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ORIGINAL CONTRIBUTION

Prediction of the General Election 2024 Result in Pakistan: Using Markov Chain

Asma Zaffar[1*], Ovais Siraj Siddiqui [2], Hina Zafar [3]

[1,2] Department of mathematics and sciences, Sir Syed University of Engineering and Technology, Karachi, Pakistan

[3] Crop Diseases Research Institute, SARC, Pakistan Agricultural Research Council, University of Karachi, Karachi, Pakistan

Abstract— The election is an event where all the political parties and factions and their Leaders are projected to participate. Predicting election outcomes is complicated, encompassing different factors that influence voter conduct and political dynamics. This study introduces a novel approach to predict the outcomes of the 2024 general election in Pakistan by employing Markov chain analysis. The abstract highlights the methodology, theoretical foundations, practical implications, and potential future research directions. The paper discusses the theoretical foundations of Markov chain theory as applied to electoral systems, emphasizing state transitions, steady-state distributions, and electoral process periodicity. The study's predictions offer valuable insights for political parties, policymakers, and the public in making informed decisions. The methodology can be adapted for future elections, contributing to data-driven political strategies. It is advisable to rent a couple of forecasting strategies, incorporate extra statistics assets, which include polling records and professional critiques, and analyze the consequences within the broader context of political dynamics in Pakistan. This study shows that PTI has a bright chance to win the election 2024.

Index Terms— Markov chain models, Election, Pakistan, Predict, Dynamics

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Introduction

Predicting election results is a complicated undertaking that includes expertise in voter conduct, analyzing historic statistics, and thinking about diverse influencing factors. Mathematical fashions like Markov chains have recently been applied to forecast election effects by shooting the dynamics of transitions among one-of-a-kind political parties or candidates. In the context of the general election in Pakistan in 2024, using a Markov chain model can offer insights into the capacity final results primarily based on historical records and assumptions regarding celebration transitions (Tan et al., 2018; Karaaslan et al., 2016; Iqbal, 2019; Aziz et al., 2020 and Election commission report).

The aim of the study is to describe the technique of a Markov chain version to expect the general election result in Pakistan in 2024. The statistics of the historical election show the estimated transition chances due to a couple of election situations to simulate and generate predictions for each political birthday party or candidate (Islam et al., 2019). However, it is critical to acknowledge the constraints and uncertainties associated with election predictions, as they rely upon various assumptions and outside elements.

[*]Email: aszafar@ssuet.edu.pk

In Pakistan, general elections are held after 5 years, 272 constituencies across the country held elections to choose one member for the National Assembly. Provincial elections were conducted in all four provinces to choose the MPAs, or Members of the Provincial Assemblies.

The election procedure in Pakistan is managed with the aid of the Election Commission of Pakistan (ECP), an independent constitutional frame liable for organizing and carrying out loose and truthful elections (Leblang et al., 2004). The ECP assures that elections are held according to the rules of electoral law and the constitution of Pakistan. The general election process typically involves the following steps:

Delimitation of constituencies

The ECP determines and demarcates electoral constituencies based on population statistics and other applicable factors.

Nomination of candidates

Political events and independent applicants nominate their candidates for various constituencies. Every candidate needs to satisfy positive eligibility criteria, along with being a citizen of Pakistan, meeting age necessities, and not having a crook file.

Election campaigning

Candidates and political parties interact in election campaigns to promote their manifestos and garner support from voters. This entails rallies, public meetings, advertising, and media campaigns.

Voter registration

Eligible residents need to check in as citizens before the election. The ECP maintains a voter registration database to ensure correct voter rolls.

Polling stations and poll papers

The ECP designates polling stations where voters can vote. Ballot papers are prepared and dispensed to the polling stations, listing the names and symbols of the applicants.

Balloting technique

On election day, voters visit their particular polling stations, present their identification, and cast their votes in secrecy. The ECP takes measures to ensure an evident and secure voting manner.

Vote counting and results

After the polling concludes, the ballot boxes are opened, and the votes are counted at every polling station. The consequences from all polling stations in a constituency are tallied, and the candidate with the broadest variety of votes is asserted as the winner.

Formation of government

The political birthday party or coalition that secures most people's seats inside the nationwide meeting forms the authorities. The chief of the majority birthday celebration becomes the top Minister, and the President of Pakistan appoints them based on parliamentary assistance.

Predicting election outcomes in Pakistan, a process fraught with complexities, necessitates a deep understanding of voter behavior, historical voting patterns, and many influencing factors. Mathematical models, particularly Markov chains, have recently gained prominence for their ability to encapsulate dynamic transitions between political parties or candidates. This paper delves into the utilization of a Markov chain model to forecast the 2024 general election results in Pakistan. By leveraging historical election data and calculating transition probabilities, we aim to simulate multiple election scenarios, thus providing predictive insights for each political entity involved. However, it is imperative to recognize the inherent limitations and uncertainties of such predictions, as they depend on various assumptions and external variables.

In Pakistan, general elections, held every five years, determine the composition of the National Assembly and Provincial Assemblies. The National Assembly, being the lower house of the Parliament of Pakistan, and the Provincial Assemblies in Punjab, Sindh, Khyber Pakhtunkhwa, and Baluchistan reflect the federal and regional political dynamics. The Election Commission of Pakistan (ECP), an independent constitutional body, ensures the integrity and fairness of these elections, adhering to the Constitution of Pakistan and electoral laws (Agbinya et al., 2022).

This study approach encompasses key stages of the election process, from the delimitation of constituencies to voter registration, candidate nomination, campaign strategies, and the balloting process. Our analysis not only examines these procedural aspects but also provides a comprehensive view of the voting system, including vote counting, results declaration, and government formation.

Through this study, we aim to contribute to the existing body of knowledge by filling a specific research gap: the limited application of Markov chain analysis in the context of Pakistani elections. Our study is unique in its focus on recent electoral trends and the evolving political landscape, thus offering a timely and relevant analysis. Additionally, by incorporating recent studies and data, we enhance the credibility and context of our research, making it a valuable tool for political parties, policymakers, and the public at large.

Literature Review

The general elections in Pakistan have played a sizeable position in shaping the USA's political landscape. Here's a short record of standard elections in Pakistan in conjunction with some references for additional exploration:

1970 general elections

The first nationwide, widespread elections were held in 1970. Those elections marked a vital milestone as they led to the formation of Pakistan's first immediately elected parliament (Hasan, 2015).

1977 fashionable elections

The overall election results of 1977 have been marred by allegations of electoral fraud and political unrest. The political tensions finally caused a military coup and the overthrow of the elected authorities (Jalal, 1995).

1985 widespread elections

Following a length of military rule, non-birthday party preferred elections were held in 1985. The elections have been held in controlled political surroundings, with restricted participation from political parties.

1988 preferred elections

The overall election result of 1988 marked the end of navy rule and the return to civilian democratic governance. The elections resulted in the formation of a coalition government led by the Pakistan People's Party (PPP) (Ahmed, 2013).

1990 standard elections

The 1990 trendy elections witnessed a transition of strength from the PPP-led coalition to a government formed via the Islami Jamhoori Ittehad (IJI) alliance. This marked a peaceful transfer of strength through the electoral process (Jalal, 1995).

2002 well-known elections

The overall elections of 2002 were held under the army regime of fashionable Pervez Musharraf. Those elections introduced a machine of reserved seats for girls and non-Muslim minorities in the national assembly (Nasr, 2008).

2013 trendy elections

The 2013 well-known election results marked a sizeable transition because it became the primary time a civilian government completed its whole period and transferred electricity through elections. The elections resulted in the formation of a central authority led by the Pakistan Muslim League-Nawaz (PML-N) (Abbasi, 2016; Lashari et al., 2013).

2018 preferred elections

The overall election results of 2018 witnessed an exceedingly aggressive electoral process and a sizable voter turnout. The Pakistan Tehreek-e-Insaf (PTI) emerged as the leading party, forming the authorities (Nortey et al., 2015; Fifield et al., 2020).

General elections were held in Pakistan on Wednesday, July 25, 2018, after the crowning of a five-year term by the outgoing government. At the countrywide stage, elections have been held in 272 constituencies, electing one member to the national assembly (Ali et al., 2018). At the provincial stage, elections were held in each of the 4 provinces to select participants for the Provincial Assemblies (MPA). As a result of the polls, during the 2018 general elections in Pakistan, the Pakistan Tehreek-e-Insaf (PTI) emerged as the primary party and formed the authorities. Right here are the outcomes of the fundamental political parties regarding the seats gained inside the nationwide assembly.

Table I
Results of 2018 general elections in Pakistan

Political Parties	Seats Won	Vote Percentage
Pakistan Tehreek-e-Insaf (PTI)	116	31.82%
Pakistan Muslim League-Nawaz (PML-N)	64	24.36%
Pakistan People's Party (PPP)	43	13.02%
Muttahida Majlis-e-Amal (MMA)	12	3.27%
Independents and different parties	19	N/A

Reference: Election fee of Pakistan (ECP) - reliable internet site

It is important to note that the seat distribution and vote stocks supplied above are approximate figures and may have minor versions based totally on distinctive assets. For a more comprehensive and unique breakdown of the election outcomes, it is highly recommended to consult the reputable internet site of the Election Commission of Pakistan (ECP) or legitimate news resources that protected the 2018 popular elections in Pakistan.

Imran Khan rated throughout the use of a citizens depart room open for brand new political celebration with technocrats: Gallup Pakistan Public Pulse files.

Methodology

The technique of Markov chain states is used to predict the general election 2024 will bring about in Pakistan; the following steps can be followed:

Define states

Determine the states in the Markov chain representing the one-of-a-kind political parties or applicants collaborating within the election. For example, you could recall states for leading political parties and impartial candidates.

Gather historical facts

Acquire historical election facts from previous elections, which include outcomes, voter demographics, and other applicable elements that can affect election outcomes. This statistic might be used to estimate transition probabilities.

Transition possibility estimation

Estimate the transition possibilities among states based on historical statistics. Those possibilities represent the probability of transitioning from one country (party or candidate) to another. One technique is to calculate the share of votes a party or candidate received inside the preceding election and use that as an estimate for the transition opportunity to that state within the subsequent election. As a substitute, expert evaluations and surveys can be used to derive transition probabilities.

Model calibration

The Markov chain technique is used in the historical dataset. This includes estimating the initial kingdom distribution, which represents the distribution of votes for each political party at the beginning of the election. Adjust the transition chances based on historical election outcomes, aiming to align the model with past consequences.

Simulation and prediction

As soon as the model is calibrated, simulate more than one election scenario to generate predictions for the 2024 preferred election. Starting from the initial state distribution, use the transition chances to iteratively transition among states, representing the progression of the election. Conduct a sufficiently wide variety of simulations to achieve a reliable prediction.

Sensitivity evaluation

Carry out a sensitivity analysis to evaluate the robustness of the version. Vary the transition possibilities and initial country distribution to decide the effect on the anticipated consequences. This evaluation facilitates recognizing the uncertainty related to the predictions.

External factors

Recall incorporating external elements that would influence the election consequences, polling information, expert evaluations, and modern-day events. These elements can alter the transition probabilities or initial nation distribution, providing a more nuanced and correct prediction.

Pitfall

It is crucial to note that while a Markov chain model can provide insights into election predictions, it has limitations. Factors like campaign strategies, converting voter sentiment, and unforeseen occasions can drastically impact the election's final results. Therefore, it is beneficial to mix the Markov chain model with different forecasting strategies and analyses to improve the accuracy and reliability of the predictions.

Model making

The recent decision by Pakistan's Supreme Court to bar the Pakistan Tehreek-e-Insaf (PTI) from using its iconic cricket bat electoral symbol has significant implications. This ruling is seen as a major setback for the party, particularly in light of the upcoming national election on February 8, 2024. The loss of the bat symbol, which has been a distinctive identifier for the PTI, is expected to create confusion among voters, as PTI candidates will now have to contest the polls independently with different symbols, such as tongs, kettle, and brinjal.

The PTI has expressed its determination to contest the elections despite this obstacle, unveiling what they call 'Plan C.' This plan involves PTI candidates running independently but potentially rejoining the party post-election.

The impact of individual PTI workers on the election outcomes in Pakistan can be quite significant, particularly in the context of grassroots movements and local campaigning. PTI, being a major political force in Pakistan, relies not only on its leadership but also on the active participation of its workers and supporters at the ground level (Cannon et al., 2023). These individuals play a crucial role in mobilizing support, spreading the party's message, and ensuring voter turnout, which are all critical factors in determining election results.

In the context of the Markov Chain model used for predicting the election outcomes, the behavior and actions of individual party workers might not be directly modeled, as such models typically focus on higher-level trends and probabilities (Hasan et al.,2017). However, the cumulative effect of individual workers' efforts can influence the overall political climate and voter preferences, which, in turn, would be reflected in the transition probabilities between states in the model.

Therefore, while individual PTI workers might not be explicitly accounted for in the model, their collective impact is indirectly incorporated through the data used to estimate transition probabilities and in the interpretation of the model's results (Saud et al., 2018). It's important for political forecasters to be aware of the grassroots dynamics and consider how changes in party worker activities might influence broader political trends.

