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A MULTIFACETED ANALYSIS OF THE ELECTORAL SYSTEM OF THE REPUBLIC OF SURINAME

The electoral system of Suriname has been analyzed. Suriname has a unicameral parliament, the National Assembly. The 51 seats of the National Assembly are distributed among 10 districts. There are large discrepancies between the numbers of voters represented by a seat in the various districts. Apportionment methods leading to different seat distributions are explored and compared with each other and with the current one. The comparison is done with respect to the number of voters represented by a seat, the mean majority deficit and the probability that a majority deficit will occur, the influence of a voter in a particular district using the Banzhaf power index, and the influence of a political party relative to the percentage of the popular vote that the party obtained. The method of equal proportions turns out to yield the best results in general.

Keywords: *National Assembly of Suriname, apportionment method, majority deficit, Banzhaf power index*

1. Introduction

The Republic of Suriname, or simply Suriname for short, is a South American country. To the north it is bordered by the Atlantic Ocean, to the east by French Guiana, to the west by Guyana, and to the south by Brazil. Suriname was a colony of the Netherlands from 1667 till 1954. In 1954, Suriname became one of the countries in the Kingdom of the Netherlands, together with the Netherlands and the Netherlands Antilles. In 1975, Suriname became independent. In 1980, there was a military coup, and after some turbulent years a new constitution, which contains the basis of the current electoral system of Suriname, was adopted in 1987. This electoral system was also adopted in 1987. The first elections under this system were held on November 25, 1987. It is this system that is the object of our analysis. Detailed descriptions of the electoral system of Suriname can be found in Galle [11], Martin [14], and Polanen [19].

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Suriname has a unicameral parliament, which is called the National Assembly. It consists of 51 members. For the election of the members of the National Assembly, the country is divided into 10 districts. The districts are very different in size and the number of seats in the National Assembly apportioned to a district is not proportional to the size of the population of the district or the size of the district's electorate. There are advocates for a restructuring of the way the seats are allocated among the districts. This includes a possible enlargement of the National Assembly, cf. Obsession Magazine [15], De Ware Tijd [5], and Organization of American States [16]. Since there will be elections in 2015, this topic is very relevant right now.

In the following sections, the electoral system of Suriname has been analyzed theoretically and empirically using data from past elections. In Section 2, the electoral system of Suriname has been described. In Section 3 it was considered how four well known apportionment methods would allocate the seats in the National Assembly based on the size of the electorate as it was in 2010. In Section 4, weighted majority games and the occurrence of majority deficit was used to compare the various seat apportionments. In Section 5, the theory of simple games and power indices has been applied to analyze the current seat allocation and to arrive at allocations that aim to equalize the voting power of individual voters. The outcome depends on whether we assume that the members of a district vote *en bloc* or not. In Section 6, it was taken into consideration that in Suriname the participants in the election for the National Assembly are political organizations as stated in paper 61 of the constitution. Political organizations enter the election with a list in each district in which they want to compete. It is very likely that political parties but not districts will vote *en bloc*. The data from the election of 2010 has been used to make several comparisons between different apportionment methods under this assumption. Section 7 concluded with a summary of the results obtained in the previous sections.

2. The electoral system of Suriname

Suriname has a mixed presidential-parliamentary government system. This was established in the constitution that was adopted in 1987. For governance purposes, Suriname is divided into 10 districts which vary greatly in population size. The parliament of Suriname is called the National Assembly and consists of 51 members. The 51 seats of the National Assembly are apportioned among the 10 districts in a way that is not proportional to population or electorate size. This allocation of seats was seen as a political compromise to guarantee the more rural and less densely populated districts enough influence. The current arrangement of districts dates from 1983 and is based on a division that came into place in 1948 when general suffrage was introduced. Till then, two-thirds of the members of the parliament were elected by census suffrage with only approximately 2% of the population having the right to vote, while the other third was appointed by the governor, the representative of the Dutch government in Suriname. According to Buddingh [3], the NPS, the political party that had a comfortable majority in the Staten van Suriname, as the parliament was called back then, wanted to make sure that it would maintain its position of power. It only agreed to accept general suffrage if a district system was introduced simultaneously and it made sure that the boundaries of the districts were drawn and the seats were allocated in such a way that it would retain the majority of the seats after the first election with general suffrage. The fact that the followers of the political parties were divided purely along ethnic lines facilitated this design.

The constitution of 1987 stipulates that only political parties may participate in the election for the National Assembly. A party has to submit a list of candidates in each district in which it wants to participate in the election. In each district, the seats pertaining to that district are assigned according to proportional representation using the method of greatest divisors which has been described in Section 3.

The National Assembly elects the president and the vice-president. A two-thirds majority is necessary for this. If after two sessions of the National Assembly no candidate obtains a two-thirds majority, a session of the National Assembly together with the regional councils is called. Such a session can elect a president and a vice-president with a simple majority. The president is both head of state and head of the executive branch of government. As such, he forms a cabinet and the ministers in the cabinet are accountable to him. The vice-president acts as the chair of the cabinet and as deputy of the president.

3. Four apportionment methods

The current allocation of seats among districts, together with the size of the district electorate, in 2010 is given in Table 1. The fourth column in the Table gives the number of (prospective) voters represented by a seat, and the first column gives the per capita representation, that is, the number of seats of a district divided by the number of voters. This last number can be viewed as the share of a voter of a particular district in the National Assembly, and is called the representative share.

From this table, it is clear that there is a huge discrepancy between the number of voters represented by a seat in the largest district and the smallest one. We can also see that a majority which represents only 96 886.75 voters could be reached in the National Assembly, if all of the members from Brokopondo, Commewijne, Coronie, Marowijne, Para, Saramacca, Nickerie, and 3 of the 4 members from Sipaliwini combined their votes. So members representing only 30.03% of the electorate could form a majority in the National Assembly. The difference between the greatest numbers of voters represented by a seat and the smallest number of voters represented by a seat

(Max – Min) is 8767.71. The ratio between these two quantities Max/Min is 1/10.46. The standard deviation of the numbers of voters represented by a seat is 2609.4.

Table 1. National Assembly seat allocation and district electorate size in 2010

District	Size	Seats	Voters per seat	Representative share
Brokopondo	5889	3	1963	0.000509
Commewijne	18 457	4	4614.25	0.000217
Coronie	1854	2	927	0.001079
Marowijne	10 855	3	3618.33	0.000276
Nickerie	22 295	5	4459	0.000224
Para	13 162	3	4387.33	0.000228
Paramaribo	153 236	17	9013.89	0.000111
Saramacca	10 457	3	3485.67	0.000287
Sipaliwini	18 557	4	4639.25	0.000216
Wanica	67 863	7	9694.71	0.000103
Total	322 625	51	6325.98	0.000158
SD	–	–	2609.43	0.000273
Max – Min	–	–	8767.71	0.000976
Max/Min	–	–	10.46	10.46

The problem of the fair allocation of seats among districts of varying size has been studied and discussed extensively in the literature; see for example, Balinski and Young [1], Gallagher and Mitchell [9], and Lucas [11]. In the following, four apportionment methods have been considered that are used in practice to see how each one would distribute the 51 seats in the National Assembly among the 10 districts. During the course of history, each one of these methods has been used to apportion the seats in the House of Representatives of the United States among the states. All four start from the idea that apportionment should be proportional to some measure of magnitude of the district, usually population or electorate size. Exact proportionality will not be feasible in general and each method has a different way of solving this problem. These four methods are

- the method of greatest remainders (GR),
- the method of greatest divisors (GD),
- the method of major fractions (MF),
- the method of equal proportions (EP).

For every real number $x \in R$, the greatest integer less than or equal to x will be denoted by $\lfloor x \rfloor$ and the smallest integer greater than or equal to x will be denoted by $\lceil x \rceil$.

3.1. The method of greatest remainders

This method is also known as Hamilton's method, or Vinton's method or the method of Hare–Niemeyer. It begins by giving every district i its lower quota $\lfloor q_i \rfloor$. The quota q_i of district i is defined as follows

$$q_i = \frac{p_i S}{P}$$

for all $i \in \{1, 2, ..., n\}$. Here S is the number of seats that have to be allocated, P is the size of the total electorate, and p_i is the size of the electorate of district i. In general, there will be seats left over. These are assigned to the districts with the greatest remainders. So district i with the greatest remainder $q_i - \lfloor q_i \rfloor$ will obtain an extra seat, then the district with the next greatest remainder will obtain an extra seat and so on, till all the seats have been assigned.

The other three methods are all divisor methods which determine a district's apportionment by dividing the size of its electorate by a common divisor and rounding the resulting quotient. The way in which the rounding is done is different for each method. The common divisor must be chosen in such a way that the total number of seats assigned to the districts will equal the number of seats in the National Assembly. In the following, the common divisor chosen will be denoted by d.

3.2. The method of greatest divisors

This method is also known as Jefferson's method, or the method of D'Hondt, or the Hagenbach–Bischoff method. This method rounds the quotient down. Hence, the number of seats that district i obtains equals $\lfloor p_i / d \rfloor$.

3.3. The method of major fractions

This method is also known as Webster's method or the method of Sainte Lague. It rounds up if the fractional part of the quotient is greater than or equal to 1/2 and down otherwise. So the number of seats that district i obtains equals

$$\left\lfloor \frac{p_i}{d} \right\rfloor \quad \text{if} \quad \frac{p_i}{d} < \frac{1}{2}\left(\left\lfloor \frac{p_i}{d} \right\rfloor + \left\lceil \frac{p_i}{d} \right\rceil \right) \quad \text{and} \quad \left\lceil \frac{p_i}{d} \right\rceil \quad \text{otherwise}$$

3.4. The method of equal proportions

This method is also known as the Hill–Huntington method. This method uses the geometric mean to decide whether to round up or down. So, the number of seats that district i obtains equals

$$\left\lfloor \frac{p_i}{d} \right\rfloor \quad \text{if} \quad \frac{p_i}{d} < \sqrt{\left\lfloor \frac{p_i}{d} \right\rfloor \left\lceil \frac{p_i}{d} \right\rceil} \quad \text{and} \quad \left\lceil \frac{p_i}{d} \right\rceil \quad \text{otherwise.}$$

Table 2. Allocation of seats in 2010 according to the modified (mod) GR, GD, and MF methods

