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Cybernetically sound organizational structures I: de Sitter's design theory

Organizational
structures I

405

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Abstract

Purpose – The purpose of this paper is to use de Sitter's design theory to show how organizational structures can be designed so as to attenuate organizational disturbances and amplify regulatory potential. It is argued that organizational structures with low values on so-called design-parameters are themselves no source of disturbances and have the required built-in regulatory potential.

Design/methodology/approach – Key concepts from de Sitter's design theory are introduced and used to show how structures can attenuate disturbances and amplify regulatory potential.

Findings – The analysis in this paper deepens our understanding of the role of organizational structures for dealing with organizational complexity, and of the design parameters that should be manipulated to achieve structural attenuation and amplification.

Practical implications – Having a structure permitting organizations to attenuate and amplify is a crucial condition for organizational viability. This paper provides guidelines for the design of such structures.

Originality/value – This is one of a limited number of studies that makes apparent how general insights from (management) cybernetic (e.g. viability, attenuation and amplification) may be realized in organizations by their structural design.

Keywords Organizational structures, Organizational design, Cybernetics

Paper type Conceptual paper

1. Introduction

This is the first of two consecutive papers presenting a cybernetic perspective on designing organizational structures in this special issue of *Kybernetes*. Its aim is to show how organizational structures can support organizations to deal with complexity.

In general, dealing with complexity – i.e. dealing with disturbances threatening systemic survival – may be thought of in two ways: by reducing the probability of the occurrence of disturbing events (“attenuation”) and by adding regulatory potential (“amplification”) see Ashby (1958) or Beer (1995, 1996). If one wants to understand how organizations can increase their chances of survival by means of attenuation and amplification, one has to model “organizational survival” (e.g. in terms of variables describing the relation between organization and environment), and describe how attenuation and amplification may come about, organizationally. Many authors have already applied this overall logic of “dealing with complexity by means of attenuation and amplification” to the context of organizations (Galbraith, 1973; Beer, 1995, 1996; Espejo *et al.*, 1996). Beer and Espejo use the term “variety engineering” in this respect.

In this paper, we focus on a particular way in which attenuation and amplification may be realized in organizations: by means of how tasks in organizations are defined and related into a network of tasks, i.e. by means of their structure. We will do so, drawing from



a design theory put forward by de Sitter (1994) and Sitter *et al.* (1997). In particular, we will use his design theory to arrive at a model of organizational survival and to discuss how structures may contribute to survival in terms of attenuation and amplification.

Although attenuation and amplification in organizations may come about in many different ways, we think that highlighting the role of organizational structures is particularly relevant. It is important, because structures often are themselves an important source of disturbances and it pays off to redesign them so as to reduce their “disturbing effect”. One only has to think of all those pointless meetings, of the inertia associated with large hierarchies of regulators – hierarchies in which our requests of any kind seem to vanish; of production lines with short-cycled tasks, making us feel alienated and unmotivated; or of the many large functional departments producing products in batches, resulting in a large and expensive amount of stock, to see that a particular structure may itself be a source of disturbances, threatening the realization of our task-related (and, in the end, the organization’s) targets and goals. In this paper, we set out to show that by properly designing (or redesigning) organizational structures one can make sure that these structures themselves cease to be a major source of disturbances. Phrased differently: redesigning structures makes it possible to realize “organizational” attenuation.

However, the fact that structures can be an important source of disturbances is not the only reason to focus on them. The survival of organizations crucially depends on their regulatory potential – a potential that is built into the network of tasks. Now, a second reason to focus on structures has to do with the assumption that it matters how this potential is allocated to tasks. For instance, taking regulatory potential away from operational tasks (and allocating it to a “regulatory hierarchy”) may reduce the swiftness and the relevance of reactions to disturbances in operational processes – a reasoning that has been used by many to arrive at “flat” organizational structures, making apparent that “empowering lower echelons” with appropriate “discretionary power” is good management. A structure, then, should be designed in such a way that the organization’s regulatory potential is available when and where needed; or to put it in a slightly different way: a structure should amplify requisite regulatory potential.

Given our emphasis on organizational structures as a means to attenuate and amplify complexity, the relevance of discussing de Sitter’s design theory can be appreciated. His theory is particularly suited for helping us to understand why and how organizational structures may themselves be a source of disturbances, and that, based on this understanding it can help us to design organizational structures that reduce the probability of structure-related disturbances. At the same time, his theory may help us to understand how regulatory potential can be built into tasks effectively. In all, his theory is particularly suited for designing organizational structures that attenuate disturbances and amplify regulatory potential.

In order to discuss the design of such “cybernetically sound structures”, we organize this paper as follows. In Section 2, we use concepts from de Sitter and Ashby to formulate a model of organizational survival; we identify the kind of disturbances that may threaten it and define “cybernetically sound structures” as structures that attenuate disturbances and amplify regulatory potential. In Sections 3 and 4, we discuss how such structures may be designed. Section 3 discusses de Sitter’s “design parameters”; parameters that serve as guidelines for the design of organizational structures. In Section 4, we will discuss how these parameters can be used, according to de Sitter, to design “cybernetically sound structures”. Section 5 provides a summary and a conclusion.

2. Defining “cybernetically sound organizational structures”

Since the aim of this paper is to describe the design of attenuating and amplifying organizational structures, a necessary first step should be to explain what we mean by “structures that attenuate and amplify”. In the introduction we have already given a preliminary description, but in this section we want to define these structures more precisely. In order to do that, we start by discussing some basic cybernetic concepts and describe how attenuation and amplification are linked to systemic survival. Next, we will apply these concepts to describe organizational survival and regulation. Finally, based on this model we define the contribution of organizational structures in terms of attenuation and amplification; that is, we define “cybernetically sound structures”.

2.1 Cybernetic background

In order to understand how organizational structures may attenuate and amplify it is helpful to start with a short exploration of Ashby’s description of “machines and their behavior” (Ashby, 1958). As he describes it, a machine (some concrete unity, such as organisms or organizations) shows particular behavior. He proposes to describe this behavior in terms of the flow values of certain variables. He further suggests paying special attention to so-called essential variables. Essential variables are variables that are closely tied to the survival of the machine: if they are outside certain limits (for too long), the machine disintegrates. So, for example, for a human being blood pressure and bodily temperature are essential variables – if they are outside certain limits, we die. Now, in the course of its survival, a machine may encounter all kinds of disturbing influences that may threaten its essential variables, and in order to counter them, it depends on “regulatory potential” – the potential to deal with disturbances.

Now, based on this simple regulatory logic of selecting regulatory activities in order to make sure that essential variables have appropriate values, despite the occurrence of disturbances, it becomes possible to make some general statements about the effectiveness of the “machine” or concrete unity in its efforts to survive. For instance, given a particular set of disturbances, the mechanism should dispose of “requisite regulatory variety” – enough regulatory actions, to cope with all possible disturbances. If it does not have the requisite regulatory potential, it should try to extend it. This is what is called amplification of regulatory potential. If the set of disturbances is not fixed, that is, if it may be altered, another option to deal with disturbances is to decrease the probability of their occurrence (as disturbance). (Note that, if one succeeds in reducing this probability to 0, one has eliminated the disturbance.) Reducing the probability of the occurrence of a disturbance may be called attenuation. So, amplification enables a concrete unity to deal with disturbances that may affect its essential variables; attenuation makes sure that those disturbances occur less frequently, or even no longer occur at all. Of course, if attenuation completely succeeds, the unity no longer has to deal with the disturbance, and hence, it may be a good idea to start with attenuation and, next continue with amplification.

2.2 Essential organizational variables

In this paper, we apply the above regulatory reasoning to organizations and ask ourselves how attenuation and amplification may come about by means of organizational structures. However, since attenuation and amplification have to do with “dealing with

disturbances affecting essential variables”, we should first explain what essential variables and disturbances are in the case of organizations.

As we have said before, essential variables are closely linked to survival; i.e. survival is secured as long as these variables stay within certain limits. de Sitter translates this idea to organizations and proposes three classes of variables organizations should keep in check in order to survive. These are: “quality of organization”, “quality of work” and “quality of working relations” (de Sitter, 1994, pp. 41-2). de Sitter defines the quality of organization as the organization’s capability to realize and adapt its goals in an effective and efficient way. The quality of work refers to organizational members relations to their job, e.g. in terms of the job’s meaningfulness or (the possibility to deal with) work related stress. The third class of variables, the quality of working relations, refers to the effectiveness of communication in organizations. In our paper, we will for the sake of brevity, only focus on the first two of these classes of variables.

de Sitter further uses these two classes of essential variables to arrive at what he calls “functional requirements”, that is, specific variables falling within these two classes with specific desired values. In doing so, he makes a distinction between so-called “external functional requirements” and “internal functional requirements” (Table I). According to de Sitter, external functional requirements express the desired relation between organization and environment: if they have appropriate levels, the organization maintains a balanced relation with its environment, thus securing its viability. Internal functional requirements are translations of external functional requirements into internal conditions that an organization should realize, so as to satisfy the external functional requirements. The set of internal requirements is de Sitter’s set of essential variables and desired values: if these requirements have appropriate levels, external requirements will be realized, and, hence, the organization’s viability will be secured.

A closer look at both classes of essential variables sheds more light on de Sitter’s functional requirements. de Sitter divides the class “quality of organization” into three external requirements:

- (1) the level of customer orders’ flexibility (the organization’s potential to react to changes in demand);

Class	External functional requirements	Internal functional requirements
Quality of organization	Order flexibility	Short production cycle time Sufficient product variations Variable mix of products
	Control over order realization	Reliable production and production time Effective control of quality
	Potential for innovation	Strategic product development Short innovation time
Quality of work	Low level of absenteeism	Controllable stress-conditions
	Low level of personnel turnover	Opportunities to (1) be involved, (2) learn, and (3) develop
Quality of working relations	Effective communication	Shared responsibility
		Participation in communication

Table I.
de Sitter’s list of
functional requirements

Source: Adapted from de Sitter (1994, p. 42)

-
- (2) the level of control over the production process (the organization's potential to live up to required production-demands – e.g. in terms of quality and delivery demands); and
 - (3) the potential for innovation (i.e. being able to come up with required product or process innovations).

de Sitter holds that if these requirements are met, survival is secured (Table I). High levels of order flexibility and control of the production process secures the effective and efficient realization of the organization's goals, and a high level of innovative potential realizes the required adaptation of organizational goals.

However, given these three variables, one may ask what is needed in organizations to ensure high values on flexibility, control and innovative potential. To answer this question, de Sitter proposes a further specification of these requirements into internal functional requirements. For instance, he holds that flexibility is realized by ensuring short production cycle times, sufficient product variations and a variable mix of products. In the table, it can also be seen which requirements, according to de Sitter, should have appropriate levels to ensure control over production and potential for innovation.

de Sitter also divides his second class of essential variables (the quality of work) into external and internal requirements. He proposes “a low degree of absenteeism” and “a low degree of personnel turnover” as external requirements. Low values of absenteeism and turnover may indicate that a high quality of work is realized. He further indicates that one reaches low levels of absenteeism and personnel turnover if one secures:

- (1) “controllable stress-conditions”; and
- (2) the “opportunity to be involved, to learn and develop”.

For de Sitter, the degree to which an organization succeeds in realizing these two internal requirements determine the quality of work.

Quality of work is important for organizational survival in several ways. First, as de Sitter points out, if the quality of work is high, it means that the organization is regarded as an “attractive employer”, thus securing a balanced relation with the labor market. Achterbergh and Vriens (2010) point at another reason for paying attention to the quality of work. They describe survival as “being able to maintain a separate, *meaningful* existence”, and part of such a meaningful existence can be delivering a contribution to society. Realizing a high quality of work can then be regarded as an instance of the organization's contribution to society. That is, by realizing a high level of quality of work, organizations contribute to enabling members of society to develop and realize their humanity within an organization.

As we have pointed out, the list of internal functional requirements is de Sitter's list of essential variables with desired norm values. With respect to this list, several questions may come up. One important issue concerns the completeness of this list. Are these really the only variables one should pay attention to, in order to survive? de Sitter might respond that this list is a hypothetical list about what should be realized in order to maintain the organization's viability. But, the list is one that, in our view, one can easily relate to – it is not hard to imagine that organizational survival requires that organizational goals should be realized efficiently and effectively and that these goals should be adapted (quality of organization); moreover it requires a motivated

workforce developing and using its potential (quality of work). In fact, we think, that it is hard to come up with other requirements that are not related to those figuring in de Sitter's list.

