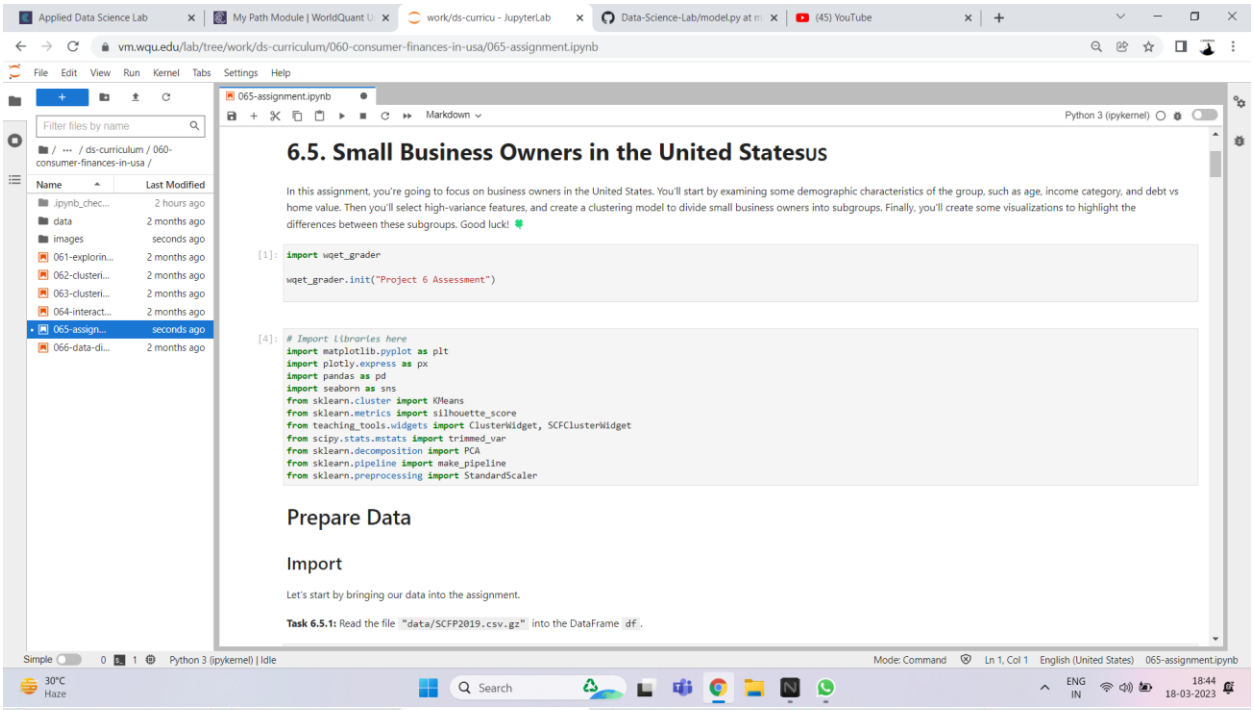
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6.5. Small Business Owners in the United Statesus
In this assignment, you're going to focus on business owners in the United States. You'll start by examining some demographic characteristics of the group, such as age, income category, and debt vs home value. Then you'll select high-variance features, and create a clustering model to divide small business owners into subgroups. Finally, you'll create some visualizations to highlight the differences between these subgroups. Good luck!
[1]:
import wqet_grader
wqet_grader.init("Project 6 Assessment")
[4]:
# Import libraries here
import matplotlib.pyplot as plt
import plotly.express as px
import pandas as pd
import seaborn as sns
from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score
from teaching_tools.widgets import ClusterWidget, SCFClusterWidget
from scipy.stats.mstats import trimmed_var
from sklearn.decomposition import PCA
from sklearn.pipeline import make_pipeline
from sklearn.preprocessing import StandardScaler
Prepare Data
Import
Let's start by bringing our data into the assignment.
Task 6.5.1: Read the file "data/SCFP2019.csv.gz" into the DataFrame df.
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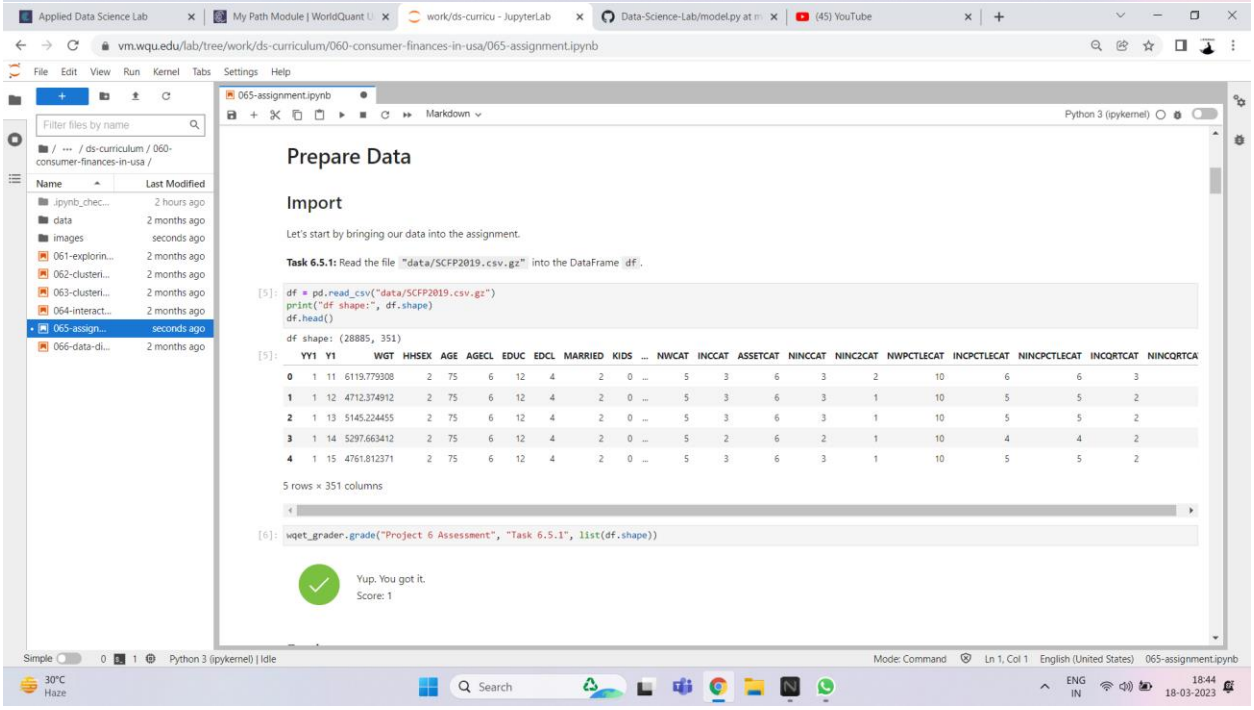
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066-data-di... 2 months ago
Prepare Data
Import
Let's start by bringing our data into the assignment.
Task 6.5.1: Read the file "data/SCFP2019.csv.gz" into the DataFrame df.
[5]:
df = pd.read_csv("data/SCFP2019.csv.gz")
print("df shape:", df.shape)
df.head()
df shape: (28885, 351)
[5]:
YY1 Y1 WGT HHSEX AGE AGECL EDUC EDCL MARRIED KIDS ... NWCAT INCCAT ASSETCAT NINCCAT NINC2CAT NWPCTLECAT INCPCTLECAT NINCPCTLECAT INCQRTCAT NINCQRTCA
0 1 11 6119.779308 2 75 6 12 4 2 0 ... 5 3 6 3 2 10 6 6 3
1 1 12 4712.374912 2 75 6 12 4 2 0 ... 5 3 6 3 1 10 5 5 2
2 1 13 5145.224455 2 75 6 12 4 2 0 ... 5 3 6 3 1 10 5 5 2
3 1 14 5297.663412 2 75 6 12 4 2 0 ... 5 2 6 2 1 10 4 4 2
4 1 15 4761.812371 2 75 6 12 4 2 0 ... 5 3 6 3 1 10 5 5 2
5 rows × 351 columns
[6]:
wqet_grader.grade("Project 6 Assessment", "Task 6.5.1", list(df.shape))
Yup. You got it.
Score: 1
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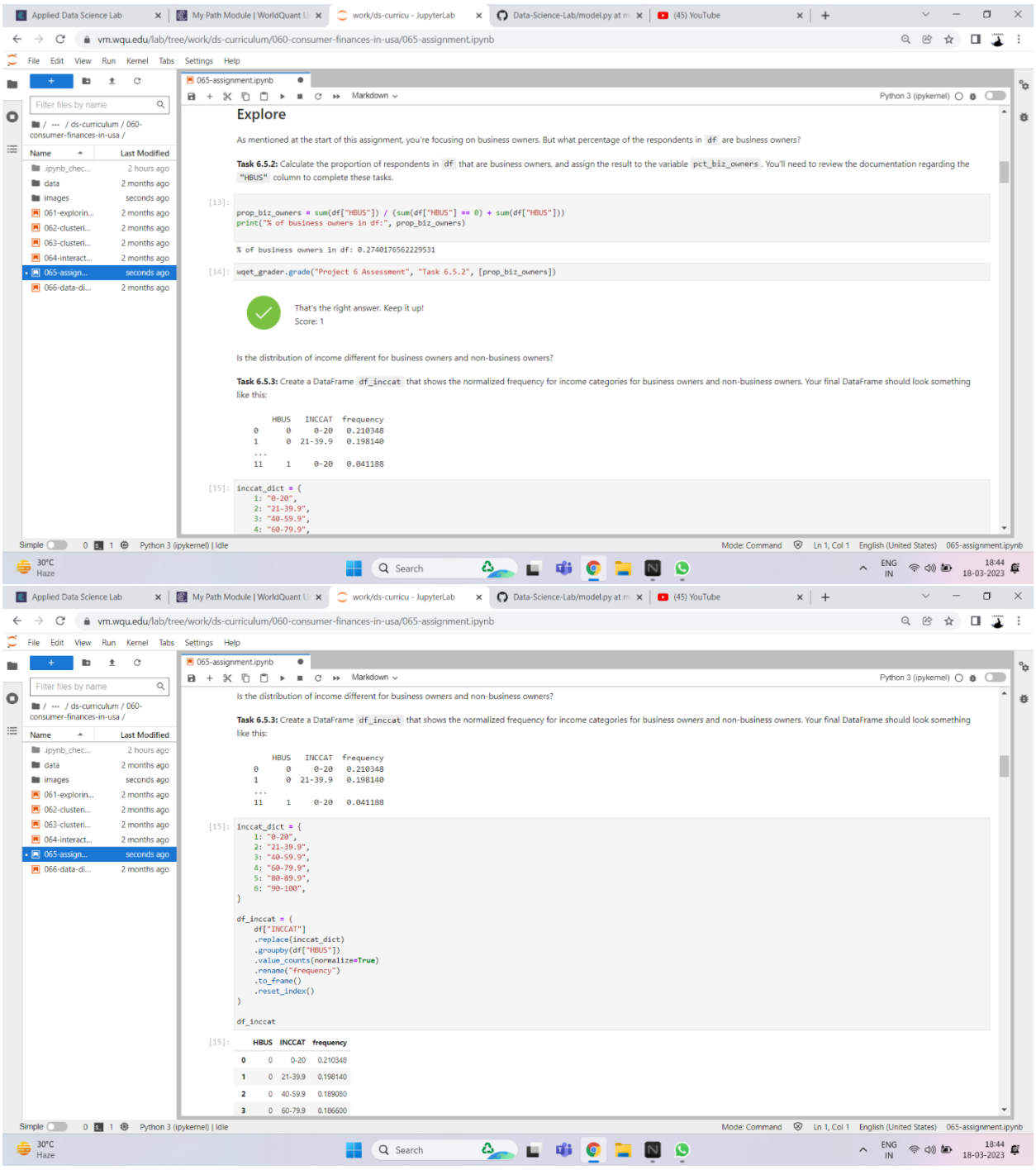
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Explore
As mentioned at the start of this assignment, you're focusing on business owners. But what percentage of the respondents in df are business owners?
Task 6.5.2: Calculate the proportion of respondents in df that are business owners, and assign the result to the variable pct_biz_owners. You'll need to review the documentation regarding the "HBUS" column to complete these tasks.
[13]:
prop_biz_owners = sum(df["HBUS"]) / (sum(df["HBUS"] == 0) + sum(df["HBUS"]))
print("% of business owners in df:", prop_biz_owners)
% of business owners in df: 0.2740176562229531
[14]:
wqet_grader.grade("Project 6 Assessment", "Task 6.5.2", [prop_biz_owners])
That's the right answer. Keep it up!
Score: 1
Is the distribution of income different for business owners and non-business owners?
Task 6.5.3: Create a DataFrame df_inccat that shows the normalized frequency for income categories for business owners and non-business owners. Your final DataFrame should look something like this:
HBUS INCCAT frequency
0 0 0-20 0.210348
1 0 21-39.9 0.198140
...
11 1 0-20 0.041188
[15]:
inccat_dict = {
1: "0-20",
2: "21-39.9",
3: "40-59.9",
4: "60-79.9",
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Is the distribution of income different for business owners and non-business owners?
Task 6.5.3: Create a DataFrame df_inccat that shows the normalized frequency for income categories for business owners and non-business owners. Your final DataFrame should look something like this:
HBUS INCCAT frequency
0 0 0-20 0.210348
1 0 21-39.9 0.198140
...
11 1 0-20 0.041188
[15]:
inccat_dict = {
1: "0-20",
2: "21-39.9",
3: "40-59.9",
4: "60-79.9",
5: "80-89.9",
6: "90-100",
}
df_inccat = (
df["INCCAT"]
.replace(inccat_dict)
.groupby(df["HBUS"])
.value_counts(normalize=True)
.rename("frequency")
.to_frame()
.reset_index()
)
df_inccat
[15]:
HBUS INCCAT frequency
0 0 0-20 0.210348
1 0 21-39.9 0.198140
2 0 40-59.9 0.189080
3 0 60-79.9 0.186600
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064-interact...	2 months ago
065-assign...	seconds ago
066-data-di...	2 months ago

```
df_inccat
```

