

Acknowledgement:

This research was supported by the German Research Foundation (DFG) as part of the Collaborative Research Centre 637 »Autonomous Cooperating Logistic Processes – A Paradigm Shift and its Limitations«.

3.2 Self-Organization in Management Science

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3.2.1 Introduction

Today's real-time economy is characterized by three phenomena: hyper-linking, hyper-competition and hyper-turbulence (Tapscott 1999; Siegele 2002). As a result, management, which is responsible for designing social systems (Remer 2003), is confronted with high complexity and dynamics. However, conventional management seems not to be capable enough to cope with highly complex and dynamic situations (Hülsmann and Berry 2004) due to limited ability of human beings to obtain and analyze information (Simon 1957). The concept of self-organization might contribute to social systems' competence and thus to managing complexity and dynamics (Hülsmann and Wycisk 2005). The concept of self-organization has its roots in various natural sciences and has been studied by quite a few natural scientists (Foerster 1960, Prigogine 1971, Haken 1983, Maturana and Varela 1982). The original idea that self-organization could enable spontaneous formation of order (Prigogine and Glansdorff 1971; Maturana and Varela 1987) inspires interests of researchers from management science. Probst claims that the idea of self-organization enriches management theories by giving new interpretations to key aspects of the conventional management approaches such as planning, organizing and motivating (Probst 1984). However, in management science, research on self-organization is dispersed, with different angles of observation and a variety of terms used as synonymies. Consequently, this lack of an overarching framework for studying self-organization may impede the recognition and application of this concept in management science.

The primary aim of this paper is therefore to develop a general understanding of self-organization in management science so as to contribute to

the establishment of a framework for studying self-organization. To fulfill this aim, this paper tries to answer the following questions: 1) how do different researchers understand self-organization in management science and what are the major aspects of self-organization in their view? 2) What are the commonness and differences between these concepts? To answer these questions, at first selected concepts using self-organization from management science will be introduced. Next, characteristics of self-organization implied by these concepts will be compared according to selected criteria in order to form a general framework to study self-organization in management science. Finally, future research needs will be proposed.

3.2.2 Selected concepts using self-organization in management science

In this section, selected concepts using self-organization from management science will be presented. However, this list of concepts relevant to self-organization is not exhaustive, that is, there are more concepts brought forward by other researchers besides those introduced in the following (e.g. Knyphausen-Aufseß 1993; Kieser 1994; Ulrich 1984; Dachler 1984). Factors taken into consideration during the selection process are primarily systematization, explicitness and citation frequency. Besides, among similar approaches (e.g. concept of evolutionary management raised by Knyphausen-Aufseß 1993, Kieser 1994, Kirsch 1992 and Malik 2000 respectively) those which might have a more comprehensive understanding are chosen (Malik 2000; Kirsch 1992).

Order as the result of human action (F. A. von Hayek)

Von Hayek (1899-1992), economist and Nobel Price winner, works with core problems in social theories and social policies. He is especially interested in topics of how structures of human society develop and how a variety of humans together build a society. His main statement is that social systems do not result from consciously steered actions, but come into being spontaneously (von Hayek 1994). In order to explain this phenomenon, he draws analogies between phenomena in social fields (e.g. development of a relationship net in social systems) and those in fields of natural science such as physics and biology (e.g. natural evolution processes) (von Hayek 1981). Göbel sees his work as the original business concept of self-organization in economics (1998).

Von Hayek attributes the formation of a society's ordered structure to a self-organizing process and calls such a structure self-organized order. (von Hayek 1994), which he characterizes as polycentric and spontaneous (von Hayek 1969). As an example, he frequently uses the image of the "invisible hand" on economic markets raised by Adam Smith (1723-1790). In this understanding, the process bringing a balance between demand and supply is not consciously controlled by any entity. Such self-organizing processes are based on the evolvement of a relationship net (Caldwell 2003). According to von Hayek, relationship net is a constitutive characteristic of human society. It is shaped by mutual adjustment of actions between humans. With the establishment of relationships, humans might anticipate their fellows' possible behavior, which will be considered when deciding their own actions. During the development process of the relationship net, some relationships will be sustained and become stable while some others are up to individual choices and unstable. At the same time, new relations will be generated and existing ones will adapt to changing situations. Thereby, the interpersonal relationships and expectations of each other's behavior lead to an ordered structure, which unifies a variety of humans into a society (von Hayek 1994). It has to be stated that characteristic of self-organization in the formation of social structures is reflected in the absence of conscious human design. The prerequisite for such a self-organizing creation of ordered structure in a system is the elements' adherence to abstract rules, which are embedded in generally accepted norms, cultural aspects, traditions and customs (von Hayek 1980). Individuals are not necessarily aware of these general rules, as education and influence of society can implicitly shape individuals' rationality of behavior without his or her consciousness (e.g. the behavior rule of respecting others' properties, which is gained through education). Only if all individuals adhere to the same rules, they can anticipate other system members' behavior and adapt themselves accordingly in order to attain their goals (Caldwell 2003). As each system element reacts in its individual environment according to generally accepted rules, a social order comes into being. In the above mentioned example of economic markets, all market participants follow the same rationality: to produce and distribute enough goods with a price capable of gaining profit (von Hayek 1984).

In contrast to the order created by a self-organizing process, there is also order resulting from conscious planning and building (e.g. in organizations), which is called by Hayek as taxonomic order (von Hayek 1969). Similarly to order out of self-organization, such order is also a consequence of behavior rationality and rules. However, these rules (e.g. organizational rules) are established with awareness. Due to the limited ability

of human beings in recognizing and analyzing problems (bounded rationality) (Simon 1957), deliberately designed structures are of a simple nature, which means that they could hardly reach states as complex as those found in self-organizing structures. Von Hayek points out that the knowledge about general principles of self-organization could help to generate complex order by creating accordant conditions (von Hayek 1994).

Self-organization in social systems (N. Luhmann)

Luhmann (1927-1998), jurist and sociologist, is one of the founders of system theory. He does interdisciplinary research in the fields of economics, jurisprudence, theology, history, literature and communication science. His aim is to apply the conceptual instrument of social system theories to describe all objects in the field of sociology (Kneer and Nassehi 1993). In 1984, he published his major work “Social Systems”, in which such a conceptual instrument is described (Luhmann 1984). His social system theory has become one of the most famous theory models in the German-speaking area applied to sociology as well as psychology, management theory and literature theory. Luhmann sees a paradigm shift in the research results of Maturana and Varela and tries to transfer their approach of autopoiesis to social systems (i.e. principles of self-organization). In his work, he regards social systems as autopoietic with the characteristics of emergence and structural coupling (Brans and Rossbach 1997).

According to Luhmann, autopoiesis in social systems means that social systems are closed operating entities, which sustain and regenerate themselves through recursive production of communications (Luhmann 1984). He interprets communications as smallest elements in social systems, which are unable to be divided. Every communication produces another succeeding communication, which is explained by Luhmann as a chain effect. After a person X hears or reads what another one has said or written, his or her words might further be heard or read by a third person. As this process keeps going, new communications are produced one after another (Luhmann 1990). Consequently, social systems keep reproducing themselves, which reflects self-organizing processes. However, Habermas criticizes that Luhmann portrays social systems as consisting of only communications (Luhmann 1990) without taking into consideration humans (Christodoulidis 1991) involved in social interaction. The consequence might be weak transferability to real life, as social interaction might disrupt cultural reproduction (Habermas 1987).

Emergence refers to the generation of a new order level, which cannot be explained by the material and energy foundations (Luhmann 1984). In a psychic system, though the generation of thoughts depends on activities in the brain for necessary material and energy supply, this process is going on without the influence of the brain. The reason is that thoughts to be produced cannot be inferred by observing the activities of the brain. At the same time, from certain thoughts the processes in the brain cannot be inferred, either. Therefore, the psychic system is an emergent order level for the brain. Similarly, communications in social systems cannot be inferred from organic, neural and psychic processes. Consequently, communications build a new order level over other systems (Luhmann 1985), which in this case describes a major principle of self-organization.

Two structural coupled systems constitute environments for each other but are closed operating systems, like the psychic system and the brain described above (Luhmann 1984). Though psychic systems have the possibilities to disturb, inspire or irritate communications (e.g. a person is happy so that he wants to tell others his story), it is impossible to conclude from a communication how the involved psychic systems think. For example, even though one party of the communication is confident that he clearly knows what his partner thinks, his thinking occurs only in his own psychic system and this is not a process of communication (Luhmann 1985). In this sense, psychic systems and social systems operate independently while having certain influence on each other (Kneer and Naasehi 1993). As a consequence, psychic and social systems are structurally coupled (Luhmann 1984), which describes another major principle of self-organization.

Though being autopoietic like the living system studied by Maturana and Varela, psychic and social systems differ from other systems in that they exist for some "meaning" (Luhmann 1984). The meaning they pursue is decided by both reality and possibilities on hand. When the risk of instability has to be faced, the possibilities for systems' further development are considered under constraints of reality. In other words, psychic and social systems are constantly choosing between possibilities to update their actual status. In psychic systems, every thought is accompanied by certain intentions and could lead to further possible intentions, which update the original thought (e.g. specify a decision on increased information over time). This selection process between possibilities in thinking is also applied to communication processes, which contain intentions and could be connected by a number of possible communications (i.e. process of self-organization). In this sense, a meaning always points to another meaning

through a selection process of thoughts and communications, as meanings are embedded in thoughts and communications (Kneer and Nassehi 1993).

Evolutionary management (F. Malik)

Malik (1944-) from St. Gallen belongs to the evolutionary management school, who is dedicated to the development of his own concept of evolutionary management. The central theme of his approach to evolutionary management is the configurability and tractability of complex and dynamic systems. He bases his theory mainly on works of Beer (Beer 1972), Drucker (1974) and von Hayek (1984). Especially cybernetics (Wiener 1948; Ashby 1974) and general system theory (Bertalanffy 1969) lay foundation for the development of his thoughts.

The evolutionary management school considers complexity and dynamics as causes for uncertainty of system behavior and thus recognizes the limits of organizational planning and controlling (Malik 2000). Malik points out the complexity in social systems which means social systems could have a number of possible states due to numerous interactions between system elements (Malik 1984, 1993). Similar to cybernetics (Ashby 1974), the evolutionary management school focuses on the central assumption that only complexity can absorb complexity (Malik 1984). In his approach, Malik tries to identify the general principles of applying complexity as well as its opportunities, limitations and consequences for management practice (Malik 2000).

The evolutionary approach claims that complete control of company systems is impossible due to a high level of complexity, which means unpredictability for the system development (Malik and Probst 1981). This recognition is reflected in systems' objectives from the perspective of evolutionary management. Unlike classic approaches arguing that profit maximization is the systems' objective, the evolutionary approach regards viability as systems' objectives (Malik 2000). A certain degree of control could only be achieved by influencing general structures and rules. Detailed rules are abandoned, because the conception and implementation of these rules are not realistic for limited human knowledge in face of high complexity in firms. Instead, Malik recommends abstract rules for guiding complex systems towards the desired direction (Malik 1993, 2000). This exhibits a self-organizing order-building process (Kieser 1994).

As the development of social systems is driven by decisions and actions of problem solving processes, Malik analyzes different problem solving processes (analytic constructivist approach vs. evolutionary cybernetic ap-

proach) combined with distinctive order building processes raised by Hayek (taxonomic order vs. self-organized order, see Section 2.1) (von Hayek 1969, Malik 2000).

The analytic constructivist approach tries to build order through detailed formulation of processes. An optimal solution would be chosen through rational evaluation of alternatives and implemented in organizational practice. This problem solving process in this sense could be considered as planned and conscious. It can often be found in tightly hierarchical organizations for ensuring organizational functions. Therefore, the rationality of the constructivist approach is to design a taxonomic order in advance and control its further development. However, this approach does not work for self-organized order. The reason is that the establishment of such order needs flexibility and adaptability of system elements, but the constructivist problem solving process might hinder the self-organization tendency by imposing pre-defined solutions (Malik 2000).

In contrast, evolutionary cybernetic approach claims that order building depends on system structures, certain general behavior rules as well as interaction patterns of elements (Malik and Probst 1987). Malik claims that the evolutionary problem-solving process is a “blind” variation and selection process (Malik 2000). “Blind” refers to the fact that “right” strategies for solving problems could only be obtained through trial and error processes when an organization faces complex situations (Malik 1984). Variation means the generation of specific actions, which are based on some basic behavior patterns but are adapted to specific environmental conditions. Selection refers to the retention of effective behavior alternatives after a number of trials. However, an evolutionary problem-solving process does not mean leaving freedom of decision and action totally to employees, because they have to behave under general objectives and rules given by management (Malik 1984). Combined with taxonomic order building, this approach introduces ideas like job-enrichment and job-enlargement as well as cooperative leadership style (Malik 2000). However, Malik points out that this approach could not be fully realized in a taxonomic order form. As the taxonomic order form is oriented to planning and optimization, it tends to offer few possibilities for an organization’s development. The combination of this approach with self-organized order could be an important component of today’s evolutionary theory in both biological and social development, because this combination might work out a variety of alternatives and thus make a system adaptable (Malik 2000).

Concept of the progressive organization (W. Kirsch)

Kirsch (1937-) is professor of management science at Ludwig Maximilians University of Munich, Germany. He works in the field of leadership and management. He focuses on the limits of managing complex dynamic systems like firms. In 1992 he published his major work “communicative action, autopoiesis and rationality”, which contains his concept of the progressive organization (Kirsch 1992).

Kirsch’s approach conforms to the understanding of the evolutionary management school and claims that firms are evolving systems, which are capable of adapting themselves to the changing environment by changing their own structures and processes (Kirsch 1992). In his work, Kirsch brings forward the hypothesis that organizations change with low predictability over time. Due to complexity and dynamics, organizations’ objectives could hardly be achieved by management’s deliberate design (Kieser 1994).

Though his approach has many similarities with that of Malik, there are two major differences in this conception. On the one hand, while Malik attributes complexity of firms to a variety of unknown data and events (Malik 1984), Kirsch credits complexity to collision of different people within different contexts, needs and goals (Kirsch 1992). Therefore, an important component of Kirsch’s research conforms to Habermas’ theory of communicative action, which studies the communication between system members (Habermas 1981). On the other hand, while in his research Malik sees the firms’ goal in survival on the market, the major concern of Kirsch’s theory is to create a goal based on consensus (Kirsch 1992). In order to meet different goals, needs and motives of firm members, decisions made by individual members should benefit the whole organization, because progress of the whole organization is the prerequisite for individual development (e.g. all employees could get satisfactory compensation or training opportunities only if the organization is operating smoothly and efficiently). As the theory of autopoiesis mainly deals with system development, it conforms to Kirsch’s core idea of progressive organization (Kirsch 1997). Therefore, Kirsch studies what knowledge of using autopoiesis to deal with complexity could be transferred to social systems and to what extent external forces could be relied on to attain the systems’ goal (Ringlstetter and Aschenbach 2003).

With the concept of the “progressive organization”, Kirsch emphasizes that in their evolutionary process organizations could develop some capabilities which enable organizational development and problem solving

with a certain degree self-organization (Kirsch 1992). The extent of self-organizing ability depends on three system capabilities (Kirsch 1997). One capability is the action capability, meaning that an organization has enough resources for further organizational development and necessary changes due to certain impetuses. This capability helps to retain an organization's identity, as it ensures that the system could respond appropriately to perceived problems. The second capability is the learning capability, which means that an organization is able to master and apply knowledge. Organizational learning builds a common knowledge base, which puts together individual employees' knowledge. However, an important premise for organizational learning is that all employees should have access to the knowledge base and have the opportunity to make use of it. Besides, the learning capability implies that an organization can filter irrelevant and redundant information (e.g. by distributed decision-making so as to reduce information overload for management). Besides absorbing new knowledge, the learning capability also means that an organization can learn from its own behavior (e.g. the failure of formal rules leads to management's decision on giving employees more power for decision-making). Therefore, this capability is self-referential. The third capability is responsiveness capability, which means that an organization is sensible to the needs and interests of its stakeholders (Kirsch 1992). A responsive organization always undertakes actions which address the needs of relevant parties. However, appropriate responses are preconditioned by the organization's ability to recognize such needs. Therefore, the organization should be sensitive to individual contexts and life styles of the concerned parties, which articulate their needs. According to Kirsch, if the above three capabilities are well developed, an organization could reach a high development level. However, he points out that complete self-organization has to be seen only as an ideal model (Ringlstetter and Aschenbach 2003).

Kirsch describes a self-organizing process like this: when a system member perceives a problem, he or she can establish his or her own hypotheses about who else is involved in this problem and who can contribute to solving the problem. Then this member sets up contact with other concerned members, who again produce hypotheses regarding concerned parties and interact with them. Kieser calls this process "self-organizing snowball process" because through this process a chain of members are connected without the influence of external forces. However, this process could only be realized when the framework for action given by external forces (e.g. management) allows members to make independent decisions (i.e. regarding concerned parties) (Kieser 1994). In this way, system elements could have a wide scope for independent decision-making, which

might lead to a self-organized problem solving without the external intervention resulted from hierarchy. However, to which extent problems can be solved by system elements in a self-organization process depends on the level of action, learning and responsiveness capability. If such a self-organization process fails to generate consensus, one of the members could take the role of leadership and impose formal rules, which would bring self-organization to an end (Kirsch 1992).

Order building processes in social systems from an integrated view (G. Probst)

Probst (1950-), professor of organization and management science at the University of Genf, Switzerland, understands self-organization as the consequence of interaction and exchange processes of organization members (Probst 1992b). He claims that the order pattern does not solely result from actions of managers, organizers and planners, but is constructed and developed by all organization members in self-organizing processes (Probst 1987). Therefore, the result of deliberate management design can not be predicted and may deviate from the original goal (Kieser 1994).

Probst regards self-organization as the prerequisite for survival of systems (Probst 1992b). He points out that a social system has a relationship of mutual exchange with its environment (e.g. a system gets resources from the environment and offers its output to the environment). When the environment changes, the system also has to change in order to retain its identity, e.g. through absorbing new technology to meet higher requirements of consumers so as to stay on the market (Probst 1992b). However, a social system is difficult to plan and control due to both external complexity (e.g. new technologies) and internal complexity (e.g. variety in attitudes towards introduction of a new technology). Due to management's inability of planning in such situations, self-organization is assumed to endow social systems with the ability to appropriately respond to changes (Probst 1987).

Probst identifies several characteristics of self-organization, namely self-reference, complexity, redundancy and autonomy. Self-reference builds a system's border and differentiates the system from its environment. It means a system makes decisions and implements actions based on its current state (e.g. to produce more due to low inventory). Due to its function of offering information for decision-making, this self-reference is the starting point for system behavior, for taking measures against disturbance and for realizing internal synergy (Probst 1992a). In this way, a social system develops its own logic and thus gains its identity.

Complexity is reflected in the fact that a self-organizing system comes into being through a high density of interactions between a variety of elements. Therefore, system order could take a variety of forms, which depends on the system history and its elements (Probst 1992a). Social systems have objectives, which might be different. Therefore, individuals and departments inside systems have to cooperate to realize common objectives. However, cooperative relationships keep changing (e.g. the cooperating relationships are only temporary inside a project within a company). Therefore, system structures change constantly and swing between order and disorder. In self-organizing processes, the whole system and the elements have to be oriented towards finding new equilibria to retain the system's identity (Probst 1987).

Self-organizing systems are redundant, because their structure and behavior are not designed by a single designer but developed by all system elements (Probst 1987). In this view, the systems' functions instead of system elements are redundant. This redundancy in functions results from a heterarchical structure, where a number of people could have the same capabilities. Therefore, it is possible that some organization members can fulfill several roles and functions. Redundancy ensures the normal organizational operation even when systems are exposed to disturbance. Therefore, the development of a firm might be based on a design of heterarchical structure, where all system members are empowered to manage the firm (Probst 1992b).

Autonomy means that elements, relationships and interactions within a system are independent of external forces. Though a system has a loose relationship with the environment for more options in the future (e.g. to absorb talents from the environment to develop new products), it can establish its own goals as well as means to attain the established goal (Probst 1992a). An example in a firm can be that each department only follows the guiding principle based on the goal of the firm and can decide its own objective and actions.

Though self-organization has potential to be applied to organizations and facilitates the organizational development, Probst stresses that self-organization has to be separately studied in specific contexts (e.g. different industries in which firms are situated, different sizes of firms) (Probst 1987). Thus, the optimal degree of every characteristic should be studied (e.g. how much autonomy should be given to each department in a firm). Moreover, an instrument measuring single characteristics of self-organization under the consideration of cost-benefit relationship is still lacking.

Autogenous and autonomous self-organization (E. Göbel)

Göbel (1956-) finished “Theorie und Gestaltung der Selbstorganisation” in 1997 (Göbel 1998). She claims that the effect of a selected structure on organizational performance can only be evaluated by observing the interaction of organization members within the formal organizational structure. According to Göbel, the structure is the result of external organization and self-organization. External organization refers to goal-oriented structure design while self-organization is based on individual as well as systemic behavior (Göbel 1993). Göbel’s goal is to assess limitations of deliberate structure design and develop suggestions for implementing self-organization (Göbel 1998).

Self-organization could be understood as the removal of bureaucracy and formality as well as the reduction of hierarchy and specialization. At the same time, a new structure should be established in the form of teams and processes (Göbel 1998). The formation of such a structure means more self-decision power for organization members, which is given by the management. Göbel stresses that management should set itself as an example and be the motivator in the learning process while being the initiator of self-organization processes (Göbel 1993). The application of concrete management concepts like divided management (Mintzberg 1990), rotating management (Peters 1993) and collective management (Heintel and Krainz 1990) however should take the specific context into consideration (Göbel 1998).

Göbel sees self-organization as a phenomenon which manifests itself in different aspects: micro-organization (autonomous complementary organization), informal organization (autonomous alternative organization), interpretation of organizational reality (autogenous alternative organization) and momentum of systems (autogenous complementary organization) (Göbel 1998). Self-organization as micro-organization means that system elements can use options given by an external organizer like management to build their internal structures. But management has limited influence on this kind of order building, which depends on some factors hardly visible to management such as personal capabilities and habits of organizational members (Göbel 1993). Self-organization as informal organization refers to the situation that formal and informal rules exist in parallel. As a result, there are both formal and informal communications. However, whether such self-organization contributes to organizational performance remains unknown. For example, informal communication could be regarded as positive for performance, as it might speed up information flow (e.g. directly between employees instead of through a complex hierarchy). How-

ever, due to the uncontrollability, informal communications could negatively impact organizational performance by deviating it from the desired state (e.g. departments work together to hide problems). Self-organization as interpretation of organizational reality exhibits an individual psychological perspective, meaning that organization members can construe reality by themselves. In this context, members evaluate and process reality by using their own experience and approaches. Consequently, it is possible that similar processes and structures could lead to very different organizations. The risk lies in the incongruity in perception, which results in conflicts for organizations (Göbel 1993). Self-organization as momentum of systems stresses that a system should be regarded as a whole. Individual elements' behavior which is totally independent from the management is regarded as harmful for the development of the whole system, as elements might misuse full autonomy and pursue their own benefits in conflict with the system's goal. Therefore, management predefines a number of actions and system elements have the freedom to choose and combine these actions.

In general, self-organization is assumed to have positive influence on organizational efficiency, as it might help to fulfill the requirements of environment concerning time (e.g. timely response by fast information flow through direct communication in heterarchical structures) and resources (e.g. employees' creativity resulting from more autonomy) (Göbel 1993; Staehle 1991). Besides, employees' satisfaction and motivation might be enhanced through gaining more power for decision-making (Göbel 1997; Laux and Liermann 1993; Ulrich 1991). However, possible negative effects of self-organization on organizational efficiency could be seen in potential conflicts (e.g. due to different perception of autonomous elements) (Göbel 1993; Rosenstiel 1985) and excessive demands and overload for employees (Göbel 1993; Jung 1985). Other problems could be resistance by rooted routines and habits, management's unwillingness to give up power (Göbel 1993) as well as organization members' opportunism for self-interest. As a consequence, a combination of external organization and self-organization might be required (Göbel 1998).

Self-organization as evolutionary process (A. Remer)

Remer (1944-) is professor of management and organization science at the University of Bayreuth, Germany. His conception of organization has human beings as its focus. He claims that the personnel in an organization have double functions: as system members they design an organization's structure; as system participants, they interact with each other to play the

defined roles and realize the desired structure which they have designed as system members (Remer 1985). This process is covered by the concepts of self-organization or organizational self-structuring.

One possibility to enhance self-organized structure building could be more frequent interaction with the concerned social systems (Remer 1994). In this context, management's role is not restricted to the realization of ideas and goals. It is regarded rather as intermediate between environmental conditions and employees in a constant process of adaptation (e.g. improve products to fit consumers' needs) and selection process (e.g. absorb necessary technology to improve products) (Weick 1985).

Remer understands self-organization as an evolutionary and learning process (Remer 1994), in which a system acquires its structure through its capabilities of "structural learning" (Pautzke 1989). The existing knowledge of a social system is regarded as "genes" or "comps" (competences) (Segler 1985). The system's ability to survive depends on processes of "self-observation" and "self-selection", where genes could adapt themselves to the environment (Remer 1994). The prerequisite for structural learning consists of feedback on actions (Argyris and Schön 1978) and variation (Hedberg 1981). Feedback on actions means that new actions should be based on existing problems (e.g. a firm's decision on updating technology, because they have recognized that the existing technology cannot fulfill consumers' needs). Variation means that the variety of comps should be facilitated, because variety contributes to evolutionary success of a system by giving more possibilities for the system's development (Remer 1987). Variation could be achieved by taking into consideration ideas of all system members and participants as well as other institutions (e.g. formal rules). A means to realize variation is decentralization of organization processes, which enhances the capacity of a whole system in problem solving (e.g. overload of information for management could be replaced by an appropriate amount of information for a number of elements) as well as diversity of perspectives. Remer calls the process of achieving structural learning as "organizational reflexivity" (Remer 1997), which refers to Luhmann's concept of "reflexive mechanisms" (Luhmann 1973).

According to Remer, the progress in thinking of organizational problems by including the concept of self-organization could be considered as a shift in perspectives (i.e. from a mechanic perspective to a biological perspective) (Remer 1994). A biological perspective emphasizes the generation and evolution of organizations with the recognition of their dynamic nature, which the rule rather than the exception in real life. Nevertheless,

Remer also points out that the introduction of self-organization means the loss of opportunities to design an organization according to certain cause-effect patterns (Remer 1997). The reason is that the endowment of organization members with a certain degree of autonomy means that management might not predict the behavior of individual members and the aggregate effect of their behavior (behavior of the whole organization) (Remer 1987).

3.2.3 Major characteristics of self-organization in management science

Criteria for comparison

In order to develop a general understanding of self-organization in management science, a comparison of the concepts introduced in Section 2 shall be carried out according to the following criteria: “organizational structure” “organizational behavior” and “organizational abilities”. Characteristics of self-organization classified under “organizational structure” depict the context of self-organization, that is, organizations themselves. Characteristics under “organizational behavior” indicate how an organization develops. Characteristics under “organizational abilities” represent what an organization is capable to do.

There are two reasons for choosing such criteria. One reason is concerning system analysis. In the comparison, a system-oriented view of organizations will be adopted, which sees organizations as systems adaptive to changing environment (Hicks and Gullett 1975). It might contribute to the generalization of research results (Ulrich 1984) while enabling an interdisciplinary observation and analysis of concepts (Remer 1982) like self-organization. The other reason is concerning system design. The above criteria stress different dimensions of system design. They are relevant for studying management problems, because management is seen as dealing with the design of organizations as social systems (Remer 2000).

Results of comparison

Organizational structure

Complexity is a common characteristic of organizations discussed in the concepts from Section 2. From a system-oriented perspective, complexity is based on the number and variety of elements, the number and variety of

connections between elements (Patzak 1982) as well as aggregated characteristics of the system (Dörner 2001). However, there are also differences in emphasis among the concepts discussed in the last section, despite their common recognition of complexity as a characteristic of self-organization. For example, Malik regards complexity as a number of possible states due to numerous interactions between organization participants (Malik 1984) while Kirsch stresses that complexity results from collision of various needs and goals of participants (Kirsch 1992).

Dynamics is another common characteristic. According to Hill et al, dynamics refers to changing of a system's state over time (Hill et al. 1994). Dynamics manifests itself in various forms among business approaches. For example, in von Hayek's approach dynamics is the evolvement of the relation net (von Hayek 1980). In Probst's approach dynamics means organizations' swinging between order and disorder, which is the result of ever changing cooperative relationships between participants (Probst 1992a).

System openness is also common to the organizations with which the above business concepts are dealing. Openness means that a system and its environment interact with each other and mutually adapt to each other. Therefore, failure to adapt will endanger a system's survival. Among the business concepts presented above, Probst explicitly points out that an organization should change according to the environment's requirements so as to retain its identity. Due to the bounded rationality (Simon 1957), self-organization ensures that an organization can timely and appropriately respond to changes (Probst 1992b). Göbel also claims that the requirements of the environment underline the importance of self-organization for the purpose of efficiency in terms of time and resources (Göbel 1993). Luhmann recognizes the interdependence between social systems and their environment. However, he lays more emphasis on the aspect of system closure, as he sees the environment mainly as the source of material and energy supply without substantially influencing the system's operations (Luhmann 1984).

Organizational behavior

Concerning the organizational behavior, non-determinism is a common characteristic. Non-linearity in this context means that effect is disproportional to cause (Sterman 2001), which refers to the behavior of the system can not be causally predetermined and thus is not predictable (Haken 1983). Among the presented business concepts, this characteristic is embodied in a number of alternatives an organization has during its process of

development. For example, Luhmann claims that social systems are constantly choosing between possibilities to update their actual status (Luhmann 1984). Probst points out that a social system can have a variety of forms depending upon its past and the interaction of participants (Probst 1992a).

Autonomy is another characteristic which can be observed in the presented business concepts. It refers to the freedom of rendering decisions by individual organizational units (Probst 1987). Examples could be variation from basic behavior patterns in specific contexts (Malik 2000), organization participants' own determination of concerned parties for solving a certain problem (Kirsch 1992), participants' options to build internal structure given by an external unit (Göbel 1993) and participants' following only general ideas and goals set by the management (Remer 1994).

Self-reference is also frequently talked of by the business concepts discussed above. Probst gives self-reference as an organization's decision making and action implementation based on its current state (Probst 1992a). Some other concepts use either different terms or elaborate the meaning of self-reference indirectly. For example, Luhmann uses the term self-reflexivity to describe social systems' analysis of themselves and optimization of their own actions based on this analysis (Luhmann 1984). Remer mentions self-reference in his understanding of self-organization as a learning process, stating that feedback on actions should be the reference for future behavior (Remer 1992).

Organization abilities

Emergence is one of the organizational abilities within a self-organizing organization, which is identified in the above business concepts. Emergence means the generation of new qualitative characteristics of a system resulting from synergy effects of interacting elements (Haken 1993). Luhmann explicitly deals with emergence, stating that a psychic system is an emergent order for the brain, whose function is merely supply of materials and energy. In contrast, other concepts implicitly address this characteristic (Luhmann 1984). For example, Göbel underlines that the order of an organization should be evaluated by observing the interaction of organizational members instead of focusing on single members (Göbel 1993). Besides, von Hayek uses the example of "the invisible hand" originally studied by Adam Smith to illustrate emergence, that is, the market order comes into being as a result of interaction of market participants who follow the same rationality (von Hayek 1984).

Dynamic equilibrium is another organizational ability found in those business concepts. It means that an organization can swing between different stable states instead of sticking to a single one (Carver and Scheier 2002). For example, Probst points out that a self-organizing organization keeps looking for new equilibria for retaining its identity and developing itself (Probst 1992a). Other researchers like Malik (2002) and Kirsch (1992) implies this idea by stressing the evolution of an organization by adapting to the changing environment for the purpose of viability. With the changing process, the organization keeps moving to a new equilibrium by changing its structure and behavior.

Another identified organizational ability, which is common to those business concepts, is self-control. This means that an organization can steer itself towards its objective with no or little external influence. The above discussed business concepts address this ability rather by explanation. For example, Kirsch sees this ability as dependent upon three capabilities, namely action capability, learning capability and responsiveness capability (Kirsch 1992). These capabilities ensure that an organization can pertain to its objective while responding appropriately to the environment. Remer points out personnel inside an organization design the organizational structure while interacting with each other to realize the structure. During this process, the steering towards the established goals is realized through the interaction of organizational participants rather than through any external forces (e.g. a central planning unit) (Remer 1985).

3.2.4 Conclusions

To establish an overarching framework for studying self-organization, this paper has compared different approaches using self-organization and deduced common characteristics classified into three groups, namely:

- Organizational structure: complexity, dynamics and system openness;
- Organizational behavior: non-determinism, self-reference and autonomy;
- Organizational abilities: emergence, dynamics equilibrium and self-control

As such a framework offers a unified terminology, it may enable clear description instead of a mess of terms; as such a framework combines different dimensions of system design, it may simplify analysis by focusing on every single dimension at each time. As a result, these categorized characteristics might allow an easier comparison and integration of differ-

ent perspectives from existing literature on the one hand and might be used as directions for further research on self-organization on the other hand. However, one remark should be made that these nine characteristics are only superordinate terms. This means that different concepts might have slight differences in understanding a certain characteristic, which is explained by the examples shown above.

Self-organization might contribute to strategic competence management, because it could simultaneously increase flexibility and stability in complex and dynamic environments (Hülsmann and Wycisk 2005). Thus, it might be worthwhile to apply self-organization in practice by the management, which is responsible for the conscious and goal-oriented structuring of purposive social systems (Remer 2003). A framework with categorized characteristics might be helpful for management to implement self-organization along different dimensions (i.e. structure, behavior and abilities) with key aspects.

Finally, there are some requirements for further research on self-organization. In this paper, a relatively small number of concepts are selected, where authors with different focus are dealing with self-organization in management science. However, due to the specific context of their research, only a limited number of aspects of self-organization are studied in respective works. Therefore, a task of future research could lie in the absorption and evaluation of more concepts. Besides, during the process of aggregating characteristics of self-organization in this paper, there is potential risk of information loss. As a result, another task might be the generation of a more detailed categorization, as this prevents the sacrificing of seemingly unimportant information which might be proved significant in practice. Finally, a third requirement on further research could be empirical studies in organizations. The verification of the existence of self-organization as well as its effect on order building might be enhanced by some real-life observation and measurement (e.g. through interviews with organizational members).

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