

```
In [2]: import numpy as np # Linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import seaborn as sns # For creating plots
import matplotlib.ticker as mtick # For specifying the axes tick format
import matplotlib.pyplot as plt

sns.set(style = 'white')
```

```
In [3]: = pd.read_csv('C:/Users/SHREERAKSHA/Downloads/WA_Fn-UseC_-Telco-Customer-Churn (1).csv')
```

```
In [4]: telecom_cust.head()
```

```
Out[4]:
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service	DS
1	5575-GNVDE	Male	0	No	No	34	Yes	No	DS
2	3668-QPYBK	Male	0	No	No	2	Yes	No	DS
3	7795-CFOCW	Male	0	No	No	45	No	No phone service	DS
4	9237-HQITU	Female	0	No	No	2	Yes	No	Fiber opti

5 rows × 21 columns

```
In [5]: telecom_cust.columns.values
```

```
Out[5]: array(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',
              'tenure', 'PhoneService', 'MultipleLines', 'InternetService',
              'OnlineSecurity', 'OnlineBackup', 'DeviceProtection',
              'TechSupport', 'StreamingTV', 'StreamingMovies', 'Contract',
              'PaperlessBilling', 'PaymentMethod', 'MonthlyCharges',
              'TotalCharges', 'Churn'], dtype=object)
```

```
In [6]: telecom_cust.dtypes
```

```
Out[6]: customerID      object
gender                object
SeniorCitizen         int64
Partner               object
Dependents             object
tenure                int64
PhoneService          object
MultipleLines         object
InternetService       object
OnlineSecurity        object
OnlineBackup          object
DeviceProtection      object
TechSupport           object
StreamingTV           object
StreamingMovies       object
Contract              object
PaperlessBilling      object
PaymentMethod         object
MonthlyCharges        float64
TotalCharges          object
Churn                 object
dtype: object
```

```
In [7]: telecom_cust.TotalCharges = pd.to_numeric(telecom_cust.TotalCharges, errors='coerce')
telecom_cust.isnull().sum()
```

```
Out[7]: customerID      0
gender                0
SeniorCitizen         0
Partner               0
Dependents             0
tenure                0
PhoneService          0
MultipleLines         0
InternetService       0
OnlineSecurity        0
OnlineBackup          0
DeviceProtection      0
TechSupport           0
StreamingTV           0
StreamingMovies       0
Contract              0
PaperlessBilling      0
PaymentMethod         0
MonthlyCharges        0
TotalCharges          11
Churn                 0
dtype: int64
```

After looking at the above output, we can say that there are 11 missing values for Total Charges. Let us replace remove these 11 rows from our data set

```
In [8]: #Removing missing values
telecom_cust.dropna(inplace = True)
#Remove customer IDs from the data set
df2 = telecom_cust.iloc[:,1:]
#Convertin the predictor variable in a binary numeric variable
df2['Churn'].replace(to_replace='Yes', value=1, inplace=True)
df2['Churn'].replace(to_replace='No', value=0, inplace=True)

#Let's convert all the categorical variables into dummy variables
df_dummies = pd.get_dummies(df2)
df_dummies.head()
```

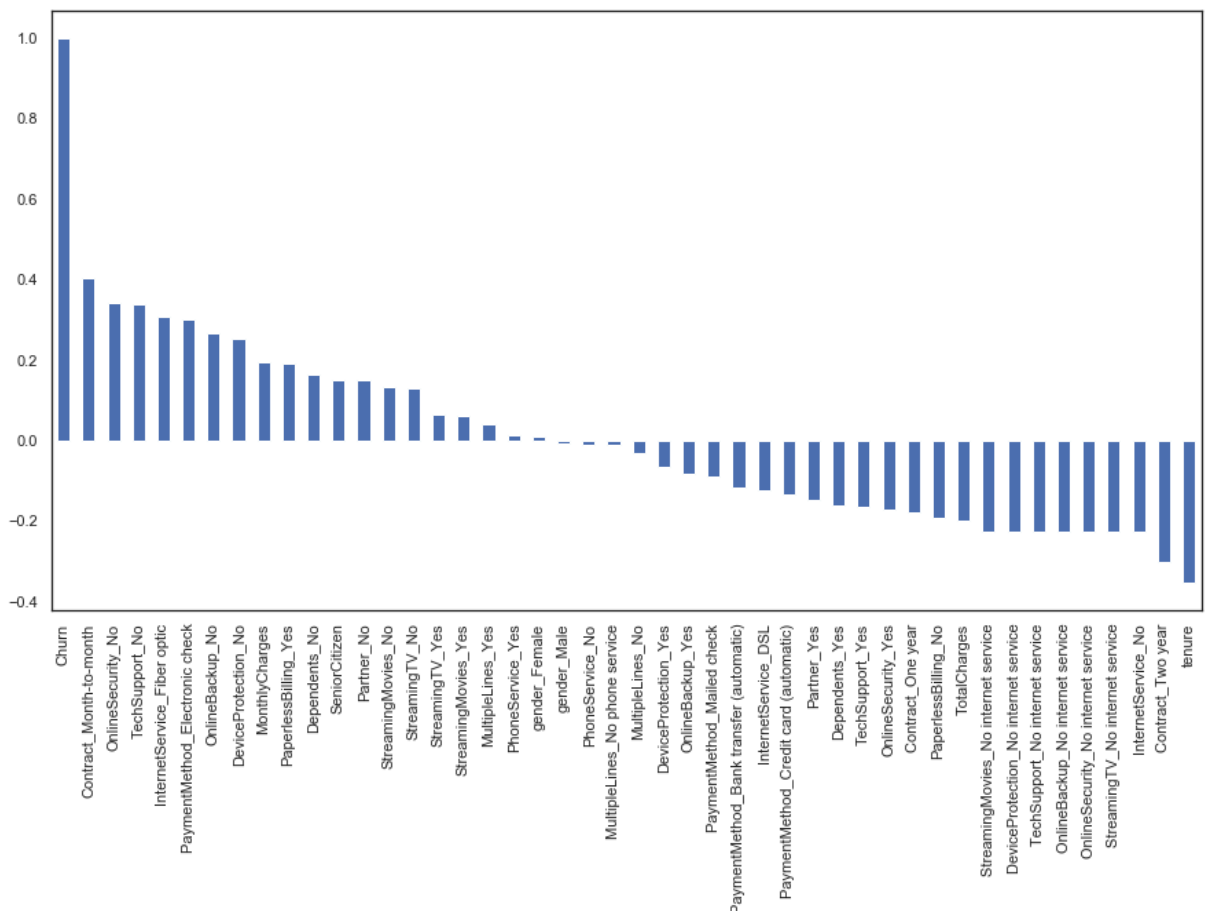
Out[8]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	Churn	gender_Female	gender_Male	Partner_No	Part
0	0	1	29.85	29.85	0	1	0	0	
1	0	34	56.95	1889.50	0	0	1	1	
2	0	2	53.85	108.15	1	0	1	1	
3	0	45	42.30	1840.75	0	0	1	1	
4	0	2	70.70	151.65	1	1	0	1	

5 rows × 46 columns

