2 Study A: A Structured Literature Review on Business Intelligence and Analytics from a Decision Process Perspective[1]

2.1 Introduction

In recent years the idea of business intelligence and analytics (BI&A) has gained an increasing amount of interest among researchers and practitioners due to a number of published success cases. These success cases report tremendous improvements in organizational performance, based on improved decision making and new business insights (Chen et al., 2012; Davenport, 2006). BI&A systems provide support for collecting and transforming data and put particular emphasis on data analysis with the purpose of improving decision making (Chen et al., 2012; Davenport, 2006; Shanks et al., 2010). BI&A systems can be attributed to the research area of decision support systems (DSS), which deals with information systems and their potential to support decision making (Arnott and Pervan, 2008). In this respect, what is understood today as BI&A has been shaped by DSS research and developments in systems like personal decision support systems, executive information systems and data warehouses (Arnott and Pervan, 2008; Chen et al., 2012; Shanks et al., 2010; Watson, 2010).

In order to achieve performance benefits from BI&A systems, organizations need to focus on their decision processes (Davenport, 2010; Shanks et al., 2010). Decision processes represent the routines by which decisions are made in organizations (Mintzberg et al., 1976; Nutt, 2008). The success of utilizing BI&A technologies highly depends on their integration with organizational decision processes (Brohman et al., 2000; Davenport, 2010; Kanungo, 2009; Shanks et al., 2010). Achieving such integration requires an understanding of how these technologies affect decision processes. Therefore, missing understanding of these effects can constrain successful utilization (Watson et al., 2002).

In this context, recent literature reviews however find that decision processes have not received enough attention: Shollo and Kautz (2010) analyze conceptions of business intelligence (BI) and conclude that only very few studies address decision processes. Moreover, they find that although BI is described as a data-driven process for decision support, it often remains unclear how BI is used in decision processes and what effects it has on decision processes. Arnott and Pervan (2008) provide a review of the DSS discipline and find that, although DSS research has the mission of improving managerial decision making, less than half of the investigated publications are explicitly related to managerial decision making research.

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They state that this creates a risk for the relevance of DSS research. Furthermore, they find that the amount of interrelation to managerial decision making research even decreases for technologies like data warehouses and business intelligence. Hence, recent literature reviews suggest more focus on decision processes and better integration of insights from managerial decision making research (Arnott and Pervan, 2008; Shollo and Kautz, 2010).

In light of these results, it becomes less surprising that although the general ideas of DSS research are consistent with management research on decision processes, the actual visibility of DSS research seems to be quite low in related management research (Papadakis et al., 2010). Papadakis et al. (2010) identify a major research gap with respect to the effects of information systems use on managerial decision making processes and explicitly call for more research in this area.

Taking into account the discussed perspectives it seems that there is a need for more integrative research with respect to the effects of technologies like business intelligence and analytics on decision processes. Therefore the goal of this research is to investigate and give an overview on the effects of those systems on decision processes. Research on decision processes is interdisciplinary and in order to support future work at this interface this paper makes three main contributions. First, we develop a research framework, based on existing results from managerial decision process research and decision support systems research. Then, using this research framework, we present results from a structured literature review and thereby integrate existing insights on the effects of decision support technologies on the distinct phases and attributes of decision processes. Finally, we propose future research directions in the area of managerial decision processes, as well as business intelligence and analytics.

This paper is organized as follows: The second section discusses the DSS background of this research. Additionally it develops a decision process research framework, which will be used for analyzing the results of our literature review. The third section describes our procedure for performing the literature review and documents the literature search process and its results. The fourth section presents the results from the literature study and the fifth section discusses those results. The sixth section identifies future research opportunities and the last section concludes this paper.

2.2 Decision Support and Decision Processes

This section starts with a conceptualization of the DSS research area. Next we discuss decision processes and we integrate existing concepts into a research framework that will be used for structuring and analysis of our literature review, as recommended by Webster and Watson (2002). The conceptualization and scoping performed in this section are also the basis for

specifying search terms and inclusion/ exclusion criteria for the literature search process (see vom Brocke et al., 2009).

