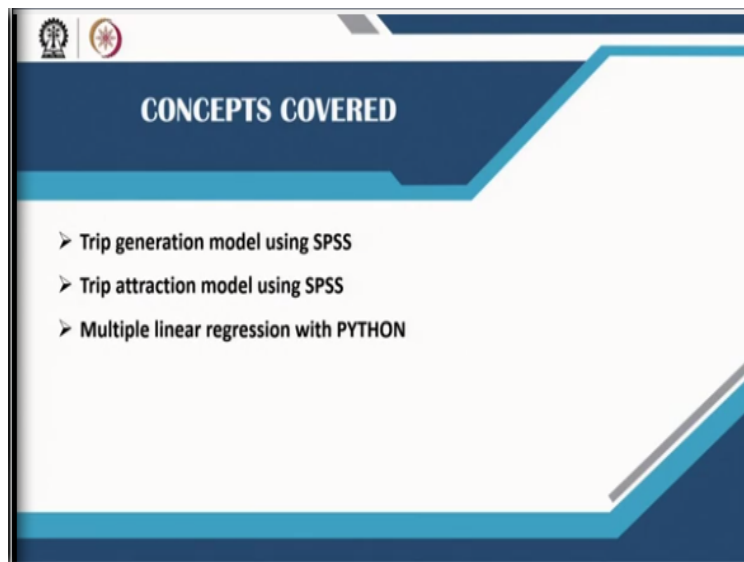


**Urban Land use and Transportation Planning**  
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**Lecture-34**  
**Trip Production and Attraction 2**


This lecture is a continuation of the trip production and attraction and covers development of trip generation model using SPSS; development of trip attraction using SPSS; and performing MLR in python.

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### Trip generation with SPSS

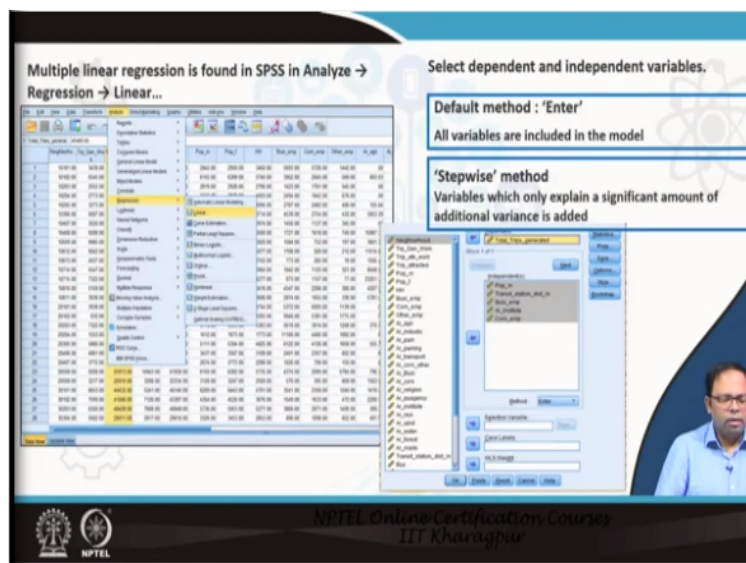
Potential dependent variables	No. of work trips generated	
	Total trips generated	
<b>Potential independent variables</b> 	Male population	Area under commercial activities
	Female population	Area under religious use
	No. of households	Area under public utilities
	No. of business employments	Area of vacant plots
	No. of Commercial employments	Area of water bodies
	No. of other type of employments	Area under forest
	Area of agricultural land	Area of roads
	Area of Industrial land	Built up area of business activities
	Area of parks	Built up area of Public utilities
	Area of vehicle parking	Built up area of Residences
	Area under transportation use	Built up area of Commercial activities
		Institutional Built up area
	Area under Business activities	Built up area of restaurants
	Area under religious use	Built up area of hotels
	Transit Station distance	Built up area of industries
	Built up area of Transportation activities	

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**Trip Generation with SPSS:**

In trip generation model, the intention is to predict is the total number of work trips generated or total trips generated from a particular zone. So, these are the potential dependent variables that are considered and the potential independent variables, as shown in the table are male population, female population, number of households, number of business employments, commercial employments, and other types of employments. Apart from these, areas under different land uses; built-up area of business activities, religious use, commercial activities; transit station distance are also considered. These are similar to the variables discussed during the use of regression model in trip generation.

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Multiple linear regression is found in SPSS in Analyze -> Regression -> Linear...

Select dependent and independent variables.

Default method : 'Enter'  
All variables are included in the model

'Stepwise' method  
Variables which only explain a significant amount of additional variance is added

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### **Trip generation demonstration in SPSS:**

After doing the data entry in SPSS, the following steps are to be performed in order to develop a regression model of trip generation:

*Menu bar → Analyze → Regression → Linear ... →*

*Select dependent and independent variables → Specify method →*

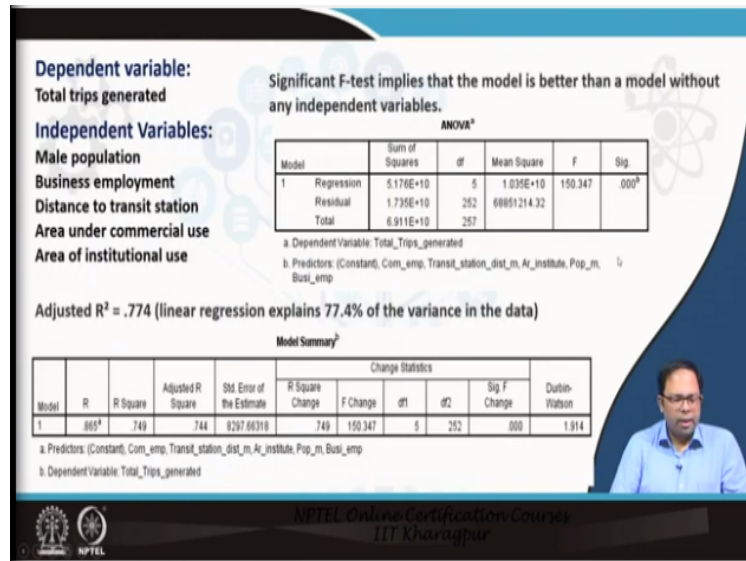
*Select statistics to be estimated → (Optional) specify elements for X – axis and Y – axis for plot(s) → (Optional) specify elements to be saved separately →*

*(Optional)select options for stepwise removal → Click '**OK**'*

From the menu bar, **analyze** option is to be selected. From the dropdown menu, **regression** needs to be selected, and then **linear** needs to be selected. The invoking of the linear regression results in a dialogue box popping up, which has three sections; a section with all the variables created in the database, a section of **dependent variable**, and another for **independent variables**. From the section with all the variable names mentioned, appropriate variable(s) are to be dragged and dropped in either of the other two sections i.e. dependent and independent sections. After that the method to be followed for including variables in the model needs to be specified from the dropdown menu adjacent to **method**. The default method is '**Enter**', which allows all the selected independent variables in the model together. Another method is '**Step-wise**', which includes the independent variables that explain a significant amount of variance in dependent variable. Other available methods are; step-wise, forward, backward, etc.

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### Model interpretation of trip generation:

In this demonstration, total trips generated was taken as the dependent variable. The independent variables chosen were; male population, business employment, distance to transit station, area under commercial use, and area of institutional use. Male population, rather the working age groups of male population have impact on trip generation. But as per the data in the demonstration, male population was found to be more appropriate. Total number of business employment actually determines the number of work trips that would be generated. As many people move from office to retail area for shopping purposes, area under commercial use and area under institutional use also plays a role in trip generation. The distance to transit station also plays a role in trip generation.

In the ANOVA table, the statistically significant value of F-statistic shows that the model is and it significantly better than the model without any independent variables. The model summary table shows that the adjusted R square value is 0.744, which implies that this regression model explains around 77.4% of the variance in the data. The Durbin Watson statistic which is slightly less than 2 indicates the presence of a slightly positive auto-correlation, but it is negligible.


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**Coefficients<sup>a</sup>**

Model	Unstandardized Coefficients		Standardized Coefficients		Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t		Zero-order	Partial	Part	Tolerance	VIF
1										
(Constant)	5677.893	2727.922		2.081	.038					
Pop_m	4.336	.323	.568	13.409	.000	.647	.645	.422	.551	1.816
Ar_institute	.022	.009	.080	2.354	.019	.334	.147	.074	.854	1.171
Busi_emp	2.764	.181	.502	15.276	.000	.389	.693	.480	.915	1.093
Ar_com	.153	.023	.257	6.608	.000	.604	.384	.208	.652	1.533
Transit_station_dist_m	-11.085	4.536	-.077	-2.444	.015	-.073	-.152	-.077	.983	1.017

a. Dependent Variable: Total\_Trips\_generated

- T test is used to check the significance of individual regression coefficients in the multiple linear regression model.
- Constant represents the no. of trips generated in case all the variables are zero.
- 1-unit increase in male population, we will see 5.36 additional trips generated.
- Similarly, increase in Institutional area, commercial area and no. of business employment leads to the increase in no. of trips generated.
- Increase in transit station distance from residence reduces the no. of trips generated.



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The output also has the table of coefficients that has the coefficients (beta values), the t-test statistic, and the p-value of each independent variable and the constant as well. All the variables were found to be statistically significant and positively related to trips generated, except for ‘distance from transit’ which has a negative beta value. This implies that an increase in the distance from transit results in the decrease in the number of trips. The constant represents the number of trips generated in case all the variables is 0. Unlike the F-test testing the overall significance of the model, t-test tests the significance of individual coefficients. If the absolute value of t-statistic is  $1.97 \leq$ , the p-value is  $\geq 0.05$ .

A one unit change in the male population results in the increase in 4.33 increase in the number of trips. Similarly, one-unit increase in the area under institutional use, business employment, and area under commercial use results in the increase in 0.022, 2.76, 0.153 trips respectively. One-unit increase in the distance from transit station results in the reduction of around 11 trips. All of these results match with the theoretical underpinnings of the model and implies that the signs are what they should be. Hence it can be said that the model is valid.

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Trip attraction with SPSS		
Potential dependent variables	Total work trips attracted Total trips attracted	
Potential independent variables	Male population	Area under commercial activities
	Female population	Area under religious use
	No. of households	Area under public utilities
	No. of business employments	Area of vacant plots
	No. of Commercial employments	Area of water bodies
	No. of other type of employments	Area under forest
	Area of agricultural land	Area of roads
	Area of industrial land	Built up area of business activities
	Area of parks	Built up area of Public utilities
	Area of vehicle parking	Built up area of Residences
	Area under transportation use	Built up area of Commercial activities
	Area under Business activities	Institutional Built up area
	Area under commercial activities	Built up area of restaurants
	Area under religious use	Built up area of hotels
	Area under public utilities	Built up area of industries
	Distance from transit station	Built up area of Transportation activities

### **Trip attraction with SPSS:**

In the trip attraction model, the potential dependent variables considered are total work trips that are attracted and total trips that are attracted. The potential independent variables are same as discussed in trip generation, which are; number of households; male population; female population; number of households; number of business employments; commercial employments; other types of employments; areas under different land uses; built-up area of business activities, religious use, commercial activities, roads; transit station distance; etc.

For some aspects like business or commercial, number of employment might be a better indicator as compared to built-up area or area under landuse. The subtleties of the appropriateness of the different kinds of the same variable needs to be understood or a combination of these can also be taken.

**(Refer Slide Time: 09:29)**

**Dependent variable:**  
Total trips attracted

**Independent Variables:**  
Business employment  
Other forms of employment  
Area under institutional use.  
Floor area of commercial activities.  
Floor area of residential use.  
Area of vacant plots  
Male population

Significant F-test implies that (Institively) the model is better than a model without any independent variables.

ANOVA<sup>a</sup>

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.772E+10	6	1.129E+10	260.317	.000 <sup>b</sup>
	Residual	1.086E+10	251	43350239.28		
	Total	7.860E+10	257			


a. Dependent Variable: Trip\_attracted  
b. Predictors: (Constant), Ar\_splot, Fl\_Ar\_com, Other\_emp, Ar\_institute, Pop\_m, Busi\_emp

Adjusted R-square of 0.858 is achieved by the model with the given variables.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.926 <sup>a</sup>	.862	.858	6594.69736	.862	260.317	6	251	.000

a. Predictors: (Constant), Ar\_splot, Fl\_Ar\_com, Other\_emp, Ar\_institute, Pop\_m, Busi\_emp



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### Model interpretation of trip attraction:

In the demonstration model for trip attraction, total trips attracted has been taken as the dependent variable. The independent variables used were business employment, other forms of employment, area under institutional use, floor area of commercial activities, floor area of residential use, area of vacant plots, and male population. It should be noted that business employment has been considered against business land use. Area of vacant plots represent the empty space in the respective zone.

In the ANOVA table, the statistically significant value of F-statistic shows that the model is and it significantly better than the model without any independent variables. The model summary table shows that the adjusted R square value is 0.858, which implies that this regression model explains around 85.8% of the variance in the data. Although many people have different opinions, but most people consider any value of adjusted R-square above 0.75 as a good fit for a dataset generated from natural environment.

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Model	Unstandardized Coefficients			Standardized Coefficients		Collinearity Statistics				
	B	Std. Error		Beta	t	Sig.	Zero-order	Partial	Tolerance	VIF
Constant	-844.090	1091.037			-.889	.375				
Male population	3.320	.780	.408	4.308	.000	.004	.268	.191	.062	16.258
Business employment	2.265	.142	.386	13.960	.000	.445	.662	.323	.703	1.423
Floor area of commercial use	.158	.010	.411	16.674	.000	.579	.724	.384	.873	1.146
Area of institutional use	.024	.008	.084	3.218	.001	.324	.199	.075	.760	1.285
Other employments	1.449	.361	.193	4.009	.000	.739	.246	.093	.820	1.220
Floor area of residences	.022	.008	-.271	-2.837	.005	.658	.177	.066	.058	16.939
Area of vacant plots	-.007	.002	-.079	-3.136	.002	.189	-.195	-.073	.850	1.177

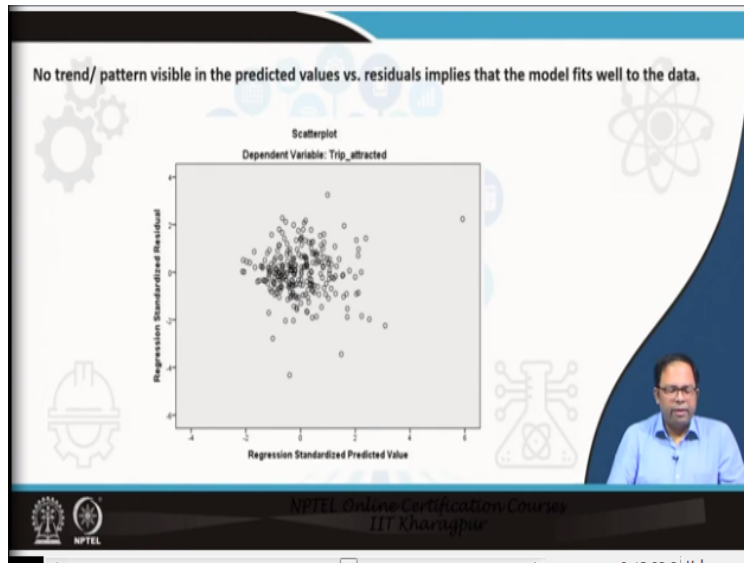
a. Dependent Variable: Trip\_attracted

- The intercept (constant) is statistically insignificant (not different from 0) implies that when all the independent variables are ZERO, there will be no trips attracted.
- VIF is a measure of multicollinearity among the independent variables. FLOOR AREA OF RESIDENCES has a high collinearity with male population (considering trip attraction).
- All the independent variables have positive regression coefficients as expected except for Ar\_vplot which is negative. This is justified since increase in vacant land indicates less chance for attracting people.

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The estimated coefficient of the constant is not statistically significant. The estimated value of the constant implies that when all the other variables are 0, no trips will be attracted. It is interpreted so as the estimated constant is less than zero but in reality number of trips cannot be a negative entity. VIF is a measure of collinearity among independent variables. The variable 'floor area of residences' is found to have high collinearity with male population in this trip attraction model. So, even though the significance value for this variable is 0.005, since it is highly multicollinear with male population, it should be ignored and removed from the model. All independent variables have positive regression coefficients except for 'Ar\_vplot' which is negative, all of which do have theoretical underpinnings. Increase in vacant plot implies no landuse and hence no trips attracted, ultimately reducing the total trips attracted to the respective zone.

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The plot of residuals against the dependent variable shows no trend as such. Such a plot having no trend or pattern implies that the model fits properly with the given data.

