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## Was there voter fraud in the 2021 Peru Presidential Elections?

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### Abstract

This paper performs a forensic study of the Peru's presidential election on June 6<sup>th</sup>, 2021 between Pedro Castillo and Keiko Fujimori, where ex-candidate Keiko Fujimori claimed there had been irregularities. We calculate three p-values that help us determine if there was fraud. The consensus of the results indicates that there was no manipulation of the results.

### Introduction

On April 11<sup>th</sup>, 2021 the first round presidential election was held with 24 political parties, where it was projected as potential winners the Peru Libre candidate Pedro Castillo and the Fuerza Popular candidate Keiko Fujimori with 2,724,752 and 1,930,762 votes, respectively. The second round was held on June 6<sup>th</sup>, 2021, where Pedro Castillo was chosen as winner with 8,835,579 votes against the 8,791,521 obtained by Fujimori. As a matter of fact, the National Office of Electoral Processes (known as ONPE, by Spanish initials) declared that there was 17,620,000 valid votes, 121,477 blank votes and 25.43% of abstention (details in ONPE, <https://www.resultadossep.eleccionesgenerales2021.pe/SEP2021/>).

However, on June 8<sup>th</sup> the right-wing conservative candidate Keiko Fujimori denounced there had been irregularities in favor of Pedro Castillo<sup>1</sup>, and even claimed that the elections had to be held again<sup>2</sup>. Nevertheless, Keiko Fujimori recognized the victory of her opponent on July 26<sup>th</sup>, and finally the ONPE declared as winner to Pedro Castillo.

For this reason, we performed a study based on statistical techniques according to the Benford's Law<sup>3</sup> to determine if there actually was any manipulation in results. This methodology has been employed in some many studies<sup>3-7</sup>. Moreover, this law has even been used in presidential elections as explained by Mebane<sup>8</sup> and Deckert et al<sup>9</sup> as explained in the next section.

### Methodology

The forensic analysis was performed with the same computational methodology employed both in the Covid-19 registered cases study<sup>6</sup>, and in the recent US elections held in 2020<sup>7</sup>. This methodology is based in the Benford's Law, and we determine three critical values.

The p-value( $\chi^2$ ), p-value(Man) and p-value(FW), refer collectively to as p-values, were calculated in the following way<sup>6,7</sup>. The first value [ p-value( $\chi^2$ ) ] comes from the occurrence frequency of first digit of the data (left to right), which is based on the Benford's Law of the first digit, and the probability should follow the following mathematical relation<sup>10</sup>:

$$Prob(d_i) = \log_{10} \left( 1 + \frac{1}{d_i} \right)$$

Where i goes from 1 to 9 (excluding zero). With these probabilities, the Pearson value ( $\chi^2$ ) is calculated to detect discrepancies in data, which is given by:

$$\chi^2 = \sum_{k=1}^9 \frac{[P(k) - b(k)]^2}{b(k)}$$

where P(k) and b(k) are the distributions obtained from the votes and the expected from Benford's Law, respectively. Thanks to this value, it was possible to determine the p-value( $\chi^2$ ) which indicates us whenever data is correct, as long as it is greater than or equal to 0.05<sup>6,7</sup>.

The next value, p-value(Man), employs the Mantissa Arc test, and to do so we must find the mass center of data according to the following mathematical relation<sup>10</sup>:

$$Coord - X = \frac{\sum_{i=1}^N \cos(2\pi \cdot (\log(x_i) \bmod 1))}{N}$$

$$Coord - Y = \frac{\sum_{i=1}^N \sin(2\pi \cdot (\log(x_i) \bmod 1))}{N}$$

where the  $x_i$  are the votes to validate, and N is the total number of them. We then calculated the  $L^2$  term given by:

$$L^2 = (Coord - X)^2 + (Coord - Y)^2$$

where  $L^2$  should be almost zero, it means, while greater than zero, it is possible to suspect a manipulation of the elections.

So the p-value(Man) equals to:

$$p\text{-valor (Man)} = 1 + e^{L^2 \cdot N}$$

Finally, the p-value (FW) is known as the Freedman-Watson test (FW), designed to compare discrete distributions based on the following mathematical relation<sup>11</sup>:

$$\frac{N}{9 \cdot 10^{k-1}} \sum_{i=10^{k-1}}^{10^k-2} \left[ \sum_{j=1}^i (f_i^0 - f_i^e) \right]^2 - \frac{1}{9 \cdot 10^{k-1}} \sum_{i=10^{k-1}}^{10^k-2} \left[ \sum_{j=1}^i (f_i^0 - f_i^e) \right]^2$$

However, it is recommended to check Freedman's original paper<sup>11</sup> to know every mathematical detail of this last equation.

So, there would be no suspicion of manipulation of the election, if any of the p-values is greater than or equal to 0.05. Nevertheless, if all three values are less than 0.05, it is a sign of inconsistency or fraud<sup>6,7</sup>.

Finally, we want to validate this methodology according to the total number of voters inscribed in twenty five Peru states according the ONPE data, i.e. in the states of Amazonas, Ancash, Apurimac, Arequipa, Ayacucho, Cajamarca, Callao, Cusco, Huancavelica, Huanuco, Ica, Junin, La Libertad, Lambayeque, Lima, Loreto, Madre de Dios, Moquegua, Pasco, Piura, Puno, San Martin, Tacna, Tumbes, and Ucayal. Finally we analyzed

Table 1. Peru's states where is indicated the number of electors for each state, and the votes obtained for Pedro Castillo and Keiko Fujimori.

State	Total voters	Votes for Pedro Castillo	Votes for Keiko Fujimori
Amazonas	161,890	98,716	52,913
Ancash	597,055	314,394	233,325
Apurimac	209,560	160,943	36,737
Arequipa	900,759	549,681	299,759
Ayacucho	287,140	223,383	49,130
Cajamarca	690,285	456,128	190,041
Callao	642,766	195,098	403,813
Cusco	718,117	561,406	116,299
Huancavelica	174,567	139,498	26,243
Huanuco	367,857	229,059	114,648
Ica	515,652	231,546	225,920
Junin	693,301	377,083	271,117
La Libertad	1,022,886	376,424	570,558
Lambayeque	711,954	274,662	387,053
Lima	6,418,172	2,127,809	3,903,451
Loreto	366,268	176,864	171,514
Madre de Dios	76,770	50,244	20,533
Moquegua	114,448	78,009	28,926
Pasco	130,700	80,358	42,140
Piura	996,743	363,786	560,618
Puno	733,093	624,592	76,280
San Martin	430,319	222,029	177,108
Tacna	219,577	150,672	57,187
Tumbes	131,348	41,464	80,064
Ucayali	258,435	115,356	126,116

Table 2. The p-values for the total of all registered votes in the electoral roll of Peru, the votes received by Pedro Castillo and Keiko Fujimori, according to the data indicated in Table 1.

	Total votes of the electoral register	Votes obtained for Pedro Castillo	Votes obtained for Keiko Fujimori
p-Valor( $\chi^2$ )	0,19	0,97	0,53
p-Valor(Man)	0,21	0,44	0,22
L <sup>2</sup>	0,06	0,03	0,06
p-Valor(FW)	0,19	0,88	0,44

the second round election results grouped by political party.

## Results

In Table 1 we present all the data collected for the study according to the ONPE results. In this table we can observe that Pedro Castillo loss in six of twenty five states (*ie.*, Callao, La Libertad, Lambayeque, Lima, Piura, and Tumbes). In the Loreto state, for instance, Castillo won only for 5,350 votes (which represent about 1.46% of the electoral roll), and in the Ica state while the votes difference was a little higher (5626 votes ahead for Castillo), this difference is only 1.09% of the electoral register in this last state. In contrast, there were some states where the difference was way higher, such as Puno: where Castillo won over with more than 580 thousand votes (a difference of almost 75% of the electoral roll). The most favorable state for Fujimori was Lima, where she outnumbered Castillo by almost two million votes, which only represent 27,67% of difference in between them.

We show the p-values for the total of all registered votes in the electoral roll of Peru in the Table 2, and also the analysis of the votes obtained by Pedro Castillo and Keiko Fujimori, respectively. As we can see in this table, there's no evidence of data manipulation as the all surpass the threshold value of 0.05. Furthermore, the L<sup>2</sup> value must be close to zero and there are also similarities between all of them (see Table 2)

## Conclusion

This paper determined a forensic analysis of the Peru's presidential elections on June 6, 2021. We determined three p-values that can help us determine if there have been manipulations of the results. The results indicated that there is no fraud. Moreover, we show how valid is the methodology when we analyzed the electoral register in twenty five states, and therefore, we concluded that there was no fraud in Peru election.

## Conflict of Interest

The authors declare there are no conflicts of interests.

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