In [1]:
```
import math
import numpy as np
import pandas as pd
from matplotlib import pyplot as plt
from mpl_toolkits.mplot3d import Axes3D
from sklearn.model_selection import train_test_split
from sklearn.model_selection import StratifiedKFold
from sklearn.svm import SVC
from sklearn.metrics import average_precision_score
```

Reading in the data

In [2]:
```
sales_data = pd.read_csv("wholesale-customers.csv")
```

In [3]:
```
sales_data.shape
```

Out[3]:
```
(440, 8)
```

In [4]:
```
sales_data.head(5)
```

Out[4]:

	Channel	Region	Fresh	Milk	Grocery	Frozen	Detergents_Paper	Delicassen
0	2	3	12669	9656	7561	214	2674	1338
1	2	3	7057	9810	9568	1762	3293	1776
2	2	3	6353	8808	7684	2405	3516	7844
3	1	3	13265	1196	4221	6404	507	1788
4	2	3	22615	5410	7198	3915	1777	5185

In [5]:
```
sales_data.tail(5)
```

Out[5]:

	Channel	Region	Fresh	Milk	Grocery	Frozen	Detergents_Paper	Delicassen
435	1	3	29703	12051	16027	13135	182	2204
436	1	3	39228	1431	764	4510	93	2346
437	2	3	14531	15488	30243	437	14841	1867
438	1	3	10290	1981	2232	1038	168	2125
439	1	3	2787	1698	2510	65	477	52

Train/Test Split

In [6]:
```
X = sales_data.iloc[:, 2:]
```

In [7]:
```
X.head(5)
```

Out[7]:

	Fresh	Milk	Grocery	Frozen	Detergents_Paper	Delicassen
0	12669	9656	7561	214	2674	1338
1	7057	9810	9568	1762	3293	1776
2	6353	8808	7684	2405	3516	7844
3	13265	1196	4221	6404	507	1788
4	22615	5410	7198	3915	1777	5185

In [8]:
```
X.tail(5)
```

Out[8]:

	Fresh	Milk	Grocery	Frozen	Detergents_Paper	Delicassen
435	29703	12051	16027	13135	182	2204
436	39228	1431	764	4510	93	2346
437	14531	15488	30243	437	14841	1867
438	10290	1981	2232	1038	168	2125
439	2787	1698	2510	65	477	52

In [9]:
```
y = sales_data.iloc[:, [0]]
```

In [10]:
```
y.head(5)
```

Out[10]:

	Channel
0	2
1	2
2	2
3	1
4	2

In [11]:
```
y.tail(5)
```

Out[11]:

	Channel
435	1
436	1
437	2
438	1
439	1

In [12]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, ra
```

Model Development

Linear Support Vector Machine

Perform stratified k-fold cross validation

In [13]:
```
avg_precision_recall_scores = [0, 0, 0, 0, 0]
c_values = [0.0001, 0.001, 0.01, 0.1, 1.0]
num_iterations = 0
```

In [19]:

```
kf = StratifiedKFold(n_splits = 2)

for train_index, test_index in kf.split(X,y):
    X_train_indexed, X_test_indexed = X.iloc[train_index, :], X.iloc[test_i
    y_train_indexed, y_test_indexed = y.iloc[train_index, :], y.iloc[test_i

    for i in range(5):
        c_value = c_values[i]
        linear_svm_model = SVC(C = c_value, kernel = "linear")
        linear_svm_model.fit(X_train_indexed, y_train_indexed)
        y_score = linear_svm_model.decision_function(X_test_indexed)
        avg_precision_recall_score = average_precision_score(y_test_indexed
        avg_precision_recall_scores[i] += avg_precision_recall_score
        num_iterations += 1
```

