

# Business Intelligence Maturity Models: An Overview

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**Abstract** In order to identify and explore the strengths and weaknesses of business intelligence (BI) initiatives, managers need to assess the maturity of their BI efforts. For this, a wide range of maturity models has been developed. In this paper, we present an overview of BI maturity models and elaborate their methodical and conceptual characteristics. This overview helps to understand the topic of BI maturity and can be used to guide the selection of an appropriate BI maturity model.

## Introduction

Business intelligence (BI) is a topic widely discussed in information systems (IS) literature. Since its first mentioning, BI has become an essential component of the information supply infrastructure and a contributor (and prerequisite) to the overall organizational success [12, 54]. Over the time, the terminology for BI, its role, and its impact have evolved [54]. Its role has changed from a single-analytical-application-view to an organizational capability of strategic importance [36]. Challenges of technical implementation are more and more replaced by questions of business value of the overall approach, e.g. strategic business alignment and competence in usage, operations, and further development [40, 53].

In order to be more effective, BI requires an comprehensive overall view of the design and changing of its structures [41]. An established means to identify strengths and weaknesses of certain domains of an organization are maturity models (MMs) [32]. They consist of multiple, archetypal levels of maturity of a certain domain and can be used for organizational assessment and organizational development [32]. Quite a high number of BI MMs has been proposed [54].

In a recent BI workshop with practitioners, we were not able to identify a source where different BI MMs are compared, so that e.g. the selection of an appropriate BI MM would be simplified. Therefore, we want to answer the following research question: “What BI MMs do exist and what are their characteristics?”

To answer this question, we synthesize prior research and contribute to a conceptualization of BI maturity research. This should help to “facilitate theory development, close areas where a plethora of research exists, and uncover areas where research is needed.” [52] Therefore, we conduct a literature review on BI MMs.

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## Research study

In order to document existing BI MMs and to identify their key characteristics, we conduct a literature review as outlined in table 1.

**Table 1.** Overview of the literature review (based on two established frameworks [10, 52])

Item	Description
Scope & goals	Our scope is to focus on research outcomes in the form of BI MMs. The goal of the literature review is to analyze existing models (integration/generalization).
Perspective, coverage strategy, & timeframe	Out of the perspective of a neutral representation, we follow an exhaustive coverage strategy, as we try “to be comprehensive in the presentation of works relevant to the topic.” [10] In accordance to this strategy, we do not restrict the covered time period (we include BI MMs published up to the end of Q1/2010).
Organization	Reviews can be organized historically, methodically, or conceptually, and different forms can be combined [10]. We organize our review of BI MMs historically in combination with an analysis as regards content and a methodical analysis.
Conceptualization & search terms	As our topic of interest is BI MMs, we first explicate the two terms BI and MM (cf. section 3). Based on the explication, we use a combination of the search terms (“maturity model” OR “capability model” OR “assessment model”) and (“business intelligence” or “BI” or “data warehousing” or “data warehouse” or “DW”) in our literature search ensuring the above mentioned exhaustiveness.
Addressees, sources, & procedure	Addressing the specialized BI scholar and BI practitioners, we proceed with a journal and a database (DB) search (cf. table 2), as we expect to find many BI MMs within practitioner sources. In the journal search, we examine 19 leading IS journals as identified in the context of generic BI literature reviews and by the AIS [2, 3, 29]. In the DB search, we examine five scholarly DBs, as these cover (further) journals, books, conference proceedings, and practitioner sources [49]. Next, we go backward by reviewing the citations found in the first step. As a last step, we “go forward by using the Web of Science [...] to identify articles citing the key articles identified in the previous steps” [52]. In all steps, we examine at least titles and abstracts in order to evaluate only relevant sources [49].
Outcome	The anticipated outcome is an identification of the key characteristics of the models (analysis as regards content and methodical analysis). Cooper [10] recommends to “combine organizations, for example, by addressing works historically within a given conceptual or methodical framework”. The methodical analysis is based on a classification scheme for MMs in IS [33], besides which, to the best of our knowledge, still “no classification system for MMs exists to date.” [33] For the content analysis of the MMs, we use a concept-centric approach based on so-called concept matrices [52].

## Business intelligence

Initially, BI was coined as a collective term for data analysis tools [1]. Meanwhile, the understanding broadened towards BI as an encompassment of all components of an integrated decision support infrastructure [4]. In BI systems, data from operational IS is combined with analytical frontends to “present complex and competitive information to planners and decision makers” [35]. A central component of BI systems is the data warehouse (DW), which integrates data from transactional IS for analytical tasks [28, 30].

**Table 2.** Journals and databases in study

#	Journal/DB name	#	Journal/DB name	#	Journal/DB name
1	Comm. of the ACM	9	IEEE Tr. on SW Eng.	17	J. of Org. Comp. & E. Comm.
2	Dec. Sciences	10	Inf. & Mgt.	18	J. of Strategic Inf. Sys.
3	Dec. Support Sys.	11	Inf. & Org.	19	J. of the ACM
4	EBSCOhost BSP	12	Inf. Sys. Journal	20	JSTOR
5	Europ. J. of Inf. Sys.	13	Inf. Sys. Research	21	Mgt. Science
6	Google Scholar	14	J. of AIS	22	MIS Quarterly
7	Group Dec. and Neg.	15	J. of Inf. Technology	23	ProQuest
8	Harvard Bus. Review	16	J. of Mgt. Inf. Sys.	24	ScienceDirect

But still, “there is no universally-accepted definition of BI.” [54] In the context of this article, we adhere to a broader BI definition, which also includes processes (including the usage of data, i.e. business processes): “Business intelligence (BI) is a broad category of technologies, applications, and processes for gathering, storing, accessing, and analyzing data to help its users make better decisions.” [54] Advantages of this definition are, for example, that it does not restrict BI to analytical front-end applications, but includes “getting data in [...] and getting data out” [54]. Furthermore, it does not only focus on technology and/or applications. For our purpose, it is important to have a BI definition which is not too narrow in scope.

Besides data warehousing (“getting data in”), there are other terms which consistently occur within the context of BI. Or, as Herschel [25] puts it: “Today, the practice of BI clearly employs technology. However, it is prudent to remember that BI is also about organizational decision-making, analytics, information and knowledge management, decision flows and processes, and human interaction.” Further related terms, partially used synonymously for BI, are decision support systems, executive IS, management support systems, and (business/corporate) performance management (PM) [9, 27, 35, 50].

## **Maturity models and development thereof**

Maturity describes a “state of being complete, perfect or ready” [46]. To reach a desired state of maturity, an evolutionary transformation path from an initial to a target stage needs to be progressed [17]. MMs are used to guide this transformation process. Initially proposed in the 1970’s [20], more than a hundred MMs have been published in the field of IS up to date [5, 32]. As these high numbers led to a certain arbitrariness of the design process [5, 13, 32], methods for the design of MMs were developed. Important characteristics of MMs are the maturity concept, the dimensions, the levels, the maturity principle, and the assessment approach (cf. table 3).

The literature proposes slightly different MM development processes which all adhere to a basic design [5, 13, 32]. De Bruin et al. [13] propose a development process consisting of the phases of scope, design, populate, test, deploy, and main-

tain. Becker et al. [5] propose a similar process emphasizing the use of existing MMs and an iterative development. Table 4 gives an overview.

**Table 3.** Properties of MMs [31]

Property	Description
Maturity concept	Three different maturity concepts (or understandings of maturity) can be distinguished [32]. People (or workforce) capability defines “the level of knowledge, skills, and process abilities available for performing an organization’s business activities.” [11] Process maturity defines “the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective.” [38] Object (or technology) maturity defines the respective level of development of a design object [19].
Dimension	Dimensions are specific capability areas, process areas, or design objects structuring the field of interest. They should be exhaustive and distinct [13, 32]. Each dimension is further specified by measures (practices, objects, or activities) at each level [13, 17].
Level	Levels are archetypal states of maturity of a certain dimension or domain. Each level has a distinguishing descriptor providing the level’s intent and a detailed description.
Maturity principle	MMs can be continuous or staged. Continuous MMs allow a scoring of activities at different levels. Therefore, the level can be either the (weighted) sum of the individual scores or the individual levels in different dimensions. Staged models require the compliance with all elements of one level [17]. They specify a number of goals and key practices to reach a predefined level. Staged MMs reduce the levels to the defined stages, whereas continuous MMs open up the possibility of specifying situational levels.
Assessment	The assessment approach can be qualitative using descriptions or quantitative using e.g. Likert-like scales [17].

**Table 4.** Basic MM development process [31]

Phase	Description
Scope	The scope phase defines the focus and identifies the relevant stakeholders and targeted audiences. It determines the balance between complex reality and model simplicity.
Design	The design phase addresses the requirements-based design and outlines the principle concept of maturity, the structure of levels, dimensions, and sub-dimensions (the meta-model). Based on this, the descriptors of the levels and their definitions are outlined. Thereby, the design process can follow a top-down or a bottom-up approach. A top-down approach first specifies the levels and their descriptions. The bottom-up approach first defines dimensions and characteristics representing maturity and then derives descriptions from it.
Populate	In the populate phase, the corresponding characteristics are determined and the maturity assessment is defined, which includes the specification of assessment instruments.
Test	The constructed model is tested on content completeness and intended model scope accuracy, and the assessment instrument is tested regarