Hacktiv8 PTP Introduction to Data Science Projects 3

Banking Term Deposit Subscribe Classification

Pendahuluan

Deskripsi Permasalahan

The data is related with direct marketing campaigns of a Portuguese banking institution. The marketing campaigns were based on phone calls. Often, more than one contact to the same client was required, in order to access if the product (bank term deposit) would be ('yes') or not ('no') subscribed.

There are four datasets: 1) bank-additional-full.csv with all examples (41188) and 20 inputs, ordered by date (from May 2008 to November 2010), very close to the data analyzed in [Moro et al., 2014] 2) bank-additional.csv with 10% of the examples (4119), randomly selected from 1), and 20 inputs. 3) bank-full.csv with all examples and 17 inputs, ordered by date (older version of this dataset with less inputs). 4) bank.csv with 10% of the examples and 17 inputs, randomly selected from 3 (older version of this dataset with less inputs). The smallest datasets are provided to test more computationally demanding machine learning algorithms (e.g., SVM).

The classification goal is to predict if the client will subscribe (yes/no) a term deposit (variable y).

Input variables:

bank client data:

1 - age (numeric) 2 - job : type of job (categorical: 'admin.','blue-collar','entrepreneur','housemaid','management','retired','self-employed','services','student','technician','unemployed','unknown') 3 - marital : marital status (categorical: 'divorced','married','single','unknown'; note: 'divorced' means divorced or widowed) 4 - education (categorical: 'basic.4y','basic.6y','basic.9y','high.school','illiterate','professional.course','university.degree','unknown') 5 - default: has credit in default? (categorical: 'no','yes','unknown') 6 - housing: has housing loan? (categorical: 'no','yes','unknown') 7 - loan: has personal loan? (categorical: 'no','yes','unknown')

related with the last contact of the current campaign:

8 - contact: contact communication type (categorical: 'cellular','telephone') 9 - month: last contact month of year (categorical: 'jan', 'feb', 'mar', ..., 'nov', 'dec') 10 - day_of_week: last contact day of the week (categorical: 'mon','tue','wed','thu','fri') 11 - duration: last contact duration, in seconds

(numeric). Important note: this attribute highly affects the output target (e.g., if duration=0 then y='no'). Yet, the duration is not known before a call is performed. Also, after the end of the call y is obviously known. Thus, this input should only be included for benchmark purposes and should be discarded if the intention is to have a realistic predictive model.

other attributes:

12 - campaign: number of contacts performed during this campaign and for this client (numeric, includes last contact) 13 - pdays: number of days that passed by after the client was last contacted from a previous campaign (numeric; 999 means client was not previously contacted) 14 - previous: number of contacts performed before this campaign and for this client (numeric) 15 - poutcome: outcome of the previous marketing campaign (categorical: 'failure','nonexistent','success')

social and economic context attributes

16 - emp.var.rate: employment variation rate - quarterly indicator (numeric) 17 - cons.price.idx: consumer price index - monthly indicator (numeric) 18 - cons.conf.idx: consumer confidence index - monthly indicator (numeric) 19 - euribor3m: euribor 3 month rate - daily indicator (numeric) 20 - nr.employed: number of employees - quarterly indicator (numeric)

Output variable (desired target): 21 - y - has the client subscribed a term deposit? (binary: 'yes','no')

Data Overview

Import Pustaka

In [1]:

```
%matplotlib inline

import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib as mpl
import matplotlib.pyplot as plt

pd.options.mode.chained_assignment = None
sns.set_style("white")
```

Persiapan Data

In [2]:

```
df = pd.read_csv('dataset/bank-additional/bank-additional-full.csv', delimiter=';')
```

Cuplikan Data

In [3]:

```
df
```

Out[3]:

	age	job	marital	education	default	housing	loan	contact	month	day_of
0	56	housemaid	married	basic.4y	no	no	no	telephone	may	

	age	job	marital	education	default	housing	loan	contact	month	day_of
1	57	services	married	high.school	unknown	no	no	telephone	may	
2	37	services	married	high.school	no	yes	no	telephone	may	
3	40	admin.	married	basic.6y	no	no	no	telephone	may	
4	56	services	married	high.school	no	no	yes	telephone	may	
...	...	...	...	...	...	...	...	...	...	
41183	73	retired	married	professional.course	no	yes	no	cellular	nov	
41184	46	blue-collar	married	professional.course	no	no	no	cellular	nov	
41185	56	retired	married	university.degree	no	yes	no	cellular	nov	
41186	44	technician	married	professional.course	no	no	no	cellular	nov	
41187	74	retired	married	professional.course	no	yes	no	cellular	nov	

41188 rows × 21 columns

In [4]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 41188 entries, 0 to 41187
Data columns (total 21 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   age             41188 non-null  int64  
 1   job             41188 non-null  object 
 2   marital         41188 non-null  object 
 3   education       41188 non-null  object 
 4   default         41188 non-null  object 
 5   housing         41188 non-null  object 
 6   loan            41188 non-null  object 
 7   contact         41188 non-null  object 
 8   month           41188 non-null  object 
 9   day_of_week     41188 non-null  object 
 10  duration        41188 non-null  int64  
 11  campaign        41188 non-null  int64  
 12  pdays           41188 non-null  int64  
 13  previous        41188 non-null  int64  
 14  poutcome        41188 non-null  object 
 15  emp.var.rate    41188 non-null  float64
 16  cons.price.idx  41188 non-null  float64
 17  cons.conf.idx   41188 non-null  float64
 18  euribor3m       41188 non-null  float64
 19  nr.employed     41188 non-null  float64
 20  y               41188 non-null  object 
dtypes: float64(5), int64(5), object(11)
memory usage: 6.6+ MB
```

Cek Missing Values

In [5]:

```
df.isnull().sum()
```

Out[5]:

```
age               0
job               0
marital           0
education         0
default           0
housing           0
loan              0
contact           0
month             0
day_of_week       0
duration          0
campaign          0
pdays             0
previous          0
poutcome          0
emp.var.rate      0
cons.price.idx    0
cons.conf.idx     0
euribor3m         0
nr.employed       0
y                 0
dtype: int64
```

Pengenalan Data Lanjut

In [6]:

```
numerical_features = ['age', 'duration', 'campaign', 'pdays', 'previous', 'emp.var.rate
categorical_features = ['job', 'marital', 'education', 'default', 'housing', 'loan', 'c
```

Profiling Fitur

In [7]:

```
from pandas_profiling import ProfileReport

profile = ProfileReport(df, title="Pandas Profiling Report")
```

In [8]:

```
# profile
```

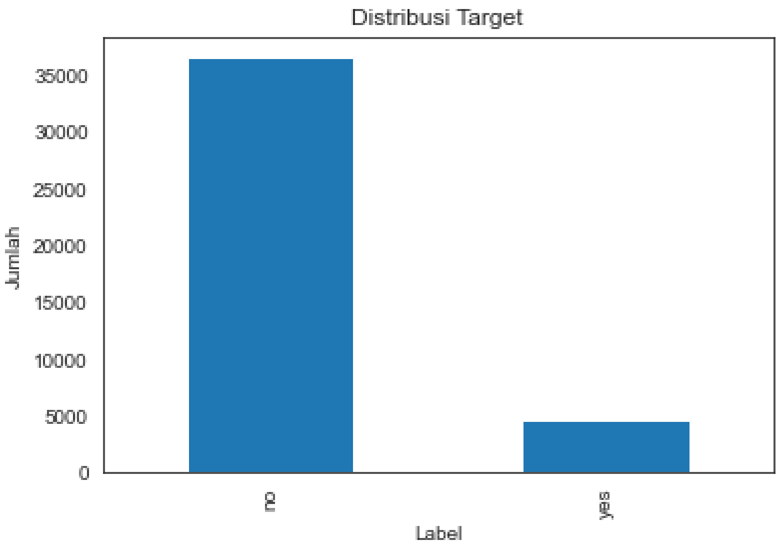
In [9]:

```
%matplotlib inline
```

Perbandingan/Distribusi Kelas

In [10]:

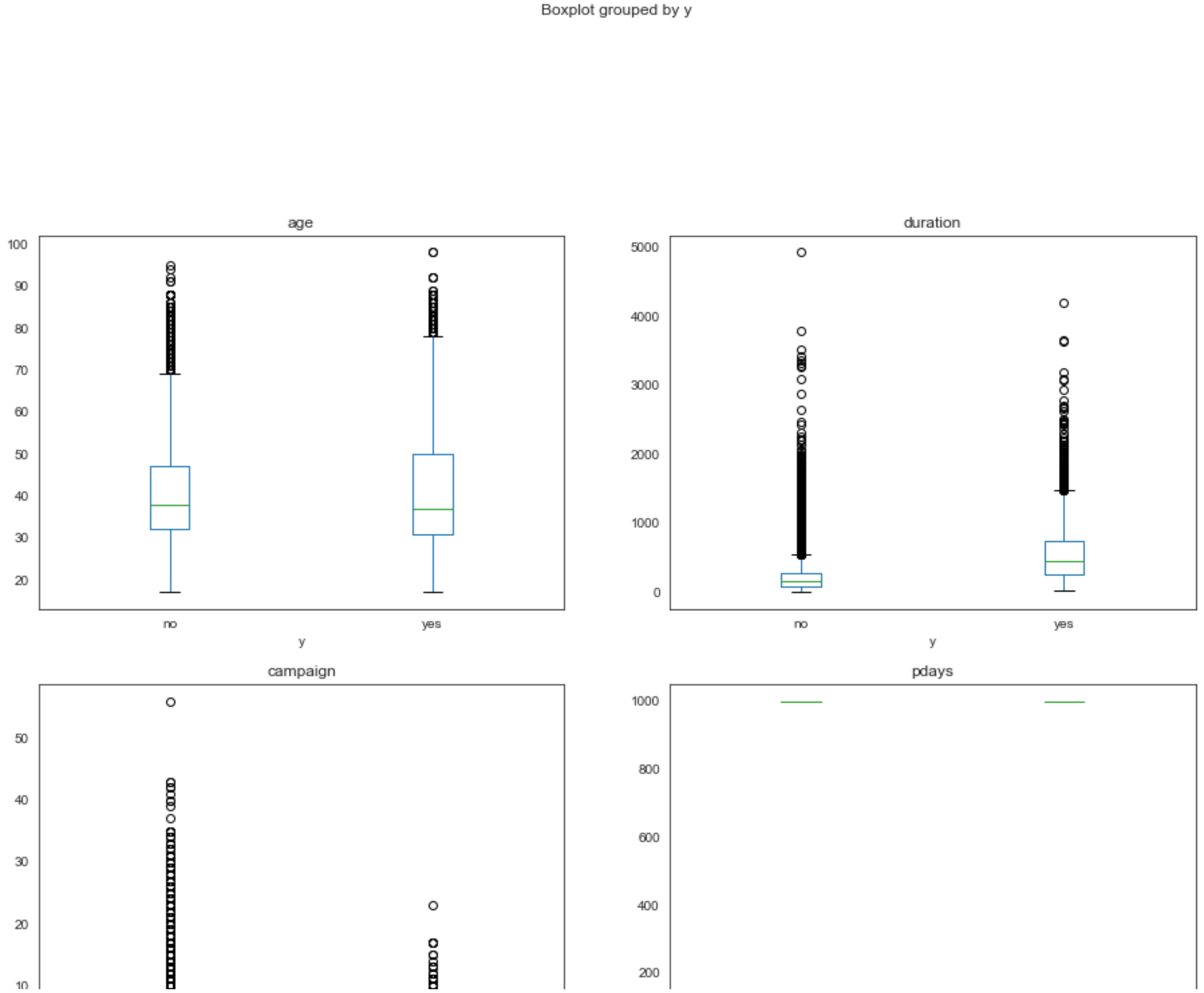
```
df['y'].value_counts().plot.bar();

plt.title('Distribusi Target');
plt.xlabel('Label');
plt.ylabel('Jumlah');
```

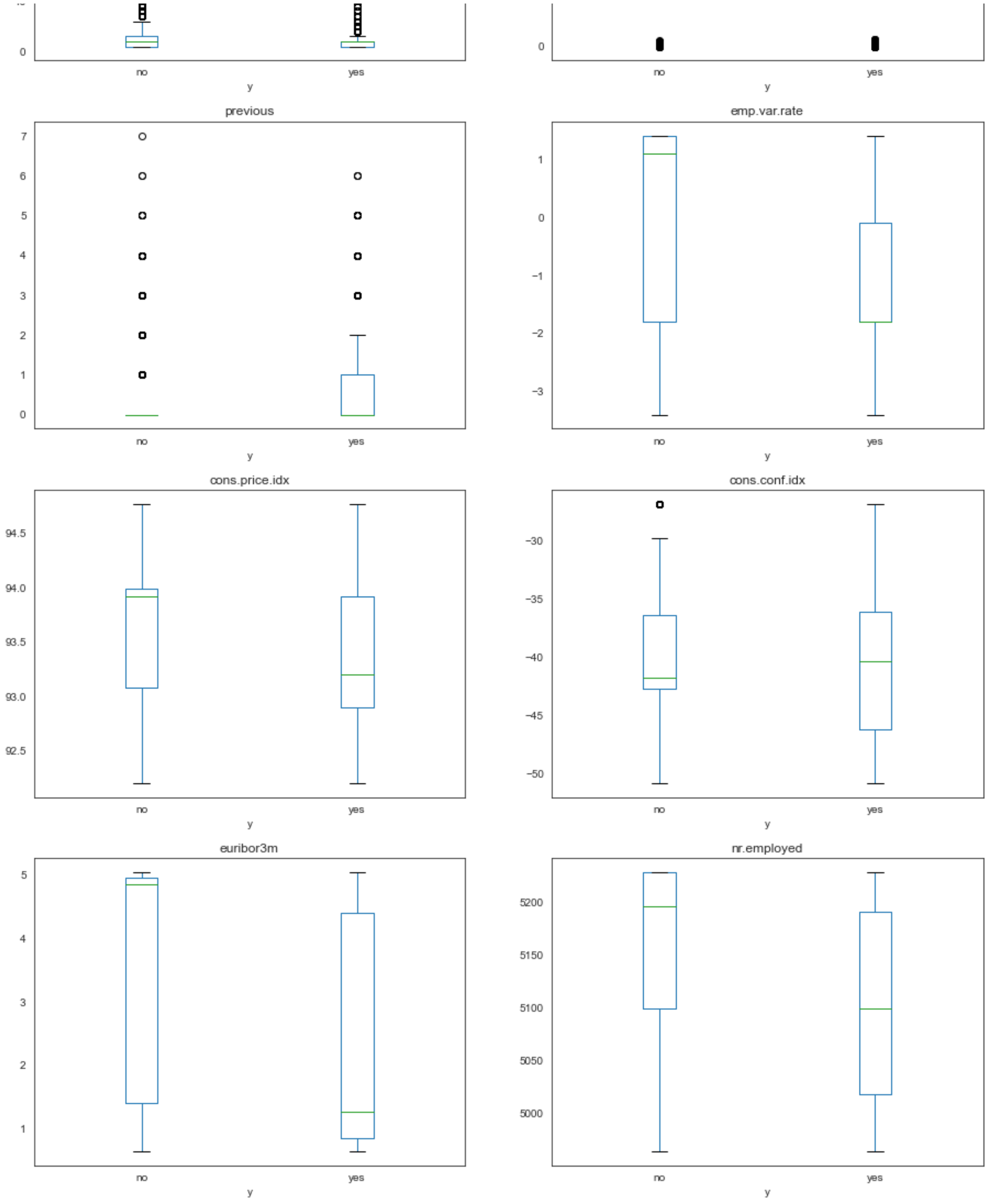


Boxplot Numerical

In [11]:

```
fig, axn = plt.subplots(5, 2, figsize=(15, 30))

for idx, feature in enumerate(numerical_features):
    disp = df.boxplot(by ='y', column =[feature], grid = False, ax=axn[idx//2][idx%2])

plt.show();
```

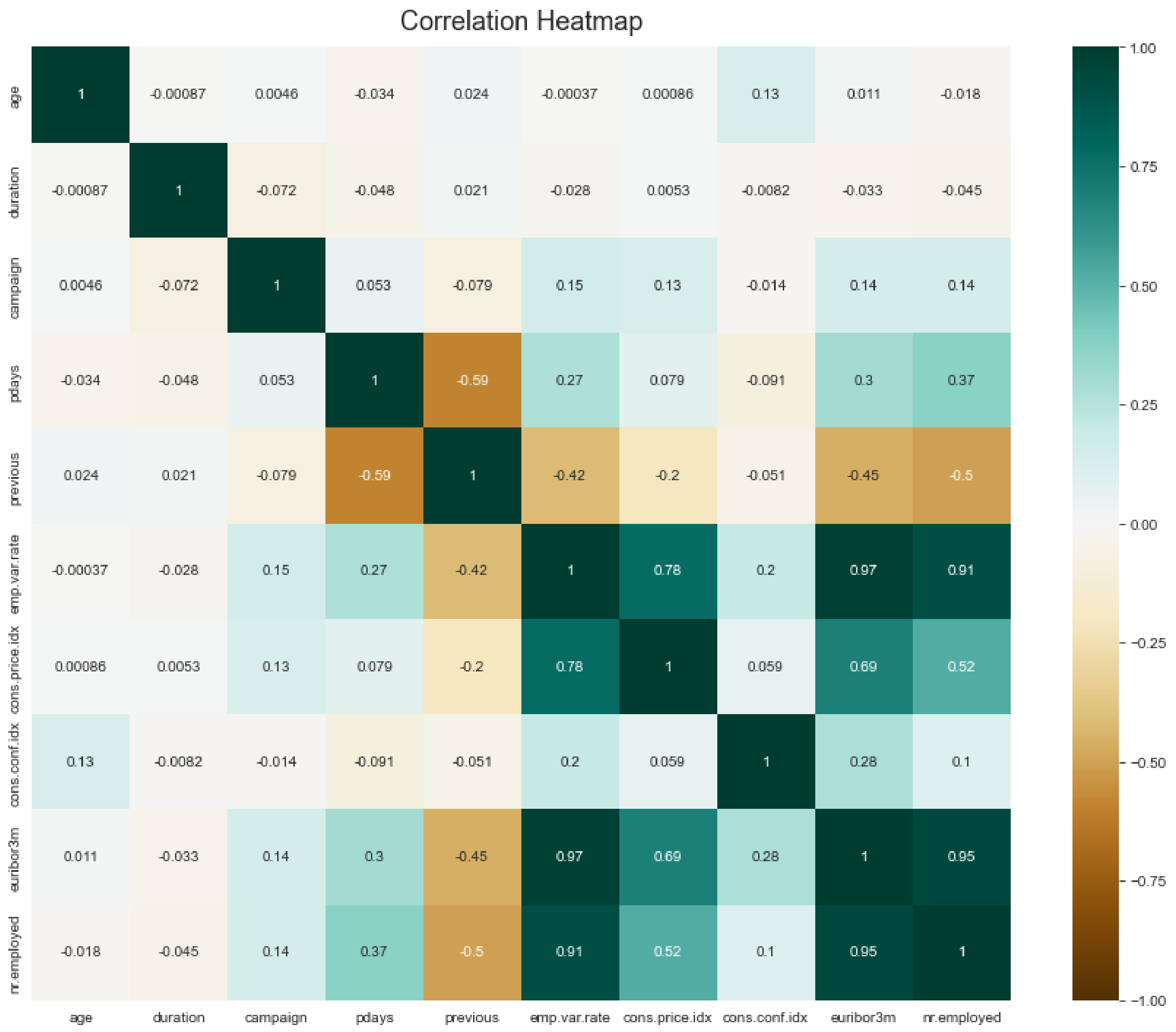




Matriks Korelasi

In [12]:

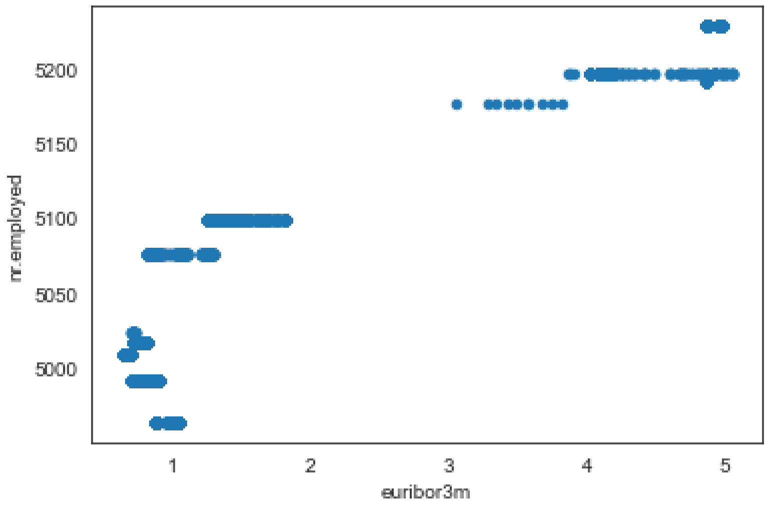
```
plt.figure(figsize=(15, 12))
heatmap = sns.heatmap(df.corr(), vmin=-1, vmax=1, annot=True, cmap='BrBG')
heatmap.set_title('Correlation Heatmap', fontdict={'fontsize':18}, pad=12);