[15]:

	HBUS	INCCAT	frequency
0	0	0-20	0.210348
1	0	21-39.9	0.198140
2	0	40-59.9	0.189080
3	0	60-79.9	0.186600
4	0	90-100	0.117167
5	0	80-89.9	0.098665
6	1	90-100	0.629438
7	1	60-79.9	0.119015
8	1	80-89.9	0.097410
9	1	40-59.9	0.071510
10	1	21-39.9	0.041440
11	1	0-20	0.041188

[16]:

```
wqet_grader.grade("Project 6 Assessment", "Task 6.5.3", df_inccat)
```

You got it. Dance party time!

Score: 1

Task 6.5.4: Using seaborn, create a side-by-side bar chart of `df_inccat`. Set `hue` to `"HBUS"`, and make sure that the income categories are in the correct order along the x-axis. Label to the x-axis `"Income Category"`, the y-axis `"Frequency (%)"`, and use the title `"Income Distribution: Business Owners vs. Non-Business Owners"`.

[17]:

```
# Create bar chart of `df_inccat`

sns.barplot(
    x="INCCAT",
```

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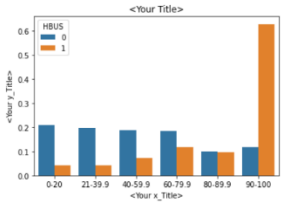
Task 6.5.4: Using seaborn, create a side-by-side bar chart of `df_inccat`. Set `hue` to `"HBUS"`, and make sure that the income categories are in the correct order along the x-axis. Label to the x-axis `"Income Category"`, the y-axis `"Frequency (%)"`, and use the title `"Income Distribution: Business Owners vs. Non-Business Owners"`.

[17]:

```
# Create bar chart of `df_inccat`

sns.barplot(
    x="INCCAT",
    y="frequency",
    hue="HBUS",
    data=df_inccat,
    order=inccat_dict.values()
)
plt.xlabel("<Your x_Title>")
plt.ylabel("<Your y_Title>")
plt.title("<Your Title>");

# Don't delete the code below 👇
plt.savefig("images/6-5-4.png", dpi=150)
```



[18]:

```
with open("images/6-5-4.png", "rb") as file:
    wqet_grader.grade("Project 6 Assessment", "Task 6.5.4", file)
```

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Task 6.5.5: Using seaborn, create a scatter plot that shows `"HOUSES"` vs. `"DEBT"`. You should color the datapoints according to business ownership. Be sure to label the x-axis `"Household Debt"`, the y-axis `"Home Value"`, and use the title `"Home Value vs. Household Debt"`.

[19]:
```
# Plot "HOUSES" vs "DEBT" with hue=Label
sns.scatterplot(x=df["DEBT"] / 1e6, y=df["HOUSES"] / 1e6, palette="deep")
plt.xlabel("Household Debt")
plt.ylabel("Home Value")
plt.title("Home Value vs. Household Debt");
# Don't delete the code below 👇
plt.savefig("images/6-5-5.png", dpi=150)
```

For the model building part of the assignment, you're going to focus on small business owners, defined as respondents who have a business and whose income does not exceed $500,000.

[21]:
```
with open("images/6-5-5.png", "rb") as file:
    wqet_grader.grade("Project 6 Assessment", "Task 6.5.5", file)
```

Yes! Keep on rockin'. 🎸 That's right.
Score: 1

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Task 6.5.6: Create a new DataFrame `df_small_biz` that contains only business owners whose income is below $500,000.

[22]:
```
mask = (df["HBUS"]) & (df["INCOME"] < 500_000)
df_small_biz = df[mask]
print("df_small_biz shape:", df_small_biz.shape)
df_small_biz.head()
```

```
df_small_biz shape: (4364, 351)
```

[22]:

	YY1	Y1	WGT	HHSEX	AGE	AGECL	EDUC	EDCL	MARRIED	KIDS	...	NWCAT	INCCAT	ASSETCAT	NINCCAT	NINC2CAT	NWPCTLECAT	INCPCTLECAT	NINCPCTLECAT	INCQRTCAT	NINCQRTC
80	17	171	7802.265717	1	62	4	12	4	1	0	...	3	5	5	5	2	7	9	9	4	
81	17	172	8247.536301	1	62	4	12	4	1	0	...	3	5	5	5	2	7	9	9	4	
82	17	173	8169.562719	1	62	4	12	4	1	0	...	3	5	5	5	2	7	9	9	4	
83	17	174	8087.704517	1	62	4	12	4	1	0	...	3	5	5	5	2	7	9	9	4	
84	17	175	8276.510048	1	62	4	12	4	1	0	...	3	5	5	5	2	7	9	9	4	

5 rows × 351 columns

[23]:
```
wqet_grader.grade("Project 6 Assessment", "Task 6.5.6", list(df_small_biz.shape))
```

Way to go!
Score: 1

We saw that credit-fearful respondents were relatively young. Is the same true for small business owners?

Task 6.5.7: Create a histogram from the `"AGE"` column in `df_small_biz` with 10 bins. Be sure to label the x-axis `"Age"`, the y-axis `"Frequency (count)"`, and use the title `"Small Business Owners: Age Distribution"`.

[24]:
```
# Plot histogram of "AGE"
df_small_biz["AGE"].hist(bins=10)
plt.xlabel("Your x_Label")
plt.ylabel("Your y_Label")
```

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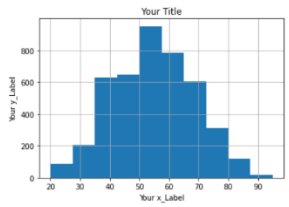
We saw that credit-fearful respondents were relatively young. Is the same true for small business owners?

Task 6.5.7: Create a histogram from the `"AGE"` column in `df_small_biz` with 10 bins. Be sure to label the x-axis `"Age"`, the y-axis `"Frequency (count)"`, and use the title `"Small Business Owners: Age Distribution"`.

[24]:
```
# Plot histogram of "AGE"
df_small_biz["AGE"].hist(bins=10)
plt.xlabel("Your x_Label")
plt.ylabel("Your y_Label")
plt.title("Your Title");
# Don't delete the code below 👇
plt.savefig("images/6-5-7.png", dpi=150)
```



So, can we say the same thing about small business owners as we can about credit-fearful people?

[25]:
```
with open("images/6-5-7.png", "rb") as file:
    wqet_grader.grade("Project 6 Assessment", "Task 6.5.7", file)
```

Yes! Great problem solving.
Score: 1

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Task 6.5.8: Calculate the variance for all the features in `df_small_biz`, and create a Series `top_ten_var` with the 10 features with the largest variance.