2.2.1 DSS Background and Technological Conceptualization

Although BI&A are the most current technologies for supporting managerial decision making, research and systems in this area have evolved over several years. One of the earlier reviews on the effects of use of decision support systems was done by Benbasat and Nault (1990). In their analysis they come to the conclusion that empirical investigations on the overall performance effects of DSS are inconclusive, as some studies report positive effects and others do not. They find several reasons for this, which are variances in the investigated variables, a lack of distinction between decision aiding techniques and a lack of process focus. Benbasat and Nault (1990) provide a functional classification of DSS, but they do not link it to distinct decision processes phases or characteristics.

The recent review by Arnott and Pervan (2008) provides a high-level overview on the DSS field. They classify the DSS field into: Personal DSS, group support system, negotiation support systems, intelligent DSS, knowledge management-based DSS, data warehousing and enterprise reporting and analysis systems (incl. business intelligence, executive information and performance management systems). In their study they find, among others that within the DSS field, the newer technological sub-fields of data warehouses and BI are least grounded in decision making research. This creates a risk of decoupling technologies from their actual purpose in decision processes (Shanks et al. 2010). These results are supported by findings of Shollo and Kautz (2010) in the context of BI systems and they conclude that decision processes have not been considered sufficiently.

BI&A includes collection, analysis and dissemination of information with the purpose of supporting decision making (Davenport 2010; Watson 2010). Thus, the focus of BI&A can be related to process models for modeling and predicting real-world processes, choice models for supporting decision making, analysis and reasoning methods, as well as information control techniques. We subsequently focus our research on these technological aspects. We do not include representational aids, judgment and group supporting techniques, as former are broadly covered in human-computer interaction research and latter mainly address different facets of communication and group collaboration. After this technological conceptualization, we develop a research framework for decision processes.

2.2.2 Decision Process Background and Research Framework

In order to systematically investigate the effects that decision support technologies have on decision processes it is necessary to operationalize those effects. For this purpose we define

decision processes by using a phase-based conception defined by Mintzberg et al. (1976) and we discuss common quality attributes of decision processes from management research.

Mintzberg et al. (1976) developed a decision processes conception, which includes phases for (1) identification, (2) development, and (3) selection. They investigated the decision process phases and found that distinct steps within those phases are performed iteratively, rather than sequentially during decision making. Additionally, they found that competing steps exist within each phase. This conception of the decision process has been further refined and extended in decision process research (e.g. Nutt 2008), as well as partially adopted in the DSS field.

For investigations of the quality of decision processes two main dimensions of attributes have been suggested in management research: Decision process characteristics and decision process outcomes (Papadakis et al., 2010; Rajagopalan et al., 1993). Process outcomes describe the results from a decision process or its sub-phases. In contrast, decision process characteristics encompass procedural attributes that are related to the execution of the process (Papadakis et al. 2010; Rajagopalan et al. 1993). In order to obtain a comprehensive view on a decision process it is important to consider attributes related to process characteristics and process outcomes (Forgionne, 1999; Phillips-Wren et al., 2004). Research by Forgionne (1999) comes to the conclusion that this is seldom the case in DSS research. This may lead to a fragmentation of insights with respect to the effects on decision processes.

Therefore, our research framework combines a selection of process outcomes, as well as process characteristics that are considered as relevant in managerial decision process research. The framework considers the decision process phases (1) identification, (2) development and (3) selection, and we focus on the following attributes for each of the three phases:

- Information quality: One of the major benefits of BI&A systems is the provision of accurate, high quality information which is easily accessible (Davenport 2010; Watson et al. 2002). Therefore usage of such systems should make available information of better quality.
- Comprehensiveness and procedural rationality: In managerial decision process research procedural rationality describes the level of reliance upon analysis of information in decision making and comprehensiveness characterizes the extent to which analysis is exhaustive within the decision process (Dean and Sharfman, 1996; Papadakis et al., 2010).
- Speed: Time savings are another major benefit that is proposed to be realized by BI&A systems (Davenport 2010; Watson et al. 2002). Such systems should not only provide faster access to information but also help to speed-up the decision process.

- Phase outcomes: The final decision is not the only result, within a decision process. Each phase produces results, which can be analyzed with respect to their quality and quantity. For the identification phase this is a set of problems and opportunities that are identified and specified. The development phase deals with defining a set of solution alternatives. Finally the selection phase deals with analysis and choice of alternatives. The analyzed alternatives and whether a choice was made are outputs from this phase (Nutt 2008; Phillips-Wren et al. 2004).

Additionally we focus on decision results and total decision speed:

- Decision result: The decision result is the outcome of the overall process. The quality of this outcome can be evaluated using performance and accuracy measures or on the basis of expert evaluations (Papadakis et al. 2010; Phillips-Wren et al. 2004).
- Total decision speed: The total decision speed characterizes duration of the overall decision process, which is expected to be reduced (Davenport 2010; Watson et al. 2002).

2.3 Review Method

For structuring the literature review we used the guidelines provided by vom Brocke et al. (2009) and Webster and Watson (2002). This section describes our review procedure in detail, with the purpose of making our review procedure as transparent as possible in order to achieve high validity and reliability. In this context, validity means the degree of accuracy in identifying and handling sources, which includes selection of scientific databases and search terms. Reliability refers to the replicability of the search process and can be achieved by thoroughly documenting the procedure and making selection criteria explicit (vom Brocke et al. 2009). In the following, we first define the review scope, search terms and explicit inclusion/ exclusion criteria. Then, we describe the search process and sources used in this literature review, as well as our approach for data extraction and analysis.

2.3.1 Review Scope

Following the recommendations by vom Brocke et al. (2009) we used the taxonomy proposed by Cooper (1988) in order to characterize the scope of our literature review. The focus of our research is mainly on research outcomes and partially on the research methods of the analyzed publications. Our goal is to integrate existing results on the effects of decision support technologies on decision processes. We organize our results conceptually according to the distinct phases of a decision process. Through summarizing and synthesizing findings we aim at a neutral perspective for representing the findings. We tried to achieve exhaustive coverage of the literature with respect to our research goal by performing searches in eight scientific databases, but simultaneously we were limited to the sources available in the chosen databases. Our intended audience is researchers specialized in BI&A systems or DSS in general, as well

as management researchers in the field of decision processes. The results might also be interesting for practitioners who want to gain insight into the effectiveness of such technologies.

2.3.2 Search Terms

At the beginning of a literature review it is recommended to start with a conception of the topic and a definition of key terms in order to derive meaningful search terms (vom Brocke et al. 2009). As discussed in the previous section, we investigated existing reviews on decision making, decision processes and supporting technologies. During this initial investigation we identified two main topics: Decision processes, including their characteristics and outcomes, and decision support technologies, including their effects on decision processes. We discussed those topics with experts and practitioners in order to extract the relevant terms and their relationships. Using those terms, we experimentally searched through a set of databases with different combinations of search queries in order to verify their usefulness and to improve the search queries iteratively. Thus we enhanced the queries by adding synonyms, abbreviations and wildcard symbols, which account for different spellings. We created the final search query, which addresses the two main topics by combining search terms through logical operators. The search query presented below was used for the EBSCOhost database. Queries for other databases differed slightly due to the technical specifics of each database.

Terms related to decision support technologies:

(("business" AND (analytic* OR "intelligence")) OR (("decision support" OR "executive information" OR "management information" OR "management support" OR "corporate performance management") AND system*) OR ("data warehouse" OR "data warehousing") OR ("BI" OR "BA" OR "DSS" OR "EIS" OR "MIS" OR "MSS" OR "CPM" OR "DW"))

Terms related to decision processes and their characteristics:

(decision* AND ((process* OR routine* OR pattern* OR "making" OR procedure* OR practice* OR activit*) OR (effic* OR effectiv* OR satisfaction* OR performance* OR "commitment" OR "consensus" OR participation* OR "involvement" OR conflict* OR "confidence" OR "speed" OR time* OR qualit* OR comprehen* OR "extensiveness" OR rationalit* OR "interaction" OR adaptiv* OR flexibil*)))

2.3.3 Inclusion and Exclusion Criteria

In order to guide our evaluation procedures during the literature search process, we derived a set of explicit inclusion and exclusion criteria in accordance with our research goal. Those criteria provide additional transparency, not only on the search procedure but also on follow-up literature evaluation procedures (i.e. title, abstract and full text evaluation). Publications were eligible for inclusion if they provided empirical results related to our research goal and we included suitable qualitative and quantitative research studies. With respect to time frame,

we anchored our study using the review of Benbasat and Nault (1990) as it provides an overview on DSS research from its early beginnings. Thus, we focused on research performed after 1990 and furthermore publications had to be peer-reviewed, written in English and available in full text. Due to the diversity of DSS research topics we also defined a number of explicit exclusion criteria. Publications were excluded if they dealt solely with aspects related to design, interface, architecture or implementation of DSS. Additionally, publications that focused on the effects of user characteristics like satisfaction, learning and group collaboration techniques were not in our scope. Many DSS publications concentrate exclusively on decision results (Forgionne 1999) and as we focused our research on decision processes, we excluded such studies. Finally, we excluded publications that dealt with implementation, validation or verification of specific optimization techniques or algorithms from a purely technical perspective.

2.3.4 Data Sources and Search Process

For finding relevant data sources we queried scientific databases, which contained journals and publications from relevant conferences (Webster and Watson 2002). We decided to query the scientific databases by title and without further restricting the searches to specific journals or conference proceedings in order to be exhaustive and address the interdisciplinary nature of the topic. We performed searches in the following databases: EBSCSOhost (Business Source Premier and Econlit), Science Direct, Thomson Reuters Web of Knowledge (Web of Science), Wiley Online Library, ACM Digital Library, IEEE Xplore Digital Library and AIS Electronic Library. This selection of databases allowed us to search more than 3000 journals from the information systems, management and computer science, including the top 25 MIS journals listed by the AIS. Additionally, we searched through the most important information systems conferences like ECIS and ICIS.

Figure 2.1 gives an overview of our literature search process and the number of publications at the end of each process phase. Using the keyword-based search we obtained a total of 1136 publications. These publications were entered into a Zotero database for better handling and documentation of the process phases. For each phase of the search process we created a separate Zotero database. Having the initial set of publications we read through titles and abstracts of those publications and excluded those that did not match our defined inclusion and exclusion criteria. In uncertain cases we kept the publications for subsequent full text analysis. This resulted in a set of 121 publications for which we intensively investigated the full text and again applied our inclusion and exclusion criteria as part of the evaluation. Additionally, we excluded similar publications by the same author groups and in such cases we kept results from the highest quality source or if those were similar we kept the newest one.

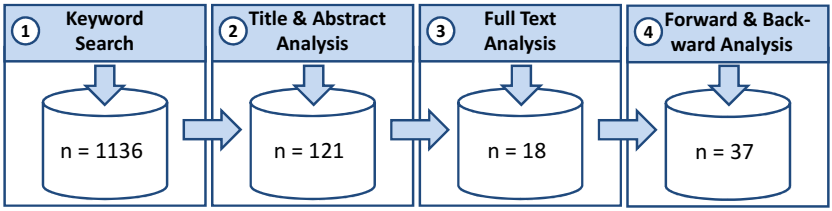

Figure 2.1: Search Process

Following this procedure we obtained a set of 18 publications, which were in scope of our research goal. As recommended by Webster and Watson (2002), we additionally conducted a forward and backward search on the set of relevant publications. We searched backward by analyzing the references of the publications. We searched forward by utilizing respective functions of Thomson Reuters Web of Knowledge and Google Scholar for identifying citing publications. During forward and backward search we adhered to the same procedure as before by identifying potentially relevant candidates through their title and abstract and further investigating them with a full text analysis. At the end we obtained a final set of 37 publications from which we extracted data for the analysis.

2.3.5 Data Extraction and Analysis Procedures

From the final set of 37 publications, data was extracted using a predefined extraction form. Besides basic bibliographic information (date, author and source), we encoded information on the research design (research method and research context), system type, the decision under investigation and related tasks that were described. Furthermore we noted a short summary of the most important results and for documenting the effects on the decision processes, we extracted independent variables (if available), decision process characteristics and outcomes, as well as reported effects on those elements.

For analyzing the extracted information, we applied the research framework. In our analysis we distinguish contributions that explicitly examine distinct decision process phases, from contributions that examine decision processes implicitly. In this context we used the information about the investigated decision types and performed tasks for identifying such implicit process contents, including distinct process phases. With respect to the actual effects on decision process phases, we analyzed the variables that were investigated within the publications and assigned the evidence on their effects to the respective categories of the research framework.

