The Model Innovation and Organizational Structure: A Zoom Lens on Organizational Structure

L. J. Lekkerkerk

Abstract This chapter presents a comparison of the first 17 applications of the Model Innovation and Organizational Structure (or 'the MIOS') in organizations. This MIOS is a cybernetic model containing 'necessary and sufficient' functions that should be fulfilled in an organization that aims to remain viable. It is both a research and diagnostic tool developed to study organizational structures, including the 'innovation structure', by making a systematic description. By systematically comparing organizational structures of successfully innovating organizations, the ultimate aim is to deliver concrete design guidelines for a well-integrated embedded innovation structure. This should help to improve the persistently low performance of innovation and change activities (less than 30% success on average) by organizations. To date, seventeen organizations have been studied. In spite of the pragmatic sampling by the student researchers and the limited number of very different cases, the comparison shows a few promising results:

- The comparison yields seven observations on the innovation structures and the way they are designed.
- This allows us to conclude that the MIOS is usable for further empirical research and diagnostic application.

Keywords Structure · Organization Design · Innovation Structure

Reviewing the applications of a cybernetic tool for researching and diagnosing an organizational structure and the embedded innovation structure.

L. J. Lekkerkerk (✉)
Nijmegen School of Management, Radboud University, Nijmegen, The Netherlands
e-mail: hans.lekkerkerk@ru.nl

R. Dekkers and L. Morel (eds.), *European Perspectives on Innovation Management*,
https://doi.org/10.1007/978-3-031-41796-2_2

1 Introducing the Background of the Research

It is generally believed that innovations are needed to keep organizations viable and competitive in a 'VUCA world'. For such an important process, including innovation and other change projects, the success rate was and is staying at a frustratingly low 30% for decades (an overview in Lekkerkerk, 2012, p. 261). How can that be improved?

In their book 'Competing by design' Nadler and Tushman (1997) focus our attention to organizational structure design as an important factor to improve operational performance. The twelve cases presented by Laloux (2014) also show that their organizational structure design improves their competitive advantage. They perform well on the market and at the same time offer good quality of work to their employees. The latter improves their position on the labour market where a war on talent is going on.

From these two points the idea follows: organizations may innovate more successful 'by design', that is by organizational structure design. Unfortunately, most if not all approaches to organization design focus on operations or the primary process of organizations (e.g. the two books mentioned above, lean (Womack & Jones, 2003), Business Process Redesign (Hammer & Champy, 1993), configurations (e.g. Mintzberg, 1989), contingency or fit (e.g. Burton et al., 2015). Even the Lowlands sociotechnical systems design approach (L-STSD) lacked concrete 'innovation structure' design guidelines admits founder De Sitter in his last book. He concludes this after an attempt to develop such guidelines in the final chapter via a theoretical line of reasoning. He challenged 'young business administration scholars' to develop more concrete design guidelines for the innovation structure, including new product development (1994, p. 403).

During my first work experience upon graduation, as an employee at Fokker Aircraft's Composite Structures Division between 1985 and 1996, I witnessed both the lack of success of many innovation projects and the success of an organizational redesign of the Composites Plant's Operations. The OD approach used in this redesign was mainly an early version of L-STSD (De Sitter & Groep Sociotechniek, 1987), combined with insights from 'The Delft Systems Approach' (In 't Veld, 1994, Veeke et al., 2008). Based on this experience I decided later to take on De Sitter's challenge mentioned above by doing a PhD. Because he failed to develop the guidelines theoretically, I decided to try to empirically study the organizational structure, including the innovation structure, of preferably successfully innovating organizations.

At the start it was clear that the relation between (innovation) structure and performance is not easily laid. Crossan and Apaydin concluded in their review that innovation research did not lead to generalizable insights into the link between innovation and organizational performance (Crossan & Apaydin, 2010, p. 1176). One can safely assume that the link between the innovation structure and organizational performance is not yet firmly established either. The improved organizational performance in the reorganized Composite Plant cannot be credited to the new structure alone, because at the same time several capable new team leaders and 'flow managers' were appointed. Additionally, all team members were educated in the new way of working, e.g. by a Lego-simulation game named 'The JIT game'.

Another problem that popped up when drawing a research proposal to address De Sitter's challenge was the huge variation in organizational structures; each organization is different. A method or tool to describe organizational structures, and especially the embedded innovation structure, in a way that enables systematic comparison was not available (Lekkerkerk, 2012). Even with a set of cases that can be compared using such a systematic 'structure photo', it would still be another challenge, based on Crossan and Appaydin's findings, to causally link the innovation performance of these cases, e.g. in time-to-market for new product development, in commercial success rate of innovation projects, to the characteristics of their (innovation) structure and thus innovation to organizational performance.

Against this background, Lekkerkerk (2012) developed the Model Innovation and Organizational Structure (acronym the MIOS) to systematically describe structures. This chapter aims to describe this model, to report on its application in practice and reflect on its usability for further research.

The chapter is built as follows. First the MIOS, a recursive function model, will be explained. Then, the 'grey literature' case selection is explained in a brief methods section. The 17 suitable studies are then presented and compared, leading to seven interesting observations.

Given the complexity of the problems at hand, this chapter presents a modest step forwards by showing the usability of the MIOS for researching (innovation) structures and also for making some practical recommendations to improve the structure. This proof of usability opens the way to further research.

Restructuring: Step by Step Towards a Flow-Based Organization

Restructuring the Composite Structures Division in flows.

Composite aircraft parts were fibre reinforced plastic parts and metal-bonded structures. The operational units were divided in product/customer groups, mainly serving final assembly units for Fokker F27/50, Fokker F28/100 and Airbus A300/310. Exterior parts are either in a left and right pair or one-per-aircraft (e.g. radome, vertical stabilizer). Interior parts are in small numbers (e.g., cabin overhead luggage bins and side panels, airco-ducts) or in one-per-aircraft (cockpit, lavatory, galley). Exterior and interior parts used different materials (fibres, resins, sandwich) and different processes and skills. Especially both Fokker units had to deal with this variety in batch sizes (1–40), materials and processes. For Airbus only exterior parts were delivered (e.g., flap track fairings).

Starting in 1985 the structure within Operations was redesigned into a flow-based structure. The three flows were formed using a simple group technology approach that linked to material and process of interior one-per-aircraft, interior series and exterior. This structure reduced the variety in the units leading to simpler planning and resulted in much improved lead time, better quality and higher efficiency.

At first several other functional supporting departments were left untouched, but after a while these started internally to form subgroups linked to each of the flows in Operations. After another, all people involved agreed that it would make sense to split these functional supporting departments and form a Support unit in each of the Operations flows. This effectively formed three autonomous business units within the Composites Plant.

The approach used to redesign was mainly an early version of L-STSD (De Sitter and Sociotechniek, 1987) combined with insights from 'The Delft Systems Approach' (In 't Veld 1994, Veeke et al., 2008).

2 Elaborating on the Reasons for Developing the MIOS

By redesigning their organizational structure from bureaucratic, functional structures to a structure with independent flow-based units, many organizations showed much enhanced performance in their operations, e.g. increased controllability, less cost, shorter lead times, less work in process, higher on-time delivery, more customer value and higher quality of work. Such a redesign may be inspired and guided by approaches or theories such as:

- Business Process Redesign, BPR (Hammer, 1996; Hammer & Champy, 1993).
- Lowlands sociotechnical system design, L-STSD (De Sitter et al., 1997; De Sitter, 1994; Van Hootegem et al., 2008; Kuipers et al., 2010, 2018, 2020).
- Lean thinking, LT (Womack & Jones, 2003), and preceding work about the Toyota Production System, Just-in-Time-management and Kaizen.

A common characteristic of these OD approaches is the design of an operations structure consisting of autonomous units with an end-to-end responsibility for a subset of all the types of customer orders the organization fulfils. The classic functional, activity-based or 'silo' structures, seeking to obtain economies of scale, are abandoned because they can be characterized as 'complex structures (with simple, narrow jobs)' with a high need for coordination. These approaches favour 'Simple structures with complex (i.e. meaningful, high quality) work'. Both De Sitter et al. (1997) and Hammer and Champy (1993) use this statement.

By analogy, the question arises:

> Would redesign of an 'innovation structure' lead to innovation performance improvements such as those seen in operations?

Unfortunately, neither BPR nor lean nor the Lowlands sociotechnical design approach present concrete guidelines for the redesign of the innovation (sub)structure; not as an independent subsystem and not as part of an integral redesign of the entire structure (De Sitter, 1998, p. 397).

Hence, a first problem is: how can these innovation structure design guidelines be obtained? Studying the organizational structures of successfully innovating organizations and how these integrate their 'innovation structure' with it might reveal these design guidelines. Applying these will eventually improve innovation performance.

To obtain these design guidelines, organizational structures will have to be studied in detail. To date, quantitative studies relating structure to organizational performance operationalized structure using insights from Pugh et al. (1968), as Andersen and Jonsson did:

> All organization structures (designs) can be expressed in these terms. The degrees of complexity, formalization and centralization/complexity vary in organizations. Nevertheless, these dimensions are found in all organizations. (Andersen & Jonsson, 2006, p. 239)

However, Crossan and Apaydin (2010) concluded that studies such as these, trying to link innovation and performance, did not reveal much guidance on organizational structure design.

A potential reason for this may be that the way structure was operationalized in these surveys, based on Pugh et al. (1968), does not capture those dimensions of structure that are essential for high (innovation) performance. To fruitfully study organizational structures, the operationalization should be able to surface whether a structure is functional (activity-based), 'lean' (flows, product based) or customer based (product/service/geographical/market-segment based). The latter two use autonomous units as mentioned above, and such structures have less interfaces and hence a much lower need for coordination, a lower risk of coordination problems and a higher controllability as De Sitter's (1994) showed. He demonstrates that the redesign of the production structure influences the quality of the organization, including controllability and innovativeness, as well as the quality of work.

Now the trouble is that these three truly different structures may have the same degrees of formalization (high) and centralization (low), and yet at the same time one would expect quite an increase in performance when changing the functional structure in a flow-based one using indicators like order lead time and work in process (e.g. Womack & Jones, 2003), but also in absenteeism and employee turnover due to differences in quality of work (De Sitter, 1998; Pot, 2022).

Another (partial) explanation for why the relation between structure and (innovation) performance is not yet clear also follows from Lowlands sociotechnical systems design thinking (De Sitter et al., 1997), which states that controllability can only be influenced by integrally redesigning an organizational structure using De Sitter's design guidelines. Low performance is an effect of a lack of controllability caused by a complex design of the production structure and hence of a complex coordination and control structure. A complex structure has many interfaces, such as 'handovers' in a relay race, in all of its (order) processes, and each interface requires coordination effort and is a potential source of disturbances. Another characteristic of such a complex network of related activities is the propagation of disturbances through the network, e.g. how a problem at the first station of an assembly line eventually stops the whole line. Following Ashby (1956), innovation can be regarded as a 'regulatory activity', and in the integral sociotechnical view, innovation performance is negatively influenced by a complex production structure to which the control structure, including the innovation structure, should be properly linked. Therefore, to study the effects of structure on innovation performance, not only the innovation structure but also the whole organizational structure should be integrally studied. This requires such an amount of intricate details in the data that it seems impossible to use a survey. Additionally, the lack of clearly defined, unambiguous and objectively measurable organizational structure concepts, well understood by all practitioners filling in the questionnaires, does not help survey research on organizational structure either.

Therefore, qualitative research is needed here, but doing detailed comparative case studies with large numbers of cases on such a complex object as the organizational structure is much work collecting and analysing data. First and foremost the question now to be answered is:

How can organizational structures be meaningfully and efficiently compared?

Hence, before even starting research to answer the ultimate question 'how to integrally redesign an organizational structure, especially the embedded innovation structure, to positively influence (innovation) performance?', a research tool for comparatively studying organizational structures with an emphasis on the innovation structure was needed. Lekkerkerk (2012) developed such a tool and named it the Model Innovation and Organization Structure (acronym: the MIOS) in his PhD project. His work is firmly based in Dutch and European systems thinking (or cybernetics), and all empirical data were collected in Dutch SMEs that are embedded in an economy that is considered to be part of the European Rhineland tradition (Peters & Weggeman, 2019 *Het grote Rijnland boekje*, Business contact).

3 Closer Look at Lowlands Sociotechnical Systems Design and the Gaps

System theory (e.g. Ashby, 1956; Beer, 1994, 2000) and Lowlands sociotechnical theory (e.g. De Sitter et al., 1997; De Sitter, 1994; Achterbergh & Vriens, 2009) provided ingredients for a framework or model to enable comparative case studies on organizational structures and their effect on performance. Sociotechnical organization design originated in research by the Tavistock Institute in the Durham coal mine in the 1950s (Kuipers et al., 2020; Mumford, 2006; Trist & Bamforth, 1951; Van Hootegem et al., 2008). In the Netherlands, further development was led by De Sitter (1998) (e.g., Achterbergh & Vriens, 2009, 2019), starting with his study for the Dutch Scientific Council for Government policy (1981) until his retirement in 1995. A unique systematic design sequence was developed: top-down for the 'production structure' and bottom-up for the three-layered 'control structure', as is visualized in Fig. 1.

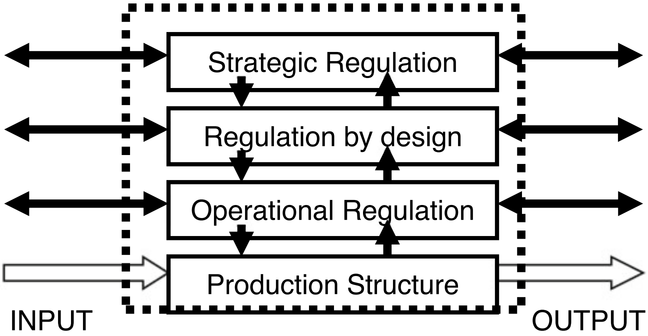

Fig. 1 Lowlands sociotechnical design-view of an organization as an open system

3.1 Production Structure

The production structure (PS), encompassing the operational activities of the primary process, which is selling and delivering the products and services of the organization, should be designed in a way that minimizes the number of interfaces between organizational units. In the usual functional structures, each customer order is handled by numerous departments between intake and delivery. A handover between departments is an interface, requiring coordination between the departments, and interfaces are a notable source of trouble (such as in relay races and in ICT between hardware components and between different software systems). By assigning the activities needed for each type of customer order to one organizational unit or group, 'parallel flows' are created, which are similar to the flows designed in a lean approach to manufacturing (Womack & Jones, 2003) and to a BPR rule to assign end-to-end responsibility for a workflow to one organizational unit (Hammer, 1996). Most former handovers in the order fulfilment process are now *within* these groups, and hence coordination can be by mutual adjustment. Apart from activities that transform input (material, customer, data, energy and combinations) into output, the production structure (PS) includes two other types of work. The first is named 'preparatory activities' (order intake, process planning, invoicing), which are linked to the individual orders but not transforming the main input, and the second is 'supporting activities' (HR, logistics, maintenance, catering, ICT, other facilities) with an indirect link to orders and as basic purpose 'to keep the primary process up and running'. Adding these preparatory and support activities, as much as feasible, to the tasks of the parallel groups responsible for the independent order flows makes these groups even less dependent on the previously existing functional staff and support departments. The primary task of the Lowlands sociotechnical organization designer is to find such independent flows to reduce the number of interfaces, with an at least threefold aim,

- To reduce the interface-related coordination effort and chance of disturbances,
- To prevent disturbances from propagating through the network of tasks of the system,

- To lay a foundation for job enrichment and enlargement because of the larger variety of tasks in autonomous units and to introduce self-management (a.k.a. self-managing, self-organizing teams) in a meaningful way (Lekkerkerk, 2017).

It is worth mentioning that PS design is performed top-down, starting with the whole organization. A first divide may be in the familiar ‘independent divisions or business units’ or ‘flows’ at a macro-level of recursion. While Mintzberg (1989) shows his divisionalized form to exist of functionally organized little machine bureaucracies, L-STSD tries to divide these in subflows, and subsubflows, as many times as is needed to arrive at work floor units that have a teamwork enabling size of approximately 6–12 employees (with extremes 4–20). Explaining this design approach is beyond the aim of this chapter, so for further details, use the latest handbook, recently translated into English (Kuipers et al., 2020). De Sitter et al. (1987) may have also been inspired by Simon’s concept of nearly decomposable systems (Simon, 1996, p. 197).

3.2 Control Structure

The control structure is modelled in three layers following Ashby (1956): operational control, regulation by design and strategic regulation (shown in Fig. 1). In addition, it is designed ‘bottom-up’.

To enable the independent PS groups to truly function as ‘plants-within-the-plant’ or ‘hospital-within-the-hospital’, as much of the operational control activities as possible should be decentralized to the members (including a team leader) of these groups. Furthermore, some or all of the group members may contribute to ‘regulation by design’ and even to ‘strategic regulation’. This may range from being a part-time member of a product development project team to just attending joint biannual discussions on the strategy.

After implementing the newly designed structure, the group leaders may be responsible for all control activities assigned to the teams at first. However, these groups may develop into self-directing work teams and gradually divide not only prepare and support tasks over a larger part of the members but also control tasks. This team development process may easily take 2–4 years according to Kuipers et al. (2020). Jumping to that blue print end state of team development immediately, or even worse just relabelling all departments to ‘self-directing work team’ and lay-off the supervisors, so without any change in the production structure at all, proved a recipe for failed ‘social innovation’-projects in practice. This may explain why (Dutch) managers lost interest in sociotechnical redesign in the 1990s. However, one should never accuse a theory that it ‘doesn’t work’ because of such poor implementation practices.

The next control structure layer, ‘regulation by design’, entails all activities aimed at adapting the organization to changes or opportunities in the environment or to fresh strategic insights and new goals developed internally. Achterbergh et al. (1999)

explain that innovation and change projects are the core of 'regulation by design' and coined the term 'innovation structure'. De Sitter (1998) uses 'innovation structure' for this control structure layer and even splits it into 'innovation production structure' and 'innovation (operational) control structure'.

De Sitter (1998) concluded at the end of his last book that developing concrete design guidelines for the innovation structure is needed and presents this as 'a challenge for young scholars' (1998, p. 397). Given that the need for innovation and for higher innovation success rates is still present, this gap in Lowlands sociotechnical design theory should be closed to help achieve that.