[26]:
```
# Calculate variance, get 10 largest features
top_ten_var = df_small_biz.var().sort_values().tail(10)
top_ten_var
```

[26]:
```
EQUITY      1.005088e+13
FIN         2.103228e+13
KGBUS       5.025210e+13
ACTBUS      5.405021e+13
BUS         5.606717e+13
KGTOTAL     6.120760e+13
NHNFIN      7.363197e+13
NFIN        9.244074e+13
NETWORTH    1.424450e+14
ASSET       1.520071e+14
dtype: float64
```

[27]:
```
wqet_grader.grade("Project 6 Assessment", "Task 6.5.8", top_ten_var)
```

Yes! Great problem solving.
Score: 1

We'll need to remove some outliers to avoid problems in our calculations, so let's trim them out.

Task 6.5.9: Calculate the trimmed variance for the features in `df_small_biz`. Your calculations should not include the top and bottom 10% of observations. Then create a Series `top_ten_trim_var` with the 10 features with the largest variance.

[28]:
```
# Calculate trimmed variance
top_ten_trim_var = df_small_biz.apply(trimmed_var, limits=(0.1, 0.1)).sort_values().tail(10)
top_ten_trim_var
```

[28]:
```
EQUITY      1.177020e+11
KGBUS       1.838163e+11
FIN         3.588855e+11
KGTOTAL     6.367828e+11
```

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063-clusteri...	2 months ago
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065-assign...	a minute ago
066-data-di...	2 months ago

Task 6.5.9: Calculate the trimmed variance for the features in `df_small_biz`. Your calculations should not include the top and bottom 10% of observations. Then create a Series `top_ten_trim_var` with the 10 features with the largest variance.

[28]:
```
# Calculate trimmed variance
top_ten_trim_var = df_small_biz.apply(trimmed_var, limits=(0.1, 0.1)).sort_values().tail(10)
top_ten_trim_var
```

[28]:
```
EQUITY      1.177020e+11
KGBUS       1.838163e+11
FIN         3.588855e+11
KGTOTAL     5.367878e+11
ACTBUS      5.441806e+11
BUS         6.531708e+11
NHNFIN      1.109187e+12
NFIN        1.792707e+12
NETWORTH    3.726356e+12
ASSET       3.990101e+12
dtype: float64
```

[29]:
```
wqet_grader.grade("Project 6 Assessment", "Task 6.5.9", top_ten_trim_var)
```

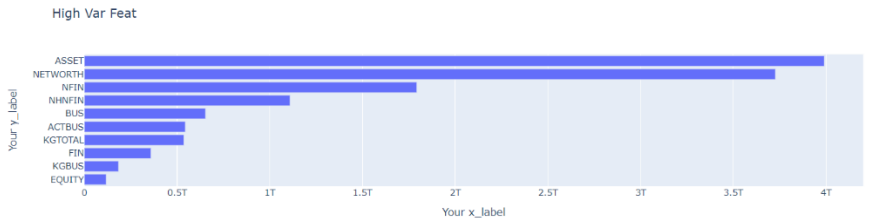
Python master
Score: 1

Let's do a quick visualization of those values.

Task 6.5.10: Use plotly express to create a horizontal bar chart of `top_ten_trim_var`. Be sure to label your x-axis `"Trimmed Variance [$]"`, the y-axis `"Feature"`, and use the title `"Small Business Owners: High Variance Features"`.

[33]:
```
# Create horizontal bar chart of `top_ten_trim_var`
fig = px.bar(
    x=top_ten_trim_var,
    y=top_ten_trim_var.index,
    title="High Var Feat"
)
fig.update_layout(xaxis_title="Your x_label", yaxis_title="Your y_label")
# Don't delete the code below 👇
fig.write_image("images/6-5-10.png", scale=1, height=500, width=700)

fig.show()
```



[34]:
```
with open("images/6-5-10.png", "rb") as file:
    wqet_grader.grade("Project 6 Assessment", "Task 6.5.10", file)
```

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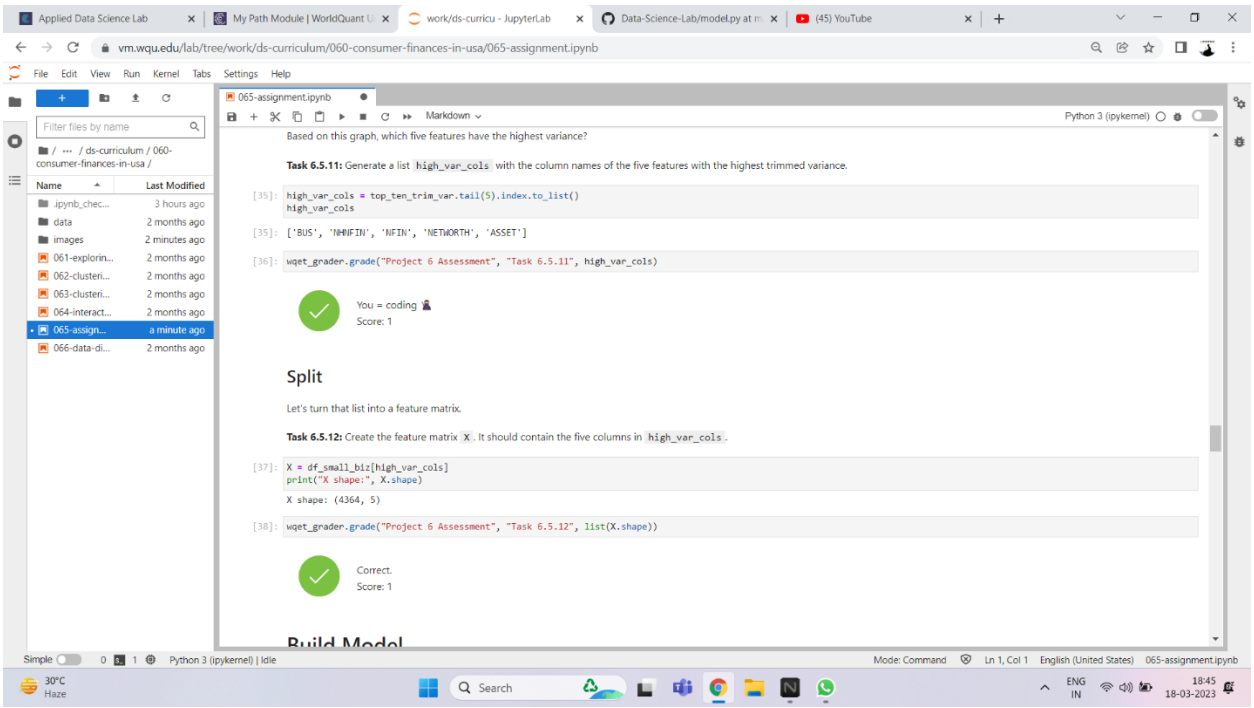


Based on this graph, which five features have the highest variance?

Task 6.5.11: Generate a list `high_var_cols` with the column names of the five features with the highest trimmed variance.

```
[35]: high_var_cols = top_ten_trim_var.tail(5).index.to_list()
      high_var_cols
```

```
[35]: ['BUS', 'NMHFIN', 'NFIN', 'NETWORTH', 'ASSET']
```

```
[36]: wqet_grader.grade("Project 6 Assessment", "Task 6.5.11", high_var_cols)
```

You = coding
Score: 1

Split

Let's turn that list into a feature matrix.