```
In [9]: #Get Correlation of "Churn" with other variables:
plt.figure(figsize=(15,8))
df_dummies.corr()['Churn'].sort_values(ascending = False).plot(kind='bar')
```

Out[9]: <matplotlib.axes._subplots.AxesSubplot at 0x15d0030>



Month to month contracts, absence of online security and tech support seem to be positively correlated with churn. While, tenure, two year contracts seem to be negatively correlated with churn.

Interestingly, services such as Online security, streaming TV, online backup, tech support, etc. without internet connection seem to be negatively related to churn.

We will explore the patterns for the above correlations below before we delve into modelling and identifying the important variables.

Data Exploration¶ Let us first start with exploring our data set, to better understand the patterns in the data and potentially form some hypothesis. First we will look at the distribution of individual variables and then slice and dice our data for any interesting trends.

A.) Demographics - Let us first understand the gender, age range, partner and dependent status of the customers

Gender Distribution - About half of the customers in our data set are male while the other half are female

```
In [10]: colors = ['#4D3425', '#E4512B']
ax = (telecom_cust['gender'].value_counts()*100.0 / len(telecom_cust)).plot(kind='bar',
                                                                              stacked = True,
                                                                              rot = 0,
                                                                              color = colors)

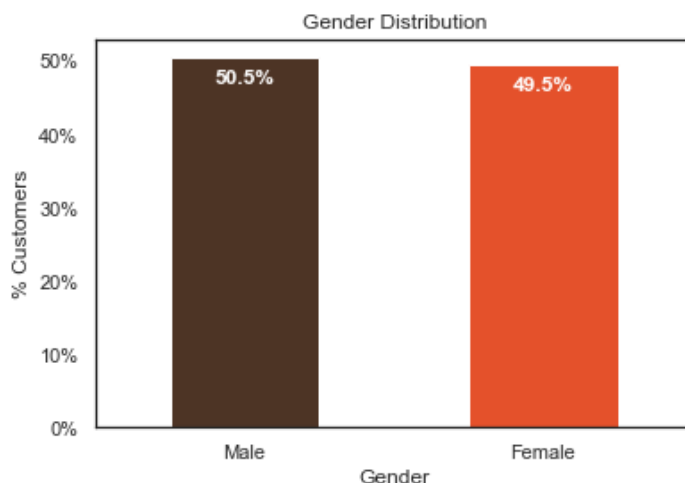
ax.yaxis.set_major_formatter(mtick.PercentFormatter())
ax.set_ylabel('% Customers')
ax.set_xlabel('Gender')
ax.set_ylabel('% Customers')
ax.set_title('Gender Distribution')

# create a list to collect the plt.patches data
totals = []

# find the values and append to list
for i in ax.patches:
    totals.append(i.get_width())

# set individual bar labels using above list
total = sum(totals)

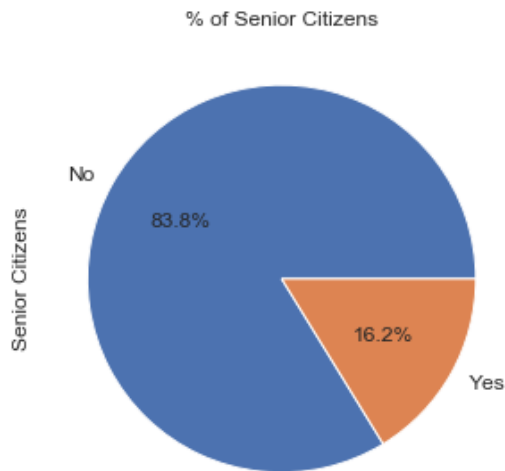
for i in ax.patches:
    # get_width pulls left or right; get_y pushes up or down
    ax.text(i.get_x()+.15, i.get_height()-3.5, \
            str(round((i.get_height()/total), 1))+'%',
            fontsize=12,
            color='white',
            weight = 'bold')
```



1% Senior Citizens - There are only 16% of the customers who are senior citizens. Thus most of our customers in the data are younger people.