plt.show();
```



Scatter Plot Antara Dua Feature Berkorelasi Tinggi

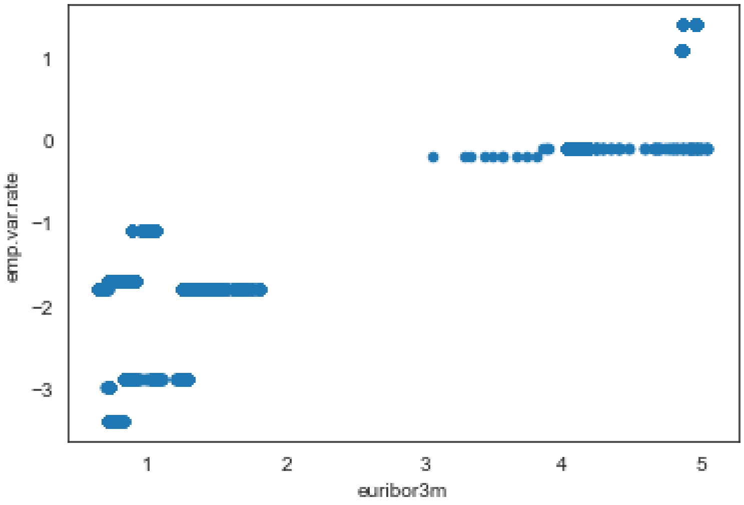
In [13]:

```
# euribor3m x nr.employed

df.plot.scatter(x='euribor3m', y='nr.employed');
```



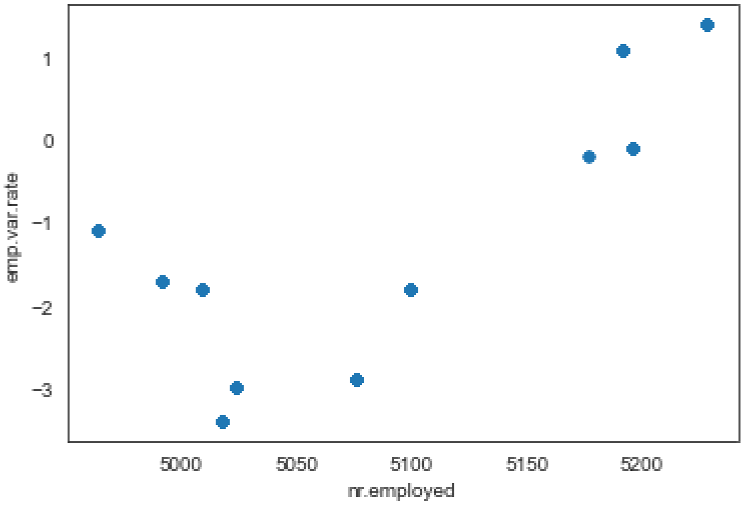
In [14]:

```
# euribor3m x emp.var.rate

df.plot.scatter(x='euribor3m', y='emp.var.rate');
```



In [15]:

```
# nr.employed x emp.var.rate

df.plot.scatter(x='nr.employed', y='emp.var.rate');
```



Preprocessing

Split Data

In [16]:

```
from sklearn.model_selection import train_test_split

X = df.drop('y', axis=1)
y = df['y']

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.1, random_state=1
X_train_plain, y_train_plain = X_train, y_train
```

Handling Imbalance Data

In [17]:

```
from imblearn.over_sampling import RandomOverSampler
from imblearn.under_sampling import RandomUnderSampler
from imblearn.over_sampling import SMOTENC

ros = RandomOverSampler(random_state=11)
rus = RandomUnderSampler(random_state=11)
sm = SMOTENC(random_state=11, categorical_features=[df.columns.get_loc(feature) for fea

X_train, y_train = rus.fit_resample(X_train, y_train)
```

Eksperimen Model

Preprocessing Pipeline

In [18]:

```
from sklearn.preprocessing import OrdinalEncoder
from sklearn.preprocessing import OneHotEncoder
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import StandardScaler

from sklearn.metrics import ConfusionMatrixDisplay

from sklearn.pipeline import make_pipeline
from sklearn.compose import ColumnTransformer

preprocessing = ColumnTransformer([
    ('preprocess_num', MinMaxScaler(), numerical_features),
    ('preprocess_cat', make_pipeline(OrdinalEncoder(), MinMaxScaler()), categorical_fea
])
```

Model Tanpa Handling Imbalance

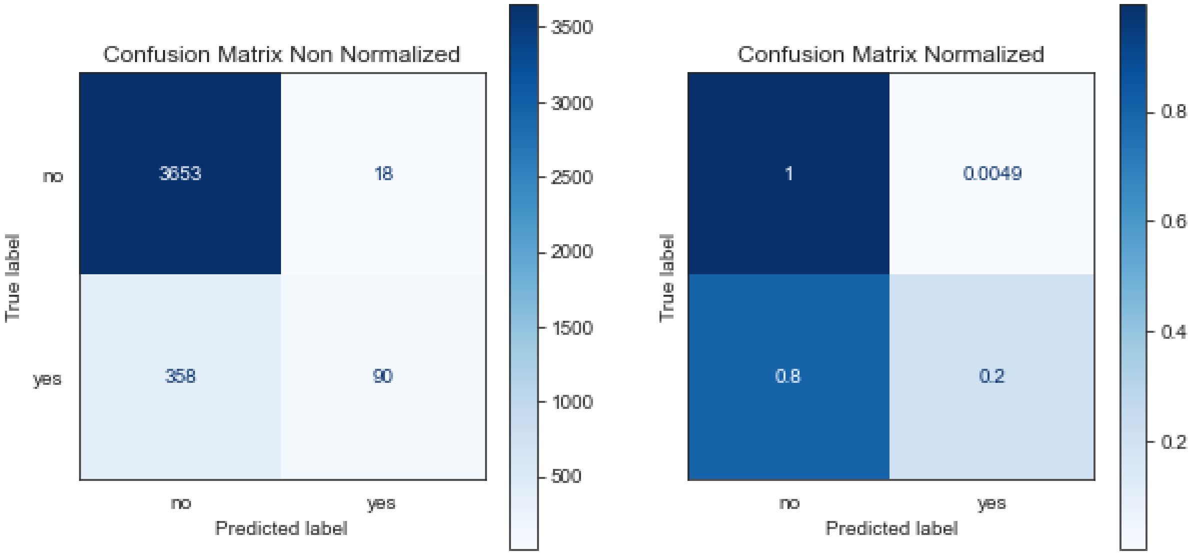
Random Forest Classifier

In [19]:

```
from sklearn.metrics import classification_report
from sklearn.ensemble import RandomForestClassifier

pipeline = make_pipeline(preprocessing, RandomForestClassifier(max_depth=3, random_stat
pipeline.fit(X_train_plain, y_train_plain)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support
```

```
          no       0.91      1.00      0.95      3671
         yes       0.83      0.20      0.32       448

    accuracy                           0.91      4119
   macro avg       0.87      0.60      0.64      4119
weighted avg       0.90      0.91      0.88      4119
```



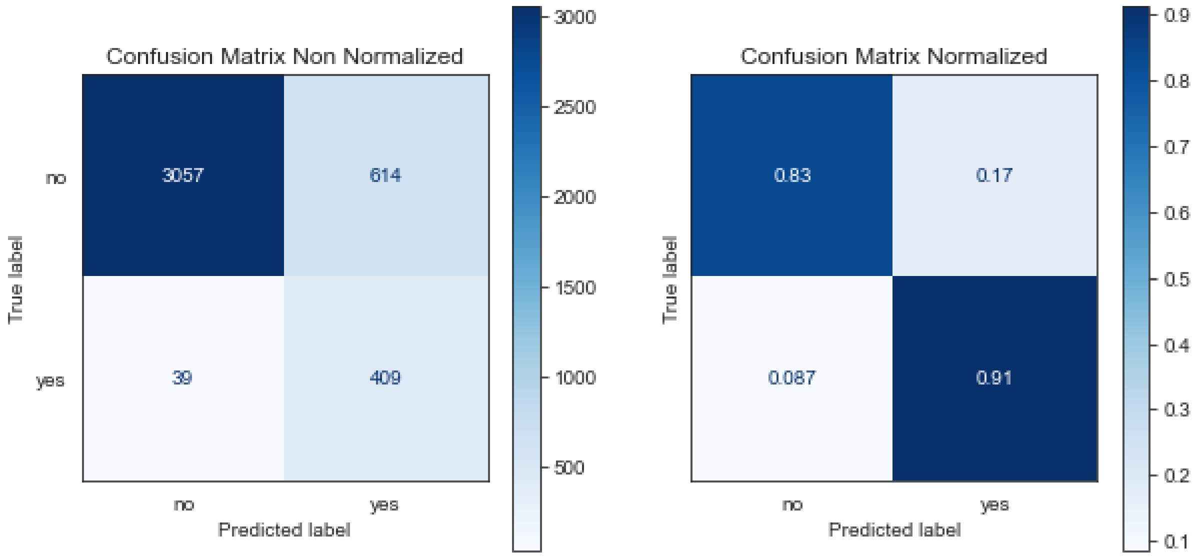
Model Dengan Handling Imbalance

Random Forest Classifier

In [20]:

```python
from sklearn.metrics import classification_report
from sklearn.ensemble import RandomForestClassifier

pipeline = make_pipeline(preprocessing, RandomForestClassifier(max_depth=4, random_stat
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.99      0.83      0.90      3671
         yes       0.40      0.91      0.56       448

    accuracy                           0.84      4119
   macro avg       0.69      0.87      0.73      4119
weighted avg       0.92      0.84      0.87      4119
```

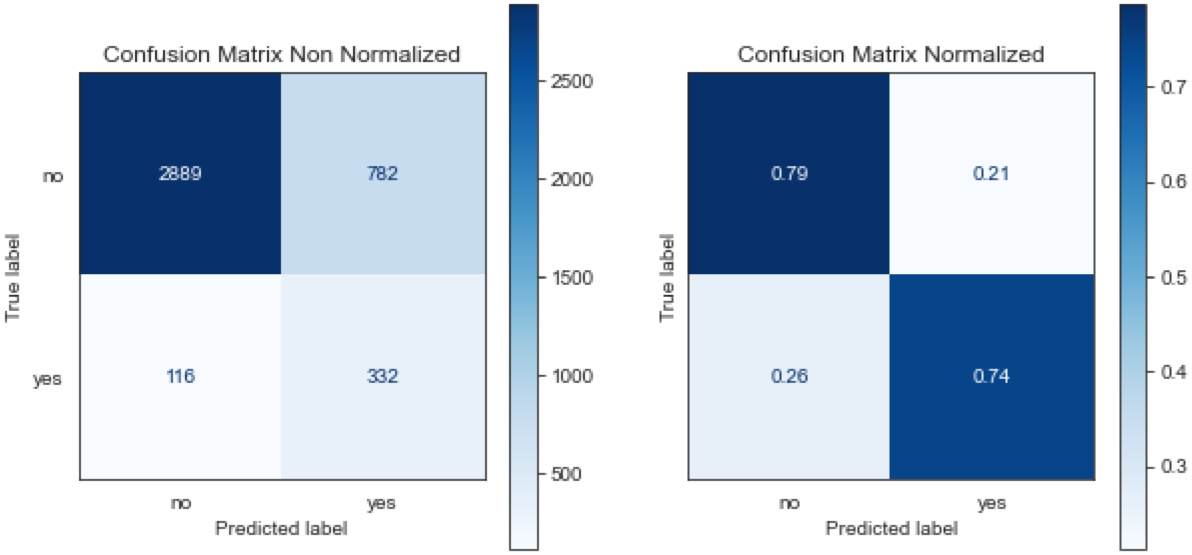


Naive Bayes Classifier

In [21]:

```
from sklearn.metrics import classification_report
from sklearn.naive_bayes import GaussianNB

pipeline = make_pipeline(preprocessing, GaussianNB())
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.96      0.79      0.87      3671
         yes       0.30      0.74      0.43       448