```
/Users/ryanlim/anaconda3/lib/python3.7/site-packages/sklearn/utils/valida
tion.py:761: DataConversionWarning: A column-vector y was passed when a 1
d array was expected. Please change the shape of y to (n_samples, ), for
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d array was expected. Please change the shape of y to (n_samples, ), for
example using ravel().
  y = column_or_1d(y, warn=True)
```
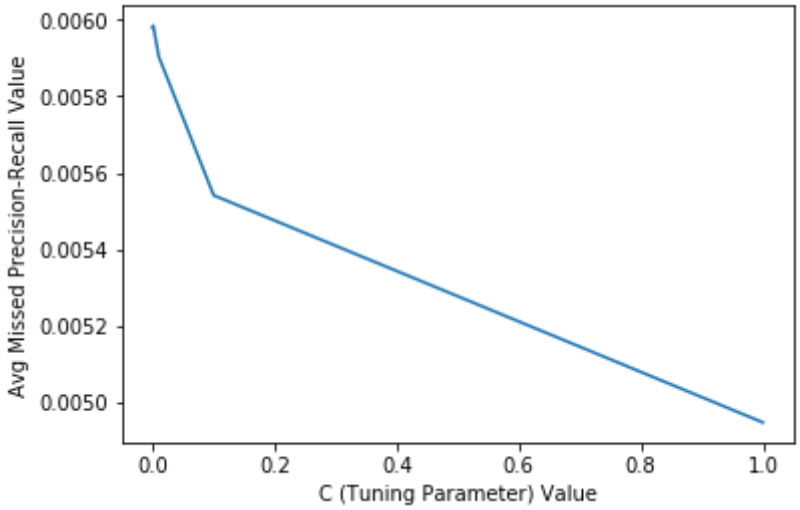

In [20]:
```
averaged_missed_precision_recall_scores = [(1 - avg_precision_recall_score)
```

Create a plot of the c (tuning parameter) and average missed precision-recall values

In [21]:
```
plt.plot(c_values, averaged_missed_precision_recall_scores )
plt.xlabel("C (Tuning Parameter) Value")
plt.ylabel("Avg Missed Precision-Recall Value")
plt.show()
```



Find the optimal c (tuning parameter) value and use it to build a linear support vector machine model.

In [22]:
```
min_avg_missed_precision_recall_score = min(averaged_missed_precision_recal
min_error_index = averaged_missed_precision_recall_scores.index(min_avg_mis
c_value = c_values[min_error_index]
```

In [23]:
```
linear_svm_model = SVC(C = c_value, kernel = "linear")
linear_svm_model.fit(X_train, y_train)
y_score = linear_svm_model.decision_function(X_test)
avg_precision_recall_score = average_precision_score(y_test, y_score)
avg_precision_recall_scores[i] += avg_precision_recall_score
```

```
/Users/ryanlim/anaconda3/lib/python3.7/site-packages/sklearn/utils/valida
tion.py:761: DataConversionWarning: A column-vector y was passed when a 1
d array was expected. Please change the shape of y to (n_samples, ), for
example using ravel().
  y = column_or_1d(y, warn=True)
```

Specify the linear support vector machine model coefficients and intercept

In [24]:
```
coefficients = pd.DataFrame({"Features":X.columns,"Coefficients":np.transpo
coefficients.head(8)
```

Out[24]:

	Features	Coefficients
0	Fresh	-0.001861
1	Milk	0.002976
2	Grocery	0.001329
3	Frozen	-0.009764
4	Detergents_Paper	0.024569
5	Delicassen	0.004162

In [25]:
```
intercept = pd.DataFrame({"Intercept": linear_svm_model.intercept_})
intercept.head()
```

Out[25]:

	Intercept
0	-80.197733

Specify the minimum cross validation error

In [26]:
```
print("The minimum average cross validation missed precision-recall score i
```

```
The minimum average cross validation missed precision-recall score is: 0.
004947229711484813
```

Support Vector Machine With Polynomial Kernel

Perform stratified k-fold cross validation

In [27]:
```
avg_precision_recall_scores = [0, 0, 0, 0, 0]
c_values = [0.0001, 0.001, 0.01, 0.1, 1.0]
num_iterations = 0
```

In [29]:
```
kf = StratifiedKFold(n_splits = 2)

for train_index, test_index in kf.split(X,y):
    X_train_indexed, X_test_indexed = X.iloc[train_index, :], X.iloc[test_i
    y_train_indexed, y_test_indexed = y.iloc[train_index, :], y.iloc[test_i

    for i in range(5):
        c_value = c_values[i]
        polynomial_kernel_svm_model = SVC(C = c_value, kernel = "poly")
        polynomial_kernel_svm_model.fit(X_train_indexed, y_train_indexed)
        y_score = polynomial_kernel_svm_model.decision_function(X_test_inde
        avg_precision_recall_score = average_precision_score(y_test_indexed
        avg_precision_recall_scores[i] += avg_precision_recall_score
        num_iterations += 1
```

```
/Users/ryanlim/anaconda3/lib/python3.7/site-packages/sklearn/utils/valida
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'scale' in version 0.22 to account better for unscaled features. Set gamm
```

