BI Systems Managers' Perception of Critical Contextual Success Factors: A Delphi Study

Completed Research Paper

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Abstract

The present article investigates critical contextual success factors (CCSFs) that influence business intelligence (BI) system success in terms of their relevance and controllability. The initial set of CCSFs is based on an analysis of existing literature and serves as the basis for further exploration of these factors. Advances to previous studies are the validation of possible CCSFs influencing BI system design by domain experts in a Delphi Study and the multi-dimensional view of these factors. A carefully selected expert panel investigated CCSFs not only with regard to the dimensions of relevance – which is typical for ranking-type Delphi studies – they also assessed each factor in the dimension of controllability. This two-dimensional approach allowed us to identify five distinct clusters of CCSFs that influence BI system success. This paper contributes to information systems (IS) research on critical success factors in general and provides the BI domain with specific insights. The results contribute to the BI success factor literature and can potentially be generalized to other IS. BI managers may use the results to assess their daily challenges in BI system development and maintenance projects.

Keywords: Business intelligence, IS success, critical success factors, Delphi study

Introduction

The potential of business intelligence (BI) systems to contribute to corporate success is considered enormous and, therefore, many organizations have launched BI initiatives with the intention to implement or to improve these systems (Hawking and Sellitto 2010; Lahrmann et al. 2011; Wixom and Watson 2010). Through BI systems, they aim to gain useful insights from their data that would not be available otherwise, in order to increase sales, reduce costs, or detect opportunities for new or improved products and services (Hwang and Hongjiang 2005). In 1996, a study by the International Data Corporation (IDC) found that companies that use BI effectively can achieve an average of 401% return on investment (ROI) over a three year period (IDC 1996). Several reports document that a great number of organizations have invested heavily in BI systems (Computer Economics 2008; Cutter Consortium 2003). Recently, a worldwide survey of 1500 CIOs even identified BI as the number one technology priority (Gartner 2009). BI implementation projects, however, are expensive, time-consuming and risky undertakings (Rosenkranz et al. 2010; Wixom and Watson 2001). There is evidence that a significant number of organizations have failed to realize the expected benefits of BI (Chenoweth et al. 2006; Hwang and Hongjiang 2005; Joshi and Curtis 1999; Sammon and Adam 2004; Shin 2003). For instance, the Cutter Consortium Report (2003) revealed that 41% of respondents had experienced at least one BI project failure and that only 15% believed their BI initiative was a success.

Information systems (IS) success has been studied from very different angles (DeLone and McLean 1992; Wixom and Watson 2001). Numerous studies identify critical success factors (CSF) with the intention to help professionals in ensuring successful IS adoption (Hwang et al. 2004). In particular, CSF for enterprise resource planning (ERP) system implementation have been extensively studied (Hawking and Sellitto 2010; Holland and Light 1999; Lechtchinskaia et al. 2011; Seidel and Back 2011). There are also studies that examine CSF specifically for BI systems (Hawking and Sellitto 2010; Hwang et al. 2004; Ramamurthy et al. 2008; Yeoh and Koronios 2010). Such studies are helpful to BI managers as they provide an overview of the factors that have a substantial influence on BI initiatives. These factors, however, might differ in relevance and, therefore, some factors require more thorough attention than others. Existing studies provide only tentative insights into the varying criticality of such factors (Hawking and Sellitto 2010; Yeoh and Koronios 2010). Furthermore, we consider BI managers to be deeply interested as well in the controllability of the factors, because CSFs "are those few things that must go well to ensure success for a manager or an organization" (Boynton and Zmud 1984, p. 17), and, hence, they may require the BI managers' intervention. Existing studies have only discussed whether a factor is relevant or not. We take a novel approach in this study, as we address the dimensions of relevance and controllability simultaneously.

The roots of BI implementation success or failure, however, do not necessarily lie only within the BI project itself (e.g., project management) but can also be identified in the surrounding organizational and environmental setting (Hwang et al. 2004; Lechtchinskaia et al. 2011). Top management support, financial resources, skilled IT personnel, for instance, are factors that lie within the organizational context. Beyond that, it is hypothesized that dynamic changes in the environment of the organization also influence BI system success (Ewusi-Mensah 1981; Hwang et al. 2004). In the present paper, we specifically study the CSFs that lie in the organizational and environmental context of BI system implementation and maintenance projects. We therefore introduce the term Critical Contextual Success Factors (CCSF) for factors that are external to the core BI project activities. It is our primary research interest to identify these factors and to rank and to group them according to their relevance and controllability. In order to accomplish these research goals, we apply the Delphi method because it has proven an established tool in IS research for identifying and prioritizing issues for managerial decision-making (Okoli and Pawlowski 2004). Specifically, we refer to the ranking-type of Delphi (Schmidt 1997) in order, first, to elicit BI managers' perceptions of the relevance and controllability of CCSF and, second, to obtain rankings of these factors. Finally, we expect this two-dimensional ranking to allow us to identify groups of certain CCSF types that can help BI managers to identify implications for action and that may serve as meaningful categories for future research into BI and IS success. Against this background, we seek to address the following research questions with the present paper:

1. *What are relevant CCSFs that require the BI manager's attention in order to ensure the successful implementation and use of BI systems in the organization?*
2. *How do CCSFs differ in relevance as perceived by BI managers?*

3. *How do CCSFs differ in controllability as perceived by BI managers?*
4. *Can certain factors be clustered into groups based on two-dimensional ranking and what are the implications of these factor groups for practice and future research?*

In the remainder of this paper, we first report on the research background. We review IS literature on CSF and BI success, identify an initial set of CCSFs, and introduce the dimensions of interest to this study. We then describe our research approach in detail. In order to analyze the influence of diverse CCSFs on BI system success, we conducted a Delphi study among qualified experts with significant experience in BI system management. The expert panel was invited to critically review and then to rank the initial list of CCSF. The description of the research design is followed by the presentation of our results, which we subsequently discuss in the light of five CCSF groups that we were able to identify. We then draw conclusions and provide an outlook on potentially fruitful avenues for future research.

Research Background

Business Intelligence Success

BI is a broad category of information systems that support decision makers through business analyses on the basis of internal and external data (Abbasi and Chen 2008; Chung et al. 2005; Watson and Wixom 2007). BI can be defined as a set of technologies, applications, and processes for gathering, storing, accessing, and analyzing data that helps users make better decisions (Chamoni and Gluchowski 2004). BI supports problem and opportunity identification, decision-making, and alignment of operations with the corporate strategy (March and Hevner 2007) and, thus, contributes to the organization's competitiveness and sustainable development. Advanced BI systems include unstructured data (Abbasi and Chen 2008), integrate external data sources (e.g., via the Internet) (Chung et al. 2005), trigger (real-time) actions (Shim et al. 2002), and enable data mining techniques. They support the intelligent exploration, integration, aggregation, and multidimensional analysis of data originating from a diverse set of information resources (Olszak and Ziemba 2007).

BI involves the effective deployment of organizational practices, processes, and technology to create value from the data available to the organization. Accordingly, we consider BI success to be a multi-faceted construct (Wixom and Watson 2001) that addresses more than the successful technical realization of an individual BI implementation or maintenance project (Yeoh and Koronios 2010). In their model of data warehousing success, Wixom and Watson (2001) evaluate the implementation success from an organizational, project, and technical perspective and measure the overall system success by means of the net benefits that are achieved through improved decision-making. Other authors distinguish between the performance of the BI implementation process and the infrastructure quality to evaluate BI system implementation success (Ariyachandra and Watson 2006). Yeoh and Koronios (2010) emphasize that BI system success must be viewed as evolving over time because the overall BI system is subject to a constant loop of re-evaluation, modification, and improvement. Accordingly, they state "that the completion of the system implementation does not mean that all BI related problems are resolved." (Yeoh and Koronios 2010, p. 25) Building on Wixom and Watson (2001), we consider BI success to be the creation of net benefits for the organization that are achieved through the implementation and ongoing maintenance of a BI system that supports the collection, aggregation, and distribution of data and thereby leads to improved decision-making.

