Organizing innovation

Comparative casestudy using a new research tool to study innovation structures.

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Abstract

This paper presents the development and tests of a cybernetic model containing necessary and sufficient functions that should be fulfilled in an organization that aims to remain viable. This 'Model Innovation and Organizational Structure' (or 'the MIOS') is needed as a research tool to study organizational structures within which the 'innovation structure' must be embedded. By doing comparative case studies using the MIOS the ultimate aim is to deliver the concrete design guidelines for the innovation structure that are still lacking in the Lowlands sociotechnical system design approach. With these guidelines it is expected that redesigning organizational structures with an integrally embedded and linked innovation structure will help to improve the persistently low performance of the innovation and change activities (less than 30% success on average) by organizations. Seventeen organizations participated in the tests showing that the MIOS can be used as a research tool by its developer, and also by master students in business administration. Inevitably, due to pragmatic sampling and the limited number of very different cases, the comparison showed just a few results yet. However, the paper shows that the road to further research is now open, and also that practitioners may use the MIOS to diagnose organizational structures.

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Introduction

The controllability of the innovation and episodic change processes in organisations seems poor given the average failure rate of 70% (an overview in Lekkerkerk 2012:261). Although innovation research did not lead to generalizable insights in the link between innovation and organizational performance according to a review by Crossan & Apaydin (2010:1176), this poor performance is a problem worth solving. More innovation success may lead either to more innovation for the same amount of resources or the same amount of innovation may require less resources.

Now, primary processes of organizations showed enhanced performance by 'reshaping workplaces' i.e. a redesign of the organizational structure, leading to increased controllability and higher quality of work. The redesign may be inspired by Lowlands sociotechnical system design (De Sitter et al. 1997, Van Hootegem ea. 2008), by Business Process Redesign (Hammer & Champy 1994, Hammer 1996), or by lean thinking (Womack & Jones 2003). Some companies even report a 'six sigma level of quality control' in their operations.

By analogy the question comes up: Would redesign of an 'innovation structure' lead to improvements like those seen in primary processes? Unfortunately the Lowlands sociotechnical design approach lacks concrete guidelines for the redesign of the innovation (sub)structure as part of an integral redesign of the entire structure (De Sitter 1998: 396).

Hence a first problem is: How to obtain these design guidelines? Studying the organizational structures, and how an 'innovation structure' is integrated in it, of successfully innovating organisations might reveal these design guidelines. Applying them will eventually improve innovation performance.

To obtain these design guidelines organizational structures, preferably of successful innovators, will have to be studied in detail. So far, quantitative studies, e.g. those relating structure to organizational performance, operationalized structure using insights from Pugh e.a. (1968) like Andersen and Jonsson (2006) 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' (239).

However, like Crossan and Apaydin (2010) concluded for innovation and performance, these studies did not reveal much guidance on organizational structure design. A potential reason for this may be that the way structure was operationalized in the surveys does not capture the dimensions of structure essential for high (innovation) performance. De Sitter (1998) demonstrates that the design of the production structure influences the quality of the organization including controllability and innovativeness. To fruitfully study organizational structure the operationalization should be able to surface whether a structure is functional (activity based) or 'lean' (flow-based), which are respectively less and more controllable from De Sitter's point of view. Now the trouble is that such two, really different structures may have the same degrees of formalisation (both high) and centralisation (both low), and yet at the same time one would expect quite a difference in performance indicators like order lead time and work in process (e.g. Womack & Jones 2003).
Another (partial) explanation why the relation between structure and (innovation) performance is not yet clear also follows from Lowlands sociotechnical systems design thinking (De Sitter e.a. 1997) which states that controllability can only be influenced by integrally redesign an organizational structure using De Sitter's design guidelines. Low performance is an effect of lacking controllability caused by a complex design of the production structure and hence of the control structure. Innovation is a 'control activity' and in this integral sociotechnical view the innovation performance may be negatively influenced by a complex production structure to which the innovation structure should be properly linked. So, to study (innovation) performance effects of structure the whole organizational and innovation structure should be integrally studied, and this implies such an amount of detail in the data that it seems not possible using a survey. Also, the lack of clearly defined, unambiguous and objectively measurable organizational structure concepts, well understood by practitioners filling in the questionnaires, doesn't help survey research on organizational structure either.