```
In [11]: ax = (telecom_cust['SeniorCitizen'].value_counts()*100.0 / len(telecom_cust))\
.plot.pie(autopct='%.1f%%', labels = ['No', 'Yes'],figsize =(5,5), fontsize = 12 )
ax.yaxis.set_major_formatter(mtick.PercentFormatter())
ax.set_ylabel('Senior Citizens',fontsize = 12)
ax.set_title('% of Senior Citizens', fontsize = 12)
```

Out[11]: Text(0.5, 1.0, '% of Senior Citizens')

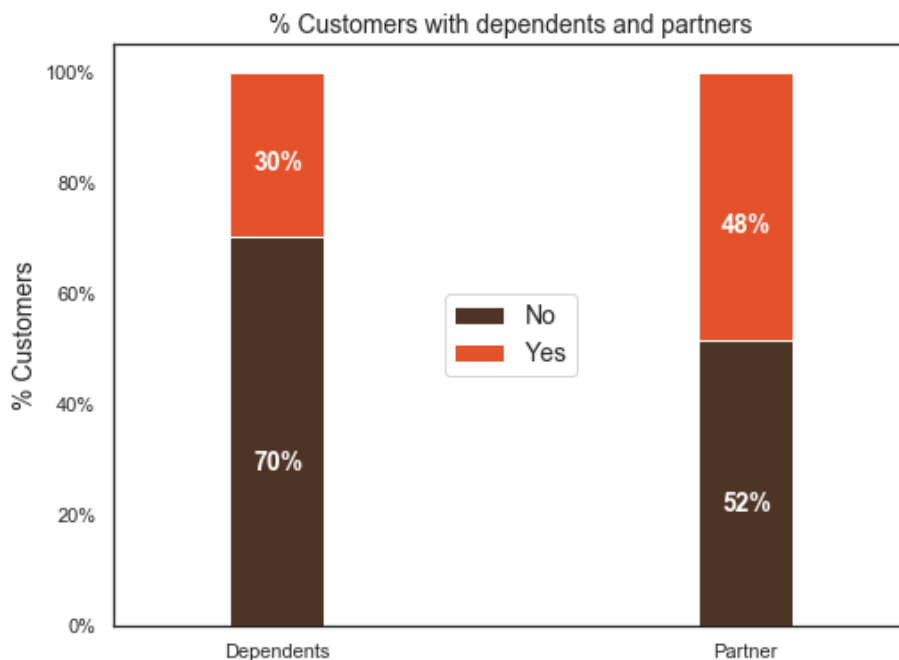


Partner and dependent status - About 50% of the customers have a partner, while only 30% of the total customers have dependents.

```
In [12]: df2 = pd.melt(telecom_cust, id_vars=['customerID'], value_vars=['Dependents', 'Partner'])
df3 = df2.groupby(['variable', 'value']).count().unstack()
df3 = df3*100/len(telecom_cust)
colors = ['#4D3425', '#E4512B']
ax = df3.loc[:, 'customerID'].plot.bar(stacked=True, color=colors,
                                       figsize=(8,6), rot = 0,
                                       width = 0.2)

ax.yaxis.set_major_formatter(mtick.PercentFormatter())
ax.set_ylabel('% Customers', size = 14)
ax.set_xlabel('')
ax.set_title('% Customers with dependents and partners', size = 14)
ax.legend(loc = 'center', prop={'size':14})

for p in ax.patches:
    width, height = p.get_width(), p.get_height()
    x, y = p.get_xy()
    ax.annotate('{:.0f}%'.format(height), (p.get_x()+.25*width, p.get_y()+.4*height),
               color = 'white',
               weight = 'bold',
               size = 14)
```



interesting is to look at the % of customers, who have partners, also have dependents. We will explore this next.

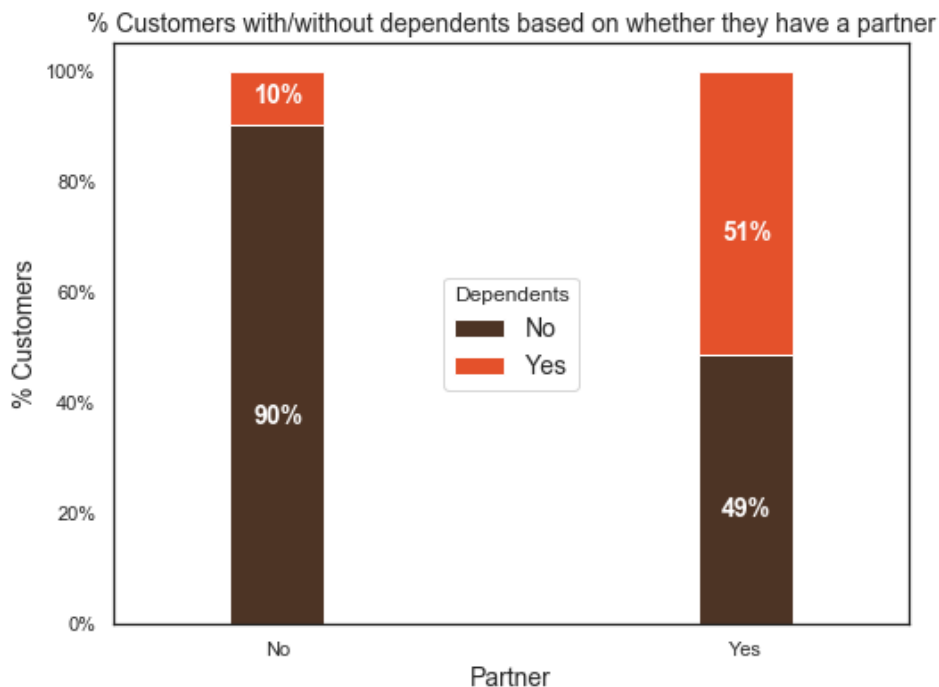
Interestingly, among the customers who have a partner, only about half of them also have a dependent, while other half do not have any dependents. Additionally, as expected, among the customers who do not have any partner, a majority (80%) of them do not have any dependents .