2.4 Results of the Structured Literature Review

This section presents the results from the literature review. The complete list of publications that have been used for this analysis is provided in the appendix. In the set of 37 publications the majority has been published in journals (33 publications) and some on conferences (4 publications). Research related to the effects of decision support technologies on decision processes has been performed mainly in the information systems (28) but also in management literature (7) and other domains (2). Most prevalent research methods are experiments (21), followed by surveys (11) and case studies (5).

2.4.1 Studies on the General Support of Decision Processes

Within the set of publications we identified five survey studies that were performed in industrial contexts and deal with perceived support of decision support technologies (see Table 2.1). In those studies, the subjects were directly asked about their perceived level of support for the distinct process phases. Most of those studies (2-5) report positive effects with respect to the perceived support of the investigated technologies. In the oldest study (1) from this sample support was only found for the selection phase. This is consistent with the development of the DSS field, as initial developments in DSS focused on techniques for the selection phase.

Table 2.1: Overview of Survey Studies on Support of Decision Process Phases

Nr.	Year	Research Method	Context	System Type	(1) Identification	(2) Development	(3) Selection
1	1990	Survey	Industrial (n = 87)	DSS	o	o	+
2	1998	Survey	Industrial (n= 55, 63)	IS	+ (most support)	+	+ (most support)
3	2002	Survey	Industrial (n=51)	EIS	+	+	+
4	2004	Survey	Industrial (n=117)	IS	+ (most support)	+	+ (most support)
5	2008	Survey	Industrial (n=42)	BI	+ (most support)	+	+ (most support)

Notes: "+" indicates support and "o" indicates that no effect was found.

2.4.2 Studies on the Specific Effects on Decision Processes

This sub-section presents studies that focused on distinct phases of decision processes, as well as the associated process characteristics and outcomes. We divided the overall set into three sub-sets according to the number of phases (one, two or three) that have been investigated in the studies. Tables 2.2, 2.3 and 2.4 present the analysis results and they provide information about research method and context, the investigated technology, and explicit or implicit con-

ceptualization of process phases. Furthermore, they provide results on the effects with respect to the specific process attributes. For each of the three phases (1) Identification, (2) Development and (3) Selection, the associated attributes (IQ) Information Quality, (C) Comprehensiveness and Procedural Rationality, (S) Speed and (O) Phase Outcome are covered explicitly. In the last two columns the effects on (D-Res) Decision Results and (DP-Speed) Total Decision Speed are provided. The interpretation of the effects is as follows: "+" and "-" indicate the direction of the effect with respect to an attribute. "++" and "- -" additionally indicate that the effect was found to be statistically significant. "o" shows that the attribute was investigated but no resulting effect was found. Additionally, in order to provide transparency on assignments of effects to process phases that were only covered implicitly, we use brackets "( )".

Table 2.2 presents the results of ten single-phase studies. Two studies (6, 7) explicitly address the identification phase using case studies in an industrial context. Studies 8-15 focus on the selection phase using experiments in an academic research setting. System type is mainly classified as general DSS. Single-phase studies concentrate on attributes 3-C and D-Res. Six studies (8, 9, 11, 12, 13, 14) find positive effects with respect to 3-C and six studies (9-11, 13-15) find mainly positive effects on D-Res.

Table 2.2: Overview of Single-Phase Studies and Investigated Effects

						(1) Identification				(2) Development				(3) Selection					
Nr.	Year	Research Method	System Type	#-implicit / explicit	Phases	1-IQ	1-C	1-S	1-O	2-IQ	2-C	2-S	2-O	3-IQ	3-C	3-S	3-O	D-Res	DP-Speed
6	1994	Case Study (Industrial)	DSS	1-explicit	Identification	++		++	o										
7	2003	Case Study (Industrial)	DSS	1-explicit	Identification		+	-											
8	1994	Experiment (Academic)	DSS	1-explicit	Selection										+				
9	1996	Experiment (Academic)	DSS	1-explicit	Selection										++			++	
10	1997	Experiment (Academic)	ES	1-explicit	Selection													++	
11	1998	Experiment (Academic)	DSS	1-explicit	Selection										++			++	
12	2000	Experiment (Academic)	DSS	1-explicit	Selection										+				
13	2001	Experiment (Academic)	DSS	1-explicit	Selection										++			++	
14	2004	Experiment (Academic)	DSS	1-explicit	Selection										++			++	o
15	2007	Experiment (Academic)	DSS	1-explicit	Selection										o			+	

Notes: "+" and "-" indicate the direction of the effect, "++" and "- -"additionally indicate significance of the effect.

The results from eleven two-phase studies are presented in Table 2.3. Experiment research is also the prevailing research method. We find a focus on the development and selection phases. General DSS remain the most common system type. D-Res is covered ten times (17-26) and mainly positive results are reported. The coverage of the other four phase-specific attributes is higher than in single-phase studies. IQ is addressed in one study (23) and we find positive implications. For C we find positive implications in three studies (22, 23, 25). For S, O, and DP-Speed we find mixed results.

Table 2.3: Overview of Two-Phase Studies and Investigated Effects

						(1) Identification				(2) Development				(3) Selection					
Nr.	Year	Research Method	System Type	#-implicit / explicit	Phases	1-IQ	1-C	1-S	1-O	2-IQ	2-C	2-S	2-O	3-IQ	3-C	3-S	3-O	D-Res	DP-Speed
16	1995	Case Study (Industrial)	EIS	2-explicit	Identification Selection			+								+			+
17	1993	Experiment (Academic)	DSS	2-implicit	(Development) (Selection)													+	
18	1994	Experiment (Industrial)	DSS	2-implicit	(Development) (Selection)											- -	- -	-	
19	1994	Experiment (Academic)	DSS	2-implicit	(Development) (Selection)								(++)				(++)	+	-
20	1995	Experiment (Academic)	DSS	2-implicit	(Development) (Selection)													++	
21	1996	Experiment (Academic)	DSS	2-implicit	(Development) (Selection)								(++)				(++)	++	
22	1998	Experiment (Academic)	DSS	2-implicit	(Development) (Selection)						(++)	(++)			(++)	(++)		+	++
23	2001	Experiment (Industrial)	DSS	2-implicit	(Development) (Selection)					(+)	(+)			(+)	(+)			+	-
24	2001	Experiment (Academic)	DSS	2-implicit	(Development) (Selection)													++	++
25	2004	Experiment (Academic)	DSS	2-implicit	(Development) (Selection)						(+)	(+)			(+)	(+)	o	++	
26	2006	Experiment (Academic)	DW	2-implicit	(Development) (Selection)													++	o

Notes: "+" and "-" indicate the direction of the effect, "++" and "- -"additionally indicate significance of the effect. "( )" indicate assignment of effects to implicitly covered decision process phases.

Table 2.4 presents eleven studies that encompass all three decision process phases. We find a variety of research methods, with survey-based research being the largest group. In contrast to the other sub-sets, general DSS is not the prevailing system type and business intelligence and executive information systems are represented more often. The coverage of process attributes is broader and we do not observe a concentration on one attribute. Instead IQ is addressed by eight studies and C, as well as S are addressed by six studies. Attributes O, D-Res and DP-Speed are only addressed by five or less studies. With respect to IQ we find rather positive implications throughout the three phases and particularly for BI and EIS systems (33, 36, 37). Evidence on the effects on C is mainly positive throughout the phases (28-30, 33, 36, 37). Interestingly we find that studies related to the overall process are less focused on actual phase outcomes and even fewer consider decision results. For studies that address both, process characteristics and outcomes (29, 30, 32, 34) we find rather positive effects. We find mixed results for decision speed.