The list of functional requirements (Table I) comprises de Sitter's set of essential variables and their norm values (e.g. essential variable: production cycle time; norm value: short). If the internal requirements are met, the external requirements are met and the organization's viability is secured. de Sitter further argues that it is the task of a designer to design an organizational structure that aids in meeting all these requirements at the same time. Therefore, the overall adequacy of an organizational structure should be evaluated in terms of its capacity to contribute to satisfying all internal, and hence external, requirements.

2.3 Defining structural attenuation and amplification

Given de Sitter's set of functional requirements, it is possible to identify many disturbances threatening their realization. Examples of such disturbances are: people getting sick, machines breaking down, suppliers delivering the wrong material, lack of communication between departments, lack of overview over the process, a large amount of stock, waiting time of work-in-process, lack of motivation, redundant meetings, etc. With respect to these disturbances it is possible to make a distinction between two broad classes of disturbances, those that are and those that are not related to the structure of organizations. For example, people may get sick independent of how tasks are defined and coupled into a network of tasks. However, disturbances can also be related to the organizational structure. We would like to point at two important relations:

- (1) structures may themselves be a source of disturbances (e.g. many lean organization theorists argue that stock and waiting times are caused by the structure of an organization – see Womack *et al.*, 1990); and
- (2) structures may increase the probability of the dispersion of disturbances if they lack regulatory potential to deal with them.

For example, if a supplier delivers the wrong material and if the organization lacks the requisite regulatory potential to deal with it, it may affect the whole production process. In this case, disturbances are “dispersed throughout the organization”.

Based on these two types of disturbances, it now becomes possible to be somewhat more precise about attenuation and amplification by means of organizational structures. “Structural attenuation” can be taken to mean that a structure is designed in such a way that it ceases to be a source of disturbances and disturbance-dispersion (or: that probability of disturbances caused by the structure is reduced as much as possible). “Structural amplification” means that a structure is designed in such a way that it has the regulatory potential to deal with disturbances that cannot be attenuated away.

3. Designing “cybernetically sound structures”: de Sitter's design parameters

Now that we have explained the desired effect of organizational structures – attenuation and amplification with respect to two types of functional requirements, we can turn our attention to building these structures. In order to build them, de Sitter states that designers should make sure that so-called “structural design-parameters” have “low values”. de Sitter discusses seven design parameters that describe particular characteristics of organizational structures. These parameters can be used by

designers to diagnose and design a particular organizational structure. He treats these parameters as dimensions that can have a specific value. de Sitter's general idea is that specific values of these parameters have an effect on attenuation and amplification, which, in turn have an effect on the realization of the functional requirements, and, hence, on the viability of the organization (Figure 1).

Now, with respect to these values de Sitter formulates his overall design-guideline: the lower the values on these design parameters, the more the underlying structures will be able to attenuate and amplify, and the better the prospect of realizing the functional requirements. In this section we will explain this guideline for design. That is, we will discuss de Sitter's design parameters and show how organizational structures with high and low values on these parameters look like. In Section 4, we will discuss why low values on these parameters lead to attenuation and amplification and, hence, to a better prospect of realizing the functional requirements.

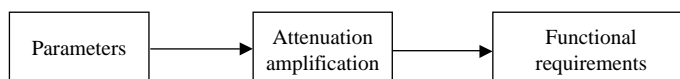
3.1 de Sitter's design parameters

de Sitter's parameters can be divided into three groups. One group of parameters mainly refers to operational activities in organizations – those activities that are directly related to realizing the organization's output. This group of parameters describes what de Sitter calls the production structure (the grouping and coupling of operational activities into tasks and their relation to orders). A second group of parameters refers to the organization's regulatory potential (i.e. those activities related to "dealing with disturbances"). This group of parameters describes what he calls the control structure (the grouping and coupling of regulatory activities into tasks and their relation to operational tasks). Finally, he identifies one parameter that relates to the "separation" between operational and regulatory activities.

3.1.1 Parameters describing the production structure

3.1.1.1 Parameter 1: the level of functional concentration. The first design parameter is called functional concentration, and refers to the degree to which operational tasks are coupled to all order types (de Sitter, 1994, p. 43). If this parameter has a high value, all operational tasks are (potentially) coupled to all order types. In such a structure, workers perform tasks related to all possible order types. If functional concentration has a low value, all operational tasks necessary for the production of some order type, are only coupled to this specific order type.

To understand this parameter, consider a factory producing two types of orders: tables and chairs. In this factory, the operational tasks consist of all the operational activities needed to realize these orders (e.g. sales, planning, maintenance, sawing pieces of wood, drilling, assembling parts into tables and chairs, and distributing tables and chairs). Now, producing tables and chairs can be realized in structures with a different level of functional concentration. In a structure with a high level of functional concentration, operational tasks (planning, sales, sawing, drilling, etc.) are tied to both order types (i.e. to tables or chairs) – see Figure 2. In this lay-out, someone whose task it is to saw pieces of wood may perform this task for either tables or for chairs.



Note: Parameter values affect attenuation and amplification, which, in turn, affect functional requirements

Figure 1.
de Sitter's general
contention

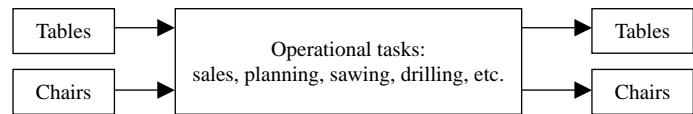
Figure 3 shows a production structure with a low level of functional concentration. In this case, each order type has its own particular set of operational tasks. That is, there is one set of activities dedicated to producing tables, and one that only produces chairs. In a structure with low functional concentration, so-called (more or less autonomous) “parallel flows”, coupled to types of orders may appear. In such a structure, a worker only performs a task related to one order type.

3.1.1.2 Parameter 2: the level of differentiation of operational activities. The second design parameter is the level of differentiation of operational activities. According to de Sitter (1994) three types of operational activities can be differentiated: “making”, “preparing”, and “supporting”. Making refers to actually producing an order – for instance, performing the sequence of activities, needed to actually make a table. Preparation refers to providing the necessary conditions for performing “make”-activities (e.g. scheduling “workers”; providing the required raw materials, tools and equipment for producing a table). Typical preparation activities in organizations are purchase, sales or planning. Both making and preparing are directly tied to the orders an organization realizes. Support activities refer to all operational activities that are indirectly tied to producing orders, such as maintenance, human resources management, or technical service.

