorr(window_start, None)
```

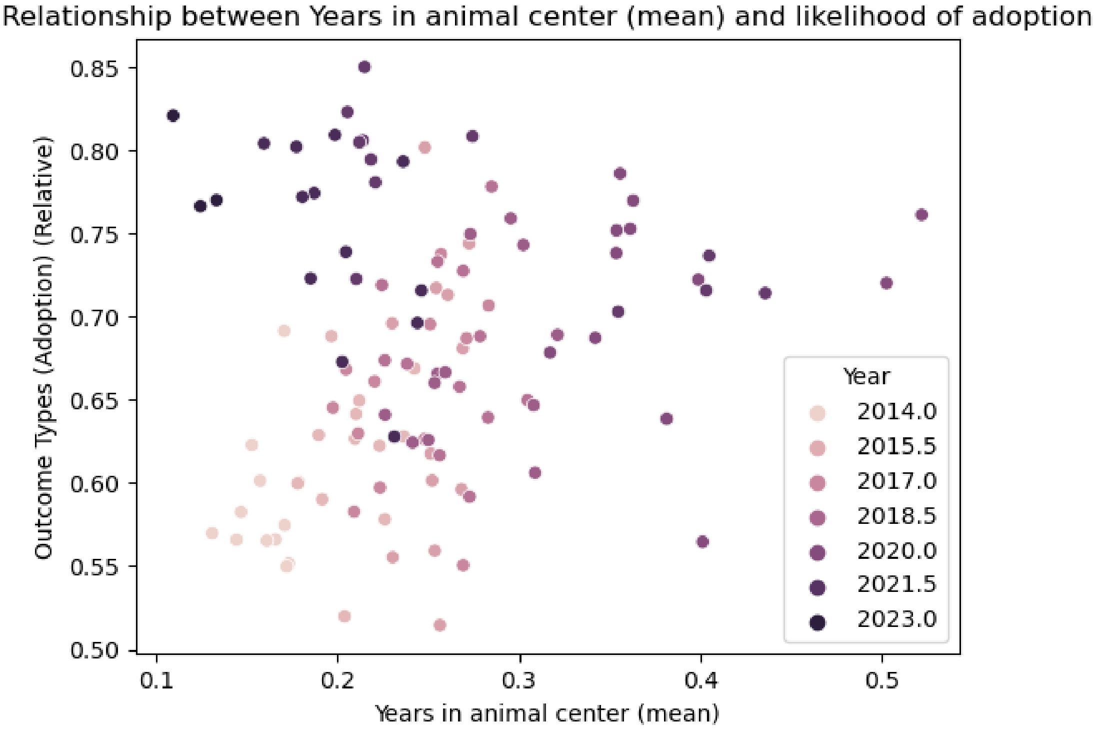


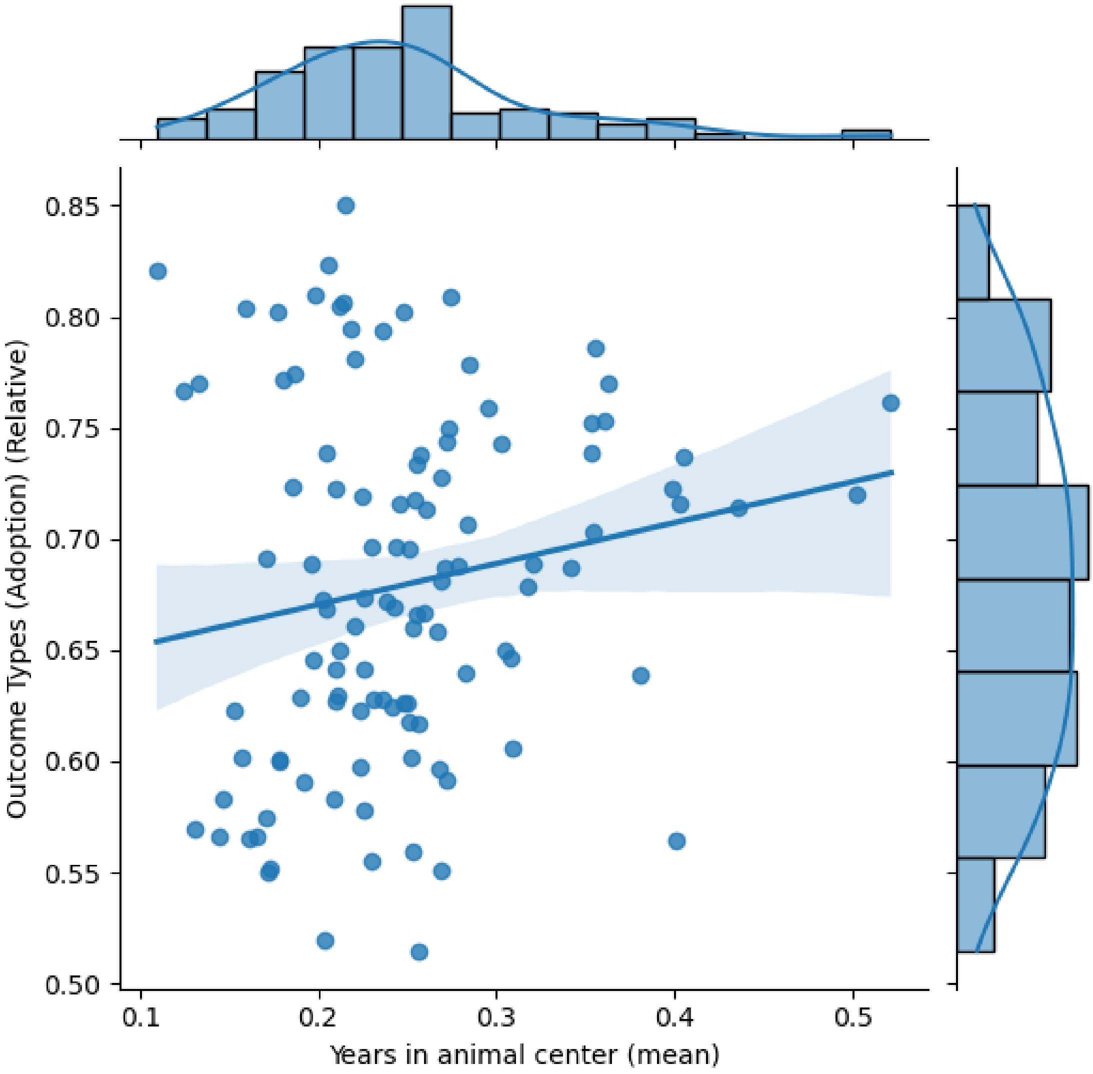

0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Outcome Types (Adoption) (Relative)
125
150
175
200
225
250
275
300
Breeds (unique)

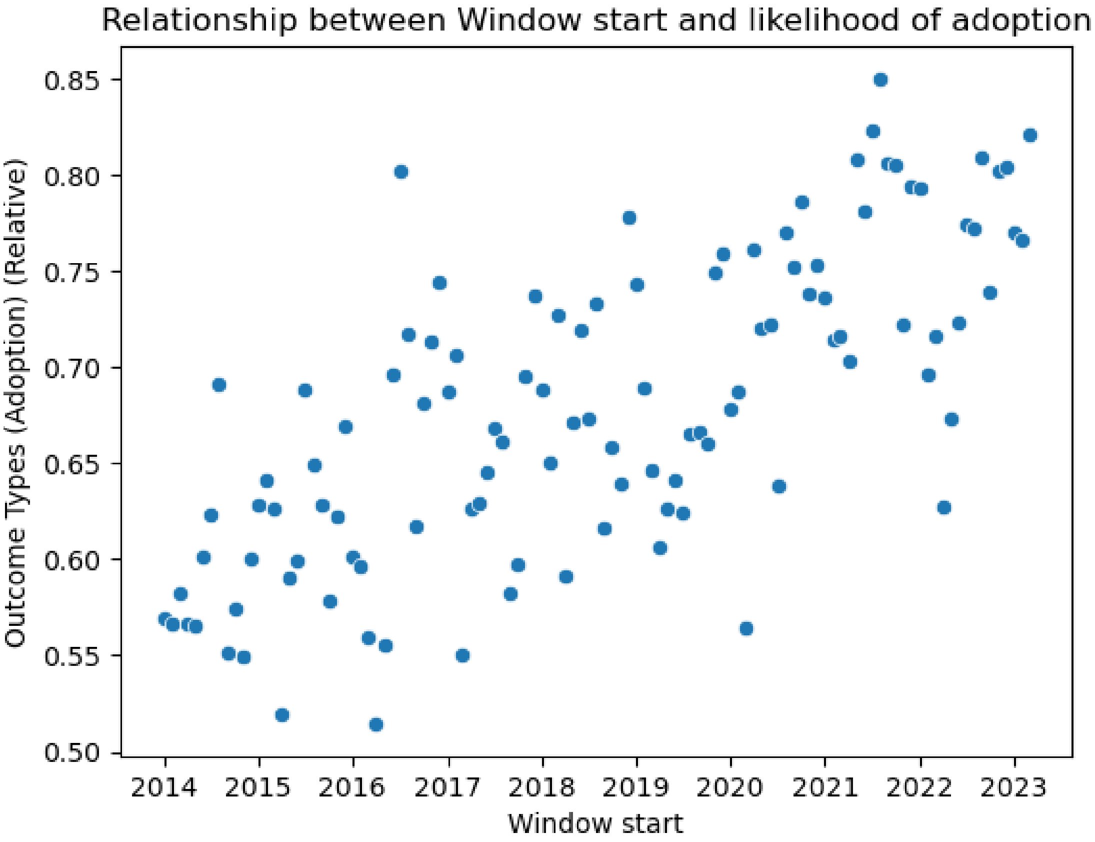

Relationship between Animals (count) and likelihood of adoption
Outcome Types (Adoption) (Relative)
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Animals (count)