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SPSS demonstration of TRIP ATTRACTION:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
Neighborhood	Pop	Area	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	Distance	Price	
1	10102.00	3429.00	45495.00	14162.00	10142.00	2842.00	2903.00	3409.00	6003.00	5726.00	1442.00	0.00	1979.00														
2	10102.00	6546.00	11476.00	9314.00	6487.00	6165.00	6309.00	5748.00	3942.00	2646.00	689.00	683.03	1171.94														
3	10203.00	2942.00	19969.00	4817.00	27932.00	2919.00	2929.00	2796.00	1423.00	1761.00	548.00	0.00	1762.87														
4	10204.00	2713.00	20904.00	1547.00	22745.00	3737.00	3978.00	4023.00	2484.00	1442.00	676.00	0.00	3489.63														
5	10205.00	3273.00	20969.00	4268.00	22212.00	3649.00	3779.00	4034.00	2787.00	2442.00	408.00	105.64	6274.42														
6	10306.00	6997.00	46939.00	9779.00	70772.00	10589.00	9069.00	10774.00	4539.00	2714.00	432.00	5853.39	1824.00														
7	10407.00	3568.00	20979.00	2791.00	20758.00	3161.00	3279.00	2974.00	1438.00	1137.00	345.00	0.00	1548.84														
8	10408.00	6388.00	48373.00	1087.00	48372.00	7495.00	7967.00	6939.00	1721.00	1619.00	749.00	15967.34	2898.31														
9	10409.00	6988.00	60939.00	2621.00	52375.00	6133.00	6284.00	10293.00	1684.00	1752.00	197.00	3491.31	2229.76	44													
10	10410.00	1642.00	43987.00	3764.00	48925.00	7973.00	7341.00	10377.00	1798.00	169.00	212.00	11514.87	684.76	11													
11	10411.00	4997.00	20746.00	1721.00	21537.00	3299.00	3393.00	2742.00	773.00	382.00	18.00	1636.42	0.00														
12	10714.00	5547.00	37764.00	2973.00	38532.00	2688.00	2793.00	2884.00	1442.00	1129.00	321.00	8848.30	1311.76	2													
13	10715.00	7322.00	37163.00	2713.00	38389.00	5384.00	6188.00	4277.00	673.00	1107.00	77.00	2293.71	3611.63	3													
14	10716.00	6191.00	48412.00	1762.00	10988.00	1623.00	1712.00	1614.00	4647.00	2204.00	389.00	4281.62	1641.63	4													
15	10811.00	7938.00	43543.00	1547.00	48223.00	2934.00	2794.00	2608.00	2974.00	1610.00	336.00	1791.62	418.36	16													
16	20141.00	3638.00	37472.00	13391.00	36419.00	3424.00	3544.00	3744.00	1372.00	6899.00	1139.00	0.00	7364.16	17													
17	20142.00	632.00	20688.00	16196.00	34311.00	1168.00	1192.00	1263.00	8940.00	5391.00	1775.00	0.00	2099.72	18													
18	20203.00	7322.00	61299.00	17286.00	18197.00	6776.00	6996.00	5393.00	3619.00	2914.00	1248.00	376.27	8339.00	19													
19	20204.00	1613.00	26919.00	12581.00	27643.00	1613.00	1673.00	1119.00	4489.00	1802.00	0.00	1371.74	0.00	20													
20	20205.00	1689.00	47462.00	12645.00	12290.00	1111.00	1334.00	1426.00	6122.00	4138.00	1638.00	666.36	6362.21	21													
21	20406.00	4891.00	32891.00	4393.00	33726.00	3437.00	3947.00	1709.00	2491.00	2397.00	602.00	0.00	1644.94	22													
22	20407.00	3712.00	19474.00	2688.00	28393.00	2674.00	2773.00	2288.00	1028.00	799.00	160.00	0.00	3534.84	23													
23	20408.00	6388.00	69113.00	14843.00	61938.00	6169.00	6362.00	5736.00	4374.00	2999.00	1794.00	796.72	44919.00	24													
24	20409.00	5917.00	19114.00	3268.00	22334.00	3126.00	3247.00	2949.00	631.00	180.00	898.00	1463.17	15249.00	25													
25	30101.00	9653.00	44432.00	5241.00	46140.00	6299.00	5643.00	5791.00	3547.00	2316.00	1249.00	1479.91	39911.44	26													
26	30102.00	7398.00	47466.00	7129.00	43387.00	4334.00	4029.00	3676.00	1549.00	1633.00	472.00	2296.96	14098.00	27													
27	30103.00	4701.00	46479.00	7988.00	49743.00	4736.00	5063.00	5272.00	3693.00	3073.00	649.00	391.76	17108.00	28													