Critical Contextual Success Factors for Business Intelligence

The concept of success factors was first introduced by Daniel (1961). In his seminal article, he argues that each industry would be reliant on three to six factors to indicate success or failure. Later on, Rockart (1979) defined critical success factors (CSF) as areas of activity that need to be prioritized and must receive constant and careful attention from management to ensure successful competitive performance for the organization. Events, circumstances, or conditions, that can positively or negatively influence organizational performance are also considered CSF (Boon et al. 2005). Research on CSF has received considerable interest in the information systems (IS) literature. This becomes obvious from the numerous studies that have identified CSF for the implementation and use of various IS types (such as ERP, customer relationship management, and BI systems) (Boynton and Zmud 1984; DeLone and McLean 1992; DeLone and McLean 2002; Petter et al. 2008; Shank et al. 1985; Williams and Ramaprasad 1996).

Researchers have identified different sources of CSF (Cooper 2008), including external environmental issues, such as the economic or social climate, or issues specific to a given industry or organization (Cooper 2008; Rockart 1979). Other studies emphasize factors that are directly connected to the IS implementation project itself, e.g., on effective project management including project planning, requirements analysis, resource management, and project performance measurement (Lechtchinskaia et al. 2011), but, nevertheless, acknowledge the relevance of organizational and environmental factors that form the context of IS projects. In a case study on knowledge management systems (KMS) in the public sector, for instance, it was found that influences from the institutional environment, which lay outside the locus of control of the organization, led to sub-optimal system performance, even though the KMS-specific CSF had been successfully attained (Butler and Murphy 2007). Wade and Hulland (2004) also refer to organizational and environmental factors as those two groups of moderators that have the potential to affect the relationship between an IS and organizational performance.

Despite the recognition of BI as an important field of IS practice and research, only a limited number of studies have examined CSF for BI (Hawking and Sellitto 2010; Yeoh and Koronios 2010). Hawking and Sellitto (2010), for instance, took a practitioner's point of view. They analyzed industry presentations and identified the most extensive collection with 22 BI CSF that comprise a wide range of factors such as, for instance, source systems, management support, and user participation. In their model of data warehousing success, Wixom and Watson (2001) identify only seven relevant implementation factors. These are considered to have an influence on the technical, project, or organizational implementation success. By means of a Delphi study with 15 BI experts, Yeoh and Koronius (2010) also identify seven relevant BI CSF, which they group according to Wixom and Watson (2001). Similarly, Hwang et al. (2004) investigated two environmental, four organizational and four project-planning factors that influence data warehouse adoption. Also addressing data warehousing adoption, Ramamurthy et al. (2008) identify five organizational factors (e.g., organization size) and two technology factors (e.g., data warehouse complexity) that are hypothesized to have an influence. Hence, it is also common to distinguish between environmental, organizational, and project-related factors when studying BI CSF.

In the present paper, we specifically study the CSF that lie in the organizational and environmental context of BI system implementation and maintenance projects. We deliberately neglect those areas of activities that are directly related to the core BI project, as we find a plethora of guidelines published by IS practitioners and researchers on how to conduct effective project management, project planning, requirements analysis, and project monitoring in general, and for BI initiatives in particular. Instead, we see the need to detail the research on organizational and environmental context factors. Therefore, we introduce the term Critical Contextual Success Factor (CCSF). We define CCSF as those factors that lie outside the actual BI system implementation and maintenance project but still influence BI system success, positively or negatively. These factors may be either external or internal to the organization (Ein-Dor and Segev 1978; Ewusi-Mensah 1981; Wade and Hulland 2004), but they are external to the BI project team by definition. Accordingly, one of the main research objectives of this paper is to identify a comprehensive set of CCSF, those organizational and environmental factors that influence BI system success. We approach this research objective by means of a Delphi study with BI experts from practice. This approach has previously proven useful for examining BI CSF (Yeoh and Koronios 2010). We draw on existing literature from the fields of BI (e.g., Chamoni and Gluchowski 2004; Hwang et al. 2004; TDWI 2011; Wixom and Watson 2001; Yeoh and Koronios 2010), CSF (e.g., Boon et al. 2005; Hawking and Sellitto 2010) and context factor research (e.g., Benson et al. 1991; Cheney et al. 1986; Ein-Dor and Segev 1978; Rosemann et al. 2006; Srinivasan and Kaiser 1987) in order to provide the participants with an initial set (seed list) of potentially relevant CCSF. The a priori identification of critical factors from literature is a common extension to the original CSF method (Cooper 2008).

The majority of this initial set are organizational factors. One of the first studies on organizational factors as determinants of management information system (MIS) success was presented by Ein-Dor and Segev as long ago as 1978. They suggested a framework of organizational context factors, including, for instance, organization size, organizational structure, and organizational resources (e.g., in terms of financial resources and personnel). We were able to identify further organizational factors from literature (Table 1). From a rather strategic perspective, corporate strategy, business model, product range, and distribution channels set the main directions of the organization and thus define the internal requirements for the BI system. Aspects of organizational governance and corporate culture are addressed by factors such as the role of informal communication, location of the IT department within the organizational structure, ownership structure, and selection criteria for IT projects. Studies on BI CSF have further emphasized the importance of factors such as top management support, skills of the IT personnel, and user involvement (Hwang et al. 2004; Wixom and Watson 2001). Finally, from a technology perspective, organizational factors also include the existing IT infrastructure and the data sources that a BI system is supposed to build on (Wixom and Watson 2001; Yeoh and Koronios 2010).

Environmental factors reflect the external uncertainties an organization is exposed to (Wade and Hulland 2004). Dynamic changes in the environment require the organization to measure and reduce such uncertainties, e.g., by actively adopting information technology like a BI system (Ewusi-Mensah 1981; Hwang et al. 2004). The degree of environmental turbulence can be described by factors such as the degree of competition and market dynamics (Hwang et al. 2004; Wade and Hulland 2004). Potentially, there are legislative regulations that the BI system must comply with (Rosemann et al. 2006). Furthermore, it can be helpful to know about the state of the art of BI systems at competitors and across industries (Chamoni and Gluchowski 2004; TDWI 2011). The complete seed list of 27 organizational and environmental CCSFs that we were able to identify is given in Table 1 (in alphabetical order).

