

## Research Article

# Mean Vector Analyses of the Voting Patterns of Ghanaians for Three Consecutive Periods: A Case Study of the Greater Accra Region

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**Abstract:** The aim of this paper was to find out whether the outcome of future elections in the Greater Accra region could be predicted based on empirical data. The voting patterns of the presidential elections in Ghana deserve notice, not because of their political significance but because of the theoretical weight they carry. The shifts in electoral fortunes between the two main political parties in the country, especially in the greater Accra region provide a unique leverage for assessing theories of voting behavior. The paper uses statistical tools to examine the electoral performance of the four major political parties in Accra and the Hotelling's  $T^2$  Statistic to test whether a prediction could be made to predict future outcomes of elections. Our results revealed that there was not enough statistical evidence to predict future outcomes of elections in the greater Accra district.

**Keywords:** Mean vector, multivariate analysis, voting patterns

## INTRODUCTION

There are four main political parties in Ghana, namely: National Democratic Congress (NDC), New Patriotic Party (NPP), People's National Convention (PNC) and the Convention's Peoples Party (CPP) (Damnyag, 2013). There are also ten regions in Ghana. There are certain regions that are considered strong hold for certain prominent political parties where as other regions are considered swinging regions. The strong hold regions are those that are always won by one political party during elections, whereas the swinging regions can be won by any political party. One of the swinging regions is the Greater Accra region where the research focused on. The voting pattern in the Greater Accra region does not appear to have any relationship with the performance of the incumbent, that is to say that the incumbent can still win though they may have performed poorly during their tenure of office. We therefore set out to study the voting patterns of Ghanaians in the Greater Accra region.

An intriguing characteristic of electoral politics in Ghana and Africa as a whole is that the incumbents, however bad, tend to win elections. Key and Anebo (2000) asserted that people may not really govern themselves, but they can stir up a deafening commotion if they dislike the way they are governed. The commotion could be in the form of voting out that political party which is not performing well out of power to make way for a new one. However, the results of elections in Ghana do not appear to agree with the above assertion.

Some of the reasons for the political parties that win swinging regions have been attributed to ethnicity, marketing strategy and history of the area. Some also do assert that, winning in the swinging regions do not follow any special pattern. Alabi and Alabi (2008) analyzed the effects of ethnicity on political marketing in Ghana using vote data. The analysis made it evident that political parties with very strong ethnic support bases are those that have stood that test of time no matter what marketing tools or approaches are employed.

Ntow-Ababio (2010) worked on settler communities, voting patterns and national integration: A case study of the Dormaa East constituency. The study found that even though members of settler communities in the Dormaa East Constituency may be influenced by their ethnic background when it comes to voting, their voting pattern does not follow any special pattern and hence explaining their voting pattern becomes very difficult especially in terms of ethnicity. The study also showed that there is no significant difference between the voting behavior of settler communities and that of the indigenous people.

This mini paper seeks to address the most basic and standard statistical problem about analyzing the trend of presidential voting patterns in Ghana. we intend to apply the various multivariate data analysis tools to explore the data gathered from the Electoral Commission on the voting patterns of Ghana's one of the most 'swinging' regions-the Greater Accra Region. That is: we seek to make inferences about the various characteristics of the population under study. Some of these characteristics are the mean, the variance, the

covariance, the standard deviation and so on. The study captures the trend of analysis of the results of the four major political parties in Ghana- The ruling National Democratic Congress (NDC), strongest opposition party, the New Patriotic Party (NPP), the People's National Convention (PNC) and Ghana's first president's party, the Convention's Peoples Party (CPP). A thorough knowledge of the voting patterns of each region is essential for every political party, the registered voters and the general public as a whole. The Greater Accra Region which has been described as one of the most 'swinging' regions in Ghana elections will be analyzed.

