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Information filters as one of the means of managing strategic fit in a complex environment

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Abstract

Purpose – *This paper aims to investigate the role of information as a source of resilience in organizations. It presents both a theory based construct of information filters of the environment scanning and a pragmatic tool for managing the process.*

Design/methodology/approach – *The filter construct was tested in three qualitative case studies where the filter setting was changed in order to identify its impact on the results of the environment scan. This paper used Igor Ansoff's theory of information filters as a basis and added the required additional elements by applying complex adaptive systems theory.*

Findings – *The authors were able to define two dimensions: information filters' width and depth, that define the outcome of the environment scanning process. The preliminary testing of the research hypotheses was possible with the new research tool.*

Research limitations/implications – *There was only one case that analyzed the impact of connectivity: the role of feedback loops with the external stakeholders and their impact on the outcome of the scanning process. This interesting finding should be studied further.*

Practical implications – *By applying the filter construct, management is able to either destabilize the organization (for innovation or in order to facilitate a major transformation) or to stabilize the organization (e.g. post-merger integration).*

Originality/value – *This paper is one of the rare pragmatic applications of complex adaptive systems theory.*

Keywords *Adaptive system theory, Cognition, Strategic planning, Uncertainty management, Information*

Paper type *Research paper*

It has been predicted that the new and distinctive features of the environment of the next century will be increasing volatility, a growing number of climate-related extreme events and increasing uncertainty (Casti, 2010; Makaridakis and Taleb, 2009; OECD, 2011; Ulanowicz *et al.*, 2008). The global environment is characterized by complex interdependencies. How should we respond to the challenges posed by those kinds of environments?

Because of the very nature of a complex[1] emerging environment, it is very difficult to anticipate its behavior and how it might develop. According to the recent strategy literature (Brown and Eisenhardt, 1998; Hamel *et al.*, 1999, Hamel, 2007; Mendonca *et al.*, 2009; Porter and Kramer, 2011; Raynor, 2007), the most suitable way of ensuring the continued existence of an organization, or even its success, is to increase that organization's flexibility (Folke, 2006; Morel and Ramanujam, 1999). According to complex adaptive systems theory, in order to adapt flexibly, an organization has to achieve a self-organizing state. The organization can reach this state by increasing its intake of resources – whether this be manpower, monetary/physical resources or information (Stacey, 1995, 2001; Ulanowicz, 1986, 2000).

In this study, we turn our attention to the last resource: information. Our objective is to understand information intake and make sense of it (please see research questions on the

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next page). If management is able to adjust information flows according to the situation-dependent needs of the organization, they are able also to manage the flexibility of the organization.

Width and depth of information filters

As stated above, the intake of information is key for increasing flexibility of an organization. To manage flexibility the management has to have a means of managing the information scanning process. This is the challenge at which we look closely in our research (Figure 1).

The level of analysis of the research presented here is the organization. We will focus in this paper on the early phase of the corporate strategy process: the environment-scanning process of knowledge-intensive organizations operating in a turbulent environment.

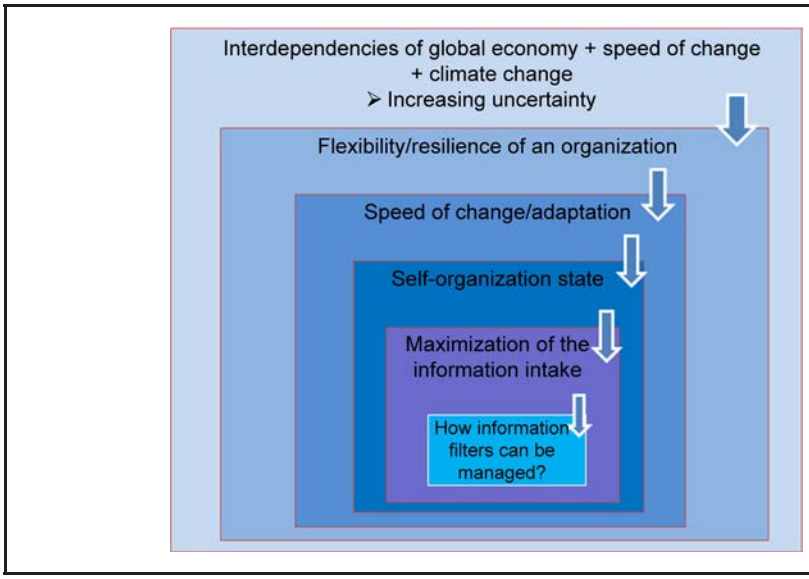
Our research questions are:

1. In the early phase of the strategy process, what structural features are relevant for the information filters?
2. What are the impacts of filters with different widths and depths on the practical outcomes of the environment scanning process?

Data channels are a means of delivering data from one point to another (www.its.bldrdoc.gov/projects/devglossary/_data_channel.html). In the discussion that follows, the information filters of an organization are represented by all the rules, methods and procedures, explicit or implicit, that the organization uses for acquisition, distribution, interpretation and analysis of data from its data channels.

Underpinning our discussion are, in particular, four theoretical frameworks. Karl Weick's cognitive sensemaking theory, which describes the processing of the early signs of change (cues) (Weick, 1979, 1995, 2001) and Igor Ansoff's theory of three successive information filters (observation, mentality and power filters), which have a major impact on the information that management accepts for the strategy process (Ansoff, 1979). Like Ansoff, we study how organizations are able to take into account weak signals of change. Systems thinking is presented by introducing some of the principles of social constructionism (reality is a social construction) by Berger and Luckmann (1966) and social systems theory (Luhmann, 1995). The fourth framework is complex adaptive systems theory, which studies

Figure 1 The logic of the research question



the social system as a system of adaptive agents (Anderson, 1999; Holland, 1995, 1998; Ulanowicz, 2000).

We discuss the structure and function of information filters, focusing on two particular aspects: their width and their depth. We first define these two aspects. Our next step is to make a number of hypotheses with respect to the principles that organizations follow when selecting the width and depth of their information filters. Finally, we test these hypotheses through four case studies. Our study is very much based on the specific weak signal monitoring tool used in the case studies.

