Filters of weak signals hinder foresight: Monitoring weak signals efficiently in corporate decision-making

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Abstract

Already two decades ago strategy literature started a discussion on weak signals (H.I. Ansoff, Implanting Strategic Management, Prentice-Hall International, Englewood-Cliffs, NJ, 1984). Currently the weak signals approach is experiencing a renaissance in strategic planning but now either in the context of strategic flexibility or peripheral vision. In this paper we aim, firstly, to present theories describing filters that a weak signal has to pass in the strategy-creation process. Secondly, we present a construction for information filters in the strategy process and prove that the nature of objectives and the method used in environment scanning have a major impact on the outcome. Thirdly, we introduce an application that opens filters for weak signals in the strategy process and thus provides the organization with an opportunity for pro-active decision-making.

1. Background

In a rapidly changing environment the biggest competitive threat is the steady pace of competence-destroying change that occurs combined with the inability of management to foresee these changes [1,2]. In the complex environment decision-making has to cope with complexity with some mechanisms.

The traditional linear planning methods commented by Minzberg [3] and Ansoff [4] are concentrating on an efficient, well-focused strategic plan with a clearly defined vision, mission and strategy implementation [5]. A strong strategy process is, however, reducing the organization's sensitivity for unpredicted shifts in its environment and weakens its

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capability to adjust to the changing environment [2,3,6,7]. As a result the efficient, strict focus on the current market accentuates the risk of surprise [4,8]. Simultaneously when the risk of strategic surprise is rising, the time to cope with the unexpected is getting shorter [4].

Flexibility, either avoidance of strategic surprises or fast utilization of sudden opportunities, becomes one of the key issues in strategic planning. In order to avoid strategic surprises the strategy process should be able to open the scope of observation for periphery incidents and early, unstructured data that implicate potential discontinuities in the market. But this is not enough. Defensive and surprise-averse planning seldom creates a sustainable competitive advantage. To achieve and sustain competitive advantage, companies in turbulent environments need to scan the business environment to capture weak signals of early opportunities. If they are captured, activities on the periphery can be a source of new strategic insight [9]. To gain the advantage of pro-active decision-making, companies need to integrate early information into dynamic vision that can utilize the dynamics of their operating environment.

The prerequisite for dynamic business planning is to capture this 'unknown'. When faced with an avalanche of often conflicting signals, companies need to develop and employ systematic methods for scanning the dynamic, volatile environment. The methods of environment monitoring and their implementation scope will determine [10,11] which observations and weak signals are taken into more intensive consideration, which are filtered out, and which issues eventually find their way into the vision statement of an organization.

In order to reveal the dynamics of signal-capturing, analysing and decision-making process, we analyze a case where the management of an energy company uses different means to collect and analyze weak signals and considers the impact on their business performance. The construction of the early business environment information filters is tested with four different group processes and filtering dynamics in each of the groups described.

In this research context we are applying the term weak signal by following Godet's [12] definition of a weak signal as "a factor of change hardly perceptible at present, but which will constitute a strong trend in the future".

The process of capturing the stimulus and processing it refers to Karl Weick's [13] sense-making process. In analyzing the filters we are also referring to mental models. Mental models are the cognitive knowledge structures management is using in their decision-making when they are making sense of their environment. These mental models have a strong impact on the organization's information acquisition and the processing of the information.

While the importance of weak signals has been widely recognized (see e.g. the theme number of Long Range Planning April 2004 [14]), the actual capturing and filtering processes as the shapers of organizational cognition have not received any significant attention in the empirical studies. Weak signal filtering is a subtle process that is difficult to observe and analyze, because information pertaining to weak signals is very seldom coded during the filtering process. A strategy process is also a time- and resource-consuming process that is not easily accessible to external researchers because of the sensitivities involved.

By describing the features of weak signal filters and their impact on decision-making, our paper seeks to make several distinctive contributions to the literature on

organizational sense-making. First, there are only few researches to study the weak signals filtering processes in real-life contexts as the process unfolds. Second, this study employs actual codified data, weak signals, as coded during the strategy challenge process. Third, the study provides a rare glimpse on organizational information filters in operation. Fourth, employing this rich data we build a coherent model of the shaping of organizational cognition in turbulent environments.

2. Sense-making, schemata and cognitive filters

Information filtering as a phenomenon has been mentioned within literature concerning the complexity theory, the sense-making theory and strategic decision-making theory [10,13,15]. However, there does not seem to be any comprehensive analysis of the filtering processes and mechanisms that operate within the forecasting and vision building processes in organizations operating in turbulent environments.

When we consider an organization to be a subsystem of a complex, turbulent market system, sense making is related to information about the requirements for information filtering [15]. Sense making process creates organizational perception, a socially constructed mental model about the business environment. Also, the strategy building process of an organization has defined objectives, methods and processes that will have a major implication on its capability to adjust.

An organization operating in a complex and unpredictable environment has to be flexible and in order to adapt it needs to scan and filter complex, often conflicting sets of information. The nature of this obligatory interaction is to pick up data and signals from the operating environment, identify patterns and regularities, and compress the information into internal models that reflect the complexity of the external environment. The complex adaptive systems literature [13,16,17] calls these models schemata. As the organizations base their actions on schemata, the cognitive structures determine the actions that the agent takes.

According to Anderson [15], the system is most flexible, capable to adjust, when it is on the edge of chaos, in the state of self-organizing. The organization as a social system has a tendency to seek stability. Stable schemata reduce uncertainties and thus increase the sense of security. The self-organizing state requires an import of energy into the subsystem. In the organizational context the imported energy may be considered to be either resources or information. In principle the external signals of potential discontinuities import energy to the system by shaking the current schemata and cause disorder in the organization. This disorder will require a new meaning-building process, a sense-making, which will create new shared interpretive schemes. The system is stabilizing again, but now with the different schemata [15,18]. Thus schemata is the major mechanism either for adjustment [17] or for reduction of equivocality in the organization [15] and filters of environmental scanning play a primary role in adjusting it.

The process of changing the schemata takes place in the intersubjective process of sense-making, where an organization or a group is constructing a meaning for their operations. Sense-making as a cognitive process includes both explicit and implicit mental processes of scanning, framing, interpreting, and constructing a conception of the situation at hand. The result of the process is a shared mental model or a set of different mental models in an organization. As a process that is preceding decision-making, sense-making plays

a significant role in framing the scope of forthcoming decisions [19]. If the organization is defined to be a meaning system [18] then the key for understanding flexibility or the organization's capability to adjust is sense-making.

A weak signal is by definition unstructured information and its implications to the organization are at an early stage very hard to define. A weak signal represents potential discontinuity, something that the organization has not interpreted before. Understanding current mental models in an organization will help the organization to control the weak signals capturing process [18]. In order to have an impact on the organization's strategy or behavior, the captured weak signal has to change influential mental model(s) in the organization. The flexibility challenge in this learning process is that mental models are stable by their nature. The complex operating environment produces a good deal of dissonance and management has to reduce this complexity and eliminate any stimulus that does not fit into the current mental models.

3. Strategic decision-making and filters

Igor Ansoff was one of the pioneers to consider the impact of complexity of the operating environment on organizations. He studied the strategic behavior of organizations in complex environments and recognized the failures of long-range planning in a dynamic environment. Ansoff created a whole construction covering the entire strategic planning process and capabilities in order to [10] find more adequate explanations for the managers fighting discontinuities and complexities in their organizations and business environment. According to Ansoff strategic behavior is the process of interaction with the environment. The main purpose of strategy is [4, p. xvi] to position and relate the firm into its environment, and accompanied by a process of changing internal configurations and dynamics of the organization [10] as a real-time response to the change [4].

The key issue of Ansoff's construction of transition behavior is adaptation to the environment. An effective [4] strategic transition response requires a clear perception of the changes, both prospects and threats, in the firm's environment. This clear perception is needed in order to minimize the delays of response to major new threats and opportunities. When the environment is complex the organization is forced [10] to start its response at a progressively earlier state of knowledge. The time available for reaction becomes shorter and simultaneously the organization becomes more complex, and this requires more time for effective response. In order to fulfil these requirements the organization has to identify the weak signals of change (either opportunities or threats) as early as possible, the organization has to scan the environment [10] frequently. The quality of these scanning and analysis methods limits the organization's capability to apply the right kinds of strategic behavior. All scanning systems—either conscious or unconscious—have some kinds of filters [10]. Filters are Ansoff's operationalization of mental models used in the evaluation of weak signals in an organization.

Ansoff describes his filter construction with three concepts [4]. A surveillance filter includes methodology and analysis techniques used in information acquisition. When the signal is passing the surveillance filter, it is captured, and will go through a mentality filter, a close counterpart of mental model discussed above. The last filter is the power filter. On the one hand it represents influential mental models in an organization. On the other hand, it will be active when a weak signal challenges the power structure of the organization. The
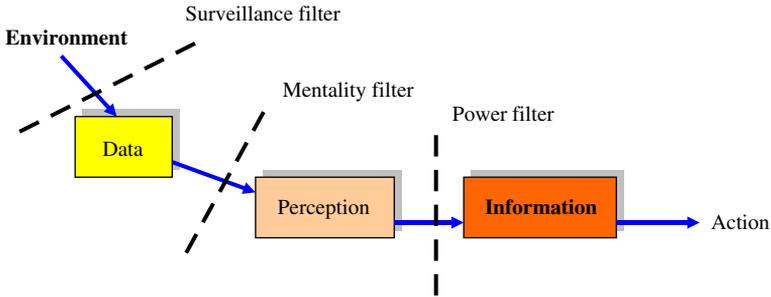
Fig. 1. Filters named by Ansoff [4, p. 510].

power filter works so that the managers whose importance would be reduced by the novel discontinuity try to neglect and/or delay vital information. These managers usually stand for the tradition of the organization (Fig. 1).

The filter construction nicely describes the role and the struggle of mental models relevant for company's strategic flexibility. It is important to realize that there might be very different kinds of mentality filters in an organization. This is especially typical, e.g. when a new technological paradigm is emerging. Substantial qualitative and theoretical work is already available on the emergence of a new technological paradigm. Debackere and Rappa [20] have suggested that a technological paradigm typically emerges in two phases: bootlegging and bandwagon.

During the bootlegging period only a small number of champions are responsive to weak signals related to the emerging technological paradigm. Their peers do not share their enthusiasm. Not infrequently, champions from such an emerging community have to face severe criticism. Typically, they have difficulties in securing adequate funding because the mentality filters of those in power (the power filter) and the mentality filters of the champions differ. 'Bootlegging' enables fledging research to proceed without the full knowledge and scrutiny of managers, up to a point at which the promise of the idea is clear. It is reasonable for managers to accept the bootlegging because it is often followed by the so-called bandwagon phase. In a relatively short period of time the mentality filters in the field change and firms which have allowed the bootlegging have the strongest position. A key issue which concerns the use of weak signals in an organization is how an organization should handle ''minority mentality filters''. Is bootlegging the only reasonable choice? We consider that a closer analysis of filters would provide better choices for organizations in the case of differing mentality filters.

4. Filters in the strategy process

As the above discussion suggests, weak signals filters may influence the decision-making processes in multiple ways. For the purposes of our model development, we describe these influences with two dimensions of our construction: the width and the depth of the filter. The width of a filter means that the filter (or the mental model) is open to different types of signals or ideas. The depth means that the filter is able to make detailed analysis of signals.

Definitions:

> Width describes the filter's capability to produce cognitive variety of relevant signals.
> Depth describes the filter's capability to produce plausible sense-making information in some content categories. Depth is based on informative argumentation processes and sense-making focused on relevant signals.

Key concepts in the definitions are cognitive variety, relevance, new information and sense-making. Sense-making is already discussed above. We suggest that an operational measure of the cognitive variety of a filter is that captured signals belong to many content categories. The relevancy means that the actor (person, organization, etc.), filtering the signals finds it to be of importance to the theme under consideration. A wide filter provides the actor with a lot of signals which in the light of future developments should have been taken into account. Wide filters also provide irrelevant signals or noise, which is of course an important problem in the time of information overflow.

Using Ansoff's interpretation of filters, the width means that the mentality filter provides the actor with a large variety of signals. Though it is rather easy to define when a signal has passed the mentality filter of a person, it is not easy to define when an organization has really perceived a signal. An operational definition for this is that the signal is provided and accepted for discussion in some evaluation process of signals in the organization. In practice, many or perhaps even most of the really important signals never go through any formal process. The depth of a filter is related to the mentality filters and the nature and number of phases of sense making process. They focus the attention of the actor to some signals making sense. The minimum for taking into account is following Ansoff [4, p. 353] "conviction that some discontinuity is impending". The limited capacity to handle information requires that the deepening processes of the filter are focused on signals that have considerable information content for the organization. We can define that the information content of a signal or new information produced by it depends besides on the relevance of the signal also on its surprise value to the actor.

As was mentioned above, much or perhaps most of the filtering of signals takes place in organizations without an explicit or guided process. However, in order to make explicit organizational strategy processes more efficient, it is important to look at the processes which produce width and depth to the filters. The following propositions make some suggestions as to how some briefing processes would produce width and depth for filters.

The dependent variables in the empirical research described below in this paper were the width and the depth of the filters. The operational measure of the width is the variety of descriptions. Depth of the argumentation is measured by the richness of the explication/narrative and by the length of the argumentation chains.

The independent variables of the construction to be described are:

- the scope of the briefing;
- the argumentation requirements;
- the number of levels of the analysis;
- the format of the processing (virtual or intersubjective processing).

Proposition 1. *The open scope of the briefing increases the width of the filter.*

The open scope (the area the posed question covers) of the briefing opens also the surveillance filter. An open question increases the opportunity for diverse information [10] because then the mental models the observers use for collecting and processing information are not predefined but more diverse. This will increase cognitive flexibility in the sense-making process [21]. According to Weick the more ambiguous the problem at hand, the more versatile the information provided for the solution [13]. Since the ambiguous problem cannot be adequately defined, management is not able to use the prefixed heuristics and thus cannot respond in predictable way [22,23] and that increases the variety by decreasing the potential for expected or canonized responses. The open scope allows the acquisition of diverse information that has the potential to change the schemata [24].

Proposition 2. *A multi-step process increases the depth of the filter promoting strong argumentation.*

During the sense-making process the stimulus captured from the external business environment is going into a reflecting process that compares the captured stimulus with current mental models [13]. The goal of all organizations, viewed as sense-making systems, is to create and identify events that recur to stabilize their environments and make them more predictable. The nature of the cognitive process is complexity-reducing [4] and if there are several succeeding steps of reduction the stabilizing effect is even stronger. The impact of the reduction mechanism is stronger if there is a requirement of comprehensive argumentation and if there are several succeeding steps of argumentation. This stabilizing effect will reduce the equivocality of the schemata the organization is applying [15].

Proposition 3. *Social interaction as a processing method will increase the depth of the filter but reduces the width of the filter.*

The stability of the organization requires shared interpretations that reinforce each other in the sense-making process [25]. In the group process intersubjective level individual meanings are synthesized or merged in conversations into common meanings, shared schemata. Objective of this process is to minimize the tension that uncertainty creates and this requires a sense-making process until the social interaction process has reconstructed the current reality [13,26] and schemata is again stabilizing. According to Ansoff [4] the power filter activates and causes bias when an extracted cue will have the potential to change the power structure. The observation filter is activated especially when the captured cue is threatening [27] and the organization is applying their primary rules of sense-making process [25].

5. How we operationalized the propositions?

The operationalization of the propositions was mainly based on the use of the Signal Web Toolset (see http://www.strategysignals.com and Appendix A). The participants are invited to reveal their spontaneous observations on recent changes in the business environment (narratives). Anonymous, collected observations (signals) are sent back to respondents for their assessment. Every respondent gets 40 random signals and he assesses the relevance of those signals for the future of the company on the web-aided cognitive map.

Propositions have been tested in a globally operating energy company. We studied one part of the strategy building process of the company in April and May 2004. The objective of this part of the strategy process was to identify new, alternative growth options for the future of the company.

We were able to invite all members of the organization on a certain level of qualification (nature of the tasks, education, level of expertise) to participate. As a total of 170 managers or senior experts that represented all the business units and functions participated.

The participants were randomly divided (by classified sampling) into four homogeneous groups. The key criteria for the homogeneity were the division (divisions had very different fields of business) and professional age. We had the unique opportunity to brief groups A&B and groups C&D with different scopes of questions and then run a different process for each of them. The study of four different groups within the same organizational context was beneficial, since we were thereby able to reduce the variance on external conditions and focus on changes caused by variation along dimensions of theoretical interest (Table 1).

The first-phase observations on the business environment were collected by the above described web-tool and the questions used were:

Open question for Groups A&B:

> What observations have you made in the current business environment that could be a challenge to our strategy?

A more focused question for Groups C&D:

> What kinds of novel opportunities, big or small, do you detect in the business environment for our Company?

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 collected signals' relevance for the future of the company on the web-aided cognitive map. In this phase the respondent rate was 95%. The processing of the reports was focused on the current mental model (the signals that were agreed to be very relevant for the future of the company). The mental models included all the basic features of the current strategy of the company:

> Be aware of the resourceful Xxxxxn competitors, partner with them if nothing else is effective. New players are coming, but we are competing by specialising in clean xxxxxs and xxxxxxs, by being ambitious, investing in R&D and by assuring our decision-making is sufficiently clear.
> Be sensitive, innovative and strengthen current expertise in order to benefit the environmental trend in the short run by developing xxxx xxx and, in the long run, xxxxxxxxs. Seek fast growth from ZZZZZn and new BBBB countries with base products and xxxxxxxx network. Invest NOW in a new xxxxxx xxxxx.

This mental model was challenged by weak signals (signals with high deviation and low average relevance) with 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 become true.

Table 1
Case study: participating groups and their different processes

Group	Open question	Focused question	Web processing of results	Work shop processing
A	X		Scenario telling and recommendations	
B	X			Two workshops: first basic assumptions of Golden Age, second challenging them
C		X		One workshop: dynamics of the growth
D		X	Predictability and impact map ≫ argumentation	

Fig. 2. The mental model of groups A&B measured by signals categories and by the number of signals in each of the category.

Group B: Two-phase workshop: creation of alternative futures (similar task as group A did web-aided) and evaluation of the created material in the predictability and impact grid.

Group C: One workshop: alternative growth options that were based on weak signals collected from the material of groups C&D.

Group D: Assessment of the predictability and impact of collected weak signals virtually. Every group member did this part using a 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 filter construction applied.

The outcome of phase I (collecting signals) that was analyzed was all signals collected. Here we assessed the width of the filter by number of different signals categories.

Table 2
The empiric data matrix

Group	Open question	Focused question	Virtual analysis	One workshop	Two-stage workshop
A	The top 3 categories represents 53% of signals (evaluated signals), which is 3.5% units less than in the focused question		More variety in themes, 8.7 issues as average in a description, long argumentation chains number of radical ideas 40%		
B					4 descriptions from one theme (production)—4 issues as average in description: • Groups shortened descriptions (those parts that did not fit were deleted) • Argumentation chains: one issue had 2–7 arguments/ more detailed descriptions
C		The amount of signals was 26.6% smaller than in the open question		6 descriptions from one major theme (production) 5/6 6.3 issues as average in description, half of the descriptions no argumentation 1 out of 6 radical (predictability low)	
D					

Categories were built based on judgments of the researchers and the clients of the study. The categorization was done by two researchers independently and also the client commented the categorization (Fig. 2). In this respect the result of this part of analysis should be considered validated. The depth of the filter was reflected by the number of signals in each of the categories (to reduce the impact of interpretation we accepted that some of the signals were overlapping) (Table 2).

The outcome of phase II varied according to the task the group was involved in. The analyzed material from groups B and C were the reports from their workshops, group A produced several individual scenario descriptions that all were analyzed. The number of different categories of issues/themes in the descriptions referred to the width of the filter. The depth of the filter was operationalized by analyzing the nature and length argumentation chain applied in the descriptions. Both the multiple argumentations and long argumentation chains indicated a deep filter.

The results of the second phase of group D, who had a virtual predictability and impact assessment of weak signals, are not valid in this research because in order to serve the strategy process of the case company the task of group D was changed and is not comparable with the results of the equivalent workshop process of group B.

6. Conclusions

The result of the case study was that a deep, narrow filter produces a well-focused, very predictable one-scope aggregate level output. A flat and wide filter produces a wide diversity of concrete issues emerging from many different sources.