Task 6.5.12: Create the feature matrix `X`. It should contain the five columns in `high_var_cols`.

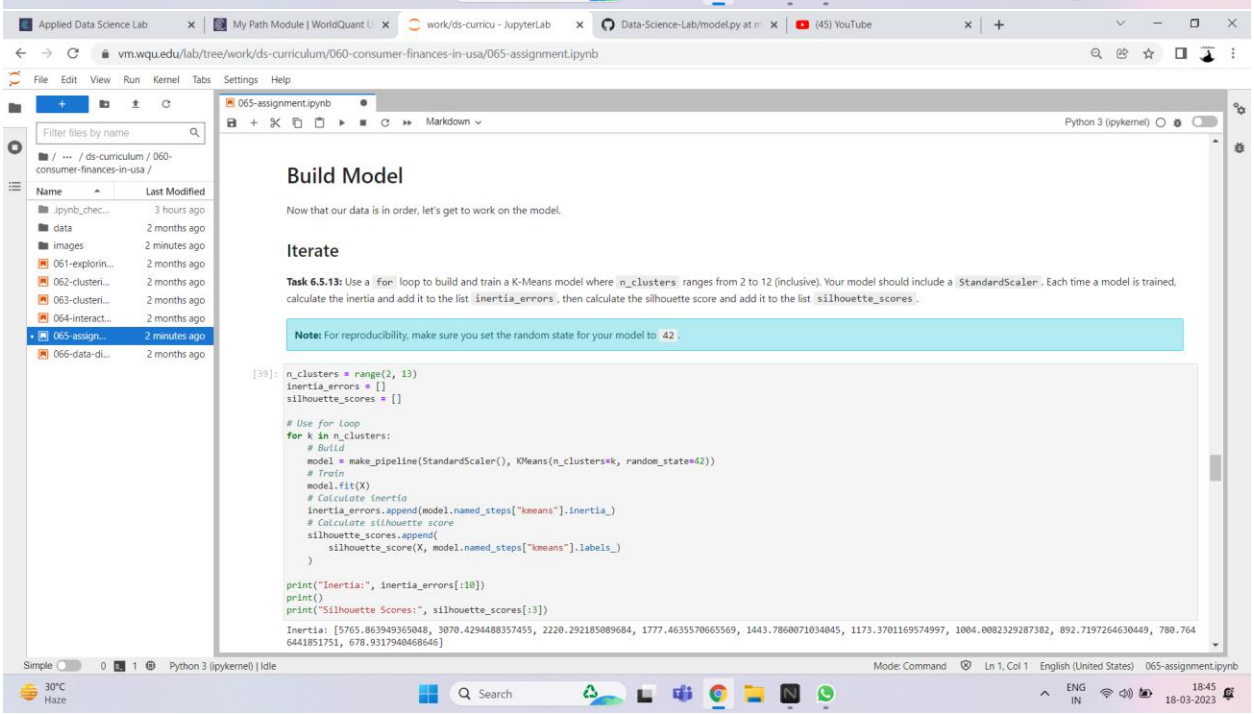
```
[37]: X = df_small_biz[high_var_cols]
      print("X shape:", X.shape)
```

```
X shape: (4364, 5)
```

```
[38]: wqet_grader.grade("Project 6 Assessment", "Task 6.5.12", list(X.shape))
```

Correct.
Score: 1

Build Model



Build Model

Now that our data is in order, let's get to work on the model.

Iterate

Task 6.5.13: Use a `for` loop to build and train a K-Means model where `n_clusters` ranges from 2 to 12 (inclusive). Your model should include a `StandardScaler`. Each time a model is trained, calculate the inertia and add it to the list `inertia_errors`, then calculate the silhouette score and add it to the list `silhouette_scores`.