3.3 Diagnosing a Structure

Another task for organization designers is to diagnose existing organizational structures first and later on their proposed redesigns for it. They need to answer the following question: when is a structure or redesign good, and when is it a source of trouble? De Sitter (1998) developed seven design parameters to help answer this question, but it is beyond the scope to explain them.

However, if in a redesign project only the present activities carried out by the employees of an organization are taken into account for redistribution, the designer might overlook something. If he would have a model containing 'necessary and sufficient' functions for viability of the organization, he might use that too to find essential activities that are not done at all, probably explaining another part of the problems of the organization. Such a function model is lacking in Lowlands sociotechnical theory, and this is a second gap, next to the innovation structure design guidelines.

These two gaps in Lowlands sociotechnical systems design are linked in the following way. A model containing 'necessary and sufficient' functions will serve as such a diagnostic device but also as the framework needed to systematically describe any organizational structure. An organizational chart only shows the hierarchical reporting lines, and the names of the departments in the boxes hint at what their tasks may be (e.g. quality assurance, operations, marketing). However, an org-chart alone will not do, and by listing tasks per department in the chart, the resulting descriptions of the structures of various organizations become incomparable.

By looking instead through the lens of the functions in such a model, the researcher may put aside the charts and their departments and 'map' the contributions of various employees, groups, (sub)departments, etc., to these functions for each of the organizations in his study. By doing so for each function and for the relations between the functions, the question of which individuals, project teams or departments are involved is answered.

Such an analysis may be described in text and then summarized in a table with two columns; left the functions and right those responsible for each function (see Table 3 in the results section). By adding a third column with data on a second organization, differences between the structures may appear (see Table 4). Now suppose that two competitors, similar in size, product, technology and market, but different in innovation success, are compared, a link may be established between their innovation performance and their organizational and innovation structure. Such a comparison is much more systematic than just comparing processes (e.g. innovation project management, innovation portfolio management), the boxes appearing on the two organization charts or the engineering departments only. In this way, the structures of the cases are studied in an integral way, which is mandatory according to De Sitter:

> So innovation is not a 'separate' topic. From the structure design perspective, it would be wrong to see innovation as a partial problem, to be solved via a redesign of an 'innovative subsystem" (De Sitter, 1998, p. 354, translated Lekkerkerk)

3.4 Reorganizing and Diagnosing Innovation Capabilities and Processes

Following De Sitter (1998), it does not make much sense to study the structure of one part of the organization. This unit is part of a whole, and it has a number of coordination and control relations with other parts of the organizational network. In activity-based structures, as noted before, the number of relations is quite high, which is a reason to call such a structure complex. Reorganizing one of the nodes of such a complex network internally may help slightly, but it is in no way reducing the number of coordination and control relations that must be maintained.

Now, suppose an organization has a functional 'innovation department', and there are signals that the overall innovation performance can be improved. Needless to say, this innovation department has many linkages with most if not all of the other units of the organization. Any innovation project it undertakes will eventually bring about change in several units, so for each project, the interfaces of the project team with each of these units must be defined. When organizing innovation, these interfaces are to be part of the design effort.

Another point is the question of what can be done to diagnose and then improve the innovation process and performance. The literature provides several innovation audit tools, and Lekkerkerk already listed approximately 50 (2012, App. C). Using these tools may be helpful, but they focus on innovation as a functional subunit and/or do not include the organizational structure perspective in sufficient detail according to Lekkerkerk. Therefore, these audits will at best lead to some observations leading to partial improvements. These tools do not incorporate an integral organizational structure perspective advocated by De Sitter (1998, p. 354).

However, Beer (2000) takes such an integral perspective when 'diagnosing the system for organizations' with his Viable System Model, but only one of the five functions (Function 4 or 'outside and then') can be considered the larger part of the innovation structure.

Because innovation audits are partial and because both De Sitter and Beer lack a detailed view on innovation, in spite of the integral nature of their respective approaches, it is necessary to expand their models or in systems thinking jargon 'to open the innovation structure black boxes' to see which subfunctions are needed.

3.5 Defining Innovation

Innovation is a core concept here and should be defined first because so many different definitions may be found both in the literature and among practitioners. Below, a specific definition that is useful at the organizational level and fits with our organizational structure design purpose is outlined. Additionally, the distinction with continuous improvement used in this research is described.

Several *types* of innovations are distinguished, e.g. technological, social, organizational, product, process, ICT, service, market or business model innovation. The OECD defines most of them in the Frascati Manual (OECD, 2002) and Oslo Manual (OECD, 2005, 2018). However, these manuals only mention as an aside that innovation projects done by organizations usually deliver several types of innovation, e.g. the new innovative product, the new process needed for it, a new group in the sales department to sell it to the new market and the new channel to be developed. In the latest Oslo Manual, this point is stressed more: '*Many innovations are bundled, presenting characteristics that span more than one type*' (OECD, 2018, Sect. 3.49). Practitioners tell the author that in their view, multiple, 'bundled' innovation-type projects are the rule rather than the exception. This aspect in the definition underpins the need to form multidisciplinary teams for innovation projects. Additionally, the basic or applied research projects a company may do that will eventually lead to new products and processes via advanced engineering and subsequent detailed development can best be considered innovation projects being part of the total 'innovation and change portfolio'. This fits with the Oslo Manual's listing of innovation activities of businesses (2018, Sect. 4.8).

Apart from the *type* of result, innovations are also often characterized by their degree of *newness*. An innovation may be new to the world (the very first car, computer, smartphone), but it is always new to the organization developing (or sometimes just buying) and implementing it. Tidd and Bessant (2021) use newness to distinguish two basic kinds of innovation projects:

1. 'discontinuous innovation' for radical or explorative innovations, adding something new to the market,
2. 'steady-state innovation' for incremental or exploitative innovations related to the existing set of products and services.

According to them, each kind has its own approach or 'funnel', which they draw as parallel processes, indicating different approaches and perhaps even different organizational units or groups. In fact, rather than a dichotomy, this is more a continuum, ranging from very similar to current practice to truly very new to the innovating organization. Apart from being new to the innovator, it may be new to the world outside the organization (or not). Usually, 'new to the world' innovations are of a more radical nature. In practice, this continuum does not lead to an endless variety of project approaches; organizations usually limit themselves to two or three combinations of project type and a matching approach. The degree of newness translates into the predictability of the results at the start of a project, which largely determines the approach.

The classic sequentially phased project approaches (e.g. Cooper's stage-gate, the 'waterfall' or in ICT the systems development methodology, SDM) are still suitable for steady-state innovation projects, and a business case will provide a financial section without large uncertainty margins (e.g. ROI or NPV calculations).

For the radical, explorative type of ideas, approaches such as rapid application development, rapid prototyping or 'the lean start-up' (Ries, 2011) seek market feedback by showing consecutive prototypes, usually of software apps, and proceed (or not) based on responses from target customers to launch the 'minimum viable product' (Ries, 2011) that may be further developed in subsequent releases.

Tidd and Bessant (2018) also describe that balancing the 'innovation and change portfolio' is necessary with only 15–20% of projects and resources in the riskier discontinuous, explorative innovation funnel.

3.6 A Practical Distinction Between Innovation and Continuous Improvement

The distinction between (incremental) innovation and continuous improvement (CI) is not clear, and the subjective degree of newness will not provide a clue. Organizations usually carry out innovation on a project-by-project basis, with each project based on a 'business case' (or innovation project proposal), which at some point was formally approved by higher management or an 'innovation board'. In contrast, continuous improvement is mainly carried out within and by employees in any department alongside their daily work, and they are empowered to implement the changes without prior higher management approval and without much involvement of other departments. From a systems theory perspective, finding, evaluating and implementing such small improvements are considered to be part of an operational control loop (Kuipers et al., 2020, p. 73). Because every activity or process needs operational control, continuous improvement (or 'kaizen' or 'high involvement innovation' (Bessant, 2003)) has its logical place there, which does not mean that it gets done. The fact that continuous improvement (CI) has to be deliberately organized and managed according to TQM and lean theory and its importance for overall performance improvement means that one should pay explicit attention to CI when diagnosing and redesigning a structure. CI being part of operational control implies that there is no separate organizational 'CI function' needed from a systems theory perspective.

To summarize, innovation is defined here as (the results of) an innovation project, incorporating at least one, but usually more types of innovation, and done by a multidisciplinary and temporary project team. Depending on the degree of newness, for the firm and perhaps for the market or wider environment, and some other factors, the project team may choose a semi-linear stage-gate approach or a more experimental, rapid prototyping approach. Contributing to incremental improvement is part of each job, e.g. using ‘kaizen’-tools and/or quality control tools (Mizuno, 1988).

4 Development of the Function Model: The MIOS

As was already mentioned, for an integral approach to the innovation structure embedded in the whole organizational structure, the (function) models described by De Sitter and Beer need further development. A ‘function model’ of an organization is a concept from organizational cybernetics (systems thinking is near synonym). Function here refers to the contribution of an element or subsystem to the system it is part of (In ‘t Veld, 1994). Therefore, it should not be confused with ‘function’ referring to ‘an individual’s job’ or to a functional (or activity-based) structure. ‘Model’ refers to a simplified representation of the complex reality to highlight certain characteristics, in this case, the different functions and their relations that are needed to keep an organizational system ‘viable’.

Beer (1994, 2000) developed a function model, known as the Viable System Model (VSM), and like De Sitter, he is building on Ashby (1956). Given the expectation that detailed design guidelines for the embedded innovation structure are the ultimate result of comparative case study research, the question is now whether Beer’s VSM is useful for this study. It has some advantages. Based on systematic reasoning, not challenged to date (Achterbergh & Riesewijk, 1999), Beer claims that his VSM incorporates ‘necessary and sufficient’ functions for viability. It incorporates the logic of recursion that fits well with the sociotechnical idea of a production structure consisting of (near) autonomous units, which (depending on the size of the organization) may be further divided into again (near) autonomous subunits. For example, there are three divisions of Philips, each divided into business units, and so on, until groups and individuals at the shop floor are reached as the lowest practical level of recursion (Beer, 2000, In’t Veld, 1994).

A first drawback of the VSM is that it only contains five functions, and only one or two functions are directly involved in innovation, with a third as a strategic innovation control function. For a detailed comparison of innovation structures that is not sufficient. Another disadvantage is its abstract nature and terminology that prevent practitioners from intuitively understanding it. Therefore, the VSM serves as a basis, but a model containing more functions to represent the innovation structure and giving all function names that appeal to practitioners is deemed necessary.

In’t Veld (1994) supplied the first ingredient for development of the new model. He developed two models based on systems thinking and pragmatic engineering logic that contain more innovation-related functions using understandable names (Veeke et al., 2008).

Second, the innovation management literature supplies the steps in any innovation process: search, select, implement and capture (Tidd & Bessant, 2009, p. 44).

The distinction between exploration and exploitation (March, 1999, p. 133), linked to radical and incremental innovation, with the idea that any organization should do both in an 'ambidextrous' way (O'Reilly III & Tushman, 2004), was also used.

Closely linked to ambidexterity is the notion of a balanced innovation portfolio of projects (Kester et al., 2009, p. 328).

Combining newly developed and existing knowledge is related to innovation (Hislop, 2005), so organizational memory is important.

Due to the size limits of a chapter, only the outcome of the theoretical work using the ingredients listed above is presented. In Lekkerkerk (2012), the full line of reasoning can be found. The resulting model is named 'the Model Innovation and Organizational Structure' (acronym: the MIOS). Figure 2 presents the model. The names of the functions contain a verb, according to system theory custom and a code (I, C and V for **i**nnovation, **c**entral and supply (**v**oortbrengen in Dutch), respectively, and a number) serving as a practical shorthand when discussing how functions are assigned.

The contributions of the twelve functions of MIOS to an organizational system are summarized in Table 1, and continuous improvement is added for the reasons

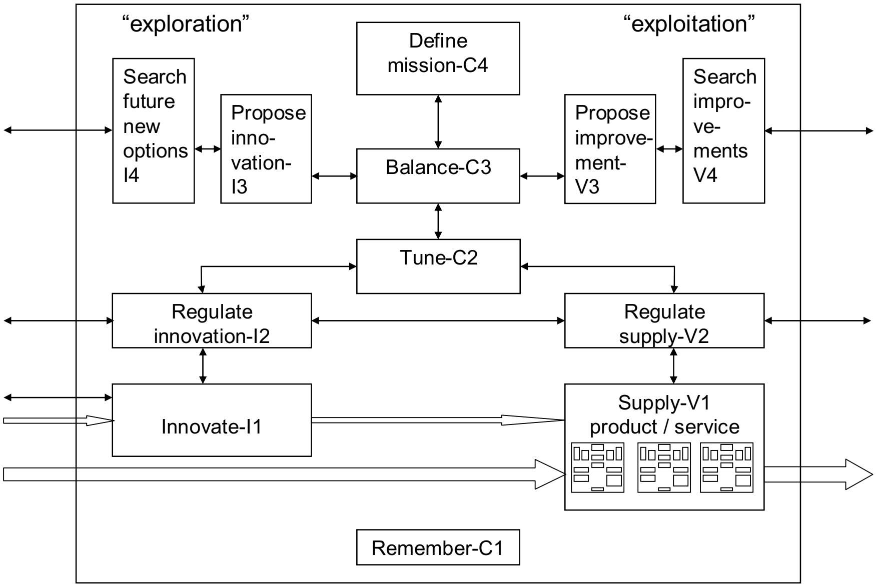

Fig. 2 Developed function model: the Model Innovation and Organizational Structure or 'the MIOS'. (Lekkerkerk, 2012, p. 296). *Note:* Many relations between all functions, e.g. those of Remember-C1 with all other functions, are omitted for clarity of the drawing only

explained above. Being based on the logic of Beer's VSM, this new model also contains 'necessary and sufficient' functions. This implies that an organization that implements all these functions and their relations in its structure, and of course assigns them to competent employees who execute them well, is able to remain viable, i.e. 'able to maintain its separate existence' (Beer, 1994, p. 113).

Like the VSM, the MIOS incorporates the idea of recursion, meaning that the Supply-V1 function may consist of separate, independent parts that are (or should be) viable subsystems. In Fig. 2, the small versions of the MIOS in the function Supply-V1 symbolize this recursion. Large companies may have independent divisions, which consist of business units, and in such organizations, the 'right' degree of

Table 1 Brief description of the functions in the MIOS (Lekkerkerk, 2012, p. 297)

Name code	Contribution of function to organization
Supply product service-V1	Represents the primary process supplying products and/or services by transforming inputs in output Includes order-related activities: logistics, process planning, sales, finance, procurement, etc. Includes supporting activities: maintenance, HR, facilities management, etc.
Regulate supply-V2	Operational regulation of the various aspects of the primary process including continuous improvement
Propose improvement-V3	Make project proposals for the best opportunities for improvement received from V4
Search improvements-V4	Search for and find ways to improve exploitation of current products, markets, facilities, etc.
Innovate-I1	Carry out all approved innovation projects and improvement projects
Regulate innovation-I2	Operational regulation of individual innovation projects and operationally manage the portfolio of projects in progress
Propose innovation-I3	Make project proposals for the best future options for innovation received from I4
Search future new options-I4	Exploration of environment and search for future options for innovation, aimed at new and existing markets
Remember-C1	Organizational memory storing codified knowledge relevant for the organization
Tune-C2	Tuning V1 and I1 enabling smooth implementation of innovations and tuning the upper six functions contributing to the strategic planning process
Balance-C3	Balancing the project portfolio by strategically choosing which new proposals (from V3 and I3) should be funded and at the same time which of the projects in progress should be continued, paused or aborted
Define mission-C4	Define the mission, vision and strategy for the company and deriving lower level strategies for supply and innovation including performance indicators and budgets
Continuous improvement	Small-scale improvement or 'kaizen' activities within each functions operational regulation

(de)centralization of control, which includes regulation by design or innovation, is a challenging task for the structure designer.

These MIOS functions are related to the innovation management and sociotechnical literature briefly described above. The generic, somewhat simplified innovation process steps from a well-known textbook (Tidd & Bessant, 2009, p. 44) mentioned above link to the MIOS functions in the following way:

Search	Both Search functions (V4/I4) and both Propose functions (V3/I3)
Select	Preliminary selection is part of both Search and Propose
	Final selection of proposals by Balance-C3
Implement	Carrying out and operationally managing the selected innovation projects by Innovate-I1 and Regulate innovation-I2

Figure 3 presents this in a visual form, highlighting the distinction between explorative and exploitative innovation projects. Because both types have to be present in a 'balanced' innovation portfolio, the function Balance-C3 cannot be divided. The execution of innovation projects (Innovate-I1) may also depend on this distinction, but that is not shown here. Opening the Innovate-I1-box may, for example, reveal a research subfunction (delivering new knowledge to the system), feeding into a radical innovation project function. Parallel to these, an incremental innovation project function will be present.

The Lowlands sociotechnical theory matches the MIOS functions in the following way. The production structure as defined by De Sitter (1998) equals Supply-V1.

The three layers of his control structure are incorporated as follows. Regulate supply-V2 is his operational regulation layer, and Define mission-C4 equals strategic

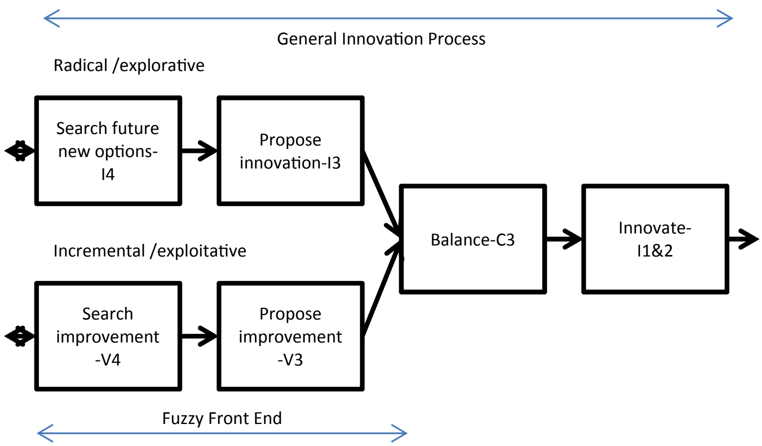

Fig. 3 MIOS functions and a general innovation process model

regulation. The remaining functions are detailing the layer regulation by design (or the innovation structure).

Remember-C1 supports all other functions by serving as organizational memory.

After combining elements from various existing models in the new MIOS, the question of whether it actually serves its intended use as a research tool for comparative case studies and as a diagnostic tool for practitioners was answered by testing it. To that end, Lekkerkerk (2012) presented it first to four experienced sociotechnical organization designers and management consultants. They were positive about the completeness of the model and did not miss a function. In their opinion, it would indeed be usable for diagnosing both existing structures and redesigns.

Second, the MIOS was applied in five organizations by Lekkerkerk, and the results reported in his PhD thesis defended in 2012 at Radboud University (Nijmegen, The Netherlands). Following Lekkerkerk's project, several MSc students in business administration at Radboud University applied the MIOS in their graduation projects.

5 Methodology of the Review of the Case Studies

This chapter can best be seen as a 'grey literature review' because it searches for applications of the MIOS and then analyses the papers that contained sufficient data to enable a comparison.

To increase the amount of data, the studies conducted in five companies by Lekkerkerk (2012), listed in Table 2, were included. The methodological details of this part of the research are in the PhD thesis (Lekkerkerk, 2012). Data collection took place in 2010.

The other selected papers presented here obviously also applied the MIOS. All were the result of a successful graduation project of MSc students in Business Administration at Radboud University, and all were supervised by Lekkerkerk. Each paper, or rather Master Thesis, was rated independently as defendable by the supervisor and a second examiner. After presenting and defending the thesis to this two-person exam committee, the members agreed upon a final grade. Therefore, they all meet the minimum standards of sound academic work. They followed a case study approach

Table 2 Five anonymous companies (Lekkerkerk, 2012, Table 6.1.1, translated)

#	Name	MPS*, main product	Sites	Employees	Interviews
T1	Eline	EtO, electrotechnical	3	120	4
T2	Amelie	EtO, marine electrotechnical	9	580	7
T3	Ezra	MtO, seed improvement	11	300	4
T4	Leon	AtO, trailers, OEM modules	1	130	5
T5	Rik	AtO, mobile cranes	1	140	9

Note MPS master production schedule, indicating what part of the primary process is on customer order, *EtO* engineer to order, *MtO* make to order, *AtO* assemble to order

(Yin 2003), and were done and defended between 2011 and June 2014 by fourteen MSc students. They were coded as S1, S2 … S14 (Table 5).

Because one student made an organizational structure redesign and used the MIOS to check whether his redesign covered all necessary and sufficient functions, it was excluded. A redesign of a structure is not suited for linking it to the actual performance of an existing innovation structure, so this case (S9) is left out (Table 5).

Another student studied a software firm (S3) with a cell structure, and his case was left out of the table because it was too different, both the kind of organization, the structure and the way he applied and reported the results of the various 'cells'.

Because master's students are required to acquire their own research object, the strategy for selection of the cases is rather 'pragmatic', and as an inevitable consequence, the possibilities to 'fruitfully' compare this collection of 'apples and oranges' will appear to be somewhat limited. Most of these studies were diagnostic projects in which the innovation and organizational structure were studied using the MIOS, usually adding an innovation management problem of the organization. This increased the practical relevance of the project for the organization as a kind of reward for making time of respondents and a company supervisor available to the student.

In all organizations, students collected data on the innovation and organizational structure using an approach similar to that of Lekkerkerk (2012). They conducted approximately 8 semi-structured interviews, made full transcripts and coded the transcripts using the MIOS functions and their relations as a basis for part of the questions and subsequent coding. The transcripts were sent to the respondents for their approval. Existing organizational documents, e.g. quality manuals and job descriptions, were gathered and analysed to determine the formal organization and compare or check with the interview data. The company supervisors approved the final draft of the theses, so the data on their organization can be regarded as correct.

Thus, twelve of the companies studied thus far by students delivered results suitable to present along the five from Lekkerkerk (2012), so Table 5 in Appendix 1 shows 17 organizations. The first 5 companies studied by the author are coded T1-T5, as shown in Table 2. The student organizations are anonymously coded S1, S2, etc. (chronological according to the dates of defence of the master's theses).

All organizations are based in the Netherlands.

6 Results Based on the Cases

The first few rows of the large Table 5 (Appendix 1) contain some basic data of the organizations, which are sorted by the size in number of staff of the organization (-al unit) that was studied. There is a mix of large and small product and service companies, a large hospital department and one government agency (supervising authority).

For industrial companies, their 'MPS' or master production schedule type is mentioned to characterize the customer interaction they have. Appendix 2 lists the references to the student cases used. Fortunately, because even 'apples and oranges' have a lot in common (fruit, size, skin, seeds, edible, from a tree), some interesting observations can already be made, and these are presented below.

In each of the organizations, the structure was described and diagnosed using the MIOS and judged using mainly additional Lowlands sociotechnical theory and insights from the innovation literature. The judgement in Table 3 on Remember-C1 is based on Hislop (2005) and that on Balance-C3 is backed up by innovation portfolio management (Kester et al., 2009). Some cases go one step further and give some judgement on how well the function is performed. It is beyond the scope of this chapter to elaborate on that.

It should be noted that a diagnosis using the MIOS only is limited to a near-binary one: a function is (in)formally fulfilled or not and more or less well related to the other functions in the organization. Therefore, there are three diagnostic outcomes for each function: missing, fulfilled informally and fulfilled formally.

As an example, Table 3 presents a part of the diagnosis of Eline (T1). Lekkerkerk (2012) and the master's theses (listed in Appendix 2) show full tables of all organizations.

No missing function appeared in the seventeen organizations. For T1-T5, this was no surprise because innovation success was one of the selection criteria. To show that this may actually happen serves the example from a consultancy assignment by Lekkerkerk (personal data). All members of the management team of the Dutch branch of the organization agreed that for the last couple of years, no radical innovation projects were proposed. Reasons for that may be that 'Searching future new options-I4' is not fulfilled at all. Alternatively, as an alternative explanation, such ideas were all rejected before these managers became aware of them. For example, when the preliminary investigations were done at some central unit, assigned with the Propose innovations-I3 function and showed only problems and no market potential to develop a sound business case (or innovation project proposal).

Looking at the informal-formal option, it seems interesting to note that the functions in the upper half of the model (both Search and Propose functions and Balance, Define mission) were often just done informally (Table 5, Appendix 1).

When a function is fulfilled, its outputs are present or concrete, such as a strategy document for Define mission-C4 or proposed business cases for both propose functions (I3/V3). That enables the researcher to determine, e.g. in dialogue with the respondents or by analysing the available formal job descriptions, to what extent such a function is informally done or is a formal part of one or more job descriptions.

Obviously, action-oriented managers would like to hear more than just: this function is not fulfilled or assigned informally or formally. They need more details than the summary in the third column 'judgement' to determine whether action is needed. To reach such a more detailed conclusion and maybe give advice on a solution, researchers or consultants using the MIOS need additional (normative or prescriptive) theory to compare current practice with the state of the art on innovation portfolio management (related to Balance-C3), innovation project management (Innovate-I1, Regulate innovation-I2) or knowledge management (Remember-C1).

The comparison of organizational structures using the MIOS-based descriptions can be summarized in a table, which is briefly illustrated in Table 4, presenting the

Table 3 Partial diagnosis of the organizational structure of Eline (T1) (based on Lekkerkerk, 2012, Table 6.2.6)

Function	Assigned	Judgement (using additional theory)
Innovate-I1	Formal	Sufficient
Regulate innovation-I2	Formal	Mixed with regulate supply-V2
Propose innovations-I3	Informal	Sufficient
Search future new options-I4	Informal	Sufficient
Remember-C1	Informal	Insufficient
Tune-C2	Informal	Sufficient
Balance-C3	Informal	Too little incremental projects

Table 4 Comparison of the innovation functions of Leon and Rik (based on Lekkerkerk, 2012, Table 6.7.2)

Function	Leon (T4)	Rik (T5)
Innovate-I1	A project team mainly engineering staff	By R&D and production engineering staff sales manager
Regulate innovation-I2 per project	Project leader may report to managing owner	Head R&D, head prod. engineering
I2 portfolio	Market team	'R&D-meeting'
Propose innovations-I3	Members of market team + various other (ad hoc)	Ideator or R&D/PE staff
Search future new options-I4	Managing owner, management team and engineers	Managing owner and sales managers

four innovation functions of Leon (T4) and Rik (T5). Both companies employ 130 and 140 employees who design, manufacture and service wheeled equipment, respectively. Both had approximately 10 people in a research and (product) engineering department.

6.1 Analysis of the Cases or Attempting to 'Compare Apples and Oranges'

For each organization, Table 5 in Appendix 1 indicates which of the MIOS functions were formally assigned to, or informally done by, employee(s) or departments in the companies (or not done at all). Seven observations are drawn from the table and the case descriptions listed in Appendix 2.

First, Table 5 shows that larger companies (in number of employees) tend to assign more functions formally than smaller ones. Even small units within these larger units are formally organized, as the 2nd column (case S7) shows. This confirms common knowledge.

A second observation is that the functions that represent the primary process, or operations, are nearly always formally assigned (Supply-V1 and Regulate supply-V2). One exception for both functions is S12 (extreme left column), which is small (4 employees) and relatively young and dynamic. The partial exception for Regulate supply-V2 is S14, which is also a small company. In the fifteen other cases, the primary process responsibilities are formalized. Given the number of employees involved this is what you would expect. Apart from size, organizations holding an ISO9000 certification are required to formalize tasks and responsibilities in their customer order-related primary processes.

Third, the table shows that fifteen organizations, with S4 and S12 as the exceptions, have formally assigned Innovate-I1 and Regulate innovation-I2. Contributing and managing innovation projects involves many human and financial resources, so formalizing the core of the innovation process seems logical.

A fourth observation relates to the distinction between explorative and exploitative innovations. Some of the organizations (T1, T2 and T4) did not make an explicit distinction between the two pairs of Search and Propose functions. Therefore, the pairs V3/I3 and V4/I4 are ‘combined’ and performed by the same employee(s). Nevertheless, it is worthwhile to make this distinction because it is obvious that for ideas concerning present products, markets and processes, employees have to search (V4) somewhere else (e.g. mainly among customers and frontline employees). Searching future new options-I4 may involve a quest for disruptive innovation to be expected in mature technologies (Christensen, 1997). The criteria applied to the preparation (and selection) of the business case are different because these kinds of innovations are incremental and less uncertain (V3).

Although the fifth observation relates to only 8 out of 17 cases, it is worth mentioning that in only one of these eight organizations continuous improvement is formally organized. Because the importance of continuous improvement has been advocated since at least the mid-1980s, in publications on just-in-time, statistical process control, total quality management, ISO9000, ‘six-sigma’, lean and (high involvement) innovation, the author expected that this would have been incorporated into formal job descriptions and routines by all organizations after nearly 30 years. The excuse of T2 was that the company had to downsize the workforce by nearly 50% approximately a year before the interviews due to the 2008 economic crisis, and their lean project manager was among those fired. At the time of the interviews, T2 management had other priorities above reviving and finishing the lean implementation with an improvement mechanism. The informal ways of working at improvement were similar: employees know who to turn to with a suggestion (usually to their own manager but also directly to a product engineer), and if feasible, the ideas are implemented. However, no records were kept of the number of suggestions, rejection rates or total savings.

A sixth observation links to the general innovation process and to the concept of the ‘fuzzy front end’ (FFE) of innovation (Koch & Leitner, 2008). In the ‘innovation journey’ process model by Van de Ven et al. (1999), a similar period, from the generation of an idea or opportunity and the decision to select and hence formally start and fund the innovation project, is labelled the ‘gestation period’. The three steps 'Search-Select-Implement' and the distinction between radical and incremental innovation projects are linked to the functions as explained and shown in Fig. 3 above. Both Search functions (V4 and I4) and Propose functions (V3 and I3) were formally assigned in approximately one-third (4–7) of the 17 companies only. As Kurkkio et al., (2011, p. 134) already noted, the lead time between the generation of an idea and deciding upon the business case or innovation project proposal based on it (Select by Balance-C3) can be shortened by introducing a procedure for the FFE. Talke et al., (2006, p. 378) see 'select' as part of the FFE too. From a structure perspective, this implies that such a procedure makes clear to employees who have responsibilities in this FFE procedure and who may be involved in searching and converting ideas into business cases. Both 3M and Google allow certain employees to spend 10 or 25% of their working time to tinker with ideas and try to determine whether they are technically feasible and economically promising. If so, the business case can be written and presented to the 'innovation board' or a decision team with any other label that performs the function Balance-C3. If time-to-market (TtM) is measured from the generation of a product idea through to introduction on the market, formalizing the FFE may shorten TtM considerably, also enabling 'failing fast', i.e. trying to determine the feasibility of an idea as soon as possible to prevent wasting resources.

The seventh observation relates to larger companies and may not be directly visible from Appendix 1. The bigger an organization grows, the larger the number of dedicated innovators in its workforce becomes, and they are usually grouped in a department. Medium-sized companies such as T2, T4 and S4 had one separate department of approximately 10 employees, of approximately 130 employees in total, responsible for most of the (product) innovation activities. When organizations successfully grow, they develop new PMCs and may organize their activities in separate business units. This was the case with T3 having three business areas and T5 having two independent divisions. As soon as each BU grows large enough to potentially have its own separate 'innovation department', the problem arises regarding whether innovation-related functions should be assigned at the corporate level or at the divisional/business unit level or both. For (radical) ideas, with a development lead time beyond the horizon of the BU management that makes them reluctant to start and fund such innovations, a central innovation function seems necessary. Alternatively, when a radical idea cannot possibly be sold at the existing markets or via the existing channels of the BU's or requires a different business model, the BU-level does not seem appropriate for such an innovation at all (e.g. the IBM-PC was developed within and sold by a new unit completely separate from the mainframe computer division). At T3, with 300 employees distributed among 11 sites all over the world serving three business areas, a central research department already existed, which was linked to university research groups and responsible for delivering proof of concept to a central 'Development' group working together with Operations at the main site to scale up and implement. On the other hand, company T5, nearly four times as large with 1.100 employees in two divisions, did not have a central innovation group, and its two divisions did not do innovation projects together, in spite of the fact that they have a common knowledge base. At first sight, T5 seemed to miss opportunities by not sharing innovation results across the units. The Marine division that participated in the study might benefit from the results of a lean-EtO project that the other division did, but respondents did not even know about it when asked by the researcher who heard about this project at a seminar he attended. Apart from T3 and T5, students doing cases S4, S6, S7, S8, S11 and S13 were faced with the multiple levels of recursion problem.

With this seventh observation, the potential for analysing the data collected thus far seems exhausted.

7 Conclusion, Discussion and Reflection

The cases did reveal that the MIOS serves its intended purposes as a diagnostic tool for practitioners and as a descriptive tool for researchers. The systematic descriptions of the structures along the MIOS functions provided sufficient detail (not shown here, see Lekkerkerk, 2012 and the 12 theses) to compare and contrast them. Although it may seem somewhat superficial at first sight, to just summarize whether functions are fulfilled (or not), and assigned formally or done informally (only because someone likes to do it, or sees the need). However, these descriptions served as a solid, systemic basis for further diagnosis and redesign. For example, zooming in on the Supply-V1 organization, using organizational design theory as a lens, may show opportunities for simplifying the production structure in autonomous product-, service- or market-based units. Then, redesigning the innovation structure is possible whereby each (business) unit may have its own decentralized innovation function. Alternatively, zooming in on Innovate-I1 and Regulate innovation-I2 may lead to rethinking innovation project management approaches. For example, are there at least two funnels like Tidd and Bessant (2009) suggest? Does each have a state-of-the-art way of managing the projects and proper evaluation criteria for business cases?

It is too early to translate the observations into the detailed additional design guidelines for the innovation structure that the Lowlands sociotechnical systems design methodology needs (De Sitter, 1998). Additional data on innovation performance and more details about the actual organizational structure seem to be needed to single out the best practices.

Additionally, the fact that only relatively small Dutch organizations were studied, and their variety, should be mentioned. They are part of the Rhineland tradition of organizing, which is more stakeholder oriented, compared to the Anglo-Saxon tradition, where shareholder value prevails and profit maximization is the main goal and where functional structures based on economies of scale logic are the norm. Because Rhineland tends to put the work floor professional first and is more inclined to decentralize regulation and control responsibilities to the shop floor, it may be that their structures show less formality, which is not only explained by their relatively small size compared to SMEs outside the Netherlands.

7.1 Relatively Easy to Apply and Quick Results

The two to three weeks per case study by Lekkerkerk may be more consultancy hours (80–120) than a client organization can afford to pay for a diagnosis, but for research purposes, this amount of work does not seem to be prohibitive. Especially not when research is done by MSc students for which labour costs are low.

Additionally, the MIOS proved to be a suitable tool for use in graduation projects of students without much work experience. None reflected negatively upon their experience with using the MIOS, although they were explicitly encouraged to be truly critical by their supervisor ('If you find a flaw this will honestly improve your grade!'). Two quotes as an example:

> "In all, it was found that the MIOS is appropriate for diagnosing organizational structures, given that the researcher is aware of the broad theoretical basis underlying the model." Case S3, De Hosson (2011, p. 76).

> "The MIOS has proven to be truly useful and applicable in practice, although it is important that the person using the model is familiar with sociotechnical theory." Case S5, Dijkhuis (2012, p. 70).

Some of the students were determining the structure in larger organizations with multiple levels of recursion (some divisions, with business units and even subunits), and they struggled with the organizational complexity, but in the end, the MIOS helped them to cope with these recursions. In such organizations, the responsibility for innovation projects may be distributed over and assigned to subunits, to business units, to the divisions or centralized and reported to headquarters. This depends on the scope of the project. A project such as ERP implementation would be central because the entire organization would have to work with it, whereas implementing a specific piece of software, only useful for one subunit, may be done by employees from the unit, with maybe an IT architect as part of the team to ensure fit with existing ICT.

7.2 Practical Relevance and Usability

When MSc students in Business Administration, educated in the underlying theory (social system theory, Lowlands sociotechnical system design) but without much working experience, can successfully use the MIOS as a diagnostic tool in their graduation assignments, it can be assumed that consultants and managers with some education in business administration can apply it for diagnostic purposes.

Diagnosing can be done by an 'expert' interviewing a sample of employees and processing the results in (less than) a month, but a small team of organizational members may need a few days together and maybe even fewer.