So qualitative research is needed here, but doing comparative case studies with large numbers of cases on such a complex object as the organizational structure is a lot of work collecting and analyzing data. And first and foremost the question to be answered is: How to meaningfully and efficiently compare organizational structures? 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 is needed. Lekkerkerk (2012) developed such a tool in his PhD-project on which this paper is mainly based.

The paper will proceed as follows. It starts explaining some theoretical background on Lowlands sociotechnical systems design to make clear the theoretical background of this research. Then the research tool, a cybernetic function model, is explained. It proceeds with the combined results of two empirical tests of the model: first in five companies (by the author in 2010), and second in twelve more organizations (done by students between 2011 and 2014). The results are discussed and the conclusion is twofold: the model 'works' as a research tool so further research aimed at developing the sociotechnical design guidelines for the innovation structure is feasible, and practitioners can use the model for diagnosing organizational structure.

Theoretical background and gaps in Lowlands sociotechnical systems design

System theory (e.g. Ashby 1956) and Lowlands sociotechnical theory (e.g. De Sitter e.a. 1997, De Sitter 1994, Achterbergh & Vriens 2009) seemed to provide ingredients for a framework or model to enable the comparative case studies on organizational structures and their effect on performance. Sociotechnical organization design has its origin in research by the Tavistock Institute in the Durham coal mine in the 1950's (Trist & Bamforth 1951, Mumford 2006, Van Hootegem ea. 2008, Kuipers ea. 2010). In The Netherlands further development was led by De Sitter (e.g. 1998, Achterbergh & Vriens 2009) starting with his publication 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' visualised in Figure 1.

The production structure (PS), encompassing the operational activities of the primary process, which is delivering the products and services of the organisation, should be designed in a way that minimizes the number of interfaces between organisational 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

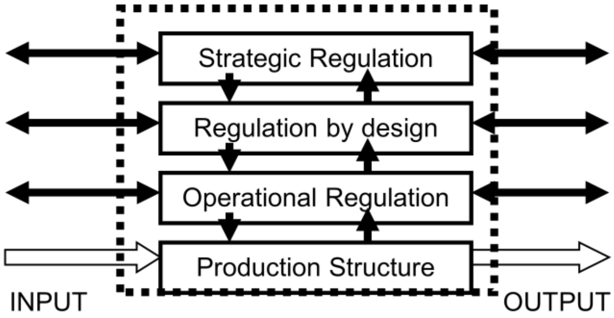

Figure 1 Lowlands sociotechnical design-view of an organization as an open system

notable source of trouble (like in ICT between hardware components and 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). Most former handovers are now within these groups, and hence coordination can be by mutual adjustment. Apart from activities transforming input (material, customer, data) into output, the PS includes preparatory activities (order intake, process planning), and supporting activities (HR, logistics, maintenance, catering, other facilities). Adding preparatory and support activities as much as feasible to the tasks of groups responsible for such flows, makes these groups even less dependent from other organisational units. The task of the designer is to find such independent flows to reduce the number of interfaces.

The control structure is modelled in three layers, shown in figure 1 following Ashby (1956): operational control, regulation by design, and strategic regulation. To enable the independent PS-groups to truly function as 'plants-within-the-plant', also 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 attend joint bi-annual discussions on the strategy respectively. At first a group leader may be responsible for all control activities, but these groups may develop into self-directing work teams and gradually divide control tasks among other members. Jumping to that end state of team development or just relabeling a department to a 'self-directing work team' without changing the Production Structure proved a recipe for failed ‘social innovation’-projects in practice. This may explain why (Dutch) managers lost interest in sociotechnical redesign.

