National College of Ireland

EXAMINATION OF DIFFERENT

STATISTICAL METHODOLOGIES

Submitted By

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Data Analytics – JAN/Batch B – 2020/2021

(1) Binary Logistic Regression With PCA

Logistic regression is a supervised classification algorithm which is used to predict the probability of dependant or target variable. When there is only two possible categories of dependent variable (Yes or No), then it is classified as Binomial logistic regression and more than two categories of dependent variables is known as Multinomial logistic regression. In this model principle component analysis is done prior to the logistic regression to increase the probability of prediction and to reduce the number of dependent variables.

DATA SET USED:

The various factors that affect the job opportunities that includes immigrants, diversity in workplace, outsourcing, automation, using foreign products, and increased exports have been extracted from the dataset for the analysis. After the removal of null values, resultant dataset consists of 108 records.

https://www.pewresearch.org/global/datasets/

Dependent Variable	Independent Variables
• Job opportunities	• Immigrants • Diversity • Outsourcing • Automation • Exports • Foreign Products • Women in workforce

OBJECTIVE OF THE ANALYSIS:

The objective is to carry out the Principal component analysis and then logistic regression to predict the dependent variable (Job opportunities) using independent variables that influences the most for US. By performing PCA, the number of factors can be reduced to smaller number and thus performing logistic regression to categorize the job opportunities.

PRINCIPLE COMPONENT ANALYSIS:

ASSUMPTIONS FOR PRINCIPAL COMPONENT ANALYSIS:

Step 1:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.755
Bartlett's Test of Sphericity	Approx. Chi-Square	303.581
	df	21
	Sig.	.000

The primary step to verify the data is suitable for performing factor analysis is to check the KMO value. In this data set Value is 0.755 which is greater than 0.6. Bartlett's test is also significant (.000). This shows that factor analysis is suitable for this data.

Step 2:

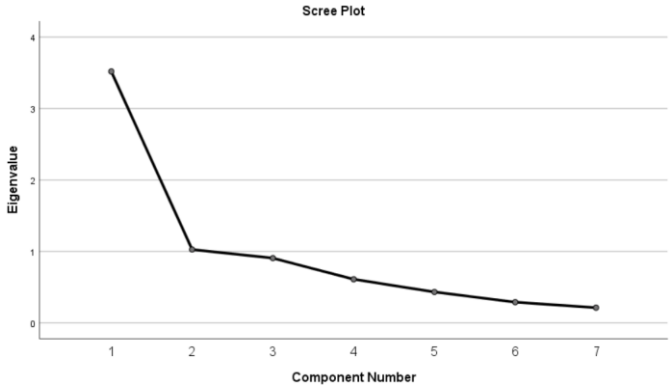
Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.518	50.260	50.260	3.518	50.260	50.260	2.407	34.383	34.383
2	1.027	14.674	64.935	1.027	14.674	64.935	2.139	30.552	64.935
3	.907	12.950	77.885						
4	.611	8.727	86.612						
5	.433	6.191	92.804						
6	.290	4.150	96.954						
7	.213	3.046	100.000						

Extraction Method: Principal Component Analysis.

By seeing at total variance explained table, the cumulative percentage of variance is 64.93 that is total variance by two components. The extraction sum of squares shows that dependent variables like immigrants and women in workforce are the most influential components among others.

Step 3:



By looking at the shape of the scree plot first and second components have explained much variance when compared to the other five components.

Step 4:

Rotated Component Matrix[a]

	Component	
	1	2
Foreign_made_products	.879	
Increased_outsourcing	.780	
Automation	.704	
Immigrants	.559	.496
Women_in_workforce		.908
Diversity		.877
Increased_exports	.366	.417

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Component matrix is rotated by principal axis using Varimax rotation method. From the table foreign made products, outsourcing, automation comes under component one and the remaining comes under component two. Immigrants and increased exports are cross loaded in both the components. By performing principle component analysis, only two components have been derived for the purpose of meaningful interpretation. The two regression factors obtained in principle component analysis are taken as independent variables for performing binary logistic regression.

BINARY LOGISTIC REGRESSION:

SAMPLE SIZE:

The sample size is calculated by the formula N > 50+8M where 'M' Is the number of independent variables in the dataset. In this dataset the sample size is 108, which satisfies the assumption.

ANALYSIS OF THE BINARY LOGISTIC REGRESSION MODEL:

BLOCK 0:

Block 0: Beginning Block

Classification Table[a,b]

Observed			Predicted: job opportunities: good jobs are available	Predicted: job opportunities: good jobs are difficult	Percentage Correct
Step 0	job opportunities	good jobs are available	0	48	.0
		good jobs are difficult	0	60	100.0
	Overall Percentage				55.6

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	.223	.194	1.328	1	.249	1.250

Block 0 predicts the results of the analysis without using any of the independent variables. From the classification table above, the model predicts with accuracy of 55%. B value is useful for calculating the probability of the cases that falls under which category. In this model, the positive B value indicates that there will be increase in the probability of dependent variable with increase in independent variable. The Exp(B) denoted odds ratios for each independent variable which is 1.25.