Additional experience on two other occasions indicated that this assumption may indeed be correct. In a seminar (November 2013) for various managers and in a one-day workshop with the management team of the Dutch subsidiary of a multinational (February 2014), where the author briefly presented the MIOS, the participants fruitfully applied it to their own organization. The latter team was slightly shocked to determine that despite their many years of combined experience in the firm, they could not indicate who of their 16,000 colleagues in North and Western Europe might be involved in or responsible for Search future new options-I4. The MIOS helped them find a/the cause for the incremental nature of their firm's innovation projects.

More detailed diagnosis may be carried out by adding additional theories or audit frameworks. For example when the innovation portfolio management responsibilities (related to Balance-C3) appear to be absent or unclearly assigned, or when the production structure seems highly complex, insights can be added from portfolio management literature or L-STSD, respectively. This will lead to additional benefits for the organization, while at the same time the case can retain its usefulness for the theoretical multiple case comparison.

7.3 Reflections on Further Research

For further research, the suggestions by Elsahn et al. (2020) can be taken into account. From this review, three potential improvements to the case research protocol surfaced from trying to analyse and compare these students' cases.

First, a further standardization of the format in which students have to report the data on their case would facilitate the comparison and prevent missing data on the organization (e.g. on continuous improvement, on general organizational performance and on its innovation success rate).

Second, the recursive thinking appeared to be difficult, so some additional guidance should be developed on how to use MIOS in large organizations with multiple divisions, each consisting of strategic business units, and business units. This can help to map out what innovation responsibilities and activities are done by all units at each of the levels; central, divisional, SBU, BU and even below to some innovation done by operational work floor teams next to their daily duties.

Third, with a relatively limited number of cases and the wide diversity of the organizations, no clear patterns can yet be expected to appear in the organization of innovation. It would be worthwhile to try to gather sets of cases done in more comparable organizations, e.g. all having one site, roughly equal number of employees, same industry or main technology, same degree of volume and variety in product/service and same or similar markets and customers (BtB or BtC). This is based on the assumption that their innovation challenges would also be similar.

8 Towards Multiple Value Creation and Innovative Workplaces

Debates on Environmental, Social and Governance (ESG) are getting stronger and strengthen the need to use a triple bottom line, People-Planet-Profit, for organizations to help solve many problems.

Currently, too many employees (*people*) suffer from stress and burnout, so improving the quality of work by redesigning the structure is greatly needed. Others propose improving the 'meaning quotient' of work (Cranston & Keller, 2013) and creating the best workplace on earth (Goffee & Jones, 2013). This social responsibility extends along the supply chain to low-wage-countries where payment and labour conditions are poor.

At the same time, innovation is deemed necessary to solve sustainability issues, and more innovation success will both increase the chances of finding solutions on time to save the *planet*, lead to more income and *profit* from successful innovations and reduce innovation costs, which may also improve *profit*.

All this requires jointly optimizing the quality of organization and of work. Lowlands sociotechnical system design is already quite capable of doing that for the primary process. Further developing this design approach by using the MIOS in sets of comparative case studies, ultimately leading to design guidelines for 'innovation structures', might speed up innovation and improve innovation success. This leads to innovative and responsible workplaces and implies that the same amount of resources will yield more innovations delivering multiple values.

Acknowledgements Thanks to all five organizations participating in the PhD project by Lekkerkerk (2012) and those in the MSc graduation projects of students. This chapter is largely based on a paper presented by the author at the 2015 STS-RT conference in Leuven, Belgium. Colleagues Kristina Lauche and Armand Smits provided useful feedback on earlier versions of this paper, as did participants of EGOS2014 and STS-RT2015. Finally, the editors of this book, Rob Dekkers and Laure Morel, and an anonymous reviewer provided insightful feedback.

Appendix 1

See Table 5.

Table 5 Combined and condensed data on 17 cases (5 by author and 12 by students supervised by author + peer review of master thesis at defence)

OrgCode	S12	S7	S14	S1	T1	T2	S4	T4	S5	S13	T3	S11	S2	T5	S10	S6	S8	
Emplo	?	1400	30	80	120	130	140	140	210		300	300	390	1100		2164		
In BU	4	4								250				580	1100		11 k	
Since	2008	1997	1884	1975	1959	1959	1987	1987	1932	< 1900	1968	1850	1884	1900	1850	1893	1881	
MPS[a]	serv	sw	AtO	EtO	EtO	AtO	EtO/MtS	AtO	AtO	MtO	MtO	care	EtO	EtO	cons	gov	fin	
MIOS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Sum
Function																		# F
V1	i/F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	16
V2	i	F	i/F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	15
V3	i	F	i	i	i	i	F	i	F	F	F	i	i	i	F	F	i	7
V4	i	i	i	i	i	i	F	i	i	i	F	F	i	i	F	F	i	5
I1	i	F	F	F	F	F	i	F	F	F	F	F	F	F	F	F	F	15
I2	i	F	F	F	F	F	i	F	F	F	F	F	F	F	F	F	F	15
I3	i	F	i	i	i	i	i	i	i	F	F	i	i	i	F	i	F	5
I4	i	i	i	i	i	i	i	i	i	i	F	F	i	i	F	i	F	4
C1	F	F	i	n	i	i	i	F	F	i	F	i	i	i	F	L2	i	6
C2	i	F	F	F	i	F	i	F	i	F	F	i	i	F	F	F	i	10
C3	i	F	i	F	i	F	i	F	F	F	F	i	F	F	F	F	F	12
C4	F	F	F	F	i	F	F	F	i	F	F	F	F	F	F	F	F	15

(continued)

Table 5 (continued)

OrgCode	S12	S7	S14	S1	T1	T2	S4	T4	S5	S13	T3	S11	S2	T5	S10	S6	S8	
# Form	2	10	5	7	4	7	5	9	7	9	12	7	6	7	12	9	8	n.a
CImpr	?	?	?	i	i	i	?	F	?	?	i	?	i	i	?	?	i	

Appendix 2

References to Student Case Studies

Archives of all MSc theses, including digital versions and most of the transcripts and other data, with the author.

The nine non-confidential theses are publicly available in the Nijmegen School of Management MSc thesis collection (a.k.a. Radboud Repository).

S1 Geukers, J. (2011). *Innovation in an engineer-to-order organization. A case-study in the superyachting industry.* **(confidential)** MSc-thesis, Business Administration, Radboud University, Nijmegen

S2 Sadelhoff, A. van (2011). *A recommendation regarding process planning for Royal Huisman Shipyard.* MSc-thesis, Business Administration, Radboud University, Nijmegen

S3 Hosson, F. de (2011). *The structural dilemma of Topicus. A story of cowboys and chameleons: evolution of an extraordinary organism.* MSc-thesis, Business Administration, Radboud University, Nijmegen

S4 Maas, J. (2012). *Can structure fix multiple problems? A diagnosis of the current and future organizational structure of "S4".* **(confidential)** MSc-thesis, Business Administration, Radboud University, Nijmegen

S5 Dijkhuis, K. (2012). *Organizing the future.* **(confidential)** MSc-thesis, Business Administration, Radboud University, Nijmegen

S6 Melgers, D. (2012). *A diagnosis of the innovation structure of the Nederlandse Voedsel- en warenauthoriteit.* MSc-thesis, Business Administration, Radboud University, Nijmegen

S7 Biesmans, mrs. M. (2012). *The reorganization of "S7". A research project focusing on the organization structure of "S7" and the involved parties at "mother company" in order to increase performance.* **(confidential)** MSc-thesis, Business Administration, Radboud University, Nijmegen

S8 Hogeveen, J. (2012). *Innovation structures for firms in the financial servces industry. A case study analysis at ING Bank the Netherlands.* MSc-thesis, Business Administration, Radboud University, Nijmegen

S9 Fikken, T.W. (2012). *Design of the organizational structure fitting the Wwnv. A research project aimed at the design of an organizational structure fitting the demands arising from the 'Wet werken naar vermogen'.* (for Delta Zutphen), MSc-thesis, Business Administration, Radboud University, Nijmegen

S10 Korteweg, M.E.H. (2012). *How to measure the innovation performance of KPN Consulting. A design-oriented case-study on how the innovation performance can be measured.* MSc-thesis, Business Administration, Radboud University, Nijmegen

S11 Bouwhuis, P.M. (2013). *Diagnosing the Radiology Department of the CWZ. A diagnostic research, focused on the organization structure of the radiology*

department in order to improve the innovation process. MSc-thesis, Business Administration, Radboud University, Nijmegen

S12 Rozemeijer, S.W. (2013). *The infrastructure of the future for an urban freight transport sustainability concept.* (for Binnenstadservice Nederland). MSc-thesis, Business Administration, Radboud University, Nijmegen

S13 Halmans, S. (2014). *Process innovation, innovation structure and project portfolio management within 'S13'; a diagnosis.* **(confidential)** MSc-thesis, Business Administration, Radboud University, Nijmegen

S14 Nijman, G. (2014). Harvesting the fruits of organizational research. Research of the organizational and control structure of Munckhof BV. MSc-thesis, Business Administration, Radboud University, Nijmegen

References[1]

Achterbergh, J.M.I.M., & Riesewijk, B. (1999). *Polished by use; four windows on organization.* Eburon, Delft, PhD-thesis Radboud University.

