An analysis of the concept of equilibrium in organization theory[1]

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Abstract

This article analyzes how the equilibrium concept is used in four organization theories: the theories of Fayol, Mintzberg, Morgan, and Volberda. Equilibrium can be defined as balance, fit or requisite variety. Equilibrium is related to observables dependent on the definition of organization as work organization, formal organization or artifact organization. The discussed theories can be mapped on a state space model in a way that clarifies the equilibrium concept. The equilibrium concept in organization theory in general can be formalized mathematically using concepts from systems theory. The equilibrium condition can be formulated in terms of a difference function that has to be zero at equilibrium. A central idea is the necessity to maintain equilibrium by actions. This is done by means of a circular causal mechanism that reinforces equilibrium once it has been established as long as the organization conforms to the Law of Requisite Variety. The difference function on which the condition of organizational equilibrium is based takes different forms for each of the four organization theories studied. The establishment of these difference functions enables a comparison with the types of fit described by Venkatraman. It turns out that all types of fit described by Venkatraman are gamma-space based. The analysis of the four theories leads to five equilibrium types, of which two (the Gestalt type and the Matching type) have been described by Venkatraman. Three types of equilibrium that were found have not been covered by Venkatraman: Fayol's *balance / mu-space* type, Volberda's *gamma-space/ variety* type and Morgan's *mu-space / variety* type.

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1. Why the equilibrium concept is needed in organization theory

Why are organization theories so difficult to formalize? The answer to this question might be that managers and consultants use organization theories as instruments for diagnosis and therapy, and that popular organization theories are formulated in a way that is suitable for this task. This means that most organization theories have not been built based on the idea that they have to offer clear rules for explaining and predicting organization behavior. Instead, they offer a framework for perceiving to what extent an organization differs from an idealized healthy state, and receipts to let an organization return to that healthy or vital state. In many cases. the idea of an healthy organization is related to the idea of maintaining equilibria. For instance, Fayol (1916) speaks of equilibria between personal interest and general interest, contingency theory (Lawrence and Lorsch, 1967; Drazin and Van de Ven, 1985; Venkatraman, 1989) speaks about fit between organization structure and organization environment, Maturana and Varela (1984) speak about autopoiesis, and Mintzberg (1967) speaks of stable configurations.

Researchers trying to formalize organization theories can make a mistake when trying to 'jump to the rules', skipping the interpretation frame of the organization theory, which often is the most important part of the theory from the view of the manager or consultant trying to apply organization theories in a diagnosis-and-therapy process. Sometimes, it is prematurely concluded that an organization theory does not have rules, while the theory is based on the equilibrium concept and therefore implicitly contains rules. It is necessary to investigate the equilibrium concept in organization theory further to be able to make better formal descriptions. These formal descriptions may be used in computer models of organizations for instance aiming at computer-supported organization diagnosis and therapy.

This article aims at answering the following questions. How is equilibrium defined? How is it related to observables? How is it related to performance? What data structure does it have? How can it mathematically be expressed in terms of functions?

Our strategy for answering these questions is to use the semi-formal descriptions of organization theories that have been made using the CAST method. The CAST method (Gazendam, 1992; 1993) takes a number of deliberate steps from verbal organization theory to semi-formal description. The following theories have been selected for further formalization: the theories of Fayol (1916), Mintzberg (1979), Morgan (1986) and Volberda (1992). These theories cover a broad spectrum of organization theory: classic (Fayol), modern (Mintzberg) and postmodern (Morgan). Volberda’s theory is a synthesis of several theories based on a contingency framework. It has been chosen because a working diagnosis instrument based on this theory exists, and its equilibrium concept has an interesting structure.

2. Equilibrium in four organization theories

2.1. Equilibrium as balance between interests: Fayol

Fayol (1916/ 1956) is the inventor of the concept of organization. In his theory, Fayol relates the characteristics of personal behavior to the characteristics of the organization as a whole (Gazendam, 1993: 200-251; 1994). Fayol distinguishes several equilibria. Each of them is related to an aspect of the task of a manager or worker. Furthermore, mechanisms are distinguished to maintain the equilibria. This means that equilibrium is seen as resulting from a dynamic process. The equilibrium state may temporarily be disturbed, but the equilibrium maintaining mechanisms will restore the equilibrium state after some time. The following equilibria can be identified (Gazendam, 1993)

1. the equilibrium between authority and responsibility;
   maintaining mechanisms:
   - rewards and penalties;
   - sanctions for undisciplined behavior;
2. the equilibrium between individual interest and general interest;
   maintaining mechanisms:
   - issuing remuneration rules with equitable remuneration of personnel;
   - firing personnel with low moral standards;
   - giving good example in behavior;
3. the equilibrium between the organization's need for personnel and its personnel resources;
   maintaining mechanism:
   - hiring and firing of personnel; assigning tasks to people;
4. the equilibrium between learning time and productive time;
   maintaining mechanism:
   - hiring and firing personnel; assigning tasks to people.

The maintenance of equilibria is seen as the task of the managers in the organization. Fayol distinguishes the following performance criteria:

- equity;
- stability of personnel;
- initiative;
- unity of personnel.

Disturbing mechanisms are, amongst others:

- acquire authority and shun responsibility;
- nepotism, embezzling and shirking (favor personal interest above general interest);
- exploitation of personnel (favor general interest above personal interest);
- opportunism of personnel in terms of leaving the organization too soon;
- opportunism of management in terms of firing personnel that is superfluous temporarily, thus destroying investments in learning time.

2.2. Equilibrium as stable configuration: Mintzberg

Mintzberg's (1979) theory of organizations is a synthetic theory using elements from systems theory, decision-making theory, and contingency theory. His theory is built up in four steps that are parts in his book. Mintzberg describes his interpretation frame in the first part of his book. This interpretation frame consists of five coordinating principles, five basic organizational parts, and five (unrelated) theories in the form of systems of flow. In the second part, definitions are given of structure variables. These definitions are stated in terms of the interpretation frame. The third part of the book explains a series of hypotheses relating contingency variables, intermediary variables, and structure variables. In the fourth part of the book, a major hypothesis is added, namely the existence of five stable organizational configurations that are based on the organizational parts and coordinating principles in the interpretation framework. This means that Mintzberg defines one state for each organization, in terms of all relevant variables (contingency variables, intermediary variables, and structure variables[4]). If this state equals one of the stable configurations, the state is, in our terms, an equilibrium state. The maintenance of equilibrium is no explicit topic in Mintzberg's theory. The rules that connect age and size with other variables, however, lead to the implicit

[4] Contingency variables:

- history-related variables (organizational age, organizational size);
- technical system characteristics (technical system regulation, technical system sophistication);
- environmental variables (environmental stability, environmental complexity, environmental diversity, environmental hostility);
- human interest variables (ownership, member needs, fashion).

Intermediary variables:

- comprehensibility of the work;
- predictability of the work;
- diversity of the work;
- speed of response needed.

Disturbing mechanisms (amongst others):

- growth of bureaucracy as a coordination mechanism;
- growth of the power of one of the organizational part;
- aging of the organization;
- growth in size of the organization;
- changing technology.

conclusion that organizations will gradually shift away from their equilibrium point because of processes of growth and aging, and at some point in time have to jump to another favorable equilibrium point, perhaps by reorganization. Mintzberg's theory has no explicit performance criteria.

2.3. Equilibrium as variety of images: Morgan

Morgan's (1986) organization theory can be seen as a postmodern theory. Using a postmodern approach, one sees an organization as a construct of the human mind, an artifact. Because of that, organizations exist because of the images of organization people have. Stimulating imagination is important for organizations, and metaphors or images can help imagining. For this purpose, Morgan distinguishes eight metaphors for organization: machine, organism, brain, culture, political system, psychic prison, flux and transformation, and instrument of domination. For further analysis, the metaphors can be grouped into three groups: the machine group, the organism group, and the mind group (Gazendam, 1993: 156). The machine group only contains the machine metaphor. The organism group focuses on the dynamic relationship of organization and environment and contains the organism metaphor and the flux and transformation metaphor. The mind group contains two subgroups. The first mind subgroup concentrates on the relationship between the minds of persons and the organization as a social construct; it contains the brain metaphor, the culture metaphor, and the psychic prison metaphor. The second mind subgroup focuses on coordination mechanisms and power plays, and encompasses the political system metaphor and the instrument of domination metaphor.

For Morgan, using a single metaphor or image for organization, especially if this is the machine metaphor, is a state that is undesirable. Using different metaphors or images is necessary to understand the complex and paradoxical character of organizational life (Morgan, 1986: 12,13). The state of an organization can be defined in terms of the variety of images used by it members. A desired state is a state in which an adequate variety of images exist. When is a collection of images adequate, that is, when is an organization in an equilibrium state? There are three possibilities:

1. Images have to fit reality. In the equilibrium state, the images used correspond to the observed organizational reality, for instance in terms of the behavior of people (within and outside the organization) cooperating in transactions or work processes, or in terms of symbol structures that express the existence of the organization like contracts, transactions, norms, financial reports and legal documents.
2. Images have to follow fashions. The fashion mechanism has a useful side-effect because it leads to a necessary periodic renewal of the organization (see Gazendam, 1993: 268, for empirical evidence). The equilibrium state corresponds to an adequate rate of renewal of the images used in an organization.

3. Images have to fit in the cultural climate of a society. Images can be seen as an expression of the somewhat fashionable forms of communicative behavior within and between organizations. People in organizations, therefore, create and follow patterns of communicative behavior (part of them expressed as images of organization) in order to remain communicating. In the equilibrium state, the images used in an organization correspond to the norms of communicative behavior in that part of society that is relevant to the organization.

The equilibrium state of an organization is maintained by people within the organization, especially people with leadership capabilities, imagining new organizational forms that are more adequate. Morgan's theory has no explicit performance criteria.

2.4. Equilibrium as match between turbulence and flexibility: Volberda

Volberda's (1992) theory is, like Mintzberg's theory, a synthetic theory based on a contingency framework. Its basic idea is that the flexibility of an organization has to match the turbulence of its environment. Based on this theory, a computer-based flexibility diagnosis system called FARSYS has been developed (Gazendam, Rutges, and Volberda, 1993). The flexibility of an organization is defined as the combination of the changeability of an organizational characteristic and the capabilities of management to change that characteristic. The capability of management to change a characteristic is measured in terms of the variety of the repertoire of available change measures. Three groups of organization characteristics are distinguished: structure, technology and culture. To measure the flexibility in these fields, concepts stemming from various theories are used. The turbulence of the environment is measured in terms of characteristics of materials, products, customers, suppliers, competitors, distribution channels, labor market, financial market, know-how, and government. Turbulence characteristics include complexity, dynamics and predictability. The measurements of flexibility and turbulence result in a 10 by 15 matrix where 10 aspects of turbulence are confronted with 15 aspects of flexibility. This means that there are 150 equilibrium points to maintain.

Equilibrium has to be maintained by the management function in the organization. Change is based mainly on reorganization. This means a change of the behavior repertoire expressed in strategies, tasks, work procedures, functions, positions, organization units, and so on. It also means changing the underlying technology, structure and culture, wherever changeable, in a more adequate direction. Volberda's theory has no explicit performance criteria.

3. Aspects of the equilibrium concept

3.1. The definition of equilibrium

The equilibrium concept in the four theories that have been analyzed ranges from balance through fit to requisite variety, and from static to dynamic. In Fayol's theory, equilibrium is a balance between forces (interests), fluxes (of personnel), and phases (learning time and productive time). The equilibrium is dynamic, it results from forces, fluxes and phases that have to be managed continuously in order to preserve the equilibrium. In Mintzberg's theory, the equilibrium is defined as fit between contingency variables, intermediary variables, and structure variables. The equilibrium is relatively static; management only has to reorganize occasionally to reach a new equilibrium point. In Morgan's theory, equilibrium is defined as a requisite variety of images. The equilibrium is relatively dynamic; management has to find new images more or less continuously to attain an acceptable rate of learning and renewal in a changing world. The rate of change in the environment has to be matched by the rate of invention of new concepts and images. In Volberda's theory, equilibrium is seen as (1) fit between turbulence and flexibility, and (2) a repertoire of available change measures of requisite variety.

We can conclude that there are (at least) three concepts of equilibrium in organization theory: equilibrium as *balance* between forces, fluxes and phases, equilibrium as *fit* and equilibrium as *requisite variety*. 'Balance' and 'requisite variety' are relatively dynamic equilibrium concepts. 'Fit' is relatively static.

3.2. How is equilibrium related to observables?

The concept of organization is a complex concept because it can be defined in three ways, each of which refers to observable reality in a specific way. An organization can be defined as:

1. a collection of actors (people or machines) and the events they produce in a stable pattern of cooperative relations (work organization);
2. an institution, that is a construct of the human mind expressed in symbol structures (legal and financial documents, norms) that reflect an agreement between people about behavior patterns (defined, for instance, in terms of work procedures, norms and contracts) to apply in a work organization (formal organization);
3. an idea, that is a construct of the human mind that, as metaphor or image, guides cooperative behavior of people (artifact organization).

The distinction between work organization and formal organization that is made here has been proposed by Schmidt (1991). According to Schmidt, formal organization is a -not always congruent- layer on top of the work organization safeguarding the interests of the owner and regulatory bodies (Schmidt, 1991: 103). In this context, formal organization is not to be seen as opposed to informal organization, but as a layer adding symbol structures to patterns of cooperation. The distinction of an organization based on one of these three definitions also implies the distinction of the part of the world that is not belonging to a specific organization (the environment). Dependent on the theory used, the environment is not in the picture (common in classic theories), handled as a unstructured object (common in modern theories), or handled as a collection or network of other organizations (common in postmodern theories).

If we go back now to our four theories in order to connect them to these organization definitions, we run into problems because Mintzberg and Volberda claim to be based on systems theory, which is an abstract theory. Systems theory has gained a prominent place in organization theory since the 1960s. Systems theory as such only offers an abstract model; whether and how this model is related to observables is strongly dependent on the author taking systems theory as a starting point. Checkland's (1981) soft systems theory, for instance, uses systems theory in a manner compatible with the artifact definition of organization. Mintzberg as well as Volberda seek most observables in the sphere of formal organization, and some in the work organization.