The layer ‘regulation by design’ entails all activities aimed at adapting the organisation to changes or opportunities in the environment or to fresh strategic insight developed internally. De Sitter (1998) also uses ‘innovation structure’ for this control structure layer. At the end of his last book he concludes that developing concrete design guidelines for this innovation structure is needed and presents this as ‘a challenge for young scholars’ (1998:396). Given the need for innovation, and for higher innovation success rates, is still there, this gap in Lowlands sociotechnical design theory should be closed to help achieve that.

Another task for designers is to diagnose existing organisational structures and redesigns for it. When is a structure or redesign good, and when a source of trouble? De Sitter (1998, De Sitter e.a. 1997, Achterbergh & Vriens 2009) 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 to find essential activities that are not done at all, probably explaining part of the problems. Such a function model is lacking in Lowlands sociotechnical theory, and this is a second gap, besides 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 organisational structure. An organizational chart shows the hierarchy, and by the names of the departments hints at what their tasks may be (e.g. quality assurance, operations, marketing). But the chart alone will not do, and by listing tasks per department, the resulting descriptions of various structures become incomparable. By looking instead through the lens of the functions, the researcher may put aside the chart and its departments, and ‘map’ the contributions of various employees, groups etc. to these functions. By doing so for each function, and for the relations between the functions, the question is answered which individuals, project teams or departments are involved. Such an analysis may be described in text and then summarised 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 another column with data on a second organisation, 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 organisational and innovation structure. Such a comparison is much more systematic than just comparing processes, or the boxes appearing on the two organisation charts, or the engineering departments only. And this way both structures are integrally studied, which is mandatory according to Lowlands sociotechnical theory.

- Defining innovation and distinguishing it from continuous improvement -
Innovation is a core concept and should be defined because so many different definitions may be found in literature. Below a specific definition that is useful at organizational level and for organizational structure design is outlined. Also the distinction with continuous improvement used in this research is described.
Several types of innovations exist e.g. technological, social, organisational, product, process, ICT, service, market, or business model and the OECD defines most of them in the Frascati and Oslo Manuals (OECD 2002, 2005). These manuals do mention that innovation projects by organizations deliver several types of innovation, e.g. the new product and the new process and a new group in the sales department to sell it to the new market. Multiple types are the rule rather than the exception, and imply the need for multidisciplinary project teams for innovation, and this makes one wonder whether studying product innovation in isolation is useful. Also 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, are considered innovation projects being part of the total ‘innovation portfolio’.
Apart from type of result, innovations are also characterised by their degree of newness. An innovation may be new to the world (the very first car, computer), but is always new to the organisation developing (or sometimes just buying) and implementing it. Tidd and Bessant (2009) use the terms ‘discontinuous innovation’ for

radical or explorative innovations and ‘steady state innovation’ for incremental or exploitative innovations, and each kind has its own approach or ‘funnel’, which they draw as parallel processes, indicating different approaches and groups.

The distinction between (incremental) innovation and continuous improvement (CI) is not clear, and the also subjective degree of newness will not give a clue. Innovation is usually done on a project by project basis, 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’. Continuous improvement is mainly carried out within and by any department alongside the daily work, and the changes are implemented without prior higher management approval and without much involvement of other departments. From a systems theory perspective finding, evaluating, and implementing such small improvements is considered to be part of an operational control loop. 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 organised and managed according to TQM and lean theory, and its importance for the overall performance improvement, means that one should pay explicit attention to it when diagnosing a structure. It being part of operational control implies that there is no separate organizational ‘function’ needed from a systems 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 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. And contributing to incremental improvement is part of each job.

Development of the function model

A function model of an organization is an organizational cybernetic concept. Function here refers to the contribution of an element or subsystem to the system it is part of (in ‘t Veld 1994). So it should not be confused with function referring to ‘an individual’s job’ or to a functional (or activity based) structure. And ‘model’ refers to a simplified representation of the complex reality to highlight certain aspects, in this case the different functions 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. And 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 organisation) may be further and further divided in again (near) autonomous sub-units. E.g. three divisions of Philips, each divided in 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 the fact that it only contains five functions, and only two 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 to intuitively understand it. So, the VSM serves as a basis, but a model containing more functions to represent the innovation structure, and giving all functions 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 ea 2008). Secondly, innovation management literature supplied the steps in any innovation process: search, select, implement, capture (Tidd & Bessant, 2009:44). The distinction between exploration and exploitation (March, 1999:133), linked to radical and incremental innovation, with the idea that any organisation should do both in an 'ambidextrous' way (O'Reilly III & Tushman 2004), was used too. Closely linked to ambidexterity is the notion of a balanced innovation portfolio of projects (Kester et al. 2009:328). Combining newly developed and existing knowledge is related to innovation (Hislop 2005) and so an organisational memory is important.

Due to size limits of a paper 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 Organisational Structure' (acronym: the MIOS). Figure 1 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.

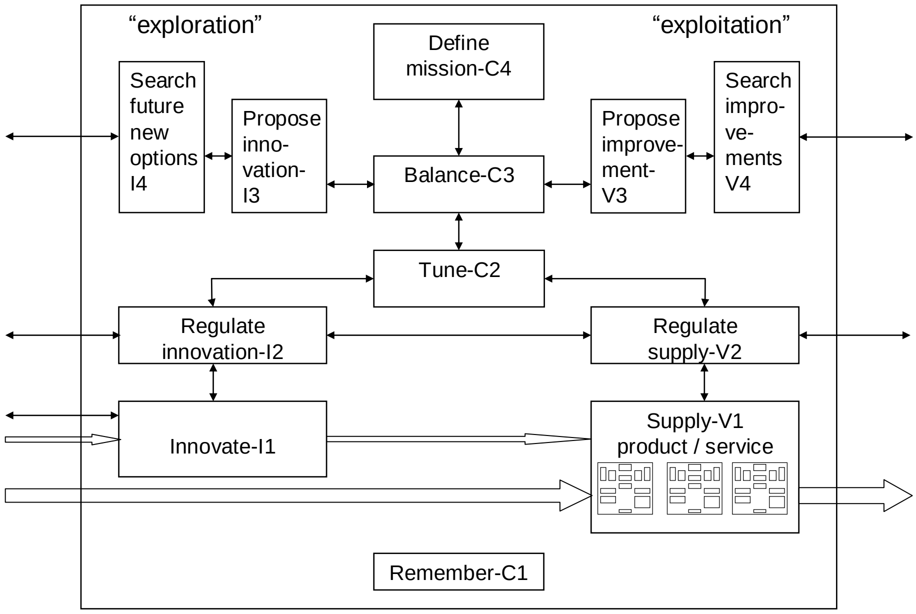

Figure 2 The developed function model: the Model Innovation and Organisational Structure or 'the MIOS'. (Lekkerkerk 2012 p. 296) (some relations, e.g. those of Remember-C1 with all other functions, are omitted for clarity of the drawing).

The contributions of the twelve functions of the MIOS to an organisational system are summarized in Table 1, and Continuous improvement is added for reasons 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 which execute them well, is able to remain viable, i.e. 'able to maintain its separate existence' (Beer 1994:113). 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 figure 2 the small versions of the MIOS in the function Supply-V1 symbolize this recursion. Big companies may have independent Divisions, which consist of Business Units, and in such organizations the 'right' degree of (de)centralisation of control, which includes regulation by design or innovation, is a challenging task for the structure designer.

Table 1 Brief description of the functions in the MIOS (Lekkerkerk 2012:297)

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 impro-vement-V3	make project proposals for the best opportunities for improvement received from V4
Search impro-vements-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 & 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

These MIOS-functions are related to innovation management and sociotechnical literature briefly described above. The generic innovation process steps (Tidd & Bessant, 2009:44) 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 these two 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 depend on this distinction too, 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.

