

STAT 110: Practice Problem 7 Solutions

Fall 2017

In 2009, Mahmoud Ahmadinejad won Iran's presidential election in an unexpected landslide victory, and many were suspicious that the election results were fraudulent. To investigate this, we could focus on the last digit of the number of votes received by each candidate in different provinces. For example, if a candidate received 14,579 votes in a particular province, we would focus on the last digit of this number, which is 9. In a non-fraudulent election, each digit (0-9) should appear equally often as the last digit (i.e., 10% of the time). However, based on the observed counts shown below, this may not have been the case in the Iranian election. For example, out of 120 provincial vote totals, we observed the digit 7 as the last digit in 19 cases (i.e., $19/120 = 16\%$ of the time).

Last Digit	0	1	2	3	4	5	6	7	8	9	
Observed Count	10	11	8	8	11	5	16	19	18	14	Total Number of Observations = 120

Research Question: Is there evidence that the digits 0-9 do not appear equally likely in the last position of the provincial vote totals (which may indicate election fraud)?

1. Write the null and alternative hypotheses for investigating this research question.

H₀: the digits 0-9 appear equally likely in the last position of the vote totals

$$(\pi_0 = \pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = \pi_6 = \pi_7 = \pi_8 = \pi_9 = .10)$$

**H_a: the digits 0-9 do *not* appear equally likely in the last position of the vote totals
(at least one of the above-mentioned π 's differs from .10)**

2. How many of the 120 provincial vote totals do we expect to end with the digit 7 if the election was non-fraudulent? Show your work to justify your answer.

$$10\% \text{ of } 120 = 12$$

3. Find the chi-square test statistic for investigating this research question by hand.

$$\begin{aligned} \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}} &= \frac{(10-12)^2}{12} + \frac{(11-12)^2}{12} + \frac{(8-12)^2}{12} + \frac{(8-12)^2}{12} + \frac{(11-12)^2}{12} + \frac{(5-12)^2}{12} + \\ &\frac{(16-12)^2}{12} + \frac{(19-12)^2}{12} + \frac{(18-12)^2}{12} + \frac{(14-12)^2}{12} = 16.0 \end{aligned}$$

STAT 110: Practice Problem 7 Solutions

Fall 2017

- Analyze the data in JMP to find the p-value for investigating this research question.

Enter the data into JMP as follows:

Be sure to click on the symbol to the left of "Last Digit" and change the data type to "Nominal" (i.e., Categorical)

	Last Digit	Count
1	0	10
2	1	11
3	2	8
4	3	8
5	4	11
6	5	5
7	6	16
8	7	19
9	8	18
10	9	14

Select **Analyze > Distribution** and enter the following:

The distribution of values in each column

Select Columns: 2 Columns
Last Digit
Count

Histograms Only:

Cast Selected Columns into Roles

Y, Columns: Last Digit (optional)

Weight: (optional numeric)

Freq: Count

By: (optional)

Action: OK, Cancel, Remove, Recall, Help

Click OK. Then, on the output that appears, select the red drop-down arrow next to the variable name "Last Digit" and choose "Test Probabilities."

Untitled 9 - Distribution of Last Digit - JMP Pro

Distributions

Last Digit

Display Options

Histogram Options

Mosaic Plot

Order By

Test Probabilities

Confidence Interval

Save

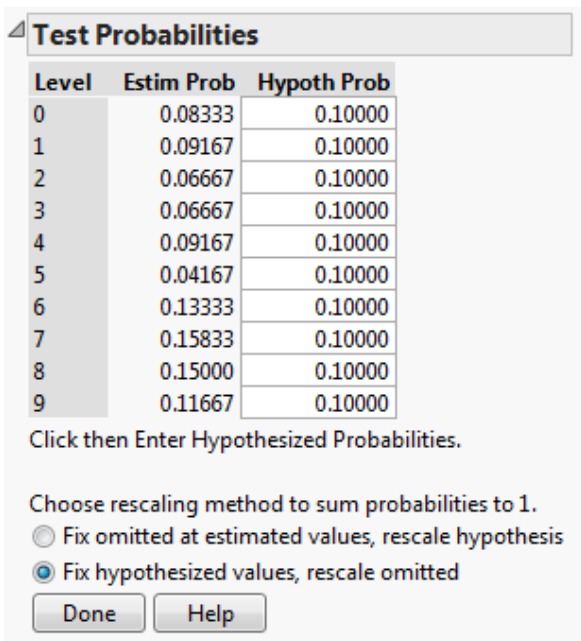
Remove

Frequencies

Level	Count	Prob
0	10	0.08333
1	11	0.09167
2	8	0.06667
3	8	0.06667
4	11	0.09167
5	5	0.04167
6	16	0.13333
7	19	0.15833
8	18	0.15000

Computes Chi-Squared tests for $p_0, p_2 = p_{20}$, etc.

On the window that appears, enter the following:



Click Done, and JMP returns the output you need:

Test	ChiSquare	DF	Prob> Chisq
Likelihood Ratio	16.3765	9	0.0594
Pearson	16.0000	9	0.0669

Method: Fix hypothesized values, rescale omitted

p-value: 0.0669

- Write a conclusion in the context of the research question.

The data do not provide enough evidence (at the .05 level) that the digits 0-9 do not appear equally likely in the last position of the provincial vote totals (which may indicate election fraud). The results are, however, marginally significant.