500
1000
1500
2000
2500
Year
2014.0
2015.5
2017.0
2018.5
2020.0
2021.5
2023.0

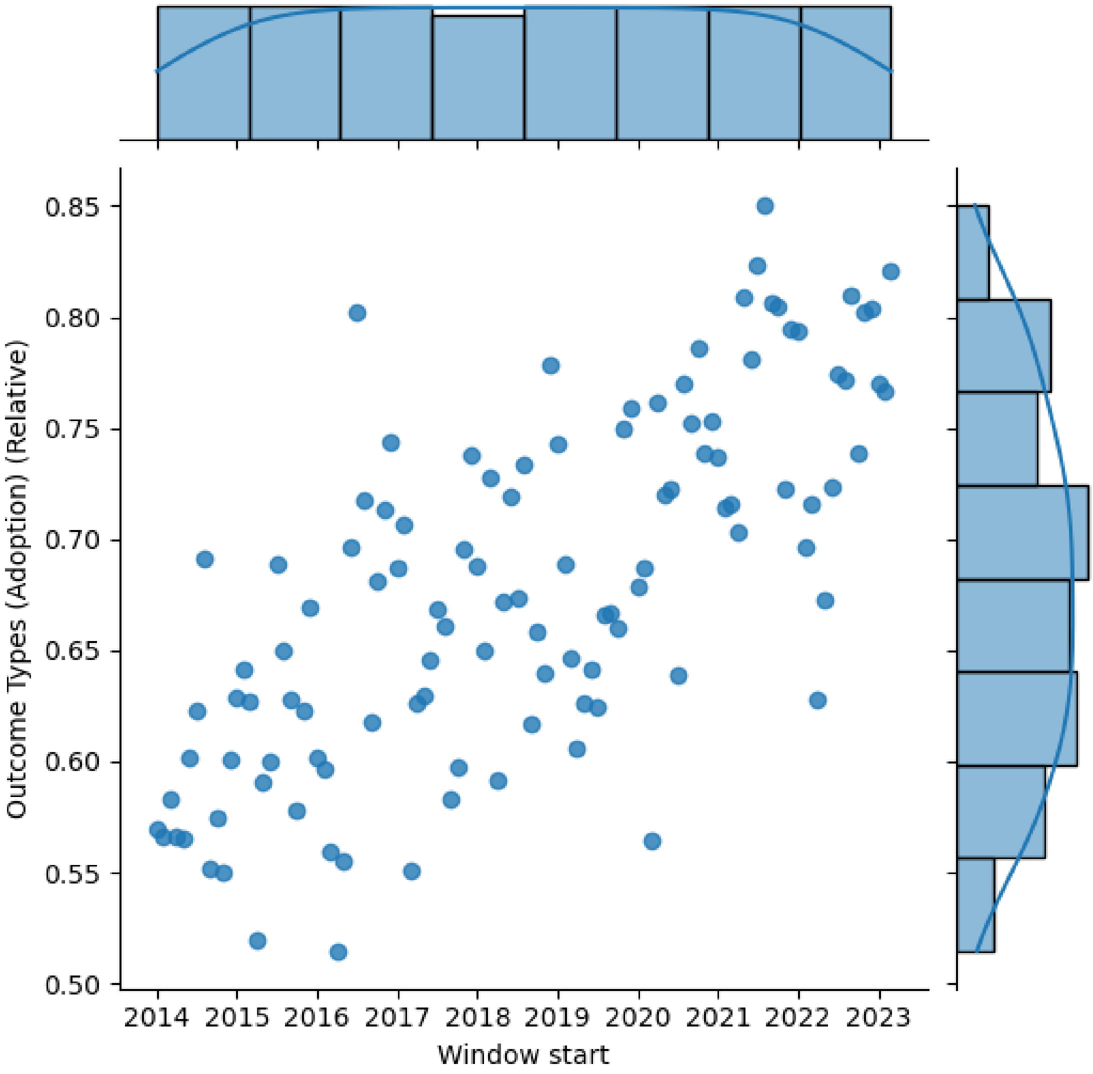


0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Outcome Types (Adoption) (Relative)
500
1000
1500
2000
2500
Animals (count)


Relationship between Years in animal center (mean) and likelihood of adoption
Outcome Types (Adoption) (Relative)
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.1
0.2
0.3
0.4
0.5
Years in animal center (mean)
Year
2014.0
2015.5
2017.0
2018.5
2020.0
2021.5
2023.0


0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Outcome Types (Adoption) (Relative)
0.1
0.2
0.3
0.4
0.5
Years in animal center (mean)


Relationship between Window start and likelihood of adoption
Outcome Types (Adoption) (Relative)
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Window start


Outcome Types (Adoption) (Relative)
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Window start