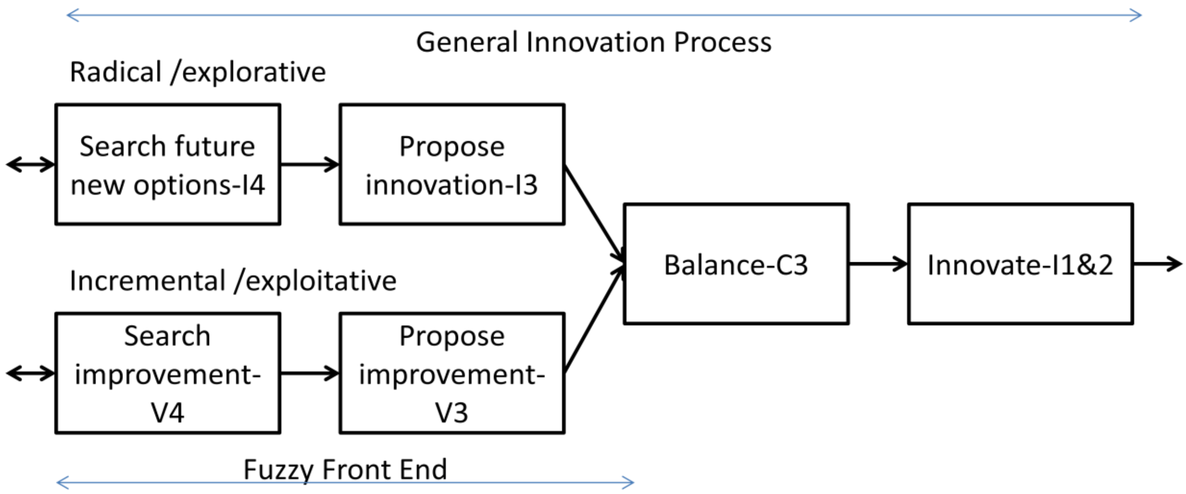

Figure 3 The MIOS functions and a general innovation process model

The Lowlands sociotechnical theory matches the MIOS-functions in the following way. The Production Structure as defined by De Sitter equals Supply-V1. The three layers of his Control Structure are incorporated of course. Regulate supply-V2 is his operational regulation layer and Define mission-C4 equals strategic regulation. The remaining functions are detailing the layer regulation by design (or the innovation structure). Remember-C1 is supporting all other functions by serving as organizational memory.

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

Methodology of the two tests

It was decided that testing the MIOS in practice was necessary to find out whether it was possible to gather enough data in a limited amount of time to systematically describe organizational structures, to diagnose them individually, and to compare them, using the MIOS. The constraint ‘limited amount of time’ is important for the feasibility of the intended further research. Empirical testing was done in two rounds. The first round was to be done by the author, and (if positive) then a second round by having student in business administration use the MIOS in their research projects for their master thesis. The latter would show whether these less experienced researchers would be able to do case studies useful for the overall research goal (i.e. develop design guidelines for the innovation structure embedded in the complete structure). If they would be able to do that, the amount of case studies per year would increase beyond the number of cases the author is able to do, and it would at least suggest that other organizational structure researchers might put it to fruitful use too. Also this second round should lead to more experience in using the MIOS as a diagnostic tool, and finally, because of the diversity of organizations, their projects had to show the applicability in various kinds of organizations. For system theorists the latter is not really necessary, because it is claimed that function models are universally applicable (Beer 2000, in ‘t Veld 1994).

-first part of test-

The author did a pilot comparative case study in five rather different, not too large organisations which should provide sufficient evidence that it would serve the intended applications (Yin 2003:78). A selection of companies was made using a database of Dutch companies available at Radboud University (company.info) on the following criteria: industry sector (automotive and general), number of employees between 100 and 1,000 (then structure becomes increasingly relevant), close to Nijmegen (to save travel time), independent own product and related service (so its own innovation responsibility), over 10 years old (as a proxy for viability). The longlist was shortened by using internet data on the companies and those with seemingly higher innovation success were on top of the shortlist. A telephone call to companies T1, T4 and T5 led to a first appointment (after which the contact person decided to participate). Company T2 was recruited through the network of the PhD- supervisor and company T3 was invited to join after their presentation during a conference organized by the School’s Student Association (Synergy). Both met the criteria mentioned previously. Table 2 presents the participating companies and some basic data. Apart from Ezra, which was owned by managers, some senior employees and an investment fund, all were family owned and managed companies. Rik (T5) was headed by the founder, T1 (Eline) and T4 (Leon) by the second generation, and T2 (Amelie) by the fourth generation.

