Code file for model : Propensity Score Matching with Logistic Regression

Installing pandas version 0.23.4 for matching library to work

In [1]:

```
!pip install pandas==0.23.4
```

```
Looking in indexes: http://archive.linux.duke.edu/pypi/simple/
Requirement already satisfied: pandas==0.23.4 in c:\programdata\anaconda3\lib
\site-packages (0.23.4)
Requirement already satisfied: pytz>=2011k in c:\programdata\anaconda3\lib\si
te-packages (from pandas==0.23.4) (2019.1)
Requirement already satisfied: python-dateutil>=2.5.0 in c:\programdata\anaco
nda3\lib\site-packages (from pandas==0.23.4) (2.8.0)
Requirement already satisfied: numpy>=1.9.0 in c:\programdata\anaconda3\lib\s
ite-packages (from pandas==0.23.4) (1.16.4)
Requirement already satisfied: six>=1.5 in c:\programdata\anaconda3\lib\site-
packages (from python-dateutil>=2.5.0->pandas==0.23.4) (1.12.0)
```

Importing relevant python libraries

In [2]:

```
import numpy as np
import pandas as pd
from pymatch.Matcher import Matcher
import seaborn as sns
import scipy.stats as stats
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
import statsmodels.formula.api as smf
import statsmodels.api as sm
from patsy import dmatrices

%matplotlib inline
```

Checking pandas library version

In [3]:

```
pd.__version__
```

Out[3]:

```
'0.23.4'
```

Reading brazil_100k dataset

In [4]:

```
brazil = pd.read_csv('brazil_100k.txt')
brazil.drop(columns='CID', inplace=True)
brazil.info()
brazil.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100000 entries, 0 to 99999
Data columns (total 11 columns):
FID            100000 non-null int64
thre2011       100000 non-null float64
thre2017       100000 non-null float64
precip2011     100000 non-null float64
precip2017     100000 non-null float64
air2011        100000 non-null float64
air2017        100000 non-null float64
slope          100000 non-null float64
elevation      100000 non-null int64
DistToRoad     100000 non-null float64
acc_50k        100000 non-null int64
dtypes: float64(8), int64(3)
memory usage: 8.4 MB
```

Out[4]:

	FID	thre2011	thre2017	precip2011	precip2017	air2011	air2017	slope	elevation
0	0	900.0	900.0	19.566700	18.599199	27.541700	26.850000	0.202823	96
1	1	244.0	226.0	15.299200	15.382500	26.799999	26.666700	0.401320	261
2	2	900.0	900.0	22.350800	22.298300	26.366699	26.316700	0.010129	100
3	3	900.0	900.0	22.016701	22.715799	27.316700	27.375000	0.028648	41
4	4	898.0	898.0	16.325800	17.838301	25.966700	24.516701	0.036519	200

Read in PES dataset

In [5]:

```
pes = pd.read_csv('within_pes_100k.csv')
pes.drop(columns='Unnamed: 0', inplace=True)
pes.info()
pes.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 99641 entries, 0 to 99640
Data columns (total 2 columns):
FID           99641 non-null int64
within_pes    99641 non-null int64
dtypes: int64(2)
memory usage: 1.5 MB
```

Out[5]:

	FID	within_pes
0	0	1
1	1	0
2	2	0
3	3	0
4	4	0

Read in PA dataset

In [6]:

```
pa = pd.read_csv('within_pa_100k.csv')
pa.drop(columns='Unnamed: 0', inplace=True)
pa.info()
pa.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 99641 entries, 0 to 99640
Data columns (total 2 columns):
FID          99641 non-null int64
within_pa    99641 non-null int64
dtypes: int64(2)
memory usage: 1.5 MB
```

Out[6]:

	FID	within_pa
0	0	1
1	1	0
2	2	1
3	3	0
4	4	0

Read in group dataset

In [7]:

```
grp = pd.read_csv('group_100k.csv')
grp.drop(columns=['Unnamed: 0', 'slope', 'elevation', 'DistToRoad', 'acc_50k',
                  'precip2011', 'precip2017', 'air2011', 'air2017'], inplace=True)
grp.info()
grp.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 99641 entries, 0 to 99640
Data columns (total 2 columns):
FID      99641 non-null int64
group    99641 non-null int64
dtypes: int64(2)
memory usage: 1.5 MB
```

Out[7]:

	FID	group
0	0	0
1	1	3
2	2	1
3	3	1
4	4	3

Merge (Inner) all 4 datasets on common key column: "FID"

In [8]:

```
brazil_grp = brazil.merge(grp, how='inner', on='FID')
brazil_grp_pes = brazil_grp.merge(pes, how='inner', on='FID')
brazil_grp_pes_pa = brazil_grp_pes.merge(pa, how='inner', on='FID')
```

In [9]:

```
brazil_grp_pes_pa.info()
brazil_grp_pes_pa.head()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 99641 entries, 0 to 99640
Data columns (total 14 columns):
FID           99641 non-null int64
thre2011      99641 non-null float64
thre2017      99641 non-null float64
precip2011    99641 non-null float64
precip2017    99641 non-null float64
air2011       99641 non-null float64
air2017       99641 non-null float64
slope         99641 non-null float64
elevation     99641 non-null int64
DistToRoad    99641 non-null float64
acc_50k       99641 non-null int64
group         99641 non-null int64
within_pes    99641 non-null int64
within_pa     99641 non-null int64
dtypes: float64(8), int64(6)
memory usage: 11.4 MB
```

Out[9]:

	FID	thre2011	thre2017	precip2011	precip2017	air2011	air2017	slope	elevation	D
0	0	900.0	900.0	19.566700	18.599199	27.541700	26.850000	0.202823	96	
1	1	244.0	226.0	15.299200	15.382500	26.799999	26.666700	0.401320	261	
2	2	900.0	900.0	22.350800	22.298300	26.366699	26.316700	0.010129	100	
3	3	900.0	900.0	22.016701	22.715799	27.316700	27.375000	0.028648	41	
4	4	898.0	898.0	16.325800	17.838301	25.966700	24.516701	0.036519	200	

Calculate forest cover loss(fcl) = threshold 2011 - threshold 2017

In [10]:

```
brazil_grp_pes_pa['fcl'] = (brazil_grp_pes_pa['thre2011'] - brazil_grp_pes_pa['thre2017'])
/900

# Converting forest loss in binary variable: 1 if loss is > 0 or 0 otherwise
brazil_grp_pes_pa['loss'] = brazil_grp_pes_pa['fcl'].apply(lambda x: 0 if x == 0 else 1)
```

In [11]:

```
brazil_grp_pes_pa.info()
brazil_grp_pes_pa.head()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 99641 entries, 0 to 99640
Data columns (total 16 columns):
FID            99641 non-null int64
thre2011       99641 non-null float64
thre2017       99641 non-null float64
precip2011     99641 non-null float64
precip2017     99641 non-null float64
air2011        99641 non-null float64
air2017        99641 non-null float64
slope          99641 non-null float64
elevation      99641 non-null int64
DistToRoad     99641 non-null float64
acc_50k        99641 non-null int64
group          99641 non-null int64
within_pes     99641 non-null int64
within_pa      99641 non-null int64
fcl            99641 non-null float64
loss           99641 non-null int64
dtypes: float64(9), int64(7)
memory usage: 12.9 MB
```

Out[11]:

	FID	thre2011	thre2017	precip2011	precip2017	air2011	air2017	slope	elevation	D
0	0	900.0	900.0	19.566700	18.599199	27.541700	26.850000	0.202823	96	
1	1	244.0	226.0	15.299200	15.382500	26.799999	26.666700	0.401320	261	
2	2	900.0	900.0	22.350800	22.298300	26.366699	26.316700	0.010129	100	
3	3	900.0	900.0	22.016701	22.715799	27.316700	27.375000	0.028648	41	
4	4	898.0	898.0	16.325800	17.838301	25.966700	24.516701	0.036519	200	

In [12]:

```
#Make copy of the merged dataset
df = brazil_grp_pes_pa.copy()
```

In [13]:

```
#Count observations for the binary forest cover loss
df.loss.value_counts()
```

Out[13]:

```
0    69760
1    29881
Name: loss, dtype: int64
```

In [14]:

```
# Drop unnecessary columns
df.drop(columns=['FID', 'precip2017', 'air2017', 'thre2011', 'thre2017', 'group'], inplace
=True)
df.describe()
```

