LAWS OF DEVELOPMENT OF INTERNATIONAL SYSTEMS

by

Ib Damgaard Petersen.

In the opinion of the author,mechanical and biological analogues are insufficient as models for the description of social systems.Social systems are open to information and ever changing in their responses to external and international changes.What keep social systems together are flows of information.A suitable term for social systems would then be "information-systems"and a suitable model for such systems the cybernetic system.

According to Ashby cybernetic systems are most simply described by means of the cybernetic principles governing their development over time. Such laws of development are conditioned by a number of background factors.It is a basic condition for the description of an open system that such background factors remain constant for a certain period.Only if this condition is fulfilled,a law of development for the system can be determined.Such conditioning factors would change from time to time and consequently change the laws of development of the systems under consideration.

Owing to its presumably anarchic character,however,the international system has not usually been considered as a cybernetic system.Even then it could be argued,that the discipline of international politics has in reality been concerned with regulation and control of the international system,either in the form of a body of law,through the balance of power or by means of some ideal regulator destined to rid the international community of the scourge of war.The discipline has also taken a deep interest in the controlled transformation of the system to a more integrated state,be it the integration of nations into a security system,or the development of a world government.Marxist scholars have displayed great interest in the world wide spread of the capitalist system and in the controlled transformation of this system into a socialist world order. In our view the basic thrust of the discipline should then be the analysis of the international system as a cybernetic system.

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This means a refutation of the idea that the anarchic character of the system precludes the regulation of the system.Our contention would be that one should accept the Grotian perspective of the international system in a modern version as a cybernetic system guided by discernable laws of development.(1)

<u>The methodological problem of the discipline of international politics. Analytic methods versus holistic theory.</u>

Cybernetics is part of systems theory,and systems theory in its more modern versions was introduced in international politics in the late fifties.(2)At the same time the "scientific" way of studying international politics was introduced,inspired by the natural sciences and behaviorism.(3)

The great success of modern physics was based on quantification and analytic methods,which means that it is only partly possible to combine systems theory as a holistic theory for social systems with the methods taken over from the natural sciences.

In the natural sciences the preoccupation is with the analysis of the characteristics and quantities of the elemental components,held in isolation for the purpose of study.The method is summative,deducing the meaning of a whole from a knowledge of the character of its elementary parts.(4)

The basic thrust of our criticism is that social systems should be treated as wholes with structures changing from time to time in accordance with some steering function and that any way of treating social entities as physical matter would destroy the structural and cybernetical characteristics of the system.

Judging from the reappraisals of both systems theory and quantitative international politics in the sixties and the seventies,the problem is a burning one.

The modern paradigm of World Politics has enlarged the scope of the discipline,but left one of the most crucial problems unsolved.The present article is concerned with the solution to this problem.

The open system.

Open systems might be considered as consisting of a number of subsystems which would be activated or deactivated in accordance with another system, the steering function of the system.
This means that social systems form and dissolve,according to the combination of goals with these instrumental activities that are thought to be suitable,given internal and external conditions.
Such subsystems might be a conference of a certain kind or the decision to implement activities of a certain kind,provided we stay at the level of the decision-maker.
If for example we were to observe a subsystem such as a diplomatic conference,we would have to reckon with many background factors,as for instance an agreement that a conference should take place,an agreement as to the time and place,agreement on the agenda etc.,etc..
This notion of an open system,always changing and yet operating through a finite number of subsystems,activated in accordance with the steering function and the combined external and internal situation of the whole system,might well be supplemented by other theoretical observations.
In 1971 the American sociologist Harrison White presented an interesting theory of society as a complex network of communications systems.(5)
The concept of role was seen as a person functioning as a node in a communications network.A person appearing in a role was simply connecting himself with a special communications network through which a message was sent to some other node.
What holds society together,according to Harrison White,is then the amount of real time spent by individuals in a set of role-frames.
However,as the person would be moving from one role-frame to another in a random way,one could not just measure the time spent in each role in order to understand the functioning of the system.
This is where stochastic models come in.

The Weibull distribution.

For ten years the Danish ethologist,Iven Reventlow,worked with the Danish statistician,Georg Rasch,in order to describe animal behavior by means of stochastic models.(6)

They worked for a long time with the poisson model on the basis of time measures of different kinds of animal behavior,but finally settled for an extension of the poisson model,known as the "Weibull-distribution". The Weibull-distribution as a time process can be considered a simple extension of the time-process equivalent with the poisson-process which can be specified as:

$$P\{T \leq t \ \lambda\} = 1 - e^{-\lambda t} \qquad (1)$$

The extension consists in a new parameter representing an exponent to the variable t.If this extension is made the cumulated distribution function could be written:

$$P\{T \leq t \ \lambda,\alpha\} = 1 - e^{-\lambda t^{\alpha}} \qquad (2)$$

(For the modified poisson-process,see:"Rasch laerebog i statistik",vol.I, p.267,Teknisk forlag,Copenhagen 1968)
In this expression P is a symbol of probability,T a stochastic time-variable,t a certain value of time(an observation of T),e the log base of the natural logarithm,alfa and lambda parameters constant for each observation,i.e.a number of values of the variable T.
In order to interpret the model we should look at the conditional probability of a change in the situation observed in the time span$(t+\Delta t)$ subject to the condition that no change has occurred up to time t.
This conditional probability(the intensity)could be written as follows:

$$P\{t\leq T\leq t+\Delta \ t|T>t\} = \frac{P\{t\leq T\leq t+\Delta t\}}{P\{T>t\}} = \frac{P\{T>t\} - P\{T>t+\Delta t\}}{P\{T>t\}}$$

If we divide both sides by Δt we get:

$$\frac{P\{t\leq T\leq t+\Delta t|T\geq t\}}{\Delta t} = \frac{P\{T>t\} - P\{T>t+\Delta t\}}{\Delta t} \quad \frac{}{P\{T>t\}}$$

If we let $\Delta t \rightarrow 0$ we get the limit value:

$$\lim_{\Delta t\rightarrow 0} \frac{P\{t\leq T\leq t+\Delta t|T\geq t\}}{\Delta t} = - \frac{dP\{T>t\}}{dt} \cdot \frac{1}{P\{T>t\}} =$$

$$\lambda\alpha t^{\alpha-1} e^{-\lambda t\alpha} e^{\lambda t\alpha} = \underline{\lambda\alpha t^{\alpha-1}} \qquad (3)$$

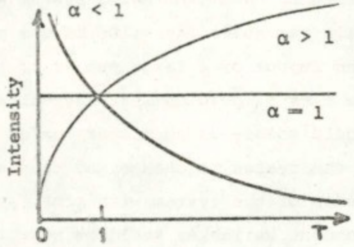
This expression we can analyse:

a)if $\alpha = 1, \lambda\alpha t^{\alpha-1} = \lambda$ which means that we have returned to the conventional poisson-process.

The intensity of the occurrence of the phenomena in question is unrelated to the time passed.

b)if $\alpha < 1, \lambda\alpha t^{\alpha-1}$ will decrease as time goes on.The probability for a change in an interval of the magnitude Δt will decrease with the time passed since the last change.

c)if $\alpha > 1, \lambda\alpha t^{\alpha-1}$ will increase with an increase in t.The probability for a change in the interval Δt will increase with the time passed since the last change.



Graph showing the variation of the intensity as a function of time for three different values of alfa(the above cases a-b-c).

Returning to Harrison White,we might view the appearance of a person in a certain role as the occurrence of an event of a certain subsystem,and the proper way to handle the description of this subsystem would be a longitudinal analysis,measuring time intervals between the appearances in this role.

The very random character of these appearances was the clue to the stochastic model,just as their character of events was the clue to the point-process in continous time.

Changes in the parameters of the distribution from time to time would reveal either changes in the priority scheme,and thus internal changes, or in the kind of messages destined for the person and communicated through the different networks,i.e.external circumstances,the situation confronting the person.

The priority scheme would present the steering function of the person. This could be directly related to the interaction theory and to the cybernetical characteristics of social systems,effectuated through decision-makers.

Another interesting point in our view was the three states of the system indicated by differing values of the parameter alfa(shown above in graphical form).These three states of the system could be interpreted as dynamic equilibrium(alfa equal to 1)or controlled change(alfa differing from the value of 1).In the last two cases the process either accellerates og decellerates monotoneously.

This way we have described an open cybernetic system without splitting up its parts into analytic variables.The value of the parameters would result from the combined impact of a large number of factors which taken together determined the laws of development.Observations of changes in parameters over time would enable us to discern major changes in some of the factors,causing the system to change,and thus would allow us to look into the relationship of the system with other systems.The notion of dependent and independent variables would be substituted for a relationship between systems.A mapping of the interrelationship between many interacting systems would be possible.The question of demarcating a system and the question of system change would have been solved by reference to the cybernetic laws and the changing of these laws at certain time-points. In the Harrison White case several role-frames could be observed at the same time and simultaneous changes in parameters in these dimensions would allow us to discern combination models combining activities with goals in multidimensional decision-making,as theorized by the Danish operations analyst Erik Johnsen.(7)
As the model is invariant to the scale we would be able to make exact comparisons between processes,even if we changed from one time unit to another.
The structure of very different systems could be compared.

Testing the model.

The empirical material for the test of the model consists of a series of values of a continous variable time,representing the time elapsed between the occurences of events.

$$(t_1,t_2.......t_n)$$

We assume these values to be n independent measures of a stochastic variable T for which the Weibull distribution holds.
Consequently also the following holds:

$$P\{T \geq t\} = e^{-\lambda t^{\alpha}} \qquad \text{for } t \geq 0 \qquad (4)$$

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In order to formulate a test of the model for the data we proceed in the following manner:
We take the logarithm of both sides of equation (4)

$$\log_{10}(P\{T \geq t\}) = \frac{-\lambda t^{\alpha}}{\log_e 10}$$

If we multiplicate with - 1 and again take the logarithm we get:

$$\log_{10}(-\log_{10}(P\{T \geq t\})) = \log_{10}\lambda + \alpha\log_{10}t - \log_{10}(\log_e 10) \qquad (5)$$

If we now approximate $P\{T \geq t\}$ by the fraction of observations that exceeds the value of t,the left hand side should be a linear function of $\log_{10}t$,-something which could be tested by means of a graph.

In order to test the allegation that"everything would fit a generalized model"a number of Monte Carlo tests were carried out using Weibull-distributed numbers and equally distributed numbers.
These tests did show that the graph tests used with the Weibull distribution could distinguish between the two kinds of distributions down to numbers of 6,thus clearly demonstrating that the graph test was a very powerful test.(8)
Furthermore,a time-series of Hitlers conferences with representatives of the German secret services was processed.(See below on time-series).
We did recognize this time-series to be defect,as a number of those meetings were held secretly and never put on Hitler's official agenda.
It could be shown that no part of this distribution would fit the model, even if we analyzed the time-series stepwise in a forward direction, adding one value at the time.
On the other hand another series,the Fuehrer directives for the conduct of the war,was reprocessed using only main directives and omitting all the smaller directives supplementing the main directives.In this case

graph tests were practically identical,so we could assume that the basic character of the process might have been deduced from the main directives alone.

Then David Singers war data on "nation months of war begun"(9)for 15o years were processed and shown not to fit the model.(Even if they had fitted,they ought not to have been used with the model,as those data are transformed data.No such transformation,except perhaps an exponential transformation,would be allowed with the model,if invariance to the scale should be conserved).

However,treating Singer's data as events,in stead of as aggregates,we found the COW-data fitting the model very neatly both for systemic war and systemic and extra-systemic war combined.

In the first instance we found a value of alfa of o.66,indicating that the use of war as an instrument in the international system was clearly on the decline in these 15o years.

The combined intra-and extra-systemic war series,however,revealed an alfa of o.88,thus indicating that war as such was much less on the decline if extrasystemic war was included.(An interesting hypothesis would be that war as a political instrument has been pressed out towards the periphery and down to the level of the nation state in the form of civil war).

<u>Estimation of the parameters.</u>

Next we will consider the problem of estimating the values of α and λ.

The starting point is the distribution function (2)

From this function we can get the density by differentiation

$$f(t)=\alpha\lambda\, t^{\alpha-1}\, e^{-\lambda t^{\alpha}} \tag{6}$$

The density for n time intervals is then given by the product of densities.

$$f(t_1,t_2,\ldots,t_n)=\lambda^n.\alpha^n.\prod_{i=1}^{n} t_i^{\alpha-1}.e^{-\lambda.\sum_{i=1}^{n} t_i^{\alpha}} \tag{7}$$

Then the likelihood function($L(\alpha, \lambda)$)can be found by inserting the observed values in f.

$$L(\alpha,\lambda)=\lambda^{n}.\alpha^{n}.\prod_{i=1}^{n} t_i^{\alpha-1}.e^{-\lambda\sum_{i=1}^{n} t_i^{\alpha}} \qquad (8)$$

The Maximum likelihood estimates of α and λ are then the values of α,λ that maximize $L(\alpha,\lambda)$

As usual $Ln(L(\alpha,\lambda))$ is maximized instead of $L(\alpha,\lambda)$ which is

$$\ln(L(\alpha,\lambda))=n\ln\lambda+n\ln\alpha+(\alpha-1)\sum_{i=1}^{n} \ln t_i-\lambda\sum_{i=1}^{n} t_i^{\alpha} \qquad (9)$$

At the maximum the derivatives of (9) with respect to α and λ should be zero or:

$$\frac{d\ln(L(\alpha,\lambda))}{d\lambda} = \frac{n}{\lambda} \quad \sum_{i=1}^{n} t_i^{\alpha} = 0 \qquad (1o)$$

$$\frac{d\ln(L(\alpha,\lambda))}{d\alpha} = \frac{n}{\alpha} + \sum_{i=1}^{n} \ln t_i-\lambda\sum_{i=1}^{n} \ln t_i t_i^{\alpha} = 0 \qquad (11).$$

From(1o)and (11)follows that for the maximum likelihood estimators $(\hat{\lambda},\hat{\alpha})$ should satisfy the following equations

$$\hat{\lambda} = \frac{n}{\sum_{i=1}^{n} t_i^{\hat{\alpha}}} \qquad (12)$$

$$\frac{n}{\hat{\alpha}} + \sum_{i=1}^{n} \ln t_i - \frac{n}{\sum_{i=1}^{n} t_i^{\hat{\alpha}}} \sum_{i=1}^{n} (\ln t_i) t_i^{\hat{\alpha}} = 0 \qquad (13)$$

Equation (13) cannot be solved analytically but an iterative solution for $\hat{\alpha}$ and consequently $\hat{\lambda}$ can be obtained.A program is available for this.

<u>Determining changes in the process.</u>

It took a long period of experimentation to find out that for the data we have studied(that constitute in systemic language "natural systems") the value of alfa is constant,whereas the value of lambda varies from time to time according to the instrumentality of the dimension in the

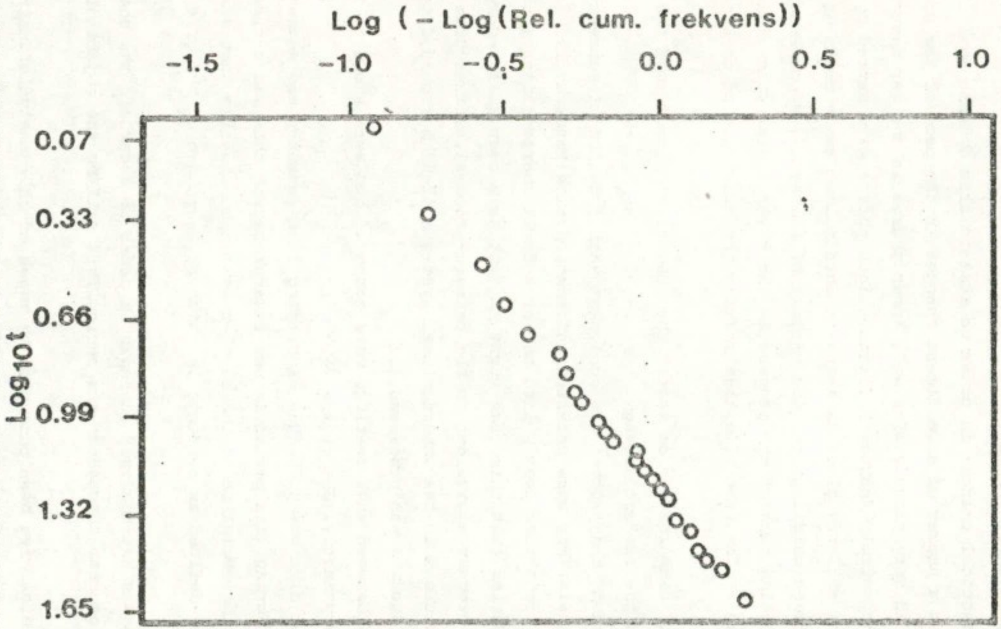
context.(lo)
Alfa then can be considered a parameter reflecting the structure of a given system,whereas the parameter lambda reflects the processes in the system.
In order to determine significant changes in lambda(alfa constant) a U-test was employed.(11)
To reveal significant time-points where changes take place one can proceed in two different ways.
The first method would be by historical hypothesis.The other would be to use the values alone by means of two moving averages computed forwards and backwards from the same point in time and then tested for significant differences.
However,when the parameter alfa differs from the value 1 the dimension of lambda becomes uncertain and one should instead estimate the value of the parameter tau,the average waiting time.(A sort of eschewed median).
Tau is estimated from the following formula:

$$\tau = \lambda^{\frac{1}{\alpha}} \cdot \Gamma \{ \frac{1}{\alpha} + 1 \}$$

Case-studies.

In order to find time-series that would correspond as closely as possible to the Harrison White conception we turned to the Nazi regime which we had been studying for years.
German historians like Andreas Hillgruber have reconstructed the actions of Hitler as supreme decision-maker during the period 1939-41 in very great detail.(As far as these actions were not simple matters of routine).
This meant that it was possible to construct a number of time-series related to Hitlers political role and to his role as Supreme Commander of the German Armed Forces(Oberbefehlshaber der Wehrmacht).
Three time-series have been studied:One,diplomatic conferences in which Hitler took part,another,conferences with the High Command of the German Army(Oberkommando des Heeres)and the third,a series of major decisions related to the war in the form of Fuehrer directives for the conduct of war.
All three fitted the model very well.(Figure 1 gives an example of a

GRAF-TEST



Hitlers samtaler med politikere og statsmænd (1.9.1939 – 31.12.1941)
(HITLERS CONFERENCES WITH POLITICIANS AND DIPLOMATS 1.9.1939-31.12.1941)

Parameterværdier: Alfa 0.96; Lambda 0.17; Tau 6.81 (Spredning 0.017)
(VALUES OF PARAMETERS) (STANDARD DEVIATION)

FIGURE 1

graphical test on one data-set).

As alfa was very near to 1 (in one case 1.o2,in two others o.96) all three dimensions revealed the same structure.

The values showed that dynamic equilibrium existed during these 28 months of military successes.Activities were considered sufficient to obtain long range goals of world conquest.

Turning to tactical changes in order to sustain this dynamic equilibrium, we discovered a number of significant changes in the pace of the processes that coincided very closely with well known phases in the war described by historians,notably Andreas Hillgruber.Such phases were marked by changing political and military plans as means to obtain long range goals of world domination.These guidlines for the conduct of the war were commensurate with the changing pace of the process in the several dimensions.Some of these changed at the same time,thus marking the existence of combination models.

Thus it could unambigously be stated that the results confirmed the philosophy behind the research design.

The structure of the process was consonant with a period of success for long range goals.(For more detailed information,vide:Petersen(1979)a).

In order to probe more deeply into the structural characteristics of the model(considering that this case might in fact have been analyzed by means of the time-process equivalent to the poisson-process),another time-series of summit meetings in the international system 1941-61 borrowed from one of Galtungs studies was processed.(12)

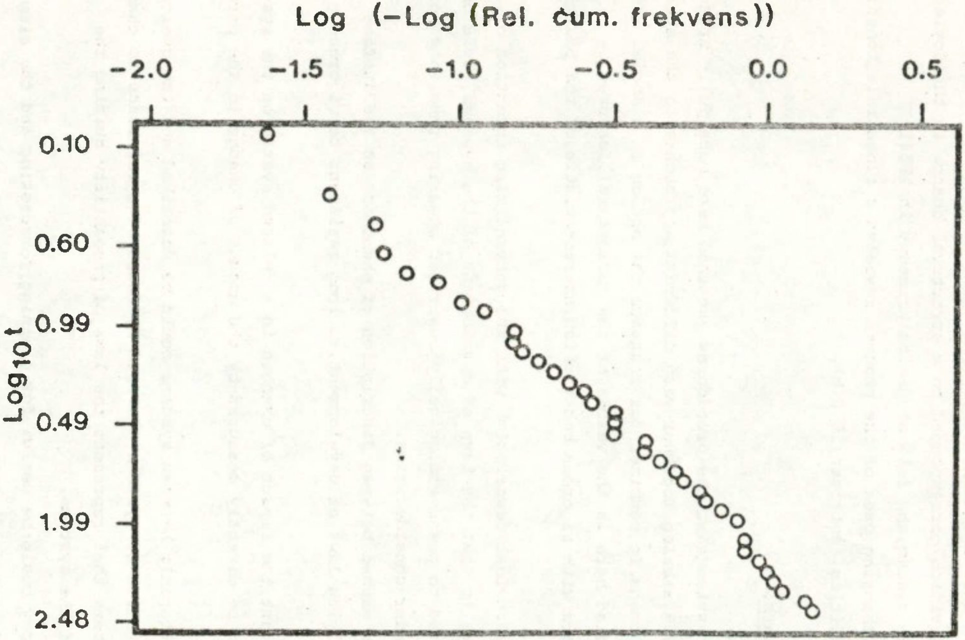
Time periods between such meetings were computed and were shown to fit the model very neatly.(See figure 2).

The values of alfa was o.79,thus signifying that summitry was somewhat on the decline during this period.In our interpretation this was a clear indication of the evolution of the bipolar system,considering that summit meetings were defined as meetings in which at least two of the great powers took part.

(This series was not analysed in depth in order to ascertain the changing pace of the process throughout the period.This will be the object of a later case-study).

Two more studies have been conducted by means of this analytic instrument. The first one treated the Sino-Indian border conflict 1959-65.(Petersen, 1978).

GRAF-TEST



Afstand mellem topmøder 1941–1961
(SUMMIT MEETINGS 1941-1961, FIVE GREAT POWERS)

Parameterværdier: Alfa 0.79; Lambda 0.05; Tau 51.78 (Spredning 0.038)
(VALUES OF PARAMETERS) (STANDARD DEVIATION)

F GURE 2

Negotiative behavior and conflict-behavior of the parties were successfully described and the changing pace of the behavior could be shown to fit the historical picture very accurately.
The Sino-Soviet border conflict 1963-73 was analyzed from Soviet data and two phases in the Soviet attitude to China discovered.(The data-set was divided into two with differing structure,i.e.differing values of alfa.This division corresponded to a structural change in the Soviet decision-making system,the fall of Nikita Kruschev in 1964).
Once more the changing pace of the process revealed a close relationship with actual politics.(Petersen,1979,b).

Concluding remark.

It is our impression that the procedures sketched here(more fully treated in Petersen,1979,a)bring together very different approaches to the study of social phenomena.It combines for instance the notion of a social totality(embodied here in the values of the parameters),featured by marxist scholars with rigorous behaviorism,characteristic of the positivist tradition.
It combines historical description with the generalizing intention of the social sciences in that the laws of development of the systems could be directly related to phenomenologically described steering functions for the systems under consideration.
The barrier is passed between description of phenomena on the surface and the underlying laws of development,so long resistent to rigorous description.
Given the context,the impact of changes in a related system on the system observed could be directly measured by the amount of change in the parameters.
Thus the relationship between systems could be described and the question of the delimitation of systems answered by means of a reference to changes in the parameters that represent the laws of probability guiding the development of the systems.
The methodology could be useful for planning,forecasting and the simple description of systems dynamics.
Because of the invariance to the scale of the model it could also be very helpful surmounting the methodological barrier to exact comparison between political and social systems.

NOTES

1)On the Grotian perspective,see:A.Leijphardt:International Relations Theory,Great Debates and Lesser Debates.
International Social Science Journal,vol.XXVI,no.1,1974.

2)A pathbreaking book was:Morton A Kaplan:System and Process in International Politics.(Wiley 1957).

3)Behaviorism entered the discipline mainly through the modern study of international conflict as embodied in Journals like"The Journal of Conflict Resolution" and "Journal of Peace Research" dating back to the midfifties and the early sixties.

4)Charles McClelland:Applications of General Systems Theory in International Relations.(Published as a contribution to J.Rosenau ed.: International Politics and Foreign Policy,Glencoe 1961.This article has been omitted from later editions).

5)Harrison White presented this theory to an international audience at the IPSA-conference in 1971 and later made it a contribution to "Mathematical Approaches to Politics",edited by Alker,Deutsch and Stoetzel.(Elsevier 1973).

6)Cfr.Iven Reventlow:Studier af komplicerede psykobiologiske fænomener, Munksgaard,Copenhagen 197o.(With an English summary).
On the early work of Georg Rasch,see:Georg Rasch:Probabilistic Models for Some Intelligence and Attainment Tests.Studies in Mathematical Psychology I,Danmarks paedagogiske Institut,Copenhagen 196o,
item:On General Laws and the Meaning of Measurement in Psychology, Proc.Fourth Berk.Symp.Math.Stat.and Prob.,4,p.321-334,1961.
item:An individualistic approach to item analysis,Readings in Math. Psychol.,1966
item:An Informal Report on a Theory of Objectivity in Comparisons. Proceedings of the NUFFIC International Summer Session in Science,Leiden 1967.

7)Erik Johnsen:Multiobjective Decision Models.Lund 1968.

8)From these experiments a criterium of a fit could be fixed thus:
A standard deviation from the straight line,using least squares method,would be tolerable in the interval o.o75-o.o51
good in the interval o.o5-o.o26
very good in the interval o.o25 -

However,the final judgement should always rest with the graph test as you could have a single very deviating point that ought perhaps to be discarded in view of the good performance of the rest.

9)Singer and Small:The Wages of War 1815-1965 a Statistical Handbook, Wiley,1972.

1o)One time-series(Soviet data on the Sino-Soviet Border Conflict) was at first considered as one data-set.Later it was discovered that in fact it consisted of two data-sets,reflecting different structural background factors.A natural system is here defined as a system with constant structure,usually delimited in the historical sense by important changes in the historical context.The important structural change dividing the period in two was the fall of Khruschev in 1964,presumably brought about to effect a change in Soviet policy towards China. (See for instance:H.C.Hinton:Communist China in World Politics,Boston 1966,or F.Schurmann:The Logic of World Power,Pantheon Books 1974). All other data-sets reflected natural systems in the sense outlined above and fitted the model right away.

11)Cfr.Iven Reventlow, opus citato,p.1o2-3.

12)J.Galtung:Summit Meetings and International Relations.Journal of Peace Research,1964,no.1.On the German data cfr.the following authors: Andreas Hillgruber:Hitlers Strategie,Politik und Kriegsführung 194o-41, Frankfurt a.M.1966 and the same author:Statsmänner und Diplomaten bei Hitler,Frankfurt a.M.1967.More data to be found in Walther Hubatsch: Hitlers Weisungen für die Kriegsführung 1939-45,Frankfurt a.M.1962.

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(1978)Laws of Development of Cybernetic Systems,the Case of the Sino-Indian Border Conflict 1959-65.(9o pages) Research Report no.2,1978,from The Institute of Political Studies University of Copenhagen.

(1979 a)Kybernetiske systemers udviklingslove,Copenhagen Political Studies,1979,(c/oThe Institute of Political Studies,Rosenborggade 15,DK-113o,Copenhagen K,333 pages with an English Summary)

(1979 b)Laws of Development of Cybernetic Systems,the Case of the Sino-Soviet Border Conflict 1963-73.Research Report no.3,1979,from The Institute of Political Studies,University of Copenhagen. (6o pages).