Table 2.4: Overview of Three-Phase Studies and Investigated Effects

						(1) Identification				(2) Development				(3) Selection					
Nr.	Year	Research Method	System Type	#-implicit / explicit	Phases	1-IQ	1-C	1-S	1-O	2-IQ	2-C	2-S	2-O	3-IQ	3-C	3-S	3-O	D-Res	DP-Speed
27	1992	Experiment (Industrial)	DSS	3-explicit	Identification Development Selection			- -				- -				o			- -
28	1993	Survey (Industrial)	EIS	3-explicit	Identification Development Selection		++	++			++	(++)			++	++			
29	1995	Case Study (Industrial)	IS / DSS (different per case)	3-explicit	Identification Development Selection	+	+	+	+	+	+	+	+	+	o	+	+		
30	1996	Experiment (Mixed)	MSS (=EIS+ ES+ DSS)	3-explicit	Identification Development Selection	(o)	++		o	(o)	o		++	(o)	++		++	++	- -
31	2000	Case Study (Industrial)	BI	3-explicit	Identification Development Selection													+	-
32	2000	Experiment (Academic)	DSS	3-explicit	Identification Development Selection	(o)			o	(o)			+	(o)			+	+	+
33	1995	Survey (Industrial)	EIS	3-implicit	(Identification) (Development) (Selection)	(++)	(++)	(++)		(++)	(++)	(++)		(++)	(++)	(++)			
34	1996	Survey (Industrial)	IS	3-implicit	(Identification) (Development) (Selection)	(++)		(o)		(++)		(o)	(++)	(++)		(o)	(++)	++	
35	1998	Survey (Industrial)	IS	3-implicit	(Identification) (Development) (Selection)	(- -)				(- -)			(- -)	(- -)			(- -)	- -	
36	1999	Survey (Industrial)	EIS	3-implicit	(Identification) (Development) (Selection)	(++)	(++)	(++)		(++)	(++)	(++)		(++)	(++)	(++)			
37	2012	Survey (Industrial)	BI	3-implicit	(Identification) (Development) (Selection)	(++)	(++)			(++)	(++)			(++)	(++)				

Notes: “+” and “-” indicate the direction of the effect, “++” and “- -”additionally indicate significance of the effect. “( )” indicate assignment of effects to implicitly covered decision process phases.

Table 2.5 provides an overview of the attribute coverage in studies 6-37. Attribute coverage describes for each attribute the fraction of studies that address this attribute. Attribute coverage is generally around one third or less and thus relatively low. Only two attributes achieve higher coverage. 3-C is covered by half of the studies and D-Res is covered by two thirds of the studies. Additionally, Table 2.5 presents the number of positive, negative and neutral effects that have been reported in those studies. It provides the relative fraction of positive effects in comparison to negative and neutral effects. The fraction of positive effects is larger than two thirds in most cases, which gives an indication of the positive effects on decision processes, but those effects don’t seem to be self-evident.

Table 2.5: Attribute Coverage, Number/Fraction of Reported Effects

	1-IQ	1-C	1-S	1-O	2-IQ	2-C	2-S	2-O	3-IQ	3-C	3-S	3-O	D-Res	DP-Speed
Attribute Coverage	0.28	0.22	0.28	0.13	0.28	0.28	0.25	0.22	0.28	0.5	0.31	0.28	0.66	0.34
# Positive	6	7	6	1	6	8	6	6	6	14	7	6	19	4
# Negative	1	0	2	0	1	0	1	1	1	0	1	2	2	5
# Neutral	2	0	1	3	2	1	1	0	2	2	2	1	0	2
Fraction of Positive Effects	0.67	1.00	0.67	0.25	0.67	0.89	0.75	0.86	0.67	0.88	0.70	0.67	0.90	0.36

2.5 Discussion of Results

Within the results from the literature review we identified a set of studies (studies 1-5) that provides evidence for the general perception that decision support technologies have a positive effect on decision processes. As these studies have a high-level view on the decision process, it is difficult to derive specific insights for distinct decision processes phases or specific characteristics and outcomes.

As part of this research we also identified a larger set of studies (6-37) that provides more detailed information on effects that are specific for decision process. Those results show that the overly positive perception from the high-level point of view is less clear when we take a more detailed look at decision processes and their characteristics and outcomes. Thus a lower level of abstraction is needed in order to understand the actual effects of decision supporting technologies on decision processes.

Within this set of studies we distinguished single-, two- and three-phase studies. We find that single-phases studies have a strong focus on the selection phase. In these studies comprehensiveness and decision results are investigated in experimental settings. This research mainly deals with choice support in academic, highly structured problem environments (i.e., alternatives and decision variables are predefined). Its purpose is to reduce biases during choice-making. In the two-phase studies this research approach is extended to the development phase. In most cases studies were also performed in experimental settings, which focused on more realistic decision problems. In those experiments subjects typically had to develop solution alternatives by themselves, before they performed the analysis and choice. In order to gain more conclusive insights, research needs to be extended to the whole decision process, including its characteristics and outcomes. In this context, three-phase studies offer insights on the effects on process characteristics and outcomes throughout the decision process. We observed that those studies are typically less decision result oriented but tend to focus more on process characteristics. This allows for investigating the direct effects of decision support technologies on decision processes and not only the resulting or indirect effects on outcomes.

