Aditya Shetty

Exploratory Data Analysis of Irish Census data

Introduction

Census data is the survey of people living in particular country with age, marital status, sex, place of birth, occupation and religion, number of family members, condition of living, education and if they are physically abled, language they speak ,etc. Once all survey is collected, the data is accumulated and overall data can be presumed for each county, city or particular region.

As per census, one person from each family or household needs to fill the form containing questions on behalf of everyone. All these information are kept confidential and not shared with anyone. This data is only used by CSO for statistical purpose.

Census data is used by variety of people for different purposes as this accumulated data is later shared in open source. Some of the important use of census population data is to predict trends, help local authorities and local services for planning policy, for government to help share funding, businesses for store locations. This census data is collected every 5 years by Central Statistics Office. The data is collected so that the government or the governing body could provide proper service to the people of that country and what is utmost required in a particular county or region. It takes nearly a year to collect this data and another year to produce the data with proper documentation.

For example, if an area has majority people are physically disabled then the governing body can provide more support towards them by improving mode of transport or roads or public schemes taking them into consideration. In this particular project I am going to check if the physically challenged population for Males and predict the population of physically challenged population for Males for next year which will be my target variable and is dependent of migrated people as well as current people living in Ireland weather they are Irish or not.

In this project we are going to do analysis on age groups, Irish speaking population, marital status of them. The main focus would be on the Male disabled population and we will fit a regression model for it, based on the given parameters and their age group.

Our dataset here contains data of people county wise in Ireland. All 31 counties with their respective population and personal information are present, there are 802 columns in total. This amount of data is accumulated with the response of people by filling the forms. The total population of Ireland is 4761865 as per 2016 census data.

In this report, we will analyse three different themes. The first will be Population aged 0 - 19 by sex and year of age, persons aged 20 years and over by sex and age group along with Population by sex and marital status. Here, we have different columns of age wise split in population based on Male &

Female. We will further club some columns to make it easier to understand as there are 15 columns given for age based on each sex, which is difficult to understand.

The second is Population aged 3 years and over by ability to speak Irish. We have been given Irish speaking count for each county.And last the third theme is Persons with disability by sex. Wherein we are given population of Male and Female who are disabled and a total of it.

We will check that if there is any linear relation between these parameters and if we can use this relation to find the significant variables to calculate the Male disabled population for next census data.

-> **Importing all required packages below**
We have used below basic packages from python library to analyse our data. Numpy and pandas are used to read data. Matplotlib and seaborn are used for creating plots and graphical interpretation which are required. Statsmodels api is used regression model testing. The warning api is imported to ignore the red warnings which are printed, which we don't require.

In [427…
```
import numpy as np
import pandas as pd
from pandas import DataFrame, Series
from matplotlib import pyplot as plt
import seaborn as sns
import matplotlib.patches as mpatches
import statsmodels.api as sm
from scipy import stats
```

In [428…
```
import warnings
warnings.filterwarnings('ignore')
```

Loading Data set

We are using data set based on county, we will use the name of the county as the index. There are 31 row data and 802 columns in total including the county names.

In [429…
```
C_county = pd.read_csv('Census_by_county.csv', index_col='GEOGDESC')
C_county.shape
```

Out[429… (31, 801)

Data cleaning/pre-processing:

Below we are storing columns only for the three themes we mentioned: Theme 1(Age) ,2(Irish speaking) and 12(disability). We have renamed all the columns for better understanding of the data.

In [430…
```
data_county = C_county[["T1_1AGETM", "T1_1AGETF","T1_1AGETT","T3_1NO","T3_1NS","T3_1YES
data_county = data_county.rename(columns = {"T1_1AGETM":"MaleTotal","T1_1AGETF":"Female
data_county.dtypes.head()
```

Out[430…
```
MaleTotal          object
FemaleTotal        object
Total              object
IrishNo            object
IrishNotStated     object
dtype: object
```

As we can notice most the data is in object datatype, which cannot be used since they should be numeric. Hence we will replace the string "," and convert it to numeric format for our use.

In [431…
```
data_county.replace(',','', regex=True, inplace=True)
X = data_county.select_dtypes(object).columns
data_county[X] = data_county[X].apply(pd.to_numeric,errors = 'coerce')
data_county.dtypes.head()
```

Out[431…
```
MaleTotal          int64
FemaleTotal        int64
Total              int64
IrishNo            int64
IrishNotStated     int64
dtype: object
```

We need some additional columns for our explonatory data analysis, they are mentioned below: Since we have 15 columns for Male age category we have divided it into 5 simple age groups Children_0_19, Millennials(20 to 34), Gen_X(35 to 49), Baby_Boomers(50 to 69) and Silent_generation(70 above). This

In [432…
```
data_county["Children_0_19"] = data_county["Male_Age_0"] + data_county["Male_Age_1"] +
data_county['Millennials'] = data_county["Male_Age_20_24"]+data_county["Male_Age_25_29"
data_county['Gen_X'] = data_county["Male_Age_35_39"]+data_county["Male_Age_40_44"]+data
data_county['Baby_Boomers'] = data_county["Male_Age_50_54"]+data_county["Male_Age_55_59
data_county['Silent_generation'] = data_county["Male_Age_70_74"]+data_county["Male_Age_
data_county['NonIrish'] = data_county["Total"] - data_county["Irish_Total"]

data_county.head()
```

Out[432…

GEOGDESC	MaleTotal	FemaleTotal	Total	IrishNo	IrishNotStated	IrishYes	Total_Married	Total_Sepa
Cork City	61722	63935	125657	72457	4555	44822	39222	
Clare	58785	60032	118817	58889	3001	52482	47160	
Cork County	206953	210258	417211	211657	8128	179317	167195	
Cavan	38330	37846	76176	46003	1657	25210	30010	
Carlow	28465	28467	56932	32896	1458	20243	21235	

5 rows × 57 columns

Below are some of the tables which we would require for analysis purpose:

In [433…
```
#data_county.dtypes
```

```
data_Age = data_county[["MaleTotal", "FemaleTotal","Total","IrishNo","IrishYes"]]
data_Marriage = data_county[["Total_Married","Total_Separated","Total_Divorced","Total_
data_IrishSpeaker = data_county[["Irish_Females","Irish_Males","Irish_Total","Total","N
```

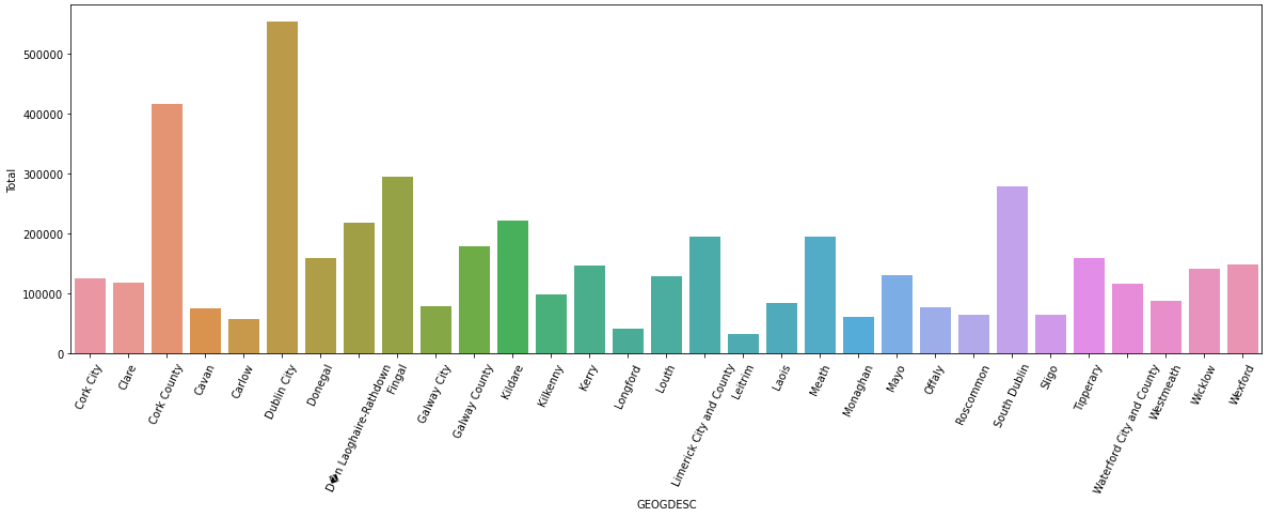
Exploratory data analysis

From below barplot we can clearly notice that Dublin City has the highest population, second is Cork followed by Fingal and South Dublin.

In [434…

```
fig_dims = (20,6)
fig, ax = plt.subplots(figsize=fig_dims)
locs, labels = plt.xticks()
plt.setp(labels, rotation=65)
sns.barplot(x=data_Age.index, y="Total", data=data_Age,ax=ax)
```

Out[434… <AxesSubplot:xlabel='GEOGDESC', ylabel='Total'>



In the below graph we can notice almost all counties have equal ratio of male and females. Also in the described table below we can notice we have almost the same ration of males and females. Altough in the dataset we can notice in Ireland non Irish speakers are more the mean of non Irish speaking native is 86062.74 and Irish speaker is 56820.

In [435…

```
data_Age.describe()
```

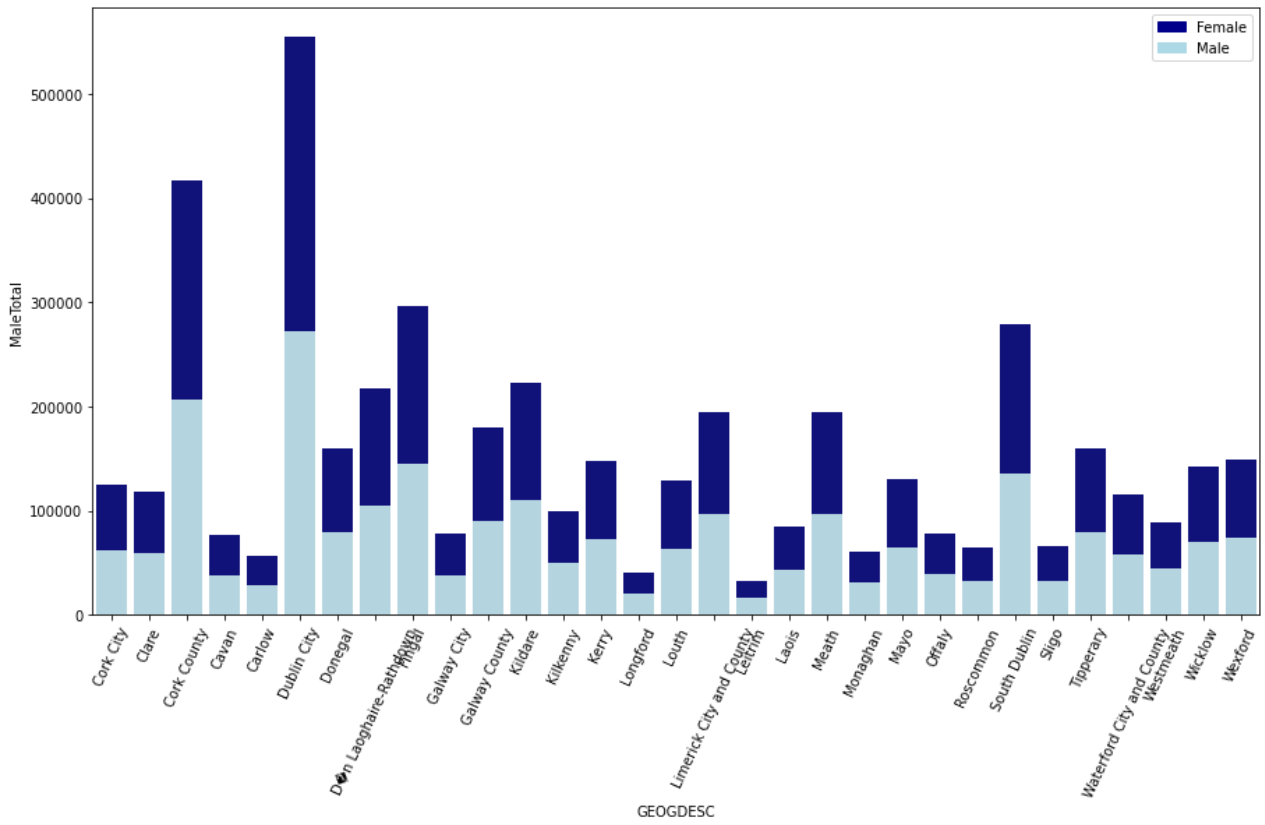
Out[435…

	MaleTotal	FemaleTotal	Total	IrishNo	IrishYes
count	31.000000	31.000000	31.000000	31.000000	31.000000
mean	75949.290323	77659.258065	153608.548387	86062.741935	56820.000000
std	54837.558564	56862.541966	111687.416866	65723.586516	38287.421603
min	16064.000000	15980.000000	32044.000000	17676.000000	12300.000000
25%	38584.000000	39995.500000	78314.500000	45443.500000	29473.500000
50%	63633.000000	65251.000000	128884.000000	72457.000000	49955.000000
75%	93319.500000	93543.000000	187144.500000	98281.500000	74538.000000

	MaleTotal	FemaleTotal	Total	IrishNo	IrishYes
max	272270.000000	282284.000000	554554.000000	344099.000000	179317.000000

In [436…

```
# set the figure size
plt.figure(figsize=(15, 8))
bar1 = sns.barplot(x=data_Age.index,  y="Total", data=data_Age, color='darkblue')

bar2 = sns.barplot(x=data_Age.index, y="MaleTotal", data=data_Age, color='lightblue')
locs, labels = plt.xticks()
plt.setp(labels, rotation=65)
top_bar = mpatches.Patch(color='darkblue', label='Female')
bottom_bar = mpatches.Patch(color='lightblue', label='Male')
plt.legend(handles=[top_bar, bottom_bar])
plt.show()
```



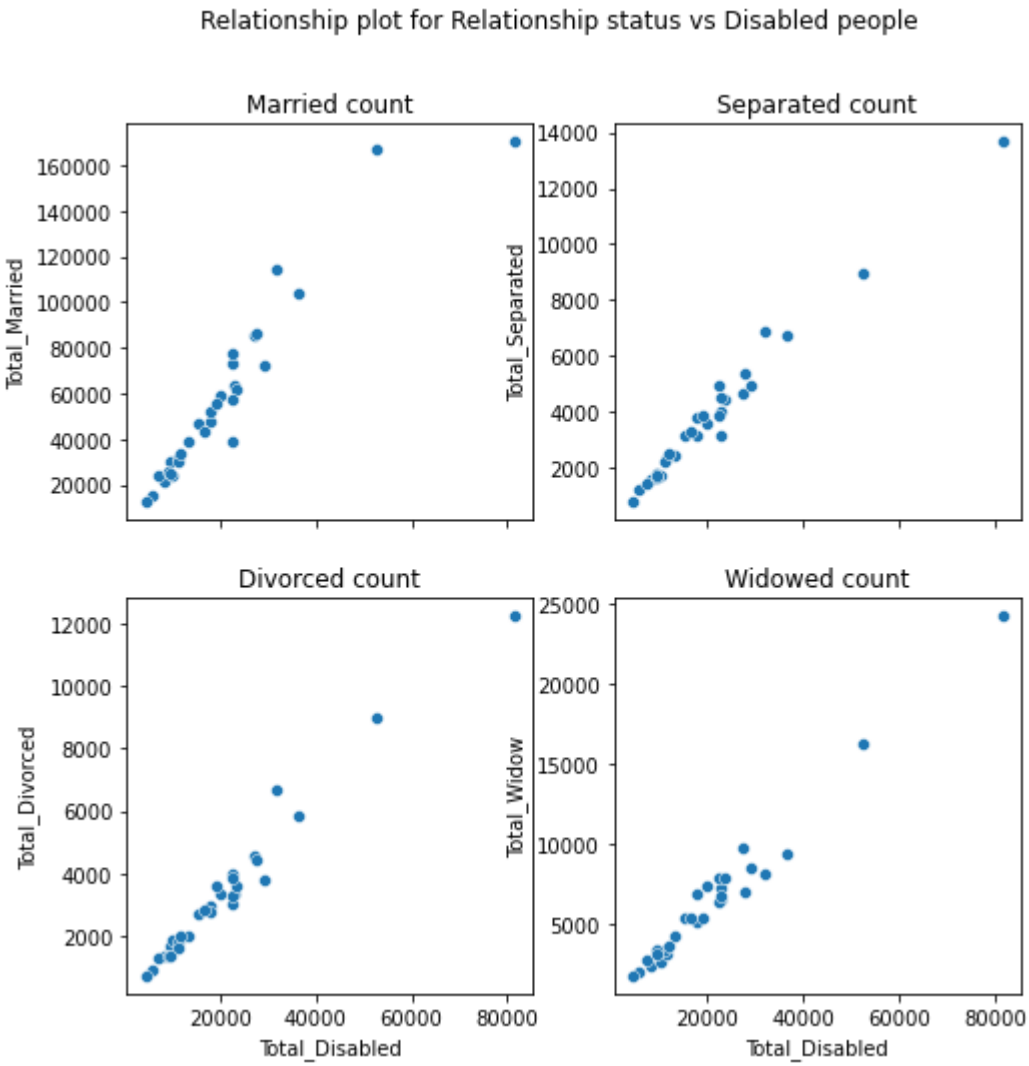
Since our aim is to analyse disabled citizens of Ireland, we would like to just check if there is any relationship between Disability of a person and his relationship status. And as we can notice there is positive relation between all the charts. Which indicates that there is a positive correlation here between columns Total_Disabled and Relationship status.

In [437…

```
fig, axes = plt.subplots(2, 2, sharex=True, figsize=(8,8))
fig.suptitle('Relationship plot for Relationship status vs Disabled people')

sns.scatterplot(ax=axes[0,0], x="Total_Disabled", y="Total_Married", data=data_county)
axes[0,0].set_title("Married count")
sns.scatterplot(ax=axes[0,1], x="Total_Disabled", y="Total_Separated", data=data_county
axes[0,1].set_title("Separated count")
sns.scatterplot(ax=axes[1,0], x="Total_Disabled", y="Total_Divorced", data=data_county)
axes[1,0].set_title("Divorced count")
```

```
sns.scatterplot(ax=axes[1,1], x="Total_Disabled", y="Total_Widow", data=data_county)
axes[1,1].set_title("Widowed count")
```

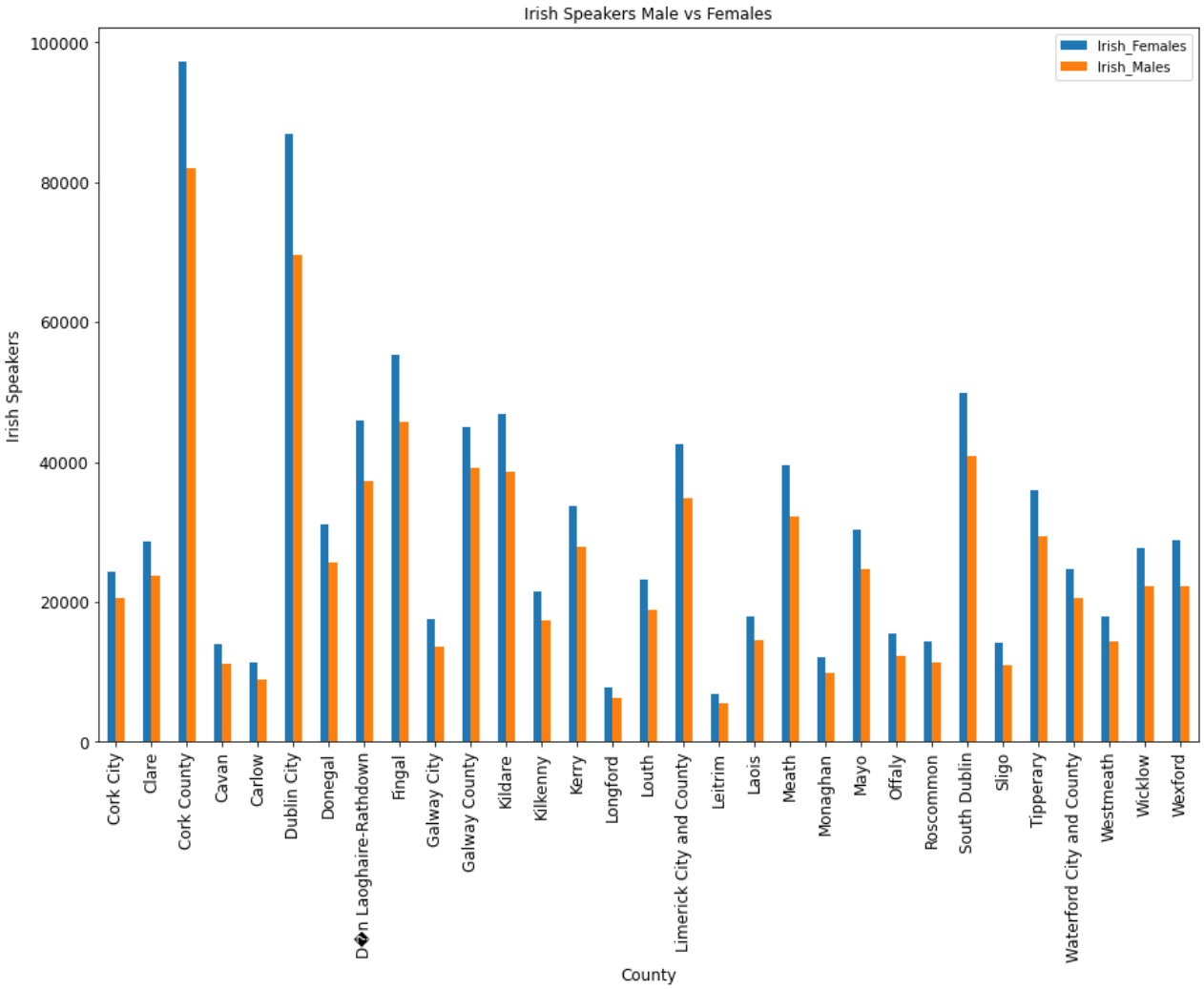
Out[437… `Text(0.5, 1.0, 'Widowed count')`



For Male and Female theme in Irish speakers, we can notice that all the counties have more females who speak Irish language. Even in smallest counties the majority of Irish speakers are females.

In [438…

```
ax = data_IrishSpeaker[['Irish_Females','Irish_Males']].plot(kind='bar', title ="Irish
ax.set_xlabel("County", fontsize=12)
ax.set_ylabel("Irish Speakers", fontsize=12)
plt.show()
```



We can clearly notice this with the below grid as the mean of Irish_Females is greater than Irish_Males.

In [439…

```
data_IrishSpeaker.describe()
```

Out[439…

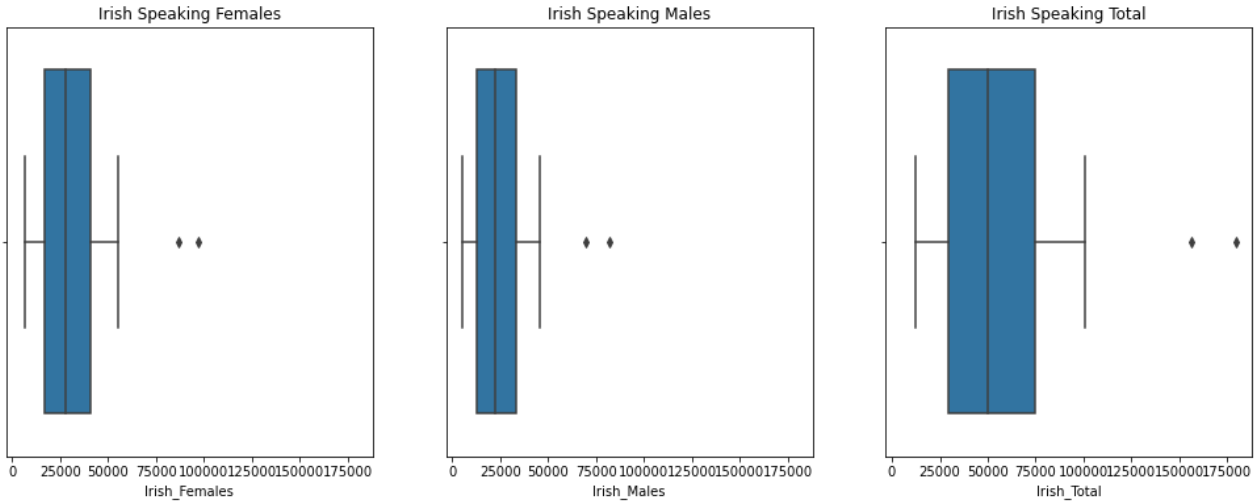
	Irish_Females	Irish_Males	Irish_Total	Total	NonIrish
count	31.000000	31.000000	31.000000	31.000000	31.000000
mean	31250.870968	25569.129032	56820.000000	153608.548387	96788.548387
std	20888.828242	17407.014716	38287.421603	111687.416866	75585.243163
min	6858.000000	5442.000000	12300.000000	32044.000000	19744.000000
25%	16536.500000	12937.000000	29473.500000	78314.500000	50560.000000
50%	27671.000000	22284.000000	49955.000000	128884.000000	80835.000000
75%	41011.500000	33526.500000	74538.000000	187144.500000	110020.000000
max	97269.000000	82048.000000	179317.000000	554554.000000	398118.000000

In [440…

```
fig, axes = plt.subplots(1, 3, sharex=True, figsize=(17,6))
sns.boxplot(ax = axes[0], x=data_IrishSpeaker["Irish_Females"])
axes[0].set_title("Irish Speaking Females")
```

```
sns.boxplot(ax = axes[1], x=data_IrishSpeaker["Irish_Males"])
axes[1].set_title("Irish Speaking Males")
sns.boxplot(ax = axes[2], x=data_IrishSpeaker["Irish_Total"])
axes[2].set_title("Irish Speaking Total")
```

Out[440… `Text(0.5, 1.0, 'Irish Speaking Total')`



As we can notice that there are two outliers in plot for Irish speaking males and females, where there are more than 150000 Irish speakers, we can get these counties as shown in below code. Dublin and Cork have highest Irish speakers due to it majority.

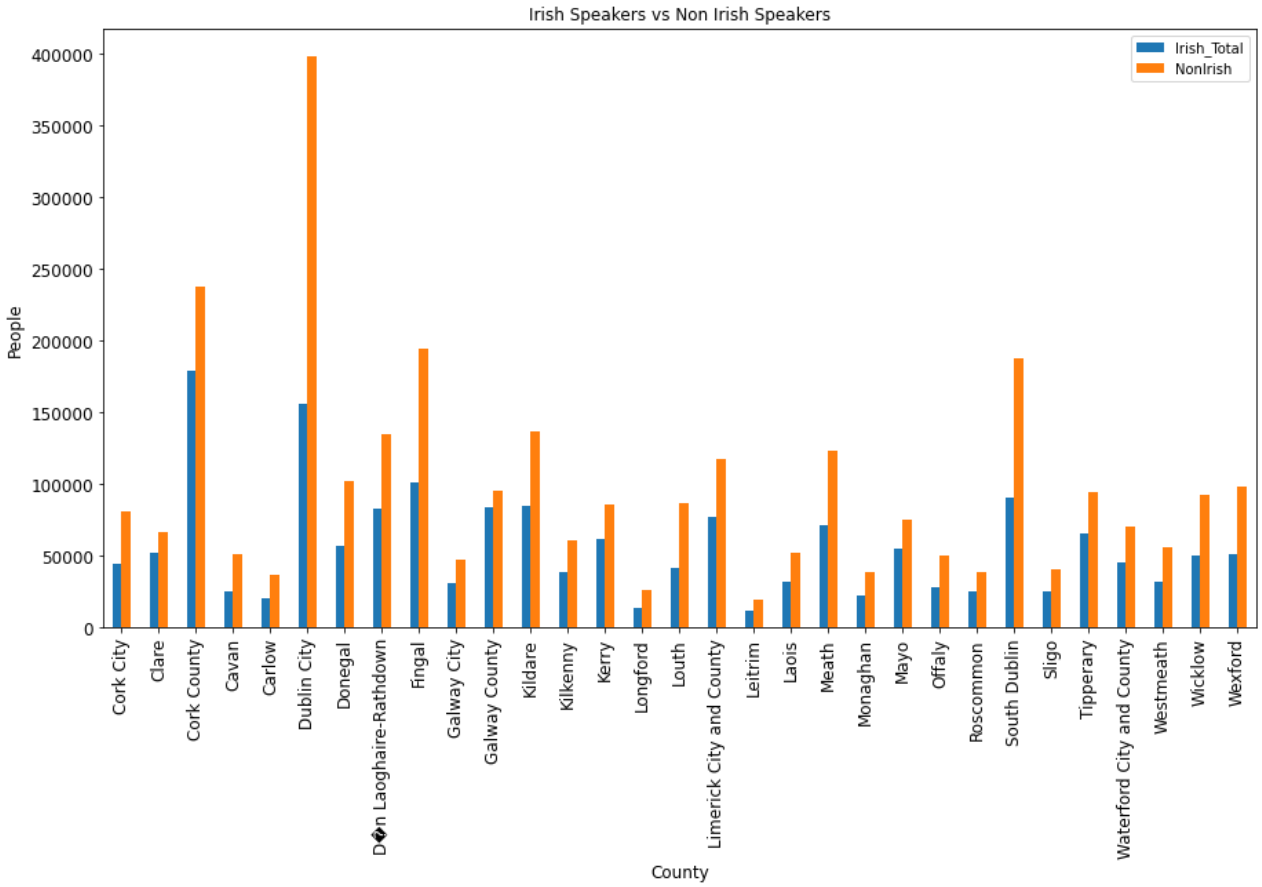
In [441…
```
data_IrishSpeaker[data_IrishSpeaker["Irish_Total"] > 150000]
```

Out[441…

GEOGDESC	Irish_Females	Irish_Males	Irish_Total	Total	NonIrish
Cork County	97269	82048	179317	417211	237894
Dublin City	86863	69573	156436	554554	398118

As we can notice below the each county has more other language people and Irish population is minority in Ireland. Dublin has less than half of Irish speaking population.

In [442…
```
ax = data_IrishSpeaker[['Irish_Total','NonIrish']].plot(kind='bar', title ="Irish Speak
ax.set_xlabel("County", fontsize=12)
ax.set_ylabel("People", fontsize=12)
plt.show()
```



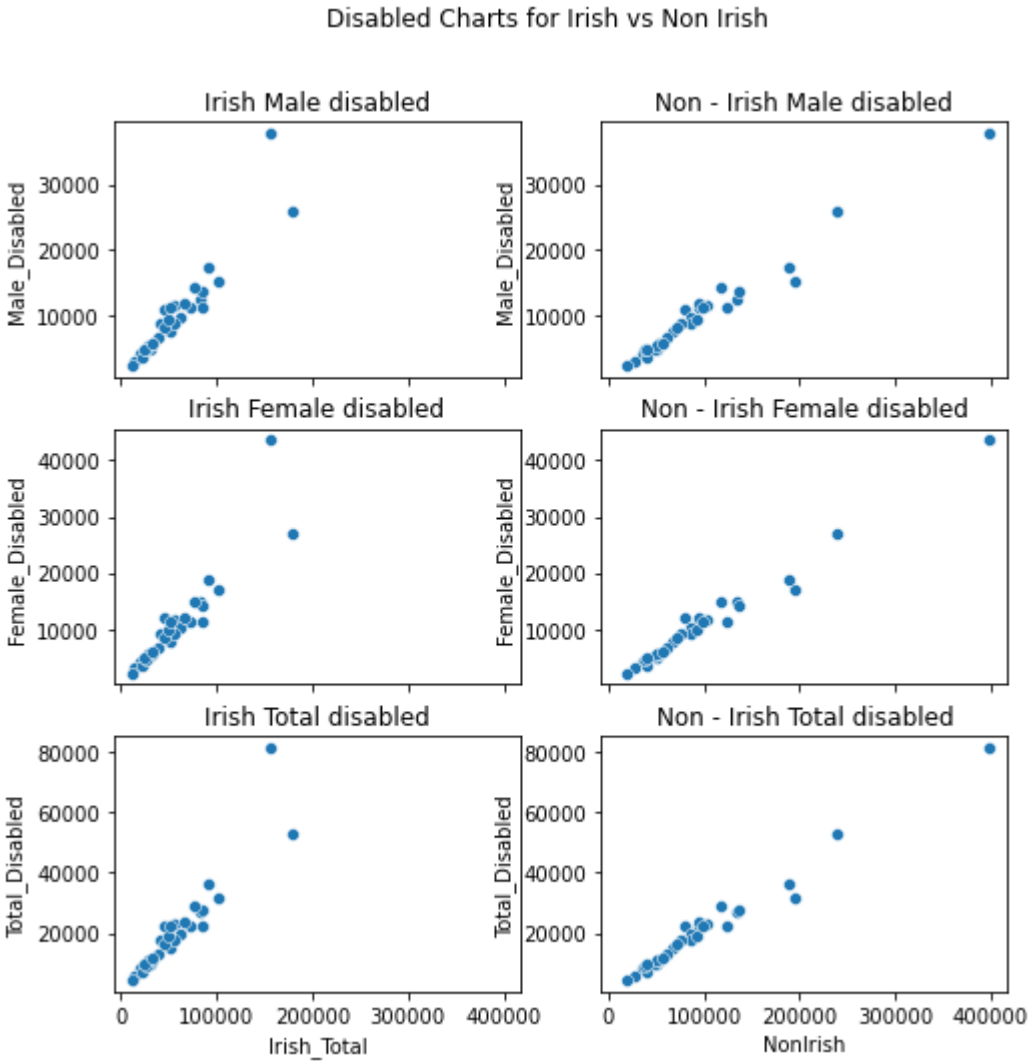
In the below scatterplot we see positive correlation for all the charts for Male, female and total based on Irish and Non Irish population.

In [443…

```
data_Disabled = data_county[["Male_Disabled","Female_Disabled","Total_Disabled","Irish_

fig, axes = plt.subplots(3, 2, sharex=True, figsize=(8,8))
fig.suptitle('Disabled Charts for Irish vs Non Irish')

sns.scatterplot(ax=axes[0,0], x="Irish_Total", y="Male_Disabled", data=data_Disabled)
axes[0,0].set_title("Irish Male disabled")
sns.scatterplot(ax=axes[0,1], x="NonIrish", y="Male_Disabled", data=data_Disabled)
axes[0,1].set_title("Non - Irish Male disabled")


sns.scatterplot(ax=axes[1,0], x="Irish_Total", y="Female_Disabled", data=data_Disabled)
axes[1,0].set_title("Irish Female disabled")
sns.scatterplot(ax=axes[1,1], x="NonIrish", y="Female_Disabled", data=data_Disabled)
axes[1,1].set_title("Non - Irish Female disabled")


sns.scatterplot(ax=axes[2,0], x="Irish_Total", y="Total_Disabled", data=data_Disabled)
axes[2,0].set_title("Irish Total disabled")
sns.scatterplot(ax=axes[2,1], x="NonIrish", y="Total_Disabled", data=data_Disabled)
axes[2,1].set_title("Non - Irish Total disabled")
```

Out[443…

```
Text(0.5, 1.0, 'Non - Irish Total disabled')
```

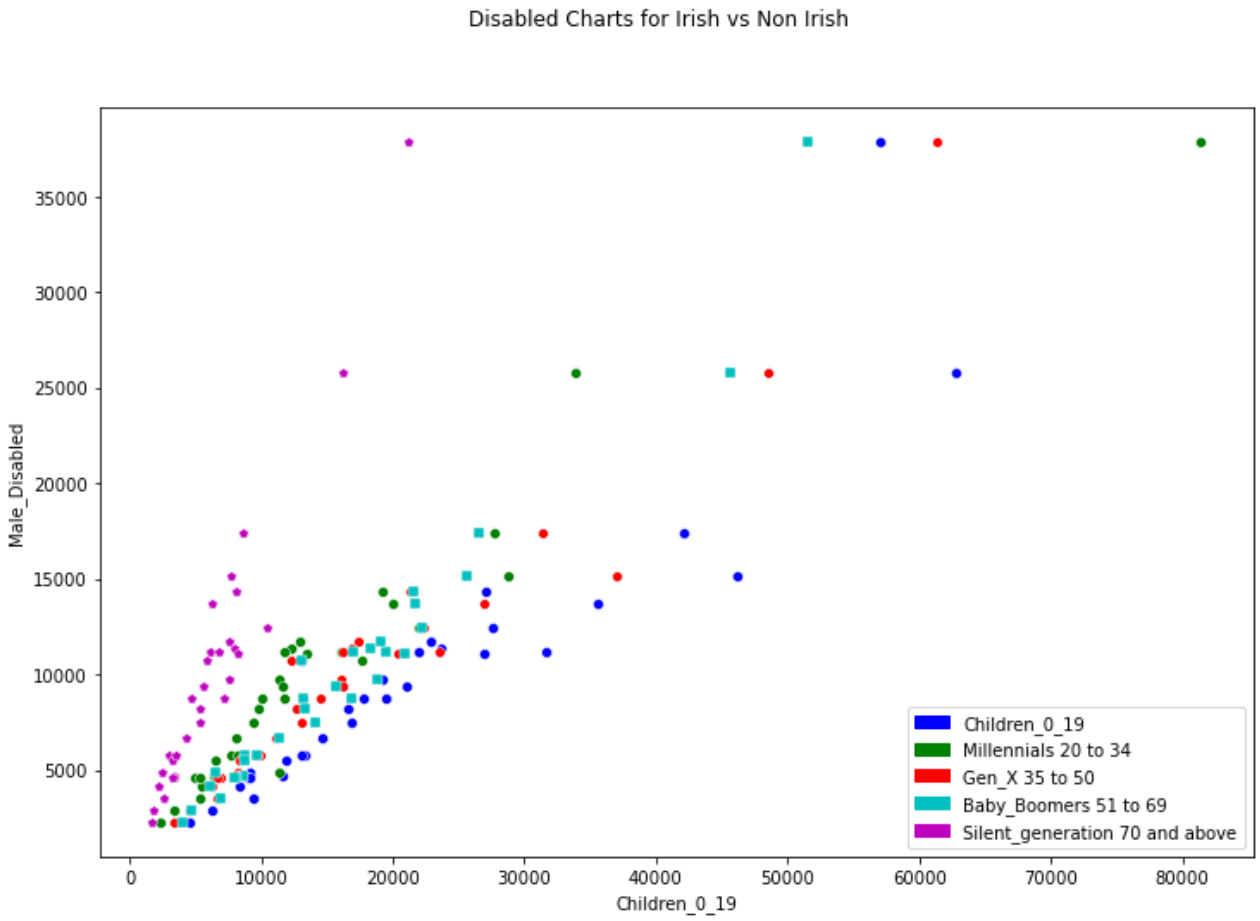


In the below plot we can observe the intercept of Silent generation is higher than others and Children_0_19 has the smallest intercept. This is because the population of Silent generation is lowest and hence higher positive correlation.

In [444…

```
fig, axes = plt.subplots(1, 1, sharex=True, figsize=(12,8))
fig.suptitle('Disabled Charts for Irish vs Non Irish')

sns.scatterplot(x="Children_0_19", y="Male_Disabled", data=data_county,color='b')
sns.scatterplot(x="Millennials", y="Male_Disabled", data=data_county,color='g',marker =
sns.scatterplot(x="Gen_X", y="Male_Disabled", data=data_county,color='r',marker = '8')
sns.scatterplot(x="Baby_Boomers", y="Male_Disabled", data=data_county,color='c',marker
sns.scatterplot(x="Silent_generation", y="Male_Disabled", data=data_county,color='m',ma

first = mpatches.Patch(color='b', label='Children_0_19')
second= mpatches.Patch(color='g', label='Millennials 20 to 34')
third = mpatches.Patch(color='r', label='Gen_X 35 to 50')
fourth= mpatches.Patch(color='c', label='Baby_Boomers 51 to 69')
fifth = mpatches.Patch(color='m', label='Silent_generation 70 and above')
plt.legend(handles=[first, second,third,fourth,fifth])
```

Out[444… <matplotlib.legend.Legend at 0x18a0b679070>



In [445…

```
data_county = data_county.drop(['Total','IrishNo','Total_Status','Irish_Total','Total_D
```

Statistical analysis:

We are keeping the target variable as "Male_Disabled" for us to calculate. We firstly will standardize the data to fit a linear model. In the above cell, we removed unwanted variables which are directly or indirectly already mentioned in below table.

In [446…

```
data_county_std = (data_county-data_county.mean())/data_county.std()
data_county_std.insert(0,'intercept',1)
mod = sm.OLS(data_county_std.Male_Disabled,data_county_std.drop('Male_Disabled',axis=1)
res = mod.fit()
print(res.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Male_Disabled   R-squared:                       1.000
Model:                            OLS   Adj. R-squared:                  1.000
Method:                 Least Squares   F-statistic:                     6485.
Date:                Mon, 20 Dec 2021   Prob (F-statistic):           9.83e-29
Time:                        14:54:03   Log-Likelihood:                 88.412
No. Observations:                  31   AIC:                            -148.8
Df Residuals:                      17   BIC:                            -128.7
Df Model:                          13
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
intercept          9.714e-17      0.003   2.87e-14      1.000      -0.007       0.007
MaleTotal             0.2910      0.068      4.296      0.000       0.148       0.434
FemaleTotal          -0.5061      0.308     -1.644      0.119      -1.156       0.143
IrishNotStated       -0.0807      0.044     -1.840      0.083      -0.173       0.012
IrishYes             -0.0593      0.080     -0.745      0.467      -0.227       0.109
Total_Married        -0.7024      0.276     -2.546      0.021      -1.284      -0.120
Total_Separated       0.0233      0.056      0.418      0.681      -0.094       0.141
Total_Divorced       -0.0403      0.060     -0.672      0.511      -0.167       0.086
Total_Widow          -0.2614      0.128     -2.046      0.057      -0.531       0.008
Female_Disabled       1.0744      0.092     11.692      0.000       0.881       1.268
Children_0_19         0.3333      0.127      2.619      0.018       0.065       0.602
Millennials           0.0613      0.181      0.338      0.739      -0.321       0.444
Gen_X                 0.3754      0.161      2.325      0.033       0.035       0.716
Baby_Boomers          0.4312      0.115      3.735      0.002       0.188       0.675
Silent_generation     0.2025      0.085      2.370      0.030       0.022       0.383
NonIrish             -0.1396      0.160     -0.870      0.396      -0.478       0.199
==============================================================================
Omnibus:                        0.547   Durbin-Watson:                   2.163
Prob(Omnibus):                  0.761   Jarque-Bera (JB):                0.452
Skew:                          -0.274   Prob(JB):                        0.798
Kurtosis:                       2.776   Cond. No.                     9.83e+16
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specifi
ed.
[2] The smallest eigenvalue is 4.42e-32. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
```

Here we fitted a linear model, with Male_Disabled as traget variable and the all the other required parameter and here our beta1 value i.e intercept value is 9.714e-17. If we compare the probability of t-test, with 95% confidence interval then Gen_X, Children_0_19 & Silent_generation are the significant variables for our target variable "Male_Disabled"

Our model should be:

$$Y = \beta_0 + X_1\beta_1 + X_2\beta_2 + \ldots\ldots + X_n\beta_n + \varepsilon$$

Examining the values of the model parameters, the model can therefore be fully described as:

Male_Disabled= 9.714e-17 + 0.2910 *MaleTotal -0.5061* FemaleTotal -0.0807 *IrishNotStated -0.0593* IrishYes -0.7024 *Total_Married + 0.0233* Total_Separated -0.0403 *Total_Divorced -0.2614* Total_Widow + 1.0744 *Female_Disabled + 0.3333* Children_0_19 + 0.0613 *Millennials + 0.3754* Gen_X + 0.4312 *Baby_Boomers + 0.2025* Silent_generation - 0.1396 * NonIrish + ε

We will now test the residuals to check our assumptions of linear model:
-> Residuals should have zero conditional mean.
-> Residuals should have constant variation.
-> Residuals should be normally distributed.

First we will calculate 'residuals' mean:

In [447…

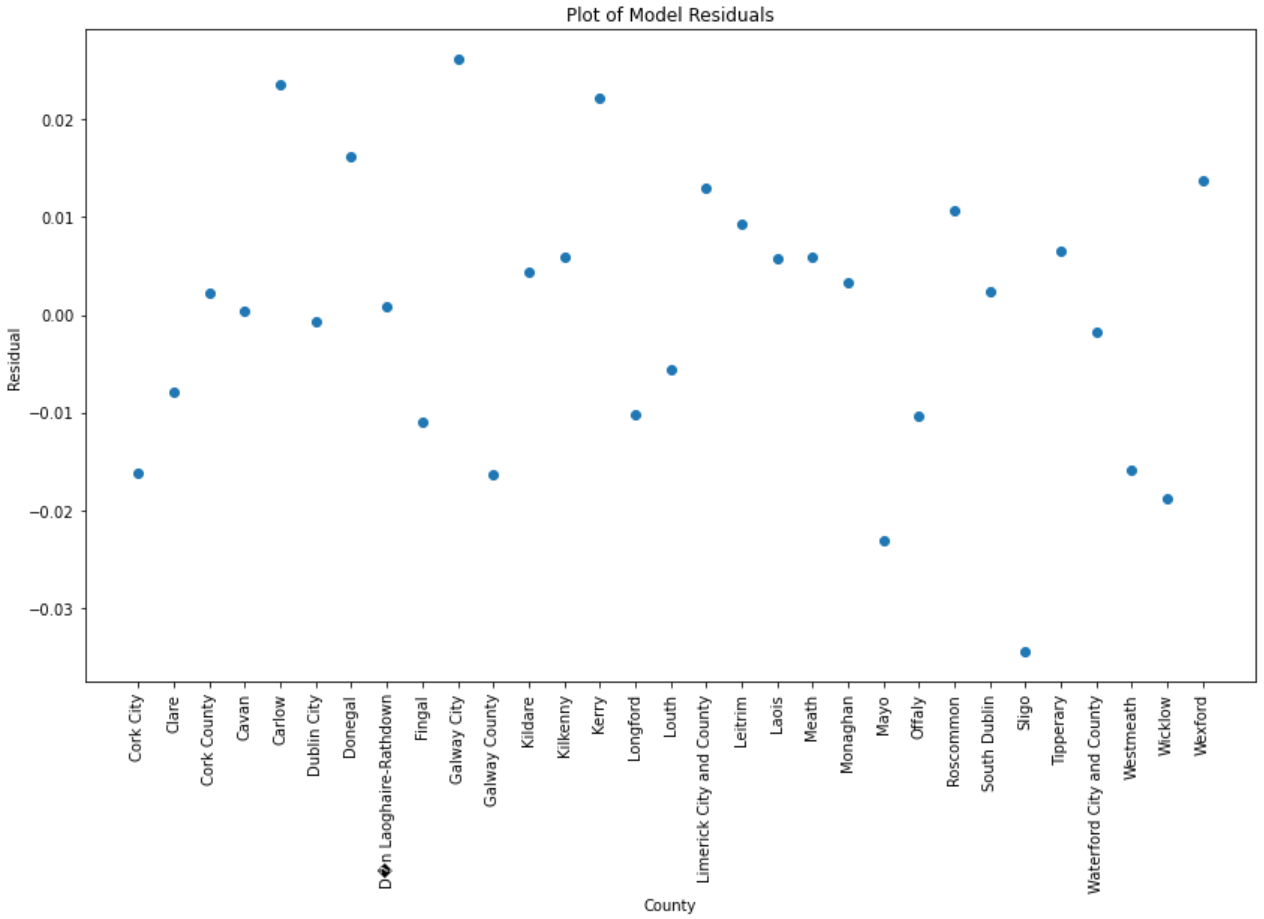
```
print("The mean of the residuals of the model is: ", res.mse_resid)
```

```
The mean of the residuals of the model is:  0.0003558042174532481
```

The residuals were then plotted against their index to assess the nature of their variation:

In [448…

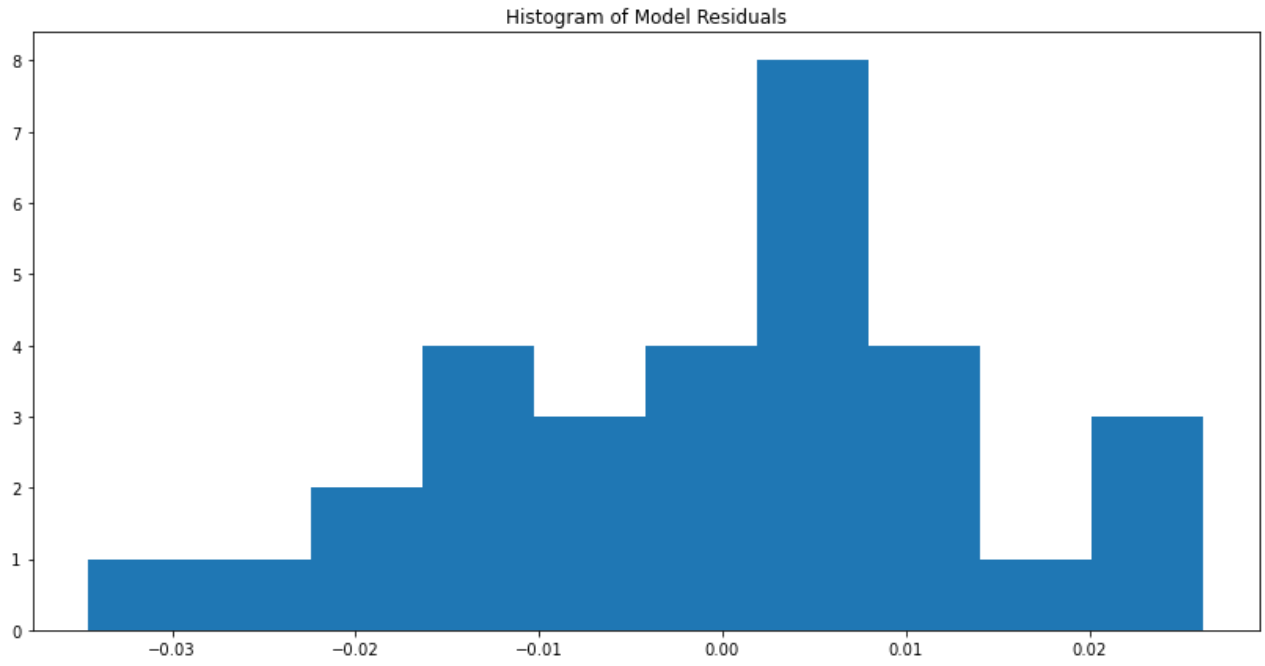
```
plt.figure(figsize=(14,8))
plt.plot(res.resid, 'o')
plt.title("Plot of Model Residuals")
plt.ylabel("Residual")
plt.xlabel("County")
plt.xticks(rotation=90)
plt.show()
```



Finally, a histogram of the residuals, and a QQ-plot were constructed to check their normality:

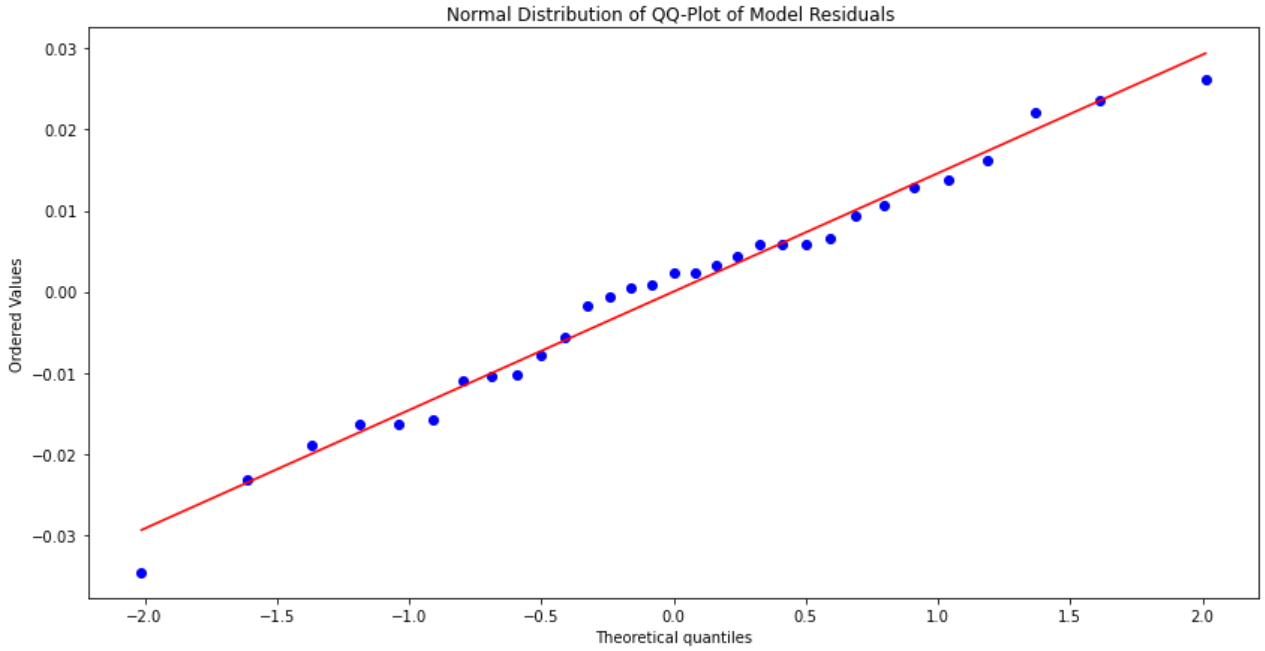
In [449…

```
plt.figure(figsize=(14,7))
plt.hist(res.resid)
plt.title("Histogram of Model Residuals")
plt.show()
```



In [450…

```
plt.figure(figsize=(14,7))
stats.probplot(res.resid, dist='norm',plot=plt)
plt.title("Normal Distribution of QQ-Plot of Model Residuals ")
plt.show()
```



Conclusion:

Investigation between the relationship of male disabled and all the other parameters Age, marital status and native language have some relationship. However, on further research we found that there exist a linear relationship between these parameters.

Our aim was to create model to calculate male disabled population based on the other parameters and we found an equation to do so:

$$Y= 9.714e\text{-}17 + 0.2910 * MaleTotal -0.5061 * FemaleTotal -0.0807 * IrishNotStated -0.0593 * IrishYes -0.7024 * Total\_Married + 0.0233 * Total\_Separated -0.0403 * Total\_Divorced -0.2614 * Total\_Widow + 1.0744 * Female\_Disabled + 0.3333 * Children\_0\_19 + 0.0613 * Millennials + 0.3754 * Gen\_X + 0.4312 * Baby\_Boomers + 0.2025 * Silent\_generation - 0.1396 * NonIrish + \varepsilon$$

We can do further research to remove some variables and add some significant variables based on some other theme parameters.

In conclusion, the objective of the expirement was met; investigation into a linear relationship between the the relationship of male disabled and all the other parameters Age, marital status and native language determined that this form of relationship is appropriate. The stage is set for further research into more complex models, aided by the release of more complete data on the subject.