Out[14]:

	precip2011	air2011	slope	elevation	DistToRoad	acc_50k	v
count	99641.000000	99641.000000	99641.000000	99641.000000	99641.000000	99641.000000	996
mean	19.569500	26.423997	0.312456	165.444466	0.916337	1735.574653	
std	3.775537	1.149533	0.617889	130.642501	0.900006	1517.721446	
min	9.404170	16.691700	0.000000	1.000000	0.000000	0.000000	
25%	16.531700	25.941700	0.022648	79.000000	0.223305	529.000000	
50%	19.414200	26.558300	0.091157	103.000000	0.615295	1302.000000	
75%	22.281700	27.183300	0.324743	219.000000	1.325920	2539.000000	
max	33.845001	28.758301	20.024401	2445.000000	4.517360	9154.000000	

In [15]:

```
# Check sample observations of the datafram after all the merging and preprocessing
df.head()
```

Out[15]:

	precip2011	air2011	slope	elevation	DistToRoad	acc_50k	within_pes	within_pa	
0	19.566700	27.541700	0.202823	96	0.025871	527	1	1	0.
1	15.299200	26.799999	0.401320	261	0.000000	145	0	0	0.
2	22.350800	26.366699	0.010129	100	0.613321	4113	0	1	0.
3	22.016701	27.316700	0.028648	41	1.351790	4169	0	0	0.
4	16.325800	25.966700	0.036519	200	0.375023	1158	0	0	0.

In [16]:

```
### Balance tables for mean of covariates before matching for PES only
```

In [17]:

```
for i in ['slope', 'elevation', 'DistToRoad', 'acc_50k', 'precip2011', 'air2011']:
    pes = df.loc[df.within_pes == 1, i].mean()
    no_pes = df.loc[df.within_pes == 0, i].mean()
    pvalue = stats.ttest_ind(df.loc[df.within_pes == 1, i].values,
                            df.loc[df.within_pes == 0, i].values).pvalue
    print(f'For {i}, the mean for pes is {pes:.2f},' )
    print(f'          the mean for no_pes is {no_pes:.2f},')
    print(f'and the p-value for this difference is {pvalue:.2f}')
    print('\n')
```

```
For slope, the mean for pes is 0.25,
          the mean for no_pes is 0.32,
and the p-value for this difference is 0.00


For elevation, the mean for pes is 130.02,
          the mean for no_pes is 169.08,
and the p-value for this difference is 0.00


For DistToRoad, the mean for pes is 0.62,
          the mean for no_pes is 0.95,
and the p-value for this difference is 0.00


For acc_50k, the mean for pes is 1743.60,
          the mean for no_pes is 1734.75,
and the p-value for this difference is 0.59


For precip2011, the mean for pes is 20.00,
          the mean for no_pes is 19.53,
and the p-value for this difference is 0.00


For air2011, the mean for pes is 26.87,
          the mean for no_pes is 26.38,
and the p-value for this difference is 0.00
```

In [18]:

```
# Divide dataset into test and control groups without considering effect of PES
test = df[df.within_pes == 1]
control = df[df.within_pes == 0]
```

In [19]:

```
# Set matcher object
m = Matcher(test, control, yvar="within_pes", exclude=['within_pes', 'within_pa', 'loss',
'fcl'])
```

```
Formula:
within_pes ~ precip2011+air2011+slope+elevation+DistToRoad+acc_50k
n majority: 90378
n minority: 9263
```

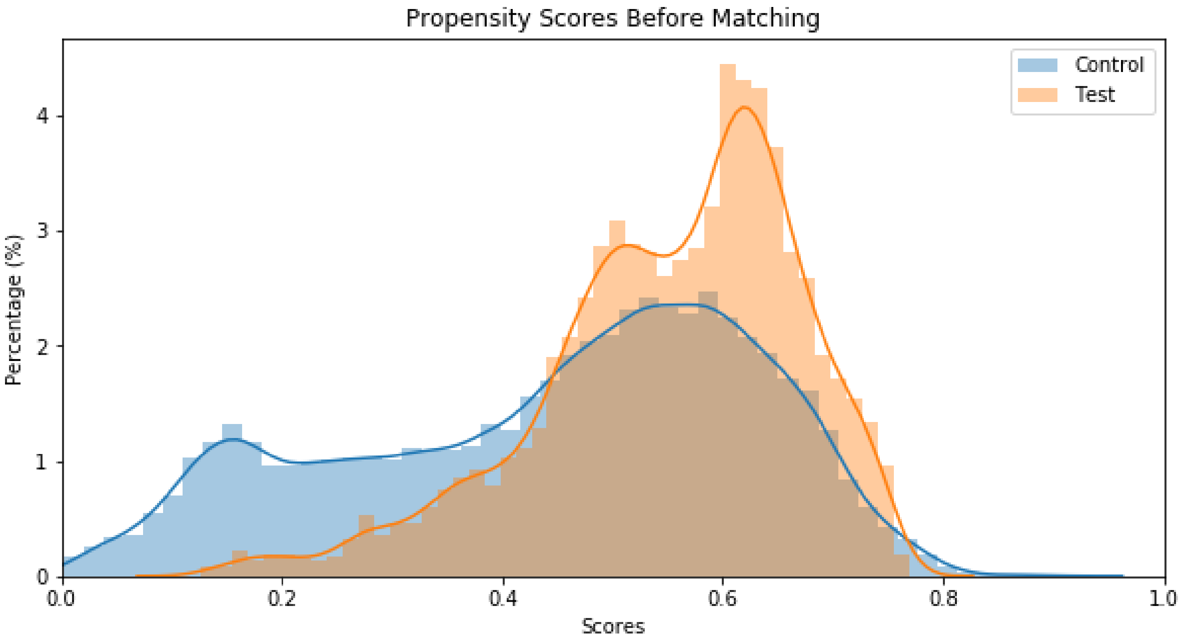
In [20]:

```
# Fitting matcher object
np.random.seed(1)
m.fit_scores(balance=True, nmodels=100)
```

```
Fitting Models on Balanced Samples: 100\100
Average Accuracy: 62.02%
```

In [21]:

```
# Plotting propensity scores
m.predict_scores()
m.plot_scores()
```



In [22]:

```
# K:1 Matching
m.match(method='min', nmatches=1)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\pymatch\Matcher.py:199: SettingWit
hCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/st
able/indexing.html#indexing-view-versus-copy
  self.matched_data['match_id'] = match_ids
C:\ProgramData\Anaconda3\lib\site-packages\pymatch\Matcher.py:200: SettingWit
hCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/st
able/indexing.html#indexing-view-versus-copy
  self.matched_data['record_id'] = self.matched_data.index
```

In [23]:

```
m.record_frequency()
```

Out[23]:

	freq	n_records
0	1	16724
1	2	766
2	3	82
3	4	6

In [24]:

```
# Assign weight vector based on matching
m.assign_weight_vector()
```

In [25]:

```
# Get matched dataset
matched = m.matched_data.sort_values('match_id')
matched.head(10)
```

Out[25]:

	record_id	weight	precip2011	air2011	slope	elevation	DistToRoad	acc_50k	with
0	0	1.0	19.566700	27.541700	0.202823	96	0.025871	527	
16990	87470	1.0	12.473300	27.791700	0.010129	76	0.018294	13	
1	1	1.0	19.481701	27.233299	0.000000	100	0.082322	758	
17077	88133	1.0	23.035000	27.241699	0.000000	1	0.545527	1271	
12964	42702	0.5	21.742500	27.783300	0.446682	89	1.474670	3386	
2	2	1.0	19.628300	27.216700	0.032029	57	0.421354	1077	
3	3	1.0	16.410801	25.866699	0.042972	94	0.737277	4008	
14087	58734	1.0	15.055800	26.783300	0.240752	136	0.124411	204	
18396	98424	1.0	23.334200	25.750000	0.010129	23	0.000000	101	
4	4	1.0	15.125800	26.633301	0.000000	200	0.082322	177	

In [26]:

```
# Balance tables after matching
matched.groupby('within_pes').mean()
```

Out[26]:

	record_id	weight	precip2011	air2011	slope	elevation	DistToRoad
within_pes							
0	54671.527799	0.897657	19.949239	26.850433	0.23637	123.293857	0.636467
1	4631.000000	1.000000	19.998899	26.868143	0.24729	130.019864	0.622463

In [27]:

```
# See matched dataset description
matched.describe()
```

Out[27]:

	record_id	weight	precip2011	air2011	slope	elevation	D
count	18526.000000	18526.000000	18526.000000	18526.000000	18526.000000	18526.000000	185
mean	29651.263899	0.948829	19.974069	26.859288	0.241830	126.656861	
std	32228.219535	0.157120	3.628543	0.721063	0.467370	87.472795	
min	0.000000	0.250000	10.343300	23.091700	0.000000	1.000000	
25%	4631.250000	1.000000	17.049999	26.358299	0.014324	72.000000	
50%	9262.500000	1.000000	19.830000	26.875000	0.070900	100.000000	
75%	56096.250000	1.000000	22.719200	27.416700	0.241602	198.000000	
max	99635.000000	1.000000	33.845001	28.758301	8.381690	1058.000000	

In [28]:

```
weight = matched['weight'].values
```

In [29]:

```
y1, X1 = dmatrices('loss ~ slope + elevation + DistToRoad + acc_50k + precip2011 + air2011
 + C(within_pes) * C(within_pa)',
                 matched, return_type = 'dataframe')
X1.head()
```

Out[29]:

	Intercept	C(within_pes) [T.1]	C(within_pa) [T.1]	C(within_pes) [T.1]:C(within_pa) [T.1]	slope	elevation	DistToRoa
0	1.0	1.0	1.0	1.0	0.202823	96.0	0.02587
16990	1.0	0.0	0.0	0.0	0.010129	76.0	0.01829
1	1.0	1.0	1.0	1.0	0.000000	100.0	0.08232
17077	1.0	0.0	1.0	0.0	0.000000	1.0	0.54552
12964	1.0	0.0	0.0	0.0	0.446682	89.0	1.47467

In [30]:

```
# Fitting logistic regression after matching
sm.Logit(y1, X1, weights=weight).fit().summary()
```

```
Optimization terminated successfully.
         Current function value: 0.487258
         Iterations 6
```

Out[30]:

Logit Regression Results

Dep. Variable:	loss	**No. Observations:**	18526
Model:	Logit	**Df Residuals:**	18516
Method:	MLE	**Df Model:**	9
Date:	Thu, 16 Apr 2020	**Pseudo R-squ.:**	0.1388
Time:	02:48:11	**Log-Likelihood:**	-9026.9
converged:	True	**LL-Null:**	-10482.
Covariance Type:	nonrobust	**LLR p-value:**	0.000

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	10.6719	0.752	14.192	0.000	9.198	12.146
C(within_pes)[T.1]	-0.2866	0.052	-5.469	0.000	-0.389	-0.184
C(within_pa)[T.1]	-0.6289	0.063	-9.955	0.000	-0.753	-0.505
C(within_pes)[T.1]:C(within_pa)[T.1]	0.0901	0.086	1.045	0.296	-0.079	0.259
slope	0.2496	0.044	5.699	0.000	0.164	0.335
elevation	-0.0036	0.000	-12.566	0.000	-0.004	-0.003
DistToRoad	-0.1228	0.041	-2.976	0.003	-0.204	-0.042
acc_50k	-0.0006	2.21e-05	-27.010	0.000	-0.001	-0.001
precip2011	-0.0578	0.006	-9.335	0.000	-0.070	-0.046
air2011	-0.3328	0.028	-11.997	0.000	-0.387	-0.278

Extract dataset with PES values for PA=1 only

In [31]:

```
df_pa = df[df['within_pa']==1]
df_pa.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 27050 entries, 0 to 99638
Data columns (total 10 columns):
precip2011    27050 non-null float64
air2011       27050 non-null float64
slope         27050 non-null float64
elevation     27050 non-null int64
DistToRoad    27050 non-null float64
acc_50k       27050 non-null int64
within_pes    27050 non-null int64
within_pa     27050 non-null int64
fcl           27050 non-null float64
loss          27050 non-null int64
dtypes: float64(5), int64(5)
memory usage: 2.3 MB
```

In [32]:

```
### Balance tables for PES with PA=1 only before matching
```

In [33]:

```
for i in ['slope', 'elevation', 'DistToRoad', 'acc_50k', 'precip2011', 'air2011']:
    pa_pes = df_pa.loc[df_pa.within_pes == 1, i].mean()
    pa_no_pes = df_pa.loc[df_pa.within_pes == 0, i].mean()
    pvalue_pa = stats.ttest_ind(df_pa.loc[df_pa.within_pes == 1, i].values,
                            df_pa.loc[df_pa.within_pes == 0, i].values).pvalue
    print(f'For {i}, the mean for pes is {pa_pes:.2f},' )
    print(f'          the mean for no_pes is {pa_no_pes:.2f},')
    print(f'and the p-value for this difference is {pvalue_pa:.2f}')
    print('\n')
```

```
For slope, the mean for pes is 0.24,
          the mean for no_pes is 0.34,
and the p-value for this difference is 0.00


For elevation, the mean for pes is 135.20,
          the mean for no_pes is 151.24,
and the p-value for this difference is 0.00


For DistToRoad, the mean for pes is 0.73,
          the mean for no_pes is 0.98,
and the p-value for this difference is 0.00


For acc_50k, the mean for pes is 1947.46,
          the mean for no_pes is 2134.80,
and the p-value for this difference is 0.00


For precip2011, the mean for pes is 19.55,
          the mean for no_pes is 20.61,
and the p-value for this difference is 0.00


For air2011, the mean for pes is 26.78,
          the mean for no_pes is 26.74,
and the p-value for this difference is 0.00
```

Repeat the same analysis but for PES=1 only

In [34]:

```
# Divide dataset for PES=1 into test and control groups
test1 = df_pa[df_pa.within_pes == 1]
control1 = df_pa[df_pa.within_pes == 0]
```

In [35]:

```
# Instatiate new matcher object
m1 = Matcher(test1, control1, yvar="within_pes", exclude=['within_pes', 'within_pa', 'los
s', 'fcl'])
```

```
Formula:
within_pes ~ precip2011+air2011+slope+elevation+DistToRoad+acc_50k
n majority: 20755
n minority: 6295
```

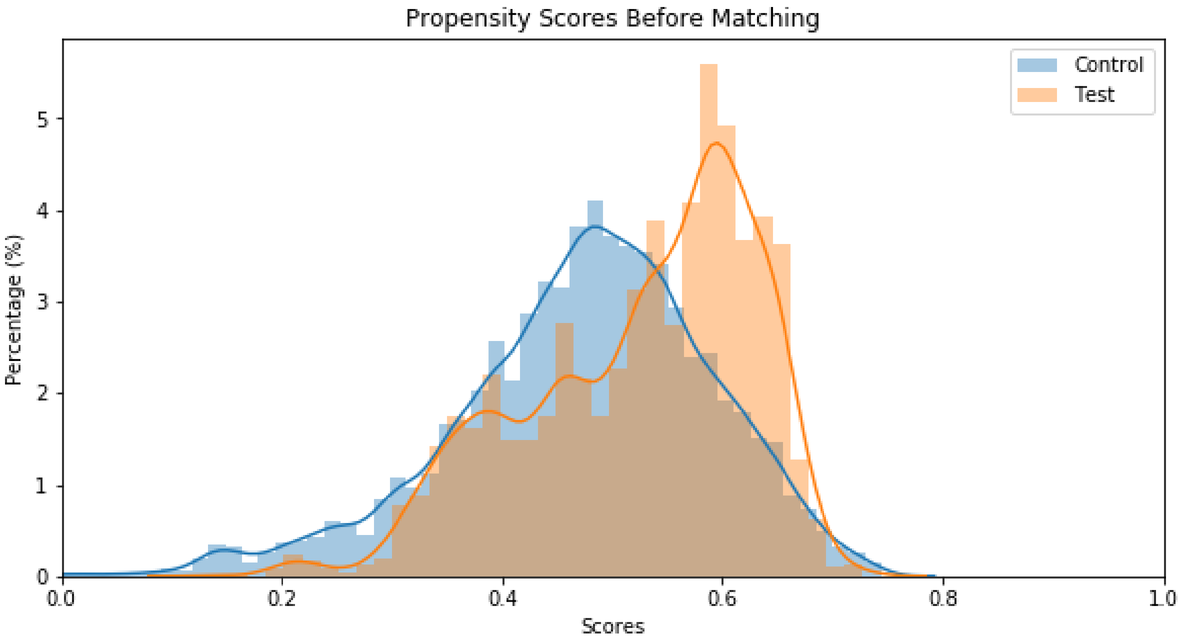
In [36]:

```
# Fit matcher object
np.random.seed(1)
m1.fit_scores(balance=True, nmodels=100)
```

```
Fitting Models on Balanced Samples: 1\100

C:\ProgramData\Anaconda3\lib\site-packages\pandas\core\frame.py:3697: Setting
WithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/st
able/indexing.html#indexing-view-versus-copy
  errors=errors)

Fitting Models on Balanced Samples: 100\100
Average Accuracy: 60.56%
```

