**37252 Regression and Linear Models**

**Lab 8: Analysis of Categorical RVs**

This lab is marked out of 20.

Please save your file in PDF format with name

**37252\_Lab8\_Surname\_FirstName**

**Due: 12 noon Wednesday 8 May 2024**

In this week’s lab we investigate field goal attempts in the NFL. The data are available in **37252\_Lab8\_ data.csv** which can be downloaded from Canvas.

The variables we consider are summarised in the table below.

|  |  |  |
| --- | --- | --- |
| **Name** | **Role** | **Description** |
| $$good$$ | response | successful field goal attempt: 1 (yes), 0 (no) |
| $$qtr$$ | predictor | game time quarter (1, 2, 3, 4) |
| $$distance$$ | predictor | kicking distance |

**Link between** $good$ **and** $qtr$

We being by looking at the relationship between successful field goal attempts and game time quarter via a cross-tabulation.

> library('gmodels')

> NFLdat <- read.csv("~/2024\_37252/Labs/Lab8/37252\_Lab8\_data.csv")

> CrossTable(NFLdat$qtr, NFLdat$good, expected = T, chisq = T)

R output is displayed below.

Cell Contents

 |-------------------------|

 | N |

 | Expected N |

 | Chi-square contribution |

 | N / Row Total |

 | N / Col Total |

 | N / Table Total |

 |-------------------------|

 Total Observations in Table: 1026

 | NFLdat$good

 NFLdat$qtr | 0 | 1 | Row Total |

 -------------|-----------|-----------|-----------|

1 | 22 | 192 | 214 |

 | 28.784 | 185.216 | |

 | 1.599 | 0.248 | |

 | 0.103 | 0.897 | 0.209 |

 | 0.159 | 0.216 | |

 | 0.021 | 0.187 | |

 ------------|-----------|-----------|-----------|

2 | 59 | 316 | 375 |

 | 50.439 | 324.561 | |

 | 1.453 | 0.226 | |

 | 0.157 | 0.843 | 0.365 |

 | 0.428 | 0.356 | |

 | 0.058 | 0.308 | |

 ------------|-----------|-----------|-----------|

3 | 28 | 154 | 182 |

 | 24.480 | 157.520 | |

 | 0.506 | 0.079 | |

 | 0.154 | 0.846 | 0.177 |

 | 0.203 | 0.173 | |

 | 0.027 | 0.150 | |

 ------------|-----------|-----------|-----------|

4 | 29 | 226 | 255 |

 | 34.298 | 220.702 | |

 | 0.818 | 0.127 | |

 | 0.114 | 0.886 | 0.249 |

 | 0.210 | 0.255 | |

 | 0.028 | 0.220 | |

 ------------|-----------|-----------|-----------|

 Column Total| 138 | 888 | 1026 |

 | 0.135 | 0.865 | |

 ------------|-----------|-----------|-----------|

 Statistics for All Table Factors

Pearson's Chi-squared test

------------------------------------------------------------

Chi^2 = 5.056845 d.f. = 3 p = 0.1676817

1. Based on the test output, what do you conclude in relation to the research question *“is field goal success linked to game time quarter”*?Write down the null and alternative hypotheses **[1 mark]**, the test statistic and p-value **[1 mark]**, the result of the test **[1 mark]** and your conclusion using a minimum of mathematical language **[1 mark]**.

**Hypotheses**

H0: $good$ and $qtr$ are independent (not associated with each other)

HA: $good$ and $qtr$ are dependent (associated with each other) **[1 mark]**

**Test statistic and p-value**

Test stat $χ\_{\*}^{2}=5.057$

P-value: $p=0.168$ **[1 mark]**

**Test result**

Since $p>0.05$ we retain the null hypothesis **[1 mark]**.

**Conclusion**

Field goal success and game time quarter are not strongly associated **[1 mark]**.

1. Using the count data (not the row probabilities), calculate the odds of successful field goal attempts ($good=1$) in the first quarter of game time ($qtr=1$) **[1 mark]**.

$$odds\left(qtr=1\right)=\frac{Prob\left(qtr=1\right)}{Prob\left(qtr=1\right)}=\frac{^{192}/\_{214}}{^{22}/\_{214}}=\frac{192}{22}$$

$$=8.72727$$

**[1 mark]**

1. Using the count data (not the row probabilities), calculate the odds of successful field goal attempts ($good=1$) in the fourth quarter of game time ($qtr=4$) **[1 mark]**.

$$odds\left(qtr=4\right)=\frac{Prob\left(qtr=4\right)}{Prob\left(qtr=4\right)}=\frac{^{226}/\_{255}}{^{29}/\_{255}}=\frac{226}{29}$$

$$=7.7931$$

**[1 mark]**

1. Calculate the odds ratio of field goal success for first quarter of game time versus last quarter of game time (fourth quarter as reference) **[1 mark]**. Describe this ratio using a minimum of mathematical language **[1 mark]**.

$$oddsRatio\left(qtr=1 v. qtr=4\right)=\frac{odds\left(qtr=1\right)}{odds\left(qtr=4\right)}=\frac{^{192}/\_{22}}{^{226}/\_{29}}$$

$$=1.11987$$

**[1 mark]**

The odds of field goal success in first quarter is about 1.12 times the odds of field goal success in last quarter **[1 mark]**.

