Improving the Applicability of Environmental Scanning Systems: State of the Art and Future Research

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Abstract. The 2008/2009 economic crisis provided a sustainable impulse for improving environmental scanning systems (ESS). Although a rich body of know-ledge exists, concepts are not often used in practice. This article contributes a literature review addressing six findings for ESS design to become more applicable than the state of the art. They are structured by the elements of information systems (IS) design theories. Addressing the lack of a sound requirements analysis, our first finding proposes 360-degree ESS for executives' "managing a company" task and presents how to select just the most important scanning areas to keep focus. Three other findings cover the IS model perspective focusing on a better "grasp" of weak signals: define concrete indicators and use IT to identify relevant cause-effective-chains, leverage IT to automate day-to-day routines and monitor the variety of indicators' movements, and—as a fourth finding—leverage expert experience with an impact matrix and translate indicators' impact into a balanced opportunity-and-threat portfolio. From the methods perspective on ESS, we propose to more closely incorporate scanning results into executives' decision-making process by generating scenarios from a set of environment assumptions as well as to use retrospective controls to continuously update the ESS and collaborate to share the scanning findings in day-to-day work.

Keywords: Corporate management, balanced chance and risk management, information and communication technology (ICT), literature review.

1 INTRODUCTION

Environments' increasing volatility is a growing concern for companies. Executives worry about not being prepared for environmental shifts or—even worse—not being able to parry them. The 2008/2009 economic crisis gave a sustainable impulse for focusing earlier on emerging threats and opportunities (Hopwood 2009; Makridakis et al. 2010). *Environmental scanning*—ideally, IT-based within a corporate business intelligence (BI) architecture (Wixom et al. 2010)[1] —can help to manage this challenge. Companies that do so will have brighter prospects than those that do not (Ansoff 1980).

With Ansoff's (1975) article "Managing Strategic Surprise by Response to Weak Signals" as an example, a rich body of knowledge exists, but it often goes unused. Practitioners perceive the task as a difficult one per se (Lesca et al. 2008). Some may not even know how to start (Albright 2004). They experience *difficulties* in designing, implementing, and operating environmental scanning systems (ESS). The objective of this article is therefore to design such information systems (IS) that are more applicable than the state of the art (Sec. 5.2).

As this work represents a first step in a larger research project, we start with a review of related work for big picture thinking and define future research to follow for more applicable ESS. Generally based on the Webster and Watson (2002) approach to literature review, we follow vom Brocke et al.'s (2009) five-step procedure. *Definition of review scope*: We motivate this article by reporting gaps between the rich body of knowledge and survey results suggesting that these concepts are often not used in practice. *Conceptualization of topic*: After revisiting foundations (Sec. 2), we show the need of ESS (Sec. 3). Hereafter we derive a framework for categorizing the literature (Sec. 4). *Literature search and analysis*: We then lay open our literature search process (Sec. 5.1). Out of 80 publications surveyed, we describe the most important ones providing accepted knowledge (Sec. 5.2). *Literature synthesis*: Based on the findings, we develop a future research agenda (Sec. 6). We close with a summary, the limitations of our work and ongoing research (Sec. 7).

2 FOUNDATIONS

A company's environment could be defined as the relevant physical and social factors within and beyond the organization's boundary (Duncan 1972). While operational analysis focuses on internal difficulties in the implementation of strategic programs with the aim of fully leveraging identified potential, strategic environmental scanning, in turn, aims at anticipating (long-term) environmental shifts and analyzing their potential impact.

This research concentrates on the latter referred to as "*environmental scanning*". Its main function is to gather, interpret, and use pertinent information about events,

[1] BI is a broad category of technologies, applications, and processes for gathering, storing, accessing, and analyzing data to help its users make better decision (Wixom et al. 2010).

trends, and relationships in an organization's environment that would assist management in planning the future course of action (Aguilar 1967).

As an IS label to support *managerial* decision making, management support systems[2] (MSS) are proposed in literature. They cover decision support systems (DSS), management information systems (MIS), executive information systems (EIS), more recently knowledge management systems (KMS), and business intelligence systems (BI, Clark Jr. et al. 2007). ESS in turn have their roots in management literature focusing on the executives' task to be aware of environmental trends (Aguilar 1967). They specify the sectors to-be scanned, monitor the most important indicators that may create opportunities or threats for the organization, cover the IT-based tools to be used (Yasai-Ardenaki et al. 1996), incorporate the findings of such analyses into executives' decision making, and often assign responsibilities to support environmental scanning (not covered in this article, but in Lenz et al. 1986).

Two information collection modes are distinguished (Choudhury et al. 1997): In contrast to the reactive mode in which information is acquired to resolve a problem, we follow the *proactive mode* in which the environment is scanned for upcoming changes that represent opportunities and threats (Fahey et al. 1977). As a result, this article aims at ESS, which are conceived as structured, reticulated IT-based IS to allow executives to scan their environment from an overall perspective for a proactive corporate management.

3 NEED FOR IMPROVING ENVIRONMENTAL SCANNING SYSTEMS

Regulatory needs: Environmental scanning is not just "nice to have", as Kajüter (2004) shows in his multicountry comparison. In the wake of several cases of fraud around the turn of the millenium that were neither detected by internal controls nor by auditors, legislators expressed a need for a more detailed risk management approach. Best known is the U.S. Sarbanes-Oxley-Act. In particular Section 404, requires companies listed on the New York Stock Exchange to extensively document internal controls, establish independent audit committees, and have internal controls' effectiveness audited mandatory (Sherman et al. 2009). Furthermore, financial statements are normally prepared on the assumption that a company will continue in operations for the foreseeable future (IASB Framework 4.1; ISA 1.25). This requires predictions of at least one year (Choo 2009). In the wake of the 2008/2009 economic crisis, the assessment of this "going-concern" has gained an increased importance.

Empirical evidence: Fuld (2003) showed the lack of an early warning system in 97% of the U.S. companies he surveyed. Interviews with 140 corporate strategists found that two-thirds had been surprised by as many as three high-impact competitive events in the past five years. Following Krystek & Herzhoff (2006), 30% of European

[2] Both, MSS (Clark Jr. et al. 2007) and DSS (Arnott et al. 2008) have been proposed as labels for IS intended to provide IT support for managerial decision making. Since DSS evolved from a specific concept that originated as a complement to MIS and was overlapped in the late 1980s with EIS, we refer to MSS on hand (Power 2008).

chemicals companies do not have strategic ESS in place. 15% said that the instruments available are not sufficiently accepted to be used in practice. Day & Schoemaker's (2005) survey of global managers found that 81% perceived their future need for peripheral vision to be greater than their current capacity. Similar findings are reported from companies within the Financial Times "Europe 500" report (Mayer 2010): most of the executives consider environmental-scanning concepts to be too complex and even too difficult to implement. Therefore, results are not a substantial part of executive decision-making process.