Aluaigba (2013) studied the voting behavior of Nigerians. In his study he found that the voting behavior of Nigerians has reflected religious instinct such that in virtually all the elections conducted in the country, the voting pattern has often towed along religious lines. During the 2011 general elections, the two major presidential candidates that contested, President Good luck Jonathan of the Peoples Democratic Party (PDP), a Christian and General Mohammadu Buhari of the Congress for Progressive Change (CPC), a Moslem, practically pitched the religious cleavages within the Nigerian electorate against each other. The research which was conducted in Fagge Local Government Area (LGA) of Kano State Nigeria found that Nigerian voters resident in Fagge LGA have the propensity to vote along religious lines but this tendency is more prevalent among Muslims than Christians. It further revealed that, even though the electorate in Fagge overtly denounces the consideration of religious background of candidates during election; on Election Day, votes were cast to reflect religious prejudices of the voters. It recommends extensive political education, good political leadership and transparent elections for Nigeria to overcome the influence of religion on her electoral process.

While much has been written on the electoral strength of Islamists in Egypt, most analysis has been done at the national level, ignoring regional divides within the country. As a means of helping U.S. policymakers and Middle East watchers better understand voting patterns in Egypt since the 2011 revolution. Worman and Martini (2013) conducted a study to identify the areas where Islamist parties run strongest and the areas where non-Islamists are most competitive. They found that while Islamists perform well across the whole of the country, they draw their strongest electoral support in Upper Egypt, North Sinai and sparsely populated governorates in the west, while non-Islamist parties fare best in Cairo and its immediate environs, Port Said, South Sinai and the sparsely populated governorates abutting the Red Sea. The voting pattern studied over a period of time reveals a narrowing of the gap between Islamist parties and their non-Islamist rivals.

Bader (2012) studied the trends and patterns in the prevalence of electoral malpractice in the post-Soviet area. The study explored the relationship between electoral malpractice and three variables: the type of elections (presidential or parliamentary), the presence of electoral competition (present in competitive elections, absent in hegemonic elections) and the advance of time. The findings suggest that electoral malpractice does not significantly decrease over time, is as widespread in parliamentary as in presidential elections, but, in line with expectations, is more severe in hegemonic elections than in competitive elections. These findings contribute to insights about the nature of authoritarian elections and are important for considerations about the future of election observation in the region.

**General objectives:** The main aim of this paper is to provide comprehensive statistical analyses for the Presidential elections voting pattern of the Greater Accra Region, which has been described as one the most "swinging" regions in Ghana as far as Presidential and Parliamentary voting is concerned. The specific objectives are as follows:

- Assessing whether the data set is normally distributed to enable us use the various multivariate tools/analyses
- Performing preliminary analyses of the data to obtain a summary of the statistics
- Making Statistical Inferences about the mean vectors

## **MATERIALS AND METHODS**

Quantitative methods were employed in this study. Data on the voting patterns of the four most recent periods were analyzed. That is the periods: 2004, 2008 and 2012 from the electoral commission. The data focuses exclusively on the Greater Accra Region Presidential elections.

This is justifiable as more than a 10-year span data is enough to predict or forecast a trend that exist in the data. The results of all the total votes cast that were recorded in the experiment years, for the various constituencies were used. The Greater Accra Region had 22 constituencies I 1996, 27 constituencies in 2004 and 2008 and 34 constituencies in 2012. It can be seen that 27 constituencies is common in all the years being considered. So we are going to use the data from the 27 constituencies that is common to all the years. The main statistical software applications were the Excel and the SPSS and the statistical tool used was the multivariate data analysis tools.

**Assessing the normality of the data:** In this section, we present the descriptive statistics of the indicators for the voting patterns of the various constituencies considered. The indicators are defined below:

Table 1: Table of descriptive statistics for the results obtained for 2004, 2008 and 2012 presidential elections

	X1	X2	X3	X4
Mean	32, 443.58	30, 432.17	286.94	437.60
Standard error	1, 308.11	1, 872.03	40.21	44.41
Median	31, 430.00	32,021.00	148.00	325.00
Mode	#N/A	#N/A	17.00	92.00
Standard deviation	11, 772.95	16,848.30	361.89	399.72
Sample variance	138,602,423.52	283, 865, 290.44	130, 964.23	159, 779.57
Kurtosis	-0.63	-0.13	8.32	0.56
Skewness	0.27	0.07	2.42	1.15
Range	47, 745.00	75, 365.00	2, 149.00	1,570.00
Minimum	12, 433.00	2, 017.00	11.00	32.00
Maximum	60, 178.00	77, 382.00	2, 160.00	1, 602.00
Sum	2, 627, 930.00	2, 627, 006.00	23, 242.00	35, 446.00
Count	81	81	81	81
Confidence interval (95%)	2, 603.21	3, 725.47	80.02	88.39

Table 2: Covariance matrix for voting pattern

	X1	X2	X3	X4
X1	136891282.49	132509882.42	133795.21	587340.82
X2	132509882.42	280360780.69	2412549.36	2017036.88
X3	1337955.21	2412549.36	129347.39	34980.58
X4	587340.82	2017036.88	34980.58	157806.98

- $X_1$  = Results of the National Democratic Congress (NDC)
- $X_2$  = Results of the New Patriotic Party (NPP)
- $X_3$  = Results of the People’s National Convention
- $X_4$  = Results of the Convention People’s Party

The table presented in Table 1 above gives important information about the normality that is needed to perform a parametric data analysis. Comparatively, the small standard error values indicate that the data collected, is good enough to be used in inferential analysis in statistics. It can be seen that the difference in errors between the population taken and the sample statistics would be very small and this is imperative for the sample statistic to provide a good estimate for the actual population parameter. The mode for X1 and X2 which represents the NDC and the NPP respectively does not exit over the period being studied. This means a particular total votes cast for any of these political parties for the period studied did not occur more than once. It can also be seen that the median and the mean are quite close with a relatively small Skewness values for both NPP and NDC. This shows how the votes are always spread between these two political parties.

It can be concluded the data appears not too far from being normal, with closeness in their medians and means and a relatively small standard error and small Skewness for NDC and NPP. This also illustrates that the voting patterns of Ghanaians has always followed a normal pattern with NPP and NDC sharing the major total votes cast. The other two political parties, the PNC and the CPP has been quite abnormal, Judging from the respective Skewness.

**Calculations for the analyses of the data to obtain summary statistics:** The voting pattern of Ghanaians for the 27 constituencies being studied is a multivariate

normal distribution expressed as:  $N_4(\mu, \Sigma)$  where  $\mu$  is the sample mean vector and  $\Sigma$  is the covariance matrix. From Table 1, the sample mean vector collected is given by:

$$\bar{x} = \begin{pmatrix} \bar{X}_1 \\ \bar{X}_2 \\ \bar{X}_3 \\ \bar{X}_4 \end{pmatrix} = \begin{pmatrix} 32443.58 \\ 30432.17 \\ 286.9400 \\ 437.6000 \end{pmatrix}$$

The sample covariance matrix is given above in Table 2.

**Inferences about the mean vector:** In this section, our aim is to perform an inferential statistics about the mean total votes cast for the various political parties. That is we seek to test at a significant level of  $\alpha = 0.5$ , whether the mean total votes cast for the 27 constituencies could exceed,  $\mu_0 = (35000 \ 35000 \ 300 \ 450)$ . The Hypothesis that would be tested are as follows:

For the Null Hypothesis, we have  $H_0 : \mu > \mu_0$ ; against the Alternate Hypothesis  $H_1 : \mu \leq \mu_0$ .

**Hotelling’s  $T^2$  statistic:** We now consider the problem of testing whether the  $k \times 1$  vector as a plausible value for the population mean vector  $\mu$ .

A natural generalization of the squared distance is its multivariate analog:

$$T^2 = (\bar{X} - \mu_0)' \left( \frac{1}{n} S \right)^{-1} (\bar{X} - \mu_0) = n (\bar{X} - \mu_0)' S^{-1} (\bar{X} - \mu_0)$$

The Statistics  $T^2$  is called Hotelling’s  $T^2$ . This has an approximate central chi-square with  $k$  degrees of freedom.

In the expression above:

$$\bar{X} = \frac{1}{n} \sum_i X_i, \quad S = \frac{1}{n-1} \sum_i (X_i - \bar{X})(X_i - \bar{X})'$$

If the observed  $T^2$  value is too ‘large’-that is, if  $\bar{x}$  is too far from  $\mu_0$ , the hypothesis  $H_0 : \mu = \mu_0$  is

rejected and to decide how large is large, we need the sampling distribution of  $T^2$  when the hypothesized mean vector is correct: The critical value is given by:

$$\frac{(n-1)k}{(n-k)} F_{k,n-k}(\alpha).$$

We reject the null hypothesis  $H_0: \mu = \mu_0$  for the  $k$ -dimensional vector  $\mu$  at level  $\alpha$  when:

$$T^2 > \frac{(n-1)k}{(n-k)} F_{k,n-k}(\alpha).$$

where,  $F_{k,n-k}(\alpha)$  is the upper  $\alpha$  percentile of the central  $F$  distribution with  $k$  and  $n-k$  degrees of freedom.

As noted earlier:

$$T^2 = (\bar{X} - \mu_0)' \left( \frac{1}{n} S \right)^{-1} (\bar{X} - \mu_0) = n(\bar{X} - \mu_0)' S^{-1} (\bar{X} - \mu_0)$$

has an approximate central chi-square distribution with  $k$  degrees of freedom and when  $\mu_0$  is correct for large  $n$ , or when  $\Sigma$  is known in which case the distribution is exact then we have normality. The exact F-distribution relies on the normality assumption and we also note that  $\frac{(n-1)k}{(n-k)} F_{k,n-k}(\alpha) > x_k^2(\alpha)$ , but these quantities are nearly equal for large values of  $n-k$ .

By the use of Microsoft Excel, the test statistic for the voting pattern is found as follows:

$$T^2 = n(\bar{x} - \mu_0)'(S)^{-1}(\bar{x} - \mu_0) = 2.0765$$

Now,

$$\begin{aligned} \frac{k(n-1)}{n-k} F_{k,n-k}(\alpha) &= \frac{4(81-1)}{81-4} F_{4,77}(0.05) = \\ \frac{4 \times 80}{77} F_{4,77}(0.05) &= 4.1558 \times 2.49 = 10.35 \end{aligned}$$

Since  $T^2$  is less than the critical value, we fail to reject the null hypothesis. This implies that there is not enough statistical evidence to infer that the mean performances of the various four political parties in the 27 constituencies are greater than hypothesized means stated in the voting pattern.

### RESULTS AND DISCUSSION

We failed to reject the null hypothesis, which stated that the mean votes can exceed a hypothesized values of 35000, 35000, 300 and 450 for NDC, NPP, PNC and CPP respectively. This implies that there is

not enough statistical evidence to infer that the mean performances of the various four political parties in the 27 constituencies are greater than hypothesized means stated.

The mean vote for NDC for the presidential elections for the four consecutive years is 32443.58. The result after the analysis revealed that there was not enough evidence to support that the mean can exceed 35000. This means that the NDC party cannot predict that they can obtain votes exceeding 35000 in any election based on the evidence available. The NPP also have a mean vote of 30432.17 and the results from Hotelling's  $T^2$  test also revealed that, based on the evidence available, the mean cannot exceed 35000 in any election.

The mean vote for PNC and CPP are 286.9400 and 437.600, similarly, the test revealed that based on the evidence available, the mean for these two political parties cannot exceed 300 and 450, respectively.

In a nutshell, the results further affirms the assertion that, based on the evidence available, each of the four political parties cannot obtain votes which far exceeds what their mean votes in Table 1 stipulates.

### CONCLUSION

The voting patterns analyzed, revealed there was not enough statistical evidence to justify that the votes will exceed the assumed mean values. This further implies that the votes for subsequent elections could not be predicted with a greater amount of certainty because of the result of the hypothesis testing using Hotelling's  $T^2$  statistic. The test further showed why the greater Accra region is popularly known as the swinging region and can be won by any political party. There may be perhaps other factors that affect the voting patterns in these regions and as a result one cannot depend on empirical evidence to win the elections.

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