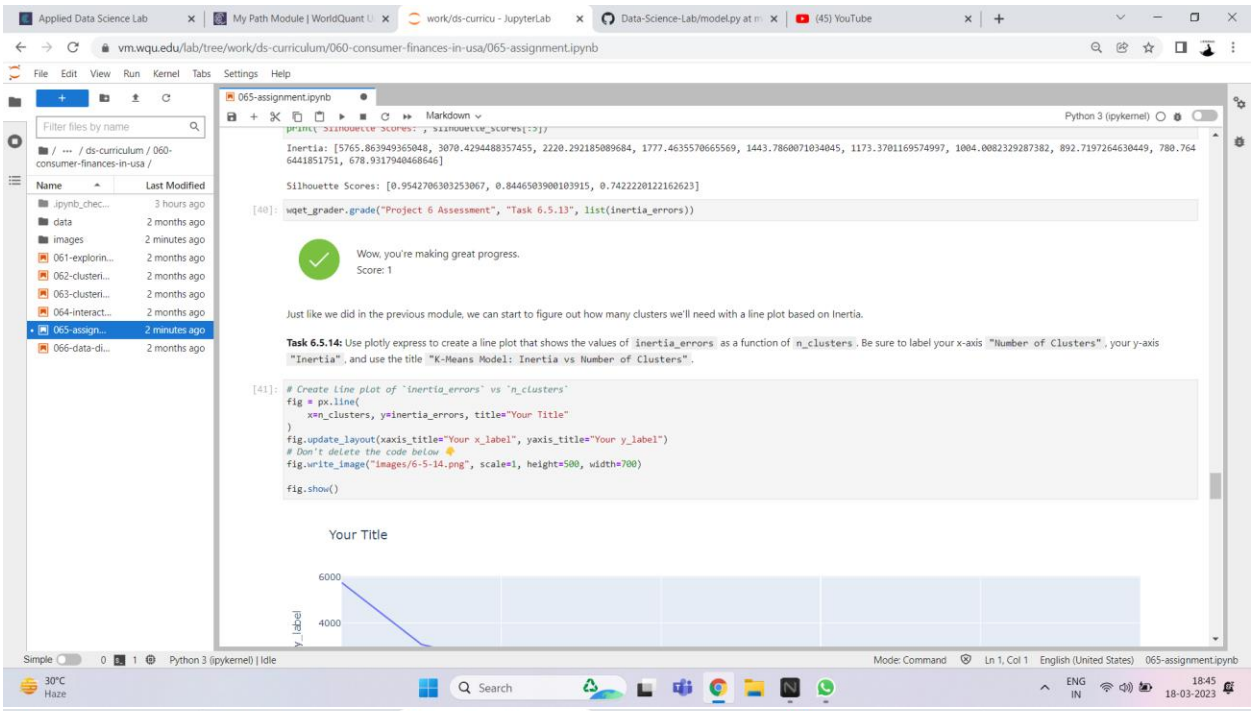
Note: For reproducibility, make sure you set the random state for your model to `42`.

```
[39]: n_clusters = range(2, 13)
      inertia_errors = []
      silhouette_scores = []

      # Use for loop
      for k in n_clusters:
          # Build
          model = make_pipeline(StandardScaler(), KMeans(n_clusters=k, random_state=42))
          # Train
          model.fit(X)
          # Calculate inertia
          inertia_errors.append(model.named_steps["kmeans"].inertia_)
          # Calculate silhouette score
          silhouette_scores.append(
              silhouette_score(X, model.named_steps["kmeans"].labels_)
          )

      print("Inertia:", inertia_errors[:10])
      print()
      print("Silhouette Scores:", silhouette_scores[:3])
```

```
Inertia: [5765.863949365048, 3070.4294488357455, 2220.292185089684, 1777.4635570665569, 1443.7860071034045, 1173.3701169574997, 1004.0082329287382, 892.7197264630449, 780.7646441851751, 678.9317940468646]
```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Inertia: [5765.863949365048, 3070.4294488357455, 2220.292185089684, 1777.4635570665569, 1443.7860071034045, 1173.3701169574997, 1004.0082329287382, 892.7197264630449, 780.7646441851751, 678.9317940468646]
Silhouette Scores: [0.9542706303253067, 0.8446503900103915, 0.7422220122162623]
[40]: wqet_grader.grade("Project 6 Assessment", "Task 6.5.13", list(inertia_errors))
Wow, you're making great progress.
Score: 1
Just like we did in the previous module, we can start to figure out how many clusters we'll need with a line plot based on Inertia.
Task 6.5.14: Use plotly express to create a line plot that shows the values of inertia_errors as a function of n_clusters. Be sure to label your x-axis "Number of Clusters", your y-axis "Inertia", and use the title "K-Means Model: Inertia vs Number of Clusters".
[41]: # Create line plot of `inertia_errors` vs `n_clusters`
fig = px.line(
x=n_clusters, y=inertia_errors, title="Your Title"
)
fig.update_layout(xaxis_title="Your x_label", yaxis_title="Your y_label")
# Don't delete the code below
fig.write_image("images/6-5-14.png", scale=1, height=500, width=700)
fig.show()
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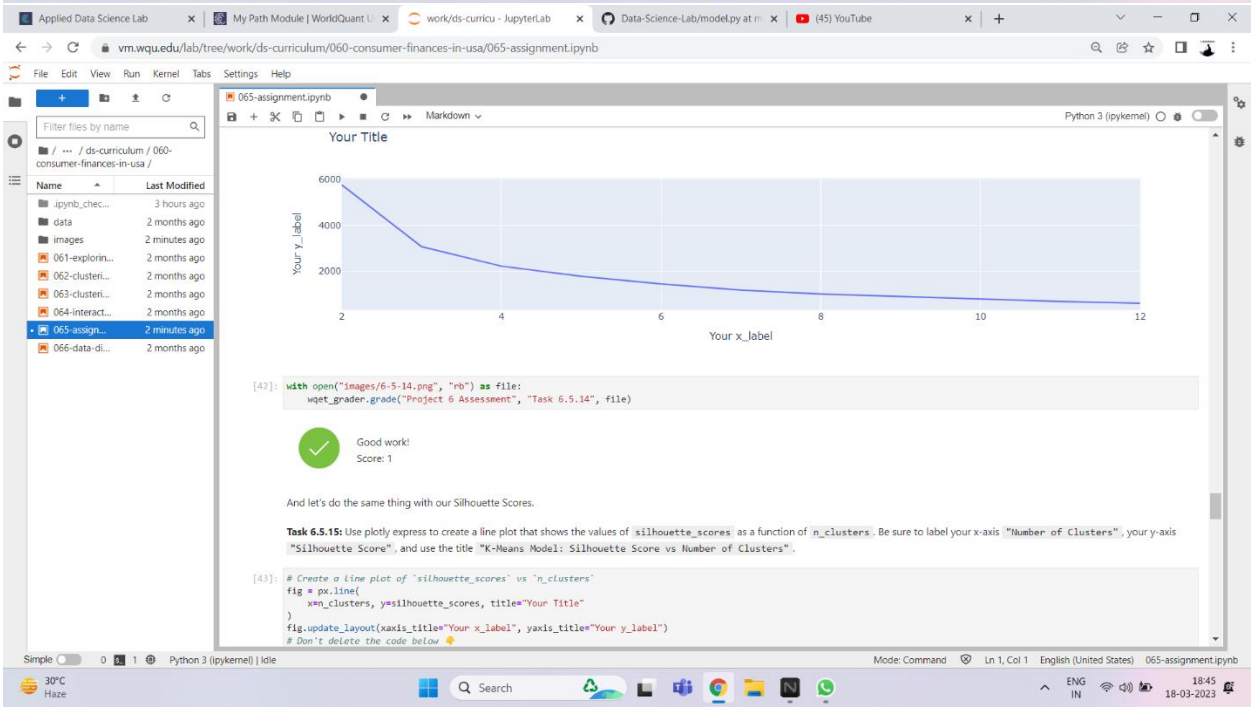
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12
Your x_label
[42]: with open("images/6-5-14.png", "rb") as file:
wqet_grader.grade("Project 6 Assessment", "Task 6.5.14", file)
Good work!
Score: 1
And let's do the same thing with our Silhouette Scores.
Task 6.5.15: Use plotly express to create a line plot that shows the values of silhouette_scores as a function of n_clusters. Be sure to label your x-axis "Number of Clusters", your y-axis "Silhouette Score", and use the title "K-Means Model: Silhouette Score vs Number of Clusters".
[43]: # Create a line plot of `silhouette_scores` vs `n_clusters`
fig = px.line(
x=n_clusters, y=silhouette_scores, title="Your Title"
)
fig.update_layout(xaxis_title="Your x_label", yaxis_title="Your y_label")
# Don't delete the code below
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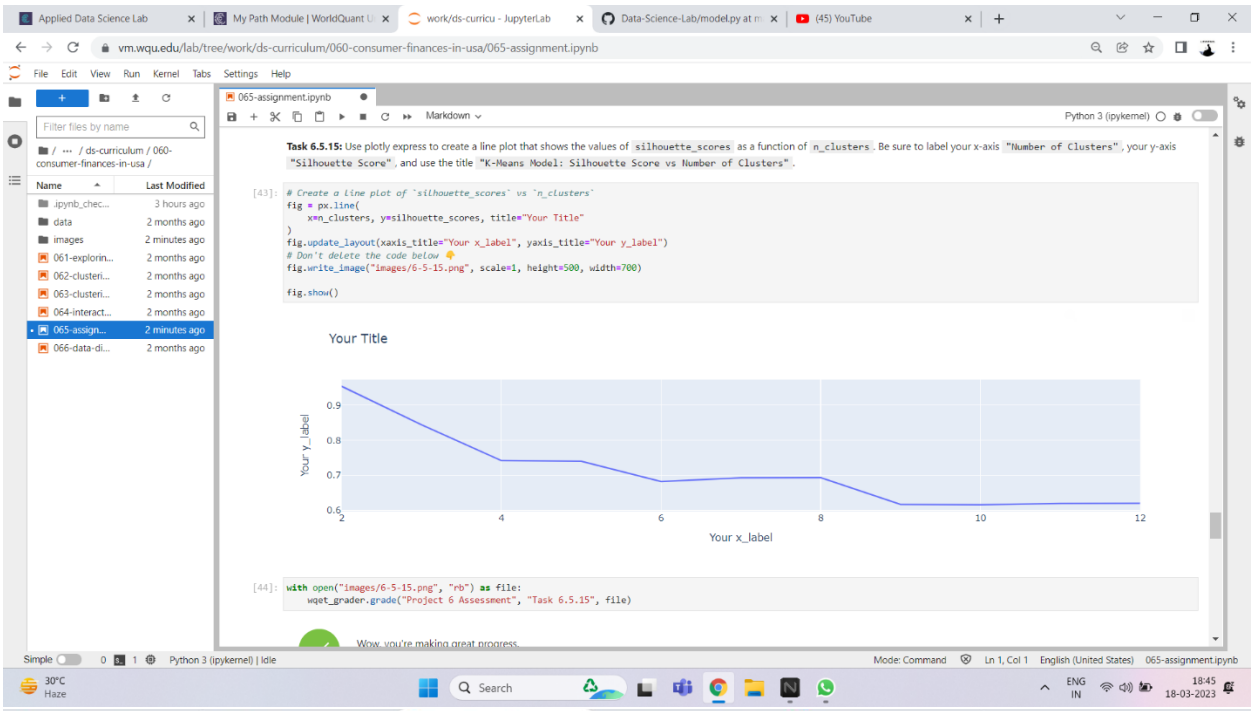
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Task 6.5.15: Use plotly express to create a line plot that shows the values of silhouette_scores as a function of n_clusters. Be sure to label your x-axis "Number of Clusters", your y-axis "Silhouette Score", and use the title "K-Means Model: Silhouette Score vs Number of Clusters".
[43]:
# Create a line plot of `silhouette_scores` vs `n_clusters`
fig = px.line(
x=n_clusters, y=silhouette_scores, title="Your Title"
)
fig.update_layout(xaxis_title="Your x_label", yaxis_title="Your y_label")
# Don't delete the code below 👇
fig.write_image("images/6-5-15.png", scale=1, height=500, width=700)
fig.show()
Your Title
Your y_label
0.9
0.8
0.7
0.6
2
4
6
8
10
12
Your x_label
[44]:
with open("images/6-5-15.png", "rb") as file:
wqet_grader.grade("Project 6 Assessment", "Task 6.5.15", file)
Wow, you're making great progress.
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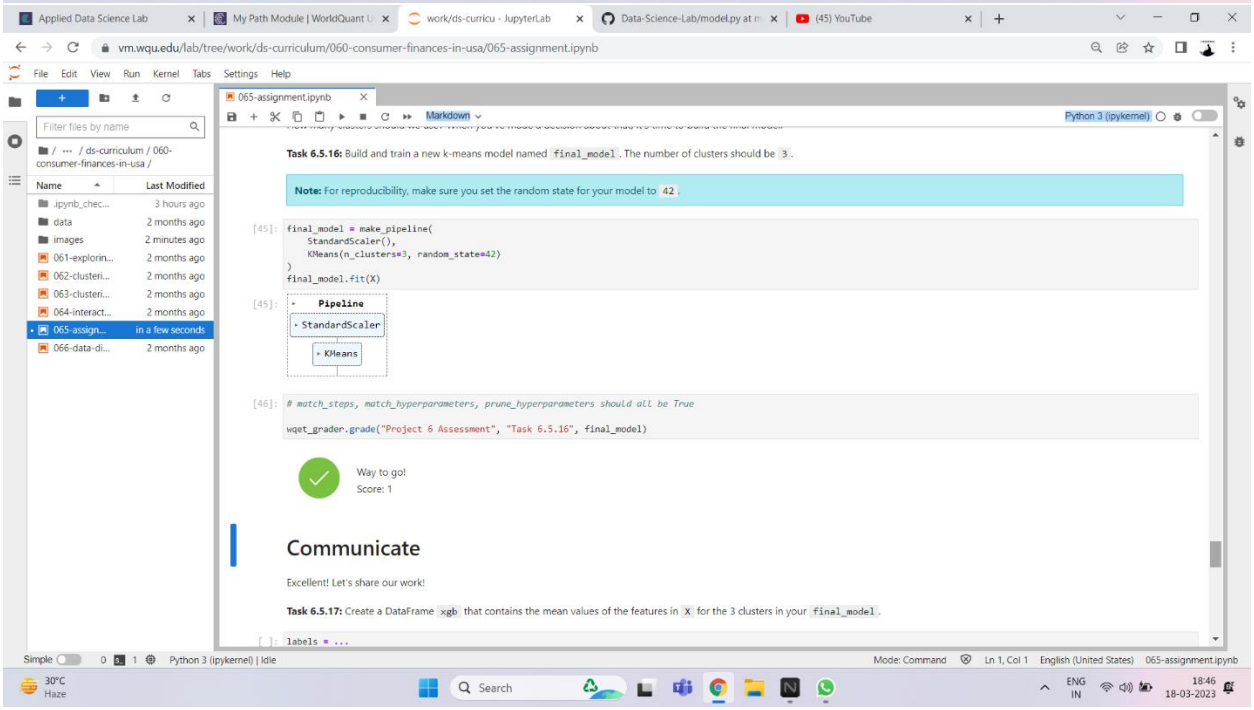
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Task 6.5.16: Build and train a new k-means model named final_model. The number of clusters should be 3.
Note: For reproducibility, make sure you set the random state for your model to 42.
[45]:
final_model = make_pipeline(
StandardScaler(),
KMeans(n_clusters=3, random_state=42)
)
final_model.fit(X)
[45]:
Pipeline
StandardScaler
KMeans
[46]:
# match_steps, match_hyperparameters, prune_hyperparameters should all be True
wqet_grader.grade("Project 6 Assessment", "Task 6.5.16", final_model)
Way to go!
Score: 1
Communicate
Excellent! Let's share our work!
Task 6.5.17: Create a DataFrame xgb that contains the mean values of the features in X for the 3 clusters in your final_model.
[ ]:
labels = ...
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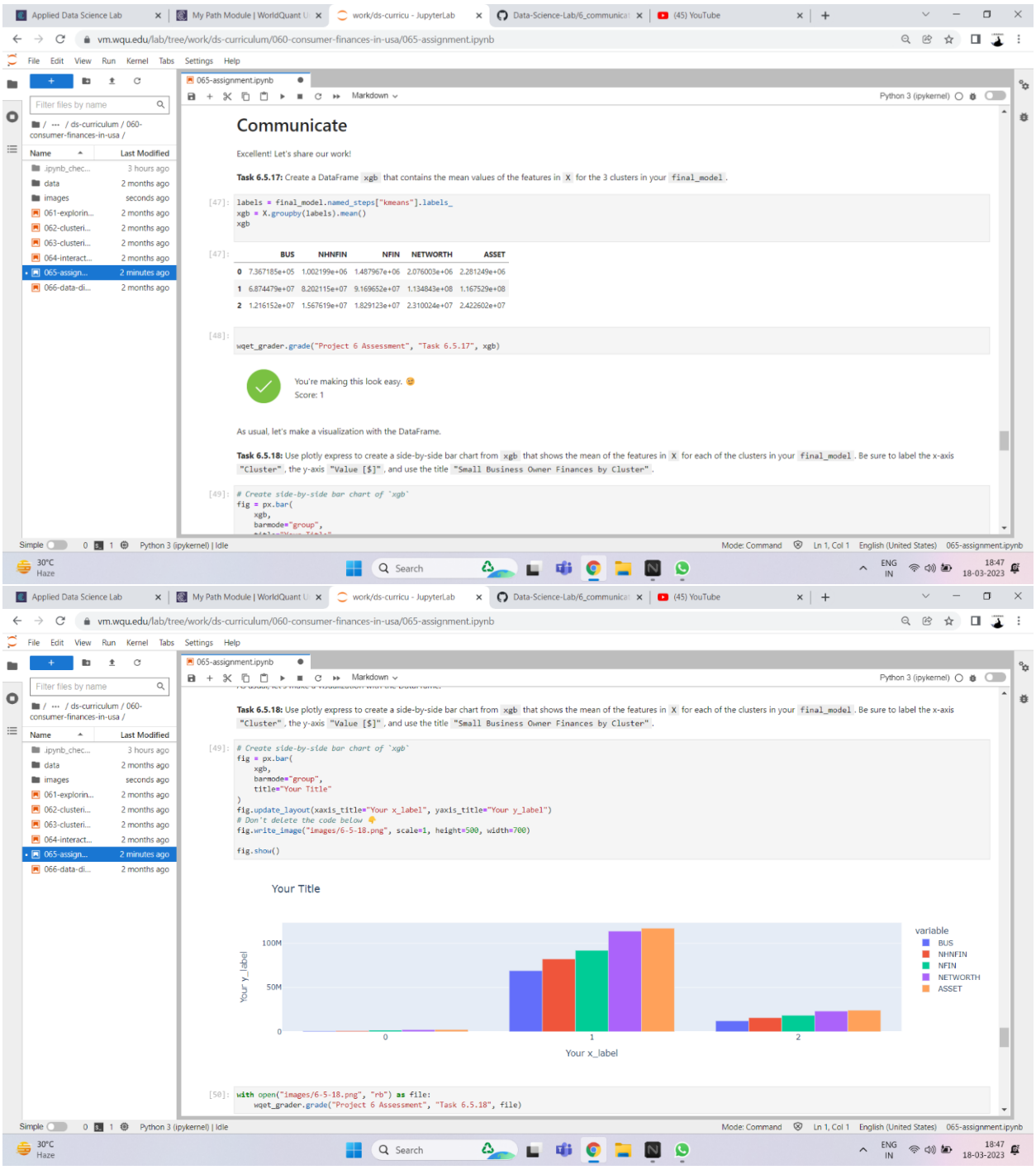
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Communicate
Excellent! Let's share our work!
Task 6.5.17: Create a DataFrame xgb that contains the mean values of the features in X for the 3 clusters in your final_model.
[47]:
labels = final_model.named_steps["kmeans"].labels_
xgb = X.groupby(labels).mean()
xgb
[47]:
BUS NHNFIN NFIN NETWORTH ASSET
0 7.367185e+05 1.002199e+06 1.487967e+06 2.076003e+06 2.281249e+06
1 6.874479e+07 8.202115e+07 9.169652e+07 1.134843e+08 1.167529e+08
2 1.216152e+07 1.567619e+07 1.829123e+07 2.310024e+07 2.422602e+07
[48]:
wqet_grader.grade("Project 6 Assessment", "Task 6.5.17", xgb)
You're making this look easy. 😉
Score: 1
As usual, let's make a visualization with the DataFrame.
Task 6.5.18: Use plotly express to create a side-by-side bar chart from xgb that shows the mean of the features in X for each of the clusters in your final_model. Be sure to label the x-axis "Cluster", the y-axis "Value [$]", and use the title "Small Business Owner Finances by Cluster".
[49]:
# Create side-by-side bar chart of `xgb`
fig = px.bar(
xgb,
barmode="group",
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Task 6.5.18: Use plotly express to create a side-by-side bar chart from xgb that shows the mean of the features in X for each of the clusters in your final_model. Be sure to label the x-axis "Cluster", the y-axis "Value [$]", and use the title "Small Business Owner Finances by Cluster".
[49]:
# Create side-by-side bar chart of `xgb`
fig = px.bar(
xgb,
barmode="group",
title="Your Title"
)
fig.update_layout(xaxis_title="Your x_label", yaxis_title="Your y_label")
# Don't delete the code below 👇
fig.write_image("images/6-5-18.png", scale=1, height=500, width=700)
fig.show()
Your Title
Your y_label
100M
50M
0
0
1
2
Your x_label
variable
BUS
NHNFIN
NFIN
NETWORTH
ASSET
[50]:
with open("images/6-5-18.png", "rb") as file:
wqet_grader.grade("Project 6 Assessment", "Task 6.5.18", file)
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Task 6.5.19: Create a `PCA` transformer, use it to reduce the dimensionality of the data in `X` to 2, and then put the transformed data into a DataFrame named `X_pca`. The columns of `X_pca` should be named `"PC1"` and `"PC2"`.