District	mod GR	mod GD	mod MF	EP	Actual
Brokopondo	1	1	1	1	3
Commewijne	3	3	3	3	4
Coronie	1	1	1	1	2
Marowijne	2	1	2	2	3
Nickerie	3	3	3	3	5
Para	2	2	2	2	3
Paramaribo	24	25	24	24	17
Saramacca	2	1	2	2	3
Sipaliwini	3	3	3	3	4
Wanica	10	11	10	10	7
Total	51	51	51	51	51

When using these four methods to allocate the seats among the districts, we see that each of the four methods assigns more seats to the two most populous districts than the current allocation. In fact, the GD method makes a dictator out of the Paramaribo district by giving it 26 seats. Under the methods of greatest remainders, greatest divisors, and major fractions, the voters of Coronie are not represented at all. So these three methods are not very suitable for deciding an allocation based on the current National Assembly size and districts. They can be modified by guaranteeing Coronie 1 seat, and then allocating the remaining 50 seats among the other 9 districts. For the GD method, this process results in Brokopondo remaining without a representative. To remedy this, Brokopondo also obtains a seat upfront when applying this method, and the remaining 49 seats are distributed among the 8 remaining districts. The results are given in Table 2 together with a column describing the actual seat distribution to facilitate comparison. From Table 2, it is clear that the modified GR method, the modified MF method, and the EP method coincide for the data of 2010. In Table 3, the number of voters per seat for the three modified methods, the EP method, and the current allocation are given together with the standard deviations, difference between maximum and minimum values, and ratios of maximum to minimum values.

Table 3. Number of voters per seat for the four apportionment methods

District	mod GR mod MF EP	modGD	Actual
Brokopondo	5889	5889	1963
Commewijne	6152.33	6152.33	4614.25
Coronie	1854	1854	927
Marowijne	5427.5	10855	3618.33
Nickerie	7431.67	7431.67	4459
Para	6581	6581	4387.33
Paramaribo	6384.83	6129.44	9013.88
Saramacca	5228.5	10 457	3485.67
Sipaliwini	6185.67	6185.67	4639.25
Wanica	6786.3	6169.36	9694.71
Total	6325.98	6325.98	6325.98
SD	1445.81	2391.48	2609.43
Max – Min	5577.67	9001	8767.71
Max/Min	4.01	5.85	10.46

If there are no reasons known to decide otherwise, one would, ideally, prefer that the number of voters per seat were equal for all districts. This comparison of methods is done with this idea in mind. In general, the measure that one uses to determine whether one allocation is closer to the ideal than another will influence the outcome. In our case, the three measures that we consider, namely, standard deviation, difference of maximum and minimum value, and ratio of maximum to minimum are all minimized by the allocation given by the EP method, or by both of the modified GR and MF methods. Using the allocation given by these three methods, the smallest number of voters represented by a majority in the National Assembly is 155 456.62, which is 48.18% of the total electorate. This can be done by combining all the seats of Brokopondo, Commewijne, Coronie, Marowijne, Saramacca, Sipaliwini, and 14 of the seats of Paramaribo. Under the modified GD method, this can be done by combining the seats of Brokopondo and Coronie with 24 of the seats of Paramaribo, resulting in a majority in the National Assembly that represents 154 849.56 voters which is 48.00% of the total electorate.

4. Majority deficit

Simple games, introduced by Shapely and Shubik [17], have been used extensively to model voting situations and situations of committee control. A simple game is a cooperative game $<N, v>$ with $v(S) \in \{0, 1\}$ for all $S \in 2^N$ and with $v(N) = 1$. If $v(S) = 1$, the coalition S is said to be a winning coalition, otherwise S is called a losing coalition.

The situation in the National Assembly, where the members can vote for or against a certain bill, can be described by a weighted majority game, which is a special type of simple game. A weighted majority game is completely described by the weights w_i of the members of N and the quota q of the game. If

$$\sum_{i \in S} w_i \geq q$$

then coalition S is winning, otherwise coalition S is losing. The notation for a weighted majority game is $[q : w1, w2, ..., w_n]$. If we assume that all the members of a district vote as a bloc in the national assembly, then the current situation can be described by the game [26; 3, 4, 2, 3, 5, 3, 17, 3, 4, 7]. A majority deficit occurs in a simple game when the outcome of a voting procedure does not coincide with what the majority wants. Thus the majority deficit is equal to the size of the majority minus the size of the set containing the members who agree with the outcome.

For example, in the weighted majority game given above, if the districts Paramaribo, Wanica and Coronie vote for a bill and the other seven districts vote against it, the bill will be passed. In this situation, the majority deficit is 7 – 3 = 4. The mean majority deficit of a simple game is the average of the majority deficits if all 2^n possible voting profiles are considered to be equally likely. For the current distribution of seats in the National Assembly, the mean majority deficit is 0.38. For the distribution given by the EP and modified GR and MF methods, the weighted majority game is [26; 1, 3, 1, 2, 3, 2, 24, 2, 3, 10] and the mean majority deficit is 0.69 and for the distribution given by the modified GD method the weighted majority game is [26; 1, 3, 1, 1, 3, 2, 25, 1, 3, 11] and the mean majority deficit is 0.71. However, this way of measuring the mean majority deficit does not take into account the fact that the seats from different districts represent different numbers of votes won by a coalition S. A more appropriate way of computing the majority deficit of a certain outcome is to compare the number of voters represented by the members who agree with the outcome with the number of voters represented by the members who disagree with the outcome. If the first number is greater than the second one or equal to it, then the majority deficit of that outcome is 0. Otherwise, it equals the absolute difference of the two numbers. In doing this, we distinguish between the situation in which each district votes as a bloc and the situation in which each member votes independently from the others in his district. The underlying assumption is that a member votes according to the voters he represents. For the purpose of computing, the mean majority deficit in the situation that each member votes independently of the others in his district, we assume that each member of a district represents the same number of voters, i.e., the size of the district's electorate divided by the number of seats of the district. In the context of two tier voting situations with non-binary choices, Maaser and Napel [12] call the difference between the outcome of the voting procedure and the position of the median voter of the electorate the direct democracy deficit.

In Table 4, the mean majority deficit for the situation in which the members of a district vote *en bloc* and the situation in which they vote independently of each other in each of the three weighted majority games described above, which we denote by $W1$, $W2$, and $W3$, respectively, are given. Table 4 also contains the number of times a majority deficit occurs and the probability that it will occur. Majority deficit is abbreviated as MD and Mean Majority deficit as MMD. The majority deficit of an outcome can be viewed as a measure of how much the voting procedure differs from a simple majority rule in which each member of the electorate of the country votes directly for or against a bill, cf. Felsenthal and Machover [7].

Table 4. Mean majority deficit and probabilities of a majority deficit occurring

	10-player game		
MMD	$W1$	$W2$	$W3$
	0.38	0.69	0.71
No. of MDs	176	254	258
Probability of an MD	0.172	0.248	0.252
	Independent voting		
MMD	Actual	EP, mod GR, mod MF	mod GD
	1711.83	75.47	20449.41
No. of MDs	3×1014	7.67×1013	1.02×1015
Probability of an MD	0.133	0.034	0.451
	Voting *en bloc*		
MMD	Actual (bloc)	EP, mod GR, mod MF (bloc)	mod GD (bloc)
	2376.12	1.30	166.70
No. of MDs	76	2	8
Probability of an MD	0.074	0.002	0.008

As such, if the simple majority rule is considered desirable, then some measure involving the majority deficit should be minimized. This could be the mean majority deficit as in Felsenthal and Machover [8], or the probability that a majority deficit will occur as in Feix et al. [6]. In a setting involving non-binary choices, Maaser and Napel [12] study the minimization of the direct democracy deficit. Analyzing the data in Table 4, we see that for the three games $W1$, $W2$, and $W3$, MMD and the probability of an MD are both minimized by the game $W1$ corresponding to the current distribution of seats in the National Assembly. This is not surprising, since the current distribution is the one that equalizes the weights of the districts the most among the three distributions that we consider. Note that by assigning five seats to nine districts and six to one district, a 10 player weighted majority game is constructed in which no majority deficit occurs. Of course, this would create a huge discrepancy between the number of voters represented by a seat in two districts with very different sizes of electorate.

When we take into consideration the number of voters represented by a seat and assume that members representing the same district need not vote *en bloc*, we see that the EP and modified GR and MF methods minimize the MMD and the probability of an MD among the three seat assignments that we consider. It is striking that the current seat allocation performs better in this situation than the allocation prescribed by the modified GD method. Also, in the situation that the members of a district vote *en bloc*, the EP and modified GR and MF methods give the minimum MMD and the minimum probability of the occurrence of an MD. In this situation, the GD method outperforms the current allocation.

Thus if minimizing the mean majority deficit or the probability of a majority deficit is an important consideration, then the allocation given by the EP and modified GR and MF methods should be used.

5. The Banzhaf power index

In Section 3, we considered the occurrence of majority deficit, i.e., situations in which the decision taken favors a minority over a majority, to evaluate the performance of seat allocation schemes. In this section, we will study the influence of each voter on an outcome under each of the schemes considered. It is well known that the weight of a player in a weighted majority game need not reflect accurately the power wielded by that player in the game. Several power indices have been proposed and used to study the power or influence of a participant in a voting situation described by a simple game, cf. Shapley and Shubik [18], Owen [15], Dubey and Shapley [5], Banzhaf [2]. Here, we will use the Banzhaf power index, which was first introduced by Penrose [16] but received little attention till it was reinvented by Banzhaf [2]. The Banzhaf power index measures the influence of a player on the outcome of a simple game by counting the number of times that the player can change the outcome of a voting procedure by changing his vote. In such a situation, the player is said to be a swing voter. Formally, the number of times b_i that player i is a swing voter equals

$$b_i = \sum_{S \ni i} \left(v(S) - v\left(S \backslash \{i\}\right) \right)$$

Here $v(S)$ is the worth of coalition S and, since we are dealing with simple games, $v(S)$ is either 0 or 1. If all the possible ways of the players voting in the game are considered equally likely, then the probability that i's vote will be crucial is given by the Banzhaf power index

$$\beta_i' = \frac{b_i}{2^{n-1}}$$

When it is desirable for the sum of the power indices of all the players to equal 1, we obtain the normalized Banzhaf power index

$$\beta_i = \frac{b_i}{\sum_{i \in N} b_i}$$

The Banzhaf power index β_i' is also called the absolute Banzhaf index in the literature. Felsenthal and Machover [6] call it the Banzhaf measure of voting power. For the three games $W1$, $W2$, $W3$, the Banzhaf power index β' is given in Table 5. These numbers give the power of a district as measured by the Banzhaf power index if we assume that the districts vote *en bloc*. The power of an individual voter in a district can be obtained as follows. If voter v lives in district i with an electorate of size p_i, then the number of times that v is a swing voter in his district is given by

$$\frac{(p_i - 1)!}{\left(\frac{p_i - 1}{2}!\right)^2} \quad \text{if } p_i \text{ is odd}$$

$$\frac{(p_i - 1)!}{\frac{p_i}{2}!\,\frac{p_i - 2}{2}!} \quad \text{if } p_i \text{ is even}$$

Table 5. Banzhaf power indices β_i' for the games $W1$, $W2$, $W3$

District	$W1$	$W2$	$W3$
Brokopondo	0.07812	0.00391	0.00391
Commewijne	0.10938	0.01172	0.00391
Coronie	0.05469	0.00391	0.00391
Marowijne	0.07812	0.01172	0.00391
Nickerie	0.11719	0.01172	0.00391
Para	0.07812	0.01172	0.00391
Paramaribo	0.83594	0.98828	0.99609
Saramacca	0.07812	0.01172	0.00391
Sipaliwini	0.10938	0.01172	0.00391
Wanica	0.15625	0.01172	0.00391
Total	1.69531	1.07814	1.03128

Using Stirling's formula

$$p_i! \approx \sqrt{2\pi p_i}\, p_i^{p_i} \mathrm{e}^{-p_i}$$

we obtain

$$\frac{(p_i-1)!}{\left(\frac{p_i-1}{2}!\right)^2} \approx \sqrt{\frac{2}{\pi(p_i-1)}}2^{p_i-1} \qquad \text{if } p_i \text{ is odd}$$

$$\frac{(p_i-1)!}{\frac{p_i}{2}!\frac{p_i-2}{2}!} \approx \sqrt{\frac{2}{\pi p_i}}2^{p_i-1} \qquad \text{if } p_i \text{ is even}$$

Dividing by 2^{p_i-1} gives us the probability that voter v will be a swing voter in the National Assembly and therefore his relative influence in the National Assembly is given by $\sqrt{\frac{2}{\pi p_i}\beta_i'}$.

Table 6. Relative influence of a voter in each district under different seat distributions

District	$W1$	$W2$	$W3$
Brokopondo	8.12×10^{-4}	4.07×10^{-5}	4.07×10^{-5}
Commewijne	6.42×10^{-4}	6.88×10^{-5}	2.30×10^{-5}
Coronie	10.13×10^{-4}	7.25×10^{-5}	7.25×10^{-5}
Marowijne	5.98×10^{-4}	8.98×10^{-5}	2.99×10^{-5}
Nickerie	6.26×10^{-4}	6.26×10^{-5}	2.09×10^{-5}
Para	5.43×10^{-4}	8.15×10^{-5}	2.72×10^{-5}
Paramaribo	17.04×10^{-4}	$201.44\cdot10^{-5}$	203.03×10^{-5}
Saramacca	6.10×10^{-4}	9.14×10^{-5}	3.05×10^{-5}
Sipaliwini	6.41×10^{-4}	6.86×10^{-5}	2.29×10^{-5}
Wanica	4.79×10^{-4}	3.59×10^{-5}	1.20×10^{-5}
Total	76.68×10^{-4}	262.62×10^{-5}	230.98×10^{-5}
SD	3.43×10^{-4}	58.42×10^{-5}	59.00×10^{-5}
Coefficient of variation	0.45	2.22	2.60
Max – Min	12.25×10^{-4}	197.848×10^{-5}	200.1832×10^{-5}
Max/Min	3.56	56.12	169.53

This result is also known as Penrose's square root rule, since he seems to be the first to have publicly noted it, albeit without a proof.

For the three seat allocations described by the games $W1$, $W2$, $W3$, these numbers are given in Table 6 together with their totals, standard deviations, coefficients of variation, differences between maximum and minimum, and ratios of maximum to minimum. When we look at the numbers in Table 6, we see that the power of a voter in Paramaribo is more than two and a half times the power of a voter in Coronie under the current seat distribution. This is unexpected, since at a glance Paramaribo is very much underrepresented compared to Coronie, because a seat from Paramaribo represents 9014 voters, whereas a seat from Coronie represents 927 voters. The district where the influence of a voter is the smallest is Wanica. The power of a voter from Paramaribo is more than three and a half times that of a voter from Wanica.

Under the two other seat allocation methods which aim at correcting the underrepresentation of the more populous districts, the situation with respect to the power of individual voters is even worse. The power of a voter in Paramaribo is almost thirty times that of a voter in Coronie and more than 166 times that of a voter in Wanica. This occurs in spite of the fact that Paramaribo is still underrepresented compared to Coronie and that a seat from Paramaribo and one from Wanica represent almost the same number of voters. A similar result was found in Curiel [4] when analyzing the electoral system of the Netherlands Antilles. There, a solution was found by constructing a weighted majority game with a quota that is greater than three quarters of the total number of seats in parliament. Since the relative influence of a voter is given by $\sqrt{2/\pi p_i}\,\beta_i'$, it follows that to equalize the power of individual voters in different districts, we have to make the numbers β_i' proportional to $\sqrt{p_i}$. Because fractions of a seat are not assigned in the National Assembly, this cannot be done exactly.

An approximation is given in Table 7 together with the Banzhaf power index that results from this seat distribution and the power of an individual voter in a district. Now a voter from Marowijne has the least amount of influence and one from Paramaribo the most. The power of a voter from Paramaribo is approximately 1.6 times that of a voter from Marowijne. For this distribution of seats, the mean majority deficit is 2642.724 when members vote independently, 9255.473 when they vote *en bloc*, and 0.191406 for the 10-player game that does not take the size of the electorate into consideration. The probabilities of the occurrence of an MD are 0.162372, 0.183594, and 0.087891, respectively. The seat allocation given by the EP and modified GR and MF methods is much better with respect to majority deficit when the size of the electorate is taken into consideration.

The analysis above used the Banzhaf power index of the districts in several 10-player games to arrive at an estimate of the relative influence of a voter in a district. So, each district was considered as a player in a weighted majority game with weight equal to the number of members assigned to the district in the National Assembly. But in cases where the members of a district do not vote *en bloc*, the Banzhaf power index of each member of the National Assembly should be used together with the number of voters represented by a seat. The Banzhaf power index of each member in the corresponding 51-player game equals 0.112275. The power of a voter in district i is given by a similar formula as 1 with p_i replaced by p_i/z_i, where z_i is the number of seats allocated to district i.

Table 7. Relative influence of a voter with a seat distribution such that β_i' is approximately proportional to $\sqrt{p_i}$

District	No. of seats	β_i	$\sqrt{\frac{2}{\pi p_i}}\beta_i$
Brokopondo	3	0.10156	0.00106
Commewijne	5	0.20312	0.00119
Coronie	1	0.04688	0.00086
Marowijne	3	0.10156	0.00078
Nickerie	5	0.20312	0.00109
Para	4	0.15625	0.00109
Paramaribo	13	0.61719	0.00126
Saramacca	3	0.10156	0.00079
Sipaliwini	5	0.20312	0.00119
Wanica	9	0.3475	0.00105
Total	51	2.07811	0.01036
SD	–	–	0.00016
Coefficient of variation	–	–	0.15
Max – Min	–	–	0.00048
Max/Min	–	–	1.62

For the four seat allocations that we considered, Table 8 gives the power of a voter in each district. The most striking feature of Table 8 is the fact that there is quite some similarity in the numbers pertaining to the current seat distribution and the numbers of the seat distribution that aims for proportionality between the β_i' of district i and the square root of the size of its electorate. Since the type of considerations that played a role in arriving at this distribution are not likely to have been considered during the negotiations to arrive at the current seat distribution, this likeness must be due to coincidence. However, it should be noted that a similar effect can also be seen in the distribution of weights and power in the Council of Ministers of the European Community [7]. Further, it can be seen that the EP and modified GR and MF methods perform the best under these circumstances. To equalize the influence of individual voters in this model, the numbers β_i' should be made proportional to $\sqrt{p_i/z_i}$. This is quite hard to achieve, since changing z_i will, in general, change both $\sqrt{p_i/z_i}$ and β_i' with the latter changing in an unpredictable way. Trial and error suggests that the seat allocation given by the EP and modified GR and MF methods cannot be improved upon much.

Table 8. Power of a voter when members in a district vote independently

District	Current	mod GR mod MF EP	mod GD	Proportional to $\sqrt{p_i}$
Brokopondo	0.00202	0.00117	0.00117	0.00202
Commewijne	0.00132	0.00114	0.00114	0.00147
Coronie	0.00294	0.00208	0.00208	0.00208
Marowijne	0.00149	0.00122	0.00086	0.00149
Nickerie	0.00134	0.00104	0.00104	0.00134
Para	0.00135	0.00110	0.00110	0.00156
Paramaribo	0.00094	0.00112	0.00114	0.00083
Saramacca	0.00157	0.00124	0.00876	0.00152
Sipaliwini	0.00132	0.00114	0.00114	0.00147
Wanica	0.00910	0.00109	0.00114	0.00103
Total	0.01515	0.01233	0.00117	0.01481
SD	0.00056	0.00028	0.00032	0.00036
Coefficient of variation	0.39	0.23	0.28	0.24
Max – Min	0.00203	0.00104	0.00122	0.00126
Max/Min	3.23391	2.00211	2.41969	2.52147

6. Voting according to party line

In the reality of Suriname, there are several political parties that participate in all or most districts in elections for the members of the National Assembly (see Table 9). Any vote is considered a vote for a party rather than a vote for a person. A more realistic assumption about the voting behavior of members of the National Assembly is that it will follow party lines. So districts will not vote *en bloc* and members will not vote independently, but members belonging to one party will vote *en bloc*. In this context it is interesting to consider the difference between the percentage of the total vote that a party obtains and the percentage of seats that this outcome yields the party. For the 2010 election there were 9 parties. Table 9 explores this difference. The outcome of the election is taken from surinaamseverkiezingen.azurewebsites.net. The method used to allocate seats to parties in each district in Suriname is the greatest divisor method. The first column gives the name of the party or combination of parties as they participated in the 2010 election. The second column gives the percentage of the popular vote that each party obtained. The third column gives the number of seats in the National Assembly that each party obtained. The fourth column gives the percentage of seats that each party obtained. The fifth column gives the absolute difference between the percentages in the third and fourth columns. The sixth column gives the ratio between the minimum and the maximum of the percentages in the third and fourth columns. The cells that are not filled in are not meaningful in the context under consideration. We see that there is a difference of more than 9 percentage points between the percentage of votes that the A Combinatie obtained and the percentage of seats that this translated into. It is also remarkable that DOE with 5.09% of the popular vote obtained 1 seat, while BVD-PVF with 5.08% obtained no seat. Even more incongruous is the fact that A Combinatie with 4.67% of the popular vote obtained 7 seats.

Table 9. Comparison of the popular vote and current seat allocation

Party[a]	Percent of votes	No. of seats	Percent of seats	Difference	Ratio
Megacombinatie	40.20	23	45.10	4.89	0.89
NFD	31.63	14	27.45	4.18	0.87
A Combinatie	4.67	7	13.73	9.05	0.34
Volksallantie	13.03	6	11.76	1.26	0.90
DOE	5.09	1	1.96	3.13	0.39
BVD-PVF	5.08	0	0	5.08	0
DUS	0.12	0	0	0.12	0
PVRS	0.11	0	0	0.11	0
NU	0.06	0	0	0.06	0
Total	99.99	51	100	27.90	–
SD	–	–	–	2.87	0.37
Max	–	–	–	9.05	–
Min	–	–	–	–	0

[a]NFD – Nieuw Front voor Democratie, Volksal – Volksalliantie voor Vooruitgang, DOE – Democratie en Ontwikkeling in Eenheid, BVD – Basispartij voor Vernieuwing en Democratie, PVF – Politike Vleugel van de FAL (Federatie van Agrariërs), DUS – Democratische Unie Suriname, PVRS – Permanente Vooruitgang van Suriname, NU – Nationale Unie.

Since the number of seats and power as measured by the Banzhaf index are not proportional, the analysis is repeated with the Banzhaf power index replacing the number of seats. In order to be able to compare percentages, the normalized Banzhaf power index expressed as a percentage is used. Looking at Table 10, we see that the situation is even worse when we compare percentage of the popular vote with the normalized Banzhaf power index β_i of the current seat allocation. The maximum difference is almost 15 percentage points. A Combinatie with 4.67% of the popular vote has the same power as NFD with 31.63% of the vote and Volksalliantie with 13.03% of the vote.

It is clear that there will always be differences between the percentage of the popular vote that a party wins and the percentage of seats that it obtains. Therefore, a better indication of how much of this difference is due to the particular district system used can be obtained by comparing the given distribution with the one that would be obtained if the seats were distributed according to overall popular vote, instead of using the district system. This is done in Table 10. To remain consistent, the seats are allocated to the parties using the Greatest Divisor method.

Table 10. Comparison of the popular vote and β_i for the current seat allocation

Party	Percent of votes	Norm. Banzhaf	Difference	Ratio
Mega Combinatie	40.20	50	9.80	0.80
NFD	31.63	16.67	14.96	0.53
A Combinatie	4.67	16.67	12.00	0.28
Volksallantie	13.03	16.67	3.64	0.78
DOE	5.09	0	5.09	0
BVD-PVF	5.08	0	5.08	0
DUS	0.12	0	0.12	0
PVRS	0.11	0	0.11	0
NU	0.06	0	0.06	0
Total	99.99	100.0	50.86	–
SD	–	–	5.18	0.32
Max	–	–	14.96	–
Min	–	–	–	0

From Table 11, we see that the maximum difference between the percentage of seats that a party would obtain under allocation proportional to the popular vote and the current allocation is almost 10%.

Table 11. Comparison of allocation according to the popular vote and the current allocation

Party	No. of seats	Percent of seats	Proportional representation	Percent of proportional representation	Difference	Ratio
Mega Combinatie	23	45.10	21	41.18	3.92	0.91
NFD	14	27.45	17	33.33	5.88	0.82
A Combinatie	7	13.73	2	3.92	9.80	0.29
Volksallantie	6	11.76	7	13.73	1.96	0.86
DOE	1	1.96	2	3.92	1.96	0.5
BVD-PVF	0	0	2	3.92	3.92	0
DUS	0	0	0	0	0	1
PVRS	0	0	0	0	0	1
NU	0	0	0	0	0	1
Total	51	100	51	100	27.45	–
SD	–	–	–	–	3.08	0.34
Max	–	–	–		9.80	–
Min	–	–	–	–	–	0

Table 12. Comparison of β_i for allocation according to the popular vote and β_i for the current allocation

Party	No. of. seats	Normalized Banzhaf	Proportional representation	Normalized Banzhaf	Difference	Ratio
Mega Combinatie	23	50	21	34.62	15.38	0.69
NFD	14	16.67	17	26.92	10.25	0.62
A Combinatie	7	16.67	2	3.85	12.82	0.23
Volksallantie	6	16.67	7	26.92	10.25	0.62
DOE	1	0	2	3.85	3.85	0
BVD–PVF	0	0	2	3.85	3.85	0
DUS	0	0	0	0	0	1
PVRS	0	0	0	0	0	1
NU	0	0	0	0	0	1
Total	51	100.0	51	100.0	56.4	–
SD	–	–	–	–	5.65	0.39
Max	–	–	–	–	15.38	–
Min	–	–	–	–	–	0

Table 13. Comparison of the popular vote and allocation according to EP, mod GR and mod MF

Party	Percent of votes	No. of seats	Percent of seats	Difference	Ratio
Mega Combinatie	40.20	23	45.10	4.89	0.89
NFD	31.63	16	31.37	0.26	0.99
A Combinatie	4.67	5	9.80	5.13	0.47
Volksallantie	13.03	5	9.80	3.23	0.75
DOE	5.09	2	3.92	1.17	0.77
BVD–PVF	5.08	0	0	5.08	0
DUS	0.12	0	0	0.12	0
PVRS	0.11	0	0	0.11	0
NU	0.06	0	0	0.06	0
Total	99.99	51	99.99	20.05	–
SD	–	–	–	2.19	0.41
Max	–	–	–	5.13	–
Min	–	–	–	–	0

In Table 12, a comparison between the normalized Banzhaf power indices and the two different seat distributions is made. We see that the maximum difference is more than 15 percentage points and that in four of the nine cases the difference is more than 10 percentage points. The following tables repeat the analysis given above with the current seat allocation for districts replaced by the one given by the EP and modified GR and MF methods. The seat allocation for the parties in each district is done using the greatest divisor method. The new seat distribution does not change the normalized Banzhaf power index. Therefore, any comparison of the popular vote and the normalized Banzhaf power index will remain the same as given in Table 10. Comparison of the normalized Banzhaf power index for the two situations yields Table 12. From Tables 13 and 14 we see that allocating seats among the districts according to the EP, mod R or mod F methods will decrease the discrepancy between the percentage of the popular vote a party obtains and the percentage of seats it obtains. It will also decrease the difference between the allocation according to the popular vote and the allocation using the district system. However, it does nothing to improve the discrepancy between the percentage of the popular vote of a party and its normalized Banzhaf power index.

Table 14. Comparison of allocation according to the popular vote and according to EP, mod GR and mod MF

Party	No. of seats	Percent of seats	Proportional representation	Percent of Proportional representation	Difference	Ratio
Mega Combinatie	23	45.10	21	41.18	3.92	0.91
NFD	16	31.37	17	33.33	1.96	0.94
A Combinatie	5	9.80	2	3.92	5.88	0.40
Volksallantie	5	9.80	7	13.73	3.93	0.71
DOE	2	3.92	2	3.92	0.00	1
BVD-PVF	0	0	2	3.92	3.92	0
DUS	0	0	0	0	0	1
PVRS	0	0	0	0	0	1
NU	0	0	0	0	0	1
Total	51	99.99	51	100	19.61	–
SD	–	–	–	–	2.16	0.33
Max	–	–	–		5.88	–
Min	–	–	–	–	–	0

7. Conclusions

We have analyzed the electoral system of Suriname from various angles. Since it is clear that under the current distribution there is a huge discrepancy between the numbers of voters represented by a seat in two different districts, we considered alternative apportionment methods in Section 3. Based on the number of voters per seat, the EP method, which gives the same distribution as the modified GR and MF methods, performs the best. In Section 4, we used the concept of majority deficit to compare the performance of various seat allocations. The EP method performs best based on minimization of the mean majority deficit and the probability of the occurrence of a majority deficit. In Section 5, we used the Banzhaf power index to compare the influence of voters in different districts. If the assumption is that the members of a district vote as a block in the National Assembly, then the allocation that assigns seats to districts in such a way that the β_1s are approximately proportional to the square root of the size of the electorate of the district performs best. If we drop this assumption, then the EP method is the best. In Section 6, the analysis was done based on the fact that in Suriname the election for the National Assembly is organized in such a way that one votes for a political party and not for a person. The EP method performs somewhat better than the current seat allocation when this is taken into consideration. In order to keep the paper relatively short, the tables for the seat allocation that make the β_1s proportional to the square root of the district size have not been included, but this allocation performs rather badly when analyzed from the perspective of parties voting *en bloc*.

It is also noteworthy that if we assume that the percentage of votes that a party receives is the same in each district, every method discussed in this paper will make the biggest party, which received 40.20% of the popular vote, a dictator by assigning 26 seats to it. Of course, in the current situation it is highly unlikely that a party will receive the same percentage of votes in each district. Overall this paper demonstrates that the EP method would give a seat distribution that is an improvement of the current seat distribution. In studying the various seat apportionments we did not deviate from the rule that a simple majority (26 votes) is sufficient for the passing of a bill in the National Assembly. In the paper by Słomczyński and Życzkowski [21], a different threshold is proposed for the case in which seats are assigned proportionally to the square root of the electorate sizes. Under certain assumptions this will make the β_1s also approximately proportional to the square root of the electorate sizes causing the power of individual voters to become approximately equal according to Penrose's square root rule. This decision rule has been called the Jagiellonian compromise. For the National Assembly of Suriname, this amounts to changing the threshold from 26 to 35. This threshold is close to the one that is currently needed for the election of the president by the National Assembly, namely 34, which is two-thirds of 51. The threshold of 34 constitutes an improvement with respect to equalizing voters' power for all the seat distributions that we have considered. However, as is to be expected it does not perform as well with respect to MMD.

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