BLOCK 1:

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	8.138	2	.017
	Block	8.138	2	.017
	Model	8.138	2	.017

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	140.246[a]	.073	.097

a. Estimation terminated at iteration number 3 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	6.732	6	.346

In block 1, predictor variables are tested. The Omnibus tests of model coefficients signifies the performance of the model. Since it is less than 0.05, it is highly significant. In model summary table, Cox's and Snell R square and Nagelkerke R square indicates the range of variance by the model in dependent variables. In this model, it suggests the variance ranging from 7% to 9% of total. In Hosmer and Lemeshow. test, Chi-square and significance values are taken into account to test the model fitness in which significance value should be greater than 0.5. In this test Chi-square value of 6.73 and significance value of 0.34 indicates that, it supports the model.

VARIABLES IN THE EQUATION:

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Step 1[a]	REGR factor score 1 for analysis 1	.520	.204	6.484	1	.011	1.682	1.127	2.510
	REGR factor score 2 for analysis 1	.243	.208	1.360	1	.243	1.275	.848	1.917
	Constant	.242	.202	1.444	1	.229	1.274		

a. Variable(s) entered on step 1: REGR factor score 1 for analysis 1, REGR factor score 2 for analysis 1.

This table tells the importance of each independent variables. The B value indicates the change in dependent variable with respect to independent variable. Regressor factor 1 is statistically significant in predicting the job opportunities by having significance value less than .05 and the other variable is not significantly contributing. The Exp(B) column values are the odds ratios that means odds of having presence in any category when independent variable is increased by one unit. In our model, the odds of people to have good job opportunities is 1.68 times greater. The last two columns represents 95% confidence intervals.

CLASSIFICATION TABLE:

Classification Table[a]

Observed			Predicted: job opportunities: good jobs are available	Predicted: job opportunities: good jobs are difficult	Percentage Correct
Step 1	job opportunities	good jobs are available	27	21	56.3
		good jobs are difficult	16	44	73.3
	Overall Percentage				65.7

a. The cut value is .500

This table tells how model predicted the desired categories that job opportunities are available or difficult. As a conclusion out of all, people who feel good jobs are available are 27 and people who feel good jobs are difficult to get are 44. The other two corresponding values are wrong predictions by the model. The model correctly predicted 65.7 percent when compared to 55.6 percent in Block 0. The sensitivity (True positive rate) of this model is 73.3 percent and the Specificity (True negative rate) is 56.3 percent.

CONCLUSION:

The availability of job opportunities is predicted using binomial logistic regression performed in SPSS software. The variance of the model is explained with Cox and Snell R square and Nagelkarke R squares are 7 and 9 percentage respectively. B coefficients and exp(B) are within the acceptable range. Hosmer and Lemeshow values are also significant and within the acceptable range. The model predicts the job opportunities for good jobs with 65.7% accuracy.

(2) ANOVA

Analysis of variance is performed to examine the differences between the mean values of dependent variables. It is the total sum of squares of squares between and within the groups. In this model one way analysis is performed.

DATA SET USED:

The dataset contains the information of Intellectual property rights and its licensing. Trademarks that are owned by different companies in Europe data was taken along with number of employees as size. The dependent variable (continuous) is number of trademarks and independent variable is categorized by number of employees. Company having employees ranging from 10 to 49 are categorised as 1, employees ranging from 50 to 249 as 2 and employees ranging from 250 and above as 3. A dummy variable has been created next to the independent variable with renamed categorical values.

https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis10_ipr&lang=en

OBJECTIVE OF THE ANALYSIS:

Is there any significant difference associated in the number of trademarks owned with respect to number of employees in the company.

ASSUMPTIONS:

1:

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Trademark	Based on Mean	10.198	2	69	.000
	Based on Median	3.705	2	69	.030
	Based on Median and with adjusted df	3.705	2	32.264	.036
	Based on trimmed mean	6.563	2	69	.002

Robust Tests of Equality of Means

Trademark

	Statistic[a]	df1	df2	Sig.
Welch	4.018	2	35.205	.027
Brown-Forsythe	3.922	2	32.153	.030

a. Asymptotically F distributed.

As the significance value is not greater than 0.05, Levene's test of homogeneity assumption is not satisfied. As a result of that Robust tests table is taken into consideration where it shows the value .024 which is satistically significant.