[51]:
```
pca = PCA(n_components=2, random_state=42)

X_t = pca.fit_transform(X)

X_pca = pd.DataFrame(X_t, columns=["PC1", "PC2"])
```

[52]:
```
wqet_grader.grade("Project 6 Assessment", "Task 6.5.19", X_pca)
```

Very impressive.
Score: 1

Finally, let's make a visualization of our final DataFrame.

Task 6.5.20: Use plotly express to create a scatter plot of `X_pca` using seaborn. Be sure to color the data points using the labels generated by your `final_model`. Label the x-axis `"PC1"`, the y-axis `"PC2"`, and use the title `"PCA Representation of Clusters"`.

[53]:
```
# Create scatter plot of `PC2` vs `PC1`
fig = px.scatter(
    data_frame=X_pca,
    x="PC1",
    y="PC2",
    color=labels.astype(str),
    title="PCA Representation of Clusters"
)
fig.update_layout(xaxis_title="PC1", yaxis_title="PC2")
# Don't delete the code below 👇
fig.write_image("images/6-5-20.png", scale=1, height=500, width=700)

fig.show()
```

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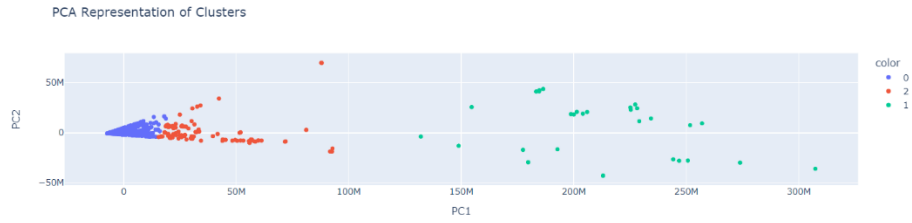

[54]:
```
with open("images/6-5-20.png", "rb") as file:
    wqet_grader.grade("Project 6 Assessment", "Task 6.5.20", file)
```

You got it. Dance party time! 🕺💃🕺💃
Score: 1

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