    accuracy                           0.78      4119
   macro avg       0.63      0.76      0.65      4119
weighted avg       0.89      0.78      0.82      4119
```

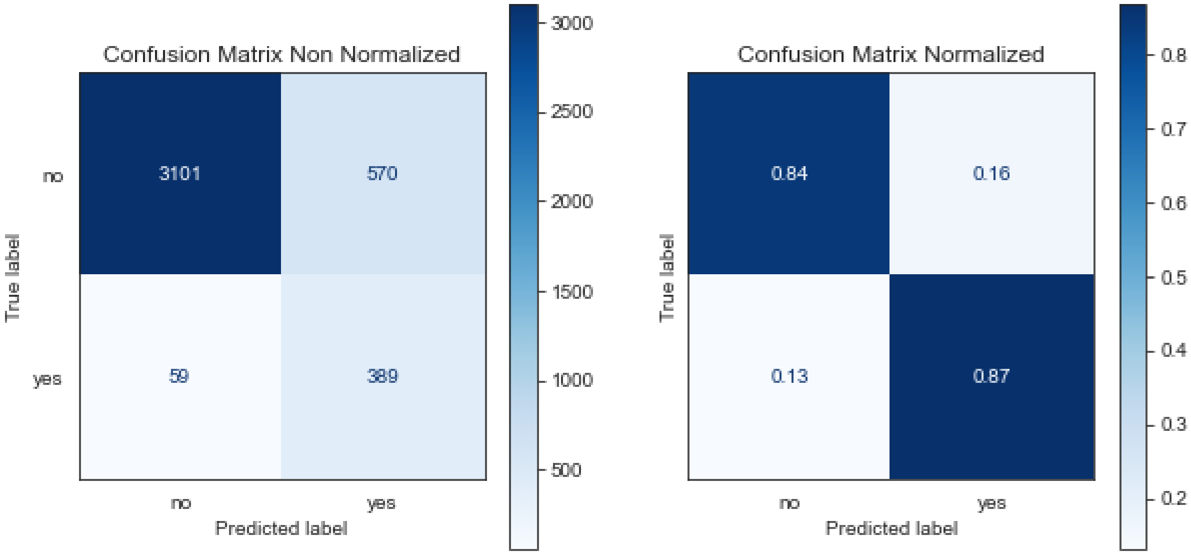


Decision Tree Classifier

In [22]:

```
from sklearn.metrics import classification_report
from sklearn.tree import DecisionTreeClassifier

pipeline = make_pipeline(preprocessing, DecisionTreeClassifier(max_depth=3))
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.98      0.84      0.91      3671
         yes       0.41      0.87      0.55       448

    accuracy                           0.85      4119
   macro avg       0.69      0.86      0.73      4119
weighted avg       0.92      0.85      0.87      4119
```

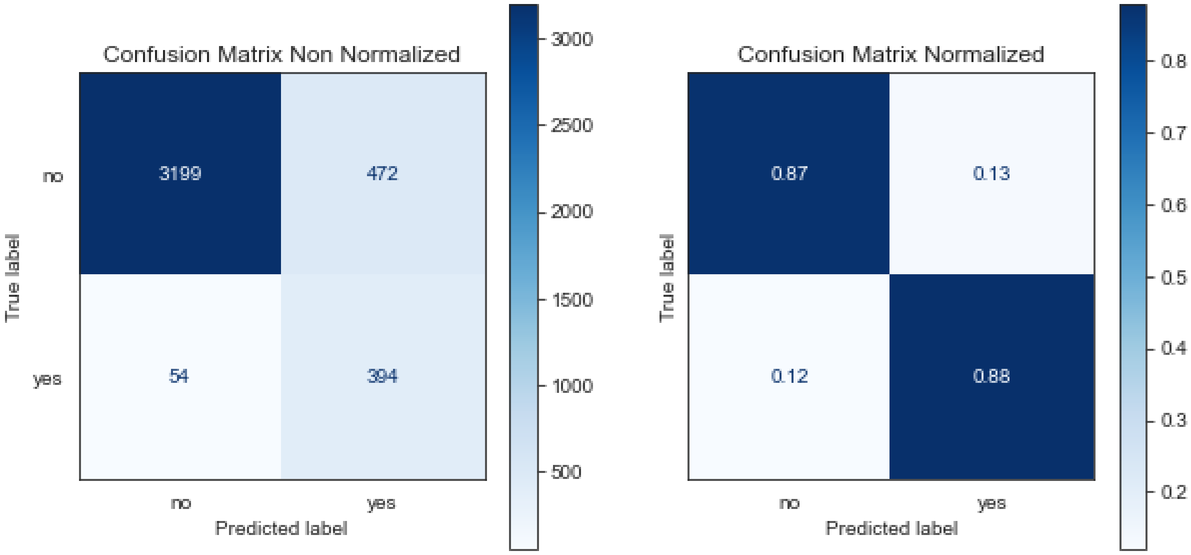


Neural Network MLP Classifier

In [23]:

```
from sklearn.metrics import classification_report
from sklearn.neural_network import MLPClassifier

pipeline = make_pipeline(preprocessing, MLPClassifier(solver='adam', max_iter=1200, alp
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.98      0.87      0.92      3671
         yes       0.45      0.88      0.60       448

    accuracy                           0.87      4119
   macro avg       0.72      0.88      0.76      4119
weighted avg       0.93      0.87      0.89      4119
```

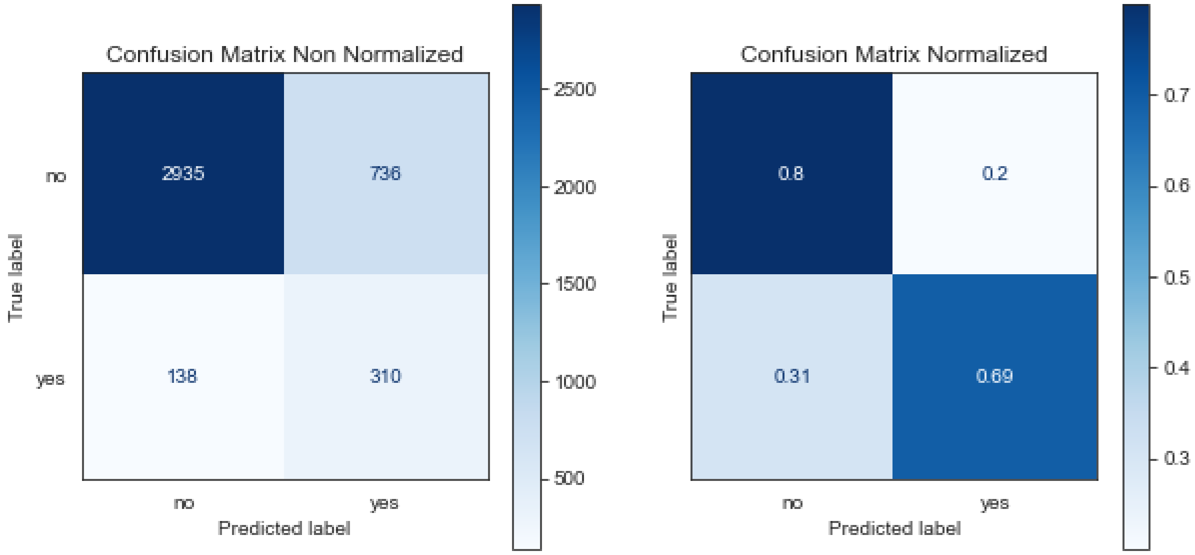


kNN Classifier

In [24]:

```
from sklearn.metrics import classification_report
from sklearn.neighbors import KNeighborsClassifier

pipeline = make_pipeline(preprocessing, KNeighborsClassifier())
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.96      0.80      0.87      3671
         yes       0.30      0.69      0.41       448

    accuracy                           0.79      4119
   macro avg       0.63      0.75      0.64      4119
weighted avg       0.88      0.79      0.82      4119
```

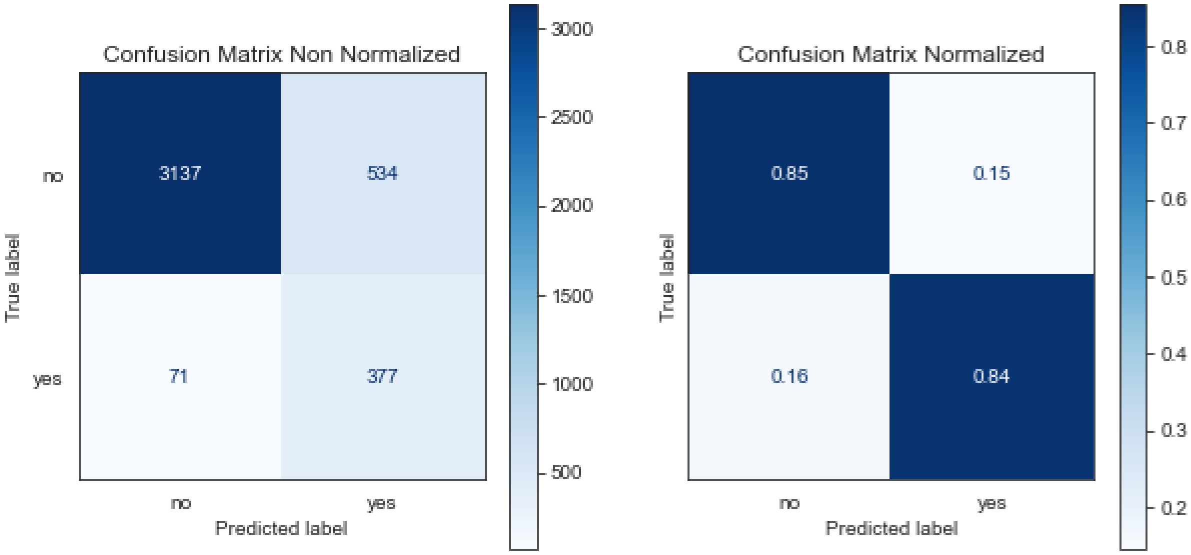


Logistic Regression Classifier

In [25]:

```
from sklearn.metrics import classification_report
from sklearn.linear_model import LogisticRegression

pipeline = make_pipeline(preprocessing, LogisticRegression(solver='lbfgs', max_iter=100
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.98      0.85      0.91      3671
         yes       0.41      0.84      0.55       448

    accuracy                           0.85      4119
   macro avg       0.70      0.85      0.73      4119
weighted avg       0.92      0.85      0.87      4119
```

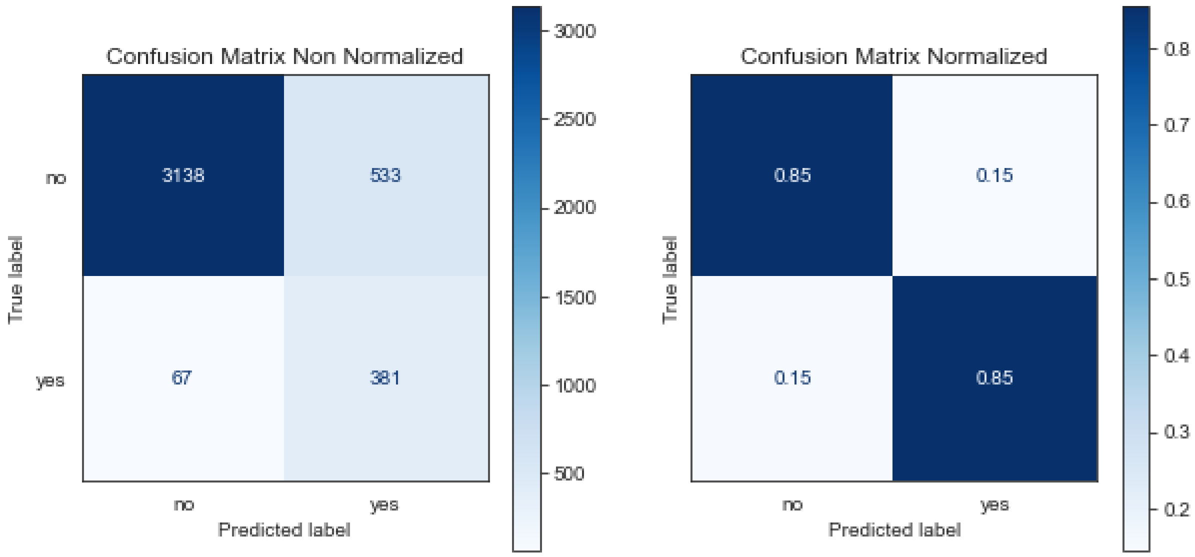


Linear SVM Classifier

In [26]:

```
from sklearn.metrics import classification_report
from sklearn.metrics import plot_confusion_matrix
from sklearn.svm import LinearSVC

pipeline = make_pipeline(preprocessing, LinearSVC(max_iter=10000))
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.98      0.85      0.91      3671
         yes       0.42      0.85      0.56       448

    accuracy                           0.85      4119
   macro avg       0.70      0.85      0.74      4119
weighted avg       0.92      0.85      0.87      4119
```

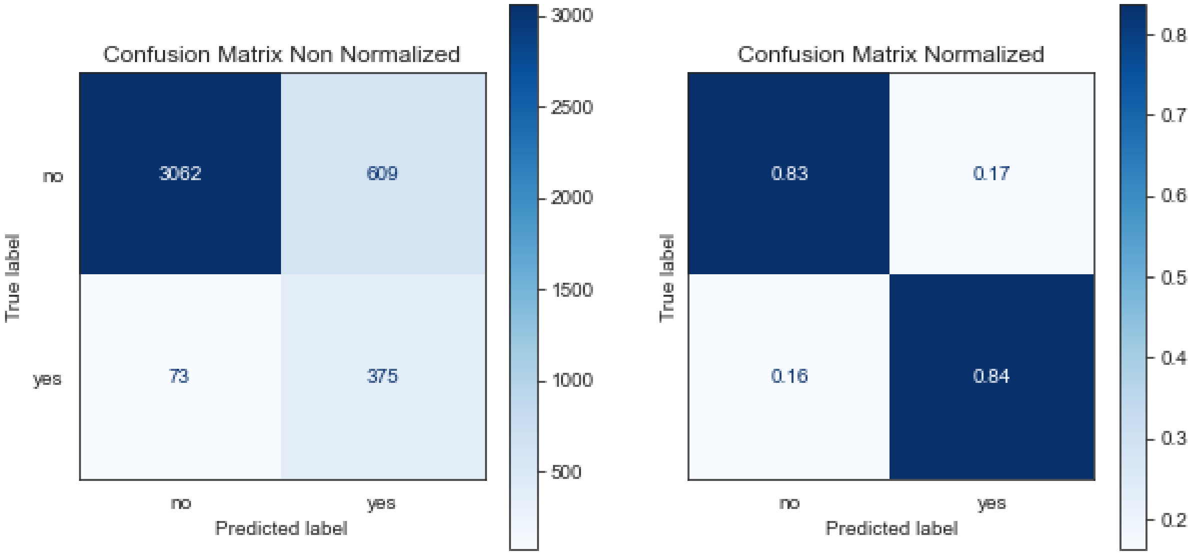


SVM Classifier Kernel Radial Basis Function (RBF)

In [27]:

```
from sklearn.metrics import classification_report
from sklearn.svm import SVC

pipeline = make_pipeline(preprocessing, SVC(gamma='auto'))
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.98      0.83      0.90      3671
         yes       0.38      0.84      0.52       448

    accuracy                           0.83      4119
   macro avg       0.68      0.84      0.71      4119
weighted avg       0.91      0.83      0.86      4119
```

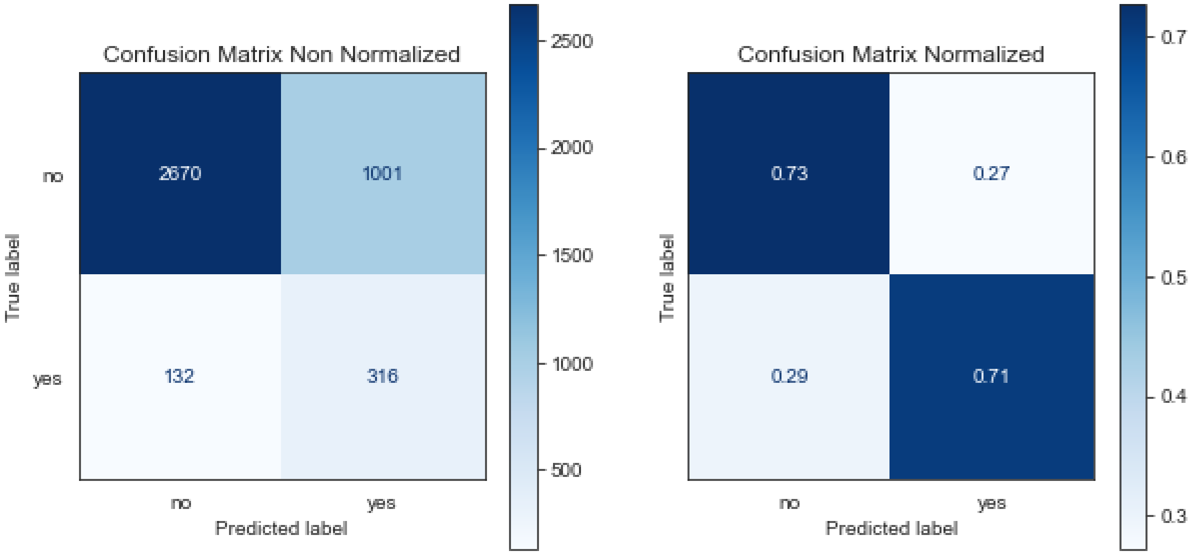


SVM Classifier Kernel Polynomial

In [28]:

```
from sklearn.metrics import classification_report
from sklearn.svm import SVC

pipeline = make_pipeline(preprocessing, SVC(kernel='poly', gamma='auto'))
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.95      0.73      0.82      3671
         yes       0.24      0.71      0.36       448

    accuracy                           0.72      4119
   macro avg       0.60      0.72      0.59      4119
weighted avg       0.88      0.72      0.77      4119
```

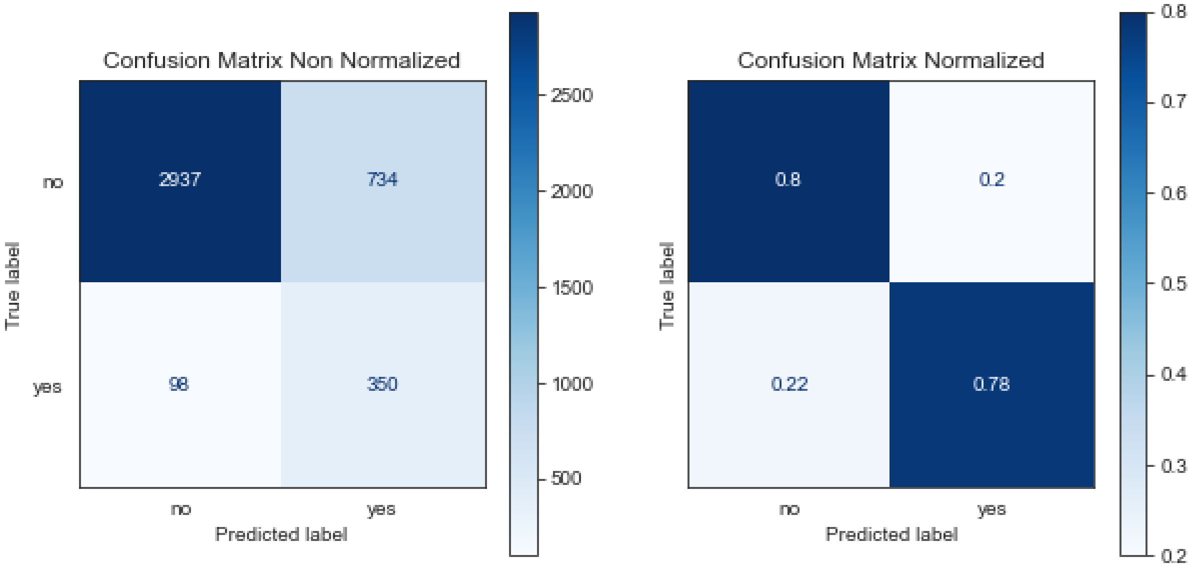


SVM Classifier Kernel Sigmoid

In [29]:

```python
from sklearn.metrics import classification_report
from sklearn.svm import SVC

pipeline = make_pipeline(preprocessing, SVC(kernel='sigmoid', gamma='auto'))
pipeline.fit(X_train, y_train)

y_pred = pipeline.predict(X_test)

print(classification_report(y_test, y_pred))

fig, axn = plt.subplots(1, 2, sharex=True, sharey=True, figsize=(10, 5))

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[0], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Non Normalized")

disp = ConfusionMatrixDisplay.from_predictions(y_test, y_pred, ax=axn[1], cmap=plt.cm.B
disp.ax_.set_title("Confusion Matrix Normalized")

plt.show();
```

```
              precision    recall  f1-score   support

          no       0.97      0.80      0.88      3671
         yes       0.32      0.78      0.46       448

    accuracy                           0.80      4119
   macro avg       0.65      0.79      0.67      4119
weighted avg       0.90      0.80      0.83      4119
```



Kesimpulan

```
In [ ]:
```