Table 2 The five anonymous test 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

*MPS = master production schedule, indicating what part of primary process is on customer order; EtO: engineer to order, MtO: make to order, AtO: assemble to order.

Based on 25 years of working experience the researcher offered to give his expert opinion on the total state of affairs on organization and innovation he observed at the companies, or a related problem the contact person mentioned, in return for their participation. This led to further discussions with Ezra (T3) on the division of work between central research, product development at main site and at sites abroad, and their relation to all manufacturing sites. With Amelie (T2) it was discussed whether or not to start a new business unit.
Some data from the company website prepared for the intake with a top manager (T1-Eline, T2-Amelie, T3-Ezra) or the managing owner (T5-Rik, T4-Leon). Additional documents obtained after the intake (e.g. organisation chart, job descriptions, quality manual) were used to prepare the interviews. The respondents were chosen with the contact persons who stated that together these 4 to 9 employees or managers were able to provide a complete overview of the organizational structure. Apart from the 5 contacts in total twenty-nine employees were interviewed. Most respondents were (operations or innovation) manager or innovation project leader (Lekkerkerk 2012 appendix G4). All were able to relate some or all of the MIOS-functions to their own job or their department's tasks. The interviews were semi-structured using a chart of the MIOS as reference, plus a number of general and respondent-related topics from the intake, from the documents or from previously held interviews to cross check. They were digitally recorded and afterwards all answers were sorted to the functions or relations they applied to. It took the researcher between two and three weeks per company to process all the data into a rich and usable case description which included the diagnostic remarks on the agreed topics. This was sent to the company for approval. After that the cases were compared. Further methodological details of this part of the test are in Lekkerkerk (2012).

-Second part of test with student researchers-
Since 2011 (until June 2014) fourteen MSc-students used the MIOS in their graduation projects supervised by the author. Because students are required to acquire their own research object, the strategy for selection of cases is 'pragmatic' and as an inevitable consequence, the possibilities to fruitfully compare this collection of 'apples and oranges' will be limited. Most of these studies were diagnostic projects in which an innovation (structure) problem of an organization was studied as a graduation project leading to an MSc-degree in Business Administration at the

Nijmegen School of Management. One student made an organisational structure redesign and used the MIOS to check whether his redesign covered all necessary and sufficient functions. A redesign is not suited for showing actual performance of an existing innovation structure so this case (S9) is left out. 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.
In all organizations students collected data on the organizational structure using semi-structured interviews, made 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 documents, e.g. quality manuals, job descriptions were gathered and analysed to find out about the formal organisation and compare or check with the interview data. The company supervisors approved the final draft of the theses.

Twelve of the companies studied so far by students delivered results suitable to present along the five from the first part of the test, so the table shows 17 Dutch organizations. The first 5 test cases by the author are coded T1-T5 as was shown in Table 2. The student cases are anonymously coded S1, S2 etc., simply based on the date of defence of the master thesis.

Combined results of the tests

The first few rows of the table in Appendix 1 contain some basic data of the organizations which are sorted to the size of the organizational unit that was studied. There is a mix of large and small, product and service companies, a big hospital department, and one government agency (supervising authority). For the 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 available to date (June 2014). Over time the number of cases will grow and studying homogeneous subsets will eventually become possible. 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.