To create a transition matrix for the Markov chain model, you need historical data on election results that indicate the transition probabilities between states (political parties or candidates). Without a specific dataset, provide an example of how a transition matrix could be constructed based on fiction. To create a transition matrix for the Markov chain model, you need a historical dataset on election results that imply the transition chances among states (political events or candidates). In the absence of precise statistics, I will offer an example of how a transition matrix could be built based totally on fictional data for three political parties: Party A, Party B, and Party C.

Markov chain

A Markov chain produced via the Markov process with a random variable (Y_0,...,Y_n sequence (Purba et al., 2017). The probabilities of transition are described as the maximum critical value via a particular chain P(i,j)=P(i→j), in which the probability moves state space t_i

to state $t_j$in, a single-step process.

$$P(i,j) = P(j \to i) = \Pr\left(Y_{t+1} = t_j \mid Y_t = t_i\right)$$

A Markov chain first order having stats $F = \{1, 2, \ldots, k\}$ for a time series x_t modeling that verify the mentioned relationship:

$$P\left(y_{s+1} = i_{s+1} \mid y_0 = i_0, \ldots, x_s = i_s\right) = P\left(y_{s+1} = i_{s+1} \mid y_s = i_s\right)$$

Here y_s, describe the time series state. The transition probabilities one-step of the Markov chain are represented as conditional probabilities $P\left(y_{s+1} = i_{s+1} \mid y_s = i_s\right)$ that are written

$$p_{ij} = P\left(y_{s+1} = i \mid y_s = j\right) \text{ for } i, j \in F$$

The one-step transition probability matrix $P = (p_{ij})_{k \times k}$ verifies the following two properties

$0 \leq p_{ij} \leq 1$ and $\sum_{i=1}^{k} p_{ij} = 1 \forall i, j \in F$

A Markov chain is irreducible if it consists of a positive integer similar to ${P_{ij}}^{n+j} > 0$ for all I, j. The meaning of irreducible is that all states communicate with each other. One state goes from another state continuously, and the chain detects a periodic.

Transition probability matrix

The Markov chain of one-step transition probabilities for a given time points sequence $t_1 < t_2 < \ldots < t_{n-1} < t_n$, characterized as conditional probabilities

$P\left(y_{s+1} = i_{s+1} \mid y_s = i_s\right)$, described $p_{ij} = P\left(y_{s+1} = j \mid y_s = i\right)$ for $i, j \in F$

The matrix of transition probability is represented by P. For states , the transition matrix of the first order has a size of and takes the form:

$$P = \begin{bmatrix} p_{1,1} & p_{1,2} & \cdots & p_{1,k} \\ p_{2,1} & p_{2,2} & \cdots & p_{2,k} \\ \cdots & \cdots & \cdots & \cdots \\ p_{k,1} & p_{k,2} & \cdots & p_{k,k} \end{bmatrix} \tag{1}$$

Where the frequencies of relative of the states and estimate probabilities state at time s. The transition number from state to state is represented by $\varepsilon_i j$. The transition probabilities are

defined as $p_{ij} = \frac{\varepsilon_{ij}}{\sum_j \varepsilon_{ij}}$. This one-step transition matrix $P = (p_{ij})_{k \times k}$ verified the following two properties. $0 \leq p_{ij} \leq 1$ and $\sum_{j=1}^{k} p_{ij} = 1 \forall i, j \in F$

RESULTS AND DISCUSSION

The model is generated by using probability theory and the movements of voters from one party to others with the help of a survey report, which is still being done in PAKISTAN, for the general election 2024, which will be held in October.

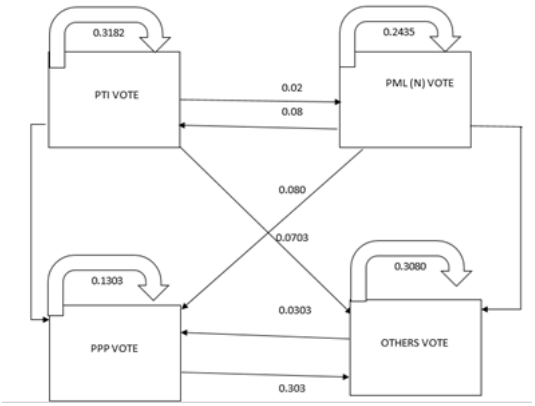

Fig. 1 *Workflow of election 2018 ratio of the political parties*

Figure 1 shows the Election 2018 results that are mentioned in bars. Whereas arrows represent the prediction probability of voters switching from one party to another political party.

Table II
Prediction of the probability of voters switching from one party to another political party

Political Parties	PTI	PPP	PMLN	OTHERS
PTI	0.31	0.01	0.03	0.38
PPP	0.08	0.31	0.02	0.59
PMLN	0.08	0.02	0.24	0.66
OTHERS	0.69	0.01	0.01	0.30

Table 2 describes the prediction probability of voters who are moving from one political party to another.

Fig. 2 *Prediction movements of voters from PTI to others*

Figure 2 expresses the predicted movements of voters from PTI to other political parties.

Fig. 3 *Prediction movements of voters from PMLN to others*

Figure 3 expresses the forecasted movements of voters from PMLN to other political parties.

Fig. 4 *Prediction movements of voters from PPP to others*

Figure 4 describes the forecasted movements of voters from the PPP to other political parties.

Fig. 5 *Prediction movements of voters from Others to remaining political parties*

Figure 5 depicts the expected movement of voters from other political parties to the remaining political parties. Table 2 to Table 5 show the states and their respective pie charts, which show the percentages of indolent.

$$\textbf{Initial state from gallup survey} \begin{pmatrix} 61 \text{ PERCENT} \\ 18 \text{ PERCENT} \\ 18 \text{ PERCENT} \\ 3 \text{ PERCENT} \end{pmatrix} \textbf{from Pakistan gallup}$$

Above, we initiate the state of probability in a table and state the probability, which was given in a chart, taking from the below references performing surveys in Pakistan for the general election 2024.

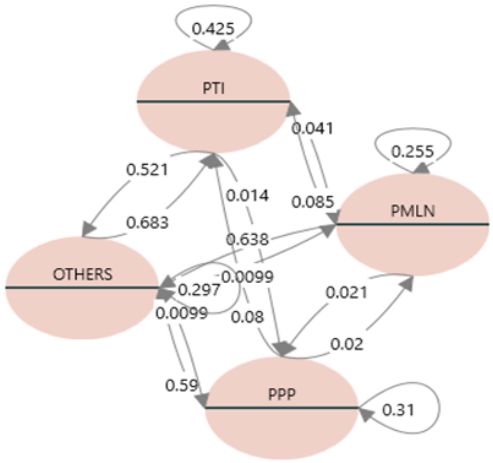

Fig. 6 *Decision graph of forecasted voters*

Figure 6 directed graph shows the moments of voters from one party to another. This decision tree graph also shows the probability of movements of voters that would be possible in the general election in 2024 in Pakistan, which will be very fruitful to politicians to understand the voter's minds set for the general election before time (Nortey et al., 2015).

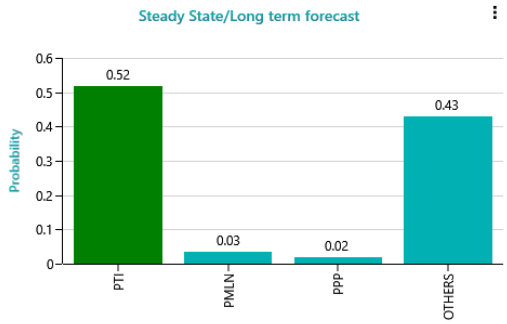

Fig. 7 *Bar diagram of forecasted popularity of political parties*

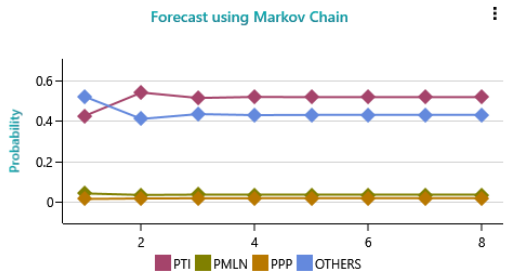

Fig. 8 *Iterative representation of forecasted probabilities*

From the above graph, after applying a Markov chain, it was found that the popularity of PTI increased from 40% to between 50% and 60%. PMLN and PPP votes shifted to PTI, and now, after a long run, they remain constant, as well as more voters coming from other parties, which have also shifted to PTI dramatically.

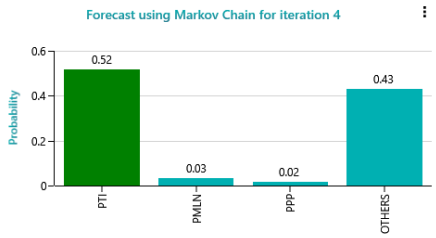

Fig. 9 *Forecast using markov chain for iteration 4*

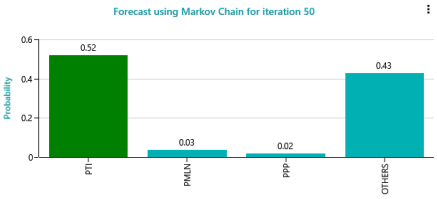

Fig. 10 *Forecast using markov chain for iteration 50*

After performing 50 iterations, it is seen that voters' minds shifted from PMLN and PPP to PTI and others, which is a very tragic loss for both parties.

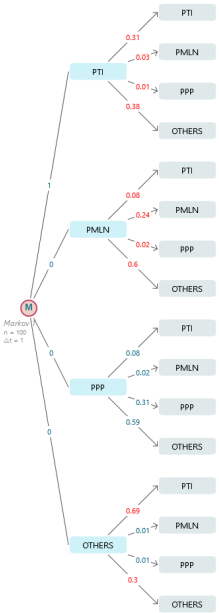

Fig. 11 *Markov probability tree diagram of forecasted voters*

The above figure shows that the probability of predicted voter/ movements within or other political parties dotted lines show, in a figure, the strong predicted probability, and the continuous lines show the weak predicted probability.

Table III
Voters forecasted moments with respect to time

Time	PTI Population	PMLN Population	PPP Population	Others Population
0	100000	0	0	0
1	42466	4110	1370	52055
2	54056	3336	1609	40999
3	51377	3511	1716	43395
4	51900	3471	1741	42887
5	51773	3479	1750	42998
6	51797	3477	1752	42976
7	51792	3478	1753	42981
8	51793	3477	1752	42981

The above table shows that after the fifth iteration, the values of the voters become constant, which shows that more than five thousand voters are still in PTI support while 3 thousand and 17 hundred are in PMLN and PPP, respectively. Other minor parties here play a significant role and would have counted almost 42 thousand. If three parties make general alliances like PDM, let's see how much it would affect the PTI popularity graph in the 2024 general election in Pakistan.

Table IV
Comparison of voters' forecasted moments PTI versus all parties

PTI%	All Parties %
42.466	57.535
54.056	45.944
51.377	48.622
51.9	48.099
51.773	48.227
51.797	48.205
510792	48.212
51.793	48.21
51.793	48.21
51.793	48.21

The above result shows that it is predicted that in the 2024 general election in Pakistan. There are 51.793% chances of winning PTI and 48.21% chances for all parties. It will be interesting to see this prediction in February 2024. This will be good news for PTI supporters and other parties will have to do something to change the mindset of voters and turn the table around. It is obvious after applying the Markova chain that there are a lot of chances for the PTI to win the general election in 2024. Pakistan has various votes because a lot of voters moved from PMLN and PPP to PTI or others, but if we want to take a clear picture, like if all parties support each other's versus PTI, then we make the sum of voters PTI versus all parties allies movement and check the percentages of votes. We make a chart above that gives a brighter picture of the forecasted result.

CONCLUSION

It is a complicated assignment after avoiding different factors in real-time, like day-to-day changes in the dynamics of political parties in Pakistan. This study actually gives us the paramount application of the Markov Chain, which is a good approach to the preferred general election in Pakistan. As a result of our calculation, the technique shows some brighter chances of PTI winning the bar in the general election, which is also an alarming sign to other parties.

Study limitations

Reliance on historical data

The study's predictions are based on historical election data, which may not fully capture Pakistan's current and future political dynamics.

Modeling constraints

The Markov Chain model, while useful, has inherent limitations, including assumptions and simplifications that might impact the accuracy of the predictions.

External factors

The study does not account for unforeseen political events and changes in voter sentiment, which could significantly alter election outcomes.

Generalizability and scope

The findings are specific to the context of the 2024 Pakistan general elections and may not be generalizable to other electoral contexts or future elections.

Future research directions

It may include exploring more dynamic models that can adapt to real-time changes in political dynamics, incorporating additional variables such as economic indicators or public opinion polls, and applying the model to different electoral contexts. Future research could also compare the Markov Chain model with other predictive models for election forecasting in Pakistan. These suggestions will help guide future studies in enhancing the understanding and prediction of electoral outcomes.

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