In a fast-changing environment, an organization can improve its ability to survive, on the one hand by monitoring diverse information, and on the other by improving the sensemaking of the information received. In our filter model, we describe these two controversial objectives using the width and depth of the filtering. The width represents the cognitive diversity of the data monitored. The depth represents the deepening of the sensemaking process, when the organization is integrating the selected information or any single signal of change into its meaning system. Because of the lack of theoretical framework in this area, we have developed our own filter model. Definitions:

- Width describes the diversity of the data from the data channels used and the cognitive variety of information after the filtering processes have taken place in the organization (e.g. how various potential signs of change are noticed in the processing of information).
- Depth describes the filter's capability in terms of producing plausible sensemaking information.

In practical terms: width describes the scope of information collected. For example, a well-focused scan covers only the core of the existing market; a wider scan may look for changes in the fields of relevant technologies, complementary or substitute markets or even the potential development of climate change and its impacts. Depth describes how strong the social sensemaking process is in the selection of meaningful information. Meaningfulness is measured by the relevance of the information from the point-of-view of the existing mental model of the organization.

We assume that the organization considers information relevant if the information is acceptable and new enough in the context of its existing mental model. The existing mental model of an organization is the combination of mental models of the stakeholders of the organization and it explains the managerial decisions made in the organization (Rouleau and Balogun, 2011). An operational measure of the depth of the information is how many times during the sensemaking process the expert groups that the organization has selected to carry out the task have assessed the material and selected the most meaningful.

As management needs are diverse, it would be useful to have a filter construct that consists of modules/elements that are easy to modify in accordance with a specific need. The next chapters will describe the elements needed both for the width and depth of the filter construction. We operationalize the elements suggested, looking at the signals handled by a specific monitoring tool. At the end of the chapter we describe some additional filter elements for turbulent environments.

Hypotheses concerning the width and depth of the filters

The width of the information filter is the most important feature of what Ansoff (1979) described as the surveillance and mentality filters. The surveillance filter consists of the techniques chosen for the first of the scanning tasks, namely, data acquisition from a data channel. Ansoff (1979) observed filters as capabilities of strategic leadership, a leader's competence. Ansoff called filters ''myopic'' if information acquisition and analysis are focused on the past and only on areas close to the core business, and ''insightful'' if their scope is future-oriented and wide.

The wide channel of the surveillance filter does not guarantee the width of the information-acquisition activity. The channel data are not necessarily transformed into

information that is really used in the sensemaking processes of an organization. According to Weick, the transformation of the data into information requires the conscious action of observation. That is why organized participation in information scanning from some specified data channel is important for the wide sensemaking process (see Daft and Weick, 1984). In this article, we evaluate the results of different kinds of methods used in the scanning process.

Our first hypothesis is that the nature of the methods used for collecting and sharing observations have an impact on the width of the information filter. We claim that social interaction produces a narrow filter and virtual anonymous scanning methods produce a wide filter. Anonymity in the scanning process tends to increase the width of the observation filters. According to Turoff and Hiltz (Turoff, 1975; Hiltz and Turoff, 1994) anonymity facilitates diversity in information collection. Anonymity both decreases the risk of identity damage and also releases requirements to justify or defend the observation in question (Berger and Luckmann, 1966; Luhmann, 1995; Bogner and Barr, 2000).

Our second hypothesis is that open task description produces width as heterogeneous output. On the other hand, a precise, brief and clear quality criterion for signals produces less diversity in the scanning or filtering process (Ansoff, 1990; Castellani and Hafferty, 2009; McCaskey, 1982; Rossel, 2011).

Our third hypothesis is that diversity of participants will increase the cognitive diversity of the scanning process outcome. We base this hypothesis especially on the study of Scholl and Binder (2010) (also Forrest, 2009; Dennis *et al.*, 2011; Goodwin and Wright, 2010; Wright and Rowe, 2011).

The next hypotheses concern the depth of the filters.

Our fourth hypothesis is that a deep sensemaking process with multiple successive sensemaking stages will produce a strong shared understanding and thus reduce the cognitive variety of the outcome. A primary organizational goal of depth-oriented data filtering is to create common meanings in a way that stabilizes the respective environment and makes it more predictable (Weick, 1995), thus increasing the efficiency of the organization through shared schemata. If there are several successive steps in the sensemaking process, the search for common meanings tends to reduce information in each of the sensemaking layers that promote coordinated action. The more sensemaking layers there are, the more decision makers obtain information that supports the existing schemata.

According to our fifth hypothesis, the depth of the filter reduces controversial information. The depth-producing sensemaking processes are controlled by people in power (Ansoff, 1979; Gioia and Chittipeddi, 1991). It is reasonable to assume that more control reduces information that is not in line with the beliefs of powerful or the information that challenges the power or belief structures of the organization.

We have so far applied Ansoff's and Weick's theoretical frameworks. But as stated at the beginning of the paper, the increasing complexity of the environment sets specific requirements for environment scanning (Forrest, 2009; McKelvey, 1999) and also sets some additional dimensions for our filter construct. The Ansoffian approach is linear: it focuses on collecting and processing external information. From the systems perspective, this is insufficient. The core feature of the social system is interaction (Cilliers, 2000; Johnson, 2008; Holland, 1998; Kauffman, 1989; Nicolis and Prigogine, 1989; Stacey *et al.*, 2000) which has the power to change the set of mental models, that is, the schemata that rules the behavior of an organization (Anderson, 1999; Holland, 1995).

Change in the complex system is mediated by internal and external feedback loops that can have either a positive or negative influence on the schemata of an organization (Luhmann, 1995; see also Ulanowicz, 2000; Ulanowicz *et al.*, 2009). In the beginning, the signs of change are nearly invisible. To be efficient the feedback loops have to be able to produce cumulative or exponential developments. The interaction with the environment either has to increase the potential (energy) of the signs of change, or the feedback loops have to be frequent enough to have a cumulative effect over time on the strength of the signs of change

with time (Berger and Luckmann, 1966; Forrest, 2009) and will thus be strong enough to be processed in the strategy process (Ericson, 2001; Gioia and Chittipeddi, 1991).

In a complex system dominated by feedback loops and signs of change, the capacity of organizations for interaction is extremely important. We describe this kind of richness of interaction using the concept of connectivity. Connectivity has been used in mathematics and in the network theory to describe the number of ways that points are connected to each other (Casti, 1995; Kauffman, 1989; 1995; Proulx *et al*., 2005). In our construction, connectivity consists of the number of connections to an organization's environment. To operationalize this feature, which is hard to measure, we will use a number of participants with different backgrounds and different contact points with the external environment to measure connectivity in our filter construct.

Our sixth hypothesis is that in increasing the width and depth of information filters, increasing the connectivity of the organization is an important target.

Our hypotheses are summarized in Table I.

Case studies

Methodology

The elements of our filter construct and the related hypotheses presented above are tested using the case study method in Yin (2009).

Our research method is comparative. The potential impact of the different filters was tested by comparing the outcomes of the different types of scanning processes. To cover all the hypothesis we had to run four different case studies. In two of the cases (cases 1 and 2) we compared a traditional scanning process with a web-process with a wide filter construct. The third case was dedicated to comparing different sensemaking methods used by four groups within the same organization. The fourth case studied the impact of the different nature of participant groups on the outcome of the scanning process. Even if we focus our research questions to the cases mentioned, our testing tool – the Signals Toolset – also implicitly takes into account our hypotheses. In every case, the scanning process was customized to take into particular account the hypotheses under investigation. The impact of the element is studied by comparing the outcome of the process (structure of the mental model measured by the relative number of comments within a dimension) with the relevant reference outcome (the outcome of the traditional process and/or the outcome of the other groups).

The Signals Toolset. The operationalization of the theories applied – Ansoff's filter theory, Weick's sensemaking theory and the principles of social systems theory and complex adaptive systems theory described above – is embedded to the web toolset developed for

Table I Hypotheses

Target of the filtering process	*Hypotheses*
Width	W1: Scanning process relying on social interaction implies less width than web-based anonymous process because more controversial information is filtered away in social interaction W2: Open task description produces width as heterogeneous output W3: Diversity of participants increases width as cognitive diversity of the scanning process outcome
Depth	D4: The depth of the sensemaking process measured with the number of successive sensemaking stages increases shared understanding as shared schemata D5: Depth of the filter reduces controversial information
Connectivity	C6: High connectivity of participants will produce width as a wider diversity of the scanning outcome than low connectivity of participants

collection. We thus developed a web-based toolset that facilitates not only the hypothesis-driven empirical testing via adjustment of different filter elements but also the analysis of the outcomes.

The tool promotes wide participation in sensemaking in an organization trying in particular to handle the problems related to hypothesis D5D5 and to promote the positive aspects of deep filters related to hypothesis D4. The anonymous collection and assessment processes are aimed at increasing the width of filtering (hypothesis W1). As well as members of the organization, people or experts outside the organization have in many cases participated into the filtering processes. This promotes the connectivity of the organization (C6). Together with the anonymity, the participation of outsiders reduces the risk of the ''group think''.

The possibilities of testing single hypotheses with the toolset are especially relevant to hypotheses W2 and W3. The systematic testing of other hypotheses is also possible in principle, but requires special arrangements that are not easy to achieve.

The data collection by using the toolset developed can be summarized as follows:

1. Selection of the panelists and contact with them via e-mail.
2. Participating panelists provide the survey with their background information.
3. Panelists suggest anonymously possible signs of change in the internet.
4. Participants assess the importance of the collected signs of change. The toolset provides each participant with a random set of proposed signs of change for his/her assessment.
5. Panelists evaluate the importance of the signs of change in the way illustrated in the picture. They can also make written comments on the web that can be seen by other evaluators.
6. The averages and variances of evaluations are used in the classification of the signs of change.

The toolset was used in all four case studies (Figure 2). We illustrate the web-based toolset through screen shots and discuss closely some aspects of the toolset.

We start the description of the toolset from the information acquisition phase.

Observation method and scope. The framing of the scanning task can either be very well specified, or, if the aim is to detect early signs of disruption of an organization's schemata, as open as possible (hypothesis W2). The Web-based method eases the social constraints of inter-subjective interaction. As the responses are anonymous (hypothesis W1), there is no need to support the respondents' identity or role. Further, the toolset is designed to encourage respondents to let go of some of their analytical thinking and to apply creative problem-solving methods instead. This should decrease the impact of the existing cognitive constructs of the schemata (hypothesis D5) (Figure 3).

The nature of the participants becomes more diverse if a web-based survey is used. The diversity of various mental models included in the survey can be increased by inviting participants with different backgrounds and roles and, in the best case, from different organizations applying different schemata. The detailed background variables allow us to report and analyze the perceptions among participants who have many external connections (hypothesis C6) and those who mainly interact internally with their own respondent group (Figure 4).

Depth of the filtering. As mentioned before, the tool promotes wide participation in sensemaking in an organization trying to handle in particular the problems related to hypothesis D5 and promote the positive aspects of deep filters related to hypothesis D4. The toolset allows the depth of the filtering to be controlled through many processing rounds. It also allows management to keep the power filter (Ansoff, 1979, 1990) open throughout the analysis phase and to postpone decision making, if need be. This will delay the final impact of their decisions until the last phase of the process. A web-based method operationalizes qualitative data into a quantitative format, so that the impact of the

Figure 2 The brief and survey questionnaires of the Signals Toolset

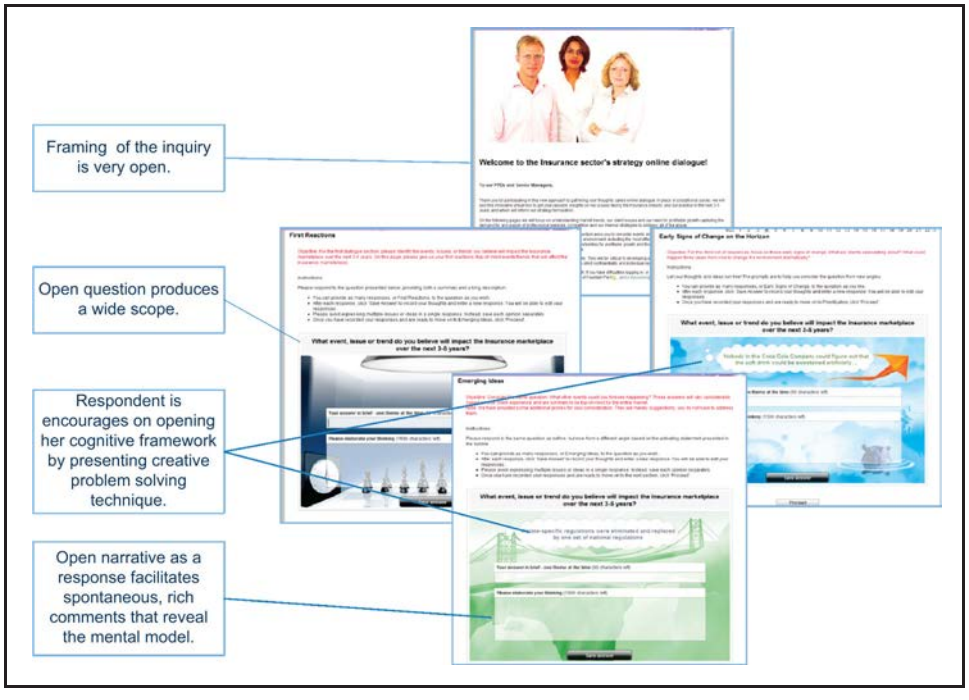
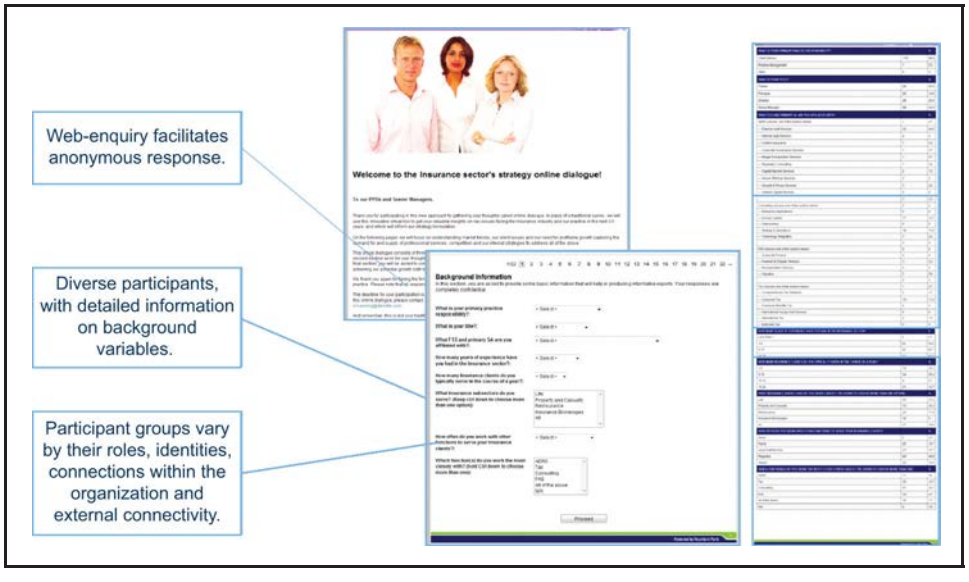


Figure 3 Participants provide the inquiry with detailed information about their backgrounds



facilitators'/researchers'/management's interpretations are postponed until the final phase (Figure 5).

The toolset reports the typical features of the data assessed (i.e. the signals/comments with the highest importance on which most of the respondents agree). The list of signals (20 percent of the assessed material) with the highest importance/lowest deviation represents the dominant mental model of participating respondents and thus the shared schemata of an organization. The toolset automatically produces a text miner report, showing the data clustered according to the most frequently used concepts in the material. The clustering is used as a basis for classifying and analyzing in detail the schemata found in the respondent groups.

Figure 4 Respondents assess the material produced by their fellow respondents

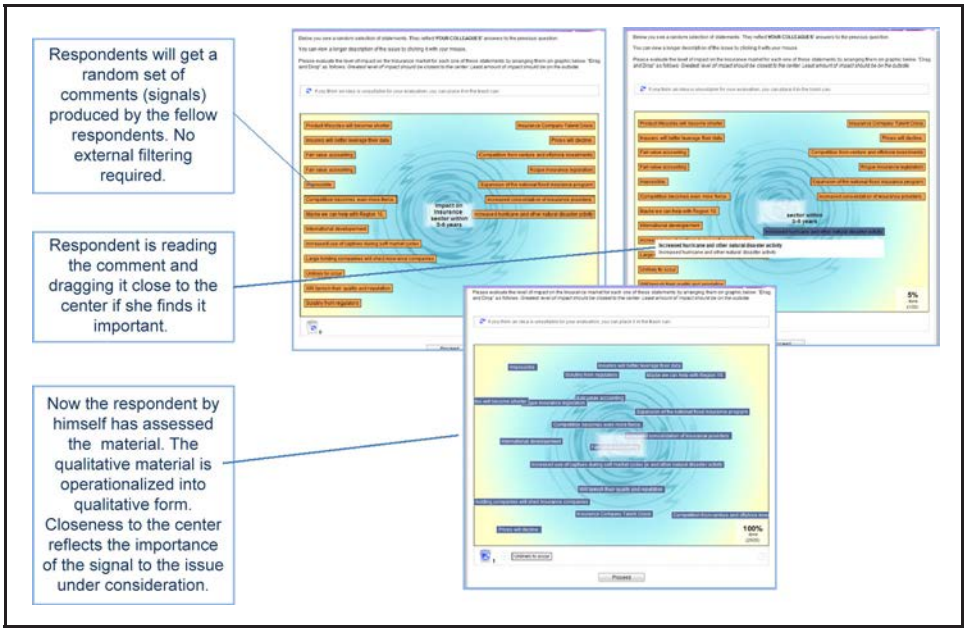
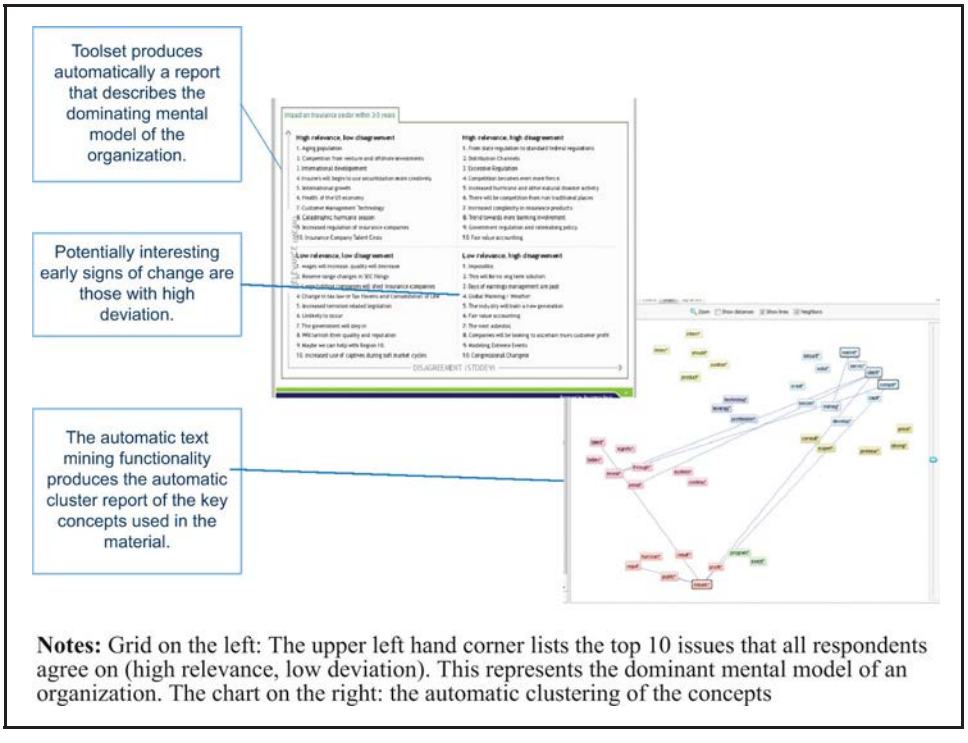


Figure 5 The dominant mental model of an organization



Notes: Grid on the left: The upper left hand corner lists the top 10 issues that all respondents agree on (high relevance, low deviation). This represents the dominant mental model of an organization. The chart on the right: the automatic clustering of the concepts

How to measure the outcome?. To adjust the filter structure according to the needs of the research question, the data collection method has to be able to report and measure both the cognitive diversity (width) and the plausibility (depth) of the outcome of the scanning process. For this purpose the toolset includes a specific reporting feature that reveals the structure of the schemata.

The diversity of the themes (number of comments within exclusive clusters of issues) is used as a measure of the cognitive width of the filter construct applied in the scanning process. In this study the thematic clustering of the narratives (data) collected was semiautomatic. The text mining tool (Hotho *et al.*, 2005) collects the signals in key thematic-cluster concepts and automatically divides them into predefined (according to the typical corporate functions) categories.

The results are reported as a radar diagram as a visual representation of the structure. We call the shape of the radar diagram a ''profile''. The profile diagram describes the frequencies of signals in a cluster as a percentage of the number of signals collected. Comparison of the profiles of the groups that have used a different scanning process layout (filter construction) provides us with information through which we can test our hypothesis.

An example of the analysis. To describe the analysis and the reporting, we will present an analysis of case 4 (below). In this example, the width of the information filter has been studied by paying attention to one of its elements: interaction connectivity (element C6) of the participants. Here we focus on hypothesis 2, high connectivity produces more variety in outcome. Here two respondent groups have been compared: one with high connectivity in their connections to the environment, the other with lower connectivity (Figure 6).

When we compare the profiles, we find that in the material produced by the high connectivity group a greater number of themes is addressed and a more diverse range of comments (the cognitive variety of group's schemata is higher). Our conclusion: the hypothesis presented in the case study (see page 25) is supported. In the environment scan where participants with numerous connections to the environment are selected, the filter is wider and produces greater cognitive variety.

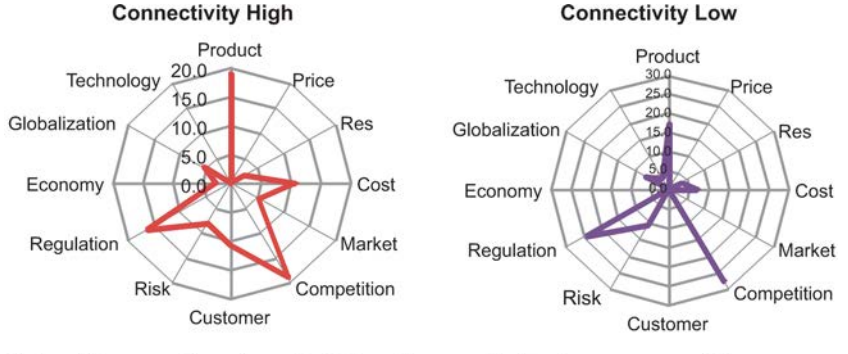
Case studies

The common denominator for the cases was that the environment scanning took place at an early phase of a key planning process. Three out of four scanning processes studied were part of corporate strategy building, and one dealt with strategic risks. The main objective of all of them was to detect early signs of previously unseen change.

Data collection

Case 1: visioning process of a technology company. In case 1 we tested the information filter structure of two different vision-building processes in the context of a globally leading ICT company. We compared the profile of the information filter and the profile of the outcome of

Figure 6 The high-connectivity group and the connectivity low group



Notes: The same clustering criteria have been applied to the responses of these two different respondent groups; the high-connectivity group consists of senior consultants operating across different industries, with plenty of client connections; specialized junior consultants with plenty of back office responsibilities are grouped to the connectivity low group

the vision-building process. Our empirical focus was on two different vision-building processes: one a hierarchical, management-driven multistage process; the other representing a lean, bottom-up process requiring broad participation from the organization.

The two cases studied came from the same unit of the same company. We studied two different visioning processes in two consecutive years. As the studies were conducted in the same organizational context, we were able to reduce the variability of external conditions and to focus on changes caused by the variation along dimensions of theoretical interest:

- *The vision process in year 1*. Traditionally, the vision-building process of the case organization has been management- (unit-, group-) driven. All groups have run their own vision meetings (one to two meetings, with comprehensive representation of the potential staff). The group leaders presented their hypotheses to the unit's vision task force that consisted of group leaders and some opinion leaders. The manager of the unit crystallized the ideas on a couple of slides. In this study these group hypotheses constitute the empirical material that was investigated.
- *The vision process in year 2*. The vision-building process in year 2 was different in two major regards. The potential issues (weak signals), 273 altogether, were collected from 30 senior scientists into a database. This database was reviewed by three group leaders and the unit manager, who chose altogether 52 potential weak signals to be evaluated on a cognitive map drawn with help from all levels of the unit. Of 120 researchers, 91 participated in the evaluation phase. The analysis report indicated the signals that were considered to be the most relevant, signals that were potential sources of future competitiveness, and signals that were considered to be weak, emerging, or dissipating. The report was discussed in a workshop (two deputy directors, one unit manager, one senior scientist and one expert, one new member of the organization). The agenda of this workshop came directly from the evaluation report: the ten most important and potential issues were discussed. Also at this time, conclusions were reported using transparencies. The objective of the process was to act as a catalyst for discussion and as an input for the formal strategy process. The vision-building process therefore represented an application of the Delphi method.

Three hypotheses were tested. The results are presented in Table II.

Case 2: risk assessment of a research institute. The aim of this case was to understand the early sensemaking process outcome concerning risk assessment. Two research hypotheses were tested by using a case study of two different risk-scanning methods: the failure mode and effect analysis (FMEA) and the web-based weak signals analysis.

ATLAS, the organization used in the case, is an international scientific collaboration project based at CERN, the European Laboratory for Particle Physics in Geneva, Switzerland. The building of the ATLAS detector involved 1,800 scientists, engineers, and students from 34 countries. This case study investigated two different methods for ATLAS risk management: the web-based weak risk signals measurement, run in year 3 and year 4, and FMEA (see e.g. McDermott et al., 1996) RUN in year 2 and updated in year 3.

- *Web-based process risk signal collection*. The participants were project management, installation project management and senior experts. The questionnaire had 19 respondents (70 percent of invited respondents), and in year 4 there were 16 respondents (reply rate 50 percent). In the first phase the participants were asked to evaluate the ATLAS project and give as many potential risk signals as they wanted to (year 3: 83 signals, year 4: 52 new signals). The format was an open survey with very open questions. In the second phase the collected signals were sent unchanged to the same respondent group for evaluation. Each of the respondents was asked to assess the 40 risk signals collected on a simple visual cognitive map, marking their relative significance. No argumentation was required. The results were discussed in the installation management team meeting.
- *Traditional FMEA process*. The FMEA process was initiated by dedicated meetings and later run by e-mail. The participants included project leaders and the installation management team. Detector-component manufacturing and installation risks were

Table II The results of case study 1

Organization and aspects studied	*Filters*	*Hypothesis*	*Results*
International technology company			
Two different visioning processes	The shape of the information filters define what signals are detected and what signals pass through the vision process	W1: Scanning process relying on social interaction implies less width than web-based anonymous process because more controversial information is filtered away in social interaction	Anonymous nature of the process. In the web-aided process, the input creators and evaluators were anonymous, and that opened the mental model of the participants
		W2: The variety of selection criteria increase the width of information filters and result in a large variety of weak signals as output	
	The width of the information filter is impacted by the objectives given to the vision process, by issues that are to chosen to be considered, thus what kind of information is therefore processed	W3: The diversity of participants and the variety of selection criteria increase the width of information filters and result in a large variety of weak signals as output	The hypothesis of the diversity of participation did not get any support
		D4a: Specialized expertise and a multi-step argumentation process increase the depth of information filter and promote deeper insight into new features of the operating environment as output	Results do not support this hypothesis at all. An internal need for credibility more or less inhibited their explication of novel, ''outside-the-box'' paradigm ideas (Kuusi, 2000)
	Depth of the process defined by the type of process chosen, what kind of participation is solicited, the methods chosen	D4b: Late decision making increases filter width and helps to elicit a large diversity of input into the vision process	These results provide support to proposition D4b

assessed separately. For methodological purposes, only the installation risks were included in the present analysis (i.e. the update of year 3). The issues for evaluation resulted from the meetings of the installation management team and a member of the project management. Using the installation sequence plan as a basis, one failure mode and possible risk (and corrective actions) were identified per installation step per sub-system. Each of the risk issues was scored from 1-10 by their potential frequency (impossible to be certain about), detectability (immediately detectable [...] possibly never detectable) and gravity (nil to catastrophic). The participants were asked to justify their scoring and reevaluate the issues if needed. Issues that got a high deviation in the FMEA process were analyzed in more detail.

The two approaches (FMEA, virtual signals collection) are comparable. The FMEA procedure was last run in middle of year 3 and the first weak signals survey early in year 3. During that period, as there were no major changes in either the context of the project or its operations, the results are comparable (Walsh, 1995). It was possible to compare the results of the weak signals survey between year 3 and 4 (Table III).

Three hypotheses were tested.

Case 3: weak signals scan of an energy company. In the third case, the management of an energy company used different means of collecting and analyzing weak signals and considered the impact on their business performance. The impact of different layouts of the information filters was tested via four different group processes, and filtering dynamics in each of the groups were described.

We were able to invite all members of the organization with a certain level of qualifications (nature of their duties, education, level of expertise) to participate. A total of 170 managers and senior experts representing all the business units and functions took part. The

Table III Results of case study 2

Organization and aspects studied	*Filters*	*Hypothesis*	*Results*
Case research institute The structure and dynamics of schemata and information filters in the risk analysis	In thus study the dependent variables are the depth and width of the filter structure		
	Width: diversity of participants, nature of the briefing , nature of the data collected and evaluated	Hypothesis MB: Diversity of participants produces a wider filter and thus increases diversity in the mental model	The empirical results strongly support the hypothesis. Wide participation increases diversity in the sensemaking process and produces a more complex mental model as an outcome of the process
		Hypothesis W2: Well-defined briefings and argumentation requirements with exact evaluation criteria produce a narrower filter	The hypothesis concerning the nature of the briefing was supported. Exact, well-defined briefing produced a narrower, closer to the existing shared mental model (less deviation in evaluation) outcome
	Depth: argumentation requirements, evaluation method, number of evaluation phases	D4: The depth of the sensemaking process measured with the number of successive sensemaking stages increases shared understanding as shared schemata	The hypothesis D4 remains open in this case: the material did not produce enough evidence about the impact of the phases on the filter and mental model. Differences of phases in the cases were not sufficient for drawing conclusions

participants were randomly divided (by classified sampling) into four homogenous groups. We briefed groups with different scopes of questions and then ran a different sensemaking process for each of them. It was beneficial to study four different groups within the same organizational context, as we were able to reduce the variability of external conditions and to focus on changes caused by variation along dimensions of theoretical interest.

Altogether 130 out of the 170 invited participants provided us with 342 signals that were evaluated in the next phase. In that phase we invited all 208 participants to evaluate the relevance of the collected signals for the future of the company on the web-aided cognitive map. In this phase the respondent rate was 95 percent. The report revealed the currently dominant mental model (the signals that were agreed to be very relevant for the future of the company), was challenged with weak signals (signals with high deviation and low average relevance) in four different processes:

- *Group A*. Web-tool aided scenario building by participants. The participants had three weak signals as their input, and their task was to create a description of the market where all of these three signals would be realized.
- *Group B*. Two-phase workshop: creation of alternative futures (similar to the web-aided task of Group A) and evaluation of the created material in the predictability and impact grid.
- *Group C*. One workshop: alternative growth options based on the weak signals collected from the material of Groups C and D.
- *Group D*. Assessment of the predictability and impact of the weak signals collected. Every group member did this part virtually, or using the web tool (predictability and impact grid) and then justified their assessment briefly.