In [37]:

```
# Get propensity scores
m1.predict_scores()
m1.plot_scores()
```



In [38]:

```
# K:1 Matching
m1.match(method='min', nmatches=1)
```

In [39]:

```
m1.record_frequency()
```

Out[39]:

	freq	n_records
0	1	9915
1	2	789
2	3	210
3	4	74
4	5	23
5	6	7
6	7	2

In [40]:

```
# Assign weight vector based on matching
m1.assign_weight_vector()
```

In [41]:

```
# Get matched dataset
matched1 = m1.matched_data.sort_values('match_id')
matched1.head(10)
```

Out[41]:

	record_id	weight	precip2011	air2011	slope	elevation	DistToRoad	acc_50k
0	0	1.000000	19.566700	27.541700	0.202823	96	0.025871	527
7785	9340	1.000000	19.749201	27.083300	0.010129	75	0.410797	1435
1	1	1.000000	19.481701	27.233299	0.000000	100	0.082322	758
6548	6811	0.500000	19.562500	26.441700	0.000000	100	0.423730	3423
7657	9098	0.333333	15.834200	25.508301	0.045296	195	0.036588	2109
2	2	1.000000	16.410801	25.866699	0.042972	94	0.737277	4008
8017	9855	0.500000	15.834200	25.508301	0.000000	200	0.156302	1602
3	3	1.000000	15.125800	26.633301	0.000000	200	0.082322	177
6790	7284	1.000000	22.016701	27.316700	0.000000	52	0.900913	1685
4	4	1.000000	21.249201	26.525000	0.028648	71	1.133220	2263

In [42]:

```
# Balance tables after matching for PES=1
matched1.groupby('within_pes').mean()
```

Out[42]:

	record_id	weight	precip2011	air2011	slope	elevation	DistToRoad	
within_pes								
0	15935.728674	0.750596	19.577321	26.776578	0.236218	133.844480	0.730412	18
1	3147.000000	1.000000	19.550147	26.777281	0.242786	135.204925	0.728684	19

In [43]:

```
weight1 = matched1['weight'].values
```

In [44]:

```
y2, X2 = dmatrices('loss ~ slope + elevation + DistToRoad + acc_50k + precip2011 + air2011
 + C(within_pes) * C(within_pa)',
                 matched1, return_type = 'dataframe')
X2.head()
```

Out[44]:

	Intercept	C(within_pes)[T.1]	slope	elevation	DistToRoad	acc_50k	precip2011	air2011
0	1.0	1.0	0.202823	96.0	0.025871	527.0	19.566700	27.541700
7785	1.0	0.0	0.010129	75.0	0.410797	1435.0	19.749201	27.083300
1	1.0	1.0	0.000000	100.0	0.082322	758.0	19.481701	27.233299
6548	1.0	0.0	0.000000	100.0	0.423730	3423.0	19.562500	26.441700
7657	1.0	0.0	0.045296	195.0	0.036588	2109.0	15.834200	25.508301

In [45]:

```
# Fit logistic regression for PES=1
sm.Logit(y2, X2, weights=weight1).fit().summary()
```

```
Optimization terminated successfully.
         Current function value: 0.449343
         Iterations 6
```

Out[45]:

Logit Regression Results

Dep. Variable:	loss	**No. Observations:**	12590
Model:	Logit	**Df Residuals:**	12582
Method:	MLE	**Df Model:**	7
Date:	Thu, 16 Apr 2020	**Pseudo R-squ.:**	0.06940
Time:	02:48:55	**Log-Likelihood:**	-5657.2
converged:	True	**LL-Null:**	-6079.1
Covariance Type:	nonrobust	**LLR p-value:**	6.473e-178

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	14.7490	0.953	15.471	0.000	12.881	16.618
C(within_pes)[T.1]	-0.3003	0.048	-6.310	0.000	-0.394	-0.207
slope	0.3750	0.057	6.629	0.000	0.264	0.486
elevation	-0.0049	0.000	-13.577	0.000	-0.006	-0.004
DistToRoad	-0.2593	0.044	-5.930	0.000	-0.345	-0.174
acc_50k	-0.0003	2.42e-05	-12.444	0.000	-0.000	-0.000
precip2011	-0.0342	0.008	-4.433	0.000	-0.049	-0.019
air2011	-0.5302	0.035	-15.108	0.000	-0.599	-0.461