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### Trip attraction demonstration in SPSS:

The course of actions to develop a trip attraction model in SPSS is similar to that for trip generation, apart from the choice of dependent and independent variables. In this case, the dependent variable is 'trip attracted'. The different independent variables selected are same as discussed in the above section. One thing to note is that it is very unlikely that we will arrive at the best model in the first attempt. One might have to try numerous combinations of independent variables before a satisfactory model or the best model (given the dataset) is found.

Various statistics like correlation coefficients, R-square, etc. are used to judge a model and provide a basis for including or excluding variables from a model. For example, in the case of the model in demonstration, 'floor area of residences' cannot be kept in the model because of high correlation with male population. This is how a trip attraction model can be developed model using SPSS.

**(Video Ends: 14:43)**

**(Refer Slide Time: 14:44)**

**Multiple linear regression with Python**

Importing Packages

```
In [10]: import pandas as pd
         from sklearn.linear_model import LinearRegression
```

Importing data from CSV file and handling EMPTY CELLS.

```
In [11]: df=pd.read_csv(r'F:\NPTEL\Trip_generation_attraction\trip_gen_attract.csv')
         df.fillna(0,inplace=True)
```

Extracting Dependent and independent variables from the dataset for both GENERATION and ATTRACTION.

```
In [12]: X_gen=df.iloc[:,[5,8,17,21,30]]
         y_gen=df.iloc[:,4]
         X_attr=df.iloc[:,[5,8,10,21,23,30]]
         y_attr=df.iloc[:,4]
```

Pandas package needs to be imported.  
Linear Regression module needs to be imported.

File is read into a DATAFRAME.

Specific variables are chosen by COLUMN INDEX and stored in array.

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### **Multiple linear regression with Python:**

Instead of using statistical packages like SPSS, python, R, etc. can be used to estimate multiple linear regression (MLR). The use of python for MLR is covered in this section. Python is a high-level, interpreted, general-purpose programming language which is very popular due to its readability and packages available. It can be freely downloaded from [www.python.org](http://www.python.org) or it can be installed through anaconda, which is a free and open source distribution of python for scientific computing. The introduction to python and a guide to developing a logistic regression model using it has been covered already in a different module.

In python, functions or a group of functions are bundled in entities called '**packages**'. Packages are imported to before writing a program and then functions are invoked from the code as and when required. One such package is '**Pandas**', which has functions for data analysis and processing. Another package is '**scikit-learn**' (Sklearn) that has popular machine learning models.

Linear regression is also a model in this package. Following is the code for linear regression using python:

<b>Python code for trip generation and trip attraction model using SKLEARN.</b>	
<pre>import pandas as pd from sklearn.linear_model import LinearRegression  df=pd.read_csv(r'file.csv') df.fillna(0,inplace=True) X_gen=df.iloc[:,[5,8,17,21,39]] Y_gen=df.iloc[:,2] X_attr=df.iloc[:,[5,8,10,21,23,30]] Y_attr=df.iloc[:,4]  gen=LinearRegression().fit(X_gen,Y_gen) b_gen=gen.coef_ b0_gen=gen.intercept_  attr=LinearRegression().fit(X_attr,Y_attr) b_attr=attr.coef_ b0_attr=attr.intercept_  print("TRIP GENERATION:\n","Intercept:",b0_gen) varg=X_gen.columns.tolist() for i in range(len(varg)):     print(varg[i], b_gen[i]) rg=gen.score(X_gen,Y_gen) print("R-squared=",rg,"\n")  print("TRIP ATTRACTION:\n","Intercept:",b0_attr) vart=X_attr.columns.tolist() for j in range(len(vart)):     print(vart[j], b_attr[j]) ra=attr.score(X_attr,Y_attr) print("R-squared=",ra)</pre>	<ul style="list-style-type: none"> <li>• <i>Importing pandas and scikit-learn</i></li> <li>• <i>Reading file into dataframe through <b>pandas.read</b></i></li> <li>• <i>Replacing blank spaces with '0'.</i></li> <li>• <i>Segregating dependent variables and independent variables for generation and attraction models by COLUMN IDs from the whole dataset.</i></li> <li>• <i>Invoking Linear regression for generation and storing the coefficients and intercept in <b>b_gen</b> and <b>b0_gen</b>.</i></li> <li>• <i>Invoking Linear regression for attraction and storing the coefficients and intercept in <b>b_attr</b> and <b>b0_attr</b>.</i></li> <li>• <i>Printing the results....</i></li> </ul> <pre>TRIP GENERATION: Intercept: 5677.892541802117 Pop_m 4.3360560073892795 Busi_emp 2.764414694500004 Ar_com 0.15296219087781626 Ar_institute 0.02186515818145311 Transit_station_dist(m) -11.085048474785665 R-squared= 0.7508230505575431  TRIP ATTRACTION: Intercept: -1161.98676285689 Pop_m 5.39001289099032 Busi_emp 2.3779124879098026 Other_emp 1.1961895873545654 Ar_institute 0.0289567197453054 Ar_vplot -0.005666003204581861 Fl_Ar_com 0.15650023658034373 R-squared= 0.8615478536390693</pre>