The level of differentiation of operational transformations is “high” if operational activities are grouped into different “make”, “prepare”, and “support” tasks, and low if operational tasks contain make, prepare and support activities. So, in the furniture factory a high level of differentiation leads to specific make-tasks (e.g. a drilling task), specific preparation tasks (a planning task) and to specific support tasks (machine-maintenance). In a factory with low differentiation of operational activities, one may identify tasks that contain, e.g. planning, make and support activities.

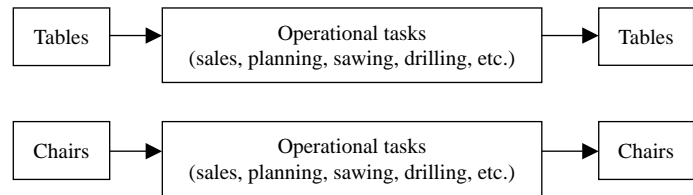
3.1.1.3 Parameter 3: level of specialization of operational activities. The level of specialization of operational activities refers to the degree to which activities are split up into small (short-cycled) sub-tasks. For instance, the operational activity “producing a chair” may be split up into sawing, drilling, painting, and assembling. Moreover, these operational activities may be further specialized into “sawing the chair’s back”, “sawing its seat”, and “sawing its support”. These may be further decomposed into smaller

Figure 2.
High level of functional concentration



Note: All operational tasks are (potentially) coupled to all order types

Figure 3.
Low level of functional concentration



Note: All order types have their own specific set of operational tasks

sawing activities, and eventually assigned as separate tasks to individual workers. A high level of specialization indicates that operational activities are decomposed into small activities and that these highly decomposed activities are assigned to one task. A low level of specialization indicates that many coherent operational activities are integrated into one task. So, for instance, in a factory with a low level of specialization, a task may be to “make a chair”, while in a factory with a high level of specialization, tasks such as “sawing left front leg, upper part” may exist. It should be noted that specialization may concern make, support as well as preparatory activities.

3.1.2 *A parameter relating to the separation between operational and regulatory activities (parameter 4).* The fourth parameter is called the level of separation between operational and regulatory activities and refers to the degree to which the operational and the regulatory part of organizational activities are assigned to different tasks. To understand this parameter, it is helpful to see that, according to de Sitter, every activity in an organization (e.g. making a chair) contains an operational and a regulatory part. The operational part refers to realizing this output; to actually making the chair, and the regulatory part refers to “dealing with disturbances occurring in the operational part”. Now, a high level of separation means that the operational and regulatory parts with respect to some activity are assigned to different tasks. In this case, “operational tasks” depend for regulation on separate “regulatory tasks”. In the factory example, there may, for instance, be one organizational member sawing pieces of wood, while another member is responsible for dealing with the disturbances encountered while sawing the wood.

Separation is low if a task consists of both the operational and the regulatory part. Workers performing these tasks may realize particular output and they may have the regulatory potential to deal with disturbances themselves.

Much separation leads to a distinct control and production structure – it leads to two separate networks of tasks: one devoted to producing orders and one devoted to regulating the first. Low separation leads to one network of tasks comprising both operational and regulatory activities (Achterbergh and Vriens, 2010).

3.1.3 *Parameters describing the control structure*

3.1.3.1 *Parameter 5: the level of differentiation of regulatory activities into strategic regulation, regulation by design and operational regulation.* According to Ashby (and de Sitter), three types of regulation exist: strategic regulation (dealing with disturbances by reformulating goals); regulation by design (dealing with disturbances by changing the organization’s infrastructural conditions, e.g. by hiring new personnel, by changing the structure of an organization, or by installing new ICT) or operational regulation (dealing with disturbances that impinge on primary processes given a particular set of infrastructural conditions – by means of error or cause controlled regulation (Ashby, 1958)).

The level of this type of differentiation is high if these types of regulation (strategic regulation; regulation by design, and operational regulation) are assigned to different tasks. An example of this is an organization where the board deals with strategic regulation, a staff of engineers takes care of regulation by design, and workshop managers take care of operational regulation. The level of differentiation of regulatory tasks is low if these three forms of regulation are combined into one task. For instance, a furniture maker, in his own studio, who takes his own strategic decisions, redesigns his own shop, and regulates making furniture to his own standards. In a large

production or service organization, a higher level of differentiation does not necessarily mean that everybody is involved in setting all organizational goals. It does mean that organizational members are, at least, involved in setting goals at appropriate levels (e.g. at individual task, team, or flow level).

3.1.3.2 Parameter 6: the level of differentiation of regulatory activities into monitoring, assessing and acting. de Sitter (1994, p. 94) explains that regulation always consists of three related activities: one has to monitor some process, one has to find out whether the process lives up to certain standards (assessment), and if it does not, one has to intervene in some way to make sure that the process will live up to particular standards in the future (acting). Now, this sixth design parameter describes the degree to which these three regulatory sub-activities are assigned to different tasks. The level of this parameter is high if these activities are indeed assigned to different tasks, and low if they are integrated into one task. As an example of high differentiation, think of low-level production bosses, who are continuously monitoring specific variables with respect to some process (e.g. the number of pieces of wood passing through his department; the amount of waste material; the number of requests for maintenance, etc.). Other managers may aggregate such data and compare them to norm values (e.g. the accepted level of waste material) and signal problems. Another group of managers may be responsible for taking action – , e.g. changing the layout of the process so as to reduce the amount of waste. In a factory having a low level of differentiation a team of workers may exist that is continuously monitoring and assessing their own operational activities and also intervening in their own activities to do something about particular disturbances themselves.

3.1.3.3 Parameter 7: the level of specialization of regulatory activities. As with specialization of operational activities, this parameter refers to the degree to which regulatory activities are split up into regulatory sub-activities and assigned to different tasks. The value of this parameter is high if regulatory activities are divided into small activities and assigned to separate tasks. For instance, operational regulation may be decomposed into several regulatory sub-activities: dealing with product quality, with efficiency, with personnel, etc. and each of these specialized transformations may become a separate task. A low level of specialization integrates such regulatory activities into one task.

3.2 High and low parameter value structures

In Section 4 we intend to show that structures with high parameter values are themselves a source of disturbances and contain insufficient regulatory potential to secure the realization of functional requirements, and, that structures with low parameter values have an opposite effect. However, before we can discuss this, it is helpful to first describe organizational structures with high and low values.

In Figure 4, an organizational structure with high values on all parameters is given. A high level of functional concentration (parameter 1) leads to a production structure in which tasks are potentially coupled to all order types (products x, y and z in the figure). A high level of differentiation of operational activities (parameter 2) leads to separate tasks that are specialized in make, prepare or support activities. A high level of specialization of operational activities (parameter 3) splits operational activities up into short-cycled sub-tasks. In the figure, specialization is only marginally depicted – tasks are only split up into four sub-tasks – normally, specialization leads to a great many

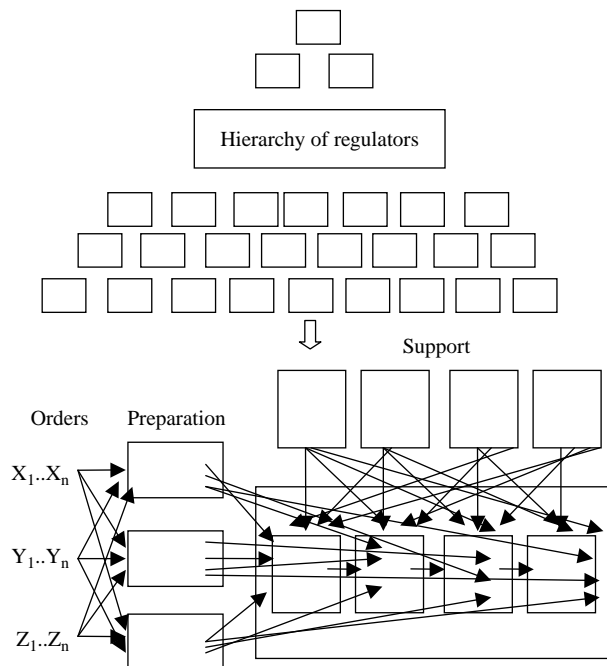


Figure 4.
An organizational
structure with high values
on all design parameters

short-cycled jobs. The figure also shows that regulatory activities are separated from operational activities (parameter 4) and that they are split up into small regulatory tasks (parameter 7), leading to a hierarchy of regulators having only a limited regulatory scope (the figure does not show all the relations between regulatory tasks and between regulatory and operational tasks). Differentiation of regulatory activities (parameters 5 and 6) is not explicitly drawn in the figure.

In practice, such high-value organizational structures tend to group operational activities of the same type into specialized departments (e.g. in a “sales department”, a “planning department”, a “sawing department”, etc.).

Although the structure in Figure 4 already gives some idea of the complexity of the resulting network of tasks, it does not – by far – represent the complexity emerging in “real-life organizations with high-level-parameter-values”, which have far more functional departments (for preparation, support and making) and the specialization into small tasks may be taken much further. de Sitter’s shorthand for describing high-parameter value structures is: “complex networks relating many simple tasks”.

Figure 5 shows an organizational structure in which the design parameters have low values. In such structures, a low level of functional concentration leads to so-called parallel order-flows. Each of these order-flows is dedicated to producing one type of order. Because of a low level of differentiation in each flow, making, support and preparation activities are integrated as much as possible. In addition, because of a low level of specialization, activities are not split up into many short-cycled tasks. As compared to the production structure with high parameter values, this structure does not have “functional departments” in which specific activities are central. Instead, activities are organized

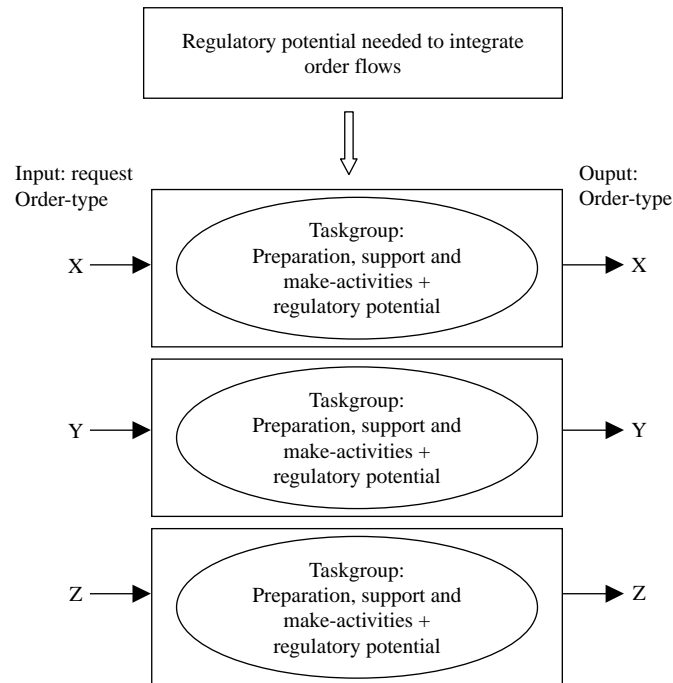


Figure 5.
An organizational
structure with a low
values on design
parameters

around more or less autonomous parallel flows producing a specific type of output (e.g. a specific type of order – e.g. qua product; type of customer or geographical area). Within these flows, activities required to produce the output are integrated into so-called “task-groups” or semi-autonomous groups (de Sitter, 1994 or Galbraith, 1973).

Ideally, these task-groups contain all required activities (prepare, support and make) to produce the output of the order-flow (e.g. some product or order type). In addition, such task-groups should also contain the necessary regulatory potential to deal with the disturbances they face. That is: the level of separation between regulatory and operational activities is low – there is no separate network of regulators – ideally, regulation is integrated in task-groups. Moreover, regulatory tasks are not split up or differentiated, but part of the work of team members. This leads to a high level of autonomy of the order-flows. However, to be part of one organization, they still require some additional regulatory potential securing their integration (e.g. regulation regarding the formulation of a joint strategy or taking advantage of certain economies of scale).

de Sitter points out that, in practice, this structure may be asking too much. Sometimes, for instance, a particular production process requires a large number of complex activities which makes it impossible for one task-group to cover the entire production flow (although there are examples of task-groups that are able to manage quite complex process – e.g. a group of nine people, capable of assembling a whole car, de Sitter, 1994). In such cases, de Sitter proposes to introduce (serial or parallel) segments in a flow, and to assign task-groups to these segments. Such segments should be defined

in such a way that they are “as autonomous as possible” – that is, these segments should have a high internal coherence and few relations with other segments.

He also adds that introducing additional regulation to integrate task-groups (e.g. joint strategy formulation or securing economies of scale) does not necessarily mean an additional network of regulators: this may be realized by representatives of task-groups.

So, in all, in low-parameter structures, task-groups do not only have the operational, but also the regulatory means to produce the desired output. There is no hierarchy of many small regulatory tasks, all aimed at different regulatory aspects. Instead, the control structure is “flat” and consists of “integrated” regulatory tasks, including as many regulatory aspects, covering as much of the production structure as possible. If high parameter value structures can be characterized as complex structures with simple jobs, low parameter value structures can be characterized as simple structures with complex jobs. That is, high-parameter value structures are large complex networks, relating simple tasks, while low-parameter value structures are simple networks with more or less autonomous parallel order-flows with a built-in control structure, containing complex jobs (integrated tasks – involving both many operational as well as regulatory sub-transformations) – see also Achterbergh and Vriens (2010) for an extensive elaboration of these structures.

4. Cybernetically sound structures require low values on design parameters

Given an idea of what organizational structures with high- and low-parameter-values may look like, we will now turn to discussing why structures with low parameter values attenuate and amplify. To this end, in Section 4.1 we elaborate what are, in general, causes for structure related disturbances. In Section 4.2 we use this elaboration to show that high parameter structures are themselves sources of disturbances and lack regulatory potential, and therefore endanger the realization of functional requirements. Finally, in Section 4.3 we explain that low parameter structures attenuate and amplify and provide opportunities for realizing functional requirements.

4.1 General causes of disturbances

To understand how a structure may itself contribute to disturbances de Sitter invites us to consider a task as a node in a network of tasks that have relations to other tasks. For instance, a particular “make-task” in a large network of tasks is related to planning, maintenance, to other make-tasks, to an HR department, to a boss, to material planning, etc. Now, according to de Sitter there are at least two reasons why performing a task can be difficult: if it has to deal with many disturbances and if it lacks regulatory potential.

The probability of a disturbance depends, according to de Sitter, on at least two things:

- (1) the number of relations a task has with other tasks in the network of tasks; and
- (2) the variability of these relations.

The number of relations of one factor determines the probability of a disturbance. As de Sitter points out: as every relation may itself be a source of something going wrong, the higher the number of relations, the higher the probability of something going wrong. He also explains that high variability of a relation causes disturbances.

He defines variability of a relation as “the variety of the content flowing through this relation” (e.g. the number of different messages, or the number of different pieces of material). As an example, consider a restaurant with one waiter and one chef. Here, there are two tasks, having one relation. The variability of this relation depends on the number of items on the menu. In fact, the total number of different orders is at least as high as $2^{(\text{number of menu-items})} - 1$. To show how this number is calculated, consider three menu items: A, B and C. At any moment in time each menu-item can be ordered or not – leaving $2^3 - 1 = 7$ different possible orders: A, B, C, AB, AC, BC and ABC. (For sake of simplicity, we are not counting the number of the same orders, which, in reality, should be taken into account.) Now, the higher the variability of a relation, the higher is the probability that something goes wrong. The most important reason for this is that every different order combination means something different for a task. In the waiter-chef example: every different order means using different ingredients, using different material, and performing a different set of activities. The more combinations there are the more pressure there is on the chef to produce them.

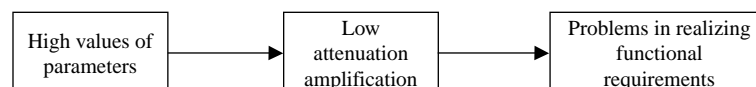
So, de Sitter argues that the probability of something going wrong in a task depends on (at least) the number of relations it has with other tasks and the variability of these relations. Moreover, many relations with high variability increase the probability of disturbances even more – because in that case a task has to react to a combination of variable relations.

In all, tasks become difficult because of a high probability of disturbances. A high probability of disturbances is, of course, problematic for the tasks experiencing them. It means that these tasks have to deal with many possible disturbances, which requires extra effort. However, the fact that tasks have to deal with them may not be the only problem for a network of tasks with a large number of relations with high variability. If tasks lack the regulatory potential to deal with disturbances, these disturbances get dispersed throughout the network of tasks, e.g. other tasks receiving the output too late, or receiving flawed output. Disturbances that are passed on to other tasks either have to be dealt with by those other tasks, or they are, again, passed on. So, on top of a high probability of disturbances, lack of regulatory potential leads to even more disturbances, as they are dispersed throughout the network of tasks.

4.2 High parameter values are sources of disturbances and lack regulatory potential

In this section, we set out to explain that organizational structures with high values on the design parameters are themselves sources of disturbances and lack regulatory potential (that is, they do not attenuate or amplify) and thus negatively affect the realization of functional requirements – see Figure 6. To explain the negative effect of high parameter values we start with the parameters related to the production structure and, next, discuss the effect of the other parameters. In the discussion of these parameters, we intend to show how high values lead to low attenuation and amplification. In addition, we will discuss how they lead to problems in realizing functional requirements – but since the possible negative effects are rather numerous and quite divers, we will only give an impression of these problems.

Figure 6.
Outline of the
argumentation of
Section 4.2



High functional concentration means that operational tasks are potentially coupled to all order types. If a furniture factory produces four types of chairs and three types of tables, the number of possible order-combinations is $2^7 - 1$ (= 127 – again: every type of chair or table can be part of an order at a particular moment in time or not). This means that the production system should be able to handle 127 different order combinations. Now, since each order combination means something different for the system (different planning, different make-activities, different material, etc. – this is similar to the waiter-chef example above) the variability of the relations of the tasks in this production system is at least 127 (and, in fact, this is an underestimation, since we are not yet taking into account the number of the same order types). So, the variability of the relations is directly related to the number of order-combinations. And since every task is related to all order types (and, hence, to all order-combinations), the variability of every task is related to this number.

A high level of differentiation and separation of operational tasks means the introduction of many short-cycled sub-tasks, devoted exclusively to make, support or preparation activities. High levels on these parameters introduce a production structure with many simple tasks with many relations to other tasks, and hence, increase the number of relations.

So, a high level for the first three design parameters leaves us with a production-structure with a considerable probability of something going wrong, due to a large number of relations and high variability of these relations. A high disturbance probability affects the quality of organization – the more disturbances occur, the longer the production cycle times. A high disturbance probability also affects negatively the control over the production process: disturbances are bound to occur everywhere in the process, but due to their probabilistic nature, one does not know where these disturbances will occur. A high value on the production structure parameters also affects negatively the quality of work – workers are tied to short-cycled jobs, with relatively few opportunities to learn or develop.

We now turn our attention to the effect of high levels of separation (parameter 4) and the parameters related to the control structure.

A high level of separation leads to a network of regulatory tasks that is separated from operational tasks. This introduces an additional complex network of tasks with many relations – which, again, all are possible sources of disturbances. Moreover, high levels of differentiation and specialization of the tasks in this regulatory network further increase the number of relations in this network.

Separation necessarily leads to a network of regulators, responsible for operational work in which they are not directly involved. This necessarily introduces a delay (monitoring, assessment and intervention are now carried out by different organizational members) and an informational disadvantage – detached regulators lack first-hand information about the nature and context of the disturbance, and therefore they may lack the relevant information to judge the appropriateness of the suggested interventions. Detached regulators may also lack the relevant operational know-how to evaluate disturbances and proposed regulatory measures. Separation, then, may negatively affect the quality of organization.

Separation also affects the quality of work, since it deprives operational workers of the regulatory potential to deal with disturbances. According to de Sitter, in high-parameter value structures operational tasks have a high probability of something going wrong,

and due to separation operational workers now also lack the regulatory potential to do something about them. Now, if your job is evaluated based on the output you deliver but you lack the regulatory potential to deal with disturbances that affect this output, it may induce stress. A production structure with much separation also leads to a situation in which operational workers can no longer be in touch with organizational goals – one is just a small part of a large operational machine, deprived of regulatory potential. Not being in touch with the goals of the organization, may lead to feelings of alienation – i.e. one may lose sight of the contribution of one's job.

Regulatory differentiation and specialization make things even worse. Owing to high levels on these parameters regulatory activities are split up into sub-tasks and divided among many regulators (managers) who may easily lose track of the whole process that is being regulated. Such lack of overview may lead to sub-optimization, thus affecting the control over the production process. Moreover, as de Sitter has it, due to a lack of overview and involvement, process-innovation becomes virtually impossible. The same holds for product-innovation, which, ideally, should integrate an overview of market opportunities with organizational (operational) competencies into a perspective on adaptation. But, due to the separation, and regulatory differentiation and specialization, such a combined perspective is hard to achieve. Quality of work is also affected by further regulatory differentiation and specialization: due to high levels on these parameters, very few organizational members are involved in goal-setting, or in redesigning the infrastructure, leading to a further lack of involvement.

In all, high levels of design parameters lead to a high level of variability and a large number of relations, which both increase the probability of disturbances. Moreover, they also lead to a diminished regulatory potential, which reduces the probability that the network of tasks can deal with the many disturbances that occur in them (thus dispersing them). In this section, we have also given an impression of how the functional requirements are affected by structures with high values on parameters, although we should note that this is necessarily only an impression – de Sitter discusses many more ways in which high parameter structures affect them.

4.3 Low parameter value structures do attenuate and amplify

Based on an understanding of how high-parameter values structures lead:

- to a large number of relations, high variability, and, hence, a high probability of structure-related disturbances; and
- to a lack of regulatory potential, it now becomes relatively easy to understand how structural attenuation and amplification may come about in organizational structures with low parameter values.

Attenuation may be realized by making sure that the number of relations in a network of tasks and the variability of these relations is as low as possible. In this way, one reduces the probability that structures themselves are a source of disturbances. Amplification comes about by integrating regulatory potential into tasks as much as needed to deal with residual disturbances. According to de Sitter, structures with low values on the design parameters secure attenuation and amplification and hence lead to better prospects for realizing the functional requirement, needed for viability. In this section, we will briefly show how low parameter value structures do so (Figure 7).

As in the previous section, we start with the parameters of the production structure and next, we discuss the rest of the parameters.

As a start, low functional concentration reduces the variability in the production structure. To see this, let us reconsider the furniture factory with four types of chairs and three types of tables. Suppose, we rearrange the tasks into two separate production flows: one dedicated to chairs and one to tables. The total number of order-combinations for the chair-flow is $2^4 - 1 (= 15)$ and for the table-flow there are only $2^3 - 1 (= 7)$ possible order combinations. This new arrangement of tasks introduces a dramatic decrease of the number of order combinations (which was 127) and, hence a dramatic decrease of variability. Low functional concentration has a positive effect on the quality of organization. For instance, it leads to lower set-up times of machines, less preparation within jobs, less complex planning. And, what is more, de Sitter point out that less variability increases the chance of having an overview over the production process – which is much easier with 15 combinations than with 127.

To be sure, even though low functional concentration reduces variability, there are limits to lowering this value. For instance, one can optimize functional concentration by making a production flow for each individual type of chair or table – but this may mean that if some type of chair is only rarely sold, the flow dedicated to that type is often without work. To counter such problems de Sitter proposes a minimum degree of capacity utilization of 80 percent (de Sitter, 1994, for more guidelines with respect to lowering values of design parameters).

Low functional concentration introduces dedicated order-flows, reducing variability. Low operational differentiation and operational specialization make sure that within these production flows, operational tasks emerge that are (qua operation) as integrated as possible, i.e. tasks comprising make, prepare and support activities, covering a part of the production process that is as large as possible (ideally: the whole process). In practice, this may lead to operational teams that cover a large part of the production process (instead of just a tiny part of it). Integrating operational tasks in this way reduces the number of relations in the network of tasks, and hence, the probability of disturbances. Moreover, they increase operational involvement in a larger part of the production process, which leads to an overview over the production process, necessary for adequate regulation (e.g. countering sub-optimization) and innovation – see also the discussion of the control structure below.