The outcome of the process was measured by the structure of the mental model that reflected the applied filter construct (Table IV).

Table IV Results of the case study 3

Organization and aspects studied	*Filters*	*Hypothesis*	*Results*
Case energy company Comparison of different means of collecting and analyzing weak signals. The construct is tested with four different group processes and filtering dynamics in each of the groups described	Width describes the filters capability to produce cognitive variety of relevant signals. The width is operationally measured by the variety of descriptions	W1: Scanning process relying on social interaction implies less width than web-based anonymous process because more controversial information is filtered away in social interaction	The hypothesis is supported by reference to the fact that with virtual methods the outcome had more diversity/variety of themes, more vivid descriptions, and the number of radical ideas was higher than in the social interaction process of the workshops
		W2: The open scope of the briefing increases the width of the filter	The results of the study do not provide very strong support for the hypothesis when the diversity of the signal categories is analyzed, but the number of produced signals was larger in the case of the open question
	Depth is based on informative argumentation processes and sense-making focused on relevant signals. The operational measure for the depth of the argumentation is the richness of the explication/narrative and by the length of the argumentation chains	D4: A mull-step process increases the depth of the filter promoting strong argumentation	The one-stage processes did produce more variety in themes than the two-stage process. In the two-stage process participants reduced the complexity of the data collected. The group also reduced the complexity of the descriptions by deleting some of the issues in them. A two-stage workshop produced fewer issues per description but simultaneously longer argumentation chains in the outcome. Thus the proposition was supported
		D5: Social interaction as a processing method will reduce the amount of controversial material	The hypothesis was supported. Social Interaction in the workshops produced less radical ideas than a virtual process. The support for hypothesis was not very strong, because virtual process produced a relatively longer argumentation chains. So eve n if the overlap with the dominating mental model was clear, the argumentation in the social interaction was not deeper

Case 4: a North American consulting company. The last of our case studies focused on interactions and their nature. We analyzed a case where the management of a North American consulting company collected market signals across all the disciplines of an industry. The construct of the information filters was tested by analyzing different respondent groups and the features of their responses.

The case study was a part of the industry-specific strategy process. The objective of the process was to establish a growth strategy and lay a foundation for the services that would apply all the competences available. We collected information from 152 respondents from all four disciplines of the organization. In this case, the structure of background variables was very detailed, thus providing an opportunity to look more closely at the nature of the response when there are different kinds of respondents. The data analyzed consisted of 320 market-related signs of change.

In this study the information filter construct was investigated from two perspectives. The width of the information filter was studied by focusing attention on one of the elements:

interaction connectivity – both internal connectivity (within the organization) and external connectivity (the company's contacts with the data collection of outside stakeholders was part of a wider internal study, which is why it was not possible to load participants with a detailed questionnaire of their interactions. Thus we had to base the analysis on the information collected on the respondents' positions, roles and customer relationships).

The groups with a naturally high external connectivity were considered to be respondents with a senior position, as they had multiple clients and dealt with several areas of the industry. The group with a high potential for intensive internal interactions is the group working in collaboration with several internal disciplines, but only within one discipline (Table V).

Results of the case studies

In the case studies described above, we collected the data and classified them using the Toolset described above. In each of the cases we presented a different filter construct and compared the results (relative number of comments within each of the themes/dimensions of the material collected with the Toolset) by measuring the outcomes by the cognitive variety. The different filter structures produced different outcomes. This indicates that the filter has a major impact on the cognitive variety of the scanning process outcomes (Figure 7, Table VI).

The plausibility of the outcome was measured by the overlap of the scanning process outcome and the equivalent dominant mental model reported as part of the scan report.

Conclusions and discussion

The complexity literature (Anderson, 1999; Stacey, 1995, 2001; Ulanowicz, 1986, 2000) claims that self-organizing organizations are the most flexible, and that this requires management of information flows. The aim of this study was to understand the structure and operation/function of information filters that select external information used as an input to the strategic planning process. We have focused our attention especially on two aspects of information filters: the width and the depth. Width describes the diversity of the data from the data channels used and the cognitive variety of information after the filtering processes in the organization (e.g. how various potential signs of change are noticed in the processing of information). Depth describes the filter's capability to produce plausible sensemaking information.

Table V Results of the case study 4

Organization and aspects studied	*Filters*	*Hypothesis*	*Results*
Case NA consulting company Collection of signs of change in the operating environment. Comparison of different groups with different kinds of interaction background	Width describes the filter's capability to produce a cognitive variety of relevant signals. The operational measure of width is the variety of themes addressed	Hypothesis C6: High connectivity produces a wider filter and a greater variety of outcome	The results of the study provide a strong support for the hypothesis. Respondents with a position that required plenty of external contacts for various stakeholders had a more diverse observation profile than those with lower connectivity
	Depth describes the filter's sensemaking capacity. The operational measure for the depth is the strength of the dominating mental model	Hypothesis D5: High internal intensity produces a stronger dominating model	Participants with a lot of internal interaction seem to share the same mental model with less diversity
		Hypothesis C6 and D5: High external connectivity and low in internal intensity produce more variety in outcome than do low external connectivity and high in internal intensity	The combined hypothesis gains moderate support by data collected

Figure 7 Cross comparison of the results of the case studies 1-4

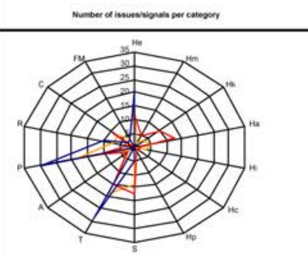
	CASE 1	CASE 2	CASE 3	CASE 4
Filter construction	Comparison between traditional linear process with multiple phases and the web-based process	Comparison between analytical FMEA risk analysis and web-based open scan in 2003 and 2004	Comparison between open scan and analysis (A and B) and focused scanning task (C & D)	Comparison of the outcome of the scanning process between different participant groups.
Cognitive variety	**confidential**			
Color codes		FMEA blue Signals 03 red Signals 04 yellow	A&B green C&D blue	Connectivity: high red, low lilac Intensity: high orange, low blue
Comments	There was a prominent difference (20 thematic classes in the web-enquiry vs 4 in the traditional process) with cognitive variety of results	Analytical and detailed FMEA process produced plenty of material on relatively fewer categories than open web-based risk scan.	Open scan produced more variety than focused scan.	Participants, who have more external contacts and a high intensity of interaction, produce more cognitive variety for the scan.