4 FRAMEWORK FOR LITERATURE SYSTEMATIZATION

Following Webster and Watson (2002) a literature review is concept-centric. Elements of IS design theories in combination with the research method used offer a framework for structuring the literature (Figure 1).

4.1 Elements of IS design theories

According to Walls et al. (1992), IS design theories consist of three elements: (1) *Requirements* can be defined as prerequisites, conditions, or capabilities needed by users of software systems to solve a problem or achieve an objective (IEEE610.12-1990). They delineate what IS should do, both from the functional and non-functional perspective (Kotonya et al. 1998). Functional requirements address "what" IS should or must do (purpose of the IS). Non-functional requirements, in contrast, reflect "how well" IS perform within the given environment as it fulfills its function, e.g. response time and reliability (Paech et al. 2004).

Designing ESS is not a Greenfield approach. For that reason, IS design theories cover guidelines for bringing the system to life. They contribute to methods and models. (2) *Models* outline concrete systems, features, or combinations of these (Gregor 2006). We distinguish between forecasting as the first generation of ESS, indicator-based systems as the second one, and environmental scanning using weak signals as the third generation. (3) *Methods* cover the process of environmental scanning. We differentiate between information gathering ("scanning"), analytical techniques to identify latent or pending changes; and the incorporation of the scanning results into executives' decision-making process.

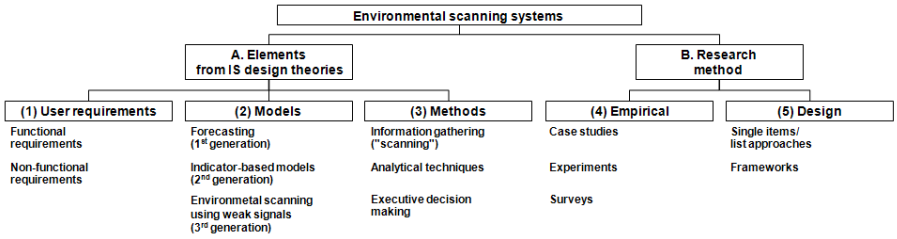

Fig. 1. Framework for literature systematization

4.2 Research methods

The type of research method is another dimension in our framework for systematizing the literature. Their distinction is important as it influences the granularity of requirements and design principles: from abstract findings by a survey regarding "appropriate technology" to detailed IS features from an in-depth case study such as "drill-down functionality to an upstream ERP" (Urbach et al. 2009).

(4) Papers are regarded as *empirical approaches* if they rely on observation and apply some type of empirical method. We differentiate between case studies to learn from single design, experiments, and surveys (Urbach et al. 2009). (5) *Design approaches* involve ideas and frameworks for creating a better world and provide more direct recommendations for IS (Walls et al. 1992). We go on differentiating between single items and broader "list" approa-ches that specify sets of requirements, design principles and frameworks that focus on the relationship between requirements and design principles.

5 5 LITERATURE ANALYSIS

Generally based on the Webster and Watson (2002) approach to literature review, we introduce our search strategy (Sec. 5.1). Then, we systematize the results to discuss the most important publications at a glance (Sec. 5.2). The synthesis of findings follows in Sec. 6.

5.1 Search Strategy

Following vom Brocke et al. (2009), we first perform a journal search. We focus on leading IS research outlets and select six of the most relevant IS journals[3] reflecting their ranking[4] and impact factor[5] (Webster et al. 2002). Furthermore, we

[3] MIS Quarterly, Decision Support Systems, Information & Management, Journal of Management Information Systems, European Journal of Information Systems, and Information System Management.

[4] Based on journal rankings of AIS (2010); VHB (2008); WKWI (2008).

[5] We considered impact factors from http://www.elsevier.com.

expand our list with proceedings from the two A-ranked international conferences listed by WKWI (2008): the International and European Conferences on IS (ICIS, ECIS). Second, we use EBSCO host, Google scholar, Science Direct, and Wiley Inter Science to access the journals. Third, the keywords "environmental scanning system" and "early warning system, weak signal, leading indicator" produce 14 relevant hits in total. Fourth, by doing a backward and forward search, we add the keywords "management support systems" and "business intelligence" to our search string, leading to additional 13 IS articles. Finally, we did the same search on strategic management literature[6] coming up with another 53 hits. So, we end up with 80 relevant publications in total (Figure 2, in detail Table A1).

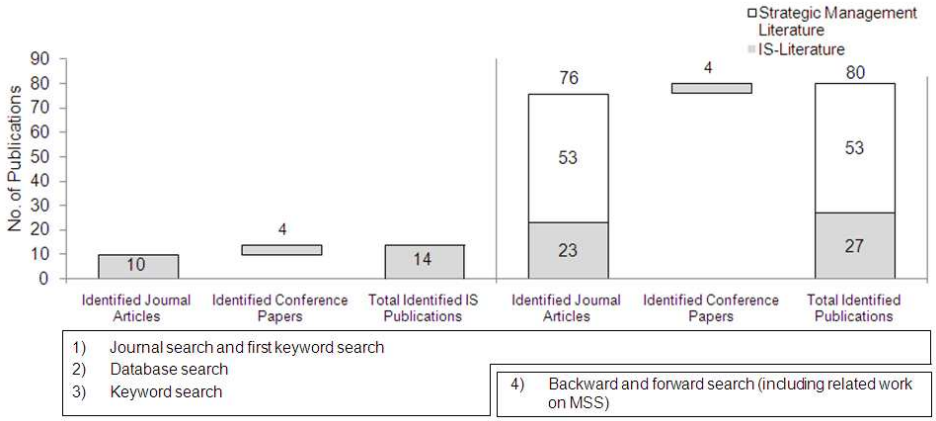

Fig. 2. Selection of the relevant publications

5.2 Results

Figure 3 presents the 80 publications identified as relevant within the framework we derived before. The most revealing publications are discussed below. The insights then allow us to develop the findings for ESS more applicable than the state of the art (Sec. 6).

[6] Strategic Management Journal (SMJ), Long Range Planning (LRP), Journal of Management Studies (JMS), Technology Analysis and Strategic Management (TASM), Academy of Management Review (AMR), Harvard Business Review (HBR).

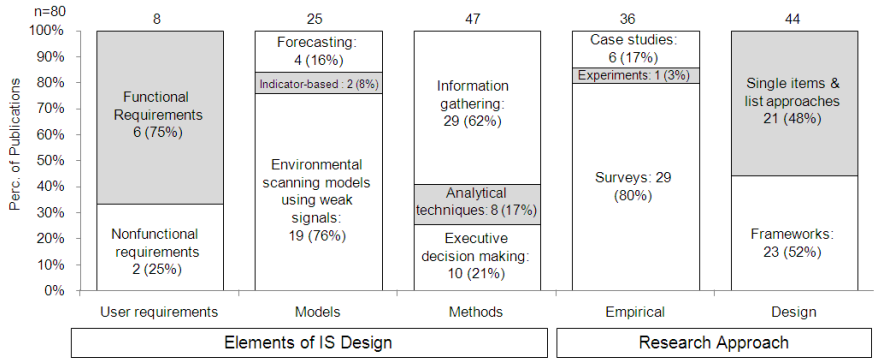

Fig. 3. Classification of the publications

User requirements.

Just six out of 80 publications focus on functional requirements and an even minor number of two on non-functional ones. Of particular relevance is Xu et al. (2003). To develop a Corporate Radar, these authors conducted a cross-industry study and found that *task-related environmental* areas are perceived to be more important than far-general environmental in-formation. For example, in the computer and electronics industry the supplier sector was assessed as a fundamental area for environmental scanning.

Another five studies reviewed functional requirements of executives by their scanning practices. For example, Yasai-Ardenaki & Nystrom (1996) emphasize a link between scanning areas and *strategy*. Especially in volatile industries, the *"periphery"*—a metaphor, describing latent changes that can come e.g. from political movements—should be considered for environmental scanning (Day et al. 2004). Regarding Daft et al. (1988) the periphery should cover at least science, politics, law and justice and international relationships. Focusing the non-functional perspective, El Sawy (1985) dealt with executives scanning requirements and suggests that a successful solution should have just a *limited number of scanning areas and sources*.

Models.

Out of our 80 articles, 25 publications cover models for environmental scanning. They can be divided into three generations: Early warning systems were first mentioned in the late six-ties by Cohen & Zinbarg (1967). These key-figure-oriented approaches are based on thresholds that define the range of tolerance. If a critical value is exceeded, an alert is triggered. Forecasting advances this technique using time series, not only for planned and actual data, but also planned and *extrapolated as-is data.*

Second generation ESS identify latent risks and chances. Such an indicator-based model is described by Davies et al. (2006). Their *key risk indicators* (KRI) are standardized indicators that focus on potential problems, e.g., staff turnover could signal inadequate human resources performance. Since random or natural fluctuations

occur, they *recommend reference values and ranges of tolerance* to avoid overreactions.

After companies failed to act proactively on the oil-crisis, Ansoff introduced the concept of *weak signals* in 1975. An example is the World Wide Web (www) changing the private and business communication or the spread of carbon fibre. The latter's usage for example has increased steadily in recent years and its potential to serve as a substitute for steel represents a strategic issue for steelmakers. As we see nowadays, weak signals do not always work out. They often lack "grasp" for direct interactions. But Ansoff's concept is still topical in recent literature. In fact, 76% of publications about models use his approach. Narchal et al. (1987) promise that a *systematic scanning and monitoring* is more effective than ad hoc scanning in giving a prognosis of future developments. Hereby, they stress descriptors indicating relevant developments, trends, and events in the environment. They explain and quantify dynamics within the scanning areas.

Methods.

Aguilar (1967) was the first to examine four different modes of scanning, namely un-directed viewing, conditional viewing, informal search and formal search. *Attaining strategic advantages* by information gathering have been of high interest and therefore 62% of articles on methods refine the concept.

Several analytical techniques for environmental scanning are distinguished in literature and covers 17 % of the publications researched: mathematical methods facilitate a systematic integration of quantifiable figures into ESS. But, the 2008/2009 economic crisis showed that they had significant scarcities for ordinary users. Often premises were too complicated (Ma-kridakis et al., 2010) or the use of confidence intervals in value-at-risk models excludes improbable, high-impact events (Fuld, 2003). Taleb et al. (2009) also criticize these models, because even small errors in the assumptions underlying the distributions can be devastating. Heuristic approaches are alternatives (Ansoff 1980). For example, the *delphi method* comprises three features: First, responses from experts to a topic are anonymous, usually using formalized questionnaires. Second, in several iterations, feedback is given to the experts. Third, after a few iterations, when the results stabilized, group response is aggregated (Dalkey 1969). Narchal et al. (1987) recommend *influence diagrams* focusing on levers and their influence on the most important environmental indicators. In order to model dependencies between single items, *cross-impact matrices* evolved (Fontela 1976). It is also argued that such matrices can contribute to find a most probable *scenario* of the future.

One dimensional performance measurement systems often do not suffice to meet the complete information need. More important, Fuld (2003) showed that companies often fail to act on generated environmental scanning information, either by measuring the impact of identified opportunities and threats on (financial) performance indicators *or incorporating the results of ESS in executives' decision making process* per se. Frolick et al. (1997) argue to embed EIS into the environmental scanning process. EIS can enhance identifying issues, establishing

means of scanning, delineating sources of external information and decision making. Finally, EIS can help to incorporate anticipated changes in the planning and reporting.

MSS and environmental scanning.

To complement our results, we also consider findings from contemporary related MSS work. Gleißner & Füser (2000) propose *artificial neural networks* to support early warning capabilities in corporations. In contrast to humans, they are not limited by psychological barriers. Moreover they can deal with many different variables coincidentally—as needed to handle the potential span of indicators. They are adaptive and robust models. Thus, they are widely used for fraud detection (Ngai et al. 2011), but not used in environmental scanning.

Using *value at risk* (VaR, Chen et al. 2011) and unstructured data from BI can predict financial market risk and thus should contribute to environmental scanning. Recent developments in the www, namely *web 2.0*, and incorporated social networking, provide useful in-formation on customers and competitors. For example, customers that judge their goods bought offer useful strategic information on products quality and future offers (Chen et al. 2011). Besides the internet, also *capital markets* provide useful information on customers, suppliers, competitors, and the economic development (Plambeck & Weber 2010). They can deliver future perspectives, e.g. on growth rates of economies or net sales of organizations.

Understanding BI in a broader sense, Goul and Corral (2007) ask for *data warehouses* (DWH) to include information about external issues such as competitors or regulations and to provide measurability of the strategic advantages. Lönnqvist and Pirttimäki (2006) performed a literature review to evaluate existing methods for measuring the *value of BI* within the organization. For example user satisfaction gives an insight. Those measurement approaches should be checked for applicability to evaluate ESS.

6 SYNTHESIS

The literature systematization in Sec. 5 reveals major gaps in research to overcome for more applicable ESS. Interpreting them, we go on with six findings for a reworked IS (also Mayer 2011). Herein, we incorporate first ideas from Narchal et al. (1987) and Mayer and Wurl (2011). The latter refer to it as the *Corporate Radar*. An instantiations at a large, international companies in the basic materials sector (Europe, sales: USD 56 bn; employees: 174,000) helped us to make the findings more concrete.

6.1 User requirements: lack of sound requirements analysis

Just six out of 80 publications focus on functional requirements and an even smaller number of two on non-functional requirements. Some may argue that improvisation could be an alternative approach (Ciborra 1999), but following the homo oeconomicus theory we believe the best way to tackle the increasingly volatile environment is reasoning on *cause and effect chains*. Thus, a series of indicators have

to be collected in order to detect threats and opportunities to anticipate for proactive corporate management.

A first finding can be proposed as follows: *Take a 360-degree approach to support executives' "managing a company" task, but select just the most important scanning areas to keep focus.* When designing ESS, we recommend starting with the most popular and wide-spread conceptual design of Xu et al. (2003) and prioritize task-related environmental areas. Because executives have the task of managing a company, a "360 degree" radar is needed (Figure 4). It should reflect the organization's vision and strategic program (Yasai-Ardenaki et al. 1996) and then follow the value chain for their scanning areas of procurement, production and sales. (Day et al. 2005). Following El Sawy (1985) and his non-functional perspective on requirements that just the most important scanning areas should be considered to keep focus, most important supporting areas are capital supply, research and development, and human resources. The more volatile the company's environment, the more the peripheral areas should be scanned. Following the PESTL scheme e.g. (Daft et al. 1988), such peripheral areas are legal and compliance or shifts in social or political behaviour. IS support for this first activity of setting up a Corporate Radar is not mandatory.

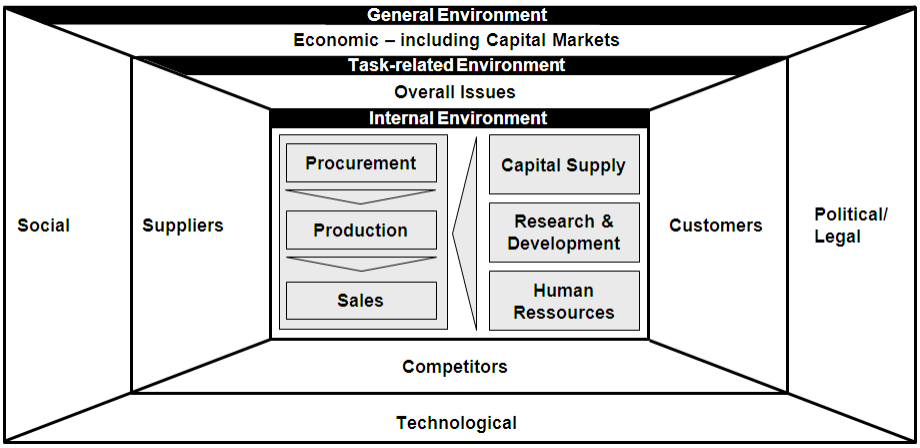

Fig. 4. Scanning areas for reworked environmental scanning systems

6.2 Models: weak signals lack the "grasp" to apply in practice

The most popular and widespread approach to find indicators giving executives the time for proactive decision making are *weak signals* (Figure 3). So we stick to that concept with the aim to improve their missing "grasp" which we identified in the literature systemization. What changes in organizations' environment are weak signals and so proactively show significant turbulences is unclear. Especially weak signals differentiation from day-to-day vibrations without consequences is difficult. With the

following three findings we translate Ansoffs´ weak signals in a more pragmatic IT-based approach of indicators.

Second finding: Define concrete indicators and use IT to identify relevant cause-effective-chains. Based on our literature review, we see two levers to improve weak signals "grasp": first, distinguishing relevant indicators foreseeing changes from the mass of data available (Narchal et al. 1987) and give guidelines on how to identify patterns attaining their strategic advantages for the organization (Aguilar 1967). Following Davies (2006), we propose as evaluation criteria indicators' lead time, clarity, and their appropriate cost-/impact ratio. For example if sales is an important scanning area, the Baltic dry index, which measures the rates charged for dry-bulk vessels, could be used to indicate overall economic development.

Second, the barriers preventing people from identifying and processing weak signals can be circumvented with IT (Frolick et al. 1997; Hand 2009). Structuring data, artificial neural networks, data mining, and semantic search should receive greater attention as ways to extract cause-effective-chains (Elofson et al. 1991). So, IS researchers should therefore focus on exploring techniques to extract non-trivial, implicit, previously unknown and potentially useful patterns.

Third finding: Leverage IT to automate day-to-day routines and to follow the variety of indicators' movements. In a third step, data sources and the frequency of data collection must be determined. A trade-off is necessary between the cost of data collection, such as license fees of data sources, costs of additional employees, the reporting system itself and its ability to indicate potential opportunities and threats. We particularly emphasize the Internet (Chen et al. 2011) as well as capital markets (Plambeck & Weber 2010) as data sources, because they have an inherent good cost/benefit ratio at least for basic information generation. The use of supportive, predefined and easy-to-handle user interfaces for data access or common IT languages, such as XBRL (eXtensible Business Reporting Language), facilitate accessing relevant information sources by automated routines to systematically monitor the movements of the most important indicators. To save even more cost and time to process information gathering data through computerized notes is proposed (Frolick et al. 1997).

Fourth finding: Leverage expert experience with an impact matrix and translate indicators' impact into a balanced opportunity-and-threat portfolio. To model the indicators' impact, instead of using complex mathematical models, we propose a heuristic approach based on the delphi method. This is for the reason that a basic understanding of risks and their implications on organizations' performance is more important than pseudo-exact calculations with difficult mathematical approaches. Within the delphi method for ESS, experts should be asked to qualify indicators' impact on threats and opportunities (Mayer and Wurl 2011). On the left hand side in Figure 5 the indicators, their scoring according to threats and opportunities

(x-axis) and their estimated lead time (y-axis), are shown. The bundling is used to derive the associated opportunities and threats for the organization (right hand side): The balanced opportunity-and-threat portfolio draws on the results of an analysis quantifying the impact of each individual indicators on the most important threats and opportunities (Fontela 1976). We choose this visualization because it is

comprehensive in terms of content, but in terms of presentation it represents a condensed overview about most important opportunities and threat for the organization.

6.3 Methods: approaches lack to incorporate results of environmental scanning systems into executives' decision making

Last, but not least, the third gap that becomes obvious is that environmental scanning is useless, as long as the results are not integrated in executives' decision-making processes. We derive another two findings for improving ESS towards more applicability from the method perspective.

Fifth finding: Incorporate scanning results more closely into executives' decision-making process by generating scenarios from a set of environment assumptions. To ensure that executives receive scanning findings in an amount and form that facilitates effective decision making, their reporting should cover critical opportunities and threats. For a periodical presentation, we propose linking the identified opportunities and threats with a companies' management control (Ansoff 1980; Frolick et al. 1997). We propose the form of an *economic value added at risk tree* (Chen et al. 2011, Figure 6). Once the indicators and the associated opportunities and threats have been identified, they should define three scenarios (Fontela 1976)

—optimistic, most probable and pessimistic—covering the set of opportunities and threats that the organization faces due to environmental changes (Narchal et al. 1987).

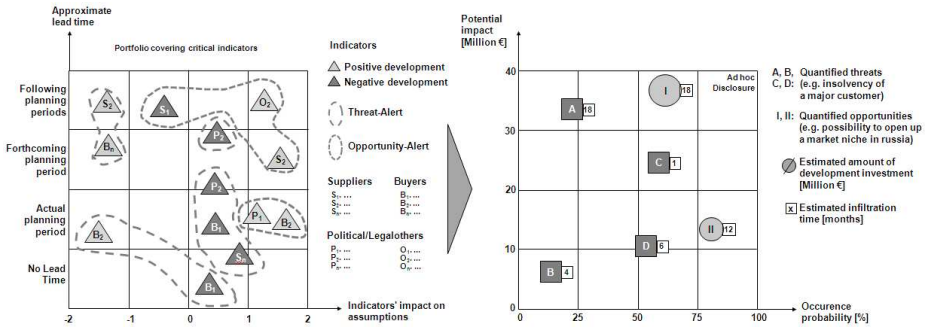

Fig. 5. Deriving and quantifying opportunities and threats in a balanced opportunity-and-threat portfolio

New business application and user-friendly interface ("frontend") should provide the scenario visualization that allows switching between the best, worst and most probable scenarios (Figure 6, right hand side). The best and worst case scenarios define the range of the most important value drivers such as net sales and costs. Because of the mathematical connections between them, also ranges for the financial performance indicators EBIT, ROCE and EVA (Figure 6, left hand side) are defined as well. The slider position shown here represents the most probable scenario. All drivers can be moved to the right or to the left to simulate changes no matter which

scenario is selected. Furthermore, on an ad-hoc basis, "breaking news" and "turning points" that refute prior assumptions can be helpful.

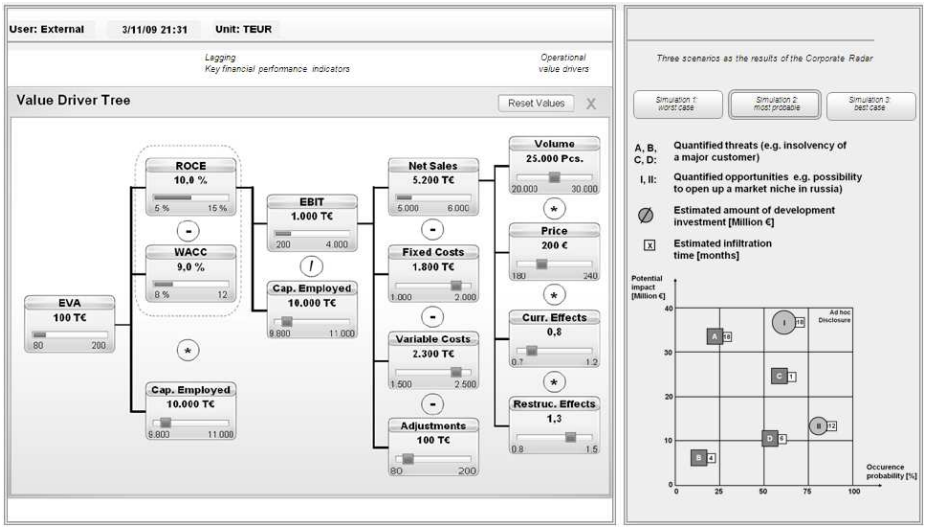

Fig. 6. Incorporating the results of ESS into executives' decision making by scenario technique (first instantiation)

Sixth finding: Use retrospective controls to continuously update the IS and collaborate to share the scanning findings in day-to-day work. Assumptions should be verified and methods applied should be checked for modifications due to new findings. In day-to-day work, group-ware allows e-mailing and other forms of collaboration.

7 OUTLOOK AND FUTURE RESEARCH

The objective of this article was to contribute to developing ESS that are more applicable than the state of the art. To do so, we conducted a *literature analysis* structured by the elements of IS design theories. We came up with three gaps to overcome and six findings.

Comparing the findings with the state of the art reveals some points worthy of discussion. On the one hand, literature based findings offer greater rigor than action research does. Thus, they should be more sustainable. However, our research has been limited to a *restricted number* of publications. But, the fact that we covered the leading journals means major contributions should be included. We see the need to expand this coverage, especially by identifying practitioner publications that are not listed in the top IS and management literature we researched or publications that do not include any of our search terms. Another limitation is that the synthesis entails *subjectivity*. In short, the validity of the derived findings could have been increased if more researchers had been involved.

Regarding IS in environmental scanning, we expect *ongoing innovations*. Today's executives grew up with IT and have a more natural attitude toward IS. New technologies have been established in the field of corporate BI, such as EIS, which have evolved from a single-system approach to an integrated module in powerful data warehouse environments. More-over, new user interfaces and end-user devices, especially for mobile computing, should simplify IS handling. Hence, ESS should claim a position in the domain of MSS (Sec. 2) as it focusing on forward looking information for managers to plan and steer their organizations.

For future research it is important to specify the findings on hand with "build" and "evaluate" activities. Another contribution could be a *survey* to get a direct perspective on executives' requirements and to evaluate the findings in a broad sample. If someone may come to the conclusion that the body of knowledge from literature research is more wishful thinking than a sound basis for applicable design principles it would be interesting to define a set of evaluation criteria, take successful implementations from practice, evaluate them, ascertain what they have in common and compare these findings with the first design principles presented on hand. Our own research will use additional instantiations to determine the generalizability of the findings on hand and, hopefully, the forthcoming extensions.

References

Aguilar, F. J. 1967. Scanning the Business Environment, New York: Macmillan.

Albright, K. S. 2004. "Environmental scanning: radar for success," The Information Management Journal (38:3), pp. 38-45.

Ansoff, H. I. 1975. "Managing Strategic Surprise by Response to Weak Signals," California Management Review (18:2), pp. 21-32.

Ansoff, H. I. 1980. "Strategic Issue Management," Strategic Management Journal (1:2), pp. 131-148.

Arnott, D. and Pervan, G. 2008. "Eight key issues for the decision support systems disci¬pline," Decision Support Systems (44:3), pp. 657-672.

Choo, C. W. 2009. "Information Use and Early Warning Effectiveness: Perspectives and Prospects," Journal of the American Society for Information Science and Technology (60:5), pp. 1071-1082.

Choudhury, V. and Sampler, J. L. 1997. "Information Specificity and Environmental Scanning: An Economic Perspective," MIS Quarterly (21:1), pp. 25-53.

Ciborra, C. 1999. "Notes in Improvisation and Time in Organizations," Accounting, Management and Information Technologies (9:2), pp. 77-94.

Clark Jr., T. D., Jones, M. C. and Armstrong Curtis, P. 2007. "The Dynamic Structure of Management Support Systems: Theory Development, Research Focus, and Direction," MIS Quarterly (31:3), pp. 579-615.

Cohen, J. B. and Zinsbarg, E. D. 1967. Investment Analysis and Portfolio Management, Homewood, Illinois: Dow Jones-Irwing Inc.

Daft, R. L., Sormunen, J. and Parks, D. 1988. "Chief Executive Scanning, Environmental Characteristics, and Company Performance: An Empirical Study," Strategic Management Journal (9:2), pp. 123-139.

Dalkey, N. C. 1969. The Delphi Method: An experimental study of group opinion, Santa Monica: Rand.

Davies, J., Finlay, M., McLenaghen, T. and Wilson, D. 2006. Key Risk Indicators – Their Role in Operational Risk Management and Measurement, in: ARM and RiskBusiness International, Prague, pp. 1-32.

Day, G. S. and Schoemaker, P. J. H. 2004. "Driving through the Fog: Managing at the Edge," Long Range Planning (37:2), pp. 127-142.

Day, G. S. and Schoemaker, P. J. H. 2005. "Scanning The Periphery," Harvard Business Review (83:11), pp. 135-148.

Duncan, R. B. 1972. "Characteristics of Organizational Environments and Perceived Environmental Uncertainty," Administrative Science Quarterly (17:3), pp. 313-327.

El Sawy, O. A. 1985. "Personal Information Systems for Strategic Scanning in Turbulent Environments: Can the CEO Go On-Line?," MIS Quarterly (9:1), pp. 53-60.

Elofson, G. and Konsynski, B. 1991. "Delegation technologies: Environmental scanning with intelligent agents," Journal of Management Information Systems (8:1), pp. 37-62.

Fahey, L. and King, W. R. 1977. "Environmental Scanning for Corporate Planning," Business Horizons (20:4), pp. 61.

Fontela, E. 1976. "Industrial Applications of Cross-Impact Analysis," Long Range Planning (9:4), pp. 29-33.

Frolick, M. N., Parzinger, M. J., Rainer Jr., R. K. and Ramarapu, N. K. 1997. "Using EISs for environmental scanning," Information Systems Management (14:1), pp. 35-40.

Fuld, L. 2003. "Be Prepared," Harvard Business Review (81:11), pp. 20-21.

Gregor, S. 2006. "The Nature of Theory in Information Systems," MIS Quarterly (30:3), pp. 611-642.

Hand, D. J. 2009. "Mining the past to determine the future: Problems and possibilities," International Journal of Forecasting (25:5), pp. 441-451.

Hopwood, A. G. 2009. "The economic crisis and accounting: Implications for the research community," Accounting, Organizations & Society (34:6/7), pp. 797-802.

IEEE 1990. The Institute of Electrical and Electronics Engineers, Inc. - Standard Glossary of Software Engineering Terminology, New York: IEEE Computer Society.

Kajüter, P. 2004. "Die Regulierung des Risikomanagements im internationalen Vergleich," Zeitschrift für Controlling und Management (47:Sonderheft 3), pp. 12-25.

Kotonya, G. and Sommerville, I. 1998. Requirements Engineering Processes and Techniques, Hoboken, New Jersey: John Wiley & Sons Ltd.

Krystek, U. and Herzhoff, M. 2006. "Szenario-Technik und Frühaufklärung: Anwendungsstand und Integrationspotential," Zeitschrift für Controlling und Management (50:5), pp. 305-310.

Lenz, R. T. and Engledow, J. L. 1986. "Environmental Analysis Units and Strategic Decision-making: a Field Study of Selected "Leading-edge" Corporations," Strategic Management Journal (7:1), pp. 69-89.

Lesca, N. and Caron-Fasan, M.-L. 2008. "Strategic scanning project failure and abandonment factors: Lessons learned," European Journal of Information Systems (17:4), pp. 371-386.

Makridakis, S., Hogarth, R. M. and Gaba, A. 2010. "Why Forecasts Fail. What to Do Instead," MIT Sloan Management Review (51:2), pp. 83-90.

Mayer, J. H. 2011. Managing the Future–Six Guidelines for Designing Environmental Scanning Systems, in: Jain, Hemant/Sinha, Atish P./Vitharana, Padmal (eds.): Proceedings of the Sixth International Conference on Design Science Research in Information Systems and Technology (DESRIST 2011), Milwaukee, USA, June, 5-6, pp. 276-290

Mayer, J. H. 2010. Organisatorische Veränderungen durch die aktuelle Wirtschaftskrise – Bestandsaufnahme und Implikationen für Unternehmenssteuerungssysteme, in:

Procee¬dings des 25. Deutschen Controlling Congresses, Dortmund, Deutschland, pp. 209-228.

Mayer, J. H. and Wurl, H.-J. "Strategische Früherkennung in internationalen Konzernen," University of St.Gallen, St. Gallen, 2011, pp. 1-28.

MIS Journal Ranking (AIS 2007) http://ais.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=432, accessed 2011-01-17.

Narchal, R. M., Kittappa, K. and Bhattacharya, P. 1987. "An Environmental Scanning System for Business Planning," Long Range Planning (20:6), pp. 96-105.

Paech, B. and Kerkow, D. 2004. Non-Functional Requirements Engineering - Quality is Essential, in: 10th Anniversary International Workshio on Requirements Engineering: Foundation for Software Quality (REFSQ'04), Riga, Latvia, pp. 27-40.

Power, D. J. Decision Support Systems: A Historical Overview. Springer, Berlin, 2008.

Rockfellow, J. D. 1994. "Wild Cards Preparing for “The Big One”," The Futurist (28:1), pp. 14-19.

Sherman, W. S. and Chambers, V. 2009. "SOX as Safeguard and Signal: The Impact of The Sarbanes-Oxley Act of 2002 on US Corporations' Choice to List Abroad," The Multi-national Business Review (17:3), pp. 163-179.

Taleb, N. N., Goldstein, D. G. and Spitznagel, M. W. 2009. "The Six Mistakes Executives Make in Risk Management," Harvard Business Review (87:10), pp. 78-81.

Urbach, N., Smolnik, S. and Riempp, G. 2009. "The State of Research on Information Sys-tems Success – A Review of Existing Multidimensional Approaches," Business & Infor-mation Systems Engineering (BISE) (1:4), pp. 315-325.

Vom Brocke, J., Simons, A., Niehaves, B., Riemer, K., Plattfaut, R. and Cleven, A. 2009. Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process, in: 17th European Conference On Information Systems (ECIS), Verona, Italy, pp. 2206-2217.

Walls, J. G., Widmeyer, G. R. and El Sawy, O. A. 1992. "Building an Information System Design Theory for Vigilant EIS," Information Systems Research (3:1), pp. 36-59.

Webster, J. and Watson, R. T. 2002. "Analyzing the Past to Prepare for the Future: Writing a Literature Review," MIS Quarterly (26:2), pp. xiii-xxiii.

Wixom, B. H. and Watson, H. J. 2010. "The BI-based organization," International Journal of Business Intelligence (1:1), pp. 13-28.

WKWI 2008. "WI-Liste der Konferenzen," Wirtschaftsinformatik (50:2), pp. 155-163.

Xu, X. M., Kaye, G. R. and Duan, Y. 2003. "UK executives’ vision on business environment for information scanning A cross industry study," Information & Management (40:5), pp. 381-389.

Yasai-Ardenaki, M. and Nystrom, P. C. 1996. "Designs for Environmental Scanning Systems: Tests of a Contingency Theory," Management Science (42:2), pp. 187-204.

Table 1. Full list of researched articles

No	Author(s)	Year	Title	Publication	Elements of IS design	Research approach
1	Aguilar, F.	1967	Scanning the Business Environment	Macmillian	Information gathering	Survey
2	Ahituv, N. et al.	1998	Environmental Scanning and Information Systems in relation to success in introducing new products	Information & Management	Information gathering	Survey
3	Albright, K.	2004	Environmental Scanning: Radar for Success	The Information Management Journal	Information gathering	Single/list approaches
4	Anderson, M.H. & Nichols, M.L.	2007	Information Gathering And Changes in Threat and Opportunity Perceptions	Journal of Management Studies	Information gathering	Experiment
5	Ansoff, H.I.	1975	Managing Strategic Surprise by Response to Weak Signals	California Management Review	3rd generation IS	Framework
6	Ansoff, H.I.	1980	Strategic Issue Management	Strategic Management Journal	3rd generation IS	Framework
7	Arnott, D. & Pervan, G.	2008	Eight key issues for the decision support systems discipline	Decision Support Systems	Information gathering	Single/list approaches
8	Boyd, B. & Fulk, J.	1996	Executive Scanning and perceived Uncertainty: A multidimensional Model	Journal of Management	Information gathering	Survey
9	Chen, H. et al.	2011	Enterprise risk and security management: Data, text and Web mining	Decision Support Systems	Information gathering	Single/list approaches
10	Cho, T.	2006	The effects of executive turnover on top management teams: environmental scanning behaviour after an environmental change	Journal of Business Research	Information gathering	Survey
11	Choo, C.W.	1999	The Art of Scanning the Environment	Bulletin of the American Society for Information Science	Information gathering	Framework
12	Choo, C.W.	2001	The knowing organization as learning organization	Education + Training	3rd generation IS	Framework
13	Cohen, J.B. & Zinsbarg, E.D.	1967	Investment Analysis and Portfolio Management	Homewood	1st generation IS	Single/list approaches
14	Daft, R. & Weick, K.	1984	Toward a Model of Organizations as Interpretation Systems	Academy of Management Review	Information gathering	Framework
15	Daft, R.L. et al.	1988	Chief Executive Scanning, Environmental Characteristics and Company performance: An Empirical Study	Strategic Management Journal	Functional requirements	Survey
16	Daheim, C. & Uerz, G.	2008	Corporate Foresight in Europe: From trend based logics to open foresight	Technology Analysis & Strategic Management	3rd generation IS	Survey
17	Davies, J. et al.	2006	Key Risk Indicators - Their Role in Operational Risk Management	RiskBusiness International Limited	2nd generation IS	Framework
18	Day, G.S. & Schoemaker, P.J.H.	2004	Driving through the Fog: Managing at the Edge	Long Range Planning	Information gathering	Single/list approaches
19	Day, G.S. & Schoemaker, P.J.H.	2005	Scanning the Periphery	Harvard Business Review	Functional requirements	Single/list approaches
20	El Sawy, O.	1985	Personal Information Systems for Strategic Scanning in Turbulent Environments: Can the CEO go online?	MIS Quarterly	Nonfunctional requirements	Survey
21	Elofson, G. & Konsynski, B.	1991	Delegation Technologies: Environmental Scanning with intelligent agents	Journal of Management Information Systems	Information gathering	Case study
22	Elofson, G. & Konsynski, B.	1993	Performing organizational learning with machine apprentices	Decision Support Systems	3rd generation IS	Framework
23	Fontela, E.	1976	Industrial Applications of Cross-Impact Analysis	Long Range Planning	Analytical techniques	Single/list approaches
24	Frolick, M. et al.	1997	Using EISs for Environmental Scanning	Information Systems Management	3rd generation IS	Framework
25	Fuld, L.	2003	Be Prepared	Harvard Business Review	3rd generation IS	Survey
26	Garg, V. et al.	2000	Chief executives scanning emphasis, environmental dynamism and manufacturing firm performance	Strategic Management Journal	Information gathering	Survey
27	Glassey, O.	2008	Exploring the weak signals of start-ups as a folksonomic system	Technology Analysis & Strategic Management	3rd generation IS	Framework
28	Gleißner, W. & Füser, K.	2000	Moderne Frühwarn- und Prognosesysteme für Unternehmensplanung und Risikomanagement	Der Betrieb	Analytical techniques	Single/list approaches
29	Gomez, P.	1983	Frühwarnung in der Unternehmung	Haupt	3rd generation IS	Framework
30	Goul, M. & Corral, K.	2007	Enterprise model management and next generation decision support	Decision Support Systems	Information gathering	Single/list approaches
31	Gray, P.	2008	From Hindsight to Foresight: Applying Futures Research Techniques in Information Systems	Communications of the Association for Information Systems	Analytical techniques	Single/list approaches
32	Hahn, D. & Krystek, U.	1979	Betriebliche und überbetriebliche Frühwarnsysteme für die Industrie	Zeitschrift für betriebswirtschaftliche Forschung	2nd generation IS	Framework
33	Hambrick, D.C.	1981	Specialization of Environmental Scanning Activities Among Upper Level Executives	Journal of Management Studies	Information gathering	Survey
34	Hand, D.	2009	Mining the Past to determin the future	International Journal of Forecasting	Analytical techniques	Single/list approaches
35	Hough, J. & White, M.	2004	Scanning actions and environmental dynamism	Management Decision	Information gathering	Survey
36	Jain, S.C.	1984	Environmental Scanning in US Corporations	Long Range Planning	Information gathering	Survey
37	Jourdan,Z. et al.	2008	Business Intelligence: An Analysis of the Literature	Information Systems Management	Information gathering	Single/list approaches
38	Krystek, U.	1993	Frühaufklärung für Unternehmen: Identifikation und Handhabung zukünftiger Chancen und Bedrohungen	Schäfer-Poeschel	3rd generation IS	Framework
39	Kuvaas, B.	2002	An Exploration of two competing perspectives on informational contexts in top management strategic issue interpretation	Journal of Management Studies	Executive decision making	Survey
40	Lauzen, M.	1995	Toward a Model of Environmental Scanning	Journal of public Relations Research	3rd generation IS	Survey

No	Author(s)	Year	Title	Publication	Elements of IS design	Research approach
41	Lenz, R. & Engledow, J.	1986	Environmental Analysis Units and Strategic Decision-Making: A field study of selected leading edge companies	Strategic Management Journal	3rd generation IS	Survey
42	Lenz, R. & Engledow, J.	1986	Environmental Analysis: The Applicability of current Theory	Strategic Management Journal	3rd generation IS	Framework
43	Lesca, N. & Caron-Fason, M.-L.	2008	Strategic Scanning Project Failure and abandonment factors: Lessons learned	European Journal of Information Systems	Information gathering	Survey
44	Liu, S.	1998	Data Warehousing Agent: In seeking of improved support for environmental scanning and strategic management	ECIS-Proceedings	Information gathering	Case study
45	Liu, S.	2000	Agent Based Environmental Scanning System: Impacts on Managers and Their Strategic Scanning Activities	AMCIS-Proceedings	Information gathering	Case study
46	Lönnqvist, A. & Pirttimäki, V.	2006	The Measurement of Business Intelligence	Information Systems Management	Functional requirements	Single/list approaches
47	Makridakis, S.	2010	Why Forecasts fail. What to Do Instead.	MIT Sloan Management Review	1st generation IS	Single/list approaches
48	McMullen, J. et al.	2009	Managerial (In)attention to Competitive Threats	Journal of Management Studies	Executive decision making	Survey
49	Menon, A. & Tomkins, A.	2004	Learning About The Markets Periphery: IBM´s WebFountain	Long Range Planning	Information gathering	Case study
50	Müller, R.M.	2010	Business Intelligence and Service-oriented Architecture: A Delphi Study	Information Systems Management	Information gathering	Survey
51	Nanus, B.	1982	QUEST - Quick Environmental Scanning Technique	Long Range Planning	Executive decision making	Framework
52	Narchal, R. M. et al.	1987	An Environmental Scanning System for Business Planning	Long Range Planning	3rd generation IS	Framework
53	Nastanski, M.	2003	The value of active Scanning to senior executives	Journal of Management Development	Information gathering	Survey
54	Nemati, H. et al.	2000	A Multi-Agent Framework for Web Based Information Retrieval and Filtering	AMCIS-Proceedings	Analytical techniques	Single/list approaches
55	Ngai, E.W.T. et al.	2011	The application of data mining techniques in financial fraud detection: A classification framework and an academic review of literature	Decision Support Systems	Information gathering	Framework
56	Nick, A.	2009	Wirksamkeit strategischer Früherkennung	Gabler	3rd generation IS	Case study
57	Plambeck, N. & Weber, K.	2010	When the glass is half empty and half full: Ceo interpretation	Strategic Management Journal	Executive decision making	Survey
58	Prahalad, C. K.	2004	The Blinders of dominant Logic	Long Range Planning	Information gathering	Single/list approaches
59	Qiu, T.	2007	Scanning for competitve intelligence: A managerial perspective	European Journal of Marketing	Information gathering	Survey
60	Reichmann, T. & Lachnit, L.	1979	Unternehmensführung mit Hilfe eines absatzorientierten Frühwarnsystems	Zeitschrift für Betriebswirtschaft	1st generation IS	Framework
61	Reinhardt, W. A.	1984	An Early Warning System for Strategic Planning	Long Range Planning	3rd generation IS	Framework
62	Romeike, F.	2005	Frühaufklärungssysteme als wesentliche Komponente eines proaktiven Risikomanagements	Controlling	3rd generation IS	Single/list approaches
63	Rossel, P.	2009	Weak Signals as a flexible framing space for enhanced management and decision-making	Technology Analysis & Strategic Management	3rd generation IS	Framework
64	Schoemaker, P.J.H. & Day, G.S.	2009	Gathering Information: How to make sense of weak signals	MIT Sloan Management Review	Information gathering	Single/list approaches
65	Simon, H.	1959	Theories of Decision-Making in Economics and Behavioral Science	The Economic Review	Executive decision making	Framework
66	Smallman, C. & Smith, D.	2003	Patterns of Managerial Risk Perceptions: Exploring the Dimensions of Managers Accepted Risks	Risk Management	Executive decision making	Survey
67	Sonnenschein, O.	2005	DV-gestützte Früherkennung	Controlling	3rd generation IS	Framework
68	Suh, W. et al.	2004	Scanning behaviour and strategic uncertainty	Management Decision	Executive decision making	Survey
69	Taleb, N. et al.	2009	The Six Mistakes Executives Make in Risk Management	Harvard Business Review	Executive decision making	Single/list approaches
70	Tan, S. et al.	1998	Environmental Scanning on the Internet	ICIS-Proceedings	Nonfunctional requirements	Survey
71	Thomas, J.B. et al.	1993	Strategic Sensemaking and organizational performance: Linkages among scanning, interpretation, action and outcomes	Academy of Management Journal	Executive decision making	Survey
72	Tseng, F.S.C. & Chou, A.Y.H.	2006	The concept of document warehousing for multi-dimensional modeling of textual-based business intelligence	Decision Support Systems	Analytical techniques	Framework
73	Vandenbosch, B. & Huff, S.L.	1997	Searching and Scanning: How Executives Obtain Information from Executive Information Systems	MIS Quarterly	Executive decision making	Survey
74	Walters, B. et al.	2003	Strategic Information and Strategic decision making: the EIS-CEO interface in smaller manufacturing companies	Information & Management	Functional requirements	Survey
75	Wei, C.-P. & Lee, Y.-H.	2004	Event detection from online news documents for supporting environmental scanning	Decision Support Systems	Analytical techniques	Single Item
76	Wheelwright, S. & Clarke, D.	1976	Probing Opinions	Harvard Business Review	1st generation IS	Single/list approaches
77	Wixom, B.H. et al.	2008	Continental Airlines Continues to Soar with Business Intelligence	Information Systems Management	Information gathering	Case study
78	Xu, K. et al.	2011	Mining comparative opinions from customer reviews for Competitive Intelligence	Decision Support Systems	Analytical techniques	Framework
79	Xu, X. et al.	2003	UK executives Vision on business environment for information scanning. A cross industry study	Information & Management	Functional requirements	Survey
80	Yasai-Ardenaki, M. & Nystrom, P.	1996	Designs for Environmental Scanning Systems: Tests of a contingency theory	Management Science	Functional requirements	Survey

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