Table 1. List of Critical Contextual Success Factors (CCSF) prior to the Delphi study

Abbreviation	*Definition of Construct*	*Origin of Construct*
BUSMODEL	Business model, i.e., the rationale of how the organization acts in the market. In order to continuously improve the business model, market and customer knowledge must be acquired.	(Benson et al. 1991; Shin 2003)
CORPSTRA	Corporate strategy, e.g., a customer-oriented strategy and quality-focused strategy vs. a cost-cutting strategy that comes along with different requirements as regards information provision.	(Chamoni and Gluchowski 2004; Rosemann et al. 2006)
DATASRCS	Data sources, i.e., the source systems that provide the data the BI system processes. The BI system's success is assumed to be dependent on the data quality provided by the source systems.	(Mukherjee and D'Souza 2003; Watson and Haley 1997; Wixom and Watson 2001; Yeoh and Koronios 2010)
DECOMPET	Degree of competition, i.e., the extent of rivalry between the organization and competitors selling similar products or services. Strong competition is assumed to lead to increasing information demand.	(Benson et al. 1991; Porter 1979)
DISTRIBC	Distribution channels. The use of multiple channels increases the variety of information sources BI systems are intended to integrate.	(Frazier 1999)
FINANCES	Financial situation, i.e., the resources available (liquidity) to cover the financial burden of a BI system implementation.	(Ein-Dor and Segev 1978)
HETEROIT	Heterogeneity of IT infrastructure, i.e. the possible great diversity of source systems whose data is to be integrated in the BI system. Limited technical compatibility may cause high implementation costs.	(Sammon and Finnegan 2000; Wixom and Watson 2001; Yeoh and Koronios 2010)
INDUSTRY	Industry, i.e., the area of economic production the organization is part of. The sophistication of general BI system use may differ from industry to industry.	(Chamoni and Gluchowski 2004; TDWI 2011; Wade and Hulland 2004)
INFOCOMM	The role of informal communication in the organization, i.e., the importance of spontaneous and interactive communication for the functioning of the organization.. Informal communication can facilitate collaboration but may also contrast with the intended structured use of a BI system.	(Kraut et al. 1990)
ITBUDGET	IT budget, i.e., the share or size of budget designated for IT expenditures that may set the limits for a BI system implementation.	(Raymond 1990; Sammon and Finnegan 2000)
ITCORPST	Influence of IT on corporate strategy, i.e., the extent to which IT is considered an enabler for business.	(Henderson and Venkatraman 1993)
LEGISLAT	Legislation, i.e., the legislative regulations the organization needs to comply with and that may pose requirements or limitations to BI systems.	(Rosemann et al. 2006)

LITERACY	IT literacy of employees, i.e., BI system success requires skilled users who are able to make use of the provided analysis functionality.	(Choe 1996; Ein-Dor and Segev 1978; Wixom and Watson 2001)
LOCITDEP	Location of the IT department, e.g., central vs. local placement of the IT department within the overall organizational structure, which may have an influence on the BI system architecture. A location independent from other organizational functions and located higher in the hierarchy is expected to increase the likelihood of system success.	(Chenoweth et al. 2006; Ein-Dor and Segev 1978; Mettler and Rohner 2009; Raymond 1990)
MARKETDY	Market dynamics, i.e., the rate of market environment change. In slowly changing markets, organizations do not need to react as quickly as those in more dynamic environments. The ability to react quickly can be supported by BI systems.	(Volonino et al. 1995; Wade and Hulland 2004)
MGMETHOD	Management methods, i.e., the methods (e.g., balanced scorecard, value-based management) applied for corporate management. These may pose specific requirements to the BI system.	(Chamoni and Gluchowski 2004; Watson and Haley 1997)
ORGASIZE	Organization size. The size of the organization is considered to affect BI systems' success due to different resource availability and different degrees of formalization of organizational systems.	(Benson et al. 1991; Ein-Dor and Segev 1978; Ramamurthy et al. 2008; TDWI 2011)
ORGSTRUC	Organizational structure of the organization, e.g., as regards degree of centralization. The complexity of decentralized organizations can lead to a high number of independent sources and even distributed BI systems.	(Chamoni and Gluchowski 2004; Ein-Dor and Segev 1978; Mettler and Rohner 2009)
OWNERSTR	Ownership structure, i.e., family-owned business vs. open corporation. Family owners may have different interests compared to stakeholders and thus may have different information demands.	(Demsetz and Villalonga 2001)
PROCAUTO	Degree of business process automation in the organization, i.e., the share of business processes that is supported by IT determines what performance data can be extracted by BI systems	(Mettler and Rohner 2009; Sammon and Finnegan 2000)
PRODINNO	Frequency of product innovations, i.e., the rate of product change. A high rate may increase the complexity the BI system has to cope with.	(Benson et al. 1991; Raymond 1990; Rosemann et al. 2006)
PRODRANG	Product range, i.e., the range of goods and services the organization sells. A diversified range may increase the complexity of the BI system.	(Benson et al. 1991)
SCOMPBIT	Sophistication of competitors' BI technology: Knowledge about the BI technology applied by competing organizations that could be interpreted as a benchmark.	(Little and Gibson 2003; Raymond 1990; TDWI 2011)
SELECRIT	Selection criteria for IT projects, e.g., what are the expected benefits to be achieved in order for the board to approve BI implementation projects?	(Mukherjee and D'Souza 2003; Raymond 1990; Watson and Haley 1997)
SITINFRA	Sophistication of IT infrastructure, i.e., to which degree does the organization's IT infrastructure conform to the technical state-of-the-art. Out-of-date legacy systems, for instance, may complicate the link with innovative BI systems.	(Raymond 1990; Rosemann et al. 2006; Watson and Haley 1997)
TOPMANSP	Top management support, i.e., does the board support the major undertaking of BI system implementation? Strong sponsorship is considered necessary to ensure BI system success.	(Chenoweth et al. 2006; Little and Gibson 2003; Mukherjee and D'Souza 2003; Sammon and Finnegan 2000; Watson and Haley 1997; Wixom and Watson 2001)
USERINVO	Degree of user involvement in IT projects, e.g., the involvement of users in requirement determination and prototype testing. User involvement is expected to increase BI system success.	(Chen et al. 2000; Chenoweth et al. 2006; Mukherjee and D'Souza 2003; Watson and Haley 1997; Wixom and Watson 2001)

Dimensions of Critical Contextual Success Factors for Business Intelligence

Existing IS literature has investigated CSF almost exclusively from a single perspective, namely the criticality or relevance of individual factors for system success. Looking at the BI field in particular, Yeoh and Koronios (2010) explored the importance of the seven CSF they identified through case studies in five organizations. They concluded that non-technical factors are more important than technological and data-related factors. Hawking and Sellitto (2010) provided the numbers of how often a certain BI CSF had been mentioned in the industry presentations they had analyzed, with user participation and team skills being among the top of this ranking. These results, however, can only give tentative insights into what are the most critical factors for BI success and, therefore, we consider further empirical research to be necessary.

As CSFs are expected to be critical for IS success, they bear implications for actions to be taken by the responsible IS managers. Organizations are expected to direct time and resources towards those factors that need most attention (Somers and Nelson 2001). The decision on where to allocate time and resources, however, is dependent not only on the relevance but also on the controllability of a factor. We refer, therefore, to Ein-Dor and Segev (1978) who distinguished between uncontrollable, partially controllable, and fully controllable factors. We consider this dimension to be of particular interest when analyzing CCSFs. Reflecting on the controllability of CCSFs helps BI managers to distinguish which factors they are actually able to influence themselves. Accordingly, uncontrollable factors are those whose status is given. The time required to change values of these factors exceeds the time frame or resources of BI implementation and maintenance endeavor. Partially controllable factors can be influenced within the time frame of the BI project. Nonetheless, the exact values for controllability cannot be chosen specifically; only changes towards the desired direction can be triggered. Controllable factors are those whose exact values or states can be managed by the BI executives involved (Ein-Dor and Segev 1978).

Research on CSFs has been criticized for producing long lists of factors (Boon et al. 2004; Cooper 2008) and because “little apparent innovation” (Boon et al. 2005, p. 796) has been used in the methods to determine CSF. Hierarchical or multiple lists have been proposed as an approach to structure CSFs (Boon et al. 2005) and, thus, as a means to provide a better understanding of the multiple perspectives of CSFs for IS implementation success. Our two-dimensional Delphi study allows us to pursue an innovative way of bringing structure into the factor list, as we can apply cluster analysis to the resulting relevance and controllability attributes of each CCSF. Cluster analysis attempts to identify distinct groups of elements that exhibit similar attributes while, at the same time, variance between groups is increased. Accordingly, groups of CCSF can help BI managers to abstract from single CCSFs and instead increase their awareness for certain factor groups, e.g., those factors that are comparatively relevant and controllable at the same time.

Research Design

Delphi Method

The Delphi method is an established systematic interactive research method that relies on a panel of independent experts. It has proven valuable in surfacing new issues and moving participants toward consensus by subjecting the panel to a number of rounds of questionnaires, interspersed with controlled feedback (Dalkey and Helmer 1963; Niederman et al. 1991). The Delphi technique is well suited to situations where subjective and complex judgments are of interest, as opposed to precise quantitative results. The Delphi method offers degrees of flexibility in the ways it can be applied (Kendall 1977); however, it has four core elements: anonymity, iteration, controlled feedback, and aggregation of group responses (Rowe and Wright 1999). Each participant within the group of pre-selected experts responds according to his/her own knowledge or opinion and the results are collected by the research team for analysis. The results of this analysis are fed back to the respondents along with an invitation to participate in the succeeding round. The experts are encouraged to revise their earlier answers in light of the replies of the other panel members. It is believed that during this process the range of answers will decrease and the group will converge towards consensus. The Delphi process stops when a reasonable level of consensus or another pre-defined stop-criterion is achieved (Kendall 1977; Schmidt 1997).

With this Delphi study, we intended to review, identify, and rank CCSFs that affect BI system design. In multiple rounds, we aimed to achieve consensus about the set of relevant CCSFs and consensus on the rankings according to the dimensions of relevance and controllability. The objective of the first round was to validate our seed list of CCSFs given in Table 1 (e.g., concerning completeness and meaningfulness) and to elicit first estimations as regards their relevance and controllability (in order to be able to compile preliminary rankings for each of these dimensions). The objective of the following phases was to gain consensus on the CCSF rankings for each dimension. From the second round on, panelists were asked to put the CCSFs into a rank order for each dimension (Schmidt 1997). In subsequent rounds, participants were asked to revise the rankings. As in previous studies, we aimed at strong degree of consensus (Evermann 2010; Nevo and Chan 2007) – as reflected by the value of Kendall's W, (Schmidt 1997) – which was reached after the third round. The Delphi study was executed with the help of online survey tools and emails were used for the communication (e.g., feedback and notifications) with the expert panel.

Composition of the Expert Panel

With the intention of producing valid and robust results, we recruited experts with significant work experience in the field of BI and corporate performance measurement. We contacted the panelists at a major BI conference (TDWI, 15-17 June 2009, Munich, Germany) and through a special interest group for BI on a social network website. Additional senior managers practicing in this field, and known to the researchers through their participation in complementary research endeavors, were also included into the expert panel. All potential participants were asked to fill out a pre-study questionnaire. Based on this pre-study, we selected 56 experts and invited them to participate in our Delphi study. The major selection criteria for inviting experts to participate in our study were the years of BI experience and their job positions. In order to ensure a homogeneous group of experts, as for this study, we excluded consultants, (project) assistants, and freshmen (less than 1 year in the current job or less than 3 years in the field of BI). Also, we admitted no more than one representative from each legal firm as a participant in the study. In order to make use of a wider knowledge base (Linstone 1978), the resulting panel comprised practicing senior managers and project managers from diverse industries with a technology or a business focus. On average, our participants had more than 11 years of general job experience and 7.4 years specifically in the field of BI. We made sure that no individual industry was over represented.

Of the 56 invited experts, 37 participated in the first round of the study; resulting in an effective response rate of 66%. Within the participating group, the trading sector was represented by six participants, automotive and chemical by five each, and IT, industrial production and telecommunication by four participants each. The remaining nine participants came from a set of other industries. Notably, 59% of the participants we invited for the first round had an economic background and 25% had a technical background; 16% enjoyed an interdisciplinary education. Consistent with the Delphi methodology (Rowe and Wright 1999) only participants in the earlier rounds were invited to participate in the subsequent rounds. Overall, 27 experts participated in the second round of the study. Hence, the effective response rate for the second round was 73% (27 / 37). We decided to conduct a third round in order to obtain a greater consensus on the rankings in which 13 out of the 27 round-two participants participated (48%). Since the Delphi method is not used to derive statistically significant results, the detection of a non-response bias, which is typically part of large-scale quantitative surveys, is not appropriate here (Daniel and White 2005).

Results

First Round

In the first round of the Delphi study, we asked the expert panel to name and to review CCSFs that influence BI system success. On the first page of the online questionnaire, and prior to disclosing our seed list, we offered free text fields in which participants could name up to 10 factors they consider important. Here, most of the responses were already included in the 27 CCSFs we had identified for the seed list. However, some additional variables were named by respondents, e.g., capabilities of the IT personnel. In a second step, we presented the 27 CCSFs of our seed list. Respondents were asked to indicate their evaluation by rating each variable on 5-point Likert-scales for relevance (1: not important; 5: very important) and controllability (1: uncontrollable; 5: very well controllable). The mean values for the relevance of each context variable confirmed that we identified an initial set of relevant context variables, as 25 out of the 27 variables have a mean value higher than 3 (medium importance). Moreover, we were satisfied that the set was fairly complete, because respondents named hardly any additional variables in the free text fields.

By the end of this round, we were able to set up rankings for the two dimensions relevance and controllability for the 27 factors of our seed list. The first-round results are given in Table 2 including the mean values ($\bar{R}_1$ and $\bar{C}_1$) and the standard deviations ($SD_{\bar{R}_1}$ and $SD_{\bar{C}_1}$) of the respondents' ratings for the two dimensions of relevance and controllability. The CCSFs are ranked by the mean values of relevance.

As indicated, we received suggestions for further variables, which we examined in regard to their variance from the existing set of variables. We also received feedback that some of the variables we had provided to the panelists were regarded as similar and therefore redundant (e.g., "frequency of product innovation" and "product range"; "degree of competition" and "market dynamics"). Based on this input from our expert panel, we modified the list of context variables to 25 items for the second round (Table 3).

Table 2. Results after the First Round of the Delphi Study

Rank (Relevance)	*CCSF*	*Relevance*		*Controllability*	
		$\bar{R}_1$	$SD_{\bar{R}_1}$	$\bar{C}_1$	$SD_{\bar{C}_1}$
1	DATASRCS	4.46	0.77	3.22	1.06
2	TOPMANSP	4.43	0.90	3.19	0.94
3	CORPSTRA	4.38	0.79	2.95	1.03
4	ITBUDGET	4.32	0.75	2.97	0.90
5	MARKETDY	4.11	0.87	1.94	1.04
6	FINANCES	4.11	0.89	2.17	1.06
7	USERINVO	4.11	1.17	3.73	1.15
8	SITINFRA	4.08	0.84	3.14	1.07
9	DECOMPET	4.05	0.94	2.24	1.32
10	MGMETHOD	4.00	1.01	3.08	1.11
11	BUSMODEL	3.94	0.86	2.53	1.16
12	SELECRIT	3.89	0.92	3.28	0.85
13	LOCITDEP	3.84	1.38	2.86	1.23
14	PRODINNO	3.81	1.00	2.70	1.20
	LITERACY	3.81	1.13	3.32	1.00
16	DISTRIBC	3.78	1.27	2.50	1.18
	PROCAUTO	3.78	1.20	3.36	1.15
18	INFOCOMM	3.70	1.10	2.94	1.09
19	LEGISLAT	3.68	1.11	1.51	0.93
20	PRODRANG	3.64	1.13	2.64	1.22
21	ORGASIZE	3.58	0.97	1.97	1.06
22	HETEROIT	3.56	1.18	2.89	1.01
23	ITCORPST	3.49	1.22	2.81	1.02
24	INDUSTRY	3.46	1.30	1.95	1.29
	ORGSTRUC	3.46	1.19	2.11	1.07
26	SCOMPBIT	2.92	1.14	2.03	1.17
27	OWNERSTR	2.69	1.33	1.50	0.85