In the shown code, both trip generation and trip attraction is modelled. At first, the packages needs to be included in the code, the data file needs to be read in comma separated values (**csv**) format. It is read through '**pandas.read**' and stored in a dataframe. From this dataframe, appropriate independent variables and dependent variables for either of the models are stored in arrays by their column IDs in the original dataset. 'Y\_gen' and 'Y\_attr' are arrays that store the dependent variables for trip generation and trip distribution respectively. 'X\_gen' and 'X\_attr' are two-dimensional arrays that store the independent variables for either of trip generation and trip attraction respectively.

**(Refer Slide Time: 16:52)**

Estimation of model using LINEAR REGRESSION function in SCIKIT LEARN

```
In [13]: gen=LinearRegression().fit(X_gen,Y_gen)
b_gen=gen.coef_
b0_gen=gen.intercept_

attr=LinearRegression().fit(X_attr,Y_attr)
b_attr=attr.coef_
b0_attr=attr.intercept_

print("TRIP GENERATION:\n","Intercept:",b0_gen)
varg=X_gen.columns.tolist()
for i in range(len(varg)):
    print(varg[i], b_gen[i])
rg=gen.score(X_gen,Y_gen)
print("R-squared=",rg,"\n")

print("TRIP ATTRACTION:\n","Intercept:",b0_attr)
vart=X_attr.columns.tolist()
for j in range(len(vart)):
    print(vart[j], b_attr[j])
ra=attr.score(X_attr,Y_attr)
print("R-squared=",ra)
```

**Fitting model to the data.**

**RESULTS**

TRIP GENERATION:  
Intercept: 5677.892541802117  
Pop\_m 4.3360560073892795  
Busi\_emp 2.764414694500004  
Ar\_com 0.15296219087781626  
Ar\_institute 0.02186515818145311  
Transit\_station\_dist(m) -11.085048474785665  
R-squared= 0.7508230505575431

TRIP ATTRACTION:  
Intercept: -1161.98676285689  
Pop\_m 5.39001289099032  
Busi\_emp 2.3779124879098026  
Other\_emp 1.1961895873545654  
Ar\_institute 0.0289567197453054  
Ar\_vplot -0.005666003204581861  
Fl\_Ar\_com 0.15659023658034373  
R-squared= 0.8615478536390693

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After these arrays are defined, the linear regression model is invoked and a MLR is fitted for trip generation using 'X\_gen' and 'Y\_gen', which are the independent and dependent variables respectively for trip generation. The estimated coefficients and the intercept is stored in 'b\_gen' and 'b0\_gen' respectively. R-squared value can be retrieved using the 'score' function of the estimated MLR model represented by 'gen'. Hence the trip generation model is estimated. A similar task is repeated for the trip attraction part and code is written to display the results at the end of operation.