```
In [13]: colors = ['#4D3425', '#E4512B']
partner_dependents = telecom_cust.groupby(['Partner', 'Dependents']).size().unstack()

ax = (partner_dependents.T*100.0 / partner_dependents.T.sum()).T.plot(kind='bar',
                                                                    width = 0.2,
                                                                    stacked = True,
                                                                    rot = 0,
                                                                    figsize = (8,6),
                                                                    color = colors)

ax.yaxis.set_major_formatter(mtick.PercentFormatter())
ax.legend(loc='center', prop={'size':14}, title = 'Dependents', fontsize =14)
ax.set_ylabel('% Customers', size = 14)
ax.set_title('% Customers with/without dependents based on whether they have a partner', s
ax.xaxis.label.set_size(14)

# Code to add the data labels on the stacked bar chart
for p in ax.patches:
    width, height = p.get_width(), p.get_height()
    x, y = p.get_xy()
    ax.annotate('{:.0f}%'.format(height), (p.get_x()+.25*width, p.get_y()+.4*height),
                color = 'white',
                weight = 'bold',
                size = 14)
```



also looked at any differences between the % of customers with/without dependents and partners by gender. There is no difference in their distribution by gender. Additionally, there is no difference in senior citizen status by gender.

B.) Customer Account Information: Let u now look at the tenure, contract

1. Tenure: After looking at the below histogram we can see that a lot of customers have been with the telecom company for just a month, while quite a many are there for about 72 months. This could be potentially because different customers have different contracts. Thus based on the contract they are into it could be more/less easier for the customers to stay/leave the telecom company.

```
In [14]: ax = sns.distplot(telecom_cust['tenure'], hist=True, kde=False,
                        bins=int(180/5), color = 'darkblue',
                        hist_kws={'edgecolor':'black'},
                        kde_kws={'linewidth': 4})
ax.set_ylabel('# of Customers')
ax.set_xlabel('Tenure (months)')
ax.set_title('# of Customers by their tenure')
```

C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:4: UserWarning:

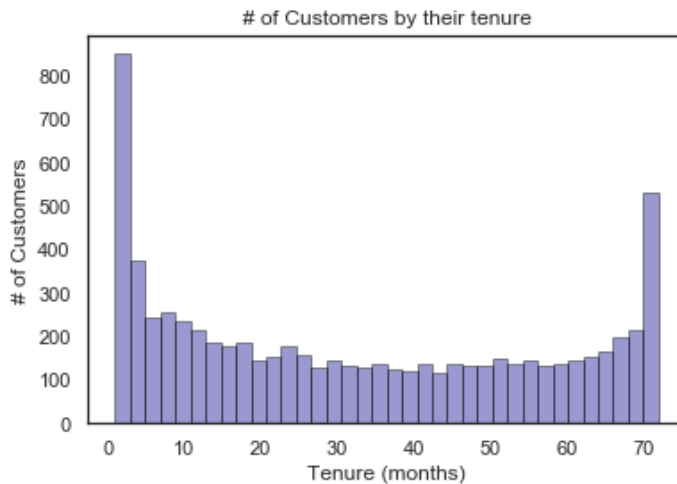
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751> (<https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>)

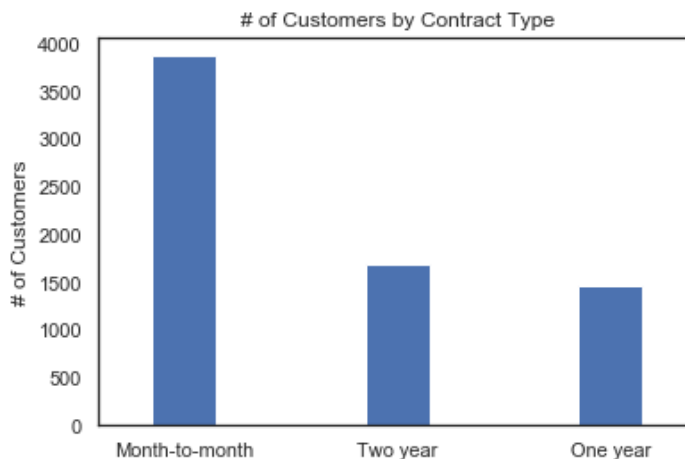
after removing the cwd from sys.path.

Out[14]: Text(0.5, 1.0, '# of Customers by their tenure')



```
In [15]: ax = telecom_cust['Contract'].value_counts().plot(kind = 'bar',rot = 0, width = 0.3)
ax.set_ylabel('# of Customers')
ax.set_title('# of Customers by Contract Type')
```

Out[15]: Text(0.5, 1.0, '# of Customers by Contract Type')



As we can see from this graph most of the customers are in the month to month contract. While there are equal number of customers in the 1 year and 2 year contracts.

Below we will understand the tenure of customers based on their contract type

```
In [16]: fig, (ax1,ax2,ax3) = plt.subplots(nrows=1, ncols=3, sharey = True, figsize = (20,6))

ax = sns.distplot(telecom_cust[telecom_cust['Contract']=='Month-to-month']['tenure'],
                  hist=True, kde=False,
                  bins=int(180/5), color = 'turquoise',
                  hist_kws={'edgecolor':'black'},
                  kde_kws={'linewidth': 4},
                  ax=ax1)
ax.set_ylabel('# of Customers')
ax.set_xlabel('Tenure (months)')
ax.set_title('Month to Month Contract')

ax = sns.distplot(telecom_cust[telecom_cust['Contract']=='One year']['tenure'],
                  hist=True, kde=False,
                  bins=int(180/5), color = 'steelblue',
                  hist_kws={'edgecolor':'black'},
                  kde_kws={'linewidth': 4},
                  ax=ax2)
ax.set_xlabel('Tenure (months)',size = 14)
ax.set_title('One Year Contract',size = 14)

ax = sns.distplot(telecom_cust[telecom_cust['Contract']=='Two year']['tenure'],
                  hist=True, kde=False,
                  bins=int(180/5), color = 'darkblue',
                  hist_kws={'edgecolor':'black'},
                  kde_kws={'linewidth': 4},
                  ax=ax3)