Fayol's theory is a work organization theory. Although reasoning about the organization as a whole takes place, all observables are at the level of the work and communication of individual actors. Secondary sources like documents are never mentioned. Morgan's theory is a typical artifact organization theory. What counts are the images of organization people have.

3.3. How is equilibrium related to performance?

The fact that an organization is in an equilibrium state is often implicitly related to the performance and viability of an organization. If an organization performs badly, it will be deserted by its participants and will not survive. Without performance criteria that follow directly from an organization theory, only the organizational survival can be predicted based on the fact that an organization is in equilibrium. This requires longitudinal research. Whenever a theory offers explicit performance criteria, cross-sectional research can be done. The relation between equilibrium and performance has been discussed in contingency theory as the relation between fit and performance. Contingency theory distinguishes a simple fit model, or criterion-free model, from an extended fit model, or criterion-specific model (Venkatraman, 1989; Schrama, 1991: 28). In the simple fit model, it is assumed that there is one type of organization structure that fits in an environment. Because of that, the organization structure that is predominant in a certain environment is seen as the best one for that environment. In the extended fit model, it is assumed that fit between organization and environment leads to a better performance (Schrama, 1991: 28). Fayol uses four criteria for measuring performance: equity, stability of personnel, initiative, and unity of personnel. In three of the theories that have been discussed (Mintzberg, Morgan, and Volberda), there is no explicit performance criterion. In order to be able to investigate these theories empirically, it is recommended to develop an extended fit model (Donaldson, 1995: 3). This means that these theories have to be supplemented with explicit assumptions about dimensions of organizational performance.

3.4. Which data structure does the equilibrium concept have?

The data structure of the equilibrium concept can be studied based on a state space model of organization. In order to elaborate the state space concept, we go back to the history of statistical mechanics in the nineteenth century (Cohen and Thirring, 1973; Gazendam, 1973). The aim of statistical mechanics, especially of its founding father Boltzmann, was to explain the macro, thermodynamic, behavior of a physical system in terms of the behavior of its components, namely molecules. In order to be able to do that, Boltzmann developed two ways of describing the system at a microscopic level, namely the mu-space model and the gamma-space model. In the *mu-space* model (Ter Haar, 1966: 41), the state of each component of the system is described *separately* in a phase space of the molecule. If there are s independent variables for describing the component, the condition of a component can be expressed in terms of the values of those s variables and the values of their time derivatives. The mu-space of a component is the space determined by the s variables and the s time derivatives of those variables. The collection of mu-spaces of all components of the system is used for deriving the state variables of the system as a whole. One could say that the way of reasoning is bottom-up, from component to system. There is, however, a problem with using the mu-space model. Interactions between components have to be neglected or simplified in order to avoid an overcomplex model. Describing the behavior of a component interacting with all other components would require that one includes a model of the system as a whole in each mu-space description. In terms of modeling organizations: if one wants to incorporate interactions between actors in organizations in a mu-space type model of organization, a model of the organization as a whole inside the model of each actor is needed.

The use of the mu-space model by Boltzmann led to a number of paradoxes, especially the Loschmidt paradox[5]. In order to overcome this paradox, Boltzmann invented a new way of describing a system, namely in terms of a gamma-space. In the *gamma-space* approach (Ter

[5] In 1876, Josef Loschmidt formulated a paradox known as the 'Umkehreinwand', the objection against Boltzmann's theory based on the reversal of the velocities of molecules. According to Boltzmann's theory at that time, the entropy function H is dependent on the positions and velocities of all molecules. Because of the time symmetry of the equations governing the position and speed of molecules, it is conceivable to reverse the speed of all molecules. If the function H in he first (nonreversed) state would increase during time, the function H for the second (reversed) system would have to decrease in time. This, however, is impossible because the H function has always to increase.

Haar, 1966: 152), it is assumed that the system as a whole can be described by n variables and their time derivatives. In statistical mechanics, each variable expresses the dependency of the system as a whole on one of the state variables of a component. The behavior of a system is derived from reasoning about collections of systems (called ensembles), in which each system has the same relevant state variables. The actual values of the state variables each system are considered to be distributed according to probability distributions compatible with a set of macro characteristics. The way of reasoning is more or less top-down, namely from the characteristics of a collection of systems to the characteristics of a single system. The main difficulty of this gamma-space approach is the plausibility of the so-called ergodic hypothesis. This hypothesis states that variables expressing the time development of a system can be predicted based on data expressing the distribution of properties over a large collection (an ensemble) of similar systems at a certain point of time. In other words, an ensemble average is equalized to a time average. In terms of gamma-space models of organizations: one will always have the difficulty of generalizing results of surveys of organizations at a certain point of time to conclusions about the time development of a specific organization.

For the theories of Fayol, Mintzberg and Volberda it is possible to make a state space model that depicts the structure of the equilibrium concept used.

Fayol's theory uses four equilibria for describing the state of each person in an organization. This leads to a mu-space description using eight variables for each organizational actor. Equilibrium of the organization as a whole can be described as a collection of 4*N equilibrium points (N being the number of actors in the organization), four points for each actor. Characteristics of the organization as a whole are derived from the collection of the mu-spaces of actors using several aggregation mechanisms (Gazendam, 1993: 217).

In Mintzberg's theory, an organization is described as a whole using 38 (see Gazendam, 1993: 165-167) relevant variables. This corresponds to a gamma-space approach. The state of an organization can be represented as a point in the gamma-space. In the gamma-space of an organization, five equilibrium points exist corresponding to the five stable configurations. The rules connecting design parameters, contingency factors, and intermediary variables stated by Mintzberg can be seen as stating statistical correlations between variables that hold for large numbers of organizations. This feature also resembles Boltzmann's use of the gamma-space, where he uses an ensemble of points (each point depicting a system) in his statistical reasoning.

Morgan's concept of equilibrium uses a collection of mental maps of persons. The contents of these mental maps are metaphors or images. These structures can be described as graphs. A further mathematical handling of these maps, may include counting the graphs that resemble certain prototypes. This handling might, however, be seen as inadequate for this type of theory that uses mainly qualitative reasoning. Furthermore, there are three possible mappings of the collection of mental maps that can determine whether a collection of mental maps is adequate, that is, in the desired equilibrium state. Because of the complications resulting from the qualitative nature of the theory and the possible mappings for determining the equilibrium state, using a state space model of organization would lead to information loss. A mu-space model, in which the mu-space variables describe the present variety and the requisite variety of metaphors for each actor would be the best approximation.

In Volberda's theory, the organization is described in terms of a set of combinations of an environmental variable and a flexibility variable. If we define equilibrium is in terms of the distance between the environmentally required flexibility and the actual flexibility, there is only one equilibrium point per variable combination; the distance is zero when in equilibrium. This means that, at first glance, there are n*m (in this case, 10*15= 150) equilibrium points, where n is the number of environmental variables, and m is the number of internal flexibility variables. This would correspond to a state space model consisting of 150 mu-subspaces. The variables in these subspaces, however, are not independent. This means that the mapping of the matrix model on the mu-space model leads to information loss. In fact, there are only 25 variables, and we can also reason in terms of a 25-dimensional gamma-space. Because of the way we have defined equilibrium, there is only one equilibrium point. This mapping to a gamma-space is better than the mu-space mapping. However, the problem with the mapping of the matrix model on the gamma-space model is that the distinction between environmental variables and internal flexibility variable vanishes, so this mapping also leads to some information loss.

The gamma space approach has been identified by several authors studying the different types of fit found in empirical investigations. Drazin and Van de Ven (1985) describe the gamma space approach as the Systems Approach. Venkatraman (1989) distinguishes two types of fit that are consistent with the gamma space approach: the Gestalt type of fit (without performance criterion) and the Profile Deviation type of fit (with performance criterion).

4. Mathematical characteristics of organizational equilibrium

All four theories that were discussed identify entities and variables that are part of a frame of interpretation. Based on these entities and variables, equilibrium is defined. The performance or existence of the organization is seen as dependent on being in equilibrium, or the distance form the actual state to the equilibrium state. From a systems theoretical point of view, however, the concept of organizational equilibrium requires a notion of the development of the organizational system in time. Equilibrium is a more or less stable state of the system that persists in time. A meaningful equilibrium concept is coupled to the time scale of the phenomenon studied, in our case the social band (Newell, 1990). Applying a more fine-grained time scale would show too much fluctuations to be able to identify an equilibrium state; using a time scale that is too coarse-grained misses the time evolution of the variables in which the equilibrium state is expressed.

The interpretation frame, the equilibrium state, and the performance of the organization are ingredients of a yet incomplete formal state space description of a organization. For the theoretical comparison of theories and for the practical application of theories such a state space description can be considered to be a scientific ideal of which a formal description of the equilibrium concept is a necessary contribution.

From a systems theoretical point of view, the study of the evolution in time of an organizational system in terms of a state space description requires the notion of state variables. At a certain point in time, the state of the system (expressed in state variables) is only dependent on the state at the previous point in time and internal or external influences not belonging to the state (expressed in input variables). By focussing on state variables and input variables a deeper insight in the behavior of the system can be gained than by only paying attention to for instance performance variables.

In the mathematical elaboration below the following convention will be used. Let **x** be the vector of all relevant variables of type x: $\{x_1, x_2, x_3, \ldots, x_n\}$, ρ^x the length of **x**, **x**(t) the vector **x** at time point t, *x* a metavariable over the elements of **x**, x_i an element of **x** at position i, and X the domain of all x_i.

Let **x** be the state variable vector of an organization, and **y** the vector of input variables (internal and external influences). The basic state equation of the organizational system reads[6]:

$$\mathbf{x}(t+1) = f_1(\mathbf{x}(t), \mathbf{y}(t))$$

We assume that equilibrium is a state $\mathbf{x}_e$ belonging to a set of equilibrium states X_e. The equilibrium state has to be maintained by actions. Disturbing internal and external influences may cause a shift from the equilibrium state to a nonequilibrium state. Such a shift has to be counteracted by actions that restore the equilibrium. If there would not be such a equilibrium-maintaining mechanism, the equilibrium state would have no special status and the occurrence of equilibrium would have a random character. Ashby's Law of Requisite Variety applies to such an equilibrium-maintaining mechanism: the variety of the repertoire of

[6] The unit in which time is expressed depends on the level of reticulation (fine-grainedness) of observation.

equilibrium-restoring actions must match the variety of the possible equilibrium-disturbing events. If no suitable action is available to restore the equilibrium after a disturbing event, the organization will have to invent or construct the necessary action and this may take some time. In the meantime, the organization is off-balance and passes through a period that can be seen as a fluctuation.

In order to adapt our first state equation to the Law of Requisite Variety, we distinguish a set of control variables **u** (standing for, amongst others, the equilibrium-restoring actions) within the state variables **x**. Planning and control are exercised by creating, altering or negating symbol structures like business rules, and commands This means that an equilibrium-restoring action, described by a control variable, often exists in applying a symbol structure for selecting the right operator, and applying this operator in an action (Newell, 1990).

$\mathbf{x} = \mathbf{w} \cup \mathbf{u}$

Our state equation becomes:

$$\mathbf{x}(t+1) = f(\mathbf{w}(t), \mathbf{y}(t), \mathbf{u}(t))$$

This function can be characterized as:

$$f: Y \times (U \cup W) \rightarrow X$$

The Law of Requisite Variety can be formulated as follows. If a state of a system is in equilibrium, and for each possible variable array **y** it is true that the variety $v(\mathbf{u}(y_i))$ of the control variable array **u** for a certain input variable y_i is larger than or equal to the variety $v(\mathbf{k}(y_i))$ of the array of possible values **k** of y_i, then the subsequent state will also be in equilibrium. This leads to the following expression:

$$(\mathbf{x}_e(t) \in X_e) \wedge (\forall \mathbf{y}\ h^{y}_{AND}(\mathbf{y}\alpha\ v(\mathbf{u}(y)) - v(\mathbf{k}(y)) >= 0)) \Rightarrow \mathbf{x}_e(t+1) \in X_e$$

In this expression, the operator α means: 'apply to all' (Eisenbach, 1987: 15). Each element of the collection of variables to the left of α is substituted for the corresponding metavariable in the function to the right of α, resulting in a collection of functions with the same data structure as the input collection. In our case, the expression yα <expr> results in an array of logical functions. The function h is an aggregation function; the superscript denotes the variable over which to aggregate (in our case, y), and the subscript the type of aggregation (in our case, logical AND). The function v determines the variety of a collection by counting the distinct members of it.

The condition for equilibrium can often be reformulated using a difference function. At equilibrium, this difference function d has to be zero. For instance, the Law of Requisite Variety yields the following difference function:

$$d_{Ashby} = h^{y}_{Ashby}(\mathbf{y}\alpha\ (v(\mathbf{u}(y)) - v(\mathbf{k}(y)) - m))$$

This function can be characterized as:
$h^{y}_{Ashby}: Y \times U \rightarrow D$

In this expression, m is some number >= 0, The parameter m can be used for setting an optimal surplus variety.

In many organization theories, the performance of an organization is seen as dependent on being in the state of equilibrium, or on the distance between the present state and an equilibrium state. A performance variable p is dependent on the value of the results of one or more difference functions function d_1, d_2, . . . and the performance p_c of the organization in some idealized state (configuration) $x_c \in X_e$.

$$p = g_1(\mathbf{d}, p_c)$$

A simple performance function could be:
$p = p_c - \beta_1 d_1 - \beta_2 d_2 - \ldots$

In this function, the β ´s are constants (weighting factors, etc.).

Another performance function might use the number of possible states of the observed system (organization and environment) that are compatible with a given value of the difference function. The number of possible states Ω is dependent on the calculated difference d, the number of state variables ρ^x, and the number of environment variables ρ^y.

$$\Omega = (\rho^x+\rho^y)!/((\rho^x+\rho^y) - d)!$$

A suitable scaling for the function Ω that rises exponentially or worse for relatively small values of d would be to use lnΩ instead of Ω itself. For the performance function, we get a function that resembles the entropy function in thermodynamics:

$$p = p_c - \beta \ln\Omega$$

The type of this function is:
g_1: D → P or
g_1: D × Λ→ P, where Λ is he domain of the values of the function ρ.

Equilibrium-maintaining mechanisms will only work if the effects of equilibrium on organizational performance is in the interest of those who have to maintain that equilibrium.
$u(t+1) = g_2(x(t), p(t))$
The type of this function is:
g_2: X × P → U

In other words, there is a cyclic chain of dependencies:

1. the organizational equilibrium results in an acceptable organizational performance (g_1: D → P);
2. an acceptable organizational performance results in an equilibrium-maintaining mechanism (g_2: X × P → U);
3. the equilibrium-maintaining mechanism results in organizational equilibrium (f: Y × (U ∪ W) → X_e , or h: Y × U → D).

Such a process of circular causation is typical for states of equilibrium (of which fit is an example): once established, the equilibrium state reinforces itself, as long as the organization conforms to the Law of Requisite Variety. A further development of this circular causation mechanism requires clear choices about the strategy for complexity reduction that will be followed and about the way possible cyclic or chaotic behavior is handled.

The handling of organization modeling thus far is typical for the gamma-space approach: looking at the organization as a whole, state variables for that whole, their time development, and so on. In the mu-space approach the organization as a whole is seen as dependent on the dynamics of its parts. An organization can be seen as a collection of actors **a**, with actor state variables (qualities) **q**.

The function for the time dependency of the system as a whole can also be written as:
$\mathbf{x}(t+1) = \mathbf{f_2}\,(\mathbf{x}(t), \mathbf{y}(t)) \bullet \mathbf{x}(t)$

In this formula, $\mathbf{f_2}$ is a matrix of dimension ρ^x by ρ^x. In the case of a mu-space model, this matrix is diagonalized with ρ^a blocks of dimension ρ^q by ρ^q along the diagonal. This is a characteristic of nearly decomposable system (Simon, 1977: 183), and the organization must have that characteristic to be able to apply the mu-space approach successfully. The state variable array **x** can be redimensioned as a ρ^a by ρ^q matrix $\mathbf{x}_{aq}$.

5. Functions related to equilibrium in four organization theories

5.1. Fayol

At the actor level, there are several balances, e.g., between authority and responsibility. At the organization level there is stability of personnel: the equilibrium between the organizations' need for personnel and its personnel resources. We see stability of personnel as an outcome, a performance indicator resulting from balances at the actor level between man and work place.

The performance vector **p** of an organization can be expressed in terms of a simple function of the difference d_{fay} found with the difference function h.

$$\mathbf{p} = \mathbf{p_c} - \beta d_{fay}$$

$$d_{fay} = h^{a}_{fay}(\mathbf{a}\alpha\ h^{q}_{fay}(\mathbf{q}\alpha\ |q(a) - r(q(a))|))$$

In other words, we have the following function characteristics:

$$\mathbf{p} = h_{fay}(\mathbf{a}, \mathbf{q}) = \mathbf{p_c} - \beta(h^{a}_{fay}(\mathbf{a}, h^{q}_{fay}(\mathbf{q})))$$
$$h_{fay}: A \times Q \rightarrow P$$

The function h^{a}_{fay} aggregates over the a dimension; the function h^{q}_{fay} aggregates over the q dimension. The function r(q) selects the actor state variable that is related to the q in question and that has to be in balance with it. Measures of q and r(q) are normalized in the sense that they incorporate weighting and comparison factors.

In Fayol's theory, the control variables have no special status. they are part of **q**.

5.2. Mintzberg

In Mintzberg's theory, the state of the organization **x** is compared with five stable configurations **c**. Based on the difference with the state variables **x**(c) of these stable configurations **c**, a difference function can be defined. In Mintzberg's theory, the performance variable has shrunken to a binary variable e about existence: existent yes or no?

$$e = e_c - \beta d_{min}$$

$d_{min} = h^c_{min}(\mathbf{c}\alpha\ h^x_{min}(\mathbf{x}\alpha\ |x - x(c))|)$

The function h^c_{min} is an aggregation function over the c dimension that takes out the (aggregated) distance to the nearest stable configuration c_i. The function h^x_{min} aggregates over the dimension x.

We have the following function characteristics:

$e = h_{min}(\mathbf{c}, \mathbf{x}) = e_c - \beta(h^c_{min}(\mathbf{c}, h^x_{min}(\mathbf{x})))$
$h_{min}: C \times X \rightarrow E$

5.3. Volberda

In the theory of Volberda, there are two equilibrium conditions. Firstly, the state variables of the organization have to match the environmental variables. Each state variable is matched with each environmental variable. Secondly, for each pair of variables to be matched the organization has to fulfill the condition of requisite variety of the repertoire of control measures. The outcome of equilibrium is again the existence variable.

$e = e_c - \beta_1 d_{vol1} - \beta_2 d_{vol2}$

$d_{vol1} = h^y_{vol1} h^w_{vol1}(\mathbf{y}\alpha\mathbf{w}\alpha\ |y - w|)$
$h_{vol1}: Y \times W \rightarrow E$

$d_{vol2} = h^y_{vol2} h^w_{vol2}(\mathbf{y}\alpha\mathbf{w}\alpha\ |\ v^u_{vol}(\mathbf{u}\alpha\ u(y, w)) - v^k_{vol}(\mathbf{k}\alpha\ k(y)) - m_{vol}|)$
$h_{vol2}: Y \times W \times U \rightarrow E$

In these expressions, the function v is the variety function as described in the explanation of Ashby's Law above, and the function k is the function that yields the possible values of a variable y. The constant m_{vol} is the ideal surplus variety.

5.4. Morgan

In Morgan's theory, each actor has to have an adequate variety of images (interpreted here as control variables) to function optimally in a varied environment. This leads to an elaboration of the difference function for this theory that is structurally similar to Volberda's second (variety-oriented) difference function. the function, however, is actor-based and therefore a mu-space function.

$e = e_c - \beta d_{mor}$

$d_{mor} = h^{y}_{mor} h^{a}_{mor}(\mathbf{y}\alpha\mathbf{w}\alpha \mid v^{u}_{mor}(\mathbf{u}\alpha\, u(y, w)) - v^{k}_{mor}(\mathbf{k}\alpha\, k(y)) - m_{mor}|)$
$h_{mor}: Y \times A \times U \rightarrow E$

5.5. Types of equilibrium defined in theory compared with types of equilibrium defined in empirical research

Approaches to fit based on empirical considerations have been described by Drazin and Van de Ven (1985) and by Venkatraman (1989). Venkatraman distinguishes the following six types of fit, of which we give the function characteristics.

Moderation
$h_{mod}: Y \times U \rightarrow P$

Matching
$h_{mat}: Y \times U \rightarrow E$

Profile Deviation
$h_{pro}: C \times X \rightarrow P$

Gestalt
$h_{ges}: C \times X \rightarrow E$

Mediation
$h_{med}: X \rightarrow P$

Covariance
$h_{cov}: X \rightarrow E$

Three types of fit without performance criterion have been distinguished: Matching, Gestalt and Covariance. These three functions map to the E domain of existence (or nonexistence) as the result of the quality of the fit. The three types with a performance criterion are: Moderation, Profile Deviation, and Mediation. These function types map to the domain of performance measures P. The Profile Deviation functions and the Gestalt functions use the domain C of stable configurations or idealized organization types.

All Venkatraman's types of fit are variants of the gamma-space approach.

If we compare these characteristics of empirically-oriented fit type with the characteristics of our four theories, we get the following result.

Fayol

h_{fay}: A × Q → P ;this is a new type of equilibrium (mu space type)

Mintzberg

h_{min}: C × X → E ; this is Venkatraman's Gestalt type of fit

Volberda

h_{vol1}: Y × W→ E ; this is similar to Venkatraman's Matching type of fit

h_{vol2}: Y × W × U → E ; this is a new type of equilibrium (variety-based)

Morgan

h_{mor}: Y × A × U → E ; this is a new type of equilibrium (mu-space type and variety-based)

6. Conclusion

Managers and consultants use organization theories as instruments for diagnosis and therapy. Popular organization theories like the discussed theories of Fayol, Mintzberg, Morgan and Volberda are formulated in a way that is suitable for this task. The concept of equilibrium in its various forms (balance, stable configuration, adequate image variety, match or fit between organization and environment) plays a major role in these diagnosis-oriented theories.

Equilibrium can be defined as *balance*, as *fit*, or as *requisite variety*. The definitions of organization as *work organization, formal organization* or *artifact organization* each imply a specific relation of theory to observables. Two major types of data structure for the equilibrium concept can be identified: a *mu-space model* and a *gamma-space model*.

The equilibrium concept in organization theory in general can be formalized mathematically using concepts from systems theory. This approach is based on a description based on state variables, input variables and control variables and enables to formulate principles like Ashby's Law of Requisite Variety. The equilibrium condition can be formulated in terms of a *difference function* that has to be zero at equilibrium. Organizational performance is some function of the difference calculated with this difference function. A central idea is the necessity to maintain equilibrium by actions. This is done by means of a *circular causal mechanism* that reinforces equilibrium once it has been established as long as the organization conforms to the Law of Requisite Variety.

The difference function on which the condition of organizational equilibrium is based takes different forms for each of the four organization theories studied. This is because these theories differ with respect to the attention paid to the actor level, their variables for the environment, and their use of the variety concept. Furthermore, the organization theories differ with respect to the question whether they have an explicit performance criterion. The establishment of these difference functions enables the comparison of the characteristics of equilibrium in the four theories studied with the types of fit described by Venkatraman from a more empirical point of view. It turns out that all types of fit described by Venkatraman are gamma-space based. The analysis of the four theories leads to five equilibrium types, of which two (the Gestalt type and the Matching type) have been described by Venkatraman. Three types of equilibrium have not been covered by Venkatraman: Fayol's *balance / mu-space* type, Volberda's *gamma-space/ variety* type and Morgan's *mu-space / variety* type.

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