Second Round

In the second round, we provided separate relevance and controllability rankings to all panelists that had participated in the first round via email. These rankings included the mean evaluations across the expert panel contrasted with their own evaluation. Thus, they could easily identify which of their CCSF evaluations deviated from the general expert panel opinion. We also informed the panel about the modifications we had made to the list of CCSFs based on the first round feedback. We asked them to provide us with comments if they were not satisfied with the changes made (e.g., lack of clarity concerning new or updated CCSF definitions). Finally, the experts were invited to take part in the second round of the Delphi study and to put the updated set of CCSFs into rank orders for relevance and controllability.

In this round of our Delphi study, the panelists had the chance to compare their previous evaluations with the expert panel evaluations. This time, however, we did not ask them to rate each CCSF on a Likert Scale for the two dimensions, but instructed them to bring the CCSFs into rank orders. In order to increase the convenience for the panelists, they were provided with the possibility to form the rank orders for the two dimensions by moving boxes with the names of the CCSFs from a reservoir to the available ranking fields (labeled from 1 to 25). The CCSFs in the reservoir were ordered according to the ranks in the previous round. The three new CCSFs were attached to the bottom of the reservoir and marked as being new to the survey. By the end of this round, we had received responses from 27 experts from the 37 first-round participants (due to missing values the final N for each dimension is 25 and 24 respectively). Based on the rank orders provided by each of the panelists, the mean ranks were calculated (Table 4). We did not receive any requests to further modify the list of CCSFs.

Table 3. List of Modified, Eliminated and New CCSF

Abbreviation	*Definition of Construct*	*Comment*
MARKETDY	Market dynamics	Modified: MARKETDY now includes DECOMPET (degree of competition) as the some perceived the two CCSFs closely related and similar in their influence on BI systems.
CORPSTRA	Corporate strategy	Modified: CORPSTRA now includes DISTRIBC (distribution channels) and BUSMODEL (business model) because panelists perceived these CCSFs closely related and similar in their influence on BI systems.
PRODRANG	Product range	Modified: PRODRANG now includes PRODINNO (frequency of product innovations). Some panelists indicated that PRODINNO was only a dynamic view of PRODRANG and therefore could be subsumed under the latter CCSF.
DECOMPET	Degree of competition	Eliminated: Now included in MARKETDY
PRODINNO	Frequency of product innovations	Eliminated: Now included in MARKETDY
DISTRIBC	Distribution channels	Eliminated: Now included in CORPSTRA
BUSMODEL	Business Model	Eliminated: Now included in CORPSTRA
SELECRIT	Selection criteria for IT projects	Eliminated: Panelists did not consider this variable as a contextual factor.
BISTRTGY	BI strategy and reporting standards, i.e., defined guidelines for the use of BI systems.	New: Panelists mentioned the existence of an agreed BI strategy and reporting standards as influencing factors.
TIMEREST	Time restrictions, i.e., the time frame that is granted to BI system implementation projects.	New: Panelists emphasized that time restrictions pose a very relevant limitation to BI system implementation projects.
BICAPABI	Technical capability of IT personnel, i.e., the existence of in-house know-how needed for the implementation and maintenance of BI systems.	New: Panelists indicated that not only users need to exhibit sufficient skills, but that also the IT department must have sufficient technical capability.

Based on the responses, we evaluated whether we had already achieved a reasonable balance between a useful consensus and the participants' willingness to engage in a further round of the study. We calculated the degree of consensus of the expert panel for each dimension using Kendall's W, with W > 0.70 signifying strong consensus and W between 0.50 and 0.70 signifying moderate consensus (Kendall 1977; Schmidt 1997). The calculations resulted in a Kendall's W of 0.471 for the dimension of relevance and 0.625 for the dimension of controllability, i.e., either close to or within the range of a moderate level of consensus. We noted that the variances of evaluations for the new CCSFs (BISTRTGY, TIMEREST, and BICAPABI) were higher compared to the CCSFs that had already been subject to the first round (Table 4). Therefore, we also calculated the Kendall's W for adjusted rankings that only included the other 22 CCSFs. These calculations resulted in a value of 0.537 for the dimension of relevance and 0.634 for the dimension of controllability, both at a moderate level of consensus. Against this background, we decided to proceed with a third round. We were confident that a further round could increase the confidence in the rankings, especially by substantiating the ranks of those CCSFs that had been added in the second round.

Table 4. Results of the Delphi Study (Second and Third Round)

Variable	Relevance						Controllability					
	R_3^*	$\bar{R}_3$	$SD_{\bar{R}_3}$	R_2^*	$\bar{R}_2$	$SD_{\bar{R}_2}$	C_3^*	$\bar{C}_3$	$SD_{\bar{C}_3}$	C_2^*	$\bar{C}_2$	$SD_{\bar{C}_2}$
TOPMANSP	1	2.08	1.26	2	4.36	3.63	9	9.00	1.47	9	9.46	4.25
DATASRCS	2	2.62	2.53	1	4.08	3.97	3	3.23	0.60	3	6.46	3.66
CORPSTRA	3	3.85	3.76	3	5.32	5.06	16	16.08	0.64	16	16.50	3.73
ITBUDGET	4	4.23	1.09	4	6.64	4.26	8	8.23	0.93	8	9.25	5.67
USERINVO	5	6.69	3.88	5	8.80	4.58	1	1.08	0.28	1	3.08	4.23
SITINFRA	6	7.31	1.18	7	9.36	3.34	10	10.54	1.66	10	9.54	4.78
FINANCES	7	8.38	4.13	6	9.16	5.62	19	18.92	0.28	19	18.54	2.75
BISTRTGY	8	8.46	2.57	8	10.04	6.54	5	5.23	0.60	5	7.08	4.87
MARKETDY	9	8.69	3.84	9	11.32	5.62	20	20.00	0.00	20	18.71	3.54
BICAPABI	10	10.00	2.97	10	11.88	7.60	4	4.38	1.80	4	6.71	5.52
LOCITDEP	11	10.38	3.10	11	12.32	5.05	12	11.77	0.83	12	11.25	5.21
PROCAUTO	12	11.46	2.76	13	13.16	4.46	6	5.23	1.79	6	8.08	6.29
ITCORPST	13	12.92	2.81	14	13.24	6.34	13	12.62	0.96	15	12.46	3.99
PRODRANG	14	13.00	1.91	12	12.64	4.79	17	17.46	1.66	17	17.29	4.18
LITERACY	15	15.69	1.49	16	13.76	4.77	2	2.31	0.63	2	4.08	3.19
MGMETHOD	16	16.46	3.10	15	13.56	6.26	11	11.46	1.39	11	11.13	5.14
HETEROIT	17	17.00	2.68	18	16.44	4.85	14	13.31	1.80	13	12.00	4.10
TIMEREST	17	17.00	4.64	17	15.40	7.83	7	7.31	1.49	7	8.92	5.60
LEGISLAT	19	17.62	4.81	19	17.00	5.99	22	22.15	0.55	22	20.96	5.49
INFOCOMM	20	19.77	3.63	20	17.68	5.27	15	14.38	2.22	14	12.29	4.80
ORGASIZE	21	19.77	2.52	21	18.24	4.68	24	24.00	0.41	24	21.21	2.43
ORGSTRUC	22	21.54	1.20	22	18.60	5.02	18	17.77	0.60	18	18.33	2.78
INDUSTRY	23	22.92	1.04	23	19.36	6.27	25	24.85	0.55	25	21.79	3.87
SCOMPBIT	24	23.08	2.75	24	19.76	5.60	21	20.85	0.55	21	18.88	4.71
OWNERSTR	25	24.08	3.04	25	22.88	3.43	23	22.85	0.69	23	21.00	5.28
Kendall's W	***0.845***			***0.471***			***0.977***			***0.625***		
N	***13***			***25***			***13***			***24***		

Third Round

At the beginning of the third round, we informed the 27 second-round participants that they had already achieved a weak to moderate level of consensus in their CCSF rankings. We again provided them with separate relevance and controllability rankings, which included the mean evaluations ($\bar{R}_2^*$ and $\bar{C}_2^*$) across the expert panel, the absolute rank (R_2^* and C_2^*) resulting from the mean rank, and the individual ranks they had assigned to the CCSFs. Thus, they were able to identify which of the ranks they had assigned deviated from the general expert panel opinion. In this round, panelists were again asked to bring the CCSFs into a rank order regarding both relevance and controllability. Once again, they were provided with the possibility to form the rank order by moving boxes with the names of the CCSFs to ranking fields (labeled from 1 to 25). The CCSFs were pre-assigned to the ranking fields according to the previous-round ranks. Hence, the participants only had to switch boxes if they wanted to modify the rankings.

By the end of this round, we had received answers from 13 experts of the 27 second-round respondents. The low number of responses confirmed our doubts about the participants' endurance to take part in a third round and their willingness to rank the same CCSFs they had already ranked in the second round again. We also assume that many participants were already satisfied with the joint rankings that had resulted from the second round. This impression was confirmed by the fact that those who participated in the third round had made only a few changes to the rankings provided. Based on the rank orders provided by the panelists, we again calculated the mean rank for each variable and each dimension (Table 4). We also analyzed the degree of consensus using Kendall's W. The calculations resulted in a W of 0.845 (second round: 0.471) for the dimension of relevance and a W of 0.977 (second round: 0.625) for the dimension of controllability, both now at a high, or even very high, level of consensus. The "unusually strong agreement" (Schmidt 1997, p. 767) for the controllability dimension is due to the fact that the third-round participants had made only very few changes to the ranking of this particular dimension (as is also observable from relatively low values of the standard deviation $SD_{\bar{C}_3}$).

The results indicate that the panel was moving to a higher level of agreement. On the one hand, this is expressed by the increasing values of Kendall's W for both dimensions. On the other hand, this development can also be seen from the quite stable set of CCSFs that were among the top ten regarding relevance and controllability in the course of all rounds. The changes in rankings from round one to two were more substantial compared to those that occurred from round two to three. From round two to three, the individual CCSF ranks either remained constant or changed by one rank at most. Most of the CCSFs that were added after the first round made it directly into the top ten of the relevance ranking of the second round and also remained there in the third round. Table 4 presents the final results including the absolute ($\mathbf{R}^*$ and $\mathbf{C}^*$) and mean ranks ($\bar{\mathbf{R}}$ and $\bar{\mathbf{C}}$) and the standard deviations ($\mathbf{SD}$) for both dimensions in rounds two and three (indicated by indices).

Cluster Identification

In order to effectively interpret and to identify distinct groups of CCSFs based on their relevance and controllability rankings, we undertook a cluster analysis using the software SPSS Statistics 17.0. Cluster analysis helps to identify meaningful groups of elements within a given data set that exhibit similar attributes while, at the same time, the between-group variance is increased (Tan et al. 2005). Traditional hierarchical clustering and K-means procedures are effective for small and medium datasets like the present one (Garson 2010; Tan et al. 2005). We apply the first approach as it requires less initialization effort than the K-means algorithm. The agglomerative hierarchical cluster analysis initially regards each element as a single cluster and then merges the elements step by step based on a linkage criterion. The linkage criterion is used for a pair-wise analysis of different clusters, and thus to identify the two that will be merged. We applied the average-link as it is recommended for achieving homogeneity within clusters (Garson 2010). It calculates the cluster proximity based on the average pair-wise proximities of all inter-cluster pairs (Tan et al. 2005). The outcome of a hierarchical cluster analysis comprises a dendrogram and an agglomeration schedule that exhibit the sequence of merging clusters (see Figure 2 and Table 5 in the Appendix). These results provide the researcher with a series of possible solutions ranging from the maximum number of clusters (each element is a single cluster) to a solution with only one cluster present (Milligan and Cooper 1985). To determine an appropriate number of clusters, the researcher can either decide that at a certain stage an interpretable solution has been reached, or refer to various procedures for determining the number of clusters in a data set (see Milligan and Cooper, 1985, for an overview of such procedures). For the present study, we decided to apply the simple stepsize criterion (Milligan and Cooper 1985). As a large difference in coefficient values would suggest that the data "was overclustered in the last merger" (Milligan Cooper, p. 164 f.), we decided that we had reached a suitable solution after stage 20, as the next mergers would result in constantly growing coefficient increases (see Table 5 in the Appendix) (Ketchen and Shook 1996). We also checked whether the resulting five-cluster solution was interpretable meaningfully, and whether each cluster was of a reasonable size. This was the case. In order to check the robustness of the CCSF groupings, we further applied the K-means algorithm as an alternative approach to clustering. The K-means algorithm is a heuristic approach that requires the researcher to specify the number of clusters before clustering and, in accordance with the previous results, we set this to 5 (Garson 2010; Milligan and Cooper 1985). For initialization purposes, we also set the initial center values to the average values of the clusters that had resulted from the hierarchical cluster analysis (Garson 2010). We conducted several runs with different randomized CCSF orders. Compared to the outcome of the hierarchical cluster analysis, the results of the K-means cluster analysis only suggested the re-grouping of the ORGSTRUC factor from cluster IV to V (see Tables 6 and 7 in the Appendix). In the following, we discuss the implications for practice that can be derived from the five identified CCSF groups:

I. *Classical topics of BI management:* As depicted in Figure 1, the first cluster contains CCSFs characterized by high relevance and high controllability. This cluster includes top management support (TOPMANSP), user involvement (USERINVO), IT budget (ITBUDGET), sophistication of the IT infrastructure (SITINFRA), and available data sources (DATASRCS). This cluster should attract the main attention of BI managers. We assume that the particular relevance of these factors is not very surprising to BI professionals and academics, because their importance has already been intensively discussed. For instance, existing studies report that BI often suffers from poor data quality, insufficient funding, or lack of management support (Eckerson 2006; Hawking and Sellitto 2010; Joshi and Curtis 1999; Wixom and Watson 2001). Hence, each CCSF in cluster I can be considered as a potential barrier to BI success. The additional value of our study results becomes evident when we look at the second dimension of controllability. BI managers might be surprised to see that our expert panel considered the controllability of those factors that matter most for the success of BI to be comparatively high. Accordingly, our results suggest that BI managers should use their abilities and influence and try to manage these very CCSFs, since the input-output ratio for these efforts is the most promising.

II. *Mastering BI technology for success:* Cluster II summarizes CCSFs that exhibit moderate relevance but high controllability as perceived by our panel of BI managers. This cluster includes IT literacy of employees (LITERACY), BI strategy (BISTRTGY), technical capability of IT/BI personnel (BICAPABI), and degree of business process automation (PROCAUTO). Our interpretation of the CCSFs in this cluster is that they are closely related to BI technology, or refer even closer to the BI knowledge and skills that exist in the organization. The factors IT literacy of employees and technical capability of IT/BI personnel can serve as proofs for this interpretation. The practical implication of this cluster is that BI managers must be able to draw on sufficient BI knowledge within the organization to successfully maintain and advance BI systems.

III. *Alignment with organizations' external orientation*: Cluster III groups CCSFs that show high relevance and low controllability. It can be seen in Figure 1 that cluster III is comparatively distant from the other clusters. We believe that this is due to the fact that the three variables, namely, corporate strategy (CORPSTRA), financial situation (FINANCES), and market dynamics (MARKETDY), all describe the external orientation of an organization. It could be stated that the factors characterize whether or not the BI system supports the organization's overall strategy on the market. Hence, the CCSFs in cluster III are highly relevant for consideration by BI managers, e.g., when implementing or adjusting the BI system in a project. However, managing the CCSFs in cluster III seems to lie beyond the ability of a BI manager and she/he might not attempt to influence the CCSFs actively.

IV. *Alignment with organizations' internal orientation:* Cluster IV comprises CCSFs of moderate relevance and moderate controllability, i.e., time restrictions (TIMEREST), management methods (MGMETHOD), location of IT department (LOCITDEP), influence of IT on corporate strategy (ITCORPST), role of informal communication (INFOCOMM), heterogeneity of the IT infrastructure, (HETEROIT) ,and product range (PRODRANG). The CCSFs all have in common that they relate to internal organizational routines, and in particular to how organizational IT is designed. It might be typical for large information systems (of which BI systems are a perfect example) that these organizational factors are ranked moderate in both dimensions, as they reflect the constant interplay between corporate strategy and IT (in the sense of Business/IT alignment). As a more definite implication for BI managers, we suggest considering the intra-organizational environment of the BI *system*.

V. *Moderating factors of organizations' environment:* The last cluster V includes CCSFs that show little relevance and little controllability. Including CCSFs such as legislation (LEGISTLAT), sophistication of competitors' BI technology (SCOMPBIT), ownership structure (OWNTERSTR), organizational structure (ORGSTRUC), organization size (ORGASIZE), and industry (INDUSTRY), we consider cluster V as the moderating intra- and inter-organizational environment for BI. This does not mean that the CCSFs can be neglected, but that the factors are rather static cornerstones for the management of BI. Although these CCSFs are the subject of many discussions among BI managers (as they are in conversation between other employees), they seem only to be relevant for strategic and top management. We suspect that strategic factors such as the ownership structure are actually of little relevance for, and hardly controllable by, the BI manager. However, the BI manager should pay attention, since these factors are moderators of the BI system success, and might justify the BI system itself, or at least they can be used to justify and to raise internal (project) funding.

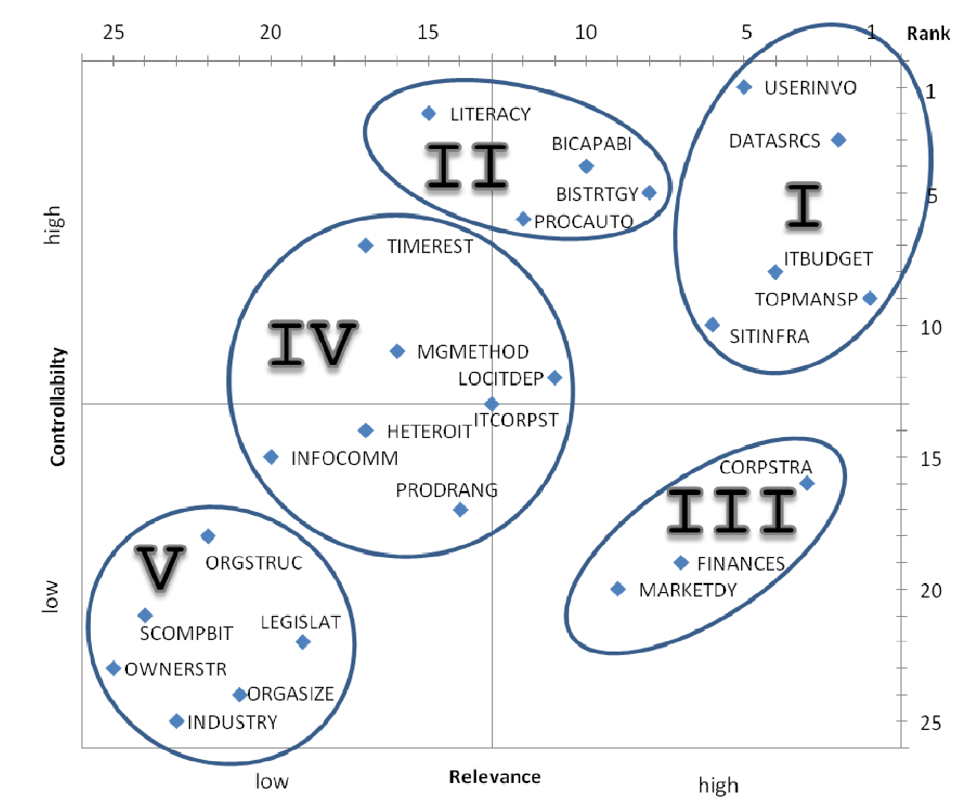

Figure 1. Plot of the Identified Clusters

Discussion and Conclusion

With our research, we contribute to the study of Business Intelligence and BI success factors:

(1) *Identification, integration, and empirical reflection of BI success factors*. Despite the recognition of BI as an important issue to IS research and practice, there has been little research as yet into CSFs for BI (Hawking and Sellitto 2010; Hwang et al. 2004; Ramamurthy et al. 2008; Wixom and Watson 2001; Yeoh and Koronios 2010). With our research, we consolidated these previous studies and complemented them by a comprehensive search for further individual CSFs that were not yet explicitly mentioned in this body of literature. We identified multiple factors, such as legislative regulation (Rosemann et al. 2006), that added up to an substantial collection of BI success factors. With the help of an empirical approach, a Delphi study, we were able to utilize expert knowledge to reflect on these factors present in the literature. As a result, the collection of CCSFs was further consolidated (e.g., degree of competition and frequency of product innovations subsumed under market dynamics) as well as extended. Novel CCSFs that have not yet been discussed in full in BI CSF literature include BI strategy and reporting standards (BISTRTGY), BI system implementation time restrictions (TIMEREST), or the technical capability of IT personnel (BICAPABI). This integrated and extended list of BI success factors can function as the basis for future research in the field. For instance, we consider it fruitful to address dimensions other than relevance and controllability, such as variability. In addition, the list of BI success factors provides a starting point for future research that investigates into how individual or groups of CCSFs impact on BI success. With our BI CCSF list, we are able to provide sound basis for such endeavors. Furthermore, such a comprehensive picture of BI success factors starts off future research that addresses the dependencies between individual CSFs

or between groups of CSFs. Here, we consider process theory as a potentially fruitful perspective that could complement the still dominant variance theory perspective in this field of study.

(2) *Multi-dimensional analysis*. The few studies specific to the field of BI have mainly addressed the dimension of relevance (Hawking and Sellitto 2010; Hwang et al. 2004; Ramamurthy et al. 2008; Yeoh and Koronios 2010), while the dimension of controllability (Ein-Dor and Segev 1978) has up to now been largely neglected by BI CSF literature. This is especially surprising against the background of a rising interest in design-oriented IS research (Gregor and Jones 2007; Hevner et al. 2004; Simon 1996). Here, controllable CCSFs can be an excellent subject for design theory building, as they may be altered by BI managers' decisions (Sein et al. 2011; Venable 2006; Webb and Gallagher 2009). Our approach of combining the dimensions has the potential to initiate a novel integrated discussion of relevance and controllability/design.

(3) *Clustering of success factors*. In order to provide a more abstract view of BI success factors, and thus to withstand the variation of individual CCSFs, we identified five groups of success factors by means of clustering. Our cluster analysis helps to identify meaningful groups of elements within a given data set that exhibit similar attributes while, at the same time, the between-group variance is increased (Tan et al. 2005). As a result, we were able to complement existing BI success literature by a success factors grouping that is based on a statistical-empirical analysis and that refers to a two-dimensional framework of both relevance and controllability. Prior studies (Hawking and Sellitto 2010; Hwang et al. 2004; Ramamurthy et al. 2008; Yeoh and Koronios 2010) have mainly suggested a content-related grouping of factors. They commonly distinguish between environmental, organizational and project-related factors when studying BI CSF. In contrast to these studies, we provide a framework that identifies, for instance, relevant and controllable factors (Cluster I) that may involve different content areas (e.g., data sources and top management support are both part of Cluster I). Future research will need to study how far these alternative (and possibly complementary) frameworks of BI success factors can be applied best to guide BI managers' actions.

(4) *Success factors for BI and other types of IS*. While it is our intention to make a contribution to BI research in IS, we believe that our approach and method could well be applied to studying CSFs for information systems other than BI. Against the background of the results achieved in our study, an integrated view of both relevance and controllability has proved to be viable. We also suggest applying a multi-step approach, including a literature review (seed list), expert reflection (Delphi study round 1), ranking (Delphi study rounds 2 and 3), as well as a statistical-empirical approach to by comparing success factors in BI and other types of IS. Here, one could address whether there are CCSFs exclusive to BI or whether CCSFs in BI are as similarly relevant and/or controllable as those in other IS fields, for instance ERP systems (Hawking and Sellitto 2010; Holland and Light 1999; Lechtchinskaia et al. 2011; Seidel and Back 2011). Here, we assume that – against the background that we study critical *contextual* success factors – we will find a strong overlap. For example, while data sources (DATASRCS) is of great relevance to BI success (rank 2), it will bear some relevance for ERP or CRM as well. We also consider that it is important to study whether – following the described methodology – other types of IS feature CCSF clusters different from those in BI.

The present study is beset with particular limitations. First, we acquired our initial seed list of CCSFs from reviewing related work from the field of BI. Although we sought to cover the relevant literature on CSF for BI and contextual factors in IS, it is possible that we missed articles that would have made an additional contribution. An alternative to our seed list approach would have been to simply ask our expert panel for CCSFs directly. However, before and after the first round, participants were free to comment on the set of factors and to add further factors. As the participants asked us to make only limited modifications to the list of CCSFs, we assume that we had compiled a high-quality initial seed list. We catered thoroughly for the comments from the expert panel by updating the list prior to the second round of the Delphi study. Second, our expert panel consists of data warehousing professionals that have a permanent position in the industry. While our experts are in an adequate position to evaluate the importance and controllability of the CCSFs, their outlook on the success of the delivered system may be limited. Experts that are independent of a particular organization (such as consultants) may evaluate individual factors differently. Third, there may be other dimensions in which a CCSF is worth investigating (e.g., variability; Ein-Dor et al. 1978). Future research needs to address these limitations.

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Appendix

```
  C A S E       0         5        10        15        20        25
 Label     Num  +---------+---------+---------+---------+---------+

 SCOMPBIT   24   -+
 OWNERSTR   25   -+-+
 ORGASIZE   21   -+ +---------------------------+
 INDUSTRY   23   -+ |                           |
 LEGISLAT   19   ---+                           |
 FINANCES    7   -+---+                         +-----------------+
 MARKETDY    9   -+   +-----------------+       |                 |
 CORPSTRA    3   -----+                 |       |                 |
 HETEROIT   17   -+-+                   +-------+                 |
 INFOCOMM   20   -+ +-----+             |                         |
 ORGSTRUC   22   ---+     +-------------+                         |
 MGMETHOD   16   -+-----+ |                                       |
 TIMEREST   18   -+     +-+                                       |
 LOCITDEP   11   -+-+   |                                         |
 ITCORPST   13   -+ +---+                                         |
 PRODRANG   14   ---+                                             |
 BISTRTGY    8   -+                                               |
 BICAPABI   10   -+---+                                           |
 PROCAUTO   12   -+   +-------+                                   |
 LITERACY   15   -----+       +-----------------------------------+
 DATASRCS    2   -+-------+   |
 USERINVO    5   -+       +---+
 ITBUDGET    4   -+-+     |
 SITINFRA    6   -+ +-----+
 TOPMANSP    1   ---+
```

Figure 2. Dendrogram of Hierarchical Cluster Analysis Results

Table 5. Agglomeration Schedule of the Hierarchical Cluster Analysis

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	24	25	5.000	0	0	10
2	21	23	5.000	0	0	10
3	11	13	5.000	0	0	14
4	8	10	5.000	0	0	8
5	7	9	5.000	0	0	17
6	4	6	8.000	0	0	12
7	17	20	10.000	0	0	15
8	8	12	12.500	4	0	16
9	2	5	13.000	0	0	19
10	21	24	15.000	2	1	13
11	16	18	17.000	0	0	18
12	1	4	18.000	0	6	19
13	19	21	24.000	0	10	23
14	11	14	25.500	3	0	18
15	17	22	27.000	7	0	20
16	8	15	37.333	8	0	21
17	3	7	38.500	0	5	22

18	11	16	50.167	14	11	20
19	1	2	57.167	12	9	21
20	11	17	65.400	18	15	22
21	1	8	87.200	19	16	24
22	3	11	154.208	17	20	23
23	3	19	196.473	22	13	24
24	1	3	321.625	21	23	0

Table 6. Cluster Membership According to K-Means Algorithm

Case Number	CCSF	Cluster	Distance
1	TOPMANSP	I	3.821
2	DATASRCS	I	3.578
3	CORPSTRA	III	4.069
4	ITBUDGET	I	1.844
5	USERINVO	I	5.385
6	SITINFRA	I	4.494
7	FINANCES	III	.943
8	BISTRTGY	II	3.335
9	MARKETDY	III	3.145
10	BICAPABI	II	1.275
11	LOCITDEP	IV	4.486
12	PROCAUTO	II	1.904
13	ITCORPST	IV	2.445
14	PRODRANG	IV	4.518
15	LITERACY	II	4.373
16	MGMETHOD	IV	1.807
17	HETEROIT	IV	2.030
18	TIMEREST	IV	5.926
19	LEGISLAT	V	3.337
20	INFOCOMM	IV	5.111
21	ORGASIZE	V	2.267
22	ORGSTRUC	V	4.180
23	INDUSTRY	V	2.911
24	SCOMPBIT	V	2.034
25	OWNERSTR	V	2.794

Table 7. Final Cluster Centers According to K-Means Algorithm

	Cluster				
	I	II	III	IV	V
Relevance	3.60	11.25	6.33	15.42	22.33
Controllability	6.20	4.25	18.33	12.71	22.16