**Link between** $good$ **and** $distance$

We now want to explore whether there is any association between field goal success ($good=1$) and kicking distance ($distance$). As $distance$ is continuous we will need to recode into quantiles (we will use quartiles for this example). Then we create a cross-tabulation between $good$ and $distanceBin$.

> NFLdat$distanceBin <- CutQ(NFLdat$distance)

> CrossTable(NFLdat$distanceBin, NFLdat$good, expected = T, chisq = T)

Total Observations in Table: 1026

 | NFLdat$good

NFLdat$distanceBin| 0 | 1 | Row Total |

 -----------------|-----------|-----------|-----------|

 Q1 | 5 | 258 | 263 |

 | 35.374 | 227.626 | |

 | 26.081 | 4.053 | |

 | 0.019 | 0.981 | 0.256 |

 | 0.036 | 0.291 | |

 | 0.005 | 0.251 | |

 -----------------|-----------|-----------|-----------|

 Q2 | 19 | 254 | 273 |

 | 36.719 | 236.281 | |

 | 8.551 | 1.329 | |

 | 0.070 | 0.930 | 0.266 |

 | 0.138 | 0.286 | |

 | 0.019 | 0.248 | |

 -----------------|-----------|-----------|-----------|

 Q3 | 29 | 206 | 235 |

 | 31.608 | 203.392 | |

 | 0.215 | 0.033 | |

 | 0.123 | 0.877 | 0.229 |

 | 0.210 | 0.232 | |

 | 0.028 | 0.201 | |

 ----------------|-----------|-----------|-----------|

 Q4 | 85 | 170 | 255 |

 | 34.298 | 220.702 | |

 | 74.950 | 11.648 | |

 | 0.333 | 0.667 | 0.249 |

 | 0.616 | 0.191 | |

 | 0.083 | 0.166 | |

 ----------------|-----------|-----------|-----------|

 Column Total | 138 | 888 | 1026 |

 | 0.135 | 0.865 | |

 ----------------|-----------|-----------|-----------|

 Statistics for All Table Factors

Pearson's Chi-squared test

------------------------------------------------------------

Chi^2 = 126.8604 d.f. = 3 p = 2.56808e-27

1. Based on the test output, what do you conclude in relation to the research question *“is field goal success linked to kicking distance quartile”*?Write down the null and alternative hypotheses **[1 mark]**, the test statistic and p-value **[1 mark]**, the result of the test **[1 mark]** and your conclusion using a minimum of mathematical language **[1 mark]**.

**Hypotheses**

H0: $good$ and $distanceBin$ are independent (not associated with each other)

HA: $good$ and $distanceBin$ are dependent (associated with each other) **[1 mark]**

**Test statistic and p-value**

Test stat $χ\_{\*}^{2}=126.86$

P-value: $p≈0.000$ **[1 mark]**

**Test result**

Since $p<0.05$ we reject the null hypothesis **[1 mark]**.

**Conclusion**

Field goal success and kicking distance quartile are strongly associated **[1 mark]**.

1. For each of the four kicking distance quartiles $distanceBin$, calculate the odds of successful field goal attempts ($good=1$) **[4 marks]**.

$$odds\left(distanceBin=1\right)=\frac{Prob\left(distanceBin=1\right)}{Prob\left(distanceBin=1\right)}$$

$$=\frac{^{258}/\_{263}}{^{5}/\_{263}}=\frac{258}{5}=51.6$$

 **[1 mark]**

$$odds\left(distanceBin=2\right)=\frac{Prob\left(distanceBin=2\right)}{Prob\left(distanceBin=2\right)}$$

$$=\frac{^{254}/\_{273}}{^{19}/\_{273}}=\frac{254}{19}=13.3684$$

 **[1 mark]**

$$odds\left(distanceBin=3\right)=\frac{Prob\left(distanceBin=3\right)}{Prob\left(distanceBin=3\right)}$$

$$=\frac{^{206}/\_{235}}{^{29}/\_{235}}=\frac{206}{29}=7.10345$$

 **[1 mark]**

$$odds\left(distanceBin=4\right)=\frac{Prob\left(distanceBin=4\right)}{Prob\left(distanceBin=4\right)}$$

$$=\frac{^{170}/\_{255}}{^{85}/\_{255}}=\frac{170}{85}=2$$

 **[1 mark]**

1. Using $distanceBin=1$ as the reference group, calculate the odds ratios for the other kicking distance quartiles **[3 marks]** and comment on what this tells you about the relationship between successful field goal attempts and kicking distance quartile **[1 mark]**.

$$oddsRatio\left(distanceBin=2 v. distanceBin=1\right)=\frac{odds\left(distanceBin=2\right)}{odds\left(distanceBin=1\right)}$$

$$=\frac{^{254}/\_{19}}{^{258}/\_{5}}=0.259078$$

 **[1 mark]**

$$oddsRatio\left(distanceBin=3 v. distanceBin=1\right)=\frac{odds\left(distanceBin=2\right)}{odds\left(distanceBin=1\right)}$$

$$=\frac{^{206}/\_{29}}{^{258}/\_{5}}=0.137664$$

 **[1 mark]**

$$oddsRatio\left(distanceBin=4 v. distanceBin=1\right)=\frac{odds\left(distanceBin=2\right)}{odds\left(distanceBin=1\right)}$$

$$=\frac{^{170}/\_{85}}{^{258}/\_{5}}=0.0387597$$

 **[1 mark]**

The odds ratio of field goal success declines as kicking distance quartile increases **[1 mark].**