Applicability of Environmental Scanning Systems: A Systematic List Approach to Requirements Criteria

Stefan Bischoff, Jörg H. Mayer, Timm Weitzel, and Reiner Quick

Abstract The increasing volatility of their companies' environment is a growing concern for executives. Environmental scanning systems should enable them to focus earlier on emerging threats and opportunities. A lack of applicability means that concepts often go unused in practice. But what does applicability mean for environmental scanning systems design? Adhering to the design science paradigm, this article contributes to better information systems (IS) design by developing a systematic list approach to requirements criteria that specify the applicability of environmental scanning systems. The criteria are derived from the principle of economic efficiency, use findings from the absorptive capacity theory, and can be applied to both evaluate existing environmental scanning systems and develop a new, more applicable generation. The findings should also be applicable to other IS domains.

Keywords Information systems (IS) analysis and design • Environmental scanning systems • Requirement analysis • Principle of economic efficiency • Absorptive capacity theory

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1 Introduction

The 2008/2009 economic crisis provided a sustainable impulse for focusing earlier on emerging threats and opportunities [20]. In particular, executives worry about not being prepared for environmental shifts or, even worse, not being able to parry them. *Environmental scanning*, ideally based on information systems (IS), can help to manage this challenge. Companies that do so will have brighter prospects.

With Ansoff's [2] article "Managing Strategic Surprise by Response to Weak Signals" as a flagship example, a substantial body of knowledge on this topic exists [3]. But, a lack of applicability means the concepts often go *unused* in practice [12]. A new examination of *requirements* with a focus on IS support can help to provide a starting point for developing more applicable environmental scanning systems.

This article contributes to better IS design by developing a *systematic list approach to requirements criteria* that specify the applicability of environmental scanning systems. Based on the principle of economic efficiency and using findings from the absorptive capacity theory, it can be applied to both evaluate existing environmental scanning systems and develop a new, more applicable generation.

We adhere to design science research in IS by developing innovative, generic solutions for practical problems [14]. Section 2 identifies current gaps in environmental scanning system design. In Sect. 3, we develop our list approach to requirements criteria. Section 4 discusses our model in terms of its applicability in a pilot study. Finally, Sect. 5 concludes the article with an outlook and proposal for further research.

2 Current Gaps in Environmental Scanning System Design

A company's environment could be defined as the relevant physical and social factors within and beyond the organization's boundaries [8]. While operational analysis focuses on (short-term) internal difficulties in the implementation of strategic programs, strategic environmental scanning aims at anticipating (long-term) environmental shifts and analyzing their potential impact [5]. This article concentrates on the latter, hereafter referred to as *environmental scanning*. As strategic issues can emerge within or outside a company, changes in both a company's external and internal environment are relevant. Thus, *environmental scanning systems* have to specify the sectors to be scanned, monitor the most important indicators of opportunities or threats for the company, cover the IS-based tools to be used, incorporate the findings of such analyses into decision making, and, often, assign responsibilities for supporting environmental scanning efforts (not covered in this article, but in [18]).

Requirements are defined as prerequisites, conditions or capabilities needed by users (individuals or systems) of a software system to solve a problem or achieve an objective [15]. Regarding a rigor requirements analysis, on the one hand, researchers work on *list approaches* dominated by a single principle: potential requirements are collected based on literature research or, most often, the authors'

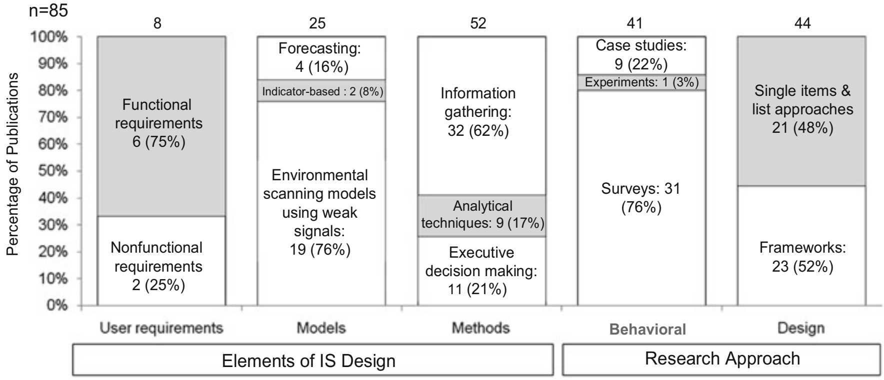

Fig. 1 Results of a current literature review [24]

own experience [23]. These approaches do not make use of an overall structuring principle or second-level structuring dimensions. Instead, the desire to be relevant for practice dominates the need for scientific rigor. On the other hand, behavioral IS research provides sound *structural models*. Examples are the DeLone and McLean IS success factors model [7] and the technology acceptance model (TAM) [6], however, in contrast to the list approaches, these are often not applicable in practice [32].

