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ANALYZING DYNAMIC INTELLECTUAL CAPITAL:
System-based theory and application

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ABSTRACT

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This research report presents an application of systems theory to evaluating intellectual capital (IC) as organization's ability for self-renewal. As renewal ability is a dynamic capability of an organization as a whole, rather than a static asset or an atomistic competence of separate individuals within the organization, it needs to be understood systemically. Consequently, renewal ability has to be measured with systemic methods that are based on a thorough conceptual analysis of systemic characteristics of organizations.

The aim of this report is to demonstrate the theory and analysis methodology for grasping companies' systemic efficiency and renewal ability. The volume is divided into three parts. The first deals with the theory of organizations as self-renewing systems. In the second part, the principles of quantitative analysis of organizations are laid down. Finally, the detailed mathematics of the renewal indices are presented. We also assert that the indices produced by the analysis are an effective tool for the management and valuation of knowledge-intensive companies.

Keywords: dynamic intellectual capital, renewal ability, systems theory, KM-factor measurement
UDC 658.3.054

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1 Introduction

1.1 Renewal Ability is Essential for Organizational Success

Globalization and new information technologies mean that businesses have to face world-wide competition in rapidly transforming, unpredictable environments, and thus, the ability to constantly generate novel and improved products, services and processes has become quintessential for corporate economic growth and competitive advantage. Performance in turbulent environments is, above all, determined by a company's ability to constantly modify its goals and operations, i.e. its capacity for self-renewal. This capacity does not only mean that a company is able to keep up with the changes in its environment, but also that it can act as a forerunner by creating innovations, both at the tactical and strategic level of operation (Hamel, 1996) and, thus, change the rules of the market.

Executives and investors have for some time recognized the inadequacy of traditional economic and operational measures for steering and valuating knowledge-based organizations. These standard measures are designed to provide information on past achievements and present states and are suitable for offering guidance in static market situations. However, the world has changed, and for the future of a discerning business potential in rapidly changing environments, new methods of firm valuation, which account for dynamic knowledge capabilities of firms, need to be developed.

Also, within the research community, there exists widespread consensus on the fact that the new, dynamic modes of competition, stemming from globalization, the development of new technologies and from new forms of organizations, are no longer adequately explained by traditional organizational and managerial theories (e.g. Eisenhardt & Tabrizi, 1995; Sanchez, 1997; Sanchez & Heene, 1997). New approaches, which recognize the complex and chaotic nature of today's business environments, are required for understanding and facilitating the creation of corporate competitive advantage.

The fact that knowledge has become the ultimate resource and key to success in the contemporary economy has resulted in the birth of a novel brand of management theory and practice that has been coined intellectual capital. However, the existing theoretical models and empirical measures of intellectual capital have neglected an essential facet of intellectual capital: an organization's ability to constantly renew its products, operational modes and strategies[1]. This dynamic capability may, in fact, be the most significant aspect of intellectual capital, especially for knowledge-intensive companies.

The volume at hand presents a method for measuring and analyzing an organization's ability for renewal. *As renewal ability is a dynamic capability of a company as a whole*, rather than a static asset or atomistic competence of separate individuals within the company, *it should be operationalized as systemic efficiency*.

This publication is both theoretical and mathematical by nature, as well as an introduction of a tool for measuring and managing knowledge in organizations. Its core rationale is summed up in the following three arguments:

1. Renewal ability is an essential part of a company's intellectual capital, especially in knowledge intensive business environments. (Chapter 2)
2. An organization's ability for renewal should be operationalized as systemic efficiency. (Chapters 3-5)
3. An organization's systemic efficiency can be analyzed using a system-based questionnaire and the system-based mathematical analyses. (Chapters 6-8)

The aim of this report is to demonstrate the theory and analysis methodology for grasping companies' systemic efficiency and renewal ability. We also assert that the indices produced by these analyses are an effective tool for the management and valuation of knowledge-intensive companies. A separate research report, based on empirical data aimed at validating this argument, will be published later.

[1] Even though some of the IC models, such as those presented by Sveiby (1997) and Kaplan and Norton (1992), do recognize the significance of organizational renewal on the theoretical level, the suggested measures for evaluating it are insufficient and neglect its essentially systemic quality. See chapter 2.3 Taking IC One Step Further: Dynamic Intellectual Capital.

The approach presented in this volume is non-financial and is suited for use in parallel with conventional financial measures as well as with other measures of intellectual capital. The method has been developed into a product in cooperation with knowledge-intensive companies and has also been used by venture capital enterprises for managing and valuating start-ups and other companies. The product is called KM-factor™[2] and at the moment it is owned by businessXray Ltd. From the client's point of view the method is easy: the data is gathered with a web-based questionnaire, which takes 15 minutes to fill in. Even though renewal ability is a highly complex issue that deals with the quality of functioning, the result of the analysis is quantitative, thus producing comparable numeric indices. An example of the report of results can be found in http://www.businessxray.com/d-load/kmfraportti.doc.

As far as we know, no other attempts to construct methods for quantitative measurement of the systemic efficiency of organizations have been presented so far. This publication presents how quantified systemic data[3] can be retrieved from social systems and how an organization's systemic efficiency can be reliably and accurately measured by implementing standard mathematical and statistical methods on retrieved systemic data.

Our approach contributes to the scientific discussion and organizational praxis on knowledge management, intellectual capital, systems thinking and the dynamic capabilities of organizations.

The production of KM-factor as well as this report has been a collaborative undertaking. The creators of KM-factor as *methodology and product* have been as follows: **Pirjo Ståhle** has constructed the systems theoretical basis and practical methodology with the assistance of **Eevakaisa Heikkilä, Sten Ståhle** and **Aino Pöyhönen**. The development work has been done in cooperation with various companies. The *research report* is based on Pirjo Ståhle's construction of three-dimensional systems presented in chapters 2, 4-5, and the report has been written under her supervision. Sten Ståhle has developed the mathematical analysis methodology presented in chapters 6-7 and appendix B. **Aino**

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[2] KM = knowledge management

[3] Systemic data can be preliminarily defined as data which depicts mechanical, organic or dynamic features of a system and which is produced by the system itself. See chapter 7.3 Systemic data.

Pöyhönen has had the main responsibility for the production of the report, and she has written the chapters 1-5 and 8 as well as significantly contributed to the rest of the chapters 6-7.

1.2 Structure of the Volume

The research report is divided into three parts. The first deals with the theory of organizations as self-renewing systems. In the second part, the principles of quantitative analysis of organizations as three-dimensional knowledge environments are laid down. Finally, the detailed mathematics of the renewal indices are presented in the appendixes, along with system semantics and an example of report of results produced by the KM-factor™ tool.

We start the discussion in chapter 2 by taking a look at how the shift towards the knowledge economy has altered the conceptions of organizations. Even though it is clear that the logic of doing business has changed, the means for measuring and valuating firms are still lagging behind. Intellectual capital, a concept designed to capture the essentials of earning power in the knowledge-era, is then outlined and its basic tenets briefly viewed. We proceed to argue that, in order to survive in fluctuating and rapidly changing environments, a firm must have the capacity to constantly renew – not only its products but also its strategies and operations. However, although the intellectual capital models presented so far are an improvement to the previous measures, even they are not able to account for the renewal ability, which is one of the key success factors for today's organizations. Thus, further development of intellectual capital models is needed to capture the essence of survival and success in turbulent conditions. Finally, we present a genuinely dynamic interpretation of intellectual capital.

The ability for renewal is a systemic capacity. In other words, the ability of an organization to act in a coherent, flexible and innovative way in unpredictable circumstances depends on how it works together as a whole in line with company strategy, rather than on the actions and capabilities of separate individuals within the organization. This also means that, for evaluation purposes, renewal ability should be operationalized as (strategy-connected) systemic efficiency. Chapter 3 deals with the systemic view of organizations in general. This view, which emphasizes the connections between the elements of a system, rather than the attributes of the elements per se, has a long history and is widely employed nowadays.

Chapter 4 presents a cross-section of systemic thinking. Systems theories have been used to explain a wide range of phenomena from cells to the solar system, and thus, it is not surprising that there is a wide spectrum of system-based theories and concepts. Ståhle (1998) has discerned three underlying paradigms in systemic theoretical writings. The three paradigms - mechanical, organic and dynamic – each portray systems in a very different way from one another. The characteristics of each paradigm will be viewed for the purpose of building a solid basis for the subsequent organizational theoretical framework.

In chapter 5, the mechanical, organic and dynamic system paradigms are applied to organizations to construct a model of organizations as three-dimensional systems. This theory then functions as the conceptual basis for the construction of the method for analyzing systemic efficiency, reported in chapters 6-8. The mechanical facet of an organization comprises orderly and defined organizational processes, which aim to produce reliable and sustained quality. The organic facet is composed of dialogical interactions and feedback processes that lead to controlled development and sustained growth. Finally, the dynamic dimension produces radical changes and innovations and deals with the self-organizing and self-producing processes within an organization. It is important to understand all these three organizational facets, as the criteria for their functioning are discrepant from one another, and even contradictory. An organization needs to be able to function in all of these three modes, and to balance its functioning so that the extent to which each systemic facet is emphasized is in line with the chosen strategy.

The chapters in part II deal with the methodology of analyzing organizations as systems, which is a necessary basis for measuring renewal ability. As the method for evaluating the systemic efficiency of organizations is the first of its kind, its phases and principles are elaborated in some detail. In chapter 6, the basic model for retrieving systemic data from organizations is established. The grounds for the systemic analysis of an organization are laid down, and the concept of the systemic profile is introduced.

Then, the development of the current questionnaire and the systemic efficiency matrix are presented.

The systemic analysis of an organization is defined as (1) the analysis of the internal characteristics of sub-systems at the different levels of hierarchy of an organization and (2) the analysis of the relations between the different sub-systems within an organization. Chapter 7 presents the complex process for analyzing systemic efficiency, which consists of several stages. Firstly, the nature of systemic data is explained and system semantics are defined. Then, the different phases and levels of the analysis process are explained. Finally, the various parameters are summed up to form a more sophisticated understanding of systemic efficiency in organizations.

As systemic efficiency is such a complex issue, its final definition has to be constructed by means of both the theoretical handling of mathematical principles, as well as by inductive reasoning based on the behavior of the acquired data. Equipped with a theoretical framework of organizations as three-dimensional systems and a method for analyzing their systemic efficiency, in appendix B we demonstrate in detail the analysis of observed systemic data, gathered in 28 organizations ($N = 1340$). The main aspects of the data and the main tools used are introduced. Ultimately, the formulas for the indices that constitute an organization's systemic efficiency are presented. The two major indices of renewal ability constructed from the data are named *strategic capability* and the *power to change.*

PART I THEORY

2 The Measurement and Valuation of Knowledge-Era Organizations

2.1 Knowledge in Organizations

The logic of doing business and creating value has changed fundamentally. Knowledge has taken the place of land, labor and economic capital as the main source of corporate wealth creation, and intellectual capital has become the principal driver of competitiveness. The marketplace is global and increasingly turbulent, with innovations altering the business landscape every so often. Information and communication technologies enable new kinds of relationships, and virtual network partnerships and organizations are becoming recurrent. (E.g. Drucker, 1993a; Drucker, 1993b; Castells, 1996; Quinn & Anderson, 1996; Quinn et al., 1997; Stewart, 1997; Cohen, 1998; Ståhle & Grönroos, 1999.)

Peter Drucker (e.g. 1993a; 1993b; 1997; 1999) argues that the fact that knowledge has become the main economic resource will fundamentally change the structure of society. Drucker uses the term post-capitalist to portray the uprising society, but in addition, the concepts of information or knowledge society and network society have been used in recent macro-sociological discussions to depict the societal changes that have sprung from the changes in the meaning and importance of knowledge (see e.g. Castells, 1996; Holma et al., 1997; Anttiroiko, 1998). These changes will entail new social, economical and political dynamics and challenges.

Companies that make profits by converting knowledge into value are called knowledge companies (Sullivan, 1999). The success of a knowledge organization depends on its ability to gather and create information and knowledge, to share it and integrate it into the existing organizational knowledge and to apply it in a profitable manner. While financial capital and other resources can also be important resources for knowledge organizations, their primary resources are intangible. Information-based and service organizations are the most obvious examples of knowledge organizations, but as all forms of business are gradually becoming more knowledge-intensive, virtually all companies can be considered to be knowledge organizations. Knowledge workers, i.e. highly educated employees who apply theoretical and analytical knowledge to developing new products, services, processes or procedures, are the fastest growing segment of the workforce in developed countries (Castells, 1996; Campion et al., 1996; Janz et al., 1997; Drucker, 1999).

There are two essential distinctions that have shaped much of the newly formed understanding of knowledge in companies. The first one is the difference between information and knowledge, which Koivunen (2000) describes as follows: ”Information is external raw material from which the human being picks elements of relevance to him- or herself. Information becomes knowledge in the human mind when people incorporate it into their unique tales in the space of associations with the help of their internal knowledge. By this definition, knowledge only exists when it has meaning for a human being and never exists outside the human being, only tied to his or her consciousness.” This division, accepted by a large part of the contemporary management thinkers, emphasizes the primacy of human beings and their creativity over computers and information technology.

The second relevant distinction is between explicit and tacit knowledge (Polanyi, 1966). It is widely agreed that knowledge, which is easy to document and to make explicit, is only a small part of all the knowledge that people possess. Most knowledge is tacit, hard to express and deeply embedded in personal experiences, and it is this semi- or unconscious knowledge that is the source of creativity and innovation. Furthermore, tacit knowledge is shared in real-time face-to-face interaction, and therefore, social processes are of critical importance for innovation. This entails that knowledge organizations are above all social entities, and thus, their capacity for knowledge creation and innovation is determined by dynamic social processes rather than by static assets.

The emphasis on knowledge as a process of creating meanings and on tacit knowledge as the source of innovations has lead to the realization that in addition to being the essential resource of organizations, knowledge can also be interpreted as a strategic asset and a capability. These intertwined viewpoints accentuate the difference between knowledge as a property of separate individuals within the company and knowledge as a property, process and characteristic of the company as a whole. While the subjective knowledge of individual employees may be seen as being a building block for organizational knowledge it is mandatory to focus on the organizational level in order to draw conclusions on the performance potential of a company. Furthermore, these two approaches emphasize the knowledge company as a strategic, goal-oriented entity, rather than a free-floating collection of stocks and flows.

Bollinger and Smith (2001) argue that the cumulative and collective knowledge of an organization is a strategic asset as it is inimitable, rare, valuable and non-substitutable. According to the dynamic capability view, the market performance of a firm depends on the combination of its capabilities with its strategic objectives or intentions (Teece et al., 1997; Ståhle & Kyläheiko, 2001). The competitive advantage of firms lies in their dynamic capabilities, which are "the capacity to sense opportunities, and to reconfigure knowledge assets, competencies, and complementary assets so as to achieve a sustainable competitive advantage" (Teece, 2000). In this approach, the firm is treated as a transformation process and not as a market-related exchange process, and thus, the emphasis is on the knowledge bases and the accumulation of knowledge, both within the firm and among the firms through market or network arrangements (Metcalfe & James, 2001). Dawson (2000) claims, "It is far more useful to think in terms of developing the organization's dynamic knowledge capabilities than about knowledge as a static asset which needs to be managed. In terms of developing knowledge capabilities, the key aspect of organizational context is the flow of information and knowledge, which is fundamental to how an organization comprised of many individuals can create greater value than those individuals working separately." Furthermore, the capability for constructing and implementing organizational strategies is itself "a knowledge capability of the highest order" (Dawson, 2000).

2.2 Intellectual Capital

As the ways of creating value have changed, the measurement and valuation of companies need to change as well. A novel academic approach, namely the intellectual capital (IC) movement, has been developed in order to understand the nature and value of intangible qualities and properties, which are the foundation of the productive capacity of knowledge-based organizations. The movement is fairly new and dispersed, and views of the nature and composition of intellectual capital tend to vary from one author to another. One definition of intellectual capital is that it is knowledge that can be converted into value (Sullivan, 1999). According to another definition, intellectual capital consists of an organization's capability to transform its intangible assets, expertise and renewal ability into economic value (Ståhle & Grönroos, 1999, 50). As the genealogy of the IC view has been presented elsewhere (e.g. Roos et al., 1998; Bontis, 2001; Sullivan, 2000), we will not repeat these accounts but rather, focus the discussion on the measurement needs of the organizations of the knowledge-era.

Intellectual capital is intimately linked with strategy. Roos et al. (1998) suggest that the theoretical roots of IC lie in two streams of thought: the strategic school, which studied the creation and use of knowledge for enhancing the value of the organization and the measurement school, which aimed at constructing reporting mechanisms that enable non-financial, qualitative items to be used along with traditional financial data. IC is a useful concept for setting corporate goals and strategies (Robinson & Kleiner, 1996). Moreover, IC reports and statements function as communication tools for presenting and maintaining the corporate vision and strategy (Bukh et al., 1999). Sullivan (1998) states that, in order to extract value from IC, it has to be strongly linked with the strategic objectives of the company. IC should be internally aligned with the company's vision and strategy to ensure that the organization's IC is focused on achieving the right goal. Also, the choice of IC indicators should be guided by the long-term strategy of the company; one should measure what is strategically important (e.g. Stewart, 1997; Bontis et al., 1999).

The intellectual capital movement attempts to overcome the limitations of conventional indicators that are used to explain, measure and manage organizational performance. Specifically, its critique is aimed mainly at three intertwined issues in performance measurement and management of organizations: 1) the extensive reliance on traditional accounting-based indicators, 2) the orientation towards the past instead of the future, and 3) the neglect of the need for non-financial information.

An often-made critique towards traditional accounting-based measures is the commonplace substantial difference between companies' book and market values. This indicates that there are key assets that are not recognized in the balance sheets. These differences arise from the intangible properties and qualities of organizations, which cannot be measured by the tools constructed by the traditional accounting practice. (E.g. Sveiby & Risling, 1987; Brennan & Connell, 2000.) As traditional accounting-based measures, which depict an organization's physical and financial capital, do not enable the identification and measurement of intangibles in the organization, new kinds of indicators need to be developed (e.g. Atkinson & Waterhouse, 1997; Bukh et al., 1999; Petty & Guthrie, 2000; Brennan & Connell, 2000; OECD, 2000). Furthermore, the current balance sheet fails to consider what counts as important for companies, and does not help management in deciding on future actions (Bukh et al., 1999). In addition, the existing financial reporting system has limitations from the viewpoint of the capital markets and other shareholders; as intangible investments and know-how become more important, conventional reporting leaves the average investor at a disadvantage compared with knowledge insiders and outsiders who have 'private' access to inside information (Stewart, 1997; Petty & Guthrie, 2000).

Yet another important drawback of conventional accounting-based indicators is that they are past-oriented - they show changes in performance only when it is too late to influence the situation (e.g. Sveiby, 1997; Edvinsson & Malone, 1997). In contrast, monitoring the dynamic intellectual qualities and properties of a firm enables the rapid re-steering and more realistic evaluation of the available alternatives. In addition to the quantitative balance sheet –centered approach, some qualitative approaches can also be criticized on the same grounds. Sanchez (1997) criticizes the traditional qualitative way to seek explanations for the strategic success factors of companies, which has been to study firms that have been successful in the past, discern their unique features and then say that these features have been the causes for the firms' success. He states that in today's dynamic market environment, this kind of analysis can, at best, provide historical information on how things have been and what should have been done. It can, by no means, provide alone reliable knowledge on what the decisive success factors will be in the future, especially in knowledge-intensive businesses, which are increasingly characterized by rapid changes and nonlinearity. Rather than study stories of past success, the view should be shifted to factors that will influence a company's future potential. Moreover, as the future truly is uncertain and no one can predict which specific competencies and resources are the ones that will emerge to rule in a given business area, the success factors cannot be content-specific, but will have to relate to the *qualities and processes by which a company masters transformations and survival in complex dynamic environments.*

In the age of the knowledge economy, human knowledge is what creates revenue. Thus, in order to measure the ability to create revenue, we have to measure things that directly deal with human knowledge, and these are undeniably non-financial in nature. Sveiby (2001) argues that non-financial measures are superior to financial ones because the profits generated from people's actions are the signs of success but not the originators of the success. The need for non-financial measures is also augmented by the fact that in addition to firm valuation, measures have an important role in assisting in the steering and management of organizations. Sveiby (1997; 1998) and Kaplan and Norton (1992; 2001a; 2001b) have stated that financial measures should be complemented with non-financial measures, especially at the strategic level of the firm. Atkinson and Waterhouse (1997) note that financial performance measures derive from accounting systems that were designed to enable comparison across firms and over time, but not to communicate decision-relevant information to people inside the organization.

Attempts to understand and conceptualize intellectual capital have yielded many intellectual frameworks (e.g. Kaplan & Norton, 1992; Edvinsson & Malone, 1997; Sveiby, 1997; Stewart, 1997; Roos et al., 1998; Sullivan, 1998; OECD, 2000) all of which divide IC into several components. However, there is no general agreement as to what these components are (Bontis et al., 1999).[4] Not surprisingly, the measurement models based on these different frameworks lack a mutual basis. This diversity with which IC has been understood, operationalized and measured has, unfortunately, led to

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[4] The most commonly shared view is that IC is constructed of three parts: human, structural and relational capital. However, this division ignores the essentially dynamic nature of IC and should be complemented with an understanding of the capability of the organization to renew its strategies, operations and knowledge.

a situation in which *inter-company benchmarking and comparison is impossible*, and the interpretation of the various IC reports is difficult. (Bontis et al., 1999; Brennan & Connell, 2000; Petty & Guthrie, 2000.) This problem is worsened by the fact that practically all scholars in the field agree that as every firm has its unique knowledge base and strategy, there can be no universal measure for IC that would be suited to all kinds of companies.

We also agree with this statement in that we believe that the importance of any given IC indicator depends on firm-specific factors. However, we claim that *some parts of IC, such as the renewal ability, can and should be evaluated with measures that can be applied, compared and generalized across a variety of companies.* This publication presents such a unifying theoretical and empirical model for organizational renewal ability[5].

2.3 Taking IC One Step Further: Dynamic Intellectual Capital

Intellectual capital is both a *property* and an *ability* of the organization. The property is produced by the capability to act in various business environments, the output of which might be patents, trademarks, business applications and other intangible assets. These properties often need to be protected from competitors. On the other hand, intellectual capital is an ability of the organization. The ability to master, create or innovate should be a capability of the organization as a whole, and not just of certain individuals. The greater the extent to which innovativeness is the ability of the whole organization, the more competitive an edge the company has - higher levels of performance as well as greater flexibility and innovativeness. These aspects of intellectual capital cannot be protected by the company and do not even need to be protected. *Innovations can be copied, whereas innovativeness cannot.* (Ståhle & Grönroos, 2000.)

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[5] Naturally, inter-company comparison and benchmarking is meaningful only to a certain extent. For example, the IC indices of a small-scale ICT startup would hardly benefit a machine factory or vice versa. This is why the indices that depict an organization’s renewal ability are formed with respect to a reference group of strategically similar organizations (see Appendix B).

The most important and interesting area, especially in fast changing business environments, is the ability to renew in a manner that produces profit and competitive advantage. Rather than only an element of IC, renewal is a functional mode, a capability or a characteristic of the organization. As the renewal ability is more of a dynamism than a component, we need a systemic view to be able to grasp its functioning.

The significance of knowledge and rapid changes in the markets are the basic points of departure for all the models of intellectual capital. The mantra of IC scholars is that the capacity for producing and leveraging intellectual capital is the key to achieving competitive advantage in the ever more intensive turbulent global business environment. Nevertheless, most of the suggested ways of measuring IC seem to ignore the dynamical aspect of the IC equation: in order for a company to survive in fluctuating and rapidly changing environments, it is essential that it have the capacity to constantly renew its strategies and operations.

Some IC models (Edvinsson & Malone, 1997; Sveiby, 1997; Roos et al., 1998) do recognize the importance of the ability for organizational renewal at the theoretical level. However, in these models, there is an unfortunate gap between the theoretical accounts and associated measures: the theories deal with the dynamic, social and future-oriented nature of knowledge in organizations, whereas the way in which IC is operationalized adheres to the asset-centered approach. There exists a serious need for a measure that is able to capture the organization's renewal ability.

The idea of organizational self-renewal has been included in some IC frameworks. For example, Edvinsson and Malone (1997) argue that a company's renewal ability itself is what determines how well it can respond to radical changes in the market. They also state that renewal and development indices lie at the opposite pole from the financials: the latter focus on the past performance of the organizations, while the former is future-oriented and attempts to establish "what the company is doing now to best prepare itself to grasp future opportunities" (p. 111). In the IC index model by Roos, Roos, Dragonetti and Edvinsson (1998), IC consists of human capital and structural capital. Structural capital includes a category called the renewal and development value, which is "the intangible side of anything and everything that can generate value in the future, through an improvement of financial and intellectual capital," (p.51). Also, Sveiby (1997) explicitly discusses organizational renewal. His IC model consists of an external and internal structure and the competence of the personnel. Each of these parts can be measured using three indicators, one of which is growth and renewal.

However, the way in which the dynamical aspect of IC has been operationalized calls for improvement, as the indicators used so far do not directly address the dynamics of knowledge creation and leverage. Edvinsson and Malone (1997) admit that this is an unexplored area of IC and propose the use of multitude of indices, because "… the more measurements, the more likely one is to find the handful that prove decisive in capturing a useful perspective on the organization's future opportunities" (p. 121). Among their handful are R&D investments, shares of training and development hours and customer-related data such customer purchases/year. In the model by Roos et al. (1998), the renewal and development value is calculated from indices such as percentage of business from new products, new patents filed, and training efforts. The measures for growth and renewal of competence, suggested in Sveiby's (1997) model, include the number of years in the profession, training and education costs and turnover. The growth and renewal of internal structure, measured from support staff, includes such measures as investments in the internal structure and information processing systems and sales per support person.

The question, therefore, is whether or not measures such as these really tap on the determinants of organizational renewal ability? Although *they are certainly related to it*, they are not at the core of the issue. No matter how educated and competent the personnel is, the firm may still be poor in intellectual capital if it lacks the ability to combine subjective knowledge into the inter-subjective knowledge system of the firm. Likewise, no matter how much financial capital has been spent on information systems and communications networks, these systems will be of little help in demonstrating how able the company is to renew itself and, thus, for indicating the company's future potential if knowledge is not circulated via these systems in a manner appropriate for the firm's strategy.

Table 1. The Measurement of Organizational Renewal in Three IC Models.

Developed by	Edvinsson and Malone (1997)	Roos, Roos, Dragonetti & Edvinsson (1998)	Sveiby (1997)
IC components	Financial focus Customer focus Human focus Process focus Renewal and development focus	Human capital Structural capital	Competence of personnel (1) Internal structure (2) External structure (3)
Location of renewal in the model	Renewal and development focus	Structural capital is divided into a) relationships b) organization c) growth and renewal	Each component can be measured with indicators for a) growth and renewal b) efficiency c) stability
Examples of suggested measures for renewal	-Share of employees under age 40 -Direct communications to customer/year -New markets development investment -Value of corporate communication networks	-Percentage of business from new products -Training efforts -Renewal expenses/operating expenses -New patents filed	-Level of education -Turnover -Training costs (1) -Investment in the internal structure -Values and attitude measurements (2) -Profitability per customer (3)

Then, how can the dynamics of organizational self-renewal be approached? The answer lies in the systems perspective, which allows us to see organizations as constantly changing networks of interrelationships and to capture the ways in which knowledge flows, and gets employed throughout the company. We argue that *the capacity of a company to produce and leverage intellectual capital is, above all, a systemic quality, which depends on how the organization functions and evolves as a whole*. The renewal ability has no direct connection with the amount of money spent on education and improvement or the qualities and competencies of individual actors, but instead it is strongly linked with the patterns in which the totality of the organization works together towards a common goal.

The fact that the renewal ability is a systemic capacity has implications for both the management and measurement of organizations. Firstly, in order to be managed, the IC of a company needs to be understood systemically. Secondly, the renewal ability needs to be measured with systemic methods that are based on a thorough conceptual analysis of systemic characteristics of organizations.

The dynamic view of intellectual capital emphasizes an essential aspect of knowledge, which has been so far largely neglected in previous IC measures; namely that most of it is created, enriched, shared and disseminated in social interaction (e.g. West & Farr, 1990; Nonaka & Takeuchi, 1995; Nemeth, 1997; Nonaka & Konno, 1998; Leonard & Sensiper, 1998; Von Krogh, 1998; Anderson & West, 1998). Thus, connectivity and coherence should play an important role in the definition and valuation of IC. The social nature of IC has been acknowledged in several of the IC frameworks, if not in the associated measures. Roos et al. (1998) suggest that in the development of knowledge, knowledge sharing is essential: "where there is not knowledge sharing, there is no knowledge creation, because all knowledge resides in the minds of the people in the organization and it does not move or grow"(p. 17). And to share knowledge, people have to communicate. Thus, communication and interaction are essential for intellectual capital. However, none of the suggested indices in the IC index measurement framework deal with the dynamics of knowledge flows. Similarly, Sveiby (1997) states that the capacity to transfer knowledge is the key activity in knowledge organizations. Despite this, none of the indices that Sveiby suggests for measurement of IC actually directly deal with knowledge sharing. This is not to say that the more static, non-systemic measures of IC are useless. This is by no means the case. Rather, they provide an important insight into IC from another angle. Nevertheless, for measuring and valuating the dynamic facet of intellectual capital, i.e. the renewal ability, systemic perspective is mandatory.

As knowledge processes are essentially social processes, it is our contention that *IC cannot be understood without its social component.* Thus, the dynamic view of IC also coincides with the recent discussions on *social capital*, which emphasize the interaction of social and economic structures. The interest in the concept of social capital has been spreading simultaneously with the understanding that social ties significantly influence economic outcomes. The concept itself has been used since the 1910's, but it was not until Coleman's (1988) and Putnam's (1995) seminal works that social capital has begun to attract attention from such diverse parties as, for example, venture capitalist, urban planners and developmental theorists.

Putnam (2000, 19) defines social capital as follows: "Whereas physical capital refers to physical objects and human capital refers to properties of individuals, social capital refers to connections among individuals: social networks and the norms of reciprocity that arise from them." However, the definition of social capital is far from consolidated in the academic discussions. According to Adler and Kwon (2002), the major dividing factor in definitions of social capital is the adopted perspective from which the network is viewed. Social capital can be approached either as a resource residing in egocentric social networks which enable various benefits to the focal actor, or as a propensity of sociocentric, holistic webs of relationships, which influence attainment of the mutual goals of the members in the network (Adler & Kwon, 2002). Examining the renewal ability of organizations, we obviously adhere to the socio-centric view, which examines the organization as a whole, rather than for example the personal networks of managers using an egocentric network approach.