Another issue, besides phase coverage, is the coverage of distinct decision process characteristics and outcomes. We find in most cases a low coverage, which is an indication for isolated investigations of process attributes. In order to obtain conclusive results with respect to decision processes it is important to consider attributes related to process characteristics and process outcomes (Forgionne 1999; Phillips-Wren et al. 2004). This is needed in order to explain observed differences in positive and negative effects (see Table 2.5) of decision supporting technologies. In this context we find that those attributes that have been investigated the most (D-Res and C) have also the highest fraction of reported positive effects. Due to a high frac-

tion of isolated investigations of these attributes it remains an open question if those effects will be stable in more realistic decision environments.

2.6 Research Opportunities

The results from the literature analysis help to characterize the current state of research related to BI&A systems, decision support technologies in general and their effects on decision processes. This provides the basis for identifying further research opportunities.

(1) BI&A coverage: For BI&A technologies we observe the need for more empirical research in relation to decision processes. Although knowledge about their implications is important for decision makers (Watson 2010), the fraction of those technologies is low within the analyzed set. Thus it would be beneficial to investigate the effects of those technologies on the phases of decision processes and their characteristics and outcomes. For example, research on current in-memory BI&A technologies would be highly valuable, as they do not only promise to impact the speed of decision processes but also have the potential to change their constitution and structure. Knowledge about these implications is important for decision makers in the context of the adoption and utilization of those technologies.

(2) Decision process coverage: In our analysis we find low values for attribute coverage. Only less than one third of the studies address decision process phases, as well as process characteristics and outcomes. Only six studies did this in an explicit manner. Therefore we see a need for more research that addresses decision processes from an integrative perspective. This means that process characteristics need to be studied together with process outcomes (Forgionne 1999). This research is relevant as it is a prerequisite for explaining the observed differences in the effects of technologies. In particular, it remains unclear if decision process attributes have properties of complements or substitutes in the context of technological decision support. Furthermore we find a high research focus on the selection phase. The preceding identification and development phases should be considered with the same priority as they provide the input for the selection phase. If an organization fails in those phases, the overall decision result will be in danger (Nutt 2008). Research in this direction is particularly relevant for the successful utilization of BI&A systems as those are supposed to support all decision process phases.

(3) Decision process constitution: Based on the implications of BI&A technologies we find indications that more research is needed on the constitution of decision processes and the roles involved. Research from DSS and management domains has found that structure and formalization of decision processes can impact their effectiveness and efficiency (Kanungo 2009; Nutt 2008) and also the usage of technology to support decisions. Decision processes supported by business intelligence were found to be highly iterative and dependent on the interaction between BI specialists and decision makers (Brohman et al 2000). Thus, the role

of BI&A specialists and their interaction with decision makers gains increasing importance (Davenport 2006) and can become a success factor for the execution of decision processes. Consequently more research in this area would be of great value in order to help organizations in designing suitable decision processes that integrate BI&A technology effectively.

2.7 Conclusion

The purpose of this paper was to systematically investigate evidence on the effects of decision support technologies, particularly business intelligence and analytics systems, on distinct phases of decision processes. For this purpose we developed a research framework, we analyzed and presented results from a comprehensive and structured literature review and we identified future research opportunities.

Hence, we "analyzed the past to prepare for the future" (Webster and Watson 2002). Although we followed acknowledged procedures for performing a structured literature review (Webster and Watson 2002; vom Brocke et al. 2009), our results are not without limitations. Our search and analysis focused on a fixed number of scientific databases and thus we cannot for sure exclude having missed some articles. With regards to the selection procedures we defined explicit criteria and followed a rigorous procedure, but nevertheless the choice may remain subjective to a certain extent. Similarly, the categorization by using the suggested research framework is derived from existing research, but is mainly characterized by the perspective of the authors on this topic.

Drawing a conclusion from this research, we can state that for BI&A more research from the decision process perspective is needed. Therefore we hope that this literature review will support further research at the interface between BI&A systems and managerial decision processes.

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