Anticipatory Simulation for Policy Support

Design and Modelling for Guided Societal Change and Evolution

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Abstract
Societal policy faces both complex and complicated challenges in a highly dynamic environment. Learning from previous experiences e.g. from advanced environmental systems, recent research begins to employ modelling and simulation for anticipatory policy support, for ex. by Early Detection Systems; Systems identifying Option and Action Space (Epstein, Axtell, 1996). The systemic nature and the preconditions of such endeavours need be to be investigated in more depth and detail as to their (meta-) methodical, procedural, object specific and actual background. Though closely connected with advanced computing, the emphasis will lie on the systemic and the societal aspect of modelling. (Conte et alii ed. , 1997) Relying on results from field research on an authentic case (Republic South Africa; 1997/98, by the author) the paper attempts a systemic approach to basic modelling/simulation in the societal domain.
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1 An Authentic Case for Policy Support and Anticipation

1.1 Allocating Development Aid

The argumentation as follows originated from an authentic societal research. Development aid for emerging countries is questioned concerning its sustainability, long term efficiency and effectiveness. Basically development aid can be seen as an investment of scarce funds to be placed where it stimulates self-development, promising a reasonable return on investments for both the recipient and the donor country. Such a allocation policy presupposes sufficiently precise long-term-knowledge as to compare the likely countries as to their developmental potential. It has to indicate when and where to invest.

1.2 Anomie as an Indicator: the Actual Case RSA

A conceptual frame included general concepts of societal development. 'Anomie' (E. Durkheim) was to serve as general indicator for development prospective in four types: two of positive Anomie, when old structures disintegrate to make way for new ones; two of negative Anomie which leads in a self-aggravating circle down to low equilibrium or destruction (Atteslander et alii ed. 1999). To acquire data mainly opinion

research was employed using questionnaires. The result intended should consist of an indicator system to be used for analysis and as an Early Warning/Detection System (EDS) serving as policy decision support. Within this general frame, *field research using direct observation and free interviews* was allowed for as a complementing sideline to contribute but indirectly in e.g. terms of a plausibility check. It was conducted by the author in *July/August 1997 in the Republic South Africa (RSA) using methods established in company strategy planning.* Given the charge of methodical grounding the author also proposed to develop a *model and simulation based computer program capable of self-improving learning. It was intended for societal control*, serving as support for a evolution guided development policy.

1.3 Modelling and Simulation

The reasoning for basic methodical considerations relies on field experiences and on modelling for Evolutional Control Learning. Both tasks demanded not only the usual steps of project management. Cultural and ethical implications were to be considered. The initial stage also recommended to postpone the design and establishment of a developmental policy to follow-up projects. Development policy as part of foreign policy and intervention had as items sui generis to be excluded. Of course interfaces had to be defined within the project itself and as a base for the subsequent projects.

1.4 Setting the Stage for Modelling for Anticipatory Computing

Already the target function asked for a complicated balance of possibly influencing factors, conceptual, instrumental and pragmatic. Also the adjoining procedural phases raised fundamental and intrinsically networked questions of factual, methodical and procedural character. Approaching the problem takes two steps. First, the argumentation will follow the procedure and their sequential networking, *using deliberately the problem/procedure and not the theory/concept oriented approach.* In each phase from Setting the Target Function to Interpretation and Policy Implementation fundamental questions turn up. General, paradigmatic issues, (meta-) methodical and procedural preconditions for the modelling and simulation of societal phenomena become apparent (Bossel, 1994). Such research appears markedly *policy oriented* and needs to deal with a new level of complexity, in dynamics and detail. On the other hand, advanced research on anticipatory computing (Rosen, 1985; Dubois, 2001) provides new opportunities to cope with extremely complex societal phenomena. Both developments mutually connect and drive each other. They force general re-consideration covering the entire field up to the science of science to go back to basics. What do we do when modelling and simulating? How to re-think the systems/systemic approach, distinguishing between macro and micro-level, synergistically integrated on the meso-level? How to construct a set of models of society and societal phenomena apt to be simulated by which kind of computing soft- and hardware? Which kind of concepts of evolution need be assumed at the base of anticipatory computing? Which is the notion of societal control, ranging from Critical Heuristics to Evolutional Control Learning? Not to forget the need for

scales of quantitative and qualitative measurement, least the necessary new approach to pragmatic ethics.

2 Modelling, Simulation and Computing to Cope with Complexity

Even 'pure' science may be seen as a response to impending challenges. The stimulation between science and existing or missing option and action space in practice is mutual; so is the dynamic interdependence connecting one branch of science to others (as an example see Pothas, 1999). As a rule it is the creative combination of interdisciplinary/ transdiciplinary tools that effectually accomplishes unprecedented tasks. Or in the negative: the full capacity to follow issues and to resolve problems can be drawn upon only if the entire system of scientific knowledge including conceptual fore fields is involved. It appears worthwhile to investigate this triviality also in the case of anticipatory simulation for policy support.

Not too many years ago the concept of a model of an entire society and of societal policy was turned down as an impossibility. It turned out not a principal impossibility, but a practical one (see Barrow, 1999). Knowledge concerning society and policy on the surface still displayed a more narrative quality than a systems structure; and even if structured no according basic models could be built upon of societal phenomena res. of viable/living systems. Other white spots on the map of science appeared in particular in theory of science. Investigation by systematic variation not assisted by computer proved troublesome, slow, and hence restricted and costly. The same was true of simulation. Sufficient basic research in the nature of simulation lacked as well as computing capacities, hard and soft. In particular anticipatory computing still stayed in the initial stages to deal with such fuzzy and highly complex problems. Most important: unconsciously assuming positions BC, that is Before Computer, it generally was agreed that such policy support could not be done yet. The complexity of societal phenomena was assumed to high. (It is another issue that politicians would not and will not be much in favour of policy support by factual and worse anticipatory knowledge; having decided already politically with reverence to the next election.)

3 The Case of the Problem Ridden Project Planning

3.1 Establishing an Indicator System

When tackling the first phase '*Issue, Purpose and actual Target*' it proved rather difficult to deal with the multi- aspectual target fields to choose from. Choosing formal ones only as survival and development did not comply cultural compliance, Gaya environment and history. And how about culturally compliant methods and procedures? That led to the second phase of *Project Design and Description*: *relevancy analysis* referring to context, environment, desired and undesired side effects. Which descriptive 'neutral' language to choose? Having decided on relevancy the next phase had to to set up an *Indicator System* reflecting the weighted focus. Which key factors might reflect the focus? Which criteria should be used to classify? How to quantify – for reasons of

programming later on - qualitative properties? Under which auspices to choose values and the scales to measure actual values? Avoiding culturally founded prejudices? A particular team was set up which undertook to differentiate the previously chosen key indicator 'Anomie'. It did so in terms of its power to explain a given societal state in terms of its future developmental prospects, allowing for alternative or complementing (!) indicators. Later these basic indicators proved essential to denote indicators as in geography, demography, cultural and other *development potential.* The indicator issue turned out a focus for creative discourses.

3.2 Modelling Society and Societal Change

The reason became obvious in the central phase of *Modelling* (Nigel, Troitsch, 1999; Gilbert, Doran, 1994; Janssen, 1996). The understanding of an indicator as reflecting the future prospects of a society presupposes a model of the society /societal change (Diamond, 1999) and the main factors influencing societal change, history as well as the eigendynamics of the system itself. A particular authentic e.g. RSA model should be seen as a sub-type. Hence, as which ordered set of models can a society be thought of? There is Platon, Thomasius Aquinus and later Tönnies, Parson, Luhmann and so forth. But what is needed is a model transferable into a computing program for simulation. Recurring to models of viable and living systems and to practices used in company strategy planning, input- output-models were evaluated against autopoietic models and their respective qualities for anticipatory simulation. Such models in turn allowed to presuppose notions of prognosis, of procedure and results. They also cleared the intention to construct a model suited computer assisted 'anticipation'. Postulating a model of society precludes not least *'universals'* of models. Platon and his 'ideas' again? The notion of general principles as constructed by human observation (cybernetics II to IV...) proved useful. They likewise helped to explicate the option and action space open to future development that human observation is able to distinguish. It might be interesting also to delve deeper into the mathematics behind. For the observant non-mathematician MATURANA's (1987) concept of the *natural drift* (Maturana,Varela, 1987) seems to offer an approach to future as well as the BAYESian syllogism, perhaps both complementing each other (Nalimov, 1985). Bayesian Structured fields of probability for future development offer carrying hypotheses to work on. The approach per se seems well suited to be combined with e.g. scenario techniques and quantitative, / qualitative opinion research. The next two phases were to be left to the computing experts;: the 'Programming' and the 'Simulation Runs' feed backs were provided for to clear eventually arising questions and details. Regrettably, though basic models, the team and computing capacity were organised, funds were lacking to implement actual programming and simulation runs.

3.3 Programming for Action

The next step following the 'programming/computing' procedure actually condensed the closely networked phases of interpretation, validation (Andelfinger, 1999), and

exploration in term of action programming . The carrying capacity of results was to be tested in terms of further research, practical application as policy supporting method. It had to be scrutinised also in terms of possible transfer to neighbouring fields, construction of useful instruments of influence, control, and not least intervention. Though essential in terms of project planning, and a rich source of learning experience, in this computing context it may suffice to point out the implications and the feed back to the foregoing phases. In particular: what may be learned concerning the interdependence of the factual material to the computing aspect, for the systemic aspectual interpretation of results achieved, and the underlying assumptions and methods. Investigation may reveal new insight from the actual case experience. It may show for example, whether, and if, in which quality, the choice of methods, procedures (and institutions), of evaluation systems and measurement scales predetermines research results.

4 Re-Thinking the Systemic Approach: Macro- and Micro Level Integrated on the Meso-Level

4.1 Investigating the Influence of Norms on Societal Behaviour

Complaints at actual (societal) policy have centred on a neglect which policy seems habitually guilty of. There is no sufficient if any systematic investigation how government measures influence the basic behaviour of people involved. Unfortunately, such failure is not restricted to ideology ridden regimes. It applies to any institutional choice, to laws, norms of any kind and evaluation scales. It is here where main causes of anomie can be found - see tax evasion for example - people distinguishing between being 'law' and being 'justified'. And it is here where the actual – desired or non desired – main and side effects are born. Of course the behavioural aspect is not the only one, but it is – or should be on a parity base – the necessary complement to the institutional, the formal aspect.

Returning to the RSA project: when, in the implementation phase, policies to curb anomie, paths to motivation and mobilisation and in consequence to an South African identity were on stake, the actual behavioural response of people emerged as the essential factor. Why is this so? Some fundamental investigation into the constituents of human behaviour came up with a tentative model (see also next chapter Back to Basics). As the systems approach tells, the behavioural propensity of a living system is influenced a) by the surrounding institutions (which represent, following the famous definition, 'a defined need and the culture surrounding it') and b) by its needs derived from the necessity to survive and develop. Which can be largely identified by beliefs, convictions, and the value systems, priority scales etc. derived. J. Zelger (Buber, Zelger ed., 2000); Stumme, Wille ed., 2000) has accomplished basic and successfully corroborating research in this field. Transferred onto the level of research approaches, roughly, the established and prevailing methods use an institutional *macro level* approach: for example in economics the main body of econometric, in the

anthropologies a sectional approach to defined sectional parts of society. Very early e.g. in aspectual disciplines like marketing the *behavioural micro- level* approach e.g. asking why people do buy a particular brand has been used. In sociology similar attempts appear often connected to the (small) group approach e.g. investigating why people do perform better or worse.

4.2 Integration and Synergy the Meso Level

Extremely foreshortened: the *macro-approach* investigates and explores, it analyses the general and in particular the institutional structure of the society. The macro view delivers also information on the preconditions of and the influence on for societal behaviour in the given societal environment as set by governmental norms. For instance hierarchic bureaucratic structures in general curb initiative. In contrast *and* in complementation the *micro approach* underpins how this field of likely behavioural response is realised in the actual behaviour of people. F. e. compare how Italians react to bureaucracy and how Swedes, or Germans do. Processing the inputs of macro/micro influence fields the actual behaviour emerges– or is generated – at the *meso level*. It is difficult to locate the level in actual societal structures. Safe enough that the group level plays an *essentially integrating* role, in particular the emotionally tinted small, the intimate primary group. Integration happens here: welding often contradictory influences into coherent and societally acceptable behaviour. If the integrative group powers does not suffice, society faces role inconsistency and subsequent *anomie*. Not amazingly the meso level is also the place of attenuation/aggravation of social disturbances and the source of synergy/disergy. The focus became rather obvious, on a small scale, when trying to understand the construction and the life in South African townships or squatter camps: the social activities, the behavioural ruled securing stability and minimum existence. Light is shed on the societal movements after Apartheid abolishment like entitlement, equal opportunity, truth commission and others.

4.3 A Notion of Culture

The threefold approach as above cannot claim to be comprehensive. In particular when leaving the level of a single actual society, when expanding the view to federations, continents or global views, other, additional factors come into play (Bühl, 1990). However, there may be some recursivity to be observed at any chosen level. Perhaps the interaction of macro- and micro-level on the meso- level, when recursively permeating all relevant societal aspects, could be conceptualised as that of *culture*.

5 Back to Basics: Models of Societal Phenomena and Societal Change

5.1 Purpose, Intended Motivation and Mobilisation

In varying degrees and qualities any structured body to perceive/attain knowledge must be seen as determined by a purpose: Models, hypotheses, views; even science with

perhaps the partly exception of the purely formal sciences. In contrast societal phenomena are prone to purpose driven inferences: from the cultural, ideological, the constitutive geographical, cultural and material base of the society internal and external. In addition, the actual stage of development attained must be considered. Directly concerning science these factors are expressed in the state of the art concerning knowledge, the methodical/methodological and the instrumental one. Together with the issues pressing, these fundaments have been changing and are rapidly and fundamentally mutating. The causes and the reasons behind are commonplace: among others globality, the limits of the planet, power shift and the societal challenges aggravating as North-South, rich- poor countries, wealth distribution etc.

In the case of the RSA research most of these factors meet. To evaluate the future prospects of society a rather elaborate model is needed of society and societal change. The need of models apply also to the dynamic phenomena of societal policy: to motivation and mobilisation for example. Which are the ingredients of a national(?), regional (?) identity, and on what factual, emotional, value orienting values, symbols, events might it be built and furthered? In Malaysia traditional dancing is encouraged to that end, in South Africa the base ball matches carry a similar weight. Which role plays identity as a societal bind networking with other societal binds? There is no end observable to the demand of models. In addition these models should be basic, or more precise: models defined as a type of a more general model within a clearly structured model. Which is, see above, one of the preconditions to construct a system of indicators.

5.2 Indigenous, Non- Western Indicators and Models

The demand becomes pressing when the Western born, fostered and trained scientist attempts field research in a Non- Western society. Of course there are the reassuring hard statistic facts and the rather, but only rather safe basic models for example from demography, geography and economy. There are indicators as GDP per head, Gini coefficient, the models of econometrics and so on. But don't they inhere latent prejudices, however hard to detect? No critics of the IWF or the World Bank intended here. On the other hand: living in an in toto overpopulated world (whatever that may mean) with certain infra-structural necessities: are there basic models for emerging countries, basic patterns of infrastructure, basic constituents for societal and political constitution, the latter for example in the democracy version? No question, when beginning field research in the RSA the author had effectually erased from his mind identified all Western models, his perceptive apparatus effectively cleaned of such disguised prejudices. After two weeks approximately a model formed how South Africans might understand themselves and their culture. So far so right. For the evaluation on scales for a future development prospects, however, both simple *and* sophisticated, general *and* specific models are needed depicting the basic preconditions for an successfully emerging country. The same general idea is needed to design a policy which supports positive developments (Midgley, 2000), to further, in South African terms, the path to the 'High Road'.

6 Critical Heuristics of Evolutional Control Learning

6.1 Towards a Model of Guided Evolutional Control Learning

The attempts resulted in preliminary models, among others of society, societal change, societal mobilisation and a relating host of meta-methodical reconsideration. They provided also the insight, that at least a ten year trans-disciplinary research program is needed to deal with but the most pressing scientific demands. Five years later, hopefully, a research program is carried on world wide.

The aim of such a program has remained the same as it originated some decennia ago from company strategy planning and recently the RSA research: *a self improving learning program for societal development and control* (Loeckenhoff, 1997, 2001)

Notions of control learning emerged probably independently from several sources. For the author it was the the systems approach to problem solving in the early sixtieths, leading to *recursive learning*. Practice in company strategy planning gave birth of recursive controlling, that is networking the operational, tactical and strategy level in a learning system. Results as planned are compared with outcome as achieved, differences are analysed and used to improve the data base, assumptions made methodical set up. Continuos learning happens by means of recurring controlling circles progressing in time. Thus the action/option space constantly is monitored. It can develop, on a systematic, reality guided base feasible visions, objectives and targets. The overall principle of development is obeyed, demanding that each plan preserves existing base potentials (as in metamorphosis) and opens new vistas/ spaces rather than narrows down opportunities for active policy. The action and option space could be defined as a defined structured field of probabilities, using the Bayesian syllogism as a concept. To pinpoint local points proved useful, that is possible future states in the space, scenario writing, varied systematically along agreed strategy lines. These complementing activities are seen as integral part of the control learning. Thinking the concept to its logic end, the entire controlling process can be oriented on Bayesian structured probability fields. They change after each control period; depending from policy decision/implementation and general change of the planning environment. The emerging learning process leads to a policy behaviour which follows, within the space of actual policy decision the general, company independent environmental development. On the other hand it responds to active company policy. In analogue the behaviour rather closely resembles what H.MATURANA (Maturana, Varela, 1987) calls responding to and employing the chances of the 'natural drift', the general over all course of development. Strategy adapts actively and passively to the natural drift, following a policy of drift dependent evolution. The concept is termed Evolutional Control Learning.

6.2. The Ethics of Strategy and Policy: TIT for TAT

From the material/actual point of view analogous transfer from industrial strategy to societal policy will meet a host of adaptation challenges (Olson, 1985). Nevertheless,

principally and from the systems point of view, the attempt appears but the natural if not the only one. The model derived from evolution biology owns more than a fair chance to be successfully applied, variatis variandis, to all viable/living systems.

There is an ethical lesson contained. In the long run, the concept and the policy outlined above follow the principle of *strategy ethics*. Game theory may be brought into the discourse, in particular the advanced concepts allowing for change of behaviour in the course of the game and open to emotional reasoning. In case of scarce life space and dwindling natural resources 'cut throat competition' or 'the winner gets all' do not pay. The winning policy is that which embarks also on predator – prey win-win plays, or a TIT for TAT policy, paying attention not to destroy nor exhaust the environment.

The above argumentation displays again but a very summarily indication of a field to be explored in more depth and detail. There is also a demand for a new approach to science of science inherent. To explore life sustaining feasible strategies inter- and trans- disciplinary research has to be strengthened. Where attempts have been made, they have initially met considerable obstacles. They concern the meta- base of methodology and hence concepts, terms, models, measurement, evaluation and so on. Incompatibilities of that kind but corroborate what was to be expected. To straighten them out a common base, grounding on a more comprehensive understanding of science has to be developed. Order theory, Mathematics beginning with number theory and extending to trans-disciplinary concepts as 'formal concept theory' (Stumme, Wille, 2000) need be the base as well as philosophy and the anthropologies investigating human behaviour. The trend 'back to basics' as discussed in the previous paragraph is compelled to question the very structures shaping human thought and action. Individual as well as social psychology are challenged, in particular referring to the micro and meso level.

7 In Need of Anticipative Measurement Scales and Pragmatic Ethics

7.1 Meeting the Measurement Challenge: Qualitative Research

Behind and beyond the continuing research on analogue and metaphoric reasoning the more recent rise of *qualitative research* also measure and measurement become subject to critical reconsideration. The by no means new idea of measure changing with the state of the system in question ('metrodynamics', A. Wheeler) and with its phase of development gained new momentum by recent hypotheses/speculations in advanced physics and cosmology. The measurement challenge in natural science may well remind similar demands that modes, procedures and instruments (including mathematical ones) have to meet.

Closely connected to indicator systems, measure systems need be specific to the system they belong to and thus to purpose and context. A well known example provides the already mentioned GNP per head index and its combination with the Gini coefficient to measure the economic status of a system. A measure is born from the wish to be able to interpret a phenomenon under a given purpose as a tool of interpretation.

In a fairly continuos and stable development measures established and known as to their foundations and their explanation capacity pose no serious uncertainties. The relative security may change drastically to threatening misinterpretation in a dynamic, rapidly changing environment. Typical examples can be extracted from industrial practice, indicated e.g. by the discourse on the so called score card. Systemic analysis revealed unexpected lines of possible interoperation between measure and interpretation and, more important, of impacts of measure upon the behaviour of people involved. Measures, as elements of models, therefore shape and control systems. They mould in particularly human behaviour (Loeckenhoff, 1997). Measurement theory, as information goes, increasingly accounts for such 'soft' effects. How to measure, for example, human behavioural propensities?

7.2 'Soft' Operations Research Paving the Path

The questions aggravate when setting on to measure expectations, probabilities, future states. A short overview over the particular role and impact of measurement in anticipatory computing systems, formally and factually, will be worthwhile to compare. Measure Research in Operations Research (OR) seems to be stimulated by growing concern on 'Hard' OR being complemented by 'Soft' OR; OR attempting a systemic view on societal issues (Loeckenhoff, 2000).

In a broad sense to know means to measure; science means to learn how to measure what cannot be measured yet (GALILEI) and to be able to interpret measurement results reliably. Measures are indicators of what we observe, of what we wish, expect, want to learn from future developments. Anticipation, then, means measurements to establish and within probability fields. Questioning the future puts forth the known critical points in a heightened degree: interpretation fields, networking; in addition the need for systemic measures of higher orders measuring systems behaviour, eigendynamics, propensities to develop. In case of strong dynamics or likely phase transformations/ catastrophes, the probable dynamics of the measure as above system have to be accounted for.

Will 'human measure', the biologically and mentally limited range of human measure capabilities suffice? Using science, in particular employing the heuristic potential of the formal sciences, we are trying to extend the space we can however indirectly observe and therefore understand. Since we have, in action, already overstepped human measure, creating dangers to survival and development, we need to be successful at least in observation, monitoring and control.

References

Andelfinger, Urs: Diskursive Anforderungsanalyse und Validierung. Dissertation. Darmstadt D 17 1999

Atteslander P.; Gransow B.; et al ed. : Comparative Anomie Research. Ashgate 1999

Barrow, J.D. Impossibility. The Limits of Science and the Sc. of Limits. Vintage 1999

Bossel, H.: Modeling and Simulation. Vieweg, 1994

Buber R.; Zelger, J. Hg.: GABEK II. Zur Qualitativen Forschung. Studienverlag, Innsbruck 2000
Bühl, W.: Sozialer Wandel im Ungleichgewicht. Encke Stuttgart 1990
Conte R.; Hegselmann R.; Terna P. ed.: Simulating Social Phenomena. Springer 1997
Diamond, Jared: Guns, Germs, and Steel. The Fates of Human Societies. W.W.Norton New York London 1999
Dubois, D. M. (Editor), International Journal of Computing Anticipatory Systems, Volume 8, 2001
Epstein,J.M.; Axtell, R.: Growing Artificial Societies. MIT Press 1996
Gilbert, N.; Conte,R. (Eds): Artificial Societies: The computer Simulation of Social Life. UVCL Press Ltd. London 1995
Gilbert,N. Doran, J.(Eds): Simulating Societies. UCL Press Ltd. London 1994
Janssen M.: Meeting Targets. Tools to support Integrated Assessment Modelling of Global Change. Dissertation, Univ. Maastricht 1996
Loeckenhoff, H. Measuring Sustainable Performance for Societal Control. Paper, 14th Intern. Conf. WACRA Europe e.V., Proceedings Madrid Espana Sept 16-19 1997
idem.: Co-operation and Complementation of 'Hard' OR and 'Soft' OR, or: The Emergence of the Qualitative on the Base of Quantitative Sciences. Attachment, Expert Opinion to the Nat. Research Foundation Rep. South Africa, Pretoria 07.03.01
Maturana, H, Varela F.: Der Baum der Erkenntnis. Scherz ,München 1987
Midgley, G.: Systemic Intervention. Philosophy, Methodology and Practice. Kluwer, Dordrecht, 2000
Nalimov V.V. Space, Time and Life. The probabilistic Pathways of Evolution. ISI Press Philadelphia 1985
Nigel,G. Troitsch, K.: Simulation for the Social Scientist. Open Univ. Press 1999
Stumme, G.; Wille, R.Hg.: Begriffliche Wissensverarbeitung. Springer Heidelberg 2000
Olson, M.: Aufstieg und Niedergang von Nationen. Ökonomisches Wachstum, Stagflation und soziale Starrheit. JCB Mohr, Tübingen 1985
Pothas, A.-M. : Operations Research Addressing Dynamic Complexity: A Re-Invention of the S. A. IR System. PhD Thesis, Potchefstroomse Universiteit 1999
Rosen, R. Anticipatory Systems, Pergamon NewYork 1985