Social capital is a multi-level phenomenon, which can be examined on many levels of analysis and from various viewpoints. Woolcock (2000) differentiates four main approaches to social capital: communitarian, network, institutional and synergy approach. Bueno et al. (2002) on the other hand, classify the existing viewpoints to social capital to economic development theories, social responsibility and ethics, corporate governance codes, and finally, intellectual capital. According to them, the latter view places social capital as a component of intellectual capital, and emphasizes the shared values in a given social system, such as solidarity, responsibility and transparency.

Nahapiet and Ghoshal (1998) have constructed a theory of the influence processes between social capital and intellectual capital. According to their definition, social capital encompasses structural, relational and cognitive dimensions. The structure of the social network influences knowledge processes by restricting or granting access to various sources of knowledge. Relational propensities of a given social network, such as trust and caring (Von Krogh, 1998), facilitate or hinder knowledge sharing and creation.

Cognitive dimension refers to the shared mental models of the members in a social aggregate, which also have an influence on IC of the social system. Also Mc Elroy (2002) has argued that models intellectual capital should be further developed to include social capital in its different forms. There exists some empirical evidence that social capital can indeed enhance knowledge processes in organizations (Yli-Renko et al., 2001; Chua, 2002). The field of social capital as a whole is still very much in its infancy, and much more work is needed on the relationship of intellectual capital, social capital and renewal ability.

3 Successful Organizations are Efficient Systems

How can the fundamental modes that direct the ability for organizational renewal be captured, and even more importantly, how can these modes be measured in a way that is quantifiable, measurable and comparable across cases? We argue that this can best be done by understanding organizations as social systems, for the system concept allows for the inherent characteristics of complexity and dynamism of any real-life organization. By a system we mean a complex network of interrelationships, which is demonstrated through communication and actions between and within the system elements.

The systemic view emphasizes connections among the elements of the system, rather than the attributes of the elements per se, as other approaches in social and economical sciences tend to do. Business organizations belong to a distinct subtype of systems, namely social systems (Luhmann, 1995, 2). As a social system, a business organization can be characterized as a coherent entity that is capable of target-oriented action.

The decisive argument made in this article is that the crucial factor that determines a company's ability for renewal and, thus, also its potential for future success is its systemic efficiency. *Systemic efficiency of a business organization consists of its ability 1) to function as a system in general and 2) to guide its activities coherently according to a chosen strategy.*

This is not a new position, as conceptualizations of organizations-as-systems have been around for decades. Shenhav (1995) has traced the genesis of the systems perspective in organizational research and management back to the professional paradigm of mechanical engineering in the late 19th century. The early proponents of the system-based view of organizations include sociologist Talcott Parsons (1937; 1951; 1960; 1969; 1971), researchers of the Tavistock Institute (e.g. Trist & Bamforth, 1951), social psychologists Katz and Kahn (1966) and contingency theorists such as Burns and Stalker (1961) and Lawrence and Lorsch (1967). In the field of strategic management, Igor Ansoff (1965) was the first to put forth a systemic model of strategic planning.

The systemic view of organizations is widely spread these days (Appelbaum, 1997). Morel and Ramanujam (1999) argue, “Organizations are now routinely viewed as dynamic systems of adaptation and evolution that contain multiple parts which interact with one another and the environment. Such a representation is so common that it has acquired the status of a self-evident fact.” Some contemporary authors address the systemic nature of organizations directly, whereas others deal with other issues departing from a viewpoint that is grounded on implicit systemic presumptions. The natural occurrence of patterns in systems and the emergence of new forms are of special interest. The key concepts used in recent literature include dynamic change, adaptation to complex environments and evolution. (See e.g. Eisenhardt and Tabrizi, 1995; Ehin, 1995; Brown & Eisenhard, 1997; Maula, 1999; 2000; Black, 2000; Ashmos et al., 2000.)

To mention a few examples, Sanchez and Heene (1997a; 1997b), for instance, have created a competence-based approach of strategic management in which organizations are viewed as “goal-seeking open systems of interrelated intangible and tangible asset stocks and flows”. According to them, competencies must be seen as arising from a system of interdependent resources and processes and as such, must be managed as systems. Also, Gary Hamel’s views on strategy innovation imply that to be strategically innovative on a sustainable basis, companies should adopt systems thinking in two respects. Firstly, conceiving the entire field of business as a system enables modification of the operational rules of this complex web of interrelationships (Hamel, 1998a). Secondly, in addition to markets at large, individual organizations should be conceived as complex systems, whose internal operations, including strategy elaboration, should ideally be “poised on the border between perfect order and total chaos, between absolute efficiency and blind experimentation, between autocracy and complete adhocracy” (Hamel, 1998b). Moreover, Eisenhardt and colleagues deal with organizations as complex adaptive systems in several articles. One of their main arguments is that achieving fast adaptation in unpredictable environments requires balancing order and disorder by creating organizational structures that are not too rigid to undermine change, but not too loose to create chaos (Eisenhardt & Tabrizi, 1995; Brown & Eisenhardt, 1997; Eisenhardt & Brown, 1999).

The systemic approach in the more recent literature on organizations as systems differs from the earlier work in many respects. The current views tend to depict organizations as complex and dynamic systems, whereas the former views emphasized internal regulation and feedback processes. In addition to these two views, a third approach to systems can be found: the mechanical view, which considers systems as static entities that operate according to predetermined rules. These three views actually depict different system types, namely mechanical, organic and dynamic – and the respective paradigms. Each system type represents a distinct facet of organizational functioning, and all of them are demonstrated in every business organization. Furthermore, each of the system types serves different purposes in the organization's strive towards efficiency and survival in competition with other organizations. (Ståhle, 1998).

4 The Three Paradigms of Systems Thinking

The systemic movement at large does not adhere to a uniform, integrated grand theory, but rather consists of a wide spectrum of theories and concepts formulated by scientists from diverse disciplines. The systemic view has been used to describe a large variety of phenomena ranging from thermodynamics to human behavior. Accordingly, even the definitions as to what consists a system tend to vary a great deal depending on the point of departure of the given author. (Ståhle 1998, Luhmann, 1995; Black, 2000.)

Based on this lack of coherence in systems-based views, Ståhle (1998) discerned 3 underlying paradigms by analyzing system theoretical writings, which can be labeled mechanistic, organic and dynamic. All the paradigms address systems, but their starting points and foci are distinctly different, and consequently, each of them depicts systems in a different way. For example, from the viewpoint of mechanistic tradition, systems are orderly and regularly functioning, while within the dynamic paradigm they are portrayed as self-organizing and self-referential. In the following, the three paradigms will be introduced along with the system characteristics associated with each of them. The system characteristics thus discerned will form a basis for establishing a model for retrieving quantified data from systems (chapter 6). The features of the mechanistic, organic and dynamic paradigms are summarized in table 3.

Many scholars, who deal with various issues from the systemic viewpoint, have traced the development of systems thinking in a manner that overlaps with the three-dimensional view presented here. In the classic division of Burns and Stalker (1962) organizational systems are classified as either mechanic or organic. Some other divisions distinguish between the mechanistic and dynamic views, while neglecting the organic open systems tradition (e.g. Tetenbaum, 1998; Black, 2000). Yet others assimilate the dynamic paradigm with the organic one (e.g. Sanchez, 1997). In addition, some authors assign categories to the subtheories according to a logic that differs from the one employed in this report; for example Maula (1996) divides systemic outlooks to those dealing with open or closed systems, and talks about self-production as a characteristic of the latter. Furthermore, Morel and Ramanujam (1999), for instance, label self-organization and complex adaptive systems as paradigms within the complex systems theory.

The three-fold division into mechanistic, organic and dynamic system paradigms categorizes the field based on thorough analysis of the chronological development of the myriad strands and applications of systems theory and research. However, it is important to note that the differences between these three approaches are far from clear-cut, and they may be seen as existing along a continuum. We are also well aware that none of the paradigms discerned here is internally unidimensional or completely consistent. The decision to employ this particular division was arrived at on the grounds that it 1) allows for a relatively comprehensive categorization and unification of the concepts and *explanations that have guided the scientific work on systems,* and that it 2) provides a robust basis for the construction of a systemic theory that comprises the significant facets of business organizations.

The three-fold division coincides with the historical three-stage model of the development of science. Prigogine and Stengers (1984) state that the first stage of science focuses on steady or equilibrium states. The second stage begins with the recognition of periodic fluctuation, i.e. the operation of oscillations whereby systems move in and out of (but still remain near to) a state of equilibrium. The third stage is the exploration of states of extreme instability, so-called chaos, where true rather than only quasi- or illusory system transformation may occur.

4.1 The Mechanistic Systems Paradigm

The first paradigm of systemic thought can be characterized as mechanical, linear and deterministic. It focuses on universal laws, principles and regularities, and stresses predictability and preservation. Systems are apprehended as closed, determined to maintain stability by reducing and minimizing all interaction with the environment. The type of research conducted in the realm of this paradigm is intended to explain and define natural laws and principles and to predict events conforming to the formulated theories. Systems are perceived as being self-contained entities and no weight is put on the environment in which they exist. Ultimately, this perspective results in a theory that considers *systems as machines that operate according to predetermined laws and aims to predict and control their functioning.*

Until the 20th century, Western scientific thinking was guided by this paradigm, which is ultimately based on the Newtonian mechanistic perspective and classical physics. Even today, this perspective governs scientific thinking in a number of disciplines. In organizational research, the mechanistic system paradigm stemmed from the efforts to apply the ideas of standardization and systematization to organizational and managerial issues. The attempt was based on the supposition that “human and nonhuman entities are interchangeable and can equally be subjected to engineering manipulation”. (Shenhav, 1995.) It has been argued (Morgan, 1997) that organizational research is still largely guided by the metaphor of organizations as machines.

4.2 The Organic Systems Paradigm

The second paradigm considers systems as organic, open and in constant interaction with their environment. Its focuses on upholding an unsettled and uncertain stability by regulating it and hindering it from declining into total disorder through steering and controlled interactions with the environment and other systems. As such it allows for change through evolution[6], as opposed to rules and regularities, and instead of total forecasting and controlling, it produces continuous development. This paradigm is ultimately based on the Second Law of Thermodynamics, which states that when systems are left to themselves, their internal dynamics are bound to become disordered, and to drift towards irreversible decay. For this reason, open systems are dependent upon their feedback with environment for stability, which, in this view, equals survival. The world is perceived as consisting of various systems, which are in constantly interaction with each other and which coexist both within one another and in parallel.

To maintain themselves, systems must exchange energy, information or matter with their environment and keep the *feedback processes* (*input, throughput, output*) ceaselessly active. Thus, within the organic paradigm, the *relationships and interactions of systems with their environment* are emphasized, and internal regulation and adaptation to both internal and external changes are regarded as crucial. All the systemic

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[6] Evolution in contrast to revolution. See 4.3, The dynamic systems paradigm.

traditions which originate from the General Systems Theory of von Bertalanffy (1950; 1967; 1968; 1972a; 1972b; 1975; 1980; 1981) adhere to this paradigm, although some advanced views, such as the Soft Systems Methodology (Checkland, 1981; Checkland & Scholes, 1990; Walsham, 1993) and the Learning organization (e.g. Senge, 1990; Senge et al., 1994), display certain features pertaining to the third paradigm. (Ståhle, 1998.)

4.3 The Dynamic Systems Paradigm

The third and the most recently emerged paradigm focuses on the non-linear and unpredictable behavior of systems, rather than on controlled growth, and on internal dynamics and self-induced change instead of adaptation to the environment via feedback processes. Its main focus is on how systems utilize extreme instability, chaos and unmanageable complexity in order to gain dynamic stability. According to this view, systems take advantage of sensitive non-linear interactions, co-working resonances, between the system as a whole and its sub-systems. As a net result, the system gains dynamic stability on the level of the system as a whole, which is based on continuous and fluctuating instability, or chaos, on all or part of its sub-system levels. This systemic paradigm, often labeled as the 'science of chaos' or 'complexity research', draws mainly from four sources: 1) the chaos theory, 2) self-organizing systems by Prigogine, 3) complexity research and 4) autopoietic systems by Maturana and Varela. The dynamic paradigm reveals the extreme complexity of systems and the significance of a chaotic, non-equilibrium state. It emphasizes the *capacity of systems for spontaneous renewal and ability for self-induced change*. [7] (Ståhle, 1998.)

As the dynamic paradigm is the most recent of the three paradigms (and perhaps the most difficult to grasp), some significant theoretical developments in this area will next be discussed in brief. The birth of the dynamic perspective on systems is often traced back to Lorenz (1963; 1993), a meteorologist, who approached systems from the viewpoint of turbulence and chaos. By studying climatic conditions, he discovered that

[7] We are well aware that the chaos theory and complexity research are by no means internally homogenous fields, and that self-organizing and autopoietic systems research partly overlap with both chaos and complexity research.

minor alterations in one part of a system can lead to amplified outcomes in its other parts. This characteristic of nonlinear systems is called the butterfly effect, illustrated by the famous question “does the flap of a butterfly’s wings in Brazil set off a tornado in Texas?” In more technical terms, dynamic systems tend to exhibit a sensitive dependence on initial conditions, to weak signals, and even to minor, but critical, fluctuations in surrounding conditions or the system itself.

Lorenz also discovered that some systems, such as the weather system, are continuously chaotic. It is of utmost importance to realize that the term chaos as a scientific concept has a thoroughly different meaning than in the lay usage: chaos stands for complex behavior that seems to be random, but is, however, governed by some underlying order and laws. As such, chaos is unpredictable but deterministic. Lorenz’s findings represent a track of thought in sharp contrast with the open systems tradition, which is based on the assumption that maintaining the system’s orderliness is a necessity and that chaos is an unwanted and exceptional condition that leads to decay.

Physicist Ilya Prigogine (1967; 1976; 1980), who studied the thermodynamics of evolution, found that there is a pattern or order that emerges out of the chaos produced by the random behavior of the elements of a system. A variety of diverse interactions causes a creative destruction of individual inputs and, thereby, generates a coherent unity. In a far-from-equilibrium state, the system is forced to explore and experiment new options, and this helps the system to discover and create new patterns of relationships and structures. Hence, the system is able to reorganize of its own accord, unpredictably and without external control. This phenomenon is called self-organization, the emergence of order and structure from chaotic conditions. Along with the Prigoginian discoveries, the focus of systems thinking shifted from systemic order to disorder and to the relationship between chaos and the emergence of order. Disequilibrium, rather that stability, began to be seen as the necessary precondition for both existence[8] and evolvement.

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[8] It is worthwhile to note at this stage that chaos not only induces spontaneous change, but is the very prerequisite for maintaining the change, the new structure it induces and creates. Chaos, therefore, is continuously present and steadily active, a never ceasing feature of dynamic systems. In fact, were chaos to degenerate into order the structure it upholds would collapse.

Complex adaptive systems are dynamic systems capable of adapting and changing within, or as a part of, a changing environment (Mitleton-Kelly, 1998). Complex systems research is a highly interdisciplinary field and is more of a research perspective than a single unified theory (Morel & Ramanujam, 1999; Cohen, 1999). The complexity and chaos theory share some characteristics and are not always distinguished from one another, although chaos refers to the dynamic behavior of nonlinear systems and not to a class of systems, as complexity does. Morel and Ramanujam (1999) note that "complex systems do not need to be chaotic to be 'complex', and chaos is not closely related to complexity".

In the context of social systems, there is an important difference between the two viewpoints. Within chaos research, interaction is explained in terms of simple rules, which are supposed to be constant. If applied to social systems, the chaos theory may thus lead to the assumption that social interaction is governed by some underlying and unchangeable rules[9]. Hence, some researchers argue that chaos theory may be applied to social systems only in the form of analogies or metaphors (Mitleton-Kelly, 1998; Maula, 1999).[10] In contrast, complex systems are capable of evolving and changing the rules of interaction. To delineate the distinct quality of human systems, namely the fact that they consist of conscious individuals who are capable of making choices and changing the patterns of interaction, Mitleton-Kelly (1998) calls them complex evolving systems.

Another important theory that pertains to the dynamic view of systems is that of autopoietic systems by Maturana and Varela, biologists who studied the internal dynamics of living systems. Autopoiesis means self-production. Autopoietic systems are characterized by two main features: 1) they construct an identifiable boundary between themselves and the environment and 2) they produce themselves by self-

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[9] This, however, can be contested. Prigogine (1976, 125) argues, "The ideas of "infrastructure" and "superstructure" have given rise to interminable discussions. It seems worthwhile, therefore, to indicate that within the framework of our formalism, these ideas take on a very direct meaning. A structural instability may result from the occurence of a *new function* arising from a fluctuation. With such a fluctuation, one may associate a modification of the infrastructure. The relation between the space-time function-structure will be modified if the fluctuation leads the system to a new dissipative structure. From this point of view, the space-time structure appears as the "superstructure."

[10] Others hold the opposite view: "At this time one of the most promising directions of research is in the systematic application of the ideas and tchniques of nonlinear dynamics to all kinds of natural systems, including those of biology, the social sciences and economics." (Ruelle, 1989.)

replication: every state of the system derives from a previous state of the system. I.e. an autopoietic system generates itself in two ways: through self-definition and self-replication. An autopoietic system is separate from its environment, and interacts with it in a distinct manner: there are no inputs and outputs as such, but rather structural couplings with the environment produced by the system itself. Living systems take in matter and energy from their environment, but view anything that enters from the perspective of their own existing organization. (Maturana & Varela, 1980; 1988.)

The dynamic paradigm exhibits many commonalties with the organic one. There are, however, many important differences between the two viewpoints. Firstly, this paradigm comprehends stability in a totally opposing manner from the organic view: for the latter, non-stability and chaos are unwanted disturbances that can potentially lead to destruction, whereas according to the dynamic view, they are the sources from which new structures and innovations emerge. Secondly, the organic paradigm views the system as "a complex of elements in interaction, these interactions being of an ordered (non-random) nature" (Von Bertalanffy, 1981, 109). The dynamic paradigm recognizes the possibility of random interaction among the elements of a system. Thirdly, the organic paradigm concentrates on the feedback processes, internal regulation and autonomy of a system; it does not consider the system's internal dynamics while the system recreates itself. Fourthly, the organic view sees systems as being open, while according to the dynamic view, systems refer to themselves for the interpretation and incorporation of the incoming matter or information and, as such, are paradoxically open and closed at the same time. Finally, the environment is understood as being a causal chain of events in relation to the system according to the organic view, whereas the dynamic paradigm holds that the environment is created by the system's self-reference. The two views are not mutually contradictory, but instead show the diverse characteristics and dimensions of systems.

Table 2. The paradigms of systemic thought.

Paradigm / Characteristic	Mechanistic	Organic	Dynamic
➢ **Theoretical origins**	Newton, classical physics	Von Bertalanffy's General Systems Theory	Chaos and complexity research, self-organizing and autopoietic systems
➢ **Research focus**	Principles, laws, regularities, predictions	Feedback processes, relationships and interactions with environment	Spontaneous organization, continuous self-production and self-induced change
➢ **Operative interest**	Predicting, controlling, preserving	Steering, sustaining	Opening up for natural evolvement, evolution and innovation
System			
➢ **Type**	Closed, static, deterministic	Open, equifinal	Uncontrollable, emerging, self-organizing, self-producing
➢ **Main function**	Efficient rule-like functioning, linear	Self-regulation, striving for stability and equilibrium, linear or cyclic	Continuous self-renewal and self-production, non-linear
➢ **State**	Static, permanent, sustaining	Near equilibrium	Far-from equilibrium
Environment			
➢ **Role**	Non-existent	Causal chain of events that effects the system	Created by the system's self-reference
➢ **Boundary**	Closed	Open	Open and/or closed
➢ **Relationship**	Systems as self-contained wholes	Adaptation to environment; open interchange with environment, inputs and outputs explained by feedback loops, interdependence	System must maintain a distinct identity and be self-productive; Systemic capacity for change is greater than environment's capacity for change
Change			
➢ **Role**	Catastrophe	Momentary disturbance	Necessity
➢ **Source**	No change	Environment, adaptation to environment	Entropy, fluctuations, continuous process of self-production
➢ **Pace**	Slow	Moderate, continuous	Sudden, bifurcative
➢ **Means of knowledge creation**	Exploitation of existing knowledge	Information from environment is processed internally into knowledge	Self-referential interpretation of data from environment / within the system, iteration of weak signals

4.4 The System Perspective in Social Scientific Research

Prigogine, who conducted his research in the fields of physics and chemistry, has pointed out that social systems may also adhere to similar self-organizing dynamics (Prigogine, 1976; Prigogine & Stengers, 1984; Prigogine & Nicolis, 1989). Even though Prigogine's work can be labeled as the science of chaos, the theory of self-organizing systems has lately become a popular issue among organization theorists (e.g. Morel & Ramanujam, 1999; Krippendorff, 1999). Furthermore, the idea of autopoiesis has attracted a lot of interest from social scientists (e.g. Luhmann, 1995; Maula, 1999), and Maturana and Varela have expressed some support to the idea of applying the theory to social systems (Varela & Johnson, 1976; Maturana, 1980).

The interest in applying dynamic system theories to organizations is accelerated by the sentiment that classic social scientific methods cannot produce knowledge that is relevant for contemporary management problems. The dynamic worldview has been suggested as a remedy to the wide gap that exists between the academia and practitioners. The latter tend to feel that social sciences adhere to an artificially simplified and biased worldview that sidesteps such essential features of real-life organizations as complexity and unpredictability. (Overman, 1996.) For example, in the introduction to the Organization Science special issue on complexity and organizations, Anderson and colleagues (1999) claim that organizational scholars tend to model phenomena as if they were linear in order to make them tractable, and to model aggregate behavior as if it is produced by individual entities which all exhibit average behavior, but that now a different view of complexity is emerging that may have important implications for organizational research. Begun (1994) argues, "Methodologically, chaos and complexity theory teach us not to force relationships to fit linear models and not to label deviations from linear models as error or unexplained variance. Instead, we should assume that most systems do not and should not fit linear models, and it is dangerous to use methods that require us to do so."

In Exploring Complexity (Prigogine & Nicolis, 1989) Prigogine states: "Our everyday experience teaches us that adaptability and plasticity of behavior, two basic features of nonlinear dynamical systems capable of performing transitions in far-from-equilibrium conditions, rank among the most conspicuous characteristics of human societies. It is therefore natural to expect that dynamical models allowing for evolution and change should be the most adequate ones for social systems." (p. 238) Earlier, he concludes: "We recognize that we are beginning to clarify these notions (by Bergson) of ‘invention’ and ‘elaboration of what is absolutely new’ by the mechanism of successive instabilities caused by critical fluctuations” (Prigogine, 1973). “The discovery of such mechanisms, which play such an essential role in a waste domain stretching from physics to sociology, is obviously a preliminary step toward some harmonization of the points of view developed in these different sciences." (Prigogine, 1976, 126.)

However, it is necessary to realize that extreme cautiousness is needed in applying models from the natural sciences to the domain of human behavior. One of the main reasons for this is that humans, unlike constituents of other kinds of systems, are conscious actors. Even when living systems have been studied, there is a limit as to how far the findings can be extended to human systems. For example, Prigogine and Stengers (1984) traced the process of self-organization in a termite colony, and presented this as a proof of the validity of self-organization in social systems. However, human social behavior surely differs from interaction within animal aggregates to a great extent (Eskola, 1982), and thus, we feel that it is reductionist and inappropriate to extend findings from the animal world to human behavior beyond a certain limit.

Is it then viable to apply principles derived from, for example, the chaos theory to social systems? In our opinion, the answer is yes, on the condition that this is done conscious of the fundamental differences between the elements of natural sciences as opposed to human sciences. We should not simply import ideas from natural sciences, but use them “to inform rich, theoretically-grounded depictions of how organizations operate” (Anderson et al., 1999). Naturally, this question pertains to the use of theories within all the three systemic traditions distinguished above. However, as the mechanical and organic paradigms are both well established within the social sciences, the discussion here is explicitly directed at the question of dynamic applications in social studies. As Begun (1994) states, “The challenge is to discover chaos and complexity theory for organization science, knowing them for natural science. It is not an issue of extrapolating, extending, or applying findings from natural science. We need to discover our own questions and theories, informed by this new understanding of nature.”

There are two principal ways in which the choice of applying concepts, such as self-organization and autopoiesis in organizations, has been justified. The first strand of thought deals with the metaphorical nature of science. The second one assumes that change is a pervasive feature of reality and, therefore, that the social sciences should benefit from the dynamic concepts and models developed in the natural sciences. According to Contractor (1999), neither perspective is without challenges: in the metaphorical approach, there is the danger that accounts remain vague and descriptive, while the second approach is likely to require an interdisciplinary group of scholars, since the modeling of (dynamical) systems demand expertise in such different areas as organizational theories, statistics and computer programming[11].

In a metaphor, a familiar, concrete or communal thing is used to depict something that is unfamiliar, abstract or has been experienced alone. Some theories, which were originally constructed to account for non-human, and perhaps even abstract phenomena, such as chaos theories, can offer powerful and convincing metaphors for understanding business organizations. This kind of view has been proposed by, for instance, Morgan (1997). Morgan (2001) states that "ideas about organizations are always based on implicit images or metaphors that persuade us to see, understand, and manage situations in a particular way". Furthermore, it may be argued that all theory building makes use of analogies and metaphors (Wheatley, 1992). For example, how would it be possible to study social networks without the use of metaphors, as a social network is a metaphor itself?

We need not, however, restrict the use of dynamical approaches to the level of descriptive and elusive metaphors. Loye and Eisler (1987) have traced the history of chaos theoretical thinking in the classics of social sciences and state: "Chaos theory is not a new or alien notion to social science… Rather than reductionism, we confront a case of cross-fertilization, with the mutuality of benefits for all levels of science that this implies. For closer scrutiny of Marx, Engels, Weber, Pareto and others reveals they were all grappling with isomorphically the same questions of change as modern 'chaos' investigators in natural science." (1987, 59.) Referring to the 3-stage model of science

[11] The group involved in the development of KM-factor tool for measuring organizational renewal ability has included members with expertise in social sciences, educational sciences, management sciences, mathematics, physics and computer science.

by Prigogine and Stengers (1984), they continue: "The fact that these connections have been so quickly forgotten, or are only sporadically pursued or emphasized, is again evidence of the hold of stage-one, stage-two and antinormative paradigms on social science" (1987, 60).

Also Cohen (1999) notes that the focus on systems and on their dynamic properties has always been of major interest in social theory, and that for both complex system researchers and the more traditional social theorists, "there can hardly be more fundamental questions than 'how do our objects of study (and our theories about them) arise, persist, change, and dissolve?'" Similarly, Morel and Ramanujam (1999) argue that "organization theory and complex systems theory grapple with similar conceptual issues such as dynamic change, adaptation, and evolution in complex systems. They seek answers for similar questions, such as naturally occurring patterns in systems, emergence of new forms."

With the realization of the pervasiveness of change in human existence, the aim of social sciences is steering towards understanding behavior through the looking glass of constant disequilibrium rather than stability. The lack of previous discoveries of chaos in human behavior "is almost certainly due to the still developing nature of nonlinear analyses in the social sciences rather than the absence of chaos in the human setting". (Brown, 1995, 9-10.) As human systems differ from other systems in the physical world, they should not be modeled in precisely the same way as are other kinds of systems (Johnson & Burton, 1994). Accordingly, new theories and methods of research are being developed that take advantage of the relevant findings in the natural sciences, but extend them to a genuinely social direction[12]. This is also the aim of the publication at hand. In the next chapter, the mechanical, organic and dynamic system paradigms will be applied to organizations to construct a model of organizations as three-dimensional systems. This theory will then function as a conceptual basis for the construction of a method for analyzing the dynamic aspect of intellectual capital, i.e. an organization's systemic efficiency, reported in chapters 6-8 of this volume.

[12] An exemple of this type of theory is the theory of self-referential systems by Niklas Luhmann (e.g. 1995), which partly leans on the theory of autopoietic systems but builds on it to achieve a veritably social view

So, we conclude that our position is that (especially dynamical) system approaches offer promising possibilities for studying social phenomena and have the potential to enable scholars to examine organizational issues which are beyond the reach of other types of approaches.

5 The Organization as a Three-Dimensional System

In this section we focus on discerning general explicit system dependent, mechanical, organic or dynamic, characteristics from a organizational and functional view. Four main factors which constitute an organization and define its functioning as a system are introduced: relationships, information flows, know-how and management.

Recent developments in organizational and managerial literature have witnessed the flourishing of theories based on systems thinking. Views based on autopoietic, self-referential systems (e.g. Huemer et al., 1998; Vicari & Troilo, 1998; Lichtenstein, 2000) and complex adaptive systems (e.g. Brown & Eisenhardt, 1997; Sanchez & Heene, 1997b; Hamel, 1998a; Anderson, 1999) have been especially numerous in recent years. It is argued here, however, that in addition to these newer developments, the older traditions of closed and open systems should not be forgotten either. All the three perspectives are correct, since they reflect the different operating possibilities open to an organization. *Therefore, any organization can be seen as a three-dimensional system where its mechanical, organic and dynamic features all have their own roles and tasks in providing competitiveness*. All three systemic modes, mechanistic, organic and dynamic, are present in every organization, and all of them should be operational in order for an organization to succeed in competition with other systems. (Ståhle & Grönroos, 2000.)

In most of the systems-based writings, the way to deal with the different accounts of systems has been to choose the one which best matches the target of the research, and then to discard the other views. We are, however, suggesting a radical departure from this procedure by arguing that organizations can be viewed as systems with mechanical, organic, as well as dynamic qualities. There are undoubtedly systems that can be categorized as belonging more or less to only one of the system types; for example, some machines are strictly mechanical, while living organisms display features of the organic and dynamic kind. However, some systems, such as organizations, can and do display features of all three types. The three types may be seen in organizations as points along a continuum, the mechanical and dynamic types being at the opposite ends.

Consistent with this track of thought, several authors have noted the limits of dynamical system theories as applied to organizations. For instance, Aula (1994, 4) notes that “chaos is only one part of the complex behavior of a complex system”. Similarly, Cohen (1999) argues that “we should also realize the limitations of complex systems theories in the study of organization… We should test the applicability to determine on which problems the ideas work best, and which should be approached with different tools.” The multi-faceted quality of organizations is also echoed in Scharmer’s (2000; 2001) constructions. He talks about three types of knowledge; namely explicit, tacit-embodied, and self-transcending (not-yet-embodied), each of which require different type of learning infrastructure and management. Maula (1999) addresses the dilemma between organizational openness and exploration, on the one hand, and learning, closure, and exploitation on the other, which every organization has to solve.

The idea of organizations as consisting of three systemic facets may be concretized by an example of the process of innovation. The innovation process is customarily depicted as being a two-stage process (see King, 1990, for a review of studies on the process of innovation). Firstly, there is the generation of a new idea. Secondly, the new idea has to be implemented or actualized in some way. An additional third stage may be identified in the sequence, which applies at least to commercialized innovations, namely marketing and customer service. All these phases pose different requirements for the organization and management of activities, as well as the pattern of interpersonal relationships (Kanter, 1984; Ancona & Caldwell, 1992; Pöyhönen, 2001). The three phases can be abstracted to link with the three modes of organizational functioning. Obviously, in idea generation, the dynamic facet is the most crucial one. In the production phase, the mechanical facet produces efficiency and sustained quality. Lastly, successful customer-oriented marketing and customer service require organic capabilities.

The three faces of organizational systems can be further described by distinguishing the qualities of the *system constituents* in each business environment. Four main factors that constitute an organization and define it as a system are its *relationships, information flows, know-how and power structures (*demonstrated and formed by *management).* The theoretical foundation of the systemic analysis of organizations is largely based on the combination of systemic characteristics with the three system classes. Their significance can be characterized as follows:

1. A system is constituted and demonstrated by its *relationships*, not only by the elements of which it is made up. The weaker the relationships are, the weaker the organization is as a system. Relationships are a common feature for all kinds of systems: mechanical, organic and dynamic. Data on the features of the relationships reveals the principle of how the system is organized. That is why the data concerning relationships is a source for systemic analyses. The relationships in different types of systems are formed and maintained in a different manner.
2. All the changes in the system are caused by *exchange of information*. Relationships form channels for *information flows* within a system. In a systemic sense, information is also the only source for the maintenance and renewal of a system. The focus is not the content of information but the flow of it. Information, however valuable it potentially would be, is totally without any value if it is not being exchanged and put in motion.
3. Organizations are purposeful and goal-oriented systems, in which information needs to be exchanged and enriched by its members. In social systems, the value of the exchanged information is always linked to its meaning (Luhmann, 1995), and the meaning (and the value of it) in business organizations in turn is connected with the organization's primary task and chosen strategy. Even if information was be widely exchanged and thus the organization had lots of potential for change, without proper and strategy-linked *know-how, capabilities* and *competencies,* the flexibility would be without any value.
4. Systems are always *hierarchical* and composed of several degrees of sub-systems which cooperate with each other. The steering and regulating forces in a system might come from anywhere on the continuum that ranges from mechanistic regulations to the principles of dynamic self-organization. In real-life organizations, these functions are set up and represented by *management*. Thus, data concerning an organization's management functions act as a source for systemic data.

5.1 Organization as a Mechanistic Machinery

From the mechanistic viewpoint, organizations are seen as ordered, regularly functioning, machine-like entities. They are directed from the top of the organizational hierarchy, and the function of top management is to control and ensure that the organizational machinery functions as effectively as possible according to predetermined objectives. The organizational hierarchy determines the patterns of the relationships within the organization, and information flows are typically one-way and top-down. The essential type of knowledge is defined and explicit. The most important characteristics of organizations are unanimity, predictability, continuity and manageability. For example, Taylor's scientific management and Weber's bureaucracy adhere to this view. The most evident contemporary examples of highly mechanistic organizations are crisis organizations such as fire departments, hospitals and the army, which are required to operate quickly and routinely according to perfectly controlled action chains – very much like programmed machines. (Ståhle & Grönroos, 1999; 2000.)

So, how is this explicitly static paradigm related to companies that have to compete in today's rapidly changing, chaotic environments? Most prominently, we say: mechanistic and carefully controlled functions are always needed, be they financial administration, logistics, customer services or invoicing. The mechanical view should not be ignored, for it bears benefits for understanding and managing 21st century organizations, even though its concepts and models may at first look seem seriously outdated. Even the most flexible organizations cannot afford to neglect the issues of building some permanent support structures, or otherwise time and effort will be wasted on doing things that could very well be systemized. In contrast to Taylor's era, the significance of mechanical systems in today's organizations lies in the opportunity that automation, routinization and rationalization open for releasing human resources for higher order work.

5.2 The Organization as a Complex Organism

When applied to organizations, the organic paradigm stresses the communicative, dialogical nature of organizations. Instead of drawing parallels between organizations and machines, this view compares them with living organisms. Organizations are seen as being organic and open systems that depend on constant interaction. Attention is drawn to information flows into the organization (input), to the processing of information inside the organization (throughput) and to the information that comes out of the organization (output). Change is managed by controlling these flows – in other words the organization is kept simultaneously in a state of constant movement and constant equilibrium. (Ståhle & Grönroos, 1999; 2000.)

As living, complex systems, organizations require a different kind of management from mechanistic organizations. Steering the organization is about delegating power, creating feedback systems and ensuring continuous two-way communication throughout the organization and not about authoritarian control. The valued type of knowledge is experiential, hidden and tacit, which can only be shared in real-time social interaction. Thus, it is highly important to establish reciprocal relationships and frequent opportunities for interaction throughout the organization. From the organic point of view, the overall operative interest lies in sustaining managed growth and adaptation to the environment, as well as producing customizing ability. Quality management programs are a good example of organic functioning with a view to controlled development, as their objective is to ensure both sufficient stability and predictability together with continuous managed growth and development. (Ståhle & Grönroos, 1999; 2000.)

5.3 The Organization as a Dynamic Network

The dynamic view depicts organizations as hectic, even chaotic entities, which have to cope continuously with uncertain, sudden and contradictory elements emerging both from within the organization and from the outside environment. It relates to the organizational features that produce constant self-renewal and radical changes, and to situations where balanced growth is increasingly hard to achieve. Organizations are seen as dynamic, constantly changing networks with fuzzy boundaries. Survival and success is the outcome of strategic position, managerial and co-working skills, sensitivity and resonance; sensitivity in the meaning as to acknowledge even small changes and weak signals, and resonance in the meaning as to steadily and immediately be able to respond or react. The system's contacts with its surroundings are close and essential: interest groups, customers, subcontractors and other partners, even competitors, are all genuine parts of the system. When left isolated, dynamic systems simply collapse.

Dynamical functioning requires that the company's top management understands and tolerates continuous change and development and has the ability to take risks and to live with unpredictable and contradictory events. The dynamical character of organizations is seen in all development that aims at achieving a strategic competitive edge, such as creating a totally new kind of product, image or operating method. It is also reflected in the breaking down of organizational barriers and in the convergence of different lines of business. The dynamic operating environment is filled with possibilities – some of which cannot be realized by the organization's own resources. Therefore, organizational boundaries blur and new kinds of alliances are formed: projects or virtual companies to achieve a shared objective. The operations aim at creating innovations, i.e. the kind of development that cannot be easily copied. The operations are also risky since it is impossible to control or predict either innovations or changes in the competitive environment. Nevertheless, when successful, the company ends up a winner and gains formidable profits. (Ståhle & Laento 2000; Ståhle & Grönroos, 2000.)

The dynamic environment is the only possible basis for continuous innovativeness. Knowledge is intuitive and potential, and intensive networking inside and outside the organization serve in the process of creating new knowledge by enabling the system's sensitivity to weak signals. The system is a spontaneous, fast-reacting, high-tempo and even chaotic entity. Chaos, however, does not refer to total disorder: there is a relationship between disorder and order – the key to profiting from the dynamic qualities of an organization is the ability of chaos to organize itself.

Table 3. The three dimensions of the organizational system.

Organization as 3D system	Mechanical	Organic	Dynamic
Objective	Permanent efficiency	Gradual development	Continuous innovation
Knowledge	Defined, explicit	Experiential, hidden, tacit	Intuitive, potential
Relations	Determined by the organizational hierarchy	Reciprocal, seeking consensus	Spontaneous, networked
Information flow	One-way	Multi-way	Chaotic
Management tool	Orders from management	Dialogue, agreed working methods, self-assessment	Networking skills, visions
Leadership method	Direct use of power	Delegation of power	Relinquishing power

(Based on Ståhle & Grönroos, 2000)

5.4 Strategy Determines the Optimal Combination of Systemic Features

Naturally, as there are different kinds of organizations as well as market situations, which fluctuate to varying degrees, not all systemic features are equally essential for every organization. The overall strategy of the organization determines the relative emphasis put on of each of the systemic qualities. For example, service organizations tend to stress organic features, while research and development -oriented organizations place much weight on dynamic features. The organization is a living instrument for fulfilling the company's strategy; it is a three-dimensional system capable of choosing purposeful ways to act. Successful management recognizes – often intuitively – what kind of operational mode and management culture is able to achieve the goals. The mechanistic organization never meets innovative strategic goals, while the dynamic organization never fulfils the targets of an effective production line.

However, every organization needs all of the systemic capabilities to some extent. The optimal combination of the three facets of the organizational system, in turn, depends on the organization's strategy: strategy should dictate how much relative weight is put on each of the operating modes. For example, the fact that organizational theories springing from the mechanistic worldview are no longer capable of fully explaining business in the rapidly changing world of today does not mean that their findings are totally useless. Every organization must still benefit from automation and rationalization, the difference with earlier times being that nowadays these modes must not be used to guide all operations but should only be implemented in the areas of the organization that deal with producing sustained quality according to permanent and codified rules, f. ex. manufacturing.

This is also where the limitation of our current framework lies: it does not provide any tools for evaluating the content of strategy. If an organization's strategy is out of place, it does not help much for the organization to be systemically efficient, for its efficiency is guided towards wrong goals. Instead, *our approach aims at analyzing how much potential the organization has to implement the chosen strategy as a coherent system.* To deal with the successfulness of strategy in a systemic framework would require us to analyze the whole global market system, which, needless to say, is out of the scope of any research. Thus, the evaluation of the chosen strategy is consciously bypassed in this approach. As such, the approach is compatible and can be complimented with theories of strategic management, such as those put forth by Hamel and Prahalad (1994), and Sanchez and Heene (1997a).

PART II PRINCIPLES OF THE SYSTEM ANALYSES

6 The Basic Model for Data Retrieval

The profound implications of the systemic viewpoint have not been adequately examined or exploited in organizational and management sciences (e.g. Morel & Ramanujam, 1999). Despite the fact that many authors talk about organizations as systems, there have been scarce attempts to develop measures that deal with the systemic qualities of organizations. The quantitative system analysis of organizations has to begin with a thorough conceptual analysis of systemic characteristics. Only then can we move onto modeling these characteristics and finally build a method for retrieving quantified data from systems, which will enable us to reliably and accurately measure systemic efficiency of organizations by implementing standard mathematical and statistical methods. The following two chapters of this volume present a method for analyzing the systemic efficiency of organizations, which, as previously argued, is antecedent of the ability for renewal. The ability for renewal, in turn, is an essential part of a company's intellectual capital, especially in knowledge-intensive business environments. The method is based on the conception of organizations as three-dimensional systems.

6.1 The Analysis of System Characteristics

An inspection of the different system classes in chapters 4 and 5 demonstrated that their main characteristics serve different purposes in the aim towards the *efficiency and survival of the organizational system in competition with other systems.*

Every organization is a mix of the three system classes, and thus, the system characteristics of an organization are expected to be a mix of mechanical, organic and dynamic system characteristics. Taking this mix into account, we pose the question: how do organizational systems survive and survive in their competition with other systems? The simple answer is, by possessing a suitable mix determined by the surrounding environment in which the organization must survive, as well as the strategic intent of the organization in question. This means that survival is a relational concept being determined by *internal* relations and *external* relations to surrounding systems and to the environment.

The balance between the three kinds of system characteristics can be visualized in a **systemic profile**. An effective systemic profile is characterized by a suitable balance between mechanical, organic and dynamic system characteristics, which gives it an advantage in the competition with surrounding systems and the environment. **Systemic efficiency** is a system's capability to sustain and constantly adjust this balance as a whole and to produce this balance at different subsystem levels. An organization's systemic profile could graphically look like this:

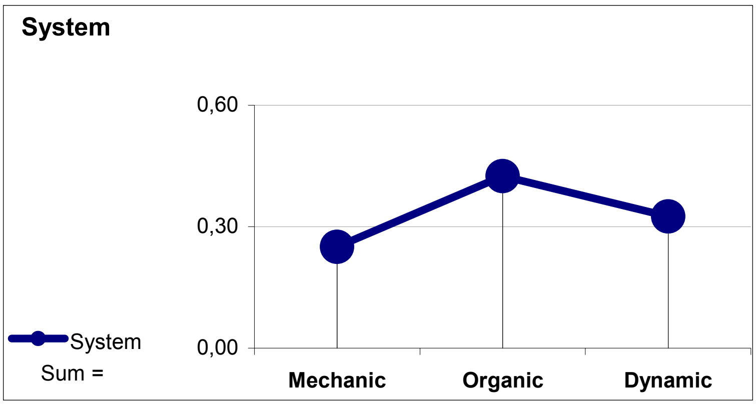

Figure 1. An example of the systemic profile of an organization, which emphasizes organic features (sum = 1.0).

As organizations are social systems, the systemic profile is never self-evident; it is always a deliberate and premeditated choice made by the system itself. It targets its features by choice – and at the risk of making wrong choices[13]! This being the case, we

[13] The necessity of making choices is a feature of autopoietic systems: Luhmann (1995, 24-25) states that complexity, in this sense, means being *forced to select*; being forced to select means contingency; and contingency entails risk. In this respect, the system profile is an autopoietic constraint in the system.

must define systemic efficiency for organizations in a twofold way. That is, we must distinguish between *the choice* made and *efficiency* as such.

Every organization **chooses** a suitable balance between mechanical, organic and dynamic system characteristics, an effective **strategic focus**, which is intended to give it an advantage in the competition with the surrounding systems and the surrounding environment. The **systemic efficiency** is the organization's capability to realize and sustain this balance as a whole, and to reproduce this balance at sub-system levels by mixing different functions of the subsystems that constitute the system as a whole.

Both aspects of the system's competitiveness, the choice of the strategic focus and systemic efficiency, will affect the overall outcome. Whereas the rightness of the choice of the strategic focus cannot be measured – or measured only over a period of time - we argue that systemic efficiency can be measured at any time.

Then, what are we to expect of a competitive organization? We can expect a mix of mechanic, organic and dynamic features:

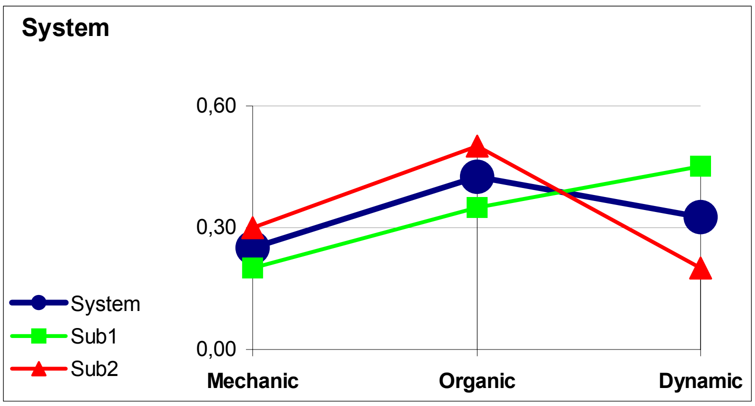

Figure 2. An example of a system and its subsystems, which emphasize organic and dynamic features, respectively[14].

[14] And with equal weight, but on different sub-levels.

Taking this mix into account, it is evident that the system profile, as a whole, is a choice made by the system. Furthermore, the systemic profile of an organization may contain large internal diversities, which are reflections of the subsystems that represent various parts and functions embedded within the whole. Each subsystem has, or should have, its own specific profile, and a system may in fact include subsystems with highly heterogeneous profiles. This can be understood as a result of a system's increasing complexity and size, as *complexity* enables differentiations between various functions within the system, and size increases system's autonomy, its possibilities to act by choice[15]. This is likely to be the case in larger organizations. For example, a large organization may include an R&D function, which has a dynamic profile, and manufacturing function, which emphasizes, above all, mechanistic features.

The measurement of systemic efficiency is primarily conducted at the subsystem level. To be systemically efficient, a subsystem has to possess a unanimous and consistent systemic profile, which clearly emphasizes either mechanical, organic or dynamic features. **Unanimity** and **consistency** at different levels of the system are the key indicators that depict the concept of systemic efficiency.

Systemic efficiency can be defined in two ways, depending on the level of differentiation of the organization under scrutiny. If the total system is undifferentiated, i.e. it does not contain distinct functional subsystems that can be separated from the whole for analytical purposes, its systemic efficiency depends, above all, on how unanimous and consistent the systemic profile is. For larger, differentiated organizations, the measurement is initially conducted at the subsystem level, in which case each subsystem is treated in the same way as an undifferentiated organization would be. However, for determining the systemic efficiency of an organization consisting of various subsystems, it is not enough to establish the degree to which the subsystems are internally unanimous and consistent. Thus, the subsystems are linked together and this aggregate is then scrutinized as a whole to see how well it is suited for maintaining and upholding the organization's chosen strategic focus.

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[15] A sufficiently small system will always be dominated by the boundary conditions (Nazarea, 1974). In order for the "nonlinearities" to be able to lead to a choice between various solutions, it is necessary to go beyond some critical spatial dimensions (Hanson, 1974). It is only then that the system aquires some autonomy with respect to the outside world.

6.2 Retrieving System Characteristics

How do we retrieve data concerning the prior-mentioned characteristics and how are we to analyze them? Were we to follow the typical paths, we would proceed in either of the following manners:

1) We could try to approach the system qualitatively, by observing and monitoring it in various situations and then estimating the systemic characteristics based on a partially quantitative analysis of the gathered data.
2) We could gather data by letting the system participants estimate the degree to which various organizational features are mechanical, organic or dynamic and then trying to evaluate the systemic features simply by averaging the quantitative variables.

The first option, as an exclusive one, is rejected due to the fact that 1) such a method would always be dependent on expert judgments, 2) the re-analysis of the gathered data (tapes, interviews etc.) conducted either for a second time or by another expert would be likely to yield a different result and 3) reliable comparisons between different organizations would be hard, if not impossible, to perform using qualitative data. We wanted to eliminate these weaknesses of the typical qualitative approach by defining *systemic data as being both quantified and produced by the system itself*.

The second option, as an exclusive one, is rejected in this study on the basis of 1) the difficulties in setting up a reliable set of questions for the measurement of measuring system characteristics directly in a straight-forward manner and 2) the difficulties in overcoming subjectivity in answering these types of questions. These difficulties are caused by the fact that in social systems, concepts like coherence and resonance are highly qualitative and hard to explicitly define. Letting system participants directly estimate the degree to which the organization is mechanic, organic or dynamic would simply be too confusing for anybody without previous knowledge on the subject, and, in fact, we would only encounter the problems of a qualitative approach in a backward manner. Perhaps even more serious than the difficulty of formulating clear questions is the inescapable subjectivity of the responses. To give an example of the problem, the questions would have to be something like: "Are you sensitive to your co-workers' attitudes?", and "To what extent do your attitudes concerning managerial practices coincide with those of your co-workers?".

To overcome the limitations of the approaches mentioned above, we finally arrived at a combinatorial solution. We reasoned that if we could find the exact linguistic practices and their connections to different system characteristics, we could accurately measure the existence of these characteristics simply by creating a questionnaire based on the theory of organizations as 3-dimensional systems. This questionnaire would not address the system characteristics directly, but rather, mediated by the ways in which they are likely to be perceived by an individual system participant. In other words, we took the stand that systemic data should be gathered through direct, explicit statements in each system class. This led, furthermore, to the development of a matrix in which the system-dependent characteristics have a well-defined position.

> In practice, this implies *quantifying explicit variables and interpreting them as signs of implicit ones*.

In fact, this is exactly what is understood by the practice and meaning of expert analysis. Based on this notion, we take the first step towards the concept of the systemic analysis of systems by asserting that

> *the systemic analysis of social systems, in general, must rely on one or several questionnaires containing simple, single-minded and single-valued explicit statements, and it is the task of the analysis method to establish the systemic characteristics and measure them.*

6.3.1 The First Model for Measuring Systemic Efficiency

The main idea of the first model and the related questionnaire was to gather system characteristics in a two-dimensional matrix where the dimensions were determined by

1) the system *classes* and 2) system *constituent*. The matrix will be henceforth referred to as the *SE matrix* and its class-constituent intersection areas as *system* components.[16]

The model, the SE matrix, is a well-defined two-dimensional model containing system characteristics of three *system classes* (a,b,c) and four *system constituents* (1-4). In this way we get 12 intersections, i.e. *components* (A1-C4).

SE matrix	A.Mechanical	B.Organic	C.Dynamic
1.Know-how	A1	B1	C1
2.Information flow	A2	B2	C2
3.Relationships	A3	B3	C3
4.Management	A4	B4	C4

Table 4. The first Systemic Efficiency matrix.

Each component was a set of 3 basic statements (connected to system classes and system constituents) concerning the participants' estimates of

1) the present situation and
2) a preferable target situation.

In other words, the respondents were asked to evaluate each statement in relation to how it was perceived to be at the moment and how they wished it would be. The response format was a 1 to 5 Likert-type scale.

The main emphasis was placed only on the task of gathering three well-behaving statements that measured the characteristics in each of the components in the SE matrix. For example,

1. "My relationship with my closest superior is formal and distant" (A3:Relationships / Mechanical)
2. "My work encourages me to take risks" (C1:Know-how / Dynamic)

[16] The first model was the KMF matrix (KM = Knowledge Management, F = Factor) as it, at that stage, was used and tested as part of a knowledge management system. For the sake of clarity, we will use its updated abreviation, the SE matrix (SE = Systemic efficiency).

6.3.2 The Analysis of the First Questionnaire

The first analysis was rather straightforward, targeted at securing and validating the questionnaire form and the applicability of the model of organizations as 3-dimensional systems.

The internal validation process of the questionnaire was guided by the following principle: In each component, the net average of the 1) internal correlation, 2) F-test, and 3) χ^2-test values between the questions, which belong to the same component, must be greater than the corresponding average in any other component. Following this principle, the statements were gradually modified to be *well behaving* in the sense that they significantly strengthened only the component to which they belonged. This process of following the behavior of the questions used in the questionnaire is still ongoing. [17]

Validating the questionnaire and data gathered by it in several performed measurements gave rise to two principles by which the data was modified prior to any further analysis:

1. the effect of the motivation levels of the participants[18]
2. the effect of single question's intrinsic features[19]

must be acknowledged and modified by the guidelines evident in the data.

The first principle gave raise to the first genuine result:

> *Once the effect of the motivation level is eliminated from the data,* ***the motivation level must be considered as a genuine systemic characteristic*** *that affects the whole system.*

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[17] The principle is implemented in a straightforward manner: each question is compared to its neighbouring questions and to all other questions using the three above-mentioned test methods. Its net average in the component must exceed its net average in relation to the other components. In this way, the weakest question in each component was identified and modified until it obtained a well-behaving character.

[18] The motivation of a person providing answers on a scale of 1 to 5 is, in general, affected in such a way that a person with a low overall level of motivation tends to give lower than average estimates of the present situation, and higher than average estimates to questions about target situations. This effect is the opposite for a person with a high overall level of motivation. It must be stated that if the aim is to carry out a climate survey, this effect should not be modified.

Later studies of the gathered data and an analysis of the motivation level index and its behavior support this conclusion: there is a strong connection between motivation levels and 1) system types and 2) different transitions between systems, e.g. systems changing from being primarily of one kind (present) towards another kind (target).

1. We can clearly establish that motivation is at its lowest in mechanical systems and at its highest in dynamic systems.
2. We can clearly distinguish between transitions maintaining a high motivation level and transitions producing a low motivation level as a result, e.g. we can distinguish between systems in preferable transitions and systems undergoing nonpreferable transitions.

Due to these findings, in developing the questionnaires special attention was paid to a subset[20] of questions, by which the motivation level is primarily determined.

At this stage, much of the analysis was led by heuristic attempts to define the concept of systemic efficiency and locate it in the behavior of the retrieved data. In the first approach, systemic efficiency was described in a *semantic* form through the four intrinsic characteristics of the system:

1. Unanimity concerning objectives
2. Commitment to objectives (personnel to management's and management to personnel's)
3. The challenges posed by the target level (personnel)
4. The motivation level

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[19] It is evident that the behavior of each question must be individually analyzed to determine its tendency to generally produce averages under or above the general average of all the questions.

[20] This subset, later to be called *a domain* within the SE-matrix, consist of a varying number of questions distributed within the SE-matrix, but not necessarily within only one component. When used, every such subset of statetements or questions measures *global*, not system class or constituent dependent system characteristics. Later on, in chapters 7 and 8, several other such subsets and domains will be introduced.

6.4 The Second Model for Measuring Systemic Efficiency

The first version of the questionnaire was straightforward and a later study of the retrieved data showed a need for not only gathering three well-behaving statements into each component, but also for ensuring that *every question has a counterpart in every system class*.[21] These modifications led to the development of the model shown in table 5.

In the newer versions of the questionnaire the questionnaire items were modified so that each component consisted of four themes running consistently through all the system classes. In other words, every questionnaire item within the SE matrix now had a counterpart in the other system classes (see table 5 for the themes within the components). For example, under the constituent of know-how, mechanical performance is measured with an item "My job requires that I have complete mastery over my duties"(A1). The organic equivalent is "I constantly evaluate the results of my work" (A2) and the dynamic one "I am encouraged to take risks in my work" (A3).

The first three themes within each component were measured using a five-step Likert scale. The fourth theme (italic in table 5) was measured by asking the respondent to *choose one of three options* depicting the mechanical, organic and dynamic facet of the theme.

Furthermore, *two generally classifying questions* were added to the questionnaire. They are responded by choosing the most suitable one of three presented options, which depict either mechanical, organic or dynamic qualities. This addition was made in order to provide further data concerning the stress put on each system class within the organization, as it forces respondents to pronounce their choice, in each case, as exclusive.

In addition, system profiles depicting the present situation and the preferred future together with "error profiles" were presented in the report of the results. The function of the error profiles in the result report was to pin point the imbalance between

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[21] By counterparts we mean statements like "I feel I work alone" and "I feel I am a part of a team".

participants' target values and the strategic focus set by the top management (See Appendix B, Detailed mathematics of the analyses.)

Table 5. The second Systemic Efficiency matrix.

SE-matrix	A.Mechanical	B.Organic	C.Dynamic
1.Know-how -performance -way of working -expertise *-problem solving practices*			
2.Information flow -activity / passivity -extroversion -introversion *-communication practices*			
3.Relationships -responsibility -significance of work -supervisor relations *-co-operation practices*			
4.Management -goal orientations -supervision impact -system orientations *-conflict handling practices*			

However, although the results based on this model were promising, it still had to be developed further, because it did not provide sufficient data for measuring *the internal network,* which is an important criteria for depicting systemic features of functioning. It was still very difficult, although not totally impossible, to determine and analyze the system characteristics of internal networking (interaction and connectedness) and the efficiency and adequacy of this network – or the lack of it.

At this stage, another problem, which we call "the 5 – 5" syndrome, was also identified. This refers to the tendency of the respondents, particularly managers, to evaluate both the items concerning the present situation and the preferred target situation with the "I totally agree" option, i.e. rating both items with 5. In these cases, it was impossible to evaluate whether the respondent wished that the situation would remain the same or that there would be even more of the characteristic in the question. Thus, the questionnaire still required further refinement.

6.5 The Third Model for Measuring Systemic Efficiency

As a solution to the internal networking problematics, *three explicit networking questions* where added to the questionnaire. The questions investigate mechanical, organic and dynamic network characteristics. In the mechanical question, the respondent is asked to name his/her supervisor. The organic network question involves naming one to three support persons and the dynamic network question one to three innovators. The network questions are supplementary to the SE-matrix, as they are not positioned within the system constituents.

To solve the "5 – 5" syndrome, we decided to use a new quantifying approach:

1. Items concerning the present situation are asked to be estimated on a scale from 1 to 5, where the opposite ends respectively represent "I totally disagree" and "I totally agree", as stated earlier.
2. Items concerning the preferred target or future situations are expressed as positive counter statements in the form "I would like more of…", and are asked to be estimated on a scale from 1 to 5, where the opposite ends respectively represent "I totally disagree" (which actually signifies that the respondent does not wish to have more of the characteristic described in question) and "I totally agree" (which signifies that the respondent would like to have a considerable increase in the characteristic in question).

This line of questioning satisfactorily solved part of the "5 – 5" syndrome. We, however, see it necessary to further extend the modification into the form: "I would like less … I would like more …", to get enable more variation between the *present* and *target* levels.

Yet another problem was detected - a problem we had encountered in several occasions earlier but had lacked the means by which to solve it: it became evident that the systemic analysis of organizations would require the use of *two questionnaires; one aimed at system staff, and the other at system management.*

This requirement became evident due to two facts: 1) Systemic analysis is the analysis of relationships and interconnectedness, not only between persons, but also between groups of persons, i.e. social systems. The referential groups/systems vary as a result and must be taken into account. As an example, the concept of a “colleague” has a different functional meaning and a different reference group for managerial personnel and staff; 2) Dividing the questionnaire into two parts enables the retrieval of data concerning the connectedness between different organizational levels in a system, e.g. connectedness and interaction between two different systems at different levels of the organizational hierarchy.

In addition to the data retrieved by the two main questionnaires, the executive manager of the target organization or organizational unit establishes the preferred weights between the mechanical, organic and dynamic organizational features, i.e. whether main and secondary weights in the organization’s operations are assigned to regular “manufacturing” functions (mechanical), service (organic), or innovative, R&D functions (dynamic). This information enables the comparison of the results of the organization with those of other organizations with a similar strategic focus, which is important in later phases when transforming the results into form of numeric indexes.

The final structure of the questionnaire is depicted in table 6.

Question type	Response format	No. of questions	Position
Statement concerning the current situation	1-5 Likert scale	36	SE-matrix
Statement concerning the target situation	1-5 Likert scale	36	SE-matrix
3 statements concerning a theme within a constituent	Choice of 1/3 options	4	SE-matrix
Motivation level in current job	1-7 scale	1	Supplementary
General classification questions: rewarding and scheduling	Choice of 1/3 options	2	Supplementary
Networking questions	Full name of 1-3 persons	3	Supplementary

Table 6. The structure of the questionnaire.

The method is called the KM-factor™ and it is nowadays a product of business Xray Ltd. The questionnaire is available in Web-based format. After the measurement is contracted, all the respondents are sent a personal login code and password to access either the staff or the management questionnaire according to their status within the unit to be measured. Responding takes about 15 minutes / person.

7 Building a Framework for Analyzing Systemic Efficiency

This chapter consists of developing the basis for a method for the *systemic analysis of organizations.* It is based on the conception of organizations as three-dimensional social systems[22] and the questionnaire introduced in the previous chapter. The premises for analyzing and measuring the systemic efficiency of organization will be laid down and basic methodological concepts introduced. Then the behavior of artificially constructed systemic data, which depicts fictitious organizations, will be analyzed in order to show what kind of things the behavior of systemic data reveals about systems. Empirical data derived from real-life organizations will not be examined at this stage.[23]

We will further argue, that systemic data is to its very nature non-random, and *systemic characteristics* can be analyzed by tracing characteristics marking

(1) the presence *of non-random behavior* within the data
(2) differentiations from average behavior within the data.

In general we will point out that systemic analysis of organizations is *analysis of relations and interactions* between elements, components, constituents, classes and the organization as a whole on all levels of the hierarchy they compose.

In this sense analysis of systemic data is a multi-layered process. In many cases, the same analysis can be performed at several different levels and in several domains of the systemic data. In order to cope with the complexity of the process and the intricacy of the concepts involved, we need both a proper terminology and a thorough analytical approach.

[22] Cmp. Sections 4.1-3 and 5.1-3.
[23] Many of the concepts used in this chapter have in fact emerged from the analysis of observed systemic data. However, to help the reader in understanding the evolvement of the model and analysis methods introduced later, we believe that it is justified to introduce the concepts from the theoretical point of view at this stage of the article. Furthermore, the behavior of all the concepts introduced in this chapter 1) are to their very nature general and 2) can further more be normalized based on the behavior of random data that only possesses a pre-established distribution pattern.

7.1. System Semantics

In this section, we introduce a proper terminology necessary for analyzing organizations as three-dimensional systems. We also introduce the concept of *continuous* systemic features, decisive for the *system classes*, i.e. mechanical, organic and dynamic. Likewise, we introduce the concept of *discrete* systemic features, decisive for the *system constituents*, i.e. the know-how, information flow, relationships and management method within the organization.

We start this examination by bringing to mind the *three dimensions of organizational systems*[24] and by summarizing the three dimensions, *mechanical*, *organic* and *dynamic* in the table 7 below[25]:

SYSTEM CLASS CONSTITUENT	Mechanical	Organic	Dynamic
Knowledge and Competence	Defined, explicit	Experiential, hidden, tacit	Intuitive, potential
Relationships	Determined by hierarchy	Reciprocal, seeking consensus	Spontaneous, networked
Information flow	One-way	Multi-way	Chaotic
Management and Leadership method	Orders, direct use of power	Dialogue, delegation of power	Networking skills, relinquishing power

Table 7. A 3D-model of an organization as a three-dimensional system.

Focusing first on the **3D-model of the organization as a three-dimensional system**, we observe and discern the fundamental difference between the three entries *Mechanical*, *Organic* and *Dynamic* and the four entries *Know-how*, *Relationships*, *Information flow* and *Management and Leadership method* in the matrix. This

[24] Cmp. chapter 5.

distinction is essential: Whereas system classes can be considered to exist along a *continuum***,** constituents are to their very nature *discrete*.

In practical terms, concerning the system classes in the matrix, i.e. moving between the columns, we can consider the degree of the feature. For example, in the case of the leadership method, the degree or the extent to which direct power is imposed upon employees indicates a continuous feature ranging from the exercising of total power to total lack of it. However and in contrast, the system constituents are discrete, as they have no direct bearing on one another.

Secondly, turning our attention to the cross-sections in the matrix, in other words the components within the system, we conclude that an organization, as a three-dimensional system, can be expressed and analyzed through the components in the 3D-model, where the components have features that belong to one of the system classes and to one of the system constituents.

In practical terms, an organization embodied in the 3D-model can be expressed and analyzed by its single components and by determining whether or not and to what degree the attributes of the component are dominant or characteristic within the organization. For example, by focusing on the cross-section between the mechanical and information flows, we can estimate whether or not a one-way information flow is the prevailing conduct in the organization.

Finally, being aware of the complexity of a single constituent in the 3D-model, e.g. complicity of information flows, we must be conscious of the fact that every single constituent consists of several simple parts or fractions, which can be labeled *elements* and generally there are several elements within every component. For instance, the information flow (a constituent) can be broken down to such elements as activeness (vs. passiveness), introversion (vs. extroversion), etc.

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[25] The original table has been somewhat modified by merging management skills and the method of leadership into one management and leadership method.

This semantics covers the building blocks necessary to identify and isolate the basic characteristics embedded in the system, which portray and distinctively describe a unique, real-life organization as a 3-dimensional system.

Though not utterly necessary in this discussion, we make the following remark for the sake of completion: A social system, such as an organization, is, however, not immanent. It is composed of persons, artifacts and various degrees of interconnectedness between these and other organizations. We, therefore, expand the semantics with a further definition:

> *An organization is a social system composed by the individuals and items that belong to the system*[26] *. Individuals refer to the presence of persons, items refer to the presence of tangible and intangible assets in the system.*

Equipped with these introductory definitions and clarifications of system structure and semantics, we now turn to the question concerning the analysis process in general, the quest for a methodology.[27]

7.2. The Analysis of Systemic Data: the Process and the Aim

In this section, we lay the ground for the concept of the *systemic analysis* of organizations as (1) *the analysis of the internal characteristics* of sub-systems at different hierarchical levels of the organization, and (2) *the analysis of the relations* between the different sub-systems within the organization. We also point out that the analysis is systemic in the sense that it focuses mainly on the behavior of the data, and we argue that analyzing, conceptualizing and quantifying the behavior of the data mirroring the organization is decisive in determining its systemic efficiency.

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[26] "Belonging to the system", refers to the boundary of the system to be analysed.
[27] A complete and thorough semantics is given in the end section of this chapter, Appendix A, System semantics.

The systemic analysis of organizations is the *analysis of the relations and interactions* between the elements, components, constituents, classes and the organization, as a whole, at all levels of the hierarchy they compose.

This is *the general conduct for systemic analysis* and this is what is meant by the multi-layered character of systemic analysis.

Taking this into account, we give a first estimate of the analysis practice.

1. The process will proceed through quantifying and analyzing the *internal characteristics* of the system and its sub-systems, moving upwards in the hierarchy. I.e. the analysis begins at the level of elements and components and then moves to the constituents and classes[28] and concludes at the level of the system as a whole[29].
2. Secondly, the process will proceed through quantifying and analyzing *relational characteristics,* e.g. the characteristics that depict the relations between the system and its sub-systems as well as the relations between the different parameters of the systemic efficiency factor. This will primarily comprise quantifying and analyzing (1) the relations between components as parts of a constituent and system class[30] and (2) relations between system and its constituents or system types represented in the system[31].

Considering the first proceeding in this conduct, it is worthwhile to note that internal is a *relational* concept, more than ever, when dealing with system analysis. *Internal* always needs a specification "*with respect to"*, and this specification can turn internal into external and vice versa. This is illustrated below; whereas the relation in figure 3 is *internal*, with respect to sub-system A, it is *external* with respect to a1 or a2. The second proceeding is schematically illustrated in figure 4.

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[28] Constituents and classes taken as wholes, e.g. 'constituent over all classes' and 'class for all constituents'.
[29] "…moving upwards in the hierarchy…" is equivalent to "increasing degrees of complexity" (which is temperd, mastered, by the hierarchy. Cmp. Nicolis, 1986).
[30] When quantifying the relations of a component to the constituent to which it belongs and its relation to the system class to which it belongs, we can figuratively interpret the result as being the component's *position and weight* in the constituent or system class.

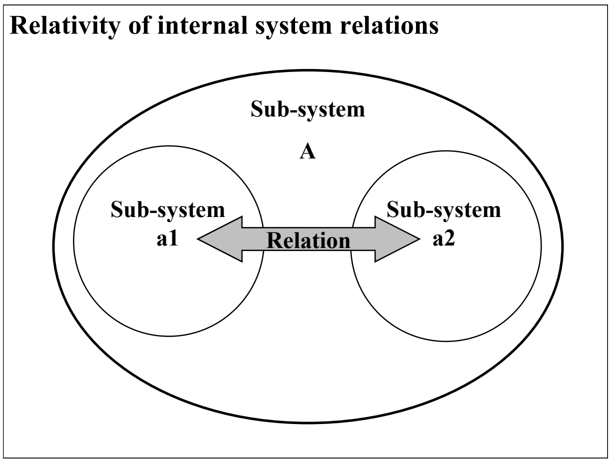
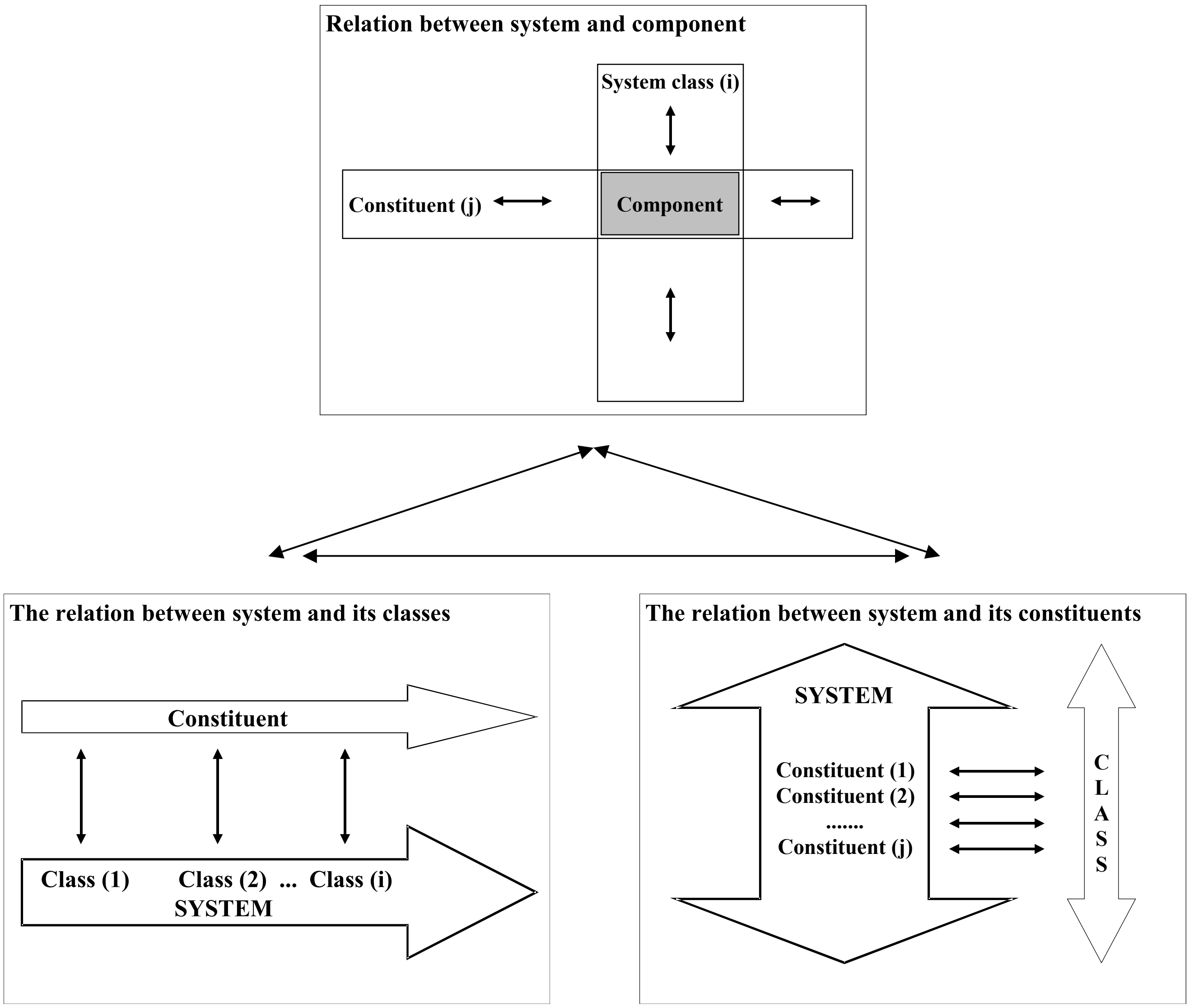


Figure 3. Internal versus external relations.

[31] As with components: this relation has bearing through the concept of *weight* together with the concept of *firmness* of the relation, in addition to its *representativeness* in the system.



Systemic efficiency requires that the same constituent is roughly emphasized throughout the system classes, and vice versa, that the same system class is emphasized along all the constituents.

Figure 4. The relational analysis of a system.

Commencing with these two practices, we will perceive the intrinsic firmness of the conduct in general. However, in order to spot the impact and the convenience of this statement, we need to define the concept of systemic data.

7.3. Systemic Data

In this section, we focus on the concept of systemic data and point out that systemic data is decisively determined by the necessary prerequisite condition to possess features *featuring the organization's three-dimensionality*, i.e. its classes and its *functioning*, i.e. its constituents. In this way, it is essential that systemic data always has a definite *position* in the model of an organization as a three-dimensional system.

For analyzing the systemic characteristics of organizations as three-dimensional systems and their systemic efficiency, in particular, *systemic data* needs to be gathered.

The method for retrieving systemic data was elaborated in chapters 6.2 –6.5. The nature of systemic data was also briefly discussed. We are now at a stage where we can define systemic data more precisely:

> *Systemic data is (1) any set*[32] *of quantified and explicit data that depicts any of the features that belong to and depict a system and (2) are produced by and retrieved from the system.*

Merging the results in the previous chapter with this definition, we obtain an operational definition for systemic data drawn together in the SE matrix:

> *By the systemic data that depicts an organization as a three-dimensional system, we understand (1) the quantified and explicit data produced by and retrieved from the organizational system and (2) that covers all the elements in the SE matrix.*

It is of importance to note that not all quantified and explicit data produced by an organization is systemic data. The data must depict, i.e. measure, attributes that belong to the elements in the SE matrix, e.g. has relevance regarding characteristics of the system. For example, a question such as "are dolphins intelligent? Please answer on a scale from 1 to 5, where 1= I totally disagree, and 5 = I totally agree" produces quantified data retrieved directly from the system, but is beside the point when

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[32] 'Any set' allows for random sampling.

measuring organizations and aiming at the same time to measure and estimate the efficiency of the organization from the systemic point of view. In this case, the data produced and retrieved reveals nothing about the organization's systemic features[33]. E.g. *the data has no position in the SE matrix*, whereas we understand the concept of *position of the data* in accordance with the following definition:

> *Every element in the SE matrix belongs to one[34] system constituent and one system class, this being the element's position in the matrix and this position consequently represents and equals the position of the data retrieved.*

As a result, an explicit statement depicting a system feature *belonging to an element* in the SE-matrix like

> "I have complete mastery of my duties (in my work)"

when *quantified* by e.g.

> Please answer on a scale of 1 to 5, where 1= I totally disagree, and 5 = I totally agree.

produces *systemic data*.

That is to say: The data produced has a *well-defined position* determined by the element to which it relates, e.g. *class* and *constituent* to which it belongs. In this case the retrieved data belongs, as an element, to the component defined by mechanical characteristics in the realm of competence.

A single statement such as this produces, when quantified and applied to several individuals in an organization, the simplest form of systemic data, i.e. a set of numbers ranging from 1 to 5. By adding other statements that depict other elements, we can acquire a larger set of systemic data *that encompasses* (and covering) all the elements in the SE matrix. Finally, we end up with a systemic data set that depicts an organization as a three-dimensional system.

Bearing in mind the general conduct for systemic analysis of organizations: it is the analysis of the relations and interactions between the elements, components, constituents, classes and the organization as a whole at all levels of the hierarchy they

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[33] Even though the data might not be systemic, it may reveal other features depicting the system.

compose. Based on this we can now easily spotlight the ingenuity of the conduct in a single sweep:

> *If systemic data, e.g. the data produced by and retrieved from a system, were random, the relational analysis, which quantifies and analyzes relational characteristics, would break down; e.g. there would be no linkage towards the concept of systemic efficiency.*

In other words,

> *any difference in the behavior of retrieved systemic data and the random matrix data, distributed in the SE matrix, can be understood as being a characteristic of the system.*[35]

As a consequence we argue that systemic data is to its very nature non-random, and systemic characteristics can be postulated and analyzed by tracing characteristics marking

1. the presence of non-random behavior within the data
2. differentiations from average behavior within the data.

Granted that this reasoning is correct and legitimate, the first phase in the realization of the conduct will accordingly be a mathematically and statistically powered inquiry and study into the behavior of systemic data in general. Though not necessary, taking into consideration the aim of the analysis to produce *an adequate and sufficient set of indexes and indicators, which measure parameters in the systemic efficiency factor,* we can make the subsequent remark: In order to link back single dropouts to real-life organizations, at this stage we promote our understanding by using a *naming practice* for each nonrandom or differentiated form of behavior as well as for the mathematical *parameters* recognized in order to link them back to concepts that characterize the organization's behavior. Taking advantage of this possibility, we will implement the following rule: the parameters that were found were named with concepts which bear a semantical resemblance to the concepts used for analyzing and characterizing the functioning of organizations as social systems in general.

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[34] In general: One and only one.
[35] By "distributed in the matrix" we understand the distribution of *random values* with same *mean averages* and same *distribution patterns*.

We stress the importance of the notion that, at this stage, *the names to be introduced are but names;* we could have just as well have called them “parameter p1, p2, …”. It will be the task for empirical testing to validate and confirm the connection between the names introduced and the systemic characteristics they semantically resemble and of which they remind the reader.

Wrapping together the issues put forth so far in this chapter, we are now able to present the general analysis process as a whole in figure 5.

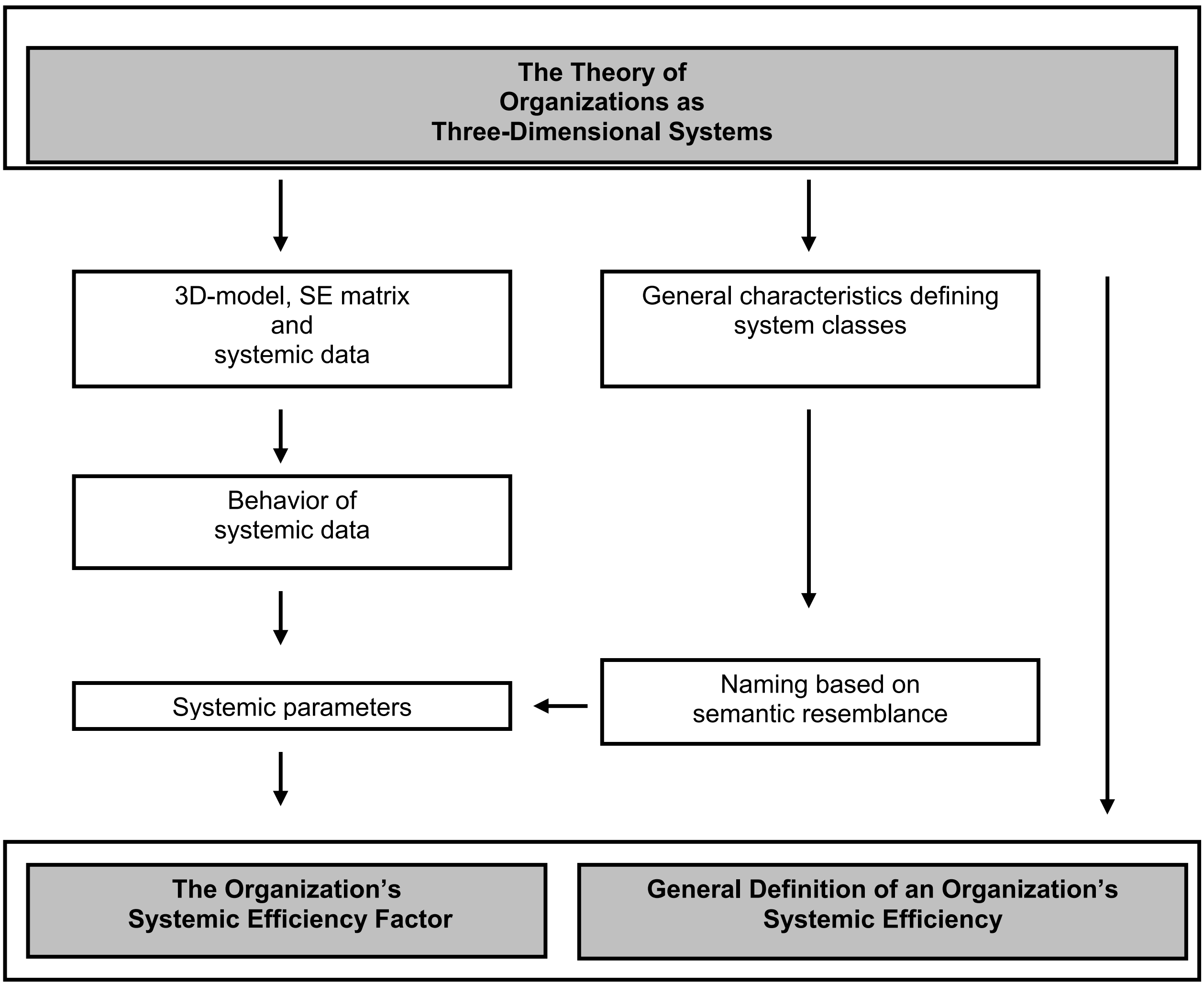

Figure 5. The analysis process and method.

Taking a quick look at the table, we point out one final uncompromising feature of the methodology developed here: The results will not rely on the interpretation of system characteristics as such, but will depend exclusively on the results that emerge from the *behavior of systemic data*, whereas the concept of systemic data simply arises from the *general paradigm of the three system classes***.**

Having defined the concept of systemic data, and having brought to a close the methodology by issuing how the systemic parameters can be marked and postulated, we call to mind the matrix structure of the systemic data which depicts organizations as three-dimensional systems, the SE matrix:

Table 8. The structure of the SE matrix.

SE	**Classes**	Class 1 - 3		
Constituents	**Elements**	Mechanical	Organic	Dynamic
Constituent 1-4	Competence	**Component**		
	Information flow		**Element 1** **Element 2** **Element 3** **Element 4**	
	Relationships			
	Management			

Guided by this structure, we carry on the subsequent theoretical survey of the behavior of systemic data throughout the following sections:

7.4 Analysis of System Elements, i.e. one-dimensional features
7.5 Analysis of System Components, i.e. two-dimensional features
7.6 Analysis of System Constituents and Classes, i.e. three-dimensional features
7.7 Analysis of Time-Dependent, i.e. four-dimensional features
7.8 Internal Network complexity
7.9 The matrix Behavior of Systemic Data

Based on the outcome and results we will then conclude the inquiry with considerations concerning the implementation of the results in the concept of systemic efficiency in section 7.10. Systemic Efficiency Considerations.

7.4 Analysis of System Elements

In this section, we focus on analyzing a single feature using one single statement, e.g. analyzing a single system element. We point out that the main behavioral and cross-compatible characteristic is *unanimity*, which is interpreted through *standard deviation and distribution patterns*. We also point out that *direct averages* are compatible only internally as *weights* between different sub-systems within the organization.

We start our investigation by analyzing the behavior of a *one-dimensional* systemic data set, which is defined as follows:

> *A one-dimensional systemic data set depicts a single feature within a system and is measured through only one element*[36].

As an example of a statement producing a one-dimensional systemic data set, take

> "My job demands faultless performance"

On a scale from 1 to 5, 1 = I totally disagree, 5 = I totally agree, a fictional result of this question, appraised by six participants in three different organizations, may look like this:

	Set 1	Set 2	Set 3
1D	Q(1,1)	Q(1,2)	Q(1,3)
	2	4	5
	3	3	2
	2	3	2
	3	3	2
	2	4	5
	3	4	5
Mean	**2.5**	**3.5**	**3.5**
Stdv	**0.5**	**0.5**	**1.6**

Table 9. An example of one-dimensional data sets.

Based purely on mathematical considerations, the features within one-dimensional data sets are mainly governed by the concepts of *distribution patterns*[37]*, averages and standard deviations.* Based on these concepts, two characteristics can be identified: ***unanimity*** and ***coherence*** within a system.

This follows the line of thought that in the exemplary data, set1 and set2 have the same standard deviation and narrow distribution patterns, whereas set3 has a considerably higher standard deviation and a broader distribution pattern.

Taking this into account, it can be stated that the one-dimensional parameters in the behavior of systemic data are *unanimity* and *coherence*, which are interpreted as *low standard deviations and narrow distribution patterns*.

What about averages and levels in a one-dimensional systemic data set? Suppose we perform the same measurement in several organizations: are the averages compatible; do the averages in this case contain information concerning the system at hand? Yes, the averages contain information, but *only in a relative sense*: in one organization, the participants' estimate is higher – on whatever grounds – than in another organization. Here this "on-what-ever-grounds" is the problematic part. From a systemic point of view averages withhold information concerning estimates, and these estimates tell us something about the system, but only internally, about the weights between the different parts or sub-systems within one and the same system. Standard deviations and distribution patterns are on the contrary cross compatible.

In the exemplary case (table 10) Set1 and 2 expose remarkable resemblance in the behavior of the data based on equal standard deviations (=0,55), though their averages differs by 1,00. On the other hand Set2 and 3 render great differences, though their averages are equal. In practical terms: Systemically Set2 is closer to Set1 than 3 though their averages tells us otherwise.

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[36] Or, more abstractly: a set of discrete, quantified and explicit data (1) depicting one and only one feature belonging to and depicting a system and (2) produced by and retrieved from the system.

[37] By distribution patterns, we understand the frequency distributions, e.g. histograms, of the particular values on a discrete scale.

We conclude:

> *Averages are, in essence, internal relational parameters,* whereas *standard deviations and pattern distributions are compatible when comparing different systems, e.g. they reveal something on the system and its functioning as such*.

In more practical terms: we can reliably state that for a low standard deviation, there is a "high level of unanimity", and vice versa. Likewise, a narrow distribution pattern can be interpreted as high level of coherence. With averages, however, it is a different case: averages are compatible only within the same organization and can be used to identify differences only between different parts of the same organization.

This leads us to the following conclusion:

> In the behavior of systemic data, unanimity and coherence are compatible parameters across different systems, and presupposing the data set measures a systemic characteristic, averages may be used for internal comparison only.

Furthermore, we argue that

> Unanimity and coherence are absolute, i.e. non-relational parameters in the systemic efficiency factor[38], whereas averages are internal relational parameters.

Before turning to the analysis of system components, e.g. two-dimensional data sets, we make one remark on the limitations concerning implementations of unanimity and coherence based on one-dimensional data sets – and the complexity of the analysis of systemic data.

> Unanimity can origin from at least two[39] systemic sources. (1) Unanimity can be understood *organically,* as the result of intensive, vivid and ongoing communication gradually evolving into equal understanding and the emergence of a unifying value-code. But, on the other hand (2) unanimity can equally well be comprehended *mechanically,* as a simple result of strict regulation, imposed power or obligatory unification and submission to this unification.

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[38] This argument will later be used when establishing the degree of unanimity concerning the present state and objectives as parts of organisastions systemic efficiency.
[39] At the least.

A single one-dimensional systemic data set reveals nothing about the origin of the unanimity and coherence it demonstrates.

7.5 Analysis of System Components

In this section, we focus on analyzing one feature using two or more statements, e.g. analyzing system components (i.e. mechanical relationships, dynamic information flow). The main cross-referential characteristics are those of *coherence* and *consistency,* which are interpreted through relational tools, mainly *correlation and* χ^2*-tests*. We also point out that *unanimity* is strengthened through *consistency*.

We proceed by analyzing the behavior of a two-dimensional systemic data set.

> A two-dimensional systemic data set depicts one component within a system, and is measured by two or several elements.[40].

As a practical example, consider the following two statements:

1. I have complete mastery of my duties at work
2. My job demands faultless performance

These statements measure the same component (attributes depicting the kind of know-how required at work) from two different angels (total mastery and need of faultless performance).

As another example, the data matrix of the answers to three statements by six participants in two different organizations, Set1 and Set2, could appear as follows:

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[40] Or more abstractly: *a joint set of two or more sets of discrete, quantified and explicit data depicting one and the same feature belonging to and depicting a system and produced by and retrieved from the system.*

	Set 1			Mean	Set 2			Mean
2D	Q(1,1)	Q(2,1)	Q(3,1)	Q(avg,1)	Q(1,2)	Q(2,2)	Q(3,2)	Q(avg,2)
	2	2	4	2.7	2	2	3	2.3
	3	2	4	3.0	3	3	4	3.3
	2	3	3	2.7	2	2	3	2.3
	3	2	4	3.0	3	3	4	3.3
	2	3	3	2.7	2	2	3	2.3
	3	2	3	2.7	3	3	4	3.3
Mean	**2,5**	**2,5**	**3,5**	**2.8**	**2,5**	**2,5**	**3,5**	**2.8**
Stdv	**0.5**	**0.5**	**0.5**	**0.2**	**0.5**	**0.5**	**0.5**	**0.5**

Table 10. An example of two-dimensional data sets.

First, we focus on unanimity and coherence, which were previously determined to be one-dimensional (1D) parameters.

Both data sets possess the same averages, the same standard deviations and the same distribution patterns; that is to say, the one-dimensional features in the data sets are the same. Yet, the data sets differ greatly from one another in terms of ***consistency*** of behavior. First, let us define the concept of *consistency* of behavior of systemic data as follows:

> *By consistency*, we understand the ***equality or regularity of behavior*** when moving between and comparing two or several one or multi dimensional data sets and/or moving between and comparing the answers of two or more participants.

Now, looking at the behavior of the data in table 11,

	Set 1					Set 2				
2D	Q(1,1)	c	Q(2,1)	c	Q(3,1)	Q(1,2)	C	Q(2,2)	c	Q(3,2)
	2	=	2	<	4	2	=	2	<	3
	3	>	2	<	4	3	=	3	<	4
	2	<	3	=	3	2	=	2	<	3
	3	>	2	<	4	3	=	3	<	4
	2	<	3	=	3	2	=	2	<	3
	3	>	2	<	3	3	=	3	<	4
	Inconsistent					Consistent				

Table 11. Examples of consistency.

we conclude that Set2 possess a significantly higher degree of consistency. Taking mathematical considerations into account, that is to say,

> *the consistency of systemic data can be measured by (1) relational tools, mainly internal correlations, F- and χ^2 - tests or (2) by applying standard deviation on internal differences.*

In the examples at hand (tables 11 and 12), the average internal correlation of Set2 is +1,00 in both cases, whereas the average internal correlation for Set1 is -0,33 (ranging between –1,00 to +0,33) between the one-dimensional data sets and +0,32 between the participants (r: participant-participant) and +0,62, participant taken against question averages. It goes without saying, that when the correlation gets close to +1.00 standard deviation gets close to 0,00.

Taking the effect of consistency into consideration, we argue that in a two-dimensional systemic data set, *unanimity* and *coherence* are *strengthened by the consistency* of behavior of the data. This is a consequence and a corollary of the fact that

> *consistency* in behavior can be interpreted and understood as the *unanimity* and *coherence* concerning the *internal weights and relations* between elements.

In more practical terms, looking at Set2, we can easily conclude that there exists a strong agreement concerning the weights between Q2 and Q3, Q3 being unanimously regarded as being on a higher level than Q2. No such conclusion can be drawn from or within Set1.

Thus,

> *unanimity and coherence are primarily one-dimensional parameters, which can be considered to be* ***strengthened*** *by the two-dimensional parameter of consistency***.**

And, as a consequence, we argue that

> ***Consistency*** *is a parameter in the systemic efficiency factor.*[41]

Consistency is, to its very nature, a ***dynamic*** parameter, which has bearing on the concept of ***resonance***. Resonance (in organizational settings) means pro-activeness, responsiveness and co-operation within the system. One can easily conclude that a high level of consistency indicates the presence of resonance and *dynamic coherence*. No such conclusions can be made on the basis of the one-dimensional parameters introduced.[42]

We will proceed by analyzing the behavior of a three-dimensional systemic data set that is defined as follows:

> A three-dimensional systemic data set is *a joint set of two or more two-dimensional data sets not belonging to the same components*.[43]

7.6 Analysis of System Constituents and Classes

In this section, we focus on analyzing two or several features and each feature with two or several statements, i.e. analyzing system constituents and classes. We point out the necessity to distinguish between continuous, system class -dependent features and discrete, system-constituent features and the fact that coherence and resonance can be

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[41] This argument will later be used when establishing the degree of coherence of developmental challenges as parts of organisations systemic efficiency.

[42] The concept of resonance within an organization induces many interpretative problems such as "is unanimity a result of the communication and resonance between individuals?" These problems and issues will be discussed in chaper 8, Analysis of Observed Systemic Data.

[43] In practical terms, this can be understood as follows: A three-dimensional systemic data set is the set of numbers from 1 to 5, for instance, aquired as answers to questions that measure two or more features,

established between continuous features. However, unanimity must be calculated at the level of averages.

Whereas unanimity, coherence and resonance may be assumed to exist in a two-dimensional data set, these features are not self-evident or obvious in a three-dimensional set. Their impact in a three-dimensional data set increases and their implementation and meaning differ from those in a two-dimensional data set.

Take, as an example, the fictitious result of 3x2 statements, evaluated by six participants in one organization. The data and its averages and standard deviations may appear as shown in table 13:

	Set 1		Mean	Set 2		Mean	Set3		Mean
3D	Q(1,1)	Q(2,1)	Q(avg,1)	Q(1,2)	Q(2,2)	Q(avg,2)	Q(1,3)	Q(2,3)	Q(avg,3)
	2	3	**2,5**	3	3	**3,0**	1	3	**2,0**
	3	3	**3,0**	4	4	**4,0**	2	4	**3,0**
	2	3	**2,5**	3	3	**3,0**	3	1	**2.0**
	3	2	**2,5**	4	4	**4,0**	3	3	**3.0**
	2	2	**2,0**	3	3	**3,0**	2	2	**2.0**
	3	2	**2,5**	4	4	**4,0**	1	5	**3.0**
Mean	**2,5**	**2,5**	**2,5**	**3,5**	**3,5**	**3,5**	**2,0**	**3,0**	**2.5**
Stdv	**0.6**	**0.6**	**0.3**	**0.6**	**0.6**	**0.6**	**0,9**	**1.4**	**0.6**

Table 12. An example of a three-dimensional data set.

Taking into account that the three data sets, Set1, Set2 and Set3, measure three different components within the same organizational system we introduce the general concept of a *profile* as follows:

> By a *profile* we understand the relative and weighted relation between two or more different features that depict a system.

---

which belong to the system and which are measured by two or more different questions on a scale of 1 to 5.

Taking into account that the three data sets measure three different components within the same organizational system we introduce the concept of a *system profile* as follows:

> By a *system profile* we understand the relative and weighted relation between two or more different features that depict a system.

In a straightforward manner, we can conclude that, in principle, there exist two different kinds of profiles determined by the internal relations between the features defining the profile. That is to say:

> The features powering the profile can be regarded as being either *continuous* or *discrete*, i.e. non-continuous[44].

To put this in more practical terms, the components measured can be those of one and the same constituent, for example all the components of the information flow, or the components can be those from different constituents but from the same system class, e.g. all mechanical components.

The way in which systemic data depicts continuous system class characteristics differs from how discrete, system-constituent features are illustrated:

> A continuous, system class feature measured by two or several statements, n, equally distributed over the continuum, can be expected to possess a mean average of 1/n*(s), where n = the number of statements, (s) = the factor normalizing scale used and random mean.

For example, when measuring characteristics of information flows with three statements depicting (1) one-way, (2) multi-way or (3) chaotic information flows, it can be assumed that high averages in one case (say chaotic information flow as a dynamic feature) will reduce the averages for the two others cases (one- and two–way information flows as mechanical and organic features). I.e., the different questions or statements measuring a continuous feature *do influence each other and are interdependent*. De facto: They work in opposite directions, they even contradict one another. This situation is illustrated in figure 6, in the example of the information flow profile of an organization where *dynamic* information flows are dominating and *mechanical* are scarce:

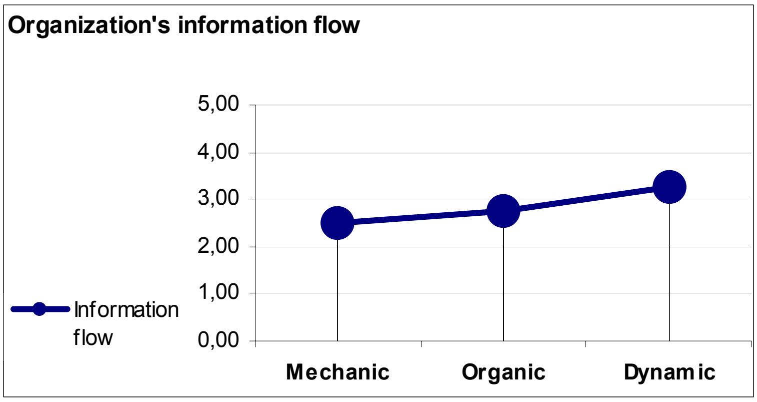

Figure 6. An example of a measured continuous feature, *N* = 3, scale 1-5.

In the case of a discrete feature, the situation is different:

> A discrete, system-constituent feature, measured by two or several statements, can be expected to possess an average of (s) = factor normalizing scale used and random mean.

For example, mechanical features can be measured using four statements that depict (1) know-how as defined and explicit, (2) information flows as one-way, (3) relationships as determined by hierarchy and (4) management and leadership methods as orders and the direct implementation of power. As there is no direct connection between the statements, assigning high values to some of the statements will, in no way, affect the possible and contingent values of the others. I.e., the different questions or statements measuring a continuous feature *do not influence each other and are independent*. This situation is illustrated in figure 7:

[44] We are at this instance neglecting the theoretical possibility of a random mix of components within the SE-matrix.

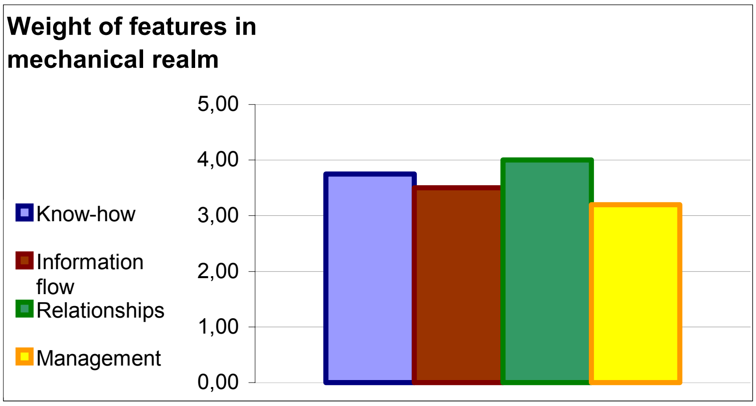

Figure 7. An example of measured discrete feature, *N* = 4, scale 1-5.

The example in figure 8 depicts an organization where the mechanical emphasis is the strongest in the realm of *relationships* and weakest in the realm of *management. Information flows* are near the mean of *mechanical* emphasis, but system's *structure* says very little, if anything, concerning system's *functioning*.

In view of this and what has previously been said about an organization's strategic focus, it is no coincidence that

> *the concept of an organization's strategic focus is connected to the concept of continuous systemic features and the concept of system profile. When several systems are compared, systems that comprise a higher degree of success and reliability in the realization of their strategic focus, as a distinct preferred and targeted system profile at all sub-system levels*[45]*, also possess a higher systemic efficiency*[46].

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[45] Not necessarily equal to strategic focus in different sub-systems, but sustaining the strategic focus on the level of the system as a whole. (Cmp. Chapters 4 and 5)

[46] This argument will later be used in the KM-factor model when establishing the degree of strategic fit of operational profiling as part of an organisastions systemic efficiency.

Taking once more into consideration the example given earlier:

	Set 1		Mean1	Set 2		Mean2	Set3		Mean3
3D	Q(1,1)	Q(2,1)	Q(avg,1)	Q(1,2)	Q(2,2)	Q(avg,2)	Q(1,3)	Q(2,3)	Q(avg,3)
	2	3	**2,5**	2	3	**2,5**	1	3	**2,0**
	3	3	**3,0**	3	4	**3,5**	2	4	**3,0**
	2	3	**2,5**	2	3	**2,5**	3	1	**2.0**
	3	2	**2,5**	3	4	**3,5**	3	3	**3.0**
	2	2	**2,0**	2	3	**2,5**	2	2	**2.0**
	3	2	**2,5**	3	4	**3,5**	1	5	**3.0**
Mean	**2,5**	**2,5**	**2,5**	**2,5**	**3,5**	**3,0**	**2,0**	**3,0**	**2.5**
Std.	**0.6**	**0.6**	**0.3**	**0.6**	**0.6**	**0.6**	**0,9**	**1.4**	**0.6**

Table 13. An example of a three-dimensional data set.

What can be said about unanimity and consistency, i.e. can they be anticipated and calculated in the same way as they previously were?

Taking again into account the two different cases, the continuous and discrete features referring to system classes and constituents, and bearing in mind that the three sets in the example, Set1-3, depict different features, we stress the obvious fact that unanimity is primarily a one- and two-dimensional parameter. Producing averages by mixing classes and constituents is inappropriate.

> *Unanimity has primarily to be calculated directly on the 1-2D-levels and not on the level of averages.*

In conjunction with this statement we also make the notion that

> producing averages is always a reduction of dimensionality and some information concerning the system is lost on the way.

As a practical example, we conclude that the unanimity of Set2 (Table 14) is the greatest, being also backed up by a high level of consistency[47]. However, taking a look at the averages, we can easily conclude that at the level of averages this information disappears, as is indicated in Table 15: The sets Mean2 and 3 have the same unanimity at the level of averages. Thus, looking only at averages is likely to produce misleading conclusions.

	Mean1	Mean2	Mean3
3/2D	Q(avg,1)	Q(avg,2)	Q(avg,3)
	2,5	2,5	2,0
	3,0	3,5	3,0
	2,5	2,5	2.0
	2,5	3,5	3.0
	2,0	2,5	2.0
	2,5	3,5	3.0
Mean	2,5	3,0	2.5
Stdv	0.3	0.6	0.6

Table 14. The mean sets of a 3D set presented in Table 13.

What, then, can be said about consistency and coherence? They are important, as has been pointed out in chapters 4 and 5, because they indicate and are linked to organic system constraints, mainly connected to the concepts of communication and co-operation. Taking first into consideration a case where the three main sets relate to one constituent, say competence, and three *system classes*, mechanical, organic and dynamic, our example could look like this:

[47] A high internal correlation

	Mechanical		Mean1	Organic		Mean2	Dynamic		Mean3
3D	Q(1,1)	Q(2,1)	Q(avg,1)	Q(1,2)	Q(2,2)	Q(avg,2)	Q(1,3)	Q(2,3)	Q(avg,3)
Competence	2	3	**2,5**	2	3	**2,5**	1	3	**2,0**
	3	3	**3,0**	3	4	**3,5**	2	4	**3,0**
	2	3	**2,5**	2	3	**2,5**	3	1	**2.0**
	3	2	**2,5**	3	4	**3,5**	3	3	**3.0**
	2	2	**2,0**	2	3	**2,5**	2	2	**2.0**
	3	2	**2,5**	3	4	**3,5**	1	5	**3.0**
Mean	**2,5**	**2,5**	**2,5**	**2,5**	**3,5**	**3,0**	**2,0**	**3,0**	**2.5**
Stdv	**0.6**	**0.6**	**0.3**	**0.6**	**0.6**	**0.6**	**0,9**	**1.4**	**0.6**

Table 15. An example of a 3D data set within the same constituent.

In this case, it directly follows that *consistency* can be anticipated between the three system classes as a result and consequence of *different (mean) averages,* i.e.

> as the system classes possess contrasting and even conflicting[48] characteristics, one can expect this to be reflected in the data retrieved from the system as consistency in the behavior of the data when comparing different system classes.

For example, in the data retrieved from a highly mechanical organization, mechanical features will have the highest average values and, consequently, the organic and dynamic features will have lower averages. In this case, the systemic profile would be coherent. Likewise, if an organization with a distinct organic emphasis is analyzed, it can be reasoned that this emphasis leads to a higher mean average in the organic components – and this, of course, at the expense of the averages for the mechanical and dynamic components. As a result, there is a consistency between the system classes in the behavior of the data.

In the example in Table 16, this expectation of consistency between system classes can be studied either through the averages (Mean1 to 3 or (1-3,avg)) , correlation +0,58 or through relating corresponding questions Q1 to 2 in the different system classes, correlation +0,47, (Q1 +0,88 and Q2 +0,06).

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[48] Cmp. previous discussion and sections 4.1-3 and 5.1-3.

The example reveals something else: *rigidity or firmness* of the consistency is an issue. Whereas Question 1 is extremely firm in the sense that the simple correlations all are in line and strong (Q1: mech-org +1,00, mech-dyn and org-dyn both +,082), this does not hold for Question 2 (Q2: mech-org –0,33, mech-dyn +0,77 and org-dyn again -0,29). This observation once more demonstrates the fact that information is lost when data is converted to averages, and this must be accounted for in the analysis.

Conveying these notions into more strict terms we argue that

> *the relational consistency between the system classes is a parameter in the systemic efficiency factor, and it is further strengthened by rigidity or firmness of the consistency, and an indicator of self-referentiality and self-awareness*[49] *present in the system.* [50]

This, however, is not necessarily true in the case of the constituents but, rather, the opposite.

Taking into reflection a case where the three main sets are those of one and the same system class, say mechanical, and three *constituents*, know-how, relationships and management, our example could look like this:

[49] Here we stress the autopoietic concepts of self-referentiality and –awarness, as they are modes and results of communication and interactions within the system. (Cmp. Luhmann, 1995)

[50] This argument will later be used when establishing the relevance of an index called Strategic fit of operational profiling for organization's systemic efficiency.

	Know-how		Mean1	Relationships		Mean2	Management		Mean3
3D	Q(1,1)	Q(2,1)	Q(avg,1)	Q(1,2)	Q(2,2)	Q(avg,2)	Q(1,3)	Q(2,3)	Q(avg,3)
Mechanical	2	3	**2,5**	2	3	**2,5**	1	3	**2,0**
	3	3	**3,0**	3	4	**3,5**	2	4	**3,0**
	2	3	**2,5**	2	3	**2,5**	3	1	**2.0**
	3	2	**2,5**	3	4	**3,5**	3	3	**3.0**
	2	2	**2,0**	2	3	**2,5**	2	2	**2.0**
	3	2	**2,5**	3	4	**3,5**	1	5	**3.0**
Mean	**2,5**	**2,5**	**2,5**	**2,5**	**3,5**	**3,0**	**2,0**	**3,0**	**2.5**
Std.	**0.6**	**0.6**	**0.3**	**0.6**	**0.6**	**0.6**	**0,9**	**1.4**	**0.6**

Table 16. An example of a 3D data set within same system class.

Again, in a straightforward manner, taking into account the fact that the three data sets are within the same system class, i.e. a class lying in or within the proximity of a specific and distinct mean average, we can expect all the mean averages of the components to be on the same level. That is,

> we can anticipate that the *unanimity* and *consistency* between the components will power this unanimity.

Turning these conceptions into more strict terms, we argue that

> *the relational consistency between system constituents is a parameter in the systemic efficiency factor and that the differences in the averages are indicators of weaknesses or strengths within systemic efficiency.* [51]

In other respects it can be stated that

> *what has been said about a two-dimensional data set can be applied as such to a three-dimensional data set within the realm of averages.*

We conclude that

> *relational consistency and coherence factors are characteristics that affect systemic efficiency.*

7.7 The analysis of Time-Dependent Features

In this section, we focus on measuring a feature by measuring its present state and preferred future[52]. We point out the difference between the *demand* for change and the *potential* for change by introducing the concept of the Gap and connecting demand for change to a *uniform Gap,* and potential for change to a *non-uniform* Gap. We also focus on the decisive difference between situations where, with equal Gap behavior, unanimity is high concerning target situations but low concerning present, and vice versa. We also point out that the former demonstrates *renewal ability,* whereas the latter, in its extreme, is mere disorder.

First, we introduce the concept of "the Gap between present and future" as
the simple difference between the estimates of future and present, F – P.

A practical example is shown in table 17.

		Present		Future		Gap
GAP		Q1		T1		G1
		2		3		1

Table 17. Single Gap calculated as F – P.

Take, as an example, a fictitious result of 3 statements concerning the present situation and the preferred future evaluated by six participants in an organization. The responses, their averages and standard deviations in addition to the gap between the future and present, may appear as follows:

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[51] This argument will later be used in the KM-factor model when establishing the success of the strategic fit of an operational profile as a part of an organisastion's systemic efficiency.
[52] At this stage, we are not taking into account the very problem of how to practically and reliably measure a systemic feature. The problematics have been discussed in detail in chapter 6, The basic model for data retrieving.

2D	Present				Future				Gap			
GAP	Q1	Q2	Q3	AvgP	T1	T2	T3	AvgF	G1	G2	G3	AvgG
	2	3	4	**3,0**	3	5	3	**3,7**	1	2	-1	**0,7**
	3	2	4	**3,0**	4	2	4	**3,3**	1	0	0	**0,3**
	2	3	3	**2,7**	3	2	4	**3,0**	1	-1	1	**0,3**
	3	2	4	**3,0**	4	5	5	**4,7**	1	3	1	**1,7**
	2	3	3	**2,7**	3	2	3	**2,7**	1	-1	0	**0,0**
	3	2	3	**2,7**	4	5	2	**3,7**	1	3	-1	**1,0**
Avg	2,5	2,5	3,5	**2,8**	3,5	3,5	3,5	**3,5**	1,0	1,0	0,0	**0,7**
Std.	**0,5**	**0,5**	**0,5**	**0,2**	**0,5**	**1,6**	**1,0**	**0,7**	**0,0**	**1,9**	**0,9**	**0,6**

Table 18. An example of a 2D time-dependent data set.

The Gap can be measured either individually or at the level of averages. Referring to table 18, we can also conclude that

> *the Gap produced by a data set comprising the future and present is a systemic data set of the same dimensional order as its generators and, what has been said about systemic data sets can be applied to the Gap.*

What can be said of the three statements Q1 – Q3 based on this observation? The two first statements seemingly have the same Gap at the level of averages (= 1), but there are important differences in their behavior, not to mention Q3, where Gap = 0.

Gap behavior can be characterized via the concepts of demand for change and potential for change. These concepts signify the ideal types situated at the opposite ends of the Gap behavior continuum, and most organizations probably reside somewhere along the space between them. The demand for change signifies a situation where change is desired and there is unanimity as to the magnitude and direction of that change. It is characterized in the data by high unanimity as to the Gap, i.e. its direction is roughly the same for all respondents (either +, - or 0), and its average is not equal to 0. Whereas the demand for change describes a situation where the change is likely to yield predictable outcomes, the potential for change characterizes a situation where there are pressures towards change, but its direction and outcome are unpredictable. This is demonstrated in the data by a Gap average of 0 and the existence of both positive and negative Gaps among individual responses.

In the table 18, the data set Q1 is an example of the demand for change and Q3 of the potential for change, while Q2 represents the middle ground between these two opposites. In the case of Q1 and Q2, we can easily state that "there is a recognized demand for change" (Gap = 1). Yet, in the case of Q2 and Q3 we can state that "there is a potential for change". That is to say, in the case of Q2, we can estimate the direction of the change, whereas in the case of Q3, the direction remains open. Looking at the behavior of the Gap, we conclude that the *demand for change* and *potential for change* are two different categories of change.

To put it yet another way, the demand for change in case Q1 possesses no change, e.g. the change induced, the outcome can be predicted with a high degree of certainty, i.e. with a high degree of reliability. In contrast, in the case of Q2 and Q3, there is an obvious potential for change, but its outcome cannot be predicted, e.g. set at the level of averages, the average possesses low reliability.

Taking this into account and applying the concept of unanimity, we state the following:

> *The demand for change is demonstrated by a high unanimity concerning the Gap between the present state and the preferred future state of the system. It differs from the concept of the potential for change, which is demonstrated by low unanimity concerning the Gap.*

And furthermore:

> *Whereas change, as such, is a quality of* ***renewal****, the demand for change is, or at least can be regarded as, a* **mechanical** *feature and the potential for change is a* **dynamic** *feature*[53]*.*

At this stage, we make two theoretical assumptions:

1. The demand and potential for change are to some extent opposites of one another; when on gets stronger, the other gets weaker. This is in full accordance with the theory of self-organization of chaotic systems based on non-linear behavior. Furthermore, both are *positive* forces yielding change as such, i.e. they

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[53] This argument will later be used in the KM-factor model when establishing the degree of challenges presented by target levels and innovation potential as parts of organization's systemic efficiency.

are parts of a system's ability for renewal, but the potential for change possesses in itself both positive and negative feedback[54].

2. The demand and potential for change can –and will – be measured by both continuous, system class and discrete, system constituent features. The former will give rise to the concept of *transition* between the present system profile and the target system profile. There clearly are (at least) two patterns for the transitions from one system profile to another. They may occur in such a manner that a high level of systemic efficiency is preserved, or the transition may also result in a temporary loss of systemic efficiency.

   Example of transition: The transition from an organic to a dynamic system profile:

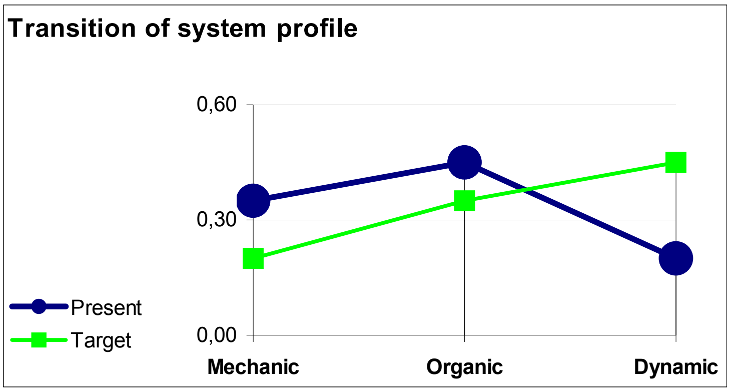

Figure 8. An example of a transition.

We end this section by spotlighting two extreme situations that occur with the same Gap behavior. Given the Gap behavior, we can center our attention on the correlated behavior of present and future situations. These extremes are illustrated in figure 9. In the illustration, the values are on the vertical y-axis and in particular, single Gap-

[54] In Exploring complexity (Prigogine & Nicolis, 1989, 238), Prigogine states: "Our everyday experience teaches us that adaptability and plasticity of behavior, two basic features of nonlinear dynamical systems capable of performing transitions in far-from-equilibrium conditions, rank among the most conspicuous characteristics of human societies. It is therefore natural to expect that dynamical models allowing for evolution and change should be the most adequate ones for social systems. … The first step in modeling complex behavior is therefore to assess the *nonlinear* character of the underlying dynamics to identify a set of variables *capable of showing instabilities and bifurcations*."

present-target triplets are distributed along the x-axis. Case A illustrates a system in which the participants have very similar views about how the system functions at the moment, but discrepant targets for the future. Case B depicts the opposite situation, in which the targets are viewed in a highly similar manner throughout the system, but where there are large internal disagreements as to where the system stands at the moment.

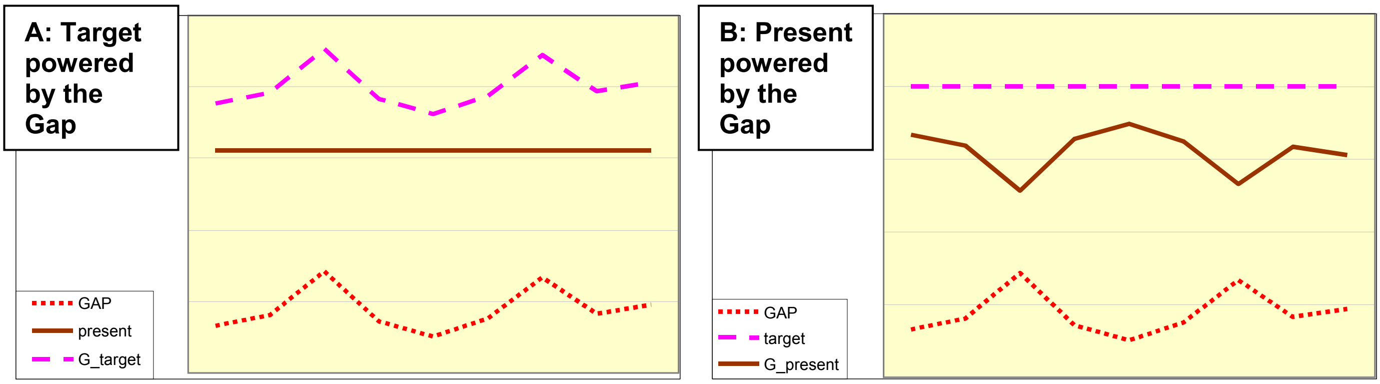

Figure 9. An example of opposite present/future Gap-powered behavior.

As can be seen and anticipated from the two situations illustrated above, the Gap itself is equal in each case, but there are large differences in the realms of the present and future. This example demonstrates how a similar Gap can illustrate systems that are in totally different phases of their change process. Before continuing, we point out and remind the reader that the two situations can be pinpointed by the concept of *consistency*.

Taking a first step by conveying the *present and future as corporeal systems in time* and making a further bold, but tangible and substantial, interpretation of *the Gap as a mediator between the present and future,* we are forced to comprehend the Gap in the Prigoginean sense: Time as Creator (e.g. Prigogine, 1980). This means that substantial qualitative changes can occur by moving from one stable system to another, while the Gap is the time-dependent mediator between the two systems. This phenomenon is illustrated in figure 10.

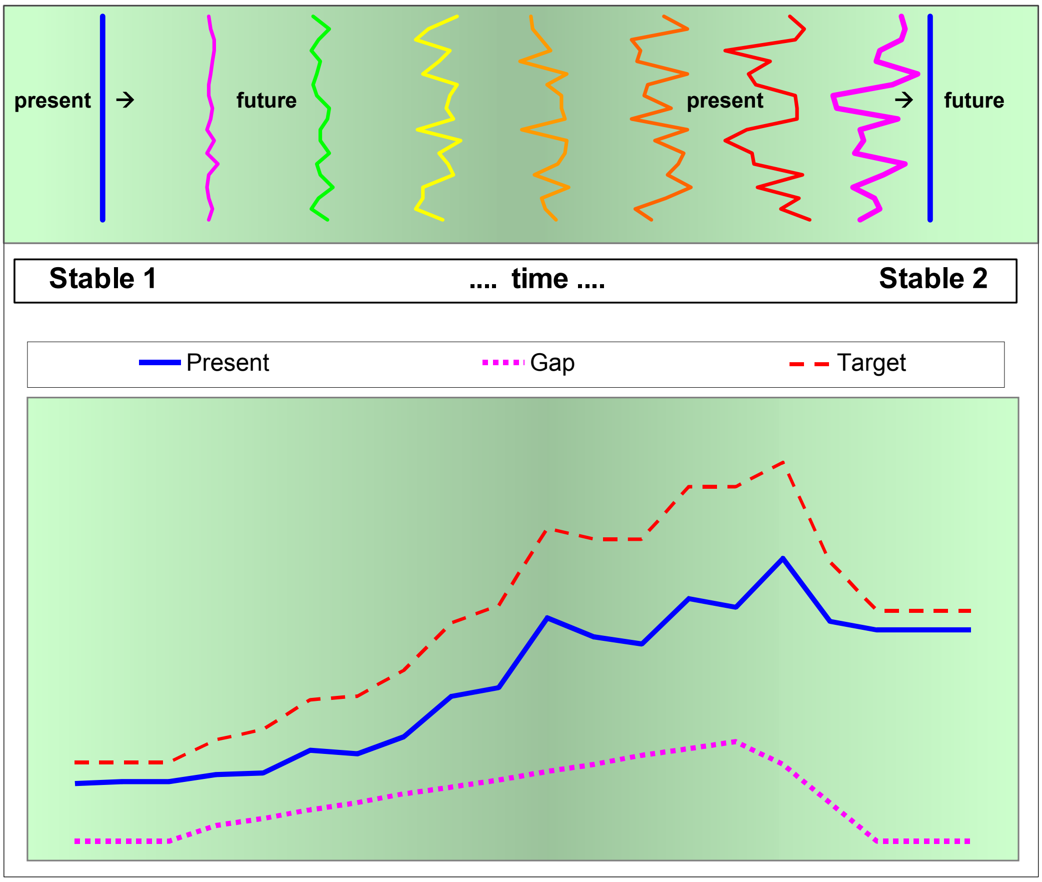

Figure 10. An illustration of the renewal process.

When a system achieves its goals, the target state is transformed into the present state. Little by little new objectives are set, and eventually the process of self-organization is set into more motion once again. The two extremes (Stable state 1 and Stable state 2) are the two different neighborhoods of the stable systems – temporarily satisfied with their current states –, the first transiting into renewal, *chaos*, the second reaching its goal, a new system structure, through bifurcation.

Having taken these steps, we advance by metaphorically and symbolically in depicting the two situations by making the following statement:

In case B of the figure 9, we have a stable future system floating over or *emerging from a chaotic present,* and in case A, we have an unstable future system floating over or *shattering out from a stagnant present*.

Enlightened by this, we argue that

inconsistency between the Gap and target state indicates a transition into bifurcation and ability of high renewal, whereas consistency between the Gap and present state indicate that a transition into chaos is near and an increased renewal ability. [55]

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[55] Taking these metaphors into contemplation we hit upon the astonishing resemblance they hold to the concepts of self-organization through chaos ending up in a new structure through bifurcation. We quote:

"... In this way the system is pushed farther and farther away form equilibrium. At some point we reach the threshold of the stability of the "thermodynamic branch". Then we reach what is generally called a "bifurcation point." … The system will in effect scan the territory (near the bifurcation) and will make a few attempts, perhaps unsuccessful at first, to stabilize. Then a particular (critical) fluctuation will take over. By stabilizing it, the system becomes a historical object." (Prigogine & Stengers, 1984, 160.)

and

"Classical thermodynamics is essentially a theory of *'destruction of structure'*. One may even consider the entropy production as a measure of the 'rate' of this destruction. But in some way such a theory has to be completed by a theory of *'creation of structure'*, lacking in classical thermodynamics." (Prigogine & Nicolis, 1980, 72 [parenthesis added].)

7.8 Internal Network Complexity

In this section, we focus on measuring network characteristics by references between participants or to third parties. We point out that *networking efficiency* can be analyzed by random behavior and by interpreting variations in behavior as systemic. We also point out how *dominant, non-double-contingent and double-contingent* network parameters can be detected and anticipated.

Can internal network complexity be measured in an easy and straightforward manner without measuring interpersonal relations in detail?[56] We argue that this can be done by using items such as

> Who in your company supports you the most in your work?
> Please answer by giving the complete name of that person.

As a set, answers to these questions will produce systemic data. In this case, the outcome is a set of data that depicts the system's internal network in the realm of organic systemic features; i.e. the data has a *position* in the system.

The following considerations and implementations deal with that which can be said about the network based on these questions.

Suppose we take a sample (S) from a population, e.g. an organization (P) and pose the question "Who in your company supports you most in your work?" to the individuals in the sample. It follows that

> a purely random distribution of the names (N) given as answers obey the binomial distribution[57]

and that

> *any difference from the random, binomial, distribution can be understood as being a characteristic of the systemic data set (N).*[58]

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[56] This requirment of not measuring relations in detail was originally a result of the demand of anonymity.
[57] The binomial distribution being N_k = BIN[k;S;1/P], k = 1 … S.
[58] It follows, that networking between subsystems can easily be measured by simply dividing the population into P = P1 + P2, etc.

In order to be able to analyze this difference, we need a preliminary pragmatic semantics for the network[59]:

1. A ***network*** within the system consists of ***network relations***[60] and ***nodes***
2. A *relation* is the explicit reference a person gives when relating to another person in the system or in another system
3. A *node* refers to an actor within the system who is in a conjunction of one or several *relations*
4. The ***magnitude*** of the *node* is the number of *relations* within a *node*.

Now, taking as an example, a random binomial distribution with 128 potential names, the random distribution would appear as follows:

Magnitude	n	total
1	48	48
2	23	46
3	8	24
4	2	8
5	(1)	(2)
6	(0)	(0)
7	(0)	(0)
8	(0)	(0)
9	(0)	(0)
10	(0)	(0)
SUM	81	128

Table 19. An example of a random binomial distribution of nodes within a network.

[59] These definitions are by no means exhaustive, but are sufficient considering their purpose and function in the systemic analysis.
[60] For the sake of simplicity: whenever no confusion or misinterpretation is close at hand we simply use the word "relation" which actually means "network relation".

There will be some 48 nodes consisting of one name given only by one other person, 23 nodes consisting of one name given by two persons, etc., with a total number of nodes N = 81.

At this stage, this is the *referential frame* for analyzing the possible differences between a random distribution of network relations and a measured, real social network in which the relations are obviously not random. The network emerges and is formed by relations based on contingent or double contingent relations and characteristics between the people who make up the network. Contingent relationships are one-directional and hierarchical, with one of the parties dominating the relationship. In contrast, double contingent relationships are equal and two-dimensional, with both parties exerting influence over one another. (Luhmann, 1995.) In plain words, it can be anticipated that in a social system, some persons are favored over others when a certain feature or value is emphasized as the decisive factor in interpersonal relations[61].

The effect of this will be a shift in the distribution pattern of the nodes as well as in the total number of nodes. This shift has two extremes which provide guidelines for the efficiency of the network as a partial factor of systemic efficiency.

1. In the case of an *extreme lack of double contingent relations* between system participants, the distribution pattern and number of nodes will tend to approach the random values
2. In the case of *extreme dominance* of only one, or a very small number of, contingent relations, the distribution pattern will shift towards a

[61] I.e., the existence of double contingent and contingent relations in a sosial system can be expected and even presupposed.

significant increase of high-value nodes, whereas the number of nodes will remarkably decrease[62].

Based on this we argue that

shifts in the distribution pattern of the nodes can be interpreted as shifts in systemic efficiency. The less the above-mentioned extreme characteristics illustrate the network, the more systemically efficient it is.

Until now we have been dealing with measuring a network through a single question, answered by one name per respondent. To acquire a more complex set of data, which depicts the network within a system, we use a modified form of inquiry. Firstly, there are three network questions in the questionnaire, one for each system class (mechanical, organic and dynamic). Secondly, each question may be answered by giving from one to three names. The first amendment was made in order to encompass and theoretically incorporate all system classes into the scrutiny and the second in order to increase the depth of the network. So what we actually obtain is a *three-dimensional systemic network data set*:

A three-dimensional *systemic network data set* is a set that consists of network *relations that depict all the system classes by two or more relations*.[63]

This extension of the network data set enables and facilitates an interrelated extension of the scope and depth of the analysis of organizational networks and their efficiency, while respecting the demand for anonymity. As the main principles for analyzing a three-dimensional systemic network are the same as those for analyzing a one-dimensional network, described earlier, we proceed by just pointing out two main parameters that can be established. Their more accurate calculation will be presented in conjunction with the analysis of the observed systemic data in Appendix B. The parameters to be discussed here are (1) systemic *connectivity* and (2) the *depth and complexity* of the internal network.

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[62] Both cases result in a lack of autopoietic constraints in the system, e.g. the system is not systemically effective. Cmp. Luhmann, 1995.

[63] A practical example of a set of questions producing a three-dimensional systemic network data set: (1, mechanical) If somebody were to ask you who your superior is, what would you answer? (2, organic) Who in your company supports you most in your work? (3, dynamic) Who in your enterprise inspires you most to develop new things?

Systemic Connectivity

By systemic connectivity, we understand the communication and information flow between different system classes, mechanical, organic and dynamic.

Figure 11 shows an example of three persons, X1-3, answering three questions which cover the system classes by naming one relation in each case, (Aa) etc. By taking advantage of the three-dimensional data set produced here, it is possible to establish the (relative) number of relations that appear in one, e.g. (Aa), in two, e.g. (Dd) and in all system classes, e.g. (Cc). These numbers, in a straightforward manner, reflect the rate of exchange of information which is *lacking in one place of the system and present as a resource in another*. Based on this observation, we argue that

systemic connectivity is a parameter in the networking efficiency factor and, thus, also in the systemic efficiency factor.

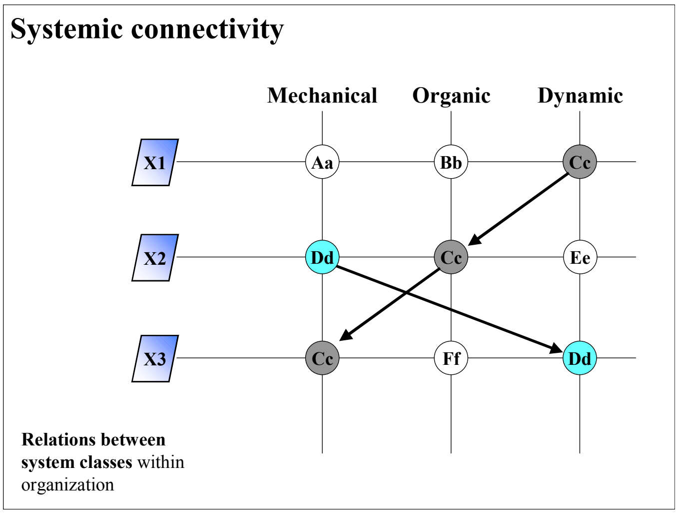

Figure 11. Systemic connectivity.

Network Depth and Complexity

The possibility to relate to several persons allows for the introduction of the depth and complexity of the network.

The adjacent figure shows an example of three persons, X1-3, who answer the same question by relating to one or several persons, (Aa), (Bb) etc. It illustrates how network depth and complexity can be approached and modeled.

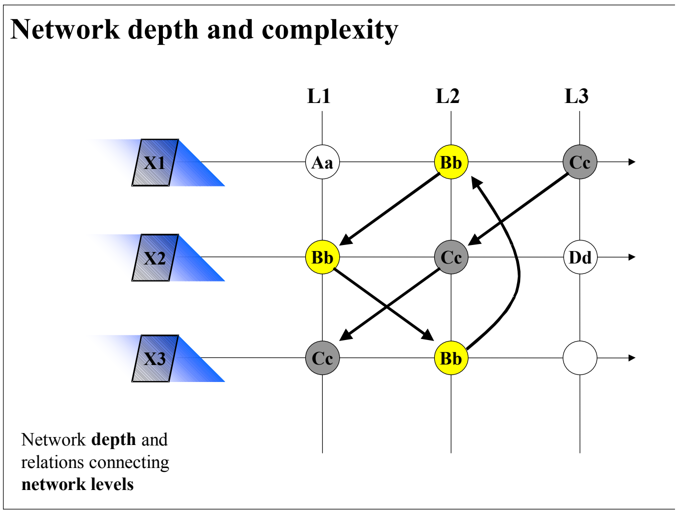

Figure 12. Network depth and complexity.

7.9 Matrix Behavior of Systemic Data

In this section, we focus on the complete and sum total of the systemic data that depicts an organization as a three-dimensional system. We point out that the various parameters established previously are substantial and tangible only when taking into consideration their legitimate and applicable *domains*. Related to this, we also introduce two *global* parameters, the *instability* of systems and *sensitivity to weak signals*.

We complete this inspection by considering the behavior of the systemic data matrix, i.e. the systemic data represented in the matrix, determined by the system classes and constituents, which covers and depicts the organization as a three-dimensional system.

We recall the SE matrix:

SE matrix		Classes		
		Mechanical	Organic	Dynamic
Constituents	Competence			
	Information flow			
	Relationships			
	Management			

Table 20. The organization as a three-dimensional system.

7.9.1 General Considerations

Dimensional parameters, parameters that emerge from data sets with different dimensions established previously in this chapter[64], can be evaluated in several different domains in the data; by domains we refer to the concepts of elements, components, constituents and system classes which comprise the system as a whole. The mathematical definition of a domain is given below:

[64] Cmp. sections 7.4-7.

A *domain* within the SE matrix is any union of two or several components of the matrix.

For example, although *unanimity* is a one-dimensional systemic parameter in the behavior of systemic data, it can be mathematically evaluated and conceptually envisioned on all the different domains of the data, even on the domain of the system as a whole. Likewise, the *Gap* level can be evaluated all over the data with various degrees of scrutiny, merging, for example, elements and components in any manner.

This is to say that from a purely mathematical point of view, it would be totally possible and justified to calculate, for example, the average of a constituent. However, from a systems theoretical point of view, this sort of an approach would not be sensible, as it has no meaningful interpretation. Therefore, the problem has two facets:

1. We have to estimate and determine a proper and systemically tangible, significant usage and domain for each parameter established.
2. We can employ any domain whatsoever and in this case we have to carefully estimate and determine its systemic meaning and significance.

We can, thus, apply two different approaches here: a) We can begin from the theory of organizations as three-dimensional systems, i.e. decide which evaluation domain is significant from the perspective of the *systemic efficiency* of an organization. b) We can begin from the behavior of data and single elements and statements, i.e. evaluate the significance of any tangible domain through examining its *effect on the system*. Both approaches will be considered.

An estimate of “where the evaluation of the parameters is meaningful”, for example, where the evaluated parameters have straightforward implementations based on their related effects on the system, is shown in table 21:

Internal parameters	Component	Constituent	System class	System
Unanimity/ present	x		x	
Unanimity / target	x		x	
Demand for change	x			x
Potential for change	(x)	x	x	
Relational indices				
Coherence	( )	●———	———	——→
Coherence / org. sub-systems			●———	——→
Coherence / strat. Focus			●———	——→

Table 21. Parameter domains.

For example, unanimity can be evaluated in a *straightforward* manner within a component and within a system class, but not within a constituent.

This is because within a system class, all the components are discrete, i.e. they *may* assume same average levels, whereas within a constituent ranging over all the system classes, the averages may be assumed *by definition* to differ remarkably.

Wrapping this line of thought together, we conclude that unanimity may be expected and even preferred within a system class taken over all its constituents. In contrast, unanimity is not preferred and is even contradictory and, therefore, not to be anticipated within a constituent taken over all its system classes[65].

The table 19 is based on similar contemplations in different cases.

Considering the second approach, we proceed by giving an example of combining domains to produce a new parameter.

To visualize this line of thought, we picture two fictional results by using a vector representation: In each component the overall average of the present (target or Gap) is represented by a point P(avg;avg) and is connected to its neighboring component by the class and constituent:

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[65] Unanimity in a constituent is demonstrated as the averages gathering close to the strategic profile.

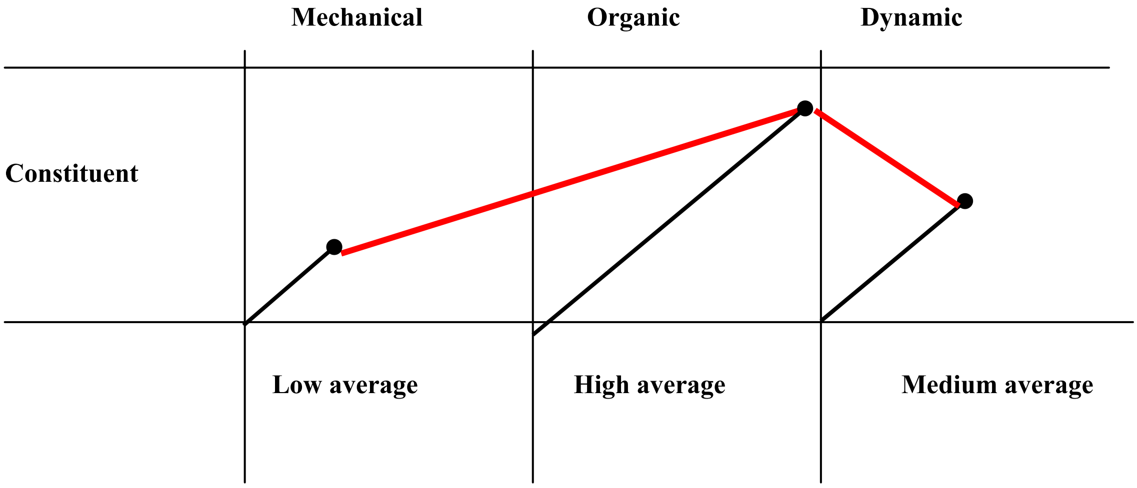

Figure 13. A vector representation of a system profile in a constituent.

By repeating the procedure in each component, we can visualize two fictional results as shown in figure 14. The one on the left depicts a harmonious and functional system profile where consistency and unanimity are high. The one on the right, in contrast, is a disharmonious and inconsistent system profile.

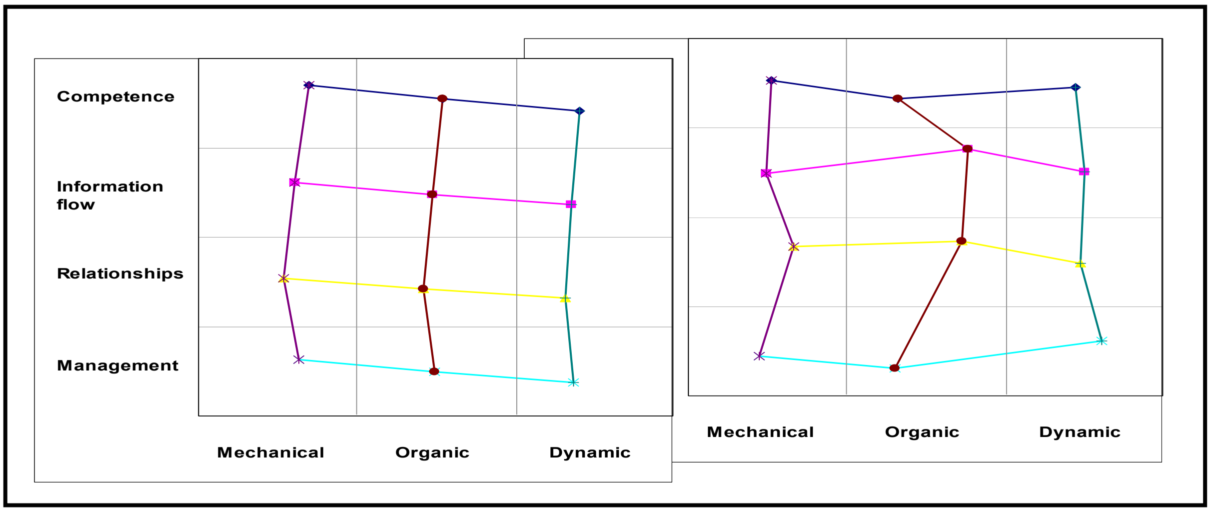

Figure 14. An example of a functional and dysfunctional vector networks.

Based on this simple visualization we argue that

Although the unanimity between the constituents is anticipated and the consistency not, unanimity (when lacking) is moderated and systemic efficiency strengthened through the consistency between constituents.

In practical terms: Based on theoretical considerations, it can be expected that an organization reflects its systemic profile in the realm of competence, information flow, relationships and management practices with equal impact and weights. However, when this is not the case and the weights of different constituents diverge significantly, *consistency restores and up-holds the systemic profile* in each constituent. I.e., even a system with large discrepancies between the different constituents may be efficient if the discrepancies are consistent. This is shown in figure 15.

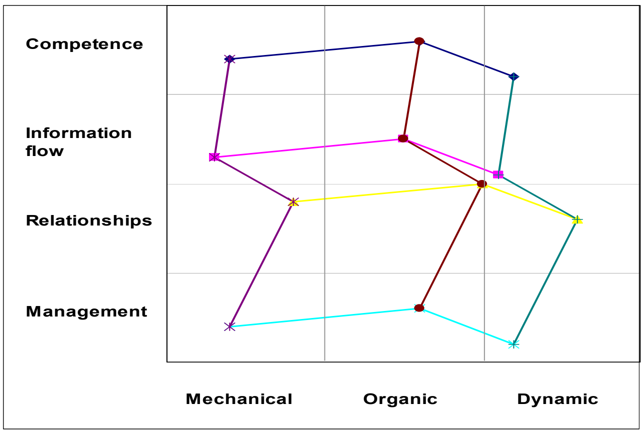

Figure 15. The consistency between constituents.

In the subsequent chapter " Analysis of Observed Systemic Data", we will elaborate in more detail on the issue regarding parameter domains and their impact.

Based on the matrix behavior of systemic data, one further parameter will be pointed out and established: the *state* of the system which can be disturbed, far-from-equilibrium or stable, near-equilibrium.

7.9.2 The State of the System

In studying systems, especially dynamic ones, the *state* of the system as *far-from or near-equilibrium* is the primary *continuous* characteristic within the system. The characteristic is to the highest degree associated to the system's potential for self-renewal and self-organization[66]. The continuity of the characteristic is obvious, as the system possesses opposites, near or total stability and near or total chaos, random behavior being the first estimate of chaos.

Based on this it is obvious that

> *a lack of unanimity, as interpreted through a high standard deviation and broad distribution pattern in any systemic domain, is an indicator of instability and, as such, a characteristic that affects systemic efficiency.*

Taking this argument into closer assessment, we once again refer to the fact that

> *Organizations, as three-dimensional systems by necessity and by their very definition, possess nonlinear, contradicting and opposite characteristics which either supplement or eliminate one another.*

This also enables a further vital and crucial conclusion:

> *Coherence and resonance, interpreted through consistency between two or more domains,* are *indicators of non-linearity present in the system. As such, it is a characteristic that affects systemic efficiency and is further strengthened by a lack of unanimity within the separate domains*[67]*.*

> In more practical terms: In the case at hand – unanimity – there is no theoretical contradiction. Unanimity is a powerful parameter in a mechanical systems

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[66] Once again, we refer to Prigogine (Prigogine & Nicolis, 1989, 238): "It is therefore natural to expect that dynamical models allowing for evolution and change should be the most adequate ones for social systems." And: "The first step in modeling complex behavior is therefore to assess the *nonlinear* character of the underlying dynamics to identify a set of variables *capable of showing instabilities and bifurcations."* (p. 218). For further considerations in his paper, we refer to sections 4.3 and 5.3 and the remarks on pages 14, 16-18, 22, 27.

[67] In fact: this conclusion reflects with the highest accuracy the essence of mechanisms creating "order through chaos" or "order through bifurcations" . Cmp. Glansdorff & Prigogine, 1971.

efficiency factor, whereas unanimity – taken with no restrictions – is a hampering parameter for a dynamic system, for example, as it hinders the emerging of redundant but indispensable chaotic behavior that fuels dynamic efficiency.

This assessment justifies the following two remarks:

1. We firstly recall the difference pointed out between the *demand* for change and the *potential* for change. Both induce the renewal of a system, but where the demand for change induces predictable change due to unanimity (mainly about the Gap), the potential for change induces non-predictable change and outcome due to the lack of unanimity. In this sense, unanimity does not obstruct or block system change as such, but only affects and influences the predictability of its outcome.
2. We are tempted to contemplate the feasible generalization of unanimity by introducing and distinguishing between *static* and *dynamic* unanimity. By doing so, we can unify the concept through the statements "static unanimity is interpreted as low standard deviation" and "dynamic unanimity is high consistency".

We conclude this section with a remark on weak signals:

The sensibility to weak signals is highly and positively correlated with contradictory, fuzzy and random behavior within the system as a whole.

This is a simple result of the nature of weak signals as the "first symptoms of change" and "early (fuzzy) information about future trends or changes."[68] As such, they are "still too incomplete to permit an accurate estimation" [69] and thus provoke and stimulate the mentioned *chaotic* situation and behavior. However, allowing this situation is the only possibility in detecting the signals while still weak.[70] In contrast with, for example, unanimity, an organization's sensitivity to weak signals is a highly complex concept

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[68] Hiltunen, 1999.
[69] Ansoff, 1984.
[70] Their *detection process* carries astounding similarities to the process of "Order through Chaos" described by Prigogine.

which is closely related to issues like managerial skills and the functioning of both the internal and external networks[71]. In this volume, we focus only on that part of weak signals which is related to chaotic functioning. The calculation of the index of sensitivity to weak signals will be discussed in Appendix B, Detailed Mathematics of the analyses.

[71] Ansoff, 1984.

7.10 Systemic Efficiency Considerations

Having, in the previous sections 4 – 9 of this chapter, established the basic parameters for the measurement of the characteristics of systemic efficiency, we call for a first, more rigid and unambiguous approximation of the concept of systemic efficiency. Facing this challenge, we recall the general conduct established in section 2:

1. The process will proceed through the quantification and analysis of the *internal characteristics* of the system and its sub-systems, the analysis moving upwards in the hierarchy; i.e. the analysis begins at the level of components, then moves to the constituents and classes and concludes at the level of the system as a whole.
2. Secondly, the process will proceed through the quantification and analysis of *relational characteristics,* i.e. the characteristics that depict the relations between the system and sub-systems as well as the relations between different parameters of the systemic efficiency factor. This will primarily comprise quantifying and analyzing (1) the relations between the components as parts of a constituent and system class, and (2) the relations between the system and its constituents or the system types represented in the system.

The theoretical aspect of the model of an organization's systemic efficiency is a broad implementation of the conduct presented earlier. This implementation generally pursues the subsequent line of thought:

1. *We need to identify the parameters that affect systemic efficiency by analyzing the internal system characteristics in a hierarchical order, proceeding beginning with elements and ending with the system as a whole.*
2. *The relational characteristics acknowledge that (1) the parameters affect each other in a non-linear manner, and (2) some parameters have distinct effects in each system class, i.e. they are system class -dependent. For example, unanimity is negative in a dynamic and positive in a mechanical environment.*

The exact realization of this conduct will be presented in the next chapter, Analysis of Observed Systemic Data. In this section, we only describe the process in general and as open-ended.

Following the conduct, we need to begin by focusing on the general aspect of systemic efficiency. Recalling the previous results, we conclude that the most decisive aspects of systemic efficiency are connected to the concepts of an organization's *systemic profile* and *strategic focus*. This is to say that

> nothing can be said about actual systemic efficiency unless the organization's systemic profile is established. In addition, nothing can be said about its actual or potential efficiency if its *strategic focus* is not acknowledged and accounted for.

This means that a company must know where its strategically most important added value comes from.

The first step in the practical application of this idea is to establish the systemic profile.

An organization's systemic profile is a complex and joint concept, and therefore, we establish the profiles on four levels (of main averages), (1) present, (2) target, (3) the Gap and, as a fourth one, (4) strategic focus (defined by the organization's top executive).

Figure 16 presents an example of a systemic profile that indicates the target system as organic with a secondary emphasis of dynamic features.

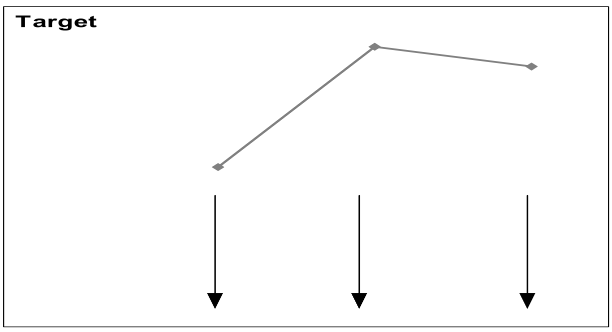

Figure 16. System profile.

Taking this into account, we introduce the connotation **E()** for the *systemic efficiency function* by arguing that

> *the systemic efficiency function,* ***E()****, must possess a suitable mechanism that reflects whether the specific system class -dependent parameters are favored or not.*

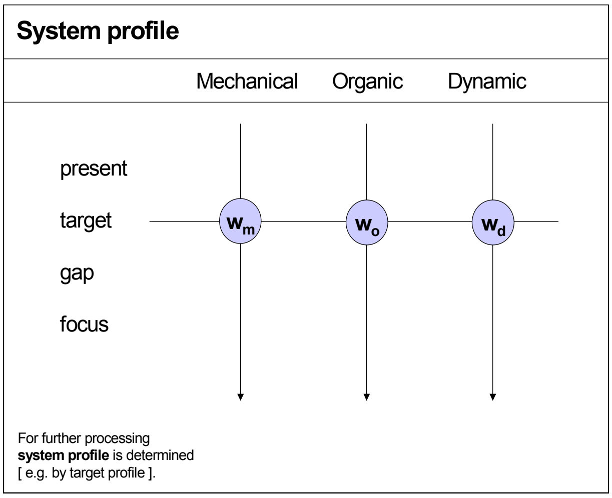

Figure 17. Parameter weights.

In practical terms, this could be done in each case by assigning a weight (W) that indicates the structure of the overall profile. These weights would be guidelines as to how significant the different parameters in the system are, and how important they are from the point of view of sustaining and empowering the profile.

Proceeding in the conduct we concurrently argue that

> *in the systemic efficiency function,* ***E()****, each parameter must be dynamically related to the system classes, e.g. they are class dependent and, as such, positive or negative characteristics in the efficiency function,* ***E().***

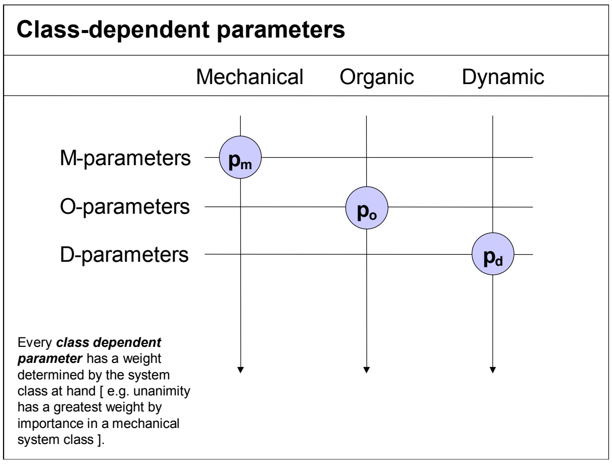

Figure 18. Class-dependent parameters.

In practical terms: In each case any parameter must be handled in such a way that its influence, effect or behavior is acknowledged as belonging to specific system characteristics as mechanical, organic or dynamic. As a remark, we recall what was mentioned previously - parameters may appear and reappear with opposite effects as was demonstrated in the case of unanimity, where a high score strengthens mechanical features, while low scores enable dynamic features.

We further argue that the same holds for system constituents:

in the systemic efficiency function, ***E()****, each parameter must be related to the system constituents.*

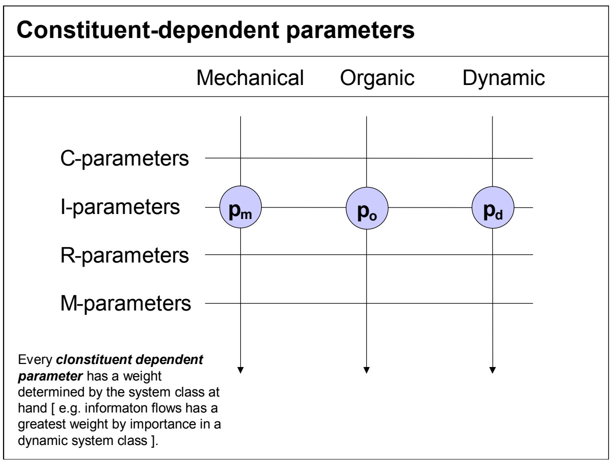

Figure 19. Constituent-dependent parameters.

In practical terms, this is to say that the same procedure, which was performed with parameters as system class -related, is to be repeated by giving due credit to parameters and their belonging to specific constituents. This has been clearly shown and pointed out, for instance, in the case of networking.

Finally, we find and acknowledge the existence of global parameters. Leaving open for debate the question as to whether any parameter is inclusively global in the sense that it *de facto* has equal importance in every system, we, however, argue that parameters such as, for instance, networking, system instability and motivation are equally important in every system type.

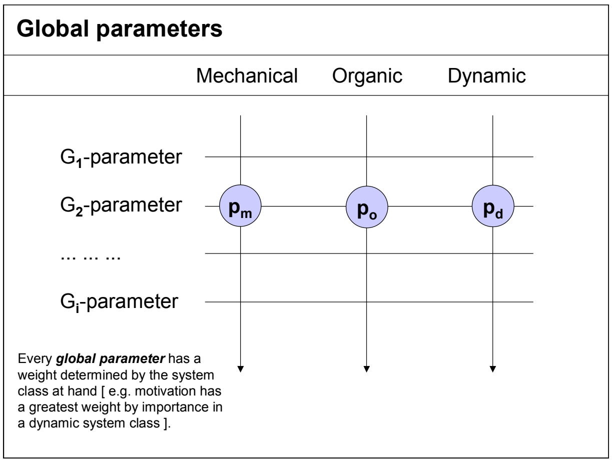

Figure 20. Global parameters.

We leave the debate open by only arguing that

> *in the systemic efficiency function,* ***E()****, global parameters must be identified and acknowledged as strongly related to the net systemic efficiency.*

As a matter of fact, this is to say that we, for example, hold that the *Motivation level* is always a positive characteristic in systemic efficiency, although we, at the same time, argue that the importance of high motivation is more important in dynamic systems than in mechanical ones.

Bringing this process to a close in all the four cases, present, target, the Gap and in the case of strategic focus will, in fact, yield four basic approaches towards the concept of an organization's systemic efficiency. At this stage, it becomes obvious that there is no single, simpleminded definition for the concept of an organizations systemic efficiency.

As should be clear by now, an organization's systemic efficiency is such a complex issue that, at this stage, we will not put forward a final definition for it. As it is not possible to take the definition to a closing based on deduction from theoretical viewpoints, we take it further based on the acquired data in Appendix B. Nevertheless, we do not leave the matter open, but wrap it into the following hypotheses.

An organization's systemic efficiency is a function of ***E()*** *of the form* $\mathbf{G}_p^t(\boldsymbol{f})$ *that*

1. *reflects the existence and force of a transition from a sustained present state,* ***p****, to an anticipated, functioning future, targeted state,* ***t***
2. *optimizes the transition through correspondence between the future, the targeted state and an explicit strategic focus,* ***f****, stated by the system.*

The structure of this function will be discussed in the next chapter in which we will also demonstrate that it is in formal concordance with the hypothesis. We end this section by arguing that

the hypothesis concerning an organization's systemic efficiency, as a function of the form $\boldsymbol{E()} = \boldsymbol{G_p^t(f)}$*, can be tested through the statement that an organizations' systemic efficiency increases the potential for survival and success in its near future and in competition with competing organizations.* This will be the task of a separate research report based on empirical data, which will be published later.

7.11 Theoretical Considerations

Focusing firstly on the characteristics of a three-dimensional systemic data set, introduced and portrayed in section 7.6, and especially on the distinction between *discrete* and *continuous* systemic features and characteristics we conclude that the analysis relates profoundly to the *distinction between discrete and continuous system features.*

This is to say that, although the model used in establishing an organizations' systemic efficiency is an implementation of the continuum mechanical-organic-dynamic,

> *the continuum can generally be 1) any continuum present in a system and 2) divided in any number, n, of distinct classes along the continuum.*

Likewise, we conclude that the use of four discrete characteristics, constituents,[72] is one of choice, the choice being made taking into consideration the concept of organizational systemic efficiency. As was stated regarding the continuum, we declare that

> *the number of discrete characteristics can be any number of features, constituents ranging over and being imbedded in the continuum.*

The general mode and its generality are illustrated in the figure below:

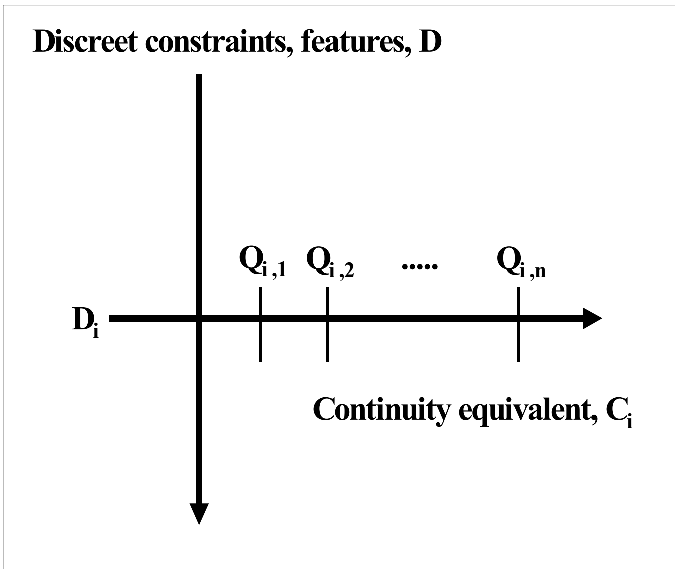

Figure 21. Generalization of systems as three-dimensional.

[72] In this approach: know-how, informaton flow, relationships and management.

Directing attention, secondly, to the main results that rise purely from the behavior of systemic data *as suggestions and indicators that measure the system (and its efficiency parameters),* we focus on their generality.

They are by their very nature general and emerge directly from the behavior of the data itself, and we therefore, argue that

> *the systemic analysis model, elaborated and presented based on the classification of systemic data sets, is a general one and lays the very foundation for a general approach towards the analysis of systemic characteristics in general.*

8 Conclusion

This volume was opened with a general review of the changes in the conception of organizations brought about by the dawn of the knowledge era. Then, the emphasis was shifted to the dynamic aspect of intellectual capital, an organization's ability for self-renewal.

To understand the concept and analysis of the ability for renewal, it is necessary to understand the systemic viewpoint on which the ability for organizational renewal is based. Therefore, the systemic foundations of the model were introduced at some length before proceeding to present the theory of organizations as three-dimensional systems. Then, the logic of systemic analysis of organizations was explained to a certain extent, and ultimately, the indices, which make up the ability for renewal, were arrived at through both the deductive and inductive application of mathematical imagination.

The sequence in which our argumentation advanced is actually consistent with the chronological order in which the development work of the KM-factor™ measure proceeded. In other words, first came Ståhle's dissertation (1998) on systems capacity for self-renewal, which included an empirical study on the level of work groups. It was followed by the implementation and extension of the theory to organizations (Ståhle & Grönroos, 1999; 2000), as well as diverse practical implementations of the theory in companies. The development of the measurement tool and method proceeded in close collaboration with several companies. Finally, the method reported in this volume was developed.

We conclude by taking a more practical look at the measurement of renewal ability and how the measured companies have perceived its benefits. We then briefly review the intended subsequent theoretical and empirical developments.

8.1 The Benefits of the KM-factor™ for the Measured Companies

KM-factor measurement provides an organization with reliable information on how efficiently the chosen management system works in practice; at what level the company's operations are compared to those of other companies which have similar strategic focuses; in what areas the operations do not fit the strategic focus chosen by the organization; and how strong an operative potential the organization has to survive the changes its strategy requires.

The report of the results of the KM-factor analysis, presented in appendix 2, consists of several parts. Firstly, there is the index that depicts the dynamic intellectual capital of the company, known as the IC index. This serves as an indicator of the organization's ability for renewal in relation to a reference group consisting of other organizations with similar strategic focuses. The index consists of the strategic capability and power to change. These are further divided into their constituents, and all the indices are expressed as percentages that express a) the organization's capabilities in relation to those of its reference group and b) the internal change compared to the organization's previous measurement, if one was conducted. Using these indices, an organization can follow the development of its efficiency in comparison with both itself and its competitors

The report is delivered in electronic format, which allow it to be easily distributed within an organization. The indices can be attached to the Balanced Scorecard or other measurement system used by a company. The indices can also be used alone for the purposes of internal and external communication. In addition, the ability for renewal and its constituents are reported separately for management and staff as well as in the areas of know-how, information flow, relationships and leadership. The report provides pinpointed information on the operational strengths and development needs of the organization.

The report also functions as a tool for continuous strategy-based development. The system profile expresses how the organization currently emphasizes its operations, and how management and personnel feel they should change. It also demonstrates the discrepancies between these targets and the organization's strategy. The change compasses inspect, in more depth, the areas where objectives are not consistent with strategy. It shows how operations and working habits should be changed in order to achieve the strategic objectives set for the organization. In other words, the KM-factor makes visible the unrecognized areas where the organization is actually operating inconsistently with its chosen strategy.

8.2 A Reflecting Note

In order to understand something as complex as the contemporary organization, some extent of simplification is obviously necessary. Nevertheless, our model may be – ironically – too mechanical and schematic, in that it over-emphasizes the significance of mechanical, organic and dynamic features as if they were some pre-fixed points in organizational operations. In reality, they are, of course, abstracted ideal types, put there to help in the task of making sense of the baffling complexity of real-life organizations, which could perhaps be more adequately described as a subtly shifting continuum.

On the other hand, dual semantic opposites may be the easiest way to comprehend an organization. Therefore, it could be that our model is, in fact, too complex, and that it could well be simplified by depicting the organization with the aid of only two ideal types, instead of the three we are using. This would, at the very least, make the questionnaire - not to mention its analysis – a great deal simpler.

Another problematic issue, related to our intellectual framework, is that the border between organic and dynamic system types is not totally clear. This is quite understandable if we remember the continuity of these features, but even then, these two system types are rather confounded, especially in the SE matrix. One of the most difficult tasks in the construction of the questionnaire was to keep these two areas as independent from each other as possible. We are not totally satisfied with the results, as many of the items, which belong to one, also reflect the other. It should be noted that the distinction between mechanical and organic features was much easier to draw. The difficulty of keeping organic and dynamic features separate from each other obviously arises from the fact that openness and chaos are such closely related issues and that dynamic features require the existence of a certain amount of organic ones.

Concerning the methodological implementation of our theory, the most notable refinement we shall undertake is the integration of level to the measurement. At the moment, the measure deals with only relations in the data, but not with the level of the responses. We decided to ignore the absolute level of the evaluations because we reasoned that it is the relational qualities, i.e. the balance between the evaluations, that matter the most. We also wanted to distinguish ourselves from traditional climate measures, as these cannot capture the systemic nature of organizational functioning. Our method is able to accurately measure relations, but the incorporation of absolute levels to its scope might still improve it. This idea is under scrutiny.

Lastly, a reflection that deals with the measurement of intra-organizational features in general. It may well be asked to what extent a company can really exert influence on how it succeeds in the markets. Perhaps it is the products or macro-level economical, political and social factors, rather than what happens inside the firm, which actually determine how the financial indicators of a company turn out at the end of the day. The IC movement began with the conviction that human competencies and intra-organizational conduct play a critical role in making or breaking a company. The extent to which this actually holds true is hard to evaluate.

8.3 Future Directions

This volume presented the first achievement in the attempt to construct a measure for an organizations' systemic efficiency. To further refine and develop both the theory and the method, it is necessary to conduct new measurements and to enlarge the pool of data. Several research projects are already being planned in order to gather data from organizations of different sizes, developmental stages and industries.

The next step in our research will be to examine the relationship between renewal ability of organizations and their success. This forthcoming study (by Pöyhönen) will look into the correlation of the ability for renewal with financial accounting-based indicators of organizational performance.

The issue of how renewal ability relates to some other models of intellectual capital was discussed in chapter 2.. However, this volume did not discuss the practical side of how the indices produced by the KM-factor™ should be integrated with the other measures of IC. Even though the ability for renewal may be the most significant part of IC, it is only one facet of it, and to get a concise view of a company's IC, it needs to be complemented with other measures. It will be the task of a future study to examine, at the empirical level, the mutualities and differences between the ability for renewal and other components and measures of IC, as well as their optimal combinations for different types of organizations.

Finally, an interesting topic for future research will be whether the development activities directed at the development points and bottlenecks demonstrated by KM-factor™ result in radical self-renewal within organizations. If the comparison and integration of KM-factor™ with other IC measures examines how apt it is for firm valuation, then this kind of study will be more of a test of its capabilities for assisting in management purposes. Based on the user experiences so far, it indeed seems to be a valid and useful tool for both these purposes.

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Appendix A. System semantics.

We sum up the structure of organizations as three-dimensional systems in the table below, the ***SE-matrix***, where SE stands for *systemic efficiency*.

SE	**Classes**	Class 1 - 3		
Constituents	**Elements**	Mechanical	Organic	Dynamic
Constituent 1-4	Competence	**Component**		
	Information flow		**Element 1** **Element 2** **Element 3** **Element 4**	
	Relationships			
	Management			

The semantics of the *matrix* to be used in the interconnected analysis *model* and further in this paper is as follows:

1. ***A system in the matrix*** consists of ***elements*** possessing different ***systemic features***
2. A *element* of a system is the smallest ***unit*** in the system, not further elaborated or analyzed intrinsically, internally, and possessing only a ***simple*** *systemic feature*, whereas simple is to be understood in the meaning of unique and not further elaborated, factorized
3. A *system unit* is any set of elements in a system
4. A *systemic feature* of a system *unit* is a set of characteristics portraying, describing and depicting, the purpose, task, function or effect of the unit as part of the system

5. Every *element* in a system belongs to one[73] system ***constituent*** and one system ***class***, this being the elements system ***position***
6. A system ***constituent*** is a set of *elements* ranging over all, e.g. represented in all system *classes* and possessing a common ***constituent characteristics,*** e.g. the feature depicting the system constituent at hand
7. A ***simple*** system ***constituent*** is a constituent represented by one *element* in each system *class*
8. A system ***class*** is a set of elements covering, e.g. represented in all *system constituents* possessing the same general ***classifying characteristics***, e.g. the feature depicting the system at hand
9. A set of two or several *elements* belonging to the same system *constituent* and the same system *type* form a system ***component***[74]
10. A ***system*** is the set comprising ***all*** the *elements* belonging to one of the system *classes* and one of its *constituents* [75].
11. An ***organization*** is a social *system* composed by the ***individuals*** and the ***items*** belonging to the system[76] and whereas *individual* refers to the presence of persons[77] *items* refers to the presence of material and immaterial articles[78] in the system.

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[73] In general: One and only one.
[74] Deductively: Every element belongs to one (and only one) component in the system.
[75] In this division constituent takes the meaning of *function* and class the meaning of *structure* when compared to Nicolis and Prigogine, 1989.
[76] "belonging to the system", though vague, this is the boundary of the system to be analysed.
[77] As human beings.

Appendix B. Detailed mathematics of the analyses

Based on the model for retrieving systemic data (the KM model and the SE matrix, presented in chapter 6), as well as on the results concerning the behavior of systemic data in general (presented in chapter 7), we turn to the question of *analyzing* observed systemic data.

Analyzing the observed systemic data involves both analysis *procedures* and *implementations* of standard mathematical tools as well as standard *statistical methods*. The outcome of this combination in the KM-factor analysis, as a whole, is astonishingly complex:

> At this moment the analysis of observed systemic data embraces 12 different *stages of the analysis*, 6 *benchmarking levels*, 1058 active *general variables* and 196 *individual variables* per participant answering one of 3 *questionnaires*, all wrapped together by the total of 3 *analysis procedures* applied on staff, management and the organization as a whole, generating the 19 calculated *indexes*[79].

Facing this and the, limited scope of this report, the emphasis in this section will be on introducing the main aspects and main tools used in analyzing observed systemic data to such a degree that the reader can estimate the adequacy of the results presented here.

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[78] As things, machines, various degrees of know-how, economical resources, legal rights, etc..

[79] In fact, this complexity should not be surprising: we are dealing with interactions of complex (social) networks involving non-linearity.

Appendix B.1 The Structure of the Analysis

Tracing the different parts and phases of the systemic efficiency function, E(), described in section 7.10, Systemic Efficiency Considerations, and following the analysis praxis, described in section 7.2, Analysis of Systemic Data: the Process and the Aim, steers the analysis into different *levels*. The different basic levels that reflect and mirror the organization as a three-dimensional system, its structure and dynamics, are

Level 1	analysis of *components*
Level 2	analysis of system *classes* and *constituents*
Level 3	analysis of *relations* between system classes, constituents and components
Level 4	analysis of *distinct systemic characteristics*

Based on the analysis of the behavior of the observed systemic data at these four levels, our task is not to produce indexes, but to *detect systemic characteristics* tangible enough to be parameters in the systemic efficiency factor and its function E(). Our analysis will, therefore, be open-minded, explorative and divided into two logical phases.

1. The first phase at each level of the analysis will be guided solely by the aim of detecting major and notable differences in the behavior of the observed systemic data when compared to the behavior of random data at a respectable level of confidence. This phase will essentially be conducted based on the findings in chapter 7[80].
2. The second phase will focus on the systemic efficiency factor and the quest for an adequate and sufficient set of indexes embedded in the systemic efficiency factor, E(). This phase will largely be carried out in acknowledgment of the theoretical considerations put forth in chapters 4 – 5[81].

In order to be able to manage the mass of retrieved data and to be able to explore the results and findings in an easily comprehensible manner, we proceed by establishing a denotation practice aimed to satisfy the more abstractly and mathematically oriented reader.

[80] Buildig a framework for analyzing an organization’s systemic efficiency.

Appendix B.2 Denotations and the Main Tools Used

Appendix B.2.1. General Denotations

1. Answers and Averages by Participant

$$\alpha(i,j,k,x,y)$$

The answer by participant **x** to a single statement or question, Q = α(), **k** =1 – 3, 4, α = **p**resent, **t**arget or s**u**pplementary in system class (i), mechanical 1, organic 2 and dynamic 3, and constituent (j), capabilities 1, information flows 2, relationships 3 and management 4, in measurement **y**. Generally, we will refer to this as the answer that a person has given to a question or statement with respect to α and denote it as **w(α(i,j,k,x,y))** or **w(α(i,j,k,x))**.

$$\overline{\alpha}(i,j,x,y)=\frac{1}{3}\sum_{k=1}^{k=3}\alpha(i,j,k,x,y)$$

The average of the responses of participant **x** to **all** the statements, Q1-3, α = **p**resent or **t**arget, within the same component (i,j). Generally, we will refer to this as the participant's answer or level of answers within a component with respect to α and denote it as **w(α(i,j,x,y))** or **w(α(i,j,x))**.

$$\overline{\alpha}(i,x,y)=\frac{1}{3}\sum_{k=1}^{k=3}\frac{1}{4}\sum_{j=1}^{j=4}\alpha(i,j,k,x,y)$$

The average of the responses of participant **x** to **all** the statements Q1-3, α = **p**resent or **t**arget, within the same system class (i) and comprising **all** = four constituents, (J). Generally, we will refer to this as a participant's answer or level of answers within a system class with respect to α and denote it as **w(α(i,x,y))** or **w(α(i,x))**.

$$\overline{\alpha}(j,x,y)=\frac{1}{3}\sum_{k=1}^{k=3}\frac{1}{4}\sum_{i=1}^{i=3}\alpha(i,j,k,x,y)$$

The average of the responses of participant **x** to **all** the statements Q1-3, α = **p**resent, **t**arget

[81] The three paradigms of systems thinking and Organization as three-dimensional system

or s**u**pplementary, within the same constituent (j) and comprising **all** = three system classes, (I). Generally, we will refer to this as the participant's level of answers within a system class with respect to α and denote it as **w(α(j,x,y))** or **w(α(j,x))**.

$$\overline{\alpha}(x,y) = \frac{1}{3}\sum_{i=1}^{i=3}\overline{\alpha}(i,x,y) = \frac{1}{4}\sum_{j=1}^{j=4}\overline{\alpha}(j,x,y)$$

The average of the responses of a participant **x** to **all** the statements Q1-3, α = **p**resent or **t**arget and taken over **all** system classes (I) and **all** the constituents (J). Generally, we will refer to this as the participant's net answer or net level of answers within the system or SE matrix with respect to α, and denote it as **w(α(x,y))** or **w(α(x))**.

2. System Component, Constituent and Class Averages

$$\overline{\alpha}(i,j,k,y) = \frac{1}{x}\sum_{x=1}^{X}\alpha(i,j,k,x,y)$$

The average of a single statement, Q, within a component (i,j) taken over **all** the participants, **X**, in a specific measurement, **y**. Generally, we will refer to this as the average of a single question or statement, Q, within a component (i,j) with respect to α and denote it as **avg(α(i,j,k,y))** or **avg(α(i,j,k)).**

$$\overline{\alpha}(i,j,y) = \frac{1}{3}\sum_{k=1}^{k=3}\alpha(i,j,k,y)$$

The average of **all** the statements, Q = α(), **k** =1 – 3, 4, α = **p**resent, **t**arget or s**u**pplementary, within a component (i,j). Generally, we will refer to this as the average of the questions or statements, Q, within a component (i,j) or simply as the average or level of the component (i,j) with respect to α and denote it as **avg(α(i,j,y))** or **avg(α(i,j)).**

$$\overline{\alpha}(i,y) = \frac{1}{4}\sum_{j=1}^{j=4}\overline{\alpha}(i,j,y)$$

The average of **all** the statements, Q, within a system class (i) taken over **all** = four constituents (J). Generally, we will refer to this as the average of the questions or statements, Q, within a system class (i) or simply as the average or level of the system class (i) with respect to α and denote it as **avg(α(i,y))** or **avg(α(i)).**

$$\overline{\alpha}(j,y) = \frac{1}{3}\sum_{i=1}^{i=3}\overline{\alpha}(i,j,y)$$

The average of **all** the statements, Q, within a system constituent (j) taken over **all** = three classes (I). Generally, we will refer to this as the average of the questions or statements, Q, within a system constituent (j) or simply as the average or level of the system constituent (j) with respect to α and denote it as **avg(α(j,y))** or **avg(α(j)).**

$$\overline{\alpha}(y) = \frac{1}{3}\sum_{i=1}^{i=3}\overline{\alpha}(i,y) = \frac{1}{4}\sum_{j=1}^{j=4}\overline{\alpha}(j,y)$$

The average of **all** the statements, Q, within the SE matrix taken over all system classes (I) and all the constituents (J). Generally, we will refer to this as the net average of the questions or statements, Q, within the system or simply as the average or level of the system with respect to α and denote it as **avg(α(y))** or **avg(α).**

3. Standard Deviations

The standard deviation will, in general or when not otherwise mentioned, be calculated using the following formula:

$$\sigma_{\omega}(\alpha(\varpi)) = \sqrt{\frac{n\sum_{1}^{n}\alpha_i(\varpi)^2 - [\sum_{1}^{n}\alpha_i(\varpi)]^2}{n(n-1)}} \quad ; \quad \omega = (i/,j/,k/,x/,y/)$$

For the sake of simplicity, we generally apply the denotation as $s_{\omega}(\alpha(\varpi)) = \sigma_{\omega}(\alpha(\varpi))$.

As an example of the denotation in full, take the following:

The standard deviation of the responses of a participant, x, Q1-3, α = **p**resent, **t**arget or s**u**pplementary, within a component (i,j). Generally, we refer to this as the standard deviation of participant's answers to questions, Q, within component (i,j) with respect to α and denote it as **s_k(α(i,j,x,y)).**

The standard deviations within components (i,j) can be calculated in two different ways:

$$\sigma_{k(x)}(\alpha(i,j,y)) = \frac{1}{3}\sum_{k=1}^{k=3}\sigma_k(\alpha(i,j,x,y))$$

As averages:

Denotation $\mathbf{s_{k(x)}(a(i,j,y))}$.

$$\sigma_{(kx)}(\alpha(i,j,y)) = \sqrt{\frac{3X\sum_{x=1}^{X}\sum_{k=1}^{k=3}\alpha(i,j,\overline{k},\overline{x},y)^2 - [\sum_{x=1}^{X}\sum_{k=1}^{k=3}\alpha(i,j,\overline{k},\overline{x},y)]^2}{3X(3X-1)}}$$

Or, direct: Denotation $\mathbf{s_{(kx)}(a(i,j,y))}$.

The difference between these two denotations can be seen in the sub-indexes:

k,(x)	counted as averages through k
(kx)	counted directly through the kx matrix.

4. Standard Deviation Implementing LSQ for System Constituents and Classes

As was mentioned previously, the standard deviation within constituents and classes must be calculated implementing LSQ, the Least Square Method. The two deviations of the constituents and classes are calculated as follows:

$$\lambda_j(i,y) = \sqrt{\frac{\sum_{j=1}^{j=4}(\overline{\sum_{k=1}^{K}\overline{\alpha}(i,j,x,y)} - \overline{\overline{\alpha}}(i,j,y))^2}{4}}$$

The deviation of the system constituent (j). Generally, we will refer to this as the squishiness or softness of the constituent and denote it as $\mathbf{l_j(i,y)}$.

$$\lambda_i(j,y) = \sqrt{\frac{\sum_{i=1}^{i=3}(\overline{\sum_{k=1}^{K}\overline{\alpha}(i,j,x,y)} - \overline{\overline{\alpha}}(i,j,y))^2}{3}}$$

The deviation of the system class (i). Generally, we will refer to this as the squishiness or softness of the system class and denote it as $\mathbf{l_i(j,y)}$.

Appendix B.2.2 Analysis of System Components

The system components (i,j) will be analyzed separately for management and staff through

1. the averages of questions Q1-3 and 4 belonging to the component and interpreted as a ***level 1 weight of the component (i,j)***
2. the standard deviation of questions Q1-3 and 4 interpreted as the basis for ***level 1 unanimity***
3. the correlation and chi-test between questions Q1-3 interpreted as the ***level 1 coherence of component (i,j)***

Component (i , j) **Denotation**	**p = present**	**t = target**	**g = gap**
k = 1,2,3 ; α = p,t,g			
Data =	**p(i,j,k,x,y)**	**t(i,j,k,x,y)**	**g(i,j,k,x,y)**
a(α,i,j,k,y)	$\overline{\alpha}\ (i,j,k,y) = \frac{1}{x}\sum_{x=1}^{X}\alpha(i,j,k,x,y)$		
s(α,i,j,k,y)	$\sigma[\alpha(i,j,k,y)]$		
r(α1,α2,i,j,k,y)	$r[\alpha_1(i,j,k,\overline{x},y);\alpha_2(i,j,k,\overline{x},y)]$		
r(α,i,j,x,y) ; x = 1, ,,, X	$r[\alpha\ (i,j,\overline{k},x\ ,y);\overline{\alpha}\ (i,j,\overline{k},X,y)]$		
R(α,i,j,y)	$\frac{1}{x}\sum_{x=1}^{X} r[\alpha\ (i,j,\overline{k},x\ ,y);\overline{\alpha}\ (i,j,\overline{k},X,y)]$		

Table 24. Level 1 denotations and the main functions used.

Appendix B.2.3 Analysis of System Classes and Constituents

System classes (i) and constituents (j) are principally analyzed by applying the same tools and methods used by components on the averages taken. The system classes and constituents are analyzed separately for management and staff. The analysis is conducted through

1. the averages of all constituents or classes interpreted as the ***level 2 weight of the system class or constituent***
2. the standard deviation within a class or constituent, which is calculated using LSQ and interpreted as the ***level 2 softness or squishiness of the system class or constituent***
3. the correlation and chi-test between classes or constituents interpreted as the ***level 2 coherence of system class constituent***

An example of system class denotations:

Class(i) **Denotation**	**p = present** **t = target** **g = gap** $\overline{\alpha}(i,j,x,y)=\frac{1}{3}\sum_{k=1}^{k=3}\alpha(i,j,k,x,y)$
α = p,t,g	
Data = **a(α,i,y)** **s(α,i,y)**	**p(i,j,x,y)** **t(i,j,x,y)** **g(i,j,x,y)** $\overline{\alpha}(i,y)=\frac{1}{x}\sum_{x=1}^{X}\frac{1}{4}\sum_{j=1}^{j=4}\overline{\alpha}(i,j,x,y)$ $\sigma_{j,k}(\alpha(i,y))$
r(α1,α2,i,y) **R(α,i,y)**	$r[\alpha_1(i,\overline{x},y);\alpha_2(i,\overline{x},y)]$ $\frac{1}{4}\sum_{j=1}^{j=4}r[\alpha(i,\overline{j},x,y);\overline{\alpha}(i,\overline{j},X,y)]$

Table 25. Level 2 denotations and the main functions used.

Appendix B.2.4 System Profiles and Correlated Weights

System profiles are calculated for management and staff separately through the net averages taken over all the constituents:

System	Mechanical	Organic	Dynamic
Capabilities			
Information flow			
Relationships			
Management			
System profile α = present, target	**avg(α(Mec))**	**avg(α(Org))**	**avg(α(Dyn))**

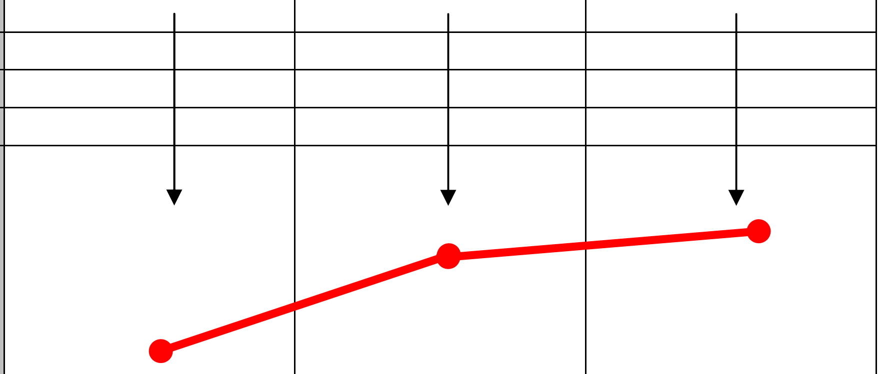

Table 26. An example of a system profile.

The ***change compass*** value is calculated for every component (i,j) as the simple difference between the system profile weight and the component's weight. As such, it is a measurement of how coherently the system profile is realized in the system as a whole:

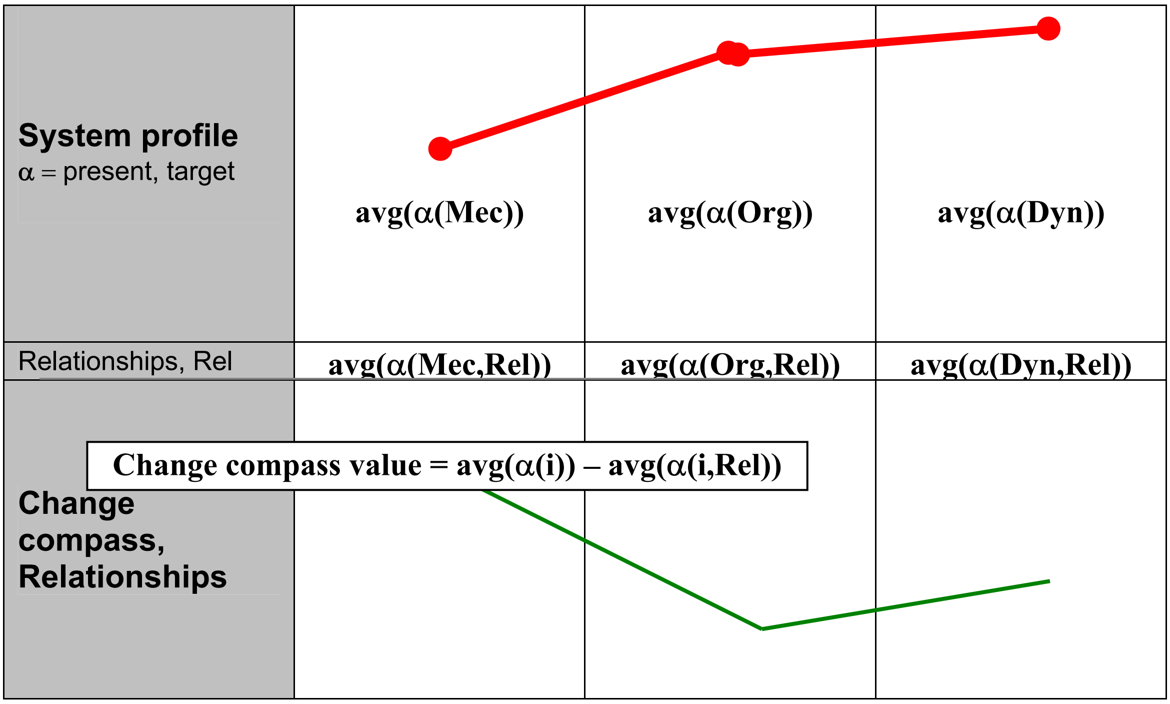

Table 27. An example of a change compass.

Appendix B.3 The Calculated Indexes

Appendix B.3.1 Referential Frame for Parameters

In calculating the basic parameters, we use a three-leveled referential base comprising

1. the theoretical *maximum* and *minimum* values of the functions used
2. the overall *mean values,* when the values are calculated in all measurements performed and the mean value is the *average* of all the measurements
3. the averages of the random values calculated using the random distribution of all the gathered data.

Through this procedure, we achieve a referential frame which (1) sets exact upper and lower *limits*, (2) enables the comparison between different measurements (*more or less, stronger or weaker)* and (3) makes general deviations from random behavior *visible*.

Based on this approach, the basic referential frame is brought together in table 27 below.

Within components, constituents and classes	**Argument**	**Parameter function**			
		Level	**Unanimity**	**Consistency**	
Basic functions **Base values**	**p, t or gap**	**Avg()**	**Stdv()**	**Corr()**	**Chi & F**
TM() = Theoretical Max()		5+	2	+ 1	1
Avg[BM()] = Average of values in *all measurements*		avg(b)	s(b)	r(b)	f(b)
Avg[Rnd()] = Average of random data with same distr. pattern as *all data*		**avg(r)**	**s(r)**	**r(r)**	**f(r)**
Tm() = Theoretical min()		1	0	- 1	0
Basic formula scaling parameter function value between 0 and 1	**Scale 0,0 – 1,0**	$\frac{avg()-1}{4+}$	$\frac{2-s()}{2}$	$\frac{1+r()}{2}$	$\frac{f()}{1}$

Table 28. The referential frame and formulas for basic parameters.

It goes without saying that reverse parameters, e.g. non-unanimity as disorder, can be calculated as 1-[parameter scaled between 0-1].

Appendix B.3.2 The Basic Indexes

In order to analyze the gathered data, 10 basic indexes were established. This was done by utilizing the results from chapter 7 and a mix of different parameters from the referential frame.

We note that at this stage the basic indexes and their names are rather tentative, aimed only at providing a suitable grammar by which to manage the behavior of the data and results to be analyzed:

Basic index	Interpretation and parameters used
1. Unanimity regarding current situation	1. Low standard deviation of present within components 2. High consistency within components
2. Unanimity regarding objectives	1. Low standard deviation of targets within components 2. High consistency within components
3. Coherence of developmental challenges	1. High consistency between constituent- and class- averages 2. Low standard deviation of change compasses
4. Strategic fit of operational profiling	1. High consistency to strategic focus stated in all constituents 2. Low standard deviation of correlated change compasses
5. Sensitivity to weak signals	1. High standard deviation of present 2. Low standard deviation of target
6. Challenge presented by the target level	1. High gap level 2. High consistency between present and target within components
7. Innovation potential	1. High gap level on high level of present 2. High standard deviation of targets 3. High levels of (I)-questions
8. Commitment to objectives (management <-> staff)	1. High consistency between management and staff
9. Internal networking	1. High double contingency 2. High levels of (N)-questions
10. Motivation level	1. High levels of (M)-questions

Table 22. The basic indexes calculated.

It is obvious that when the parameters involved are scaled between 0 and 1, the indexes produced can, likewise, be easily scaled to range between 0 and 1. However, in each index, which involved a mix of several parameters, the weight and impact of the parameters on the index has to be accounted for.

Following the approach towards the concept of systemic efficiency, two higher-level indexes will be introduced: *strategic capability* and the *power to change*. As has been previously mentioned, these concepts, as parts of systemic efficiency, are system class - dependent. The outcome will involve *filling in* the table shown below, which has been shown here only for the sake of interest and completion.

Systemic efficiency Importance and Weight of index	System class		
Strategic capability	**Mechanical**	**Organic**	**Dynamic**
Unanimity regarding current situation			
Unanimity regarding objectives			
Coherence of developmental challenges			
Strategic fit of operational profiling			
Sensitivity to weak signals			
Power to change	**Mechanical**	**Organic**	**Dynamic**
Challenge presented by the target level			
Innovation potential			
Commitment to objectives (management <-> staff)			
Internal networking			
Motivation level			

Table 23. The main indexes.

Appendix B.4 Structure of the Gathered Data

The data to be processed and analyzed in the subsequent sections was gathered in a total of 28 measurements performed during the period between 1998 and 2001. The general structure of the data, based on the explicitly stated strategic focus of the organizations measured, is shown in table 29 below.

N	Organization	Management	Staff	Total
Mechanical	2	7	37	44
Organic	12	142	602	744
Dynamic	14	108	444	552
Total	28	257	1083	1340

Table 29. The total of the gathered systemic data.

Based on the gradually increasing mass of data, the questionnaire underwent three major revisions due to results that emerged from the validation of the questionnaires themselves.

The questionnaire changed over the period between 1998 and 2001 when data has been gathered. Modifications to the questions or statements were made and two major structural changes introduced: the usage of (1) separate questionnaires for management and staff and (2) separate classifying qualitative and networking questions (see chapter 6). Taking this into consideration and denoting the three phases by *questionnaires 1-3*, the structure of the data is revealed in table 30 below.

Questionnaire 1	N	Management	Staff	Total
Dynamic	3	6	118	124

Questionnaire 2	N	Management	Staff	Total
Organic	4	44	407	451
Dynamic	2	10	50	60
Total	6	54	457	511

Questionnaire 3	N	Management	Staff	Total
Mechanical	2	7	37	44
Organic	8	98	195	293
Dynamic	9	92	276	368
Total	19	197	408	705

Table 30. The structure of the data by strategic focus of the organizations in the three questionnaires.

In the subsequent analysis, we will mainly focus on the data gathered with questionnaire 3, the third phase of this research and development project.

Scaling Target Values

As was earlier stated in sections 6.5 and 6.6, the preferred future and target values in *questionnaire 3* were requested through uniformly positive "more" statements and estimated on a scale from 1 to 5, where 1 signified "I totally disagree" and 5 "I totally agree". To be handled, the target values needed to be scaled. The calculation and conversion was made by the matrix index (present, target) presented below.

Target "More" Totally disagree / totally agree	Target value				
5	2,58	3,58	4,58	5,58	6,58
4	1,94	2,94	3,94	4,94	5,94
3	1,29	2,29	3,29	4,29	5,29
2	0,75	1,65	2,65	3,65	4,65
1	0,75	1,00	2,00	3,00	4,00
Estimation of present, value	**1**	**2**	**3**	**4**	**5**
Formula	$t(value) = index(present, target)$				

Table 31. Target value scaling.

The matrix index (present, target) is based on an analysis of the prior behavior of the data retrieved with questionnaires 1 and 2 in order to yield a near equal overall average for the target values.

Normalizing the Data

As a result of the mathematical tools used, the systemic analysis is highly sensitive to the intrinsic features of the data. Small variations, e.g. in the standard deviations, affect unanimity to a great extent. Analyzing the gathered data from this point of view led to two principles by which the data should be *normalized* prior to any further analysis:

1. The effect of motivation levels by participant: The motivation of a respondent is affected in general in such a way that a person with low general level of motivation tends to give lower average estimates of the present situation and higher average estimates of the target situations. This effect is the opposite for a person with a high general level of motivation[82].
2. Each question or statement has its intrinsic behavior, and the effect of this behavior must be acknowledged and modified by guidelines evident in the data. The behavior of each question must be analyzed in detail to determine its

[82] It must be stated that if the aim would be climate survey this effect could, and even perhaps should be unmodified.

general tendency to produce averages under or above the general mean average of all the questions.

The effect of these normalizing procedures on the indexes produced is +/- 12% with a standard deviation of 27%.

Appendix B.5 Findings in Basic Parameters and Calculated Indexes

Appendix B.5.1 Findings in Basic Parameters

The basic parameters were calculated in the components, constituents and classes separately using the same basic formulas for scaling the parameters between 0,00 and 1,00.

System Components

Present	Formula	Average	Max	min	range
Level	$\frac{avg()-1}{4_{(+)}}$	0,45	0,72	0,21	0,51
Unanimity	$\frac{2-s()}{2}$	0,76	0,98	0,24	0,76
Correlation	$\frac{1+r()}{2}$	0,57	1,00	0,25	0,75
Chi	$\frac{\chi^2()}{1}$	0,64	0,90	0,22	0,68

Target	Formula	Average	Max	min	range
Level	$\frac{avg()-1}{4_{(+)}}$	0,59	0,85	0,12	0,73
Unanimity	$\frac{2-s()}{2}$	0,69	0,99	0,00	0,99
Correlation	$\frac{1+r()}{2}$	0,64	1,00	0,28	0,72
Chi	$\frac{\chi^2()}{1}$	0,61	0,86	0,07	0,79

Table 32. The findings in the system components

As can be seen from the table above and focusing on the consistency functions, both the averages and minimum values show that, in general, the components possess behavior that differs significantly from that of random behavior. From the point of view of this paper, it can be said that

> *components, in general, possess systemic and nonrandom behavior that reveals both unanimity and consistency.*

System Constituents and Classes

Using avg**(α(i,j))** and vectors **(α(I,j,x))** for the constituents and **(α(j,I,x))** for the classes gives the following results**.**

Present	**Formula**	Average	Max	min	range
Level	$\frac{avg()-1}{4_{(+)}}$	0,45	0,72	0,21	0,51
Unanimity	$\frac{2-s()}{2}$	0,70	0,99	0,17	0,82
Correlation Constituent	$\frac{1+r()}{2}$	0,57	**1,00**	**0,00**	1,00
Correlation Classes	$\frac{1+r()}{2}$	0,63	**1,00**	**0,00**	1,00

Target	**Formula**	Average	Max	min	range
Level	$\frac{avg()-1}{4_{(+)}}$	0,59	0,85	0,12	0,73
Unanimity	$\frac{2-s()}{2}$	0,62	0,97	0,12	0,85
Correlation Constituent	$\frac{1+r()}{2}$	0,60	**1,00**	**0,00**	1,00
Correlation Classes	$\frac{1+r()}{2}$	0,68	**1,00**	**0,00**	1,00

Table 33. The findings in system constituents and classes.

Focusing once again on the behavior of the consistency functions in both cases reveals significant differences in random behavior, but the consistency both between the constituents and classes ranges between the theoretical maximum and minimum values. In conclusion, this change means that

> *whereas system components, in general, are consistent, differences between systems are exposed by examining how firmly and steadily the system profiles are realized.*

Appendix B.5.2 Findings in Basic Indexes

Unanimity Regarding the Current Situation and Objectives

Basic index	Interpretation and parameters used	Basic formulas used
1. Unanimity regarding the present situation	1. Low standard deviation of present within components 2. High consistency within components	$A = avg(\frac{2 - \frac{1}{12}\sum_{i=1}^{3}\sum_{j=1}^{4}\sigma(p((i,j,y)))}{2})$ $B = \frac{1 + avg(r[p_{k1}(i,j,k1,\overline{x},y); p_{k2}(i,j,k2,\overline{x},y)])}{2};$ $k1 \neq k2; ki = 1,2,3$
	Formula	$U(p,y) = \sqrt{AB}$
2. Unanimity regarding objectives	1. Low standard deviation of targets within components 2. High consistency within components	$A = avg(\frac{2 - \frac{1}{12}\sum_{i=1}^{3}\sum_{j=1}^{4}\sigma(t((i,j,y)))}{2})$ $B = \frac{1 + avg(r[t_{k1}(i,j,k1,\overline{x},y); t_{k2}(i,j,k2,\overline{x},y)])}{2};$ $k1 \neq k2; ki = 1,2,3$

General behavior / present	Average	Max	min	Variance
A	0,57	0,73	0,44	0,0090
B	0,57	0,69	0,47	0,0025

General behavior / target	Average	Max	min	Variance
A	0,47	0,75	0,21	0,0206
B	0,58	0,67	0,51	0,0012

Table 34. The findings in the unanimity regarding the current situation and the objectives.

Coherence of Developmental Challenges

Basic index	Interpretation and parameters used	Basic formulas used
3. Coherence of developmental challenges	1. High consistency between constituent 2. and class averages 3. Low standard deviation of change compasses	$A = avg(r[\alpha(i, j_1, \bar{x}, y); \alpha(i, j_2, \bar{x}, y)])$ $B = avg(r[\alpha(i_1, j, \bar{x}, y); \alpha(i_2, j, \bar{x}, y)])$ $\alpha = present, target$ $i_1 \neq i_2; i = 1-3; j_1 \neq j_2; j = 1-4$ $\lambda_j(i, y) = \sqrt{\frac{\sum_{j=1}^{j=4} (\overline{\sum_{k=1}^{K} \bar{\alpha}(i, j, x, y)} - \bar{\alpha}(i, j, y))^2}{4}}$ $C = \frac{2 - \lambda_j(i, y)}{2}$

General behavior	Average	Max	min	variance
A	0,63	0,99	0,35	0,0524
B	0,65	0,99	0,39	0,0407
C	0,77	0,87	0,62	0,0038

Table 35. The findings in the coherence of the developmental challenges.

Strategic Fit of Operational Profiling

Basic index	Interpretation and parameters used	Basic formulas used
4. Strategic fit of operational profiling	1. High consistency to strategic focus stated in all constituents 2. and classes 3. Low standard deviation of correlated change compasses	$A = avg(r[\alpha(\bar{i}, j, y); \overline{F}(i,y)])$ $\alpha = present, target$ $\lambda_j(i,y) = \sqrt{\frac{\sum_{j=1}^{j=4}(\sum_{k=1}^{K}\bar{t}(i,j,x,y) - \overline{F}(i,y))^2}{4}}$ $B = \frac{2-\lambda_j(i,y)}{2}$

General behavior	Average	Max	min	variance
A	0,64	0,99	0,27	0,0494
B	0,67	0,95	0,26	0,0587
C	0,71	0,86	0,48	0,0087

Table 36. The findings in the strategic fit of operational profiling.

Sensitivity to weak signals

Basic index	Interpretation and parameters used	Basic formulas used
5. Sensitivity to weak signals	1. High standard deviation of present 2. Low standard deviation of target	$A = avg(\frac{\frac{1}{12}\sum_{i=1}^{3}\sum_{j=1}^{4}\sigma(p(i,j,y))}{2})$ $B = avg(\frac{2-\frac{1}{12}\sum_{i=1}^{3}\sum_{j=1}^{4}\sigma(t(i,j,y))}{2})$

General behavior	Average	Max	min	variance
A	0,43	0,56	0,27	0,0090
B	0,47	0,75	0,29	0,0105

Table 37. The findings in the sensitivity to weak signals.

Challenge presented by the target level

Basic index	Interpretation and parameters used	Basic formulas used
6. Challenge presented by the target level	1. High gap level 2. High consistency between present and target within components	$A = \dfrac{\frac{1}{12}\sum_{i=1}^{i=3}\sum_{j=1}^{j=4}[\overline{a(t(i,j,y))} - \overline{p(t(i,j,y))}] - 1}{4_{(+)}}$ $B = \dfrac{1 + \frac{1}{12}\sum_{i=1}^{i=3}\sum_{j=1}^{j=4}(r[p(i,j,\bar{x},y);t(i,j,\bar{x},y)])}{2}$

General behavior	Average	Max	min	variance
A	0,29	0,47	0,01	0,0188
B	0,86	0,94	0,70	0,0051
C	0,84	0,92	0,71	0,0061

Table 38. The findings in the challenge presented by the target level.

Innovation Potential

Basic index	Interpretation and parameters used	Basic formulas used
7. Innovation potential	1. High gap level 2. High level of present 3. High standard deviation of targets 4. High levels of (I)-questions	$A = \dfrac{\frac{1}{12}\sum_{i=1}^{i=3}\sum_{j=1}^{j=4}[\overline{t}(i,j,y) - \overline{p}(i,j,y)] - 1}{4_{(+)}}$ $B = \dfrac{\overline{p}(y) - 1}{4_{(+)}}$ $C = avg(\dfrac{\frac{1}{12}\sum_{i=1}^{3}\sum_{j=1}^{4}\sigma(t(i,j,y))}{2})$ $D = \dfrac{\overline{p}(I,y) - 1}{4_{(+)}};$ $I = q(innovation;1-4)$

General behavior	Average	Max	min	variance
A	0,29	0,47	0,01	0,0188
B	0,45	0,53	0,41	0,0008
C	0,53	0,71	0,25	0,0206
D	0,47	0,55	0,40	0,0021

Table 39. The findings in the innovation potential.

Commitment to Objectives, Management ⇔ Staff

Basic index	Interpretation and parameters used	Basic formulas used
8. Commitment to objectives management <-> staff	1. High consistency between management and staff 2. calculated against each others means	$A = \frac{1 + \frac{1}{12}\sum_{\substack{i=1\\j=1}}^{\substack{i=3\\j=4}} avg[r[t(i,j,\bar{k},x_s,y);\bar{t}(i,j,\bar{k},X_m,y)]]}{2}$ $B = \frac{1 + \frac{1}{12}\sum_{\substack{i=1\\j=1}}^{\substack{i=3\\j=4}} avg[r[t(i,j,\bar{k},x_m,y);\bar{t}(i,j,\bar{k},X_s,y)]]}{2};$ $s = staff, m = management$

General behavior	Average	Max	min	variance
A	0,80	0,96	0,62	0,0117
B	0,83	0,98	0,50	0,0211
C	0,68	0,95	0,36	0,0388

Table 40. The findings in the commitment to objectives, management ⇔ staff.

Internal Networking

Basic index	Interpretation and parameters used	Basic formulas used
9. Internal networking	1. High double contingency 2. High levels of (N)-questions	$A = avg[\frac{Bin(ref_x = ref_y)}{Bin(Rnd())}]$ $B = \frac{\overline{p}(N,y)-1}{4_{(+)}};$ $N = q(networking;1-4)$

General behavior	Average	Max	min	variance
A	0,53	0,99	0,24	0,0461
B	0,47	0,55	0,40	0,0021

Table 41. The findings in internal networking.

Motivation Level

Basic index	Interpretation and parameters used	Basic formulas used
10. Motivation level	1. High levels of (M)-questions	$A = \frac{\overline{p}(M, y) - 1}{4_{(+)}};$ $M = q(motivation; 1-4)$

General behavior	Average	Max	min	variance
A	0,70	0,93	0,55	0,0049

Table 42. The findings in the motivation level.

Basic Formulas for the Indexes

In this discussion, the basic indexes are calculated straightforwardly by applying three basic rules are applied:

1. the basic indexes are calculated as weighted averages
2. the weights are determined by variance; the greater the variance, the greater the weight that ensures the maximum vividity of the index
3. the smallest basic parameter is squared in order to increase its impact on the final index.

Basic index	Formula
Unanimity regarding present situation	$=(2\sqrt{A}+B)/3$
Unanimity regarding objectives	$=(2\sqrt{A}+B)/3$
Coherence of developmental challenges	$=(3\sqrt{A}+2B+C)/6$
Strategic fit of operational profiling	$=(3\sqrt{A}+2B+C)/6$
Sensitivity to weak signals	$=(\sqrt{A}+2B)/3$
Challenge presented by the target level	$=(3\sqrt{A}+2B+C)/6$
Innovation potential	$=(3\sqrt{A}+B+4C+2D)/10$
Commitment to objectives (management <-> staff)	$=(A+2B+3\sqrt{C})/6$
Internal networking	$=(2A+\sqrt{B})/3$
Motivation level	$=A$

Table 43. The formulas for the basic indexes.

The use of these formulas gives the following results concerning the basic indexes:

Basic index	Average	Max	min	stdev	range	Confidence interval, α= o,05
Unanimity regarding present situation	**0,70**	0,75	0,65	0,03	0,10	0,016
Unanimity regarding objectives	**0,65**	0,73	0,57	0,05	0,16	0,025
Coherence of developmental challenges	**0,75**	0,91	0,64	0,08	0,27	0,043
Strategic fit of operational profiling	**0,74**	0,87	0,50	0,12	0,38	0,061
Sensitivity to weak signals	**0,54**	0,64	0,44	0,06	0,19	0,030
Challenge presented by the target level	**0,69**	0,77	0,55	0,06	0,22	0,031
Innovation potential	**0,50**	0,62	0,37	0,07	0,25	0,033
Commitment to objectives (management <-> staff)	**0,82**	0,94	0,59	0,12	0,35	0,060
Internal networking	**0,60**	0,86	0,41	0,12	0,45	0,061
Motivation level	**0,71**	0,87	0,65	0,06	0,22	0,032

Table 44. The findings in the basic indexes.

The outcome of the basic indexes calculated can, at this stage, be analyzed and interpreted from two different angles:

1. We can interpret the general behavior of the index through its standard deviation s() and range d() as reflecting its impact on the functioning of the system. The lower the s() and the smaller the d() are, the smaller the impact and vice versa.
2. We can monitor the results through s() and d() and interpret the results as guidelines as to how to balance the basic indexes when calculating main indexes geared towards the systemic efficiency factor. *The lower the s() and the smaller the d() are, the greater the attempt has to be to strengthen even its smallest variation in order to attain the values of the highest s() and the greatest d().*

However, based on the material, both aspects can be validated only by further comparing the empirical data already measured in an organization.

At this stage, we will not seek to interpret the differences in impact between the basic indexes, which have been calculated, nor will we speculate as to whether their impact should or should not be balanced with each other. Both decisions require further empirical – and, perhaps, theoretical – research.

Nevertheless, in all cases –and as the calculated confidence intervals reveal –,

all the basic indexes calculated here set solid ground for the measuring of significant differences in the systemic functioning of organizations.

Appendix B.5.3 Findings in System Profiles and Change Compasses

System Profiles, Present, Target and Gap

Basic index	Interpretation and parameters used	Basic formulas used
11. System profile, present, target and gap	Profile present, target and gap	$S_i\alpha(y)=\overline{\alpha}(i,y)$ $\lambda_i(j,y)=\sqrt{\frac{\sum_{i=1}^{i=3}(\overline{\sum_{k=1}^{K}\overline{\alpha}(i,j,x,y)}-\overline{\alpha}(i,j,y))^2}{3}};$ $\alpha = present, target, gap$

Present	Average	Max	min	variance
Mechanical	3,15	3,70	2,61	0,0802
Organic	3,50	4,06	3,10	0,0404
Dynamic	3,34	3,86	2,57	0,0539
λ	0,56	0,86	0,34	0,0157
Target	Average	Max	min	variance
Mechanical	3,71	4,70	2,43	0,3509
Organic	4,31	5,07	3,89	0,1607
Dynamic	4,28	5,17	3,59	0,1619
λ	0,70	1,12	0,40	0,0131
Gap	Average	Max	min	variance
Mechanical	0,56	1,01	-0,18	0,1330
Organic	0,81	1,24	-0,24	0,1719
Dynamic	0,93	1,51	0,17	0,1578

Table 45. The findings in the system profiles, present, target and gap.

At this stage, the results confirm the previously stated fact that

> *in profiling itself, the greatest differences between systems can be found in mechanical and organic systemic functioning.*

These differences are well in the scope of the confidence interval (0,12)

Error Profiles in the Constituents

Basic index	Interpretation and parameters used	Basic formulas used
12. Error profiles in the constituents	Error in component (i,j) target	$d_{i,j} = \bar{t}(i,j,y) - \bar{t}(i,y)$ $\lambda_j(i,y) = \sqrt{\frac{\sum_{j=1}^{j=4}(\overline{\sum_{k=1}^{K}\bar{t}(i,j,x,y)} - \overline{\alpha}(i,y))^2}{4}}$

Target / Average, d(i,j)	Mechanical	Organic	Dynamic
Capabilities	0,62	0,13	0,04
Information flow	**-0,67**	0,02	**-0,27**
Relationships	**-0,25**	**-0,09**	0,17
Management	0,29	**-0,05**	0,07

Target / Max, d(i,j)	Mechanical	Organic	Dynamic
Capabilities	1,15	0,52	0,61
Information flow	**-0,40**	0,47	**0,03**
Relationships	0,89	0,17	0,59
Management	0,97	0,41	0,43

Target / min, d(i,j)	Mechanical	Organic	Dynamic
Capabilities	-0,27	-0,26	-0,42
Information flow	-1,32	-0,49	-0,78
Relationships	-1,50	-0,67	-0,16
Management	-1,05	-0,49	-0,61

Table 46. The error profiles in the constituents.

In profiling, systems themselves exhibit significant differences when effectiveness is measured using the error compass, the errors in the components (i,j) that compose the constituents. Measuring the average error using LSQ gives, as the result, a mean error, Err() = 0,70, a standard deviation, s() = 0,11, and confidence interval of 0,058.

Despite these differences, the results reveal that

> *organizations, in general, tend to underestimate set their targets in a manner that is discrepant with the strategy of the organization in the mechanical aspects of information flows and relationships, the organic aspects of relationships and management praxis, and in the dynamic aspects of information (creation). This tendency is especially strong concerning the mechanical aspects of information flows and the dynamic aspects of information (creation).*

Appendix B.5.4 The Findings in the Main Indexes

As was previously stated (in the section Basic Formulas for the Indexes), the weighting of the impact of the basic indexes must rely on further empirical material. In this paper, we tentatively study the effect of allowing the system profile to affect the outcome. As a working model, we introduce the concepts of strategic capability and power to change by applying the weightings and formulas below.

Strategic Capability

Strategic capability		System class		
Weight of index		Mechanical	Organic	Dynamic
System profile, present		The basic index is weighted using the weights shown below according to the system class maximum and is calculated separately for the present, target, gap and Q-MOD profile.		
System profile target				
System profile, gap				
Q-MOD				
W	Unanimity regarding present situation	1,3	1,2	1,1
	Unanimity regarding objectives	1,3	1,2	1,1
	Coherence of developmental challenges	1,1	1,2	1,3
	Strategic fit of operational profiling	1,3	1,2	1,1
	Sensitivity to weak signals	1,1	1,2	1,3
Formula		$avg(Weighted(index_i)) = Basic(index_i)^{W_i(\alpha)}$ α=present, target, gap, q-mod		

Table 47. The findings in strategic capability.

The Power to Change

Power to change		System class		
Weight of index		**Mechanical**	**Organic**	**Dynamic**
System profile, present		The basic index is weighted using the weights shown below *according to the* (by) system class maximum, and calculated separately for present, target, gap and Q-MOD profile.		
System profile target				
System profile, gap				
Q-MOD				
W	**Challenge presented by the target level**	1,1	1,2	1,3
	Innovation potential	1,1	1,2	1,3
	Commitment to objectives (management <-> staff)	1,1	1,2	1,3
	Internal networking	1,1	1,2	1,3
	Motivation level	1,1	1,2	1,3
Formula		$avg(Weighted(index_i)) = Basic(index_i)^{W_i(\alpha)}$ α=present, target, gap, q-mod		

Table 48. The findings in the power to change.

The overall effect of the weighting procedure is shown in the table below together with the main indexes for the *strategic capability* and *power to change*.

Index	Non-weighted	W by present	W by target	W by gap	W by Q-MOD
Unanimity regarding present situation	0,70	0,65	0,66	0,67	0,65
Unanimity regarding objectives	0,65	0,61	0,62	0,62	0,61
Coherence of developmental challenges	0,75	0,70	0,69	0,69	0,70
Strategic fit of operational profiling	0,74	0,70	0,71	0,71	0,70
Sensitivity to weak signals	0,54	0,48	0,46	0,46	0,48
Challenge presented by the target level	0,69	0,63	0,62	0,62	0,63
Innovation potential	0,50	0,43	0,42	0,42	0,43
Commitment to objectives (management <-> staff)	0,82	0,79	0,78	0,78	0,79
Internal networking	0,60	0,54	0,53	0,53	0,54
Motivation level	0,71	0,67	0,66	0,65	0,67
Strategic capability	0,67	0,63	0,63	0,63	0,63
Power to change	0,66	0,61	0,60	0,60	0,61

Table 49. The effect of the weighting procedure.

As can be seen from the results, the net outcome is, in general, negligible. However, from the point view of an internal effect in a single system, the changes in the basic indexes, calculated here, range from Min()= 0,01 to Max() = 0, 07, comprising an internal change of Max() = 10 %. As this can be considered a pure mathematical fact, we argue that

For establishing the dependencies between the basic indexes and system classes, the weighting of the basic indexes must be elaborated further based on a systemic analysis of a larger amount of empirical data.

Appendix B.6 Systemic Efficiency Considerations

In order to make the systemic efficiency numerically visible, we decided to scale the final indexes by setting the average at 100 and scaling each index against the average. The results for thirteen (13) organizations are shown in the table below together with a preliminary *systemic efficiency* index as a direct average of the *strategic capability* and *power to change*.

	System												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Index													
Unanimity regarding present situation	105	103	98	94	95	106	101	104	108	92	101	95	97
Unanimity regarding objectives	113	108	107	91	93	102	103	101	109	86	100	90	96
Coherence of developmental challenges	103	90	92	128	120	94	93	99	90	91	97	122	83
Strategic fit of operational profiling	62	67	90	119	122	117	116	99	101	87	102	116	101
Sensitivity to weak signals	123	116	118	84	90	102	100	100	115	76	97	84	95
Challenge presented by the target level	100	96	96	101	98	96	87	100	76	115	112	110	112
Innovation potential	91	95	95	110	104	94	83	92	70	128	104	120	113
Commitment to objectives (management <-> staff)	95	114	113	119	95	117	101	67	67	106	118	88	98
Internal networking	91	77	75	61	114	93	84	104	157	126	120	95	102
Motivation level	129	111	98	94	88	106	98	93	89	93	110	95	96
Strategic capability	**99**	**95**	**100**	**105**	**106**	**104**	**103**	**100**	**104**	**87**	**100**	**103**	**94**
Power to change	**102**	**101**	**97**	**98**	**99**	**103**	**92**	**89**	**90**	**112**	**114**	**100**	**103**
Systemic efficiency	**101**	**99**	**98**	**101**	**102**	**104**	**98**	**94**	**98**	**100**	**108**	**100**	**98**

Table 50. The scaled results for 13 organizations.

The general behavior of the scaled indexes is shown in the table below.

Index level / Behavior	Basic indexes	Main indexes	Systemic efficiency
Average	100,00	100,00	**100,00**
Standard deviation	14,67	6,25	**3,51**
Max	157	114	**108**
Min	61	87	**94**
Range	**96**	**27**	**14**
Percentual difference between max and min	**158 %**	**30 %**	**15 %**
Confidence interval, α = 0,05, n = 13	**7,9**	**3,3**	**1,8**

Table 51. The general behavior of the scaled indexes.

Appendix B.7 Summary of the Findings and General Conclusions

Based on the general behavior of the basic parameters as well as of the basic and main indexes, we argue that

1. the indexes can reveal *significant differences in the systemic efficiency factor* of organizations
2. the indexes, in conjunction with the change compasses (i.e., the error profiles within constituents), are adequate and grounded representations of *the structure of the systemic efficiency factor*.

Decision of whether or not the weightings used in the calculation of the basic and main indexes are adequate must rely on a further investigation based of a broader database.