ax.set_xlabel('Tenure (months)')
ax.set_title('Two Year Contract')
```

C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:8: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751> (<https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>)

C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:18: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751> (<https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>)

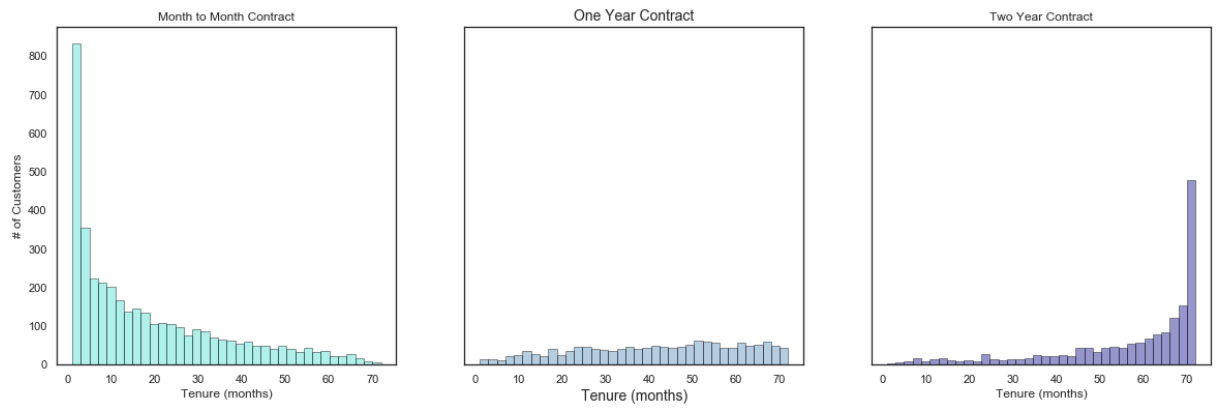
C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:27: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751> (<https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>)

Out[16]: Text(0.5, 1.0, 'Two Year Contract')



Interestingly most of the monthly contracts last for 1-2 months, while the 2 year contracts tend to last for about 70 months. This shows that the customers taking a longer contract are more loyal to the company and tend to stay with it for a longer period of time.

Finally, let's take a look at our predictor variable (Churn) and understand its interaction with other important variables as was found out in the correlation plot.¶¶ Lets first look at the churn rate in our data

```
In [17]: colors = ['#4D3425', '#E4512B']
ax = (telecom_cust['Churn'].value_counts()*100.0 / len(telecom_cust)).plot(kind='bar',
                                     stacked = True,
                                     rot = 0,
                                     color = colors,
                                     figsize = (8,6))

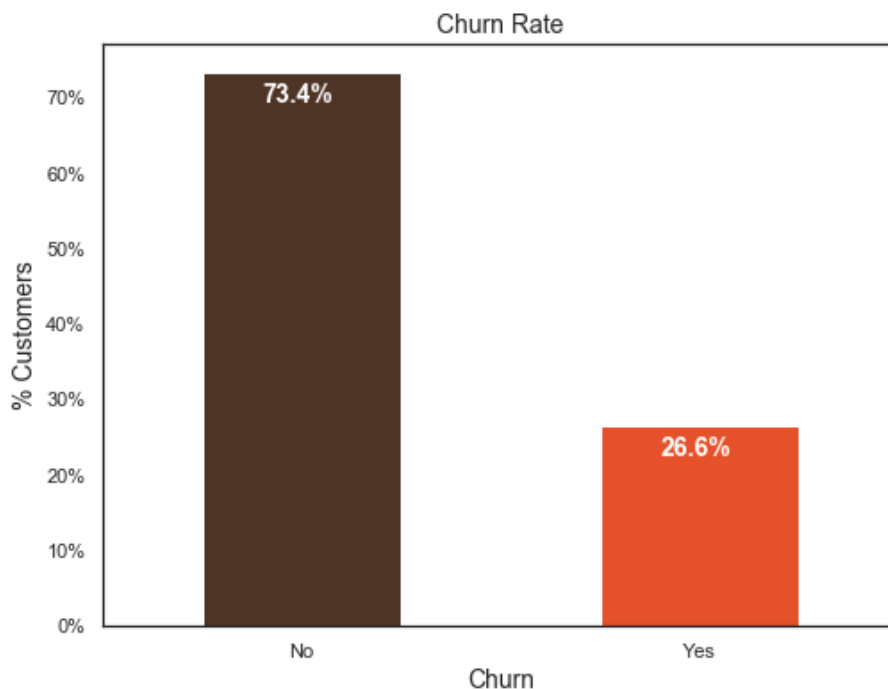
ax.yaxis.set_major_formatter(mtick.PercentFormatter())
ax.set_ylabel('% Customers', size = 14)
ax.set_xlabel('Churn', size = 14)
ax.set_title('Churn Rate', size = 14)

# create a list to collect the plt.patches data
totals = []

# find the values and append to list
for i in ax.patches:
    totals.append(i.get_width())

# set individual bar labels using above list
total = sum(totals)

for i in ax.patches:
    # get_width pulls left or right; get_y pushes up or down
    ax.text(i.get_x()+.15, i.get_height()-4.0, \
            str(round((i.get_height()/total), 1))+ '%',
            fontsize=12,
            color='white',
            weight = 'bold',
            size = 14)
```

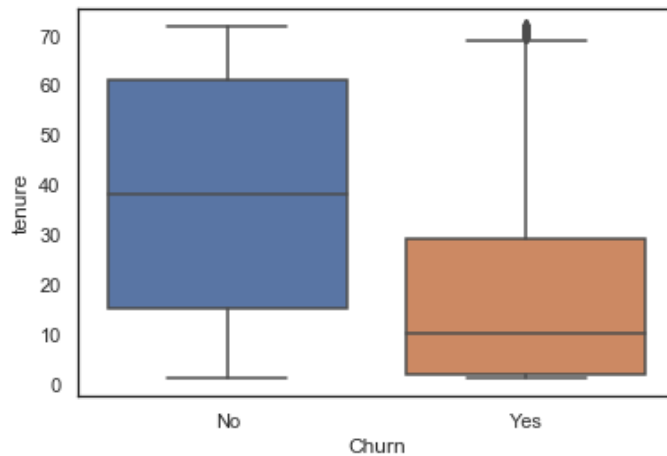


In our data, 74% of the customers do not churn. Clearly the data is skewed as we would expect a large majority of the customers to not churn. This is important to keep in mind for our modelling as skewness could lead to a lot of false negatives. We will see in the modelling section on how to avoid skewness in the data.

Lets now explore the churn rate by tenure, seniority, contract type, monthly charges and total charges to see how it varies by these variables. i.) Churn vs Tenure: As we can see form the below plot, the customers who do not churn, they tend to stay for a longer tenure with the telecom company.

```
In [18]: sns.boxplot(x = telecom_cust.Churn, y = telecom_cust.tenure)
```

```
Out[18]: <matplotlib.axes._subplots.AxesSubplot at 0xbced6d0>
```



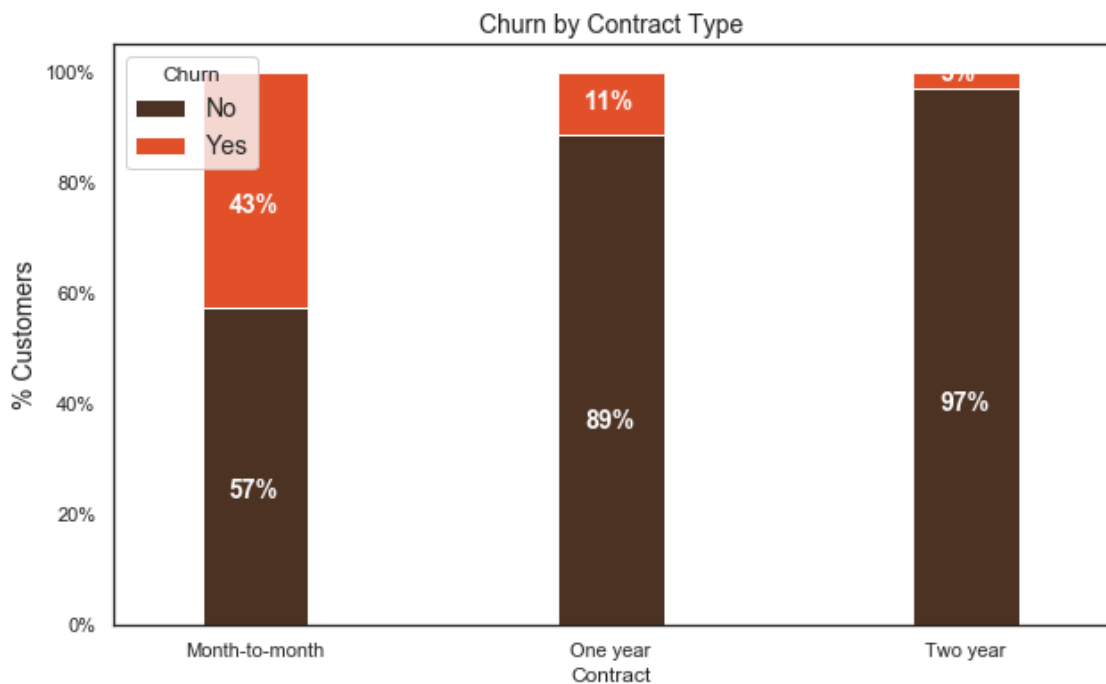
ii.) Churn by Contract Type: Similar to what we saw in the correlation plot, the customers who have a month to month contract have a very high churn rate.

```
In [19]: colors = ['#4D3425', '#E4512B']
contract_churn = telecom_cust.groupby(['Contract', 'Churn']).size().unstack()

ax = (contract_churn.T*100.0 / contract_churn.T.sum()).T.plot(kind='bar',
                                                             width = 0.3,
                                                             stacked = True,
                                                             rot = 0,
                                                             figsize = (10,6),
                                                             color = colors)

ax.yaxis.set_major_formatter(mtick.PercentFormatter())
ax.legend(loc='best',prop={'size':14},title = 'Churn')
ax.set_ylabel('% Customers',size = 14)
ax.set_title('Churn by Contract Type',size = 14)

# Code to add the data labels on the stacked bar chart
for p in ax.patches:
    width, height = p.get_width(), p.get_height()
    x, y = p.get_xy()
    ax.annotate(' {:.0f}%'.format(height), (p.get_x()+.25*width, p.get_y()+.4*height),
               color = 'white',
               weight = 'bold',
               size = 14)
```



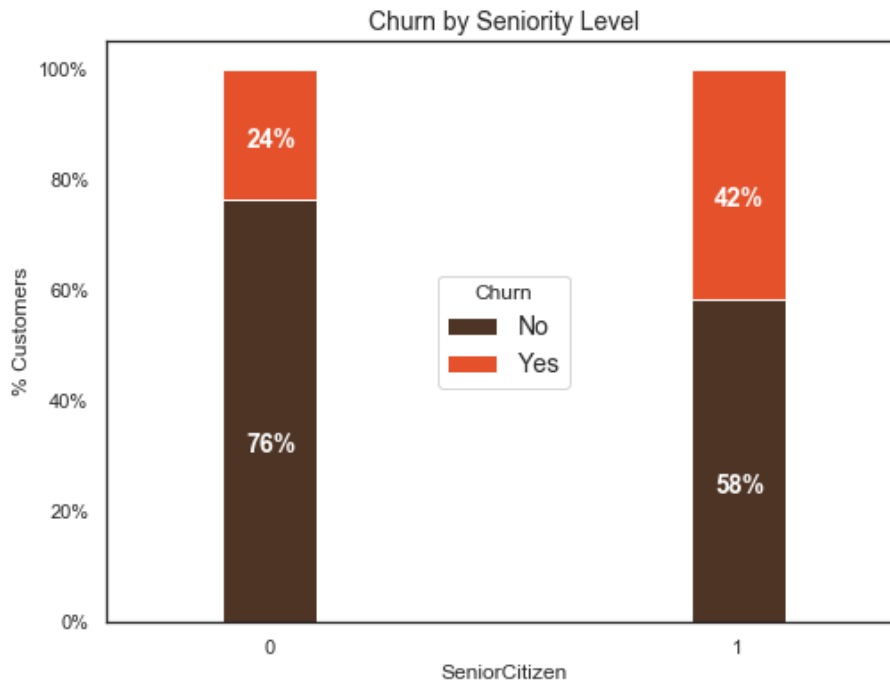
iii.) Churn by Seniority: Senior Citizens have almost double the churn rate than younger population.

```
In [20]: colors = ['#4D3425', '#E4512B']
seniority_churn = telecom_cust.groupby(['SeniorCitizen', 'Churn']).size().unstack()

ax = (seniority_churn.T*100.0 / seniority_churn.T.sum()).T.plot(kind='bar',
                                                                width = 0.2,
                                                                stacked = True,
                                                                rot = 0,
                                                                figsize = (8,6),
                                                                color = colors)

ax.yaxis.set_major_formatter(mtick.PercentFormatter())
ax.legend(loc='center',prop={'size':14},title = 'Churn')
ax.set_ylabel('% Customers')
ax.set_title('Churn by Seniority Level',size = 14)

# Code to add the data labels on the stacked bar chart
for p in ax.patches:
    width, height = p.get_width(), p.get_height()
    x, y = p.get_xy()
    ax.annotate('{:.0f}%'.format(height), (p.get_x()+.25*width, p.get_y()+.4*height),
                color = 'white',
                weight = 'bold',size =14)
```



iv.) Churn by Monthly Charges: Higher % of customers churn when the monthly charges are high

```
In [21]: ax = sns.kdeplot(telecom_cust.MonthlyCharges[(telecom_cust["Churn"] == 'No') ],
                        color="Red", shade = True)
ax = sns.kdeplot(telecom_cust.MonthlyCharges[(telecom_cust["Churn"] == 'Yes') ],
                ax=ax, color="Blue", shade= True)
ax.legend(["Not Churn", "Churn"], loc='upper right')
ax.set_ylabel('Density')
ax.set_xlabel('Monthly Charges')
ax.set_title('Distribution of monthly charges by churn')
```

C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:2: FutureWarning:

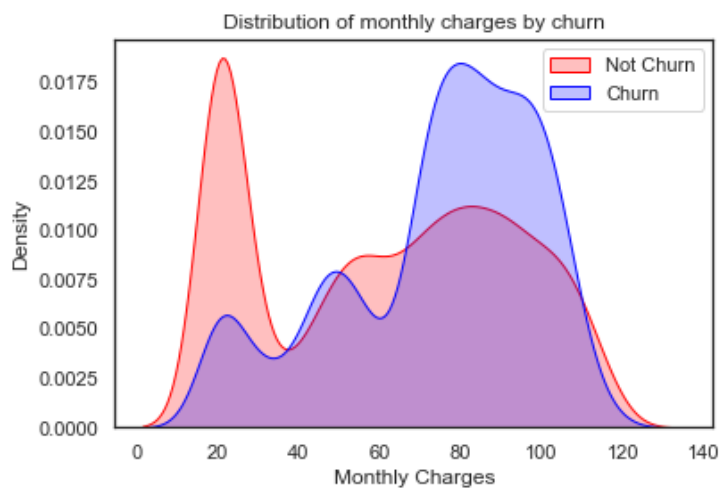
`shade` is now deprecated in favor of `fill`; setting `fill=True`.
This will become an error in seaborn v0.14.0; please update your code.

C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:4: FutureWarning:

`shade` is now deprecated in favor of `fill`; setting `fill=True`.
This will become an error in seaborn v0.14.0; please update your code.

after removing the cwd from sys.path.

Out[21]: Text(0.5, 1.0, 'Distribution of monthly charges by churn')



v.) Churn by Total Charges: It seems that there is higher churn when the total charges are lower.


```
In [22]: ax = sns.kdeplot(telecom_cust.TotalCharges[(telecom_cust["Churn"] == 'No') ],
                        color="Red", shade = True)
ax = sns.kdeplot(telecom_cust.TotalCharges[(telecom_cust["Churn"] == 'Yes') ],
                ax=ax, color="Blue", shade= True)
ax.legend(["Not Churn", "Churn"], loc='upper right')
ax.set_ylabel('Density')
ax.set_xlabel('Total Charges')
ax.set_title('Distribution of total charges by churn')
```

C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:2: FutureWarning:

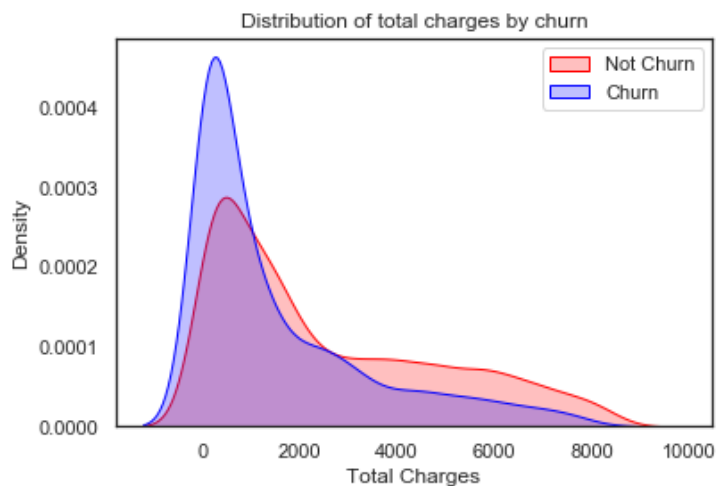
`shade` is now deprecated in favor of `fill`; setting `fill=True`.
This will become an error in seaborn v0.14.0; please update your code.

C:\Users\SHREERAKSHA\anaconda3\lib\site-packages\ipykernel_launcher.py:4: FutureWarning:

`shade` is now deprecated in favor of `fill`; setting `fill=True`.
This will become an error in seaborn v0.14.0; please update your code.

after removing the cwd from sys.path.

Out[22]: Text(0.5, 1.0, 'Distribution of total charges by churn')



After going through the above EDA we will develop some predictive models and compare them. We will develop Logistic Regression, Random Forest, SVM, ADA Boost and XG Boost