2:

ANOVA

Trademark

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33597758.58	2	16798879.29	3.922	.024
Within Groups	295510508.9	69	4282760.999		
Total	329108267.5	71			

From Anova table, the significance value is .024 which is less than .05. This indicates that there is significant difference among the number of employees in a company and hence null hypothesis was rejected.

3:

Multiple Comparisons

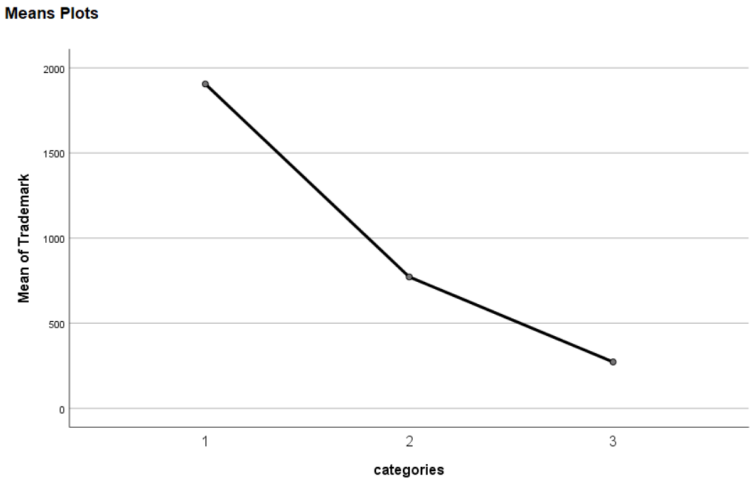
Dependent Variable: Trademark

	(I) categories	(J) categories	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD	1	2	1133.042	597.408	.147	-297.94	2564.02
		3	1632.833*	597.408	.021	201.85	3063.81
	2	1	-1133.042	597.408	.147	-2564.02	297.94
		3	499.792	597.408	.682	-931.19	1930.77
	3	1	-1632.833*	597.408	.021	-3063.81	-201.85
		2	-499.792	597.408	.682	-1930.77	931.19
Games-Howell	1	2	1133.042	723.750	.276	-648.81	2914.90
		3	1632.833	676.318	.059	-55.27	3320.94
	2	1	-1133.042	723.750	.276	-2914.90	648.81
		3	499.792	299.116	.233	-238.05	1237.63
	3	1	-1632.833	676.318	.059	-3320.94	55.27
		2	-499.792	299.116	.233	-1237.63	238.05

*. The mean difference is significant at the 0.05 level.

In the multiple comparisons table, the values that are less than .05 are significantly different. The values that are significant is also indicated by the asterisks symbol. From the above table, only group 3 and group 1 are significant. That means companies having employees range between 10 to 49 and 250 above have the significant number of trademarks.

4:



Means plot gives the mean scores for various categories. The number of employees ranging from 10 to 49 as category 1 have the highest number of trademarks compared with 250 and above employees with lowest.

5: EFFECT SIZE CALCULATION:

The effect size is calculated manually by dividing sum of squares between groups with total.

$$\text{Eta Sq.} = \frac{\text{Sum of squares between groups}}{\text{Total sum of squares}} = 0.10$$

In Cohen's terms, it is considered as medium effect (0.6 is considered as medium effect).

CONCLUSION:

One-way analysis of variance was conducted to find out the influence of number of employees in a company on the number of trademarks owned by company. Employees were divided into three categories (category 1 - 10 to 49 employees; category 2 – 50 to 249 employees: category 3 consists 250 and above employees). Category 1 and 3 are statistically significant. The effect size is 0.10. Category 1 (M=1905, SD=3271) and category 3 (M=272, SD=107) are statistically different when compared with category 2.

KRUSKAL WALLIS TEST:

As homogeneity of variances assumption is not satisfied, Kruskal test is performed to find the variance between the different groups. Assumptions for Kruskal test are same as anova above. It is divided into different ranks with highest at the top corresponding to the scores of continuous variable. The asymptotic significance is .002 which is less than .05 indicating that difference is present across the three categories of employees.

Kruskal-Wallis Test

Ranks

	categories	N	Mean Rank
Trademark	1	24	46.46
	2	24	37.75
	3	24	25.29
	Total	72	

Test Statistics[a,b]

	Trademark
Kruskal-Wallis H	12.404
df	2
Asymp. Sig.	.002

a. Kruskal Wallis Test

b. Grouping Variable: categories

CONCLUSION:

Kruskal test shows that there is significant difference among the different categories of employees and p=.002.

(3) STATISTICS FUNDAMENTALS

(i) INDEPENDENT SAMPLES T-TEST:

By performing independent sample t test, significant difference that is present in the mean scores of two groups can be found out. In our model, test is performed to compare the mean of student GPA which is a continuous variable with categorical variable gender.

OBJECTIVE OF THE ANALYSIS:

To find if there is any significant difference in the mean of current GPA scores in both the genders.

DATASET USED:

The dataset available on Moodle consists of fifty student data with eighteen variables. Current GPA score which is continuous is taken as dependent variable and gender which is categorical variable is taken as independent variable.

ASSUMPTIONS:

Group Statistics

	gender of student	N	Mean	Std. Deviation	Std. Error Mean
student's current gpa	males	26	3.023	.3983	.0781
	females	24	3.333	.3171	.0647

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
student's current gpa	Equal variances assumed	.370	.546	-3.030	48	.004	-.3103	.1024	-.5161	-.1044
	Equal variances not assumed			-3.058	47.023	.004	-.3103	.1015	-.5143	-.1062

As the significance value for Levene's test is greater than .05, Equal variances assumed column was taken into consideration. Therefore, data does not violate assumption. Then coming to 2-tailed significance value, it is 0.004 which is less than ideal value 0.05 hence proves there is a significant difference between in current GPA of both the gender students. Hence significance value is less than .05 between mean of current GPA, null hypothesis is rejected.

CALCULATING EFFECT SIZE:

It indicates the magnitude of differences between the groups by and taking events into consideration that are occurred not only by chance. One of such measure is calculating Eta squared which gives variance present in dependent variable explained by independent variable. The below formula is used for calculating the Eta squared where N1 and N2 are the number of samples in the group.

$$\text{Eta squared} = \frac{t^2}{t^2 + (N1 + N2 - 2)}$$

$$\text{Eta sq.} = \frac{(-3.03)^2}{(-3.03)^2 + (26+24-2)} = 0.16$$

The effect size is 0.16 which is greater than large effect value (0.14). Hence 16 percentage of variance in current GPA scores was explained by gender.

CONCLUSION:

This test was done to compare the current GPA scores for male and female students. There was significant difference in male (M=3.02, SD=0.39) and female students (M=3.33, SD=0.31) and

t(48)=-3.03.2-tailed significance value is 0.004 (<.05). The magnitude of differences in means was high (Eta. Sq=0.16).

(ii) CHI SQUARE INDEPENDENCE TEST:

Chi square test is performed on two categorical variables in the given population to determine the level of statistical significance associated between the categorical variables. It is a type of non-parametric test.

OBJECTIVE OF THE ANALYSIS:

To find the proportion of male watching movies is same the female proportion.

DATASET USED:

The same dataset which is used above is taken for analysing the association between males and females in watching movies. Two categorical variables are taken into consideration that includes gender (Male or Female) and tvmovies (Yes or No).

ASSUMPTIONS:

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	30.469[a]	1	.000		
Continuity Correction[b]	27.300	1	.000		
Likelihood Ratio	38.350	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	29.859	1	.000		
N of Valid Cases	50				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.64.

b. Computed only for a 2x2 table

The random samples were taken. The minimum cell frequency should be five or greater. In this case, it is zero cells indicated that assumption is not violated. The Asymptotic significance values are less than .05 which shows that number of males watching movies is significantly different from females. In this model null hypothesis is rejected as number of females and males watching movies is different. The default level of significance (alpha) used is .05.

OUTPUT ESTIMATION:

gender of student * television shows-movies Crosstabulation

			television shows-movies		
			no	yes	Total
gender of student	males	Count	26	0	26
		% within gender of student	100.0%	0.0%	100.0%
		% within television shows-movies	81.3%	0.0%	52.0%
	females	Count	6	18	24
		% within gender of student	25.0%	75.0%	100.0%
		% within television shows-movies	18.8%	100.0%	48.0%
Total		Count	32	18	50
		% within gender of student	64.0%	36.0%	100.0%
		% within television shows-movies	100.0%	100.0%	100.0%

75% of females watch movies whereas no male students watch movies. Over all 36% of population watch movies. As 2-tailed significance value is less than .05, hence null hypothesis is rejected.

EFFECT SIZE:

Symmetric Measures

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Nominal by Nominal	Phi	.781			.000
	Cramer's V	.781			.000
Interval by Interval	Pearson's R	.781	.075	8.653	.000[c]
Ordinal by Ordinal	Spearman Correlation	.781	.075	8.653	.000[c]
N of Valid Cases		50			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

For 2 by 2 tables, the effect size is calculated by using Phi coefficient that ranges from 0 to 1. In this case Phi coefficient is 0.781 indicating strong association between variables.

CONCLUSION:

The Chi square test for independence indicates that there is a significant association between gender and movies. x^2 (1,n=50)=27.30 and phi=.781.