Our current literature review [24], revealed that out of 85 relevant publications, just eight examine requirements (Fig. 1): Most of them, such as Frolick et al. [11], follow just a simple list approach by mentioning several requirements without providing an overall structuring principle or second-level structuring dimensions. Other approaches are as diverse as the requirements they provide, and none apply a systematic process for developing requirements criteria (in detail [3], e.g., for the differentiation of model-free LoP, model-related LoR).

3 Model Development

The following sections on the model development are based on Bischoff et al. [3].

3.1 Principle of Economic Efficiency

We develop our model following Popper’s approach [27], using deduction to define a systematic list to requirements criteria for environmental scanning systems. The principle of economic efficiency, which focuses on the ratio of cost and benefit, is a generally accepted paradigm in business research [28] and IS research [29]. It thus should serve as a good starting point for our model [3].

Principle of economic efficiency	Design criteria		Requirements criteria
Solution capabilities (system output)	Information gathering	R1	Coverage of strategic risks (vision and strategic program)
		R2	Coverage of operational risks (internal and external value chain)
		R3	Coverage of information for "regulatory compliance"
		R4	Consideration of chances (adhering company-specific chance/risk ratio)
		R5	IS support: intensity and speed for information gathering
	Information interpretation	R6	Bias prevention
		R7	Level of knowledge and thinking process support
		R8	IS support: range of information interpretation
	Information usage	R9	Quality of information presentation
		R10	User interface and dialog control
		R11	Communication functionalities
		R12	IS support: ease of IS handling for information usage
	Cross-process factors	R13	Timeliness
		R14	Flexibility
		R15	Correctness (formal accuracy)
		R16	Reliability (accuracy in terms of content)
		R17	Level of interorganizational integration
		R18	IS support: IS transparency for cross-process factors
Resource requirements (system input)	Effort	R19	Cost adequacy
		R20	Time adequacy

Fig. 2 List approach to requirements criteria for applicable environmental scanning systems [3]

Even though the cost of IS design can be identified to some degree, quantifying the profitability of delivered information is limited. We express economic efficiency in a system of basic criteria (Fig. 2) and follow the "black box" method from mechanical engineering. These criteria can be differentiated into solution capabilities and resource requirements [22]. *Solution capabilities* cover how IS output supports environmental scanning for managers. The *resource requirements*, in turn, cover the input needed to generate the output.

3.2 First Level of Specification: Design Criteria

We follow Aguilar's [1] process-oriented view, and specify environmental scanning which gathers, interprets, and uses relevant information about events, trends, and relationships in an organization's environment. We start specifying solution capabilities for environmental scanning systems with *information gathering, interpretation and usage* capabilities as their design criteria. In addition, we suggest *cross-process factors* that contribute to capabilities not subsumed by the previous categories (Fig. 2). Resource requirements can be measured in terms of the *effort* to set up the environmental scanning system.

3.3 Second Level of Specification: Requirements Criteria

With respect to Aguilar's [1] definition, environmental scanning systems contribute to a company's absorptive capacity [35]. Thus, we examined research based on this theory to define our requirements criteria. Figure 2 illustrates our list approach to requirements criteria for specifying applicable environmental scanning systems. Taken from [3] we suggest as follows:

Information gathering A first objective for environmental scanning systems is to gather information concerning the company's vision and strategic program [4]. Because their direction is high-level and long term, we name the associated risks *strategic* ones (R1). Environmental scanning systems also have to incorporate a more short-term perspective. Regarding our definition (Sect. 2) we just focus on the most important *operational risks* relevant for management purpose. The scanning area is most often the company's internal and external value chain (R2). Furthermore, environmental scanning systems should focus on gathering information for "*regulatory compliance*" (R3) [23]. In addition to the most important risks, information gathering must take *chances* in a company-specific ratio into account [31] (R4). To sum it up, four criteria specifying the direction of information gathering for environmental scanning systems is the result: coverage of three types of *risks* (R1–R3) plus *chances* (R4).

Oh [26] finds evidence that leveraging "modern" IS capabilities (such as data mining, semantic search, and artificial neural networks) or collaboration techniques (such as RSS feeds, customer feedback on social media, professional databases [10]), or just business intelligence (BI) with a central data warehouse (DW) significantly enhances a company's process of information gathering [21, 26]. We summarize this perspective as "*IS support: intensity and speed for information gathering*" (R5).

Information interpretation Information interpretation covers the ability of IS to analyze and transform gathered information [35]. Following the bounded rationality theory information interpretation must take biased human cognition into account [25, 33]. Teece [31] argues that decision makers are biased in several forms. Innovations, for example, appear threatening for most human beings. Thus, adopting techniques to overcome these decision biases [31] can result in a competitive advantage. Jansen et al. [16] suggests involving more people in decision making, for example, having subordinates take part in higher-level decisions, and cross-functional interfaces as mechanisms. We summarize this in measuring *bias prevention* (R6).

Human attention becomes a scarce resource as the environment becomes more dynamic and complex [19]. Niu et al. [25] propose a "thinking support module" to provide a set of tools for knowledge management, including a case base and mental models or explicit and tacit knowledge. We thus define the *level of knowledge and thinking process support* as another criterion (R7).

From the IS support, March and Hevner [21] propose a data warehousing architecture with integration of external and internal data, as well as BI methods to interpret the information with respect to business. Niu et al. [25] mention online analytical processing (OLAP), SQL reporting, linear programming, and information fusion as methods for data analysis. Covering these aspects, we include the *range of information interpretation* (R8) as a next requirements criterion to our list approach.

Information usage Bearing in mind that managers still tend to be technology-averse and most often have a cognitive working style [17], the IS user interface is a key area determining IS acceptance. Following Warmouth and Yen [34], we evaluate the design of an environmental scanning system's user interface in three dimensions; *quality of information presentation* (R9), *user interface design* and *dialog control* (R10), and advanced functionalities managers can perform themselves. In terms of the latter, we concentrate on *communication functionalities* (R11). The *ease of IS handling* should help for a better information usage from IS perspective (R12).

Cross-process factors Cross-process factors contribute to several of the above-mentioned capabilities. First, the ability to adapt in time is of utmost importance in changing situations and turbulent environments [9]. Zott [36] defines *timeliness* as an important attribute of such dynamic capabilities (R13). We add *flexibility*, the ability of the IS to adapt to changing information needs, data sources, and ways to present information (R14). Managers will not use information if it is questionable in terms of its formal aspects or content [30]. This leads us to propose the requirements criteria of *correctness* (formal accuracy, R15) and *reliability* (accuracy in terms of content, R16).

Interorganizational factors, such as a company's social embeddedness, increase its absorptive capacity [26, 33]. Gulati [13] proposes that companies should "create and utilize wide-ranging information networks." Given the importance of networking activities, supporting companies' *level of interorganizational integration* is another requirements criterion for applicable environmental scanning systems (R17). Automatic validation checks are an example for IS support in the cross-process factors. Thus *IS transparency* should contribute to the cross-process factors (R18).

Effort Zott [36] states that "even if dynamic capabilities are equifinal across firms, robust performance may arise [. . .] if the costs and timing of dynamic capability deployment differ [. . .]." *Cost adequacy* (R19) and *time adequacy* (R20) are defined as the last requirements criteria.

4 Discussion

To evaluate the model proposed here, it was first implemented at a large international company (sales: US$56 bn; employees: 174,000). Comparing the findings with the comments from literature on IS list approaches and the structural models (Sect. 2) reveals that our model offers the following advantages (for details see Bischoff et al. [3]).

The principle of economic efficiency is widely *accepted* in both management and IS research. It should therefore provide a reliable design paradigm for structuring requirements analysis in general and designing environmental scanning systems design in particular, even for practitioners. Deriving design criteria from the findings of a theory such as absorptive capacity is scientifically *rigorous*. As we also included cross-functional IS aspects, our approach should lead to an acceptable level of *completeness and distinctiveness*.

Nonetheless, our list is *not exhaustive*. Founding environmental scanning in the theory of absorptive capacity is a new approach, and can prompt the criticism that using findings from a theory for evaluating applicability is a contradiction. But research about the antecedents of these theoretical constructs has been subject to surveys [33]. Compared with approaches based on the researcher's own experience or random literature, our model should be more *systematic* and *less subjective*.

5 Outlook and Future Research

The objective of this article was to contribute to better IS design by developing a systematic list approach to requirement criteria that specifies the applicability of environmental scanning systems. Based on the principle of economic efficiency and using findings from the absorptive capacity theory, we derived 20 requirements criteria. They can be applied to both evaluate existing environmental scanning systems and develop a new, more applicable generation.

Our list approach opens up opportunities for future research as it provides a first step to measure the applicability of company's environmental scanning systems in an efficient way. Overall, the results should be applicable to other IS domains as well and thus contribute to improved requirement analysis in IS design research in general.

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