# Analysis of Party Systems by Concentration, Fractionalization, and Entropy Measures

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## 1. Introduction

Analysis of party systems comprises a great number of subapproaches, as is the case in most other studies of political phenomena. To obtain a kind of overall conception of the field I shall attempt to typologize some of these subapproaches.

The study of parties and party systems can take place at three levels: the internal arena of the parties, the electoral arena, and the parliamentary arena.[1] These levels are quite explicit and clear-cut, and thus problems of interpretation hardly arise. Orientations in the analyses of parties and party systems can be explored in the light of another typology, too. This classification, the terminology of which originates from a well-known article by Lazarsfeld and Menzel,[2] is based on the type of variables applied. At least the following approaches are possible: 1) variables describing characteristics of one party only (e.g. ideological orientation of the party, the base of support of the party and changes in it, and cohesion of the party in parliamentary roll-calls), 2) behavioral interrelations between parties (inter-party distances in parliament[3] and outside it, various aspects of coalition formation, etc.), and 3) models and variables describing the party system as a whole.

Variables belonging to the third class can be further subdivided into three classes: *analytic collective variables,* which have been obtained by performing some mathematical operation on some characteristics of individual parties, *structural collective variables* based on interaction relations between parties (e. g. sociometric indices describing the whole party system[4]), and *global variables,* which cannot be further divided into individual components. If this classification is compared with that by Sjöblom one finds that variables describing characteristics of one party can be applied at all levels, while relational and collective variables are applicable only to electoral and parliamentary arenas.

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Variables belonging to the third class can be further subdivided into three classes: *analytic collective variables,* which have been obtained by performing some mathematical operation on some characteristics of individual parties, *structural collective variables* based on interaction relations between parties (e. g. sociometric indices describing the whole party system[4]), and *global variables,* which cannot be further divided into individual components. If this classification is compared with that by Sjöblom one finds that variables describing characteristics of one party can be applied at all levels, while relational and collective variables are applicable only to electoral and parliamentary arenas.

One possible target of party analyses is to investigate the impact of the party

system on the political system *in toto* (it is, of course, possible to investigate the role of the political system in still larger systems). On this basis one is able to construct various alternative models depending on whether the dominant subsystem is the party system, system of interest groups, head of state, or perhaps some foreign power. In the same way it is possible to analyze the dominant subsystems of the whole society. Approaches to party analyses are many, but most politological theories seem to be applicable to many different problems in this field. A good example in this respect is the theory of coalitions, which can be useful in the study of intra-party coalitions as well as in the analysis of electoral and governmental coalitions.[5] Various levels and classes of variables of party studies cannot be separated from each other, but they do have several common points of both a theoretical and an empirical nature.

Data collected and analyzed in the study of parties and party systems are mostly based on voting results: votes within parties, local and national elections, as well as parliamentary roll-calls. With the aid of these data it is possible to construct, in addition to the descriptions of the voting situations per se, more general models describing political and party systems as a whole. On the other hand it is regrettable that party studies concentrate so strongly on voting situations because they can give, even at best, only a partial picture of the activities of the parties and their systems. Additional aspects can be obtained by exploring for instance party finances, communication flows within and between parties, and possible dominance relations between them.

The purpose of this article is to describe and apply some global variables to the description of party systems. It seems that global variables have been applied less frequently than analytic and structural ones.[6] In general one is able to state that global variables can be applied to the analysis of party systems at least in the following ways (some of these measures, however, are quite strongly connected to the description of political systems):

1. Indices of representativeness (e.g. Dahl and Cutright),[7]
2. Stability indices (e.g. Deutsch and Russett),[8]
3. Indices describing 'relations' between the party system and society (e.g. Alford and Lijphart),[9] and
4. Indices of concentration, fractionalization, and entropy.

In this article I am going to explore and apply empirically measures belonging to the fourth class of indices. The article has four main objectives: presentation of various measures of concentration, fractionalization, and entropy, their application to the data generated by parliamentary elections in the Nordic countries after World War II,[10] the investigation of the dimensionality of these indices by correlational analysis, and finally the evaluation of the applicability of these measures in the light of some empirical examples.

## 2. Some Measures of Concentration, Fractionalization, and Entropy

In this section a number of measures and indices will be presented for further application in the empirical part of the study. Of course, all relevant measures cannot be considered here, and for this reason main attention will be paid to those to be applied later. Other measures of interest will be mentioned only in passing.

*Concentration Ratio and Galtung's Measure of Dispersion*

One of the simplest measures of concentration in the electoral power of the parties is the concentration ratio, which has usually been applied to measure the degree of concentration in the size distribution of firms (and in general the approach outlined in this study has its origins in studies dealing with economic concentration).[11] Concentration ratio (CR) measures the proportion of the $k$ largest units of all units, the value of $k$ being usually 4, 8, or 20. In the present connection CR is applied in the way that the share of the *two* largest parties of all votes given is calculated for all Nordic countries and for all postwar elections.[12]

The main deficiency of the concentration ratio is the fact that it does not use all the information provided by a given distribution, but takes into account only a given number of largest units and measures their relative significance. This means that quite different distributions may give quite similar values of CR. A similar deficiency can be discerned in another measure of concentration (or dispersion) to be presented in this section. It is developed by Johan Galtung and its form is as follows:[13]

$$(1) \qquad d = \frac{1 - p_m}{1 - \dfrac{1}{r}} = \frac{r - rp_m}{r - 1}, \qquad 0 \le d \le 1$$

where d = Galtung's measure of dispersion, r = the number of classes in a given percentage distribution, and $p_m$ = the modal proportion.

This index attains its maximum (= 1) when $p_m$ is in minimum, i.e. when $p_m = 1/r$. The index attains its minimum when all the units are concentrated completely on one class of distribution, i.e. when $p_m = 1$. As noted above, the main deficiency of this index is that it does not take into account classes other than the modal proportion, but tells, as a matter of fact, what is missing in modal concentration relative to the maximum possible.

Despite these weaknesses, concentration ratio and Galtung's measure of dispersion will be applied in this study. The reason is that if correlational analysis shows that they measure the degree of concentration or fragmentation in the same way as more complicated measures do, it is vain to use these more complicated indices.

*Rae's Measure of Fractionalization*

Douglas Rae has attempted in several connections to develop indices of fractionalization by which the party systems could be described and compared. Rae defines fractionalization 'as the proportion of pairs of members in a system which contains persons who have voted for (or belonged to) different parties in the last previous election'.[14] Fractionalization defined in this way can be approximated relatively well by the following formula:

$$(2) \qquad F_e = 1 - \sum_{i=1}^{n} T_i^2 , \qquad 0 \leq F_e \leq 1$$

where $F_e$ = the electoral fractionalization of a party system, $T_i$ = the proportion of party i of votes given, and n = the number of parties.

As one can easily see from the formula, $F_e$ is based on two factors: the number of parties and the distribution of their shares of the votes. $F_e$ is at its minimum, i.e. the party system is not at all fractionalized, when one party gets all the votes given. The nature of this formula is such that $F_e$ never attains in practice its maximum value (= 1), because this presupposes an infinite number of equally supported parties. This index of fractionalization has values near unity in case there are, let us say, three to five parties having by and large the same share of the votes. The index applied by Rae is not very original, and in economics, for example, its complement – $\sum T_i^2$ – has been used for a long time under the name of the Herfindahl or the Herfindahl-Hirschman index.[15] What is new in Rae's analysis is its application to the description of party systems.

It was mentioned above that the index of fractionalization is calculated on the basis of the distribution of votes by parties in parliamentary elections, but of course a similar operation can be performed for the distribution of seats in the parliament and thus inquiring into the parliamentary index of fractionalization, $F_p$. This distinction between $F_e$ and $F_p$ must be made because in practice the distribution of votes and the distribution of seats are never completely identical. As a matter of fact the difference between $F_e$ and $F_p$ can be used to measure one aspect of malapportionment, to indicate the deviation from complete proportionality caused by the nature of electoral systems and electoral arrangements.[16] Almost trivial is the finding usually arrived at, that the values of $F_e$ are without exception greater than values of $F_p$, i.e. the methods of distributing seats in the parliament decrease the degree of fractionalization.[17]

Some indications of the properties of the fractionalization index can be explored by investigating the theoretical upper limit of fractionalization in party systems of various sizes (size being measured by the number of parties):

| | |
|---|---|
| 1 = 0.00 | 5 < .80 |
| 2 < .50 | 6 < .83 |
| 3 < .67 | – |
| 4 < .75 | 10 < .90 |

In order to calculate these upper limits it has been assumed that the parties in the system have equal support. These figures indicate the problem that has been already mentioned: After the attainment of a given threshold the increase in the number of parties does not influence the values of the fractionalization index very much; that is, it does not make very much difference whether there are six or eight almost equal parties operating in the system, because the system is strongly fractionalized at any rate. On the other hand this is also a deficiency, because the changes in fractionalization of highly fractionalized systems are illustrated by the measure only to a slight degree. Another deficiency in Rae's index is that it does not give very much weight to the number of parties and its influence in the index values. This deficiency can be easily removed by relating the value to its theoretical maximum in every case (this is done later for entropy measure, see pp. 144 f).[18]

In Table I the degrees of fractionalization in the Nordic party systems in the period 1944–1970 are presented. The rank-order correlation coefficients given at the bottom of the Table have been calculated between time and the degree of fractionalization in the way that a positive correlation indicates increasing fractionalization and negative correlation the opposite (a similar procedure is followed in Tables II and III, too).[19] The correlation coefficient applied is Spearman's rank-order correlation, and the levels of significance are indicated by asterisks (one asterisk meaning the level of .05, and two the level of .01). The fractionalization figures are given by two decimals, as are all other measures presented below.

*Table I. Fractionalization of the Nordic Party Systems*

| Elections | Norway | Sweden | Finland | Denmark |
|-----------|--------|--------|---------|---------|
| 1. | .75 | .70 | .81 | .78 |
| 2. | .74 | .70 | .80 | .74 |
| 3. | .72 | .70 | .80 | .75 |
| 4. | .71 | .70 | .80 | .75 |
| 5. | .72 | .70 | .81 | .74 |
| 6. | .74 | .69 | .83 | .74 |
| 7. | .71 | .71 | .80 | .74 |
| 8. | | .69 | .85 | .73 |
| 9. | | .70 | | .76 |
| 10. | | | | .78 |
| $\bar{x}$ | .727 | .699 | .811 | .751 |
| $F_{max} - F_{min}$ | .04 | .02 | .05 | .04 |
| $r_s$ | −.56 | .00 | .47 | .01 |

The degree of variation in all time-series is quite small, and it is partly due to the nature of the measure of fractionalization noted above, i.e. when the index values are near the upper limit the index is not very sensitive to changes in power relations between parties.

*The Hall-Tideman Index and Variance*

Hall and Tideman point out that the Herfindahl-Hirschman index – and thus Rae's index, too – weights every class of the distribution by its relative size, which

implies that the relative size of units is a more important determinant of the degree of concentration than the absolute number of units. One possible way to emphasize the significance of the number of units – in this case parties – is the weighting of every unit by its rank in the size order. Index $\Sigma\, iP_i$ fulfills this requirement, but one of the remaining deficiencies is its variation between unity and infinity.

This deficiency can be removed by using its inverse number – $1/\Sigma iP_i$ – which Hall and Tideman transform, in order to fulfill some additional requirements, into the following form:[20]

$$(3) \qquad TH = \frac{1}{2\,\Sigma\, iP_i - 1}, \qquad 0 < TH \leqslant 1$$

where TH = the Hall-Tideman measure of concentration, $P_i$ = the share of party i of total number of votes given, and i = rank of party i in the size order.

This measure differs from Rae's measure of fractionalization mainly in the respect that it takes into account the number of parties operating in the system and thus adds a new dimension to the analysis.

One very common, but also apparently suitable way of measuring the degree of concentration in party systems is to calculate some statistical measure of dispersion. There are, of course, several alternatives – range of variation, mean deviation, quartile deviation, etc. being the most simple ones – but the variance is probably the best of these alternatives. Symbols used in the formula hardly need any explication.

$$(4) \qquad s^2 = \frac{\sum\limits_{i=1}^{n} (x_i - \bar{x})^2}{N}, \qquad 0 \leqslant s^2 \leqslant \infty.$$

*Entropy*

Recently social scientists have begun to apply more and more extensively the principle of entropy, originally developed in statistical mechanics, and later applied by Shannon in developing his mathematical theory of information.[21] Entropy and other basic concepts of information theory have been applied to the study of international trade,[22] small group research,[23] study of industrial concentration,[24] and peace research.[25] The degree of entropy can be measured by the distribution of information between a given number of classes. Entropy measures the degree of uncertainty in the information, provided that one knows the distribution of information between various classes. The degree of entropy prevailing in a given system (or distribution) can be measured in the following way:[26]

$$(5) \qquad H_{abs} = - \sum_{i=1}^{n} p_i \; \log_2 p_i$$

in which n = the number of classes in a distribution and $p_i$ = the proportion of elements in a given class of the total number of elements (N).

The entropy measure attains its maximum when every class contains an equal number of elements, i.e. N/n elements, when the information provided by the distribution is at its minimum (in our special case this means that every party has equal support). Entropy is on the other hand at its minimum when all the elements belong to one class. In this case the amount of information is maximal, because one knows with absolute certainty to which class of the distribution an element (a voter, an MP, etc.) belongs. The entropy measure presented above is not, however, completely unproblematic, and some decisions must be made before the application of this measure. The first of these problems is the base of the logarithm. James Coleman, for example, has used in his applications the natural logarithm – the base being thus e – while Galtung has chosen the log₂-base.[27] This decision is made easier by the fact that the base applied in various measures of information theory is usually two. Another rule of thumb is that one can use natural logarithms in the case of continuous distributions, while discrete distributions require two-based logarithm. Thus the use of two-based logarithm appears to be a defensible solution.

Mark Kesselman has also applied in one of his articles a measure derived from information theory, but his measure differs from the entropy formula (H) in two respects: 1) he has used the natural logarithm as the base, and 2) he has added an antilog term to the formula.[28] The use of the natural logarithm and antilog term prevents Kesselman from interpreting his results in the light of ordinary information theory, and he fails to develop any other general interpretation of his results.[29]

In Table II the values of entropy measure, as applied to Nordic party systems, are presented.

*Table II. Absolute Entropy of the Nordic Party Systems*

| Elections | Norway | Sweden | Finland | Denmark |
|---|---|---|---|---|
| 1. | 2.33 | 2.14 | 2.50 | 2.40 |
| 2. | 2.36 | 2.01 | 2.42 | 2.27 |
| 3. | 2.20 | 1.96 | 2.45 | 2.27 |
| 4. | 2.23 | 1.99 | 2.45 | 2.28 |
| 5. | 2.33 | 1.96 | 2.54 | 2.27 |
| 6. | 2.37 | 1.98 | 2.74 | 2.28 |
| 7. | 2.22 | 2.17 | 2.60 | 2.31 |
| 8. | | 2.10 | 2.77 | 2.31 |
| 9. | | 2.11 | | 2.40 |
| 10. | | | | 2.47 |
| $\bar{x}$ | 2.29 | 2.05 | 2.56 | 2.33 |
| $H_{abs, max} - H_{abs, min}$ | 0.17 | 0.21 | 0.34 | 0.20 |
| $r_s$ | .06 | .31 | .83** | .56* |

Another measure of entropy can be obtained by relating the actual (absolute) entropy to its theoretical maximum in the following way:

$$(6) \qquad H_{el} = \frac{H_{abs}}{H_{max}}, \qquad 0 < H_r \leq 1.$$

This entropy measure is called relative entropy, and its main value is that it is normed to vary between zero and one (the upper limit of absolute entropy depends, besides on the shape of distribution, on the number of classes, too). The maximum entropy used in the formula is calculated under the assumption that every party gets an equal share of the votes. The measure of relative entropy cannot be interpreted as easily as the corresponding measure of absolute entropy can be, but it can be said to describe the part of the structure of message the sender can use freely (the complement of the relative entropy – so-called redundancy – describes, on the other hand, the part of the message or symbols whose use statistical rules influence).[30] The meaning of relative entropy can be interpreted in a bit different light, too:

> This measure of relative entropy accepts as a datum the existence of those units already in the system, and then reflects the extent to which the actual degree of concentration as measured by entropy deviates from the maximum attainable *given* the number of units.[31]

In some cases the measures of absolute and relative entropy are not entirely independent of one another. If the number of parties participating in elections is approximately the same – cross-nationally or over time – the maximum entropy remains by and large the same. Thus the only varying figure is the degree of actual entropy, and consequently the two variants of entropy measures correlate very strongly and positively with each other. If, however, there are conspicuous changes in the number of parties, the values of maximum entropy, and consequently the values of relatively entropy, oscillate in a different way than the value of absolute entropy. On the basis of the changes in the number of parties, one can hypothesize that in the case of Finland absolute and relative entropy correlate most weakly with each other, while the correlation is highest in the case of Norway, with Denmark and Sweden as kinds of in-between cases. The values of relative entropy in four Nordic countries are given in Table III.

In addition to indices presented above there are several others which are more or less akin to them. There are Gini coefficient, equal-share point, and the Schultz coefficient as well as various measures of stability and floating voters.[32] They are, however, omitted here, although they might have given some new insights.

*Table III. Relative Entropy of the Nordic Party Systems*

| Elections | Norway | Sweden | Finland | Denmark |
|---|---|---|---|---|
| 1. | .83 | .76 | .89 | .85 |
| 2. | .79 | .78 | .86 | .72 |
| 3. | .73 | .76 | .87 | .81 |
| 4. | .75 | .77 | .87 | .76 |
| 5. | .74 | .76 | .85 | .76 |
| 6. | .75 | .77 | .87 | .76 |
| 7. | .74 | .68 | .82 | .73 |
| 8. | | .67 | .87 | .67 |
| 9. | | .75 | | .72 |
| 10. | | | | .69 |
| $\bar{x}$ | .76 | .74 | .86 | .75 |
| $H_{rel, max} - H_{rel, min}$ | .10 | .10 | .07 | .18 |
| $r_s$ | −.52 | −.61* | −.31 | −.70* |

## 3. Interrelations of Indices

### Some General Remarks

The main task of this section is to investigate the dimensionality of the indices presented by correlational analysis. According to information theory the entropy of a given system is to increase over time, or as Weaver, referring to Eddington, points out: 'The law that entropy always increases – the Second Law of Thermodynamics – holds, I think, the supreme position among the laws of Nature.'[33]

Douglas Rae presents in his study of electoral systems several arguments why similar principles ought to work in the case of fractionalization, too.[34] Johan Galtung, who finds this kind of interpretation quite naïve in the social sciences, presents an alternative theory, maintaining that it is the relationship between the degree of entropy and time that resembles the pendulum movement.[35]

If the correlation of various indices with time are explored, one finds that the 'law of increasing entropy' holds true only in the case of Finland. In other cases correlations are in general quite close to zero, and thus they do not support this hypothesis. Furthermore one can observe that the relative entropy of the Nordic party systems has decreased in all cases, which is due to the fact that the number of parties has increased and this has caused more rapid increase in the maximum entropy than in the actual one. Douglas Rae concluded that the degree of fractionalization has increased conspicuously in only two countries – Finland and Luxemburg – and decreased in only one – West Germany.[36] This indicates that Galtung's hypothesis about the pendulum movement can be regarded from these starting points as the most plausible one, although this hypothesis cannot be verified by linear correlation coefficients. The exploration of the time-series appears to give support to Galtung's assumption.

A general conception of the relationships between various indices can be obtained by looking at the order of the Nordic countries on the basis of their average

values. This 'test' indicates that all indices, except Galtung's measure of dispersion, give the same order of concentration (from least to most concentrated): Finland, Denmark, Norway, and Sweden. At this level of generalization all the indices give commensurable orders in 93 percent of all cases.

## Dimensionality of Indices

The dimensionality of these indices can be investigated in two different ways: by using 1) synchronic data from one time period only, but from several countries, or 2) diachronic data from one country only. The latter alternative appears to me better because of its 'dynamism', although there is the problem of generalization from the case of one country as to the dimensionality of indices. This problem was partly solved by taking into analysis four (Nordic) countries, and thus the diachronic correlations between indices can be compared with each other. It is probable that in synchronic data correlations would have been even higher, because the differences between values of units – in this case countries – on these indices would have been greater.

In Table IV ranges of variation for correlation coefficients are given.

*Table IV. Ranges of the Correlations between Indices*

|        | CR | d       | $F_0$     | TH      | V        | $H_a$    | $H_r$     |
|--------|----|---------|-----------|---------|----------|----------|-----------|
| CR     | –  | .46–.78 | .23–.99   | .65–.98 | .55– .92 | .46–.98  | −.32–.84  |
| d      |    | –       | −.18–.88  | .45–.78 | .25– .88 | .25–.69  | −.98–.69  |
| $F_0$  |    |         | –         | .25–.95 | .80–1.00 | .47–.88  | .18–.66   |
| TH     |    |         |           | –       | .58– .95 | .70–.95  | .02–.82   |
| V      |    |         |           |         | –        | .62–.84  | −.20–.67  |
| $H_a$  |    |         |           |         |          | –        | −.37–.57  |
| $H_r$  |    |         |           |         |          |          | –         |

Closer investigation of Table IV reveals – a bit surprisingly – that some correlations are quite low and some ranges quite large. For these matters two factors are mainly 'responsible'. One of them is Sweden, in the case of which indices correlate quite weakly with each other. Another is relative entropy, which is related in a rather complicated manner to other indices. This pattern is different for different countries. As regards Sweden the situation can be explained partly by the relatively strong position of one party – the Social Democrats – which causes inconsistencies when different methods of calculation are applied. The differentiation of relative entropy from its own dimension is obviously due to its special nature (see p. 144), although the proposed hypothesis about the correlations between absolute and relative entropy does not hold completely true.

In general one can state that the same dimension is most closely approximated by concentration ratio, absolute entropy, and TH index on one hand and the mea-

sure of fractionalization and variance on the other, the latter being to some extent connected to TH index and concentration ratio. Thus one can conclude that the indices analyzed in this article form quite explicit dimensions, and only relative entropy and Galtung's measure of dispersion appear to indicate partly different dimensions of concentration and dispersion. Low correlations of Galtung's index with other ones support a conclusion stated by Alker and Russett that 'measures which concentrate only on a single standard point near the extreme of the distribution are likely to be misleading'.[37] The same conclusion ought to apply also to concentration ratio, but this is not the case, because it correlates to a higher degree with other measures than d does. Results given above also support a conclusion by Hall and Tideman, who mention that CR and TH correlate relatively strongly with each other.[38] Now it is possible to say that the use of CR does not tend to give misleading results, when compared with most of other indices, as I doubted at the beginning of the article.

The ranges of correlation coefficients are relatively great, and therefore the clustering of various indices by countries is investigated. In Figure 1 the clusters, which have been obtained by using the significance of correlation coefficients as a criterion of selection, are presented (the level of significance applied as a criterion was .05, but in practice all the correlations – except Norway, which had only seven elections – exceeded the level of .01. Thus a slightly different criterion was used in the case of Norway, because otherwise she would have had no clusters at all):
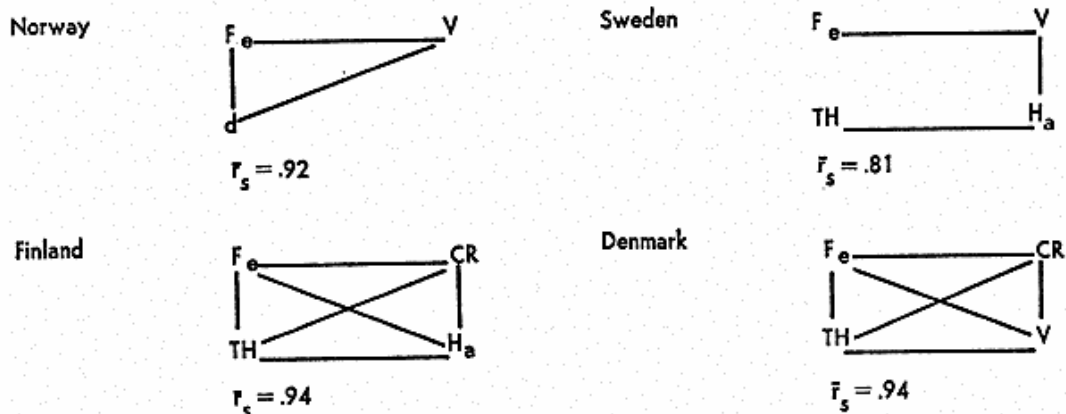


*Figure 1. Clustering of Measures of Concentration in the Nordic Countries.*

Finnish and Danish clusters resemble each other to a great extent, while a common characteristic of Sweden and Norway is that d correlates more strongly with other indices than is the case in Finland and Denmark. This – among other things – justifies the hypothesis that the degree of concentration may influence the relationships between indices (the party systems in Finland and Denmark are the least, the Norwegian and the Swedish the most concentrated).

## 4. Some Applications of Concentration Measures

*Concentration and Political Values*

With the help of fractionalization and concentration measures one is able to for-
mulate some values, applicable at least to the Nordic countries, pertaining to
these factors:

1. $F_e$ must not be too great, i.e. the dispersion of the party system and the existence
   of too many small parties must not occur.
2. $F_e$ may not be too small, i.e. the multi-party system must be preserved (the
   preservation of this value hardly requires very extensive practical measures,
   because the high degree of social differentation and the plurality of political
   forces perform the same task).
3. $F_e-F_p$ must be minimized, i.e. the electoral systems must be as proportional as
   possible.

The realization of these values can be regulated by electoral laws and other po-
litical measures. One factor tending to decrease $F_e$ in Nordic countries is the finan-
cial support given by the state to the political parties represented in the parliament.
Thus their position in elections is improved. Another quite crucial factor is the
size of electoral districts, because the degree of fractionalization in general in-
creases with the increase in the size of districts.

The degree of fractionalization can be reduced – intentionally or not – by various
methods in the distribution of the seats of the parliament. Sweden's new electoral
system gives some interesting examples of these possibilities. An excessive frac-
tionalization of the parliament is partly avoided, for example, by using as the first
divisor in the application of the Sainte-Laguë method 1.4 instead of the unity (the
same practice is followed in Denmark and Norway, too). The percentage limits,
which the parties must exceed before getting seats in the parliament, have an even
more conspicuous impact on the degree of fractionalization (in Sweden this limit
is 4 percent at the national level). These facts indicate that the high degree of
fractionalization is not favored.

There are several strategies for the minimization of $F_e-F_p$, of which one is the
application of Sainte-Laguë's method because it guarantees better proportionality
than d'Hondt's method.[39] Moreover, there are in Sweden efforts toward minimiza-
tion of the difference between $F_e$ and $F_p$ by distributing a given number of seats
of the Riksdag throughout the whole country to increase proportionality. On gen-
eral conclusion, derived from these considerations, is that the first and third value
may be conflicting, and this could result in the application of measures of which
some support the first, some the third political value (this has happened for ex-
ample in Sweden). This matter can be further specified by saying that the first
strategy is typical for big parties, because they can promote in this way the pre-
servation of their power position to some extent. On the other hand the minimiza-
tion of $F_e-F_p$ is the goal of small parties, because the achievement of complete

proportionality would give them the political influence provided by their share of total number of votes.

### Theoretical Background for Applications

Measures of concentration, fractionalization, and entropy can be used in empirical analysis in two ways: as independent or dependent variables. In the latter case an explanation of the changes in the degree of concentration of party systems can be attempted, for example by changes in social structure (income distribution, structure of the economic system, etc.). One could hypothesize very preliminarily that especially rapid transitions in the social change are prone to change the nature and structure of the party system.

Another strategy is to apply measures of concentration to the explanation of the intensity and direction of the activities of political and party systems. As regards the index of fractionalization developed by Rae, there is not very much theoretical background for its use; its applications have been restricted almost completely to empirical descriptions. Instead, there is a rich theoretical background for the use of entropy measures in this respect (this applies especially to the measure of absolute entropy on which the following presentation relies quite heavily).

Interpreting in terms of social science, increasing absolute entropy means increase in uncertainty and decrease in predictability, especially in the behavior of the members of a given system. One can speak of *actor entropy* and *interaction entropy*. The former is based on the distribution of members among various positions and the latter on the distribution of interaction relations between members.[40] Entropy/uncertainty is thus a factor describing a system as a whole and thus differs quite crucially from Downs' conception according to which 'uncertainty must refer to particular events; it is not a general condition'.[41]

Concentration measures of the party system describe the actor entropy, i.e. the distribution of parties to various positions on the basis of their support. Interaction entropy is illustrated by Johan Galtung in the following way:

> ... interaction will proliferate; not only in the sense that there will be interaction in more dyads but also in the sense that interaction will be more diffuse, cover more aspects of actors. In short, the interaction network tends to be complete.[42]

Galtung does not consider more closely the relationship between actor entropy and interaction entropy. I assume, however, for empirical examples that the 'proliferation of interaction' is due to the increase in actor entropy. On this basis some hypotheses are presented in the next section and tested – to the extent that it is possible.

### Some Empirical Examples

The examples to be presented do not attempt to completely exhaust the ways of applying various measures of concentration. My aim is rather to show that they

are really worth applying and have at least some explanatory power. In this section three of the measures will be applied: index of fractionalization and absolute and relative entropy. In general the data used originate from Finland's political system,[43] although the measures of concentration were calculated for all Nordic party systems. The omission of other Nordic countries is due partly to the difficulties in data collection – e.g. duration of cabinet negotiations – partly to the lack of variance in some variables – e.g. the size of cabinet in Sweden.

From Galtung's statement about the interaction entropy the following hypothesis, dealing with the activities of the party system, can be derived:

$H_1$: Decrease in the concentration of the party system means the increase in the cooperation between parties and greater proportion of the possible coalition alternatives will be availed.

It appears, however, to me that the effects of the changes in the degree of concentration cannot be seen immediately after elections. Rather it takes some time before the change in the degree of concentration – i.e. in the actor entropy – influences the activities of the system – i.e. interaction entropy. Obviously the impact of the degree of concentration weakens in the course of time.[44] On this basis I hypothesize that:

$H_2$: The impact of the changes in the degree of concentration on the activities of the party system is strongest immediately after elections and becomes weaker later on.

In this connection two indicators of the activities of the party systems are applied, viz. the number of parties in the cabinet and the proportion of actually used coalition alternatives of all theoretically possible alternatives.[45]

The status of $H_2$ is tested by calculating the correlation coefficients with the action variables separately for the first value of the variables after elections and for the average of other values during a given election period.

*Table V. Correlation between Concentration and the Number of Parties in Cabinet*

|                      | $F_e$ | $H_a$ | $H_r$ |
|----------------------|-------|-------|-------|
| First cabinet        | .76*  | .76*  | −.06  |
| The average of others| .33   | .65   | .24   |

Correlation coefficients ($r_s$) marked with an asterisk are significant at the level of .05.

If the correlations of the number of parties with relative entropy is for a moment left uninterpreted, the hypotheses presented are completely sustained.[46]

*Table VI. Correlation between Concentration and the Use of Coalition Alternatives*

|  | $F_e$ | $H_a$ | $H_r$ |
|---|---|---|---|
| First cabinet | .74* | .59 | .49 |
| The average of others | .30 | .18 | −.32 |

Increasing fragmentation and entropy tend to increase the proportion of coalition alternatives used. I am again in a position to state that the principles derived from the information theory can be applied quite well to the description of the activities of party systems.

The following hypothesis deals with the relationship between concentration/ entropy and the time needed for political decision-making. This hypothesis is derived rather from the 'common knowledge' of social sciences than from the theory of information.

H₃: Decrease in the concentration of the party system means increasing complications in decision-making and increasing duration of the decision-making process.

The indicator of decision-making used in this connection is the duration of negotiations between parties for the formation of a new cabinet, which supposedly describes quite well the activity of the party system in this respect.

*Table VII. Correlation between Concentration and Duration of Decision-Making Process*[17]

|  | $F_e$ | $H_a$ | $H_r$ |
|---|---|---|---|
| First cabinet | −.03 | .26 | −.74* |
| The average of others | .06 | .08 | −.43 |

If the investigation of the correlates of the relative entropy is again postponed for awhile, one can conclude that correlations are so low that the hypothesis is neither verified nor falsified, but that these two factors are not linearly dependent on each other.

Another hypothesis to be derived from outside the realm of information theory concerns the relationship between concentration and political instability. In general scholars tend to claim that the decrease in the concentration of the party systems — measured in one way or another — tends to lead to political instability, i.e. to short-lived cabinets. The same trend is indicated by an exploration of the Nordic party systems: the higher the average of the concentration indices, the fewer governments in the postwar period. In other words:

H₄: The decrease in the concentration of the party system implies increase in political instability.

The weakening impact of the actor entropy over time, mentioned in $H_2$, can be connected with this hypothesis, too. The indicator of political instability used here is the age of the first post-election cabinet and average age of other cabinets during the same election term as well as the number of cabinets during this term.

*Table VIII. Correlation between Concentration and Political Instability*

|                           | $F_e$ | $H_a$ | $H_r$ |
|---------------------------|-------|-------|-------|
| Age of first cabinet      | .58   | .26   | .31   |
| The average age of others | −.49  | −.54  | .21   |
| Number of cabinets        | −.19  | −.42  | .29   |

Correlations between $F_e$ and $H_a$ on the one hand and political instability as measured by the age of the first cabinet on the other hand, point in the direction predicted in $H_4$. After the first cabinet, a high degree of fractionalization no longer increases political instability; the situation is, rather, the opposite. Correlations between concentration, $F_e$ and $H_a$, and number of cabinets point in the same direction. In this particular case it would be reasonable to analyze more closely the essence of current thinking about the relationships between concentration and political instability, because the results given above indicate – although they do not prove this point – that the effects of increasing fragmentation do not necessarily need to be negative. But it may lead to a kind of 'creative disorder' (i.e. increasing 'disorder' may lead in some cases to the stabilization of political life). For the sake of comparison one can mention the result found by Taylor and Herman, who are using synchronic analysis of nineteen nations, that parliamentary fragmentation is negatively correlated with governmental stability ($r = -.45$).[48]

The interpretation of the correlates of the relative entropy has been postponed until now. As noted above relative entropy measures the degree of entropy after the number of units is controlled for. The main finding is that increasing relative entropy makes the decision-making process in the formation of the cabinet shorter, i.e. the more rapidly the theoretically maximum entropy increases – with the introduction of new parties into system – as compared with the actual antropy, the shorter is the period required for the formation of a new government.

## 5. A Comment

One of the main functions of this analysis has been to explore the applicability of some principles of information theory and in general the possibility of explaining the activities of party systems by systemic factors. In my opinion some of the empirical examples given indicate that collective global measures of party systems can be used to explain tendencies in political life, although in some cases – e.g. the

cabinet negotiations – the explanatory power of these measures is not very good. There is, however, no doubt of the fact that these types of approaches to the analysis of political systems are worth further development.

NOTES

1. Gunnar Sjöblom, *Party Strategies in a Multiparty System*, Lund: Studentlitteratur, 1968, Chapters 9, 10, and 11.
2. Paul Lazarsfeld and Herbert Menzel, 'On the Relations between Individual and Collective Properties', in Amitai Etzioni (ed.), *Complex Organizations. A Sociological Reader*, New York: Holt, Rinehart and Winston, 1961, pp. 422–440.
3. On approaches to this problem see Mogens N. Pedersen, 'Consensus and Conflict in the Danish Folketing', *Scandinavian Political Studies*, Vol. 2, Oslo: Universitetsforlaget, 1967, pp. 143–166; and Pekka Nyholm, *Mångpartisystemet i ljuset av en mångdimensionell modell*, Research Reports No. 20, Helsinki: Institute of Political Science, University of Helsinki, 1970.
4. Some applications of these indices are given in Raimo Väyrynen 'A Case Study of Sanctions. Finland–the Soviet Union in 1958–1959', *Cooperation and Conflict 4*, 3 (1969), pp. 224–227.
5. An excellent presentation of the most recent developments in the field of coalition theory is Sven Groennings, E. W. Kelley and Michael Leiserson (eds.), *The Study of Coalition Behavior. Theoretical Perspectives and Cases from Four Continents*, New York: Holt, Rinehart and Winston, 1970.
6. When applying contextual analysis Tapani Valkonen has come to the same conclusion; see his 'Yhteisön vaikutukset yksilöön ja niiden kvantitatiivinen tutkiminen' with English summary 'Contextual Effects and their Quantitative Analysis', *Politiikka 12*, 1 (1970), pp. 12–15.
7. See e.g. Robert Dahl, *A Preface to Democratic Theory*, Chicago: University of Chicago Press, 1956, pp. 84–86.
8. See e.g. Karl W. Deutsch, 'Toward an Inventory of Basic Trends and Patterns in Comparative and International Politics', *American Political Science Review 54*, 1 (1960), pp. 34–57.
9. See e.g. Robert Alford, *Party and Society*, Chicago: Rand McNally, 1963; Arend Lijphart, 'Class Voting and Religions Voting in the European Democracies: a Preliminary Report', *Acta Politica 6*, 2 (1971).
10. Data originate from Derek Urwin (ed.), *Elections in Western Nations, 1945–1968*, Occasional Paper No. 4–5, Glasgow: Survey Research Centre, University of Strathclyde, 1969 (mimeo); Stein Rokkan and Jean Meyriat (eds.), *International Guide to Electoral Statistics, Vol. I, National Elections in Western Europe*, The Hague and Paris: Mouton, 1969; and *Keesing's Contemporary Archives 1969–1970*.
11. For examples of economic studies in this field see M. A. Adelman, 'The Measurement of Industrial Concentration', *Review of Economics and Statistics 33*, 4 (1951), pp. 269–296; M. A. Utton, *Industrial Concentration*, Manchester: Penguin Books, 1970, esp. pp. 35–50; and P. E. Hart and S. J. Prais, 'The Analysis of Business Concentration: A Statistical Approach', *Journal of the Royal Statistical Society 119*, Part 2 (1956), pp. 150–181.
12. Because of space limitations it is impossible to present here the values of all indices. Those interested can find them from the earlier Finnish version of this study 'Puoluejärjestelmien kuvaaminen keskittymis-, fragmentoitumis- ja entropiamittojen avulla', *Politiikka 13*, 4 (1970), pp. 312–314.
13. Johan Galtung, *Theory and Methods of Social Research*, Oslo: Universitetsforlaget, 1967, pp. 213–214.
14. See Douglas Rae, *Political Consequences of Electoral Laws*, New Haven: Yale University Press, 1967, pp. 53–58; Douglas Rae, 'A Note of the Fractionalization of Some European Party Systems', *Comparative Political Studies 1*, 3 (1968), pp. 414–416; and Douglas Rae and Michael Taylor, *The Analysis of Political Cleavages*, New Haven: Yale University Press, 1970, pp. 24–33.

15. See Adelman, *op.cit.*, and Marshall Hall and Nicolaus Tideman, 'Measures of Concentration', *Journal of the American Statistical Association 62* (1967), p. 165.

16. On the ways of measuring this phenomenon in general see Glendon Schubert and Charles Press, 'Measuring Malapportionment', *American Political Science Review 58*, 2 (1964), pp. 302–327.

17. According to Rae's analysis (*op.cit.*, 1968, p. 417) the average of $F_e$–$F_p$ was 0.04 (N = 20). As to the Nordic countries, the difference was greatest in the case of Norway (0.06), with Finland (0.03), Sweden (0.02), and Denmark (0.01) following in that order. See also Rae, *op.cit.*, 1967, pp. 79–84.

18. The formula is exactly derived by Markku Laakso, M.A., from the Institute of Political Science, University of Helsinki, but its presentation is omitted here because of space limitations.

19. Table I differs from an article by Rae (*op.cit.*, 1968) mainly in the way Rae has calculated the average degree of fractionalization in postwar elections, while I have tried to give diachronic data on degree of fractionalization in Nordic countries. Erik Damgaard has presented the values of $F_e$ for Denmark in the period 1903–1968, see his 'The Parliamentary Basis of Danish Governments: The Patterns of Coalition Formation', *Scandinavian Political Studies*, Vol. 4, Oslo: Universitetsforlaget, 1969, pp. 30–31. Diachronic information on the degree of fractionalization, applying $F_p$, for almost all relevant countries is given in Arthur Banks, *et al.*, *Cross-Polity Time-Series Data*, Cambridge, Mass.: MIT Press, 1971, pp. 283–295.

20. Hall and Tideman, *op.cit.*, pp. 165–166.

21. Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication*, Urbana, Ill.: University of Illinois Press, 1963, pp. 18–26.

22. See e.g. W. R. Bihn, *Die informationtheoretische Messung von Struktursystemen des internationalen Handels. Grundlagen und statistische Methoden*, Freiburg im Breisgau: Rudolf Haufe Verlag, 1967; and Kyösti Pulliainen, 'Entropy-Measures for International Trade', *The Swedish Journal of Economics* (1970), pp. 40–53.

23. James Coleman, 'The Mathematical Study of Small Groups', in H. Solomon, J. S. Coleman, and E. W. Adams (eds.), *Mathematical Thinking in the Measurement of Behavior*, Glencoe, Ill.: The Free Press, 1960, pp. 65–69 and 113–116.

24. H. Theil, *Economics and Information Theory*, Amsterdam: North-Holland Publishing of Chicago, Rand McNally, 1967; and Ira Horowitz, 'Employment Concentration in the Common Market: An Entropy Approach', *Journal of the Royal Statistical Society 133*, Part 3 (1970), pp. 463–479.

25. Johan Galtung, 'Entropy and the General Theory of Peace', *Proceedings of the Second IPRA Conference, Vol. I, Studies in Conflicts*, Assen: Gorcum & Comp., 1968, pp. 3–37; and Uolevi Arosalo, *Methods for the Study of Social Change*, Research Reports 49, Tampere: Research Institute of the University of Tampere, 1968, pp. 100–107 (mimeo, in Finnish).

26. Shannon and Weaver, *op.cit.*, pp. 19–20. The formula for H is derived in Appendix 2, pp. 82–83.

27. Galtung, *op.cit.*, 1967, p. 214.

28. Mark Kesselman, 'French Local Politics: A Statistical Examination of Grass Roots Censensus', *American Political Science Review 60*, 4 (1966), pp. 968–969. Antilog term means the raising of the base to some power. In other words the formula used by Kesselman, $H = \text{antilog} \left[ - \sum p_i \log_2 p_i \right]$ equals $2^H$.

29. See also Rae and Taylor, *op.cit.*, pp. 121–122.

30. See Shannon and Weaver, *op.cit.*, pp. 25–26 and 103–104.

31. This definition is adapted from Horowitz, *op.cit.*, p. 469. See also Wendell Garner, *Uncertainty and Structure as Psychological Concepts*, New York: John Wiley, 1962.

32. On the three first-mentioned measures see Hayward Alker, Jr. and Bruce M. Russett, 'On Measuring Inequality', *Behavioral Science 9* (1964), pp. 212–215; Hayward Alker, Jr., *Mathematics and Politics*, New York: Macmillan, 1965, pp. 29–53. The latter measures are reviewed, for instance, in Pertti Timonen, *The Stability of the Composition of the Finnish Parliament since the Second World War*, Research Reports No. 18, Tampere: Institute of Political Science, University of Tampere, 1971 (mimeo, in Finnish); and

R. D. Masters, 'Une Méthode pour Mésurer la Mobilité des Attitudes Politiques', *Revue Française de Science Politique 10*, 3 (1960), pp. 658–672.

33. Shannon and Weaver, *op.cit.*, p. 103.
34. Rae, *op.cit.*, 1967, pp. 82–83 and 141–142.
35. Galtung, *op.cit.*, 1968, pp. 27–34.
36. Rae, *op.cit.*, 1967, p. 83.
37. Alker and Russett, *op.cit.*, pp. 216–217.
38. Hall and Tideman, *op.cit.*, pp. 166–167.
39. For some general considerations concerning these topics see Douglas Rae, Victor Hanby and John Loosemore, 'Thresholds of Representation and Thresholds of Exclusion', *Comparative Political Studies 3*, 4 (1971), pp. 479–488.
40. Galtung, *op.cit.*, 1968. pp. 7–9.
41. Arthur Downs, *An Economic Theory of Democracy*, New York: Harper and Brothers, 1957, p. 78; see also pp. 80–81 and *passim*.
42. Galtung, *op.cit.*, 1968, pp. 23–24.
43. Data illustrating the activities of the Finnish party system originate mainly from the following publications: Klaus Törnudd, 'Compositions of Cabinets in Finland', *Scandinavian Political Studies*, Vol 4, Oslo: Universitetsforlaget, 1969, pp. 58–70; Veli Merikoski, 'Hallituksen muodostaminen Suomessa' (Formation of Government in Finland), with English summary, *Politiikka 9*, 1 (1967), pp. 1–15; and Jaakko Nousiainen, *Finlands politiska system*, Stockholm: Svenska Bokförlaget (Norstedt), 1966.
44. Cf. Galtung, *op.cit.*, 1968, pp. 27–34.
45. In this connection one must recall that the number of theoretically possible coalitions is not the same as the number of these that are politically possible. Cf. Sjöblom, *op.cit.*, pp. 269–272: 'Most theoretically possible coalitions are not politically possible... A basic condition is that parties in coalition must always depart in some respects from their evaluation systems and/or declared standpoints in order to reach a mutual standpoint.
46. The base of support of the cabinet in the parliament was also used as a variable in this connection. Its correlations were lower (.38–.48 in the case of the first cabinet) than those given in Table V, but otherwise they were very similar.
47. The length of cabinet crisis, calculated from the cause of resignation of the former cabinet, was used as an alternative indicator, but its correlates did not differ essentially from those presented.
48. Michael Taylor and V. M. Herman, 'Party Systems and Government Stability', *American Political Science Review 65*, 1 (1971), p. 31.