```
In [23]: # We will use the data frame where we had created dummy variables
y = df_dummies['Churn'].values
X = df_dummies.drop(columns = ['Churn'])

# Scaling all the variables to a range of 0 to 1
from sklearn.preprocessing import MinMaxScaler
features = X.columns.values
scaler = MinMaxScaler(feature_range = (0,1))
scaler.fit(X)
X = pd.DataFrame(scaler.transform(X))
X.columns = features
```

It is important to scale the variables in logistic regression so that all of them are within a range of 0 to 1. This helped me improve the accuracy from 79.7% to 80.7%. Further, you will notice below that the importance of variables is also aligned with what we are seeing in Random Forest algorithm and the EDA we conducted above.

```
In [24]: Create Train & Test Data  
from sklearn.model_selection import train_test_split  
train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=101)
```

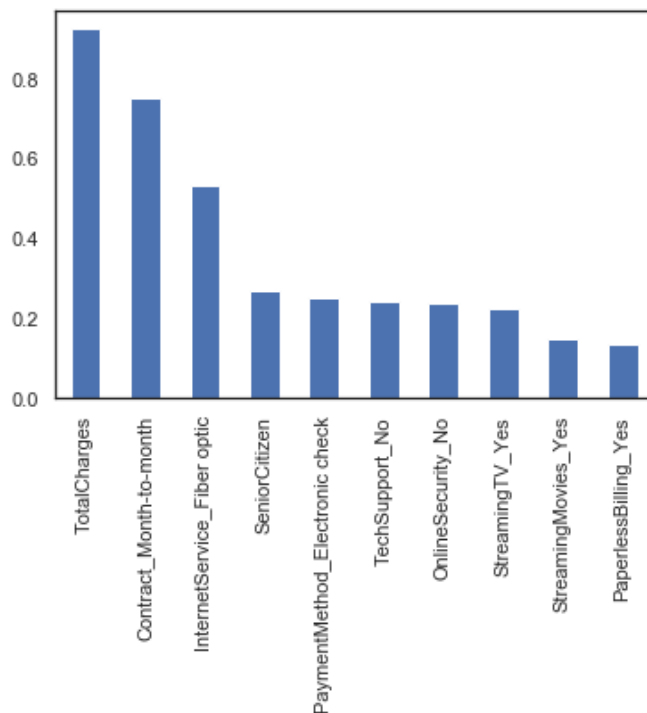
```
In [25]: # Running Logistic regression model  
from sklearn.linear_model import LogisticRegression  
model = LogisticRegression()  
result = model.fit(X_train, y_train)
```

```
In [26]: from sklearn import metrics  
prediction_test = model.predict(X_test)  
# Print the prediction accuracy  
print (metrics.accuracy_score(y_test, prediction_test))
```

0.8075829383886256

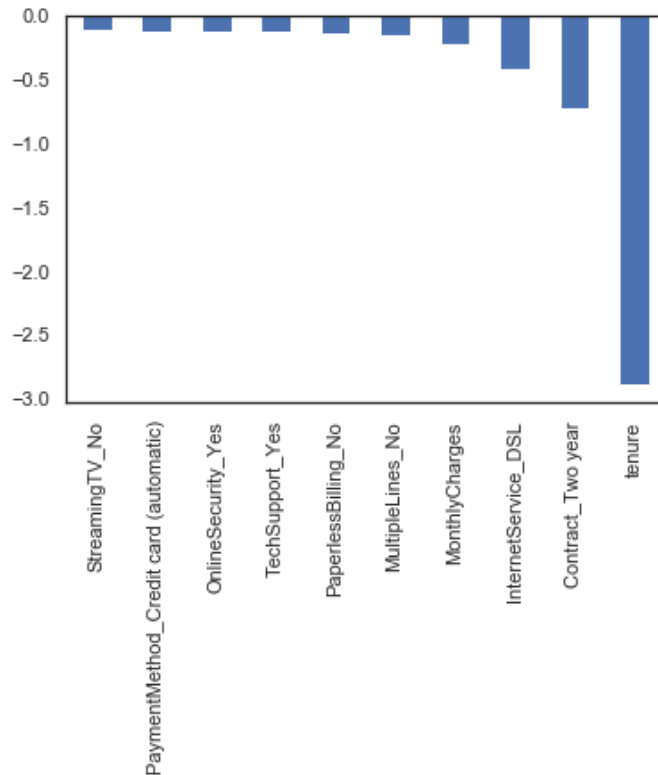
```
In [27]: # To get the weights of all the variables  
weights = pd.Series(model.coef_[0],  
                    index=X.columns.values)  
print (weights.sort_values(ascending = False)[:10].plot(kind='bar'))
```

AxesSubplot(0.125,0.125;0.775x0.755)



```
In [28]: print(weights.sort_values(ascending = False)[-10:].plot(kind='bar'))
```

AxesSubplot(0.125,0.125;0.775x0.755)



Observations

We can see that some variables have a negative relation to our predicted variable (Churn), while some have positive relation. Negative relation means that likeliness of churn decreases with that variable. Let us summarize some of the interesting features below:

As we saw in our EDA, having a 2 month contract reduces chances of churn. 2 month contract along with tenure have the most negative relation with Churn as predicted by logistic regressions. Having DSL internet service also reduces the probability of Churn. Lastly, total charges, monthly contracts, fibre optic internet services and seniority can lead to higher churn rates. This is interesting because although fibre optic services are faster, customers are likely to churn because of it. I think we need to explore more to better understand why this is happening.

In []: