

■ Research Paper

Adaptive Networks as Second Order Governance Systems

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We connect the idea of 'levers for change' with 'governance capacity' and propose 'adaptive networks' as an ideal type embedded in, and leveraging change in, governance systems. Discourses connect practices of citizens and companies with that governance system. Aware of interdependencies, individuals may act in the interest of the whole system and self-organize into adaptive networks, and influence discourses to a common end. Their effectiveness depends on second-orderedness: adaptive networks in niches outside the governance system may influence it through levers. The motivation and competence to build creative tension helps adaptive networks emerge and coevolve with power networks, improving governance capacity. Copyright © 2009 John Wiley & Sons, Ltd.

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INTRODUCTION

Seemingly competing values, like economic growth and sustainability, may appear impossible to both drive our development. Discourses driven by values that clearly are not implementable through acceptable and visible short-term changes may remain largely ineffective. Complexity may inhibit a wide sharing of innovative ideas that might reduce this tension. Such discourses may need to emerge in a 'next order' niche that somehow

creates leverage in the governance system from which it emerges. Senge (1990) has introduced systems thinking to identify 'levers for change' as relatively small, and therefore acceptable, interventions that have large impacts in social systems. We connect the public management idea of 'governance capacity' (e.g. Innes and Booher, 2003) and 'levers for change' making use of a cybernetic view on social change. Metaphors like 'the organization as brain' (Morgan, 1997) are used to express the view that social systems may develop proactive intelligence that combines and surpasses individual mental capacities. These metaphors are rooted in second order social cybernetics. We review the potential of second

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order social cybernetics with the aim to understand the governance capacity of societies. We start with the idea of observable adaptive networks that enable interactions between adaptive and power networks, building trust by not looking for personal power. Next, we apply this theory to the European transport system. We conclude with a reflection on remaining problems and the implications of this view for governance.

RELATING SOCIAL CYBERNETICS AND ADAPTIVE NETWORKS

2nd Order Cybernetics

Cybernetics is the study of communication and control (e.g. Ashby, 1956; Wiener, 1961). First order or *engineering cybernetics* studies circular causality in physical systems, with the aim of observing, understanding and controlling these systems. Second order or *biological cybernetics* includes the role of the observer, who is studied as a part of the system (Foerster, 1995; Maturana and Varela, 1998). A key feature is the circularity of reciprocity. The brain constructs images of first order reality as a second order reality. In *social cybernetics*, the observer is a social participant of the system. Ideas are supposed to be accepted if they serve the observer's purposes as a social participant; these purposes themselves are also socially constructed and perhaps driven by biological needs. On the other hand, the link between biological need fulfilment and constructed realities is often unclear. Consequently, through transformation of conceptual systems, society may change (Umpelby, 2006).

We focus on the construction of ideas about governance, and we contend that these ideas can be of two order levels: ideas about maximizing personal economic, hierarchical or electoral reward in the governance system, and ideas about governance reform for the benefit of a (much) larger social system. Second order governance levels emerge through transitions in behaviour of agents: a transition to a next order is defined by a switch to additional behaviour that itself does not fit in the continuing circular causality of the already existing order level, but seeks to influence it and if successful stabilizes. It

lives in the niches (or power networks) of the governance system that it finds 'influenceable'. This behaviour is altruistic in the sense that the actor does not aim to maximize his short-term returns at the basic level.

Governance Systems

Boundary judgments (Flood, 1999; Midgley, 2000) delineate systems that in the short term are supposed to have relatively more internal interdependency than external dependency. In case of human induced problems that affect physical systems, boundary judgments should encompass physical, ecological, market and social systems. These social systems consist of public, private, civil and science practices. Such research objects may be termed *complex process systems* (Teisman *et al.*, 2009; Nooteboom, 2006). Practices develop needs and desires, expressed in the governance system through social systems termed *policy discourses* (e.g. Hajer, 2005). In the governance system discourse leaders interact for power (see Figure 1).

Governance systems have regimes protecting vested interests in the composed subsystem, keen on their short-term interests and having strict mandates with little room for manoeuvre. This is not a favourable environment for new ideas. Any change would have complex ramifications, and circular causality makes the smallest step away from the status quo risky. A complex system should start moving as a whole, and 'reverberant doubt' may strike (Hofstadter, 1985). Change proposals may be rejected, even if some kind of

Degree of embeddedness

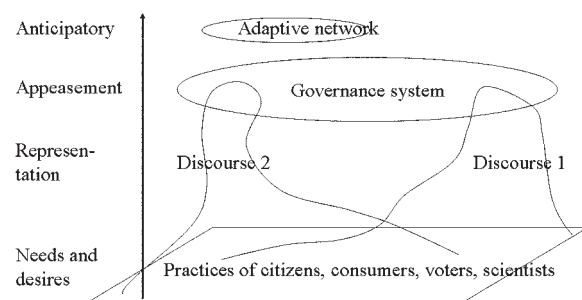


Figure 1 Four levels of embedded social subsystems in a composed subsystem

change is urgent for the group as a whole, and relative 'losers' could be compensated by the others. Scharpf (1997) points to the difficulty of mixing negotiation with learning in a single platform. Proposals for intervention made transparent prematurely will evoke a countervailing power. The governance system then needs to focus on appeasement, sometimes resulting in intractable policy controversies.

Adaptive Networks

To observe how governance systems can self-reflect and achieve governance capacity we introduce adaptive networks as ideal typical systems at a next level in the hierarchy of social systems (Nooteboom, 2006). The structuring principle of this hierarchy is the nature of reward (or needs). Reward in social systems is structured at different 'levels' (e.g. Beck and Cowan, 1996). Agents may have fulfilled some level of needs, and move to a next level. If agents have made the right choice at a certain level, they will receive reward at that level, which is not necessarily a reliable indicator for future reward at lower levels. Information therefore creates expectations of reward (e.g. trust) through interpretation. As feedbacks are delayed and expectations and real returns therefore become un-reciprocal, circularity in the social system creates its own constructs and potentially false interpretations. For example, politicians may be rewarded for firm statements if their electorate believes they can actually 'make it happen'.

Reward hierarchy follows the structure of composed subsystems as in Figure 1. In *practices* people earn their money or act in other ways they see fit to meet their immediate needs. People develop their view of the world, which includes other practices that interfere with their own. They develop needs and desires that are not met, which may then self-organize into the next level: *policy discourses* that represent their perceptions. Leaders are rewarded for properly representing partial needs and desires and showing concrete results. However, discourses in general do not match each other and therefore are sources of conflict. Leaders of discourses may be aware of

interdependency, and seek ways to avoid open conflict at the third level, self-organizing into the appeasing *governance system*. Their supporters understand that governance is in the interest of all. Trusting on fair outcomes they reward their leaders for playing obscure negotiation games. However, the governance system has difficulty making use of more complex, dynamic opportunities. Policy makers may become disappointed and spend their spare time at the next level, that of the anticipatory *adaptive networks*. Their reward is mutual acknowledgement of a contribution to the meeting of future needs of larger systems. Where the governance system is already obscure for members of the practical systems, adaptive networks are not observable to them, so there is no direct reward. Adaptive networks are a type of complex adaptive systems (defined as systems whose agents seek to adapt; e.g. Axelrod and Cohen (1999)). They increase the adaptability of the larger complex adaptive subsystems in which they are embedded. Each next level depends on the capacity of agents to make resources available for the next level and be rewarded in their self-defined way. Adaptive networks should actively adapt the reward system of its members to survive.

The aforementioned levels co-evolve with each other, which is what change managers, active at the adaptive level, may focus on. If they can break out of the circular causality of the governance system's reward system, they can join with other change managers who oversee other parts of the composed subsystem. Jointly they may reflect on the less embedded levels and look for change in a joint interest, aware of the lack of control and the need to influence co-evolution. To this end they may use levers, which produce a small but pivotal outside force in terms of its reward system (Senge, 1990). For example they may influence available resources, threaten to withdraw from a deal or create expectations of reward for initiatives addressing specific issues. These are small interventions in the governance system which must be supported by official leaders who trust that there are potential benefits in the long term and that political risk in the short term is acceptable.

Adaptive networks are *from* the first order subsystem, but they are also *detached*, so they may

become a 'virtual external force'. The governance system gets ready to enact levers that intervene at the less embedded levels of the composed subsystem. Senge (1990) has described how learning organizations may look for levers that have beneficial effects for the system as a whole. He prescribes how interactions and feedback in market systems may be analysed to find such levers, intervening in the social systems, in the practices or even in the physical system itself. Adaptive systems may for example apply personal relations to persuade leaders in the governance system to pilot constructive new ideas toward their supporters. This may create feedback in the larger system, which may be supportive and expand their room for manoeuvre in search of a next step ('wisdom of crowds').

Method

The governance system of a composed subsystem was observed by review of (policy) documents and public statements of policy makers. Its changes were hypothesized as result of interventions, i.e. proposals for a change of the official course, inspired by adaptive networks. Opponents' perceptions of intervener's motives were identified by means of interviews with influential members of this governance system. Since adaptive networks try to bridge gaps between social groups and look for interventions, their interactions may be sensitive. An observer should be trusted, and therefore should have personal relationships with several group members to be able to hear and cross-examine their stories. In this case the researcher was a reflexive practitioner who did not take part in the adaptive networks as such, but entertained close relations with several members with whom he worked in other settings. The independency of his interpretations was tested by regular meetings with scientific peers at some distance from the research object.

Triangulation of perceptions of the motives of others in real time and in hindsight revealed shared views of whether the intervention was *ex ante* and *ex post* in the common long-term interest of the composed subsystem, and how this lesson was used for new interventions. Interviewees were asked to explain how they

perceived the personal risk others were taking through their interventions in their own organizations, for a common goal, which linked room for manoeuvre in their hierarchical governance networks for relatively 'safe' interventions.

In short, a group is supposed to be an adaptive network if its members (i) oversee different parts of a complex composed subsystem (*complementarity*), (ii) in their official capacities have a tense relationship which requires innovation of the composed subsystem (*creative tension* (Fritz, 1989)), (iii) can coherently describe, first, how an intervention at governance level probably is in the common interest of their composed subsystem (*lever*), and, second, how they create conditions to make that intervention safe enough for official leaders (*trust*).

SUSTAINABLE MOBILITY

Nooteboom (2006) has applied the above method to networks of policy makers in the Dutch transport system for 5 years, looking for observable characteristics of adaptive networks as identified above. The case concerns the governance of transport fuels and car engines (automotives).

The Composed Subsystem: Automotives

Dependence on fossil fuel is widely understood as an important problem. In the Netherlands, insiders from government, oil companies, energy sector, transport unions and the environmental movement believed that although this is a globalized system, it might be possible to experiment with sustainable systems in the Netherlands. The bottleneck was believed to be the degree of cooperation between crucial actors, determining the boundaries of the composed subsystem under study.

During an EU conference in 2004 termed Energy in Motion, many members of the governance system at the highest level declared that they would focus on alternative automotive systems. Over 50 Director Generals for transport, environment and energy from all 25 EU Member States and the European Commission participated. This had been the first conference where so many

CEOs from the oil and auto industries participated (see <http://www.eu-conference2004.nl/>).

In preparation of this conference Dutch officials had been communicating with their partners in Europe, where they had shared ideas about the future of the automotive system. The *piece de resistance* was that the European car manufacturers were pressed to cooperate with scenarios that did not match their strategy. This analysis was widely shared in the conference. Polls during the conference indicated that two-thirds of the participants agreed on concrete issues, e.g. need for fiscal incentives to stimulate new fuels and propulsion systems. A month later a manager from an auto multinational said: 'While strategic cooperation in the car industry is developing worldwide, there is still little concrete cooperation in development of breakthrough technologies and technological standards. This is necessary to keep car transport affordable in the long term, but it requires short-term choices that only car users can make, either through their consumer behaviour or their acceptance of government interventions. One of the results of this conference is a greater awareness that interaction with car users about such choices is a joint responsibility of industries and governments.'

In 2007, attention for sustainable automotive systems had risen significantly. There was a common energy transition program, in which six Dutch ministries participated. The program organized transparent platforms as subsystems of the governance system. It facilitated dialogue between heads of corporations, NGOs and Cabinet; insiders used it to develop well-underpinned tension in the bureaucracy to change their policies. The finance ministry had also become involved, which was seen as a crucial step toward price corrections.

Adaptive Networks

Complementarity

The ministry for transport had organized 'Energy in Motion' during the Dutch presidency of the EU in 2004. The ministries responsible for energy and for environment had assisted. The management of the organizing team indicated that this cooperation broke with a tradition of fragmenta-

tion of these policy fields. They indicated that in the yearlong preparation period cooperation had greatly improved not only between the ministries but also with the private sector and NGOs. In fact, an oil multinational, an auto multinational, the Dutch union of private car users, and the Dutch environmental movement had been actively involved in the conference preparations as of mid 2003. They had complementary knowledge of different segments of the automotives system, and there were severe tensions between these segments, primarily between transport and environment, which cut through the public, private and civil domains.

Creative Tension

Members from all these groups first got together in 2001, after the publication of the fourth National Environmental Policy (NMP4) by the minister for environment, which stated that a transition to sustainable forms of transport was needed. Parliament and Cabinet agreed in 2001 that the minister for transport would facilitate networks to bridge the gap between the public and private sector, the NGOs and academics. Several individuals throughout the automotives system recognized NMP4 as an opportunity to develop a process to search for breakthroughs. A high-level group for sustainable mobility, termed 'IB', emerged, with directors from three ministries. They decided that each person would participate with the objective to develop a joint perception of sustainable mobility and to try to connect that perception with their own part of the composed subsystem. It took about a year to develop such a system analysis.

Levers

The analysis inspired 'interventions' in the governance system, changing the way IB members' organizations used their resources and communicated with their supporters. Nooteboom (2006) describes the analysis, the tensions and the inspired actions in detail, and how they consciously tried to maintain variety by not making decisions other than about the composition of the group, the topics for conversation and their working method. The general system analysis was connected with personal action in

several conceptual steps, representing coevolving embedded subsystems:

- Where physical resources are depleted, levers may be sought to intervene in the physical system (physical levers). The IB concluded that cleaning up automotive systems would contribute significantly. They evaluated specific market initiatives for possible contributions to a sustainable automotive system.
- In order for the market to create physical levers the government may intervene in market processes by means of 'carrot' and 'stick' (market levers). The IB coined the idea of a credible threat of a higher cost of pollution to attract more stakeholders to the negotiation table.
- The government may not be resourceful enough to implement such interventions. Complexity tends to make such solutions imperfect, and they run into barriers. Creating smart tension in governance networks can itself be a governance lever if it contributes to rethinking the common agenda in the governance system. Communications by an IB member, a deputy Director General of transport, about new problem definitions, and the role of diesel and gas, proved such a lever. The EU conference 'Energy in Motion' itself was another lever. Tensions functioned as attractor for proposals that fit the new agenda.
- Breakthroughs need to be invented before they can be brought to the forefront in governance systems. To invent clever power interventions, ample knowledge is required about the composed subsystem, its possible directions of change and the impact of envisaged governance levers. Therefore the next type of lever required is the connective lever, which brings about self-organization into adaptive subsystems that look for governance levers, with a view to market levers and physical levers. Connective levers are aimed at trust in personal intentions and competencies, and in the joint competency to create change.

Trust

The IB agreed to remain informal, fearing that becoming part of any ministry's program would add short-term stakes causing the group to sink

back to the governance system. For example, participating professors of transport and environment were not paid for their services. Members commended each other for actions in line with their analysis of the composed subsystem. Members of the IB exchanged information where they normally would have feared opportunistic misuse; for example an auto industry revealed its strategy to the group, which included the environment movement. They helped one another to communicate with their own support groups. By communicating about problem descriptions of the conference in terms that appealed widely, and after successfully inviting CEOs of an oil industry and a car manufacturer to the EU conference (a governance lever), the ideas started resonating through the European automotive system. Abstract ideas could be made concrete in European interaction. At the conference itself they could 'harvest' agreement.

A deputy DG of transport indicated: 'I participated because my ministry had never been able to develop constructive relationships with the industries because the link with political decision making was unclear. This informal setting enabled me to develop relations without the necessity of visible outcomes. Formally that would not have been possible, because the ministry would then first have to make some kind of decision about its political objectives, which is immediately threatening for the industries, and hampers the process.' Participation of someone like him had been a goal of other pioneers in this process, because they anticipated that this might become a connective lever, attracting many others to the process.

Trust in intentions and competencies was 'governanced'. Within the group, some people reminded the others of required separation from the governance system and to verify constantly that members did not use the knowledge they acquired for purposes that were not consistent with the group's view of sustainable mobility. Others intervened in the group's working method by proposing to scan all that was occurring at the political level in the composed subsystem, and to look for opportunities to apply levers for sustainable mobility in the governance

system. This led to interventions with respect to logistical developments, scientific research programs, and other related programs. Uncertainties about possible sustainable development paths were analysed as possible developments of the mobility system, and then translated to governance issues. When a new person joined, it was made sure that he was complementary to the rest of the group (with a view to their boundary judgments), that he had inside knowledge, that agendas were open and that he would use his influence where feasible.

The IB itself also adapted to feedback from the governance system. First the group adapted its focus and composition to the opportunity the governance system offered in relation to sustainable automotive systems. It created momentum for inviting someone from a car industry and when the time was right someone from the usually reluctant finance ministry. Each time this joining functioned as a lever that enabled a next step in connectivity. Insiders indicated that for the first time the public–private gap was bridged enabling a flow of knowledge, and there was momentum for a constructive solution-oriented dialogue between Cabinet, oil industries and car industries. NGOs participated to actively make the link with Parliament. After the successful EU conference, six ministries started the energy transition program.

CONCLUSION

An Adaptive Network Leveraging Change

The automotive system changed under the influence of an adaptive network, the IB, whose members used connective levers to bring about a cascade of co-evolutionary change. Connective levers were aimed at developing trust in the adaptive network, which co-evolved with the governance system. Trust was required to apply levers at other system levels to generate feedback from the automotive system about its future. The IB's ideas resonated in Europe, they used feedback to learn, and resulting ideas materialized in a major European conference.

Informal networks can develop trust by separating (power) governance from learning,

which is needed to make knowledge flow in the governance system. Tensions included those between competitors (like transport and environment ministries) and between societal domains (like public versus private). Trust made competitors act together for the long term, while not distorting their competition in the short term (i.e. requisite variety). The IB proposed levers, which their members then applied as interventions in their official role in the governance system.

Agents across the transport system coordinated their behaviour based on possible futures and created room for different innovations that fit desirable futures. Trust compensated the limited cognitive capacity of policy makers in the components of the mobility system; people simply had to trust that others made adequate analyses of their components of the composed subsystem. The adaptive network formed a connecting pattern: a collective cognition of the automotive system.

This is how the two embedded levels, the governance system and, in its niches, adaptive networks, are separated and still connected. Different adaptive networks may compete for the attention of power networks. We propose to consider such adaptive networks as a second order governance system, which metaphorically may be compared with a collective brain.

Research Implications

Adaptive networks appear as volatile and implicit structures in the context of governance processes. Still the IB teaches us that shifts in governance by the visible leadership may be explained by informal interactions. By definition, widely visible acts are power acts because they create expectations. Such expectations can act as governance lever. Knowledge from throughout the composed subsystem can be 'linked to power' in a hidden process based on trust between opponents who try to develop governance levers without putting leaders in jeopardy. A researcher looking for adaptive networks can search for persons who consciously apply connective levers across social gaps.

Also at the level of workers, consumers and citizens, adaptive subsystems may emerge and

try to influence the leadership. How can one 'measure' the total adaptability or governance capacity of a composed subsystem? Observing behaviour in governance systems creates the difficulty of mixed motives. A person may *say* he acts from a common frame, but he can actually have a hidden agenda. There is no obvious way to conclude either from visible behaviour. Interactions behind the scenes are still to large extent power interactions in terms of alliances for 'attack' or appeasement rather than adaptive interactions.

A researcher may analyse a composed subsystem based on widely available data, identify opinion leaders in the system, and iterate his initial analysis with the informal networks that support these leaders. Governance capacity may increase if members from different system components indicate that consensus about long-term challenges grows. The researcher may dig deeper to identify informal networks that moderate dialogue and build trust behind the scenes, increasing a tension between long-term images and the present situation and looking to facilitate co-evolution of thinking between opposing groups. Scientists are member in these networks, as was the case with the IB. Studying governance capacity at second order level therefore should be seen as next-order science. The researcher makes no analysis of the composed subsystem (although he starts with his own boundary judgments), but rather he looks through the eyes of adaptive networks, allowing for the views of 'first order scientists'. Adaptive networks bridging large social systems are likely to make relatively adequate analyses.

Power Networks Versus Adaptive Networks

At one extreme, the governance networks may meet and play power games, without interest in the outcomes in the longer term. At the other extreme, members of governance networks may have separate meetings in adaptive networks, to discuss power interactions and to discuss common frames and governance levers on a basis of trust. The very idea of adaptive networks itself may actually help improve governance capacity by generating a creative tension between

the long and the short term that is actually felt in the governance system and leads to other accessible paths. Being aware of that possibility may generate the will to take that path; in such a way joint knowledge itself can become a lever (e.g. Leydesdorff, 1997). There may always be some degree of adaptability in any governance network. The issue is to foster the adaptive component of governance by making it explicit, as the IB has actively done. Where motives and interactions based on power and knowledge are always mixed, it might help to make an artificial distinction between opposing 'ideal types'. Where pure adaptive networks are the first ideal type, the opposing ideal type could be defined as 'power networks' (Nooteboom, 2006). In adaptive networks, knowledge is used to develop a more complex and coherent view of reality. In power networks, knowledge is used to support positions already taken. Adaptive networks are accessible on invitation and the participants give full information about their agenda and their uncertainties. Power networks are transparent for a larger audience, under scrutiny by company controllers; therefore the real agendas are concealed. Deliberate separation may create basis for trust while the tension between the two may inspire. Adaptive networks and power networks revolve around each other, constantly influencing each other while maintaining creative tension; i.e. co-evolve.

As soon as an adaptive network intervenes in its governance network its output becomes widely visible. Here, Senge's levers, governance capacity and leadership become observable. If the idea of connective levers is added, policy makers are better able to understand their own position in a larger system and their options to contribute to a co-evolutionary cascade and governance capacity.

REFERENCES

- Ashby WR. 1956. *Introduction to Cybernetics*. Chapman and Hall: London.
- Axelrod R, Cohen MD. 1999. *Harnessing Complexity. Organizational Implications of a Scientific Frontier*. The Free Press: New York.
- Beck DE, Cowan C. 1996. *Spiral Dynamics. Mastering Values, Leadership and Change*. Blackwell. Oxford, UK.

- Flood RL. 1999. *Rethinking the Fifth Discipline: Learning Within the Unknowable*. Routledge: London.
- Foerster Hv. 1995. *The Cybernetics of Cybernetics*. Future Systems Inc.: Minneapolis.
- Fritz R. 1989. *Path of Least Resistance: Learning to Become the Creative Force in Your Own Life*. Ballantine Books: New York.
- Hajer M. 2005. Coalitions, Practices, and Meaning in Environmental Politics: from Acid Rain to BSE. *Discourse Theory in European Politics*. Howarth D, Torfing J (eds). Basingstoke: Palgrave Macmillan, pp. 297–315.
- Hofstadter DR. 1985. *Metamagical Themas: Questing for the Essence of Mind and Pattern*. BasicBooks: New York.
- Innes J, Booher D. 2003. The Impact of Collaborative Planning on Governance Capacity. *Institute of Urban & Regional Development. IURD Working Paper Series. Paper WP-2003-03*
- Leydesdorff L. 1997. Sustainable technological developments and second-order cybernetics. *Technology Analysis & Strategic Management* 9(3): 329–341.
- Maturana H, Varela F. 1998. *The Tree of Knowledge*. Shambhala Press: Boston.
- Midgley G. 2000. *Systemic Intervention*. Kluwer: New York.
- Morgan G. 1997. *Images of Organization*. Sage: Thousand Oaks.
- Nooteboom S. 2006. *Adaptive Networks: The Governance for Sustainable Development*. Eburon: Delft.
- Scharpf FW. 1997. *Games Real Actors Play: Actor-centered Institutionalism in Policy Research*. Westview Press: Boulder, CO.
- Senge PM. 1990. *The Fifth Discipline: The Art and Practice of the Learning Organization*. Currency Doubleday: New York.
- Teisman GR, Van Buuren MW, Gerrits L (eds). 2009. *Managing Complex Governance Systems. Dynamics, Self-Organization and Coevolution in Public Investments*. Routledge Critical Studies in Management. Routledge, New York.
- Umpelby SA. 2006. Fundamentals and history of cybernetics 1: a tutorial presented. *World Multi-Conference on Systemics, Cybernetics and Informatics, Orlando, Florida*.
- Wiener N. 1961. *Cybernetics*. MIT Press: New York.