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Variables

	SPSS	Scikit Learn (python)
<b>TRIP GENERATION</b>		
Intercept	5677.89	5677.89
Male Population	4.35	4.34
Business Employment	2.76	2.76
Area under commercial use	0.153	0.153
Area under institutions	0.022	0.22
Dist. From transit station	-11.085	-11.085
R-Squared	0.75	0.75
<b>TRIP ATTRACTION</b>		
Intercept	-944.1	-1161.99
Male population	3.32	5.39
Business employment	2.27	2.38
Other employments	1.45	1.196
Area under institutions	0.024	0.03
Area under vacant plots	-0.007	-0.0056
Commercial floor area	0.158	0.157
R-Squared	0.86	0.86

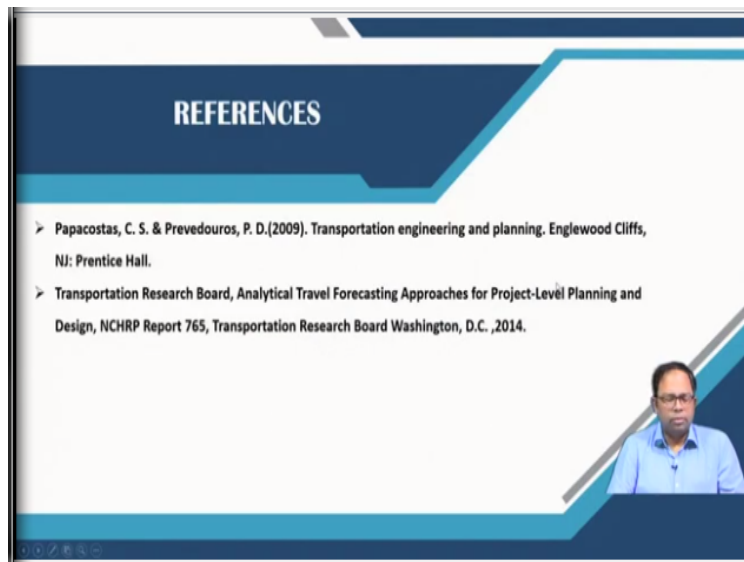
**SPSS and Python shows similar results.**

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On comparing the results obtained from SPSS and the results obtained from python using scikit-learn, it is found that apart from a few floating point changes, both the results are same. The

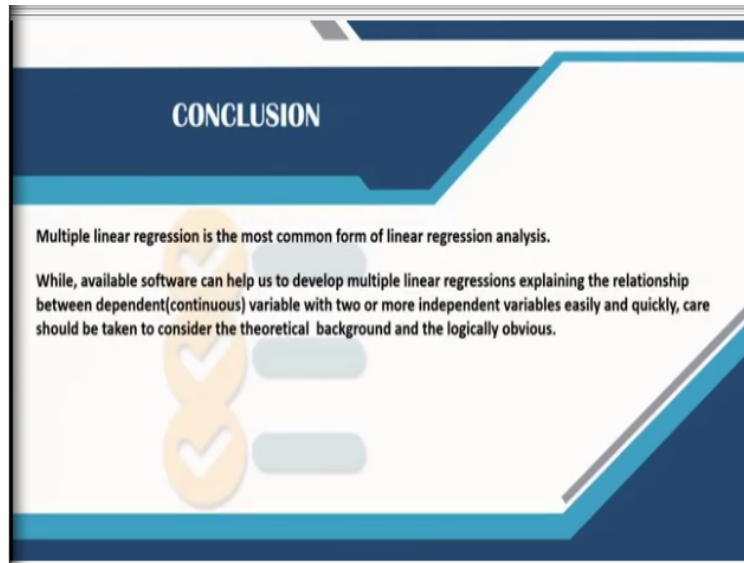
similarity was exhibited by the trip generation model. The trip attraction model shows some difference in the coefficients. The reason behind it maybe the existence of collinearity in the data. The R-square values of the models are same in both SPSS estimates and python generated estimates.

The model building process remains same in python as it is in SPSS. So it is very easy to write this kind of code in python. The only major difference is the interface of both the programs. Using python for MLR spares one from expending a lot of money on statistical software. **(Refer Slide Time: 20:09)**



And this is how we can do multiple linear regression. So, these are the references that can be looked up for further reading.

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In conclusion, it can be said that, multiple linear regression is the most common form of linear regression analysis. While, available software can help us to develop multiple linear regression explaining the relationship between dependent continuous variables and two or more independent variables easily and quickly, care should be taken to consider the theoretical background and the logically obvious. To estimate the models very fast, we should be very careful about the theoretical background i.e., our a priori knowledge regarding this kind of model is not violated and at the same time the explanatory variables should be logically obvious.