Table VI Overall results of the hypothesis testing

Target of the filtering process	*Hypotheses*	*Case international technology company*	*Case research institute*	*Case energy company*	*Case North-American consulting company*
Width	W1: Scanning process relying on social interaction implies less width than web-based anonymous process because more controversial information is filtered away in social interaction	Strong support		Strong support	
	W2: Open task description produces width as heterogeneous output	Strong support	Strong support	Weak support	
	W3: Diversity of participants increases width as cognitive diversity of the scanning process outcome	No support	Strong support		
Depth	D4: The depth of the sensemaking process measured with the number of successive sensemaking stages increases shared understanding as shared schemata	No support	Remains open	Supported	
	D5: Depth of the filter reduces controversial information	Support		Supported	Supported
Connectivity	C6: High connectivity of participants will produce width as a wider diversity of the scanning outcome than low connectivity of participants				Strong support Moderate support

To connect the width and the depth of information filters to the strategic processes of organizations we have posed two research questions:

1. In the early phase of the strategy process, what structural features of the information filters are relevant for the information filters?
2. What are the impacts of filters with different width and depth on the practical outcomes of the environment scanning process?

To answer our research questions, we made six hypotheses concerning the impacts of different structural features of the information filters on their width and depth. We tested various combinations of the hypotheses W1, W2, W3, D4, D5 and C6 in four organizations. We studied nine different scanning processes. All of these processes had the same main function. All of them were due to produce input to the strategic planning process of the organizations in question.

In answer to our first research question, the cross analysis of the outcomes of the processes with different filter construct designs showed that the six information filter variants tested produced – with some reservations – the anticipated impacts on the width or on the depth.

With respect to hypothesis W1, cases 1 and 3 provided us with a strong indication that a virtual process that protects the anonymity of participants produces more width as the variety in the outcome than scanning process based on social interaction.

An open brief produced both more diversity of information detected (the width). Cases 1 and 2 especially provided us with a strong or hypothesis W2, and even if the results were not as evident in case 3, an open brief produced a greater number of signals.

The diversity of participants tends to have an impact on the variety of data collected (hypothesis W3). We did not get any support for this hypotheses from case 1, as the participants in the both cases were so similar. But the results of the rest of the cases support W3.

We measured the depth of information filter with a number of phases in the sensemaking process. We made two hypotheses concerning the connection between the sensemaking process and its depth. The last hypothesis C6 concerned relationships between the connectivity and the width or the depth of information filters.

In hypothesis D4, we assumed that the many phases of the sensemaking process will produce an outcome that is close to the existing dominant mental mode of case organization. Our hypothesis is based on the following assumption: if the choices of the relevant signals of change are made in every stage and at very early stage of the process, the cognitive variety (the width) of the outcome will be reduced. Two out of three case studies give evidence supporting the hypothesis that phases of processes result in stronger shared mental model[2].

Hypothesis D5 concerns one specific aspect of D4. The hypothesis was tested only in two of the cases. Two cases provided strong support to the hypothesis that a multiphase process of sensemaking decreases the controversial nature of the outcome.

Our last hypothesis C6 anticipated that high connectivity on the part of participants will produce a wider diversity in the scanning outcome. We were keen to link the importance of high connectivity to the name of the hypothesis, even though the hypothesis is also connected to the width of the information filters. By doing this we also keep open the possibility that also the relationship between connectivity and depth will be studied. The hypothesis had a limited testing (this data was available only in one case), but the data collected provided us with support for the hypothesis.

Our first research question was ''In the early phase of the strategy process, what structural features are relevant for the information filters?'' The hypothesis testing results indicate that the means of collecting data (social interaction vs anonymous web-process), the structure of brief (open vs specific), composition of participants (diverse vs homogenous), and the number of filtering stages (one time vs several successive filtering stages) have a strong relevance, to the nature of the information forwarded to the strategy process.

Concerning the second research question: ''What are the impacts of filters with different width and depth on the practical outcomes of the environment scanning process?'' Results were very clear: wide and shallow filters produce large diversity in the scanning outcome, while narrow and deep process produces strong sensemaking and less controversiality and so is material that has a good match with the existing strong mental model. According to our hypothesis D4, the results of case studies indicate that a deep, narrow filter produces a well-focused, very predictable one-scope aggregate-level output. Thus we are able to draw some practical conclusions based on our theoretical discussion and case studies.

The main practical motivation for our study arises from novel requirements of complex, turbulent environments. From a management perspective the two alternative key questions are:

1. How to increase an organization's flexibility or innovativeness by managing information filters?
2. How to stabilize an organization in order to increase its efficiency?

In general, wide and not very deep filters promote the first target because of larger amount and more diverse signs of change (information) to the organization.

According to our findings, our filter design has the features that management can use for an efficient control of the information inflow, as the filters can be adjusted so that the required impact will be achieved. If the challenge is to increase the resilience or the innovativeness of an organization, management can support the scanning process with following features:

- an anonymous virtual scanning method with an open brief that allows or even enhances collection of information that challenges existing mental models;

- inviting a large number of diverse people to participate and making sure that those individuals with best connectivity are included;
- a minimal number of hierarchical phases;
- the decision making is postponed till late phase of the process; and
- last but not least: maximizing the number of feedback loops connecting conclusions to the changing reality.

For innovating organizations wide information filters seem to be a good choice. If stability and efficiency are the main problems of the organization, focus is particularly needed on the depth of the filters. The organization should not invest much in information intake, but focus should be on internal sensemaking with intensive and frequent internal interaction.

Our case studies indicate that we still have much to learn for optimal filter design in complex environments. Looking closer at filter design in the framework of complex systems theory might solve some of the problems encountered.

Notes

1. In this paper when we are speaking about complexity, we are referring to systems, where agents (people/organizations) are interacting with each other and their behavior is defined by a high number of feedback loops of the interaction. The system is complex if the interaction rules are not deterministic and the behavior of agents is producing emergent behavior in the system level (Anderson, 1999; Akoff, 1974; Johnson, 2008).
2. Please note that hypothesis D4a in Case 1, is controversial to the main hypothesis. We regret that the formulation was not the best possible.

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