Proposition 1 concerning the impact of the openness of the briefing, stated that the open scope of the briefing increases the width of the filter resulting in a large diversity in the outcome. The results of the study do not provide very strong support for the proposition when the diversity of the signal categories is analyzed, but the number of produced signals was larger in the case of the open question.

Proposition 2 stated that a multi-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 by producing fewer descriptions and finally by choosing only four of the most predictable descriptions for further analysis. During the workshop process 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.

Proposition 3 supposed that the social interaction as a processing method will increase the depth of the filter but will reduce the width of the filter. The alternative method tested, virtual scenario description building, supported the latter part of the proposition by indicating that with virtual methods the outcome had more diversity/variety of themes, more vivid descriptions and the number of radical ideas was comparably higher than in the social interaction process of workshops. Instead, the relatively longer argumentation chains of the virtual group do not support this proposition (Fig. 3).

What are the implications of the results of this study to the strategy-building process management? The objectives of the corporate strategy process at hand set the requirements
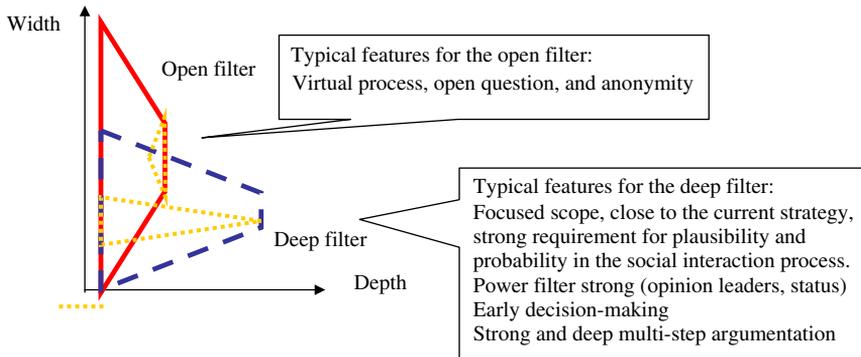
Fig. 3. The weak signals' filter shapes in different groups.

for the shape of the filter [4,10]. If the company is operating in the complex market and flexibility is the key source of competitive advantage, the environment-scanning system has to be open for potential discontinuities [10]. An open scanning filter creates the opportunity for importing "disturbing" information to the organization and thus destabilizes it [27]. Even in the case the business environment is more stable, but the ambition of the company is to enact in the market, the scanning filter has to be open enough to support peripheral vision and to identify potential discontinuities as early as possible. This way the scanning method will produce material for pro-active decision-making and thus creates a competitive advantage [12,28]. As a result the company's strategic flexibility increases.

When the operating environment is relatively predictable and/or the resources in use are scarce, the filter should be deep and the conclusions well-focused and well-argued [10,29,30]. Especially in situations where the basic strategy is reactive and the reaction time is short, well-argued strong and shared cognitions [13,31,32] create focused action. As a result the company's efficiency increases.

In this article we have focused on quantitative measures of the width and depth of the filters referring to the number and variety of produced arguments. Another potential approach would be to rely on qualitative evaluation and to ask the participants where they see relevant arguments and how they see the possibilities to increase the widths or depths of the filters in their organizations. Then, e.g. the following questions are relevant: How do you see the general importance of the signal to your company? Do you consider your organization is ready to react to the signal or to the development anticipated by the signal soon? Do you consider that somebody in your organization is ready to capture the signal, i.e. are there potential champions of the development anticipated by the signal?

We have used mental models as the research object, even though we knew that there is a linkage between the mental model and strategic behavior [33]. To be efficient, in an ideal case this research should have covered also the strategy formation and the evaluation of the performance measures when implementation is completed. Strategy-building is a thinking process: if an organization is defined as merely an actor, the actions should be more profound to have the right focus for research [3,34].

Appendix A. A tool for signal collection

The research presented applied a specific qualitative research tool developed for collecting weak signals in complex turbulent environments where there is constant need for monitoring. The tool is designed to overcome most of the filters described in the previous sections and the logic of the tool is based on the theories on strategic filters [4,10] and cognitive filters. The tool enhances diversity by facilitating wide participation of the organization; it can be used via Internet. With this tool user organizations have been able to open filters both in strategy formulation processes and in product innovation.

The tool is used in three stages: collection, evaluation and analysis of weak signals:

1. The Signals collection toolset is designed to minimize the impact of surveillance filter and power filter. Wide, heterogeneous structure of participants applies/recruits a set of diverse surveillance filters to participate in the enquiry. All responses are anonymous, so the dominating power structure or peer pressure does not have strong impact on responses. For the analysis, background variables are gathered.

   Each of the signals has to have the capability of arousal/interruption in the sense-making process [13]. The input provider is explicating his/her thoughts as a narrative. Kuusi [30] has analyzed different formats of weak signals or innovation ideas and has found out that a story format is able to carry meanings in the multi-step sense-making process. The tool has three different templates for signal collection. One for rational ideas accepted in our analytical cognitive models. The second one is for randomly chosen questions that have no direct links to the theme under investigation. The third one is used to trigger thinking and encourage the respondent to give up the analytical thinking with the help of 'distant thinking models' (Fig. A1).

Fig. A1. Three templates used in the signal collection stage. Please note: a generic example, case specific material confidential.

The second challenge the tool aims at overcoming is the qualitative format of the signals. In order to facilitate the analysis process of qualitative material, the material has to be operationalized into quantitative form. The transformation is made in the next stage.

2. *Signal evaluation*: The same respondents are invited to evaluate the collected material. The tool provides each respondent 30–40 randomly chosen signals from collected material for evaluation. The respondent is able to click the comment open and thus able to read his colleague respondents' authentic comment, both the title and long descriptive narrative. The material has not been filtered or edited by the researcher, so it is truly authentic. The method used for evaluation is a simple application of a cognitive map [35], where the respondent is asked to position the signals close to the reflected theme on the center of the screen (see Fig. A3) if they find the signal highly relevant to the theme and further from the center if the signal under consideration is not relevant at all. Argumentation of one's own views is not required and thus the mentality filter stays open (Fig. A2).

3. *Analysis of evaluated signals*: The reporting structure forces the analyzing group to overcome the mentality filter by explicating also such potential weak signals that do not fit within current mental model. Elaborating all cognitive maps of respondents with equal weights opens the power filter. The grid report (see Fig. A3) articulates both the
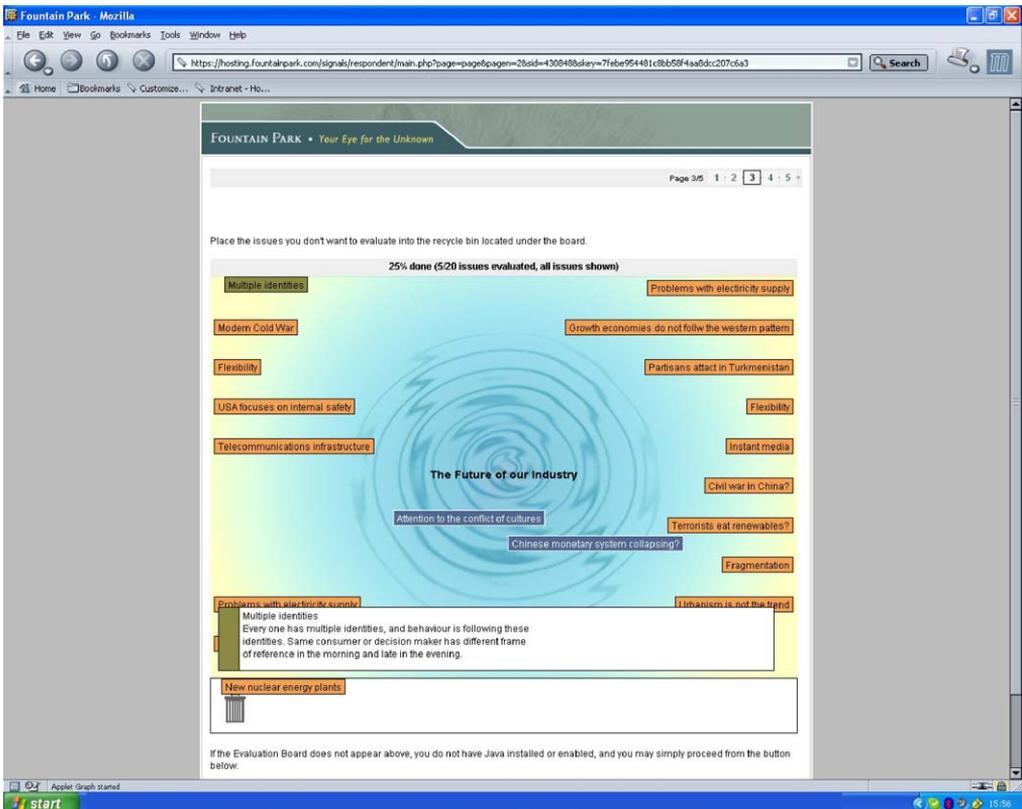

Fig. A2. Cognitive map for evaluation of the relevance of signals. Please note: a generic example—a case specific material confidential.
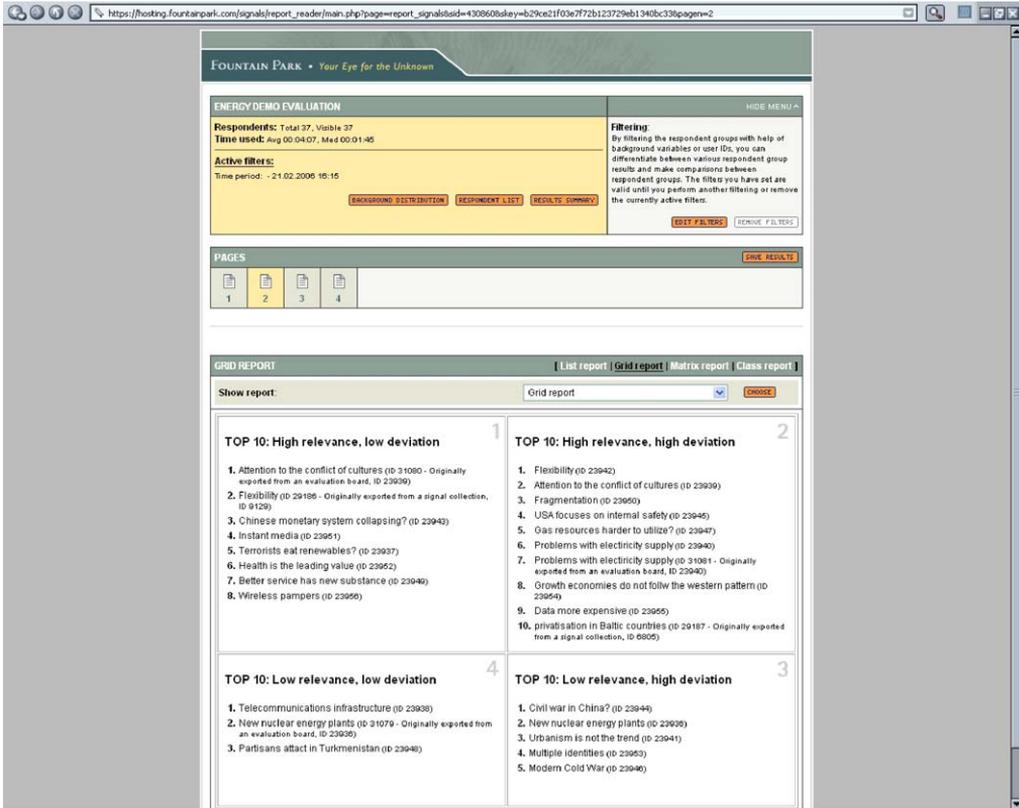
Fig. A3. The result grid that presents the weak signal. Please note: a generic example—a case specific material confidential.

dominating perception on the theme surveyed and lists potential weak signals. The slot 1 of the grid report lists signals that the majority of the respondents considered to be of high relevance (a mean of signals distances of the midpoint is low and standard deviation is low). Slot 3 lists signals where standard deviation is high and an average of relevance (a mean of distances is high) is low. This kind of evaluation pattern indicates potential weak signals that have been able to pass the surveillance filter of few respondents. In the analysis session the participants are focusing on weak signals that do not fit into the dominating perception [4]. When these potential weak signals are analyzed, e.g. with Policy Delphi methods [30], the cognitive filter of the team is opened temporarily and some of the potential discontinuities that may challenge or change the current mental model are identified. The power filter is kept open by treating all signals equal as long as possible in the process.

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