```
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  "avoid this warning.", FutureWarning)
```
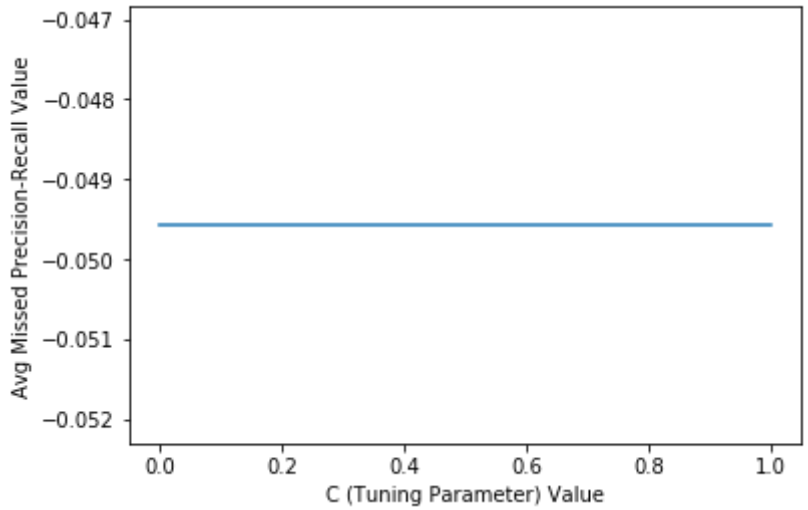

In [31]:
```
averaged_missed_precision_recall_scores = [(1 - avg_precision_recall_score)
```

Create a plot of the c (tuning parameter) and average missed precision-recall values

In [32]:
```
plt.plot(c_values, averaged_missed_precision_recall_scores )
plt.xlabel("C (Tuning Parameter) Value")
plt.ylabel("Avg Missed Precision-Recall Value")
plt.show()
```



Specify the minimum cross_validation error

In [33]:
```
min_avg_missed_precision_recall_score = min(averaged_missed_precision_recal
print(min_avg_missed_precision_recall_score)
```

```
-0.049571645366501674
```

Support Vector Machine With Gaussian Kernel

Perform stratified k-fold cross validation

In [34]:
```
avg_precision_recall_scores = [0, 0, 0, 0, 0]
c_values = [0.0001, 0.001, 0.01, 0.1, 1.0]
num_iterations = 0
```

In [35]:
```
kf = StratifiedKFold(n_splits = 2)

for train_index, test_index in kf.split(X,y):
    X_train_indexed, X_test_indexed = X.iloc[train_index, :], X.iloc[test_i
    y_train_indexed, y_test_indexed = y.iloc[train_index, :], y.iloc[test_i

    for i in range(5):
        c_value = c_values[i]
        gaussian_kernel_svm_model = SVC(C = c_value, kernel = "rbf", gamma=
        gaussian_kernel_svm_model.fit(X_train_indexed, y_train_indexed)
        y_score = gaussian_kernel_svm_model.decision_function(X_test_indexe
        avg_precision_recall_score = average_precision_score(y_test_indexed
        avg_precision_recall_scores[i] += avg_precision_recall_score
        num_iterations += 1
```

```
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example using ravel().
  y = column_or_1d(y, warn=True)
```
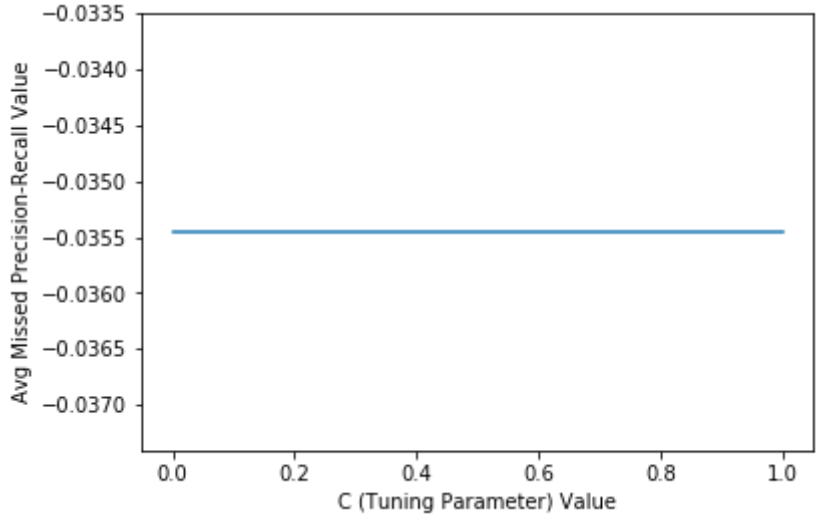

In [36]:
```
averaged_missed_precision_recall_scores = [(1 - avg_precision_recall_score)
```

Create a plot of the c (tuning parameter) and average missed precision-recall values

In [37]:
```
plt.plot(c_values, averaged_missed_precision_recall_scores)
plt.xlabel("C (Tuning Parameter) Value")
plt.ylabel("Avg Missed Precision-Recall Value")
plt.show()
```



Specify the minimum cross_validation error

In [38]:
```
min_avg_missed_precision_recall_score = min(averaged_missed_precision_recal
print(min_avg_missed_precision_recall_score)
```

```
-0.03545454545454545
```