Achterbergh, J., Dankbaar, B., Lekkerkerk, L. J., & Martens, W. (1999). Bestendiging door vernieuwing, over functies en structuren voor vernieuwing. *M&O, Themanummer Innovatie, 53*(4), 147–162.

Achterbergh, J., & Vriens, D. (2009). *Organizations.* Springer-Verlag.

Achterbergh, J., & Vriens, D. (2019). *Organizational development. Designing episodic interventions.* Routledge.

Andersen, J. A., & Jonsson, P. (2006). Does organization structure matter? On the relationship between the structure, functioning and effectiveness. *International Journal of Innovation and Technology Management, 3*(3), 237–263.

Ashby, W. R. (1956). *An Introduction to Cybernetics*. Chapman & Hall; Internet 1999: http://pcp.vub.ac.be/books/IntroCyb.pdf.

Beer, S. (1994). *The heart of enterprise.* 'The Stafford Beer Classic Library', Wiley, Chichester.

Beer, S. (2000). *Diagnosing the system for organizations.* 'The Stafford Beer Classic Library', Wiley.

Bessant, J. (2003). *High-involvement innovation; building and sustaining competitive advantage through continuous change.* Wiley.

Burton, R., Obel, B., & Håkonsson, D. D. (2015). *Organizational design.* Cambridge University Press.

Christensen, C. M. (1997). *The innovator's dilemma.* Harper Business.

Cranston, S., & Keller, S. (2013). Increasing the 'meaning quotient' of work. *McKinsey Quarterly, 1*, 48–59.

Crossan, M. M., & Apaydin, M. (2010). A multi-dimensional framework of organizational innovation: A systematic review of the literature. *Journal of Management Studies, 46*(6), 1154–1191.

Elsahn, Z., Callagher, L., Husted, K., Korber, S., & Siedlok, F. (2020). Are rigor and transparency enough? Review and future directions for case studies in technology and innovation management. *R&D Management, 50*(3), 309–328.

Goffee, R., & Jones, G. (2013). Creating the best workplace on earth. *Harvard Business Review, 91*(5), 99–106.

[1] Note: References to the student case studies are in Appendix 2.

Hammer, M., & Champy, J. (1993). *Reengineering the corporation. A manifesto for business revolution.* Harper Business.

Hammer, M. (1996). *Beyond reengineering. How the process-centered organization is changing our work and our lives.* Harper Business.

Hislop, D. (2005). *Knowledge management in organizations, a critical introduction.* Oxford University Press.

Hootegem, G. van, Amelsvoort, P. J. van, Beek, G. van, & R. Huys, R. (2008). *Anders organiseren & beter werken; handboek sociale innovatie en verandermanagement.* Acco, Leuven.

Kester, L., Hultink, E. J., & Lauche, K. (2009). Portfolio decision making genres: A case study. *Journal of Engineering and Technology Management, 26*(4), 327–341.

Koch, R., & Leitner, K. H. (2008). The dynamics of self-organization in the fuzzy front end: Empirical evidence from the Austrian semiconductor industry. *Creativity and Innovation Management, 17*(3), 216–226.

Kuipers, H., Amelsvoort, P. J. van, & Kramer, E. H. (2010). *Het nieuwe organiseren. Alternatieven voor de bureaucratie.* Acco uitgeverij. (3rd revised 2018).

Kuipers, H., Amelsvoort, P. J. van, & Kramer, E. H. (2018). *Het nieuwe organiseren: alternatieven voor de bureaucratie* (3e herziene druk). Acco uitgeverij, Leuven.

Kuipers, H., Amelsvoort, P. J. van, & Kramer, E. H. (2020). *New ways of organizing: alternatives to bureaucracy.* Acco (English translation of the 3rd revised 2018 Dutch edition).

Kurkkio, M., Frishammar, J., & Lichtenthaler, U. (2011). Where process developments begins: A multiple case study of front end activities in process firms. *Technovation, 31*(September), 490–504.

Laloux, F. (2014). *Reinventing organizations. A guide to creating organizations inspired by the next stage in human consciousness.* Nelson Parker.

Lekkerkerk, L. J. (2012). *Innovatie- en OrganisatieStructuur. Ontwikkeling en test van een functiemodel voor structuuronderzoek en diagnose.* PhD-thesis Radboud Universiteit, Innovatica, Nijmegen. http://repository.ubn.ru.nl/handle/2066/93601

Lekkerkerk, L. J. (2017). *Self-managing in a Merry-go-round*. https://www.linkedin.com/pulse/self-managing-merry-go-round-l-j-hans-lekkerkerk

March, J. G. (1999). *The pursuit of organizational intelligence.* Blackwell Business.

Mintzberg, H. (1989). *Mintzberg on management*. The Free Press.

Mizuno, S., (Ed.) (1988). *Management for quality improvement. The 7 new QC tools.* Productivity Press.

Mumford, E. (2006). The story of socio-technical design: Reflections on its successes, failures and potential. *Info Systems Journal, 16*(4), 317–342.

Nadler, D. A., & Tushman, M. L. (1997). *Competing by design.* Oxford University Press.

OECD (2002). *Frascati Manual, proposed standard practice for surveys of research and experimental development*. Pdf available from: http://www.oecd-ilibrary.org/docserver/download/9202081e.pdf?expires=1400844762&id=id&accname=oid006602&checksum=30710D27426B78E171D4A8E1DDBD34E3

OECD (2005/2018). *Oslo Manual* (3rd ed.). Pdf available from: http://www.oecd.org/science/inno/2367580.pdf

OECD (2018). *Oslo Manual* (4th ed.). Pdf available from: https://www.oecd.org/sti/oslo-manual-2018-9789264304604-en.htm

O'Reilly, C. A., III., & Tushman, M. L. (2004). The ambidextrous organization. *Harvard Business Review, 82*(4), 1–8.

Pot, F. (2022). Monotonous and repetitive work—Some people are more unequal than others. In: Abrahamsson, K., & Ennals, R., (Eds.), *Sustainable work in Europe. Concepts, conditions, challenges* (pp. 77–96). Peter Lang.

Pugh, D. S., Hickson, D. J., Hinings, C. R., & Turner, C. (1968). Dimensions of organization structure. *Administrative Science Quarterly, 13*(1), 65–105.

Ries, E. (2011). *The lean startup. How constant innovation creates radically successful businesses.* Portfolio-Penguin.

Simon, H. A. (1996). *The sciences of the artificial* (3rd ed.). The MIT Press.
Sitter, L.U. de (1981). *Op weg naar nieuwe fabrieken en kantoren*. Kluwer, Deventer (Report for the Dutch 'WRR; Scientific Council for Government Policy).
Sitter, L.U. de (1994). *Synergetisch produceren; Human Resource Mobilisation in de produktie: een inleiding in de structuurbouw*. Van Gorcum, Assen.
Sitter, L.U. de (1998). *Synergetisch produceren; Human Resource Mobilisation in de produktie: een inleiding in de structuurbouw* (2nd revised ed.). Van Gorcum, Assen.
Sitter, L. U. de, & Groep Sociotechniek (1987). *Het flexibele bedrijf. Integrale aanpak van flexibiliteit, beheersbaarheid, kwaliteit van de arbeid en produktie-automatisering*. Kluwer Bedrijfswetenschappen, Deventer.
Sitter, L. U. de, Hertog, J. F. den, & Dankbaar, B. (1997). From complex organizations with simple jobs to simple organizations with complex jobs. *Human Relations*, *50*(5), 497–534.
Talke, K., Salomo, S., & Mensel, N. (2006). A competence-based model of initiatives for innovations. *Creativity & Innovation Management, 15*(4), 373–384.
Tidd, J., & Bessant, J. (2009). *Managing innovation. Integrating technological, market and organizational change* (4th ed.). Wiley.
Tidd, J., & Bessant, J. (2021). *Managing innovation. Integrating technological, market and organizational change* (7th ed.). Wiley.
Trist, E., & Bamforth, K. (1951). Some social and psychological consequences of the Longwall Method of coal getting. *Human Relations, 4*(1), 3–38. https://doi.org/10.1177/001872675100400101
Veeke, H. P. M., Ottjes, J. A., & Lodewijks, G. (2008). *The delft systems approach*. Springer.
Veld, J. in 't (1994). *Analyse van organisatieproblemen; Een toepassing van denken in systemen en processen* (6th revised ed.). Stenfert Kroese/EPN, Houten.
van de Ven, A. H., Polley, D. E., Garud, R., & Venkataraman, S. (1999). *The innovation journey*. Oxford University Press.
Womack, J. P., & Jones, D. T. (2003). *Lean thinking; banish waste and create wealth in your corporation* (Fully revised and updated ed.). Free Press.
Yin, R. K. (2003). *Case study research; design and methods*, (3rd ed.). Applied Social Research methods Series, (Vol. 5). Sage Publications.

L. J. Lekkerkerk (Hans, born 1959) obtained his BSc in Mechanical Engineering, with an MSc in Systems thinking from Delft University of Technology in 1985. He worked for the Composite Structures Division of Fokker Aircraft in various roles contributing to many innovation projects. He was a trainer/consultant for 1, 5 year before joining Radboud University in September 1997 as a lecturer/PhD researcher. The thesis on the organization of innovation was defended in 2012. He is currently a senior lecturer in organizational structure design within the department of Business Administration of the Nijmegen School of Management.