For each of the organisations the structure was diagnosed using the MIOS and judged using mainly additional Lowlands sociotechnical theory, and insights from innovation literature. The judgement in Table 3 on Remember-C1 is based on Hislop (2005), and on Balance-C3 is backed up by innovation portfolio management (Kester e.a. 2009). As an example, Table 3 presents a part of the diagnosis of Eline (T1). Lekkerkerk (2012) and the master theses (appendix 2) show full tables of all organizations. It should be noted that a diagnosis using the MIOS alone, is limited to a near-binary one: a function is (in)formally fulfilled or not. A hypothetical example of a potentially missing function is: all respondents agree that for the last couple of years no radical innovation projects were proposed, which implies that 'Searching future new options-I4' may not be done at all, or did not come up with radical or explorative innovation ideas, or as an alternative explanation, that such ideas were all rejected during the preliminary investigations necessary to develop a project proposal by Propose innovations-I3.

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

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

In none of the seventeen organisations a MIOS-function was missing, which was not surprising, at least not for T1-T5 because innovation success was one of the selection criteria. However, functions in the upper half of the model (both Search and Propose-functions) and Remember-C1 were often just done informally (Appendix 1). When a function is fulfilled, i.e. its outputs are present, it is possible to find out in dialogue with the respondents, or by analyzing the available formal job descriptions, to what extent it is informally done or formally part of one or more job descriptions. Managers want to hear more than just: this function is not fulfilled or assigned informally/formally. They need more details than the summary in the third column ‘judgement’ to determine whether action is required. To reach such a more detailed conclusion, and may be give advice on a solution, researchers or consultants using the MIOS need additional (normative) theory.

The comparison of structures using the MIOS-based descriptions, is briefly illustrated in Table 4 by presenting the four Innovation-functions of Leon (T4) and Rik (T5). Both design and manufacture wheeled equipment with 130 and 140 employees, and had about 10 people in a research and (product) engineering department.

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

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 & Engineers	Managing owner & sales managers

-‘comparing apples and oranges’-

For each organization the table A1 in Appendix 1 indicates which of the MIOS-functions were formally assigned to, or informally done by, employee(s) in the companies. A number of observations can be drawn from the table and the case descriptions listed in appendix 2.

First the table A1 shows that bigger companies (number of employees) tend to assign more functions formally, than smaller ones. Even small units within these 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 formalised. Given the number of employees involved this is what you would expect. Apart from size, organisations holding an ISO9000-certification are obliged to formalize their customer order related primary processes.

That fifteen organisations, with S4 and S12 as the exceptions, have formally assigned Innovate-I1 and Regulate innovation-I2 is a third observation. Contributing and managing innovation projects involves quite a lot of human and financial resources, so to formalize 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. So V3/I3 and V4/I4 are ‘combined’ and done by the same employee. Still 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 be a quest to the disruptive innovation to be expected in mature technologies. And the criteria applied to the preparing (and selection) of the business case are different because these kind of innovations are incremental and uncertainty is less (V3).

Although the fifth observation relates to only 8 out of 17 cases it is worth mentioning that in only one of these eight organisations continuous improvement is formally organized. Because the importance of continuous improvement is advocated since at least the mid-1980’s, 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 in 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 with nearly 50% about a year before the interviews, due to the economic crisis, and the 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. But 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 e.a. (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 ‘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 figure 3 above. Both Search-functions (V4 and I4) and both Propose-functions (V3 and I3) were formally assigned in around one third (4-7) of the 17 companies only. As Kurkkio e.a. (2011:134) 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. (2006:378) see ‘select’ as part of the FFE too. From a structure perspective this implies that such a procedure makes clear to employees who has 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 find out 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 find out about 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 the appendix 1. The bigger an organisation grows, the larger the amount of dedicated innovators in its workforce becomes and they are usually grouped in a department. The medium sized companies like T2, T4 and S4 had one separate department of about 10 employees, of around 130 in total, responsible for most of the (product) innovation activities. When organisations successfully grow they develop new PMC’s and may organise their activities in separate business units. This was the case with T3 having three business areas and T5 with two independent divisions. As soon as each BU grows big enough to potentially have its own separate ‘innovation department’, the problem arises whether innovation related functions should be assigned at corporate level or at divisional/business unit level or both. For (radical) ideas, with a development lead time beyond the horizon of the BU-management which makes them reluctant to start and fund such innovations, a central innovation function seems necessary. Or when a radical idea can’t 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 doesn’t 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 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 big 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 test 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 this multiple level of recursion problem.

Conclusion and discussion

The first test revealed that the MIOS served 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) to compare and contrast them.

Two to three weeks per case description, 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.

The MIOS proved to be a suitable tool for use in graduation projects of students without much working experience too. None reflected negatively upon their experience using the MIOS, although explicitly encouraged to be really 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 (2011:76).
>
> "The MIOS has proven to be really useful and applicable in practice, though it is important that the person using the model is familiar with sociotechnical theory." Case S5, Dijkhuis (2012:70).

The students figuring out the structure in bigger organizations with multiple levels of recursion (some divisions, with business units and even sub-units) struggled with the organisational complexity, but in the end the MIOS helped them to cope with it.

For further research two potential improvements surfaced from trying to analyse and compare the student's cases. A further standardisation of the format in which students have to report the data on their case would facilitate the comparison and prevent missing data (e.g. on continuous improvement or on organizational performance). Secondly, with a relatively limited number of cases and the wide diversity of the organisations no clear patterns can yet be expected to appear in the organisation 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.

- Practical relevance -

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 an additional 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 too. Additional experience in two other occasions indicated that this assumption may indeed be correct: in a seminar (November 2013) for various managers, and in a workshop for the Dutch management team of a multinational (February 2014), where the author briefly presented the MIOS, the participants fruitfully applied it. The latter team was a bit shocked to find out that in spite of many years of experience 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.

Towards multiple value creation and innovative workplaces

Debate on sustainability and corporate social responsibility stress the triple bottom line, People-Planet-Profit, for organisations to help solve many problems.
These days too many employees, *people*, suffer from stress and burn-out, so improving the quality of work by redesigning the structure is much needed. Others propose improving the ‘meaning quotient’ of work (Cranston & Keller 2013), and creating the best workplace on earth (Goffee & Jones 2013).
At the same time innovation is deemed necessary to solve sustainability issues, *planet*, 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 also reduce innovation costs which may improve *profit* too.

All this requires jointly optimizing the quality of organisation and of work. Lowlands sociotechnical 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.

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Note: References to the student case studies are in appendix 2.

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About the author

L.J. Lekkerkerk (Hans, born 1959) obtained his MSc in Mechanical Engineering, with a specialization in manufacturing organisation 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. That triggered his interest in organization design as a tool to improve innovation performance. When it appeared that literature on that topic was scarce (early 1990's) he got the idea of doing a PhD on this topic. To do so he joined the Radboud University in 1997as a senior lecturer (mainly teaching operations management, innovation management and organisation design). His PhD-thesis was defended mid 2012.

He is now a member of the chair Organizational Development and Design within the department of Business Administration of the Nijmegen School of Management.

Appendix 1

Table A1 Combined and condensed data on 5 + 12 cases.

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		11k	
Since	2008	1997	1884	1975	1959	1959	1987	1987	1932	<1900	1968	1850	1884	1900	1850	1893	1881	
MPS*	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
# 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	

*MPS = master production schedule:

- EtO-engineer to order, MtO-make to order, AtO-assemble to order, MtS-make to stock
- serv = service, sw = software, cons = consultancy, gov = government ‘authority’, fin = bank
- i = informally assigned
- F = formally assigned
- i/F partly informal/formal
- L2 = assigned but at lower level of recursion

Less suitable for this comparison:

- S3: (Topicus) details of 4 small BU’s/cells only
- S9: (Delta Zutphen) used MIOS for redesign purpose only

(based on Table 6.8, Lekkerkerk 2012 & theses listed in appendix 2)

Appendix 2

References to student case studies

Archives of all theses including digital versions and most of the transcripts and other data with the author.
Nine non-confidential theses are publicly available in the Nijmegen School of Management MSc-thesis collection.

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.

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