In all, low functional concentration, operational specialization and differentiation lead to a production structure with independent order-flows with teams covering a large part of the production process. This lay-out has (as compared to a lay-out with high-parameter values) few relations and low variability, and results in integrated (team) tasks, offering better prospects for the realization of functional requirements.

If we look at the other parameters, we find that a low level of separation integrates regulatory potential into operational tasks. Moreover, low levels of regulatory differentiation and specialization ensure that relevant regulatory potential is added to operational tasks. By means of this inclusion of regulatory potential, low levels on

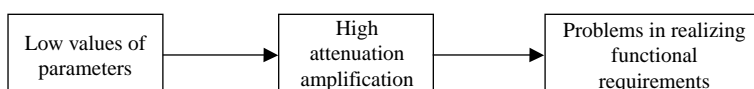


Figure 7.
Outline of the
argumentation of
Section 4.3

these parameters further reduce the number of relations in the network of tasks, and increase the regulatory potential of operational tasks.

With respect to differentiation (parameter 6), de Sitter remarks that, ideally, team-members have tasks that comprise continuous:

- monitoring of their own operational work;
- assessment of their operational work in terms of goals set for it; and
- the possibility to intervene and solve the problems that were encountered.

Embedding this kind of regulatory potential into operational tasks reduces the number of relations and amplifies operational tasks with relevant regulation. It reduces the number of relations between tasks, since regulation is no longer the duty of a separate network of regulators. It amplifies regulatory potential, because it makes sure that relevant monitoring and intervention capacity is available where it should be: in the operational process where the disturbances occur. According to de Sitter, it greatly increases probability of early detection of errors and reduces waiting time (dealing with problems is carried out directly in the production process), thus affecting the quality of organization.

In discussing these effects of low values of control structure parameters, de Sitter states that low values on separation and differentiation improve the quality of information. That is, he argues that the actuality, reliability, completeness, and relevance of information (as indicators of the quality of information) improve by decreasing separation in time and place between the monitoring of the activities that are the object of regulation, the assessment of both the differences between norms and facts and their possible causes, and the action to reduce dysfunctions.

A similar argumentation has applies to Parameter 5. Here, de Sitter also states, that, (again, ideally), tasks should comprise:

- operational regulation – the possibility to regulate with respect to all kind of disturbances that occur within a given set of organizational conditions;
- regulation by design – the possibility to recreate the conditions under which they have to perform their work (this last point has to do with the possibility to redesign parts of their own work – see also de Sitter, 1994, or Achterbergh and Vriens, 2010); and
- organizational members should be involved in relevant goal-setting as much as possible.

Again, by means of incorporation of this kind of regulatory potential into operational tasks, the number of relations between tasks decreases and operational tasks are amplified with relevant regulatory potential, which has, for similar reasons as mentioned above, a positive impact on the quality of organization.

Furthermore, a low level of regulatory specialization ensures that regulatory tasks are no longer split up into tiny sub-tasks, but cover a large part of the production process. Lowering this parameter also reduces the number of relations in the network of tasks, and makes sure that, tasks (be it team or individual tasks) have the regulatory potential required for dealing with disturbances occurring in them.

Low levels on the previous parameters (i.e. separation and parameters describing the control structure) also greatly improve the quality of organization in terms of innovative potential. Teams in low parameter-value production structures have the

required overview over the production process to suggest relevant product innovation. Moreover, in flows (or teams), an integrated perspective (integrating an operational, supportive, market, financial and other perspectives), needed for relevant product innovation also becomes available, thus increasing the prospect of innovative success (de Sitter, 1994, Chapter 10).

Above, we discussed the effect of low values of Parameters 4-7 on attenuation and amplification with respect to the quality of organization. However, they also have an effect on the quality of work. For example, as tasks become larger and more challenging, they create more and better opportunities for individual development learning. Moreover, since workers in operational tasks now have the required potential to deal with the disturbances they encounter, conditions for dealing with work-related stress may also improve (see earlier). And, finally, due to one's involvement in regulation by design and setting goals, one may feel more involved and see the point of one's work (de Sitter, 1994, Chapter 7 for similar arguments).

In all, structures with low parameter values lead to attenuation and amplification, and hence to an improved possibility to realize the functional requirements in various ways. However, at this point, one may wonder how such structures can actually be designed. It is nice to learn that designers should make sure that design parameters have low values, but without rules or guidelines for actually designing structures having low values, a design theory is still incomplete. Fortunately, de Sitter does provide an elaborate set of rules and guidelines for arriving at structures with low-parameter values. However, it is beyond the scope of this paper to treat them; our aim was "merely" to show that such structures attenuate and amplify and thus help in securing the organization's viability.

5. Summary and conclusion

In this paper, we have set out to show how organizational structures may contribute to organizational survival by means of attenuation and amplification. To this purpose we used de Sitter's design theory, to:

- arrive at a model of organizational survival (expressed by so-called functional requirements); and
- discuss how structures should be designed so as to secure the realization of these requirements.

In this discussion, we used de Sitter's proposal to design structures that have low values on so-called design parameters. Only such structures, it was argued, may attenuate disturbances and have the required built-in regulatory potential to secure the realization of the organizations functional requirements.

By means of conclusion, we would like to add two remarks. The first is that, unfortunately, we cannot give a full and complete account of de Sitter's theory in this paper. Here, we can only roughly sketch the outlines of his argumentation, thus leaving many questions unanswered (e.g. whether it holds for all organizations in all environmental circumstances; whether there are limits to lowering the value of design parameters, or with respect to the nature of the guidelines, whether they are relevant for designing cybernetically sound organizational structures). However, we hope that this paper sufficiently describes how de Sitter's design theory may be used to see how attenuation and amplification may come about by means of organizational structures – a perspective that, in our view, is rarely addressed in the "variety engineering" literature.

The second remark is that, we hope, it has become apparent that de Sitter's theory is, in fact, a cybernetic attempt to think about organizations and organizational structures. Ashby's regulatory notions are the starting point and overall guidelines for de Sitter's theory. In fact, this design theory can be regarded as an instance of theorizing in the field of "organizational cybernetics". However, in this field, other theories/models also exist – notably Beer's Viable System Model. The question, then, becomes how these two theories, as theories belonging to organizational cybernetics, relate to each other. In the second paper of the two-paper series to which this paper belongs, we set out to discuss precisely this question. More in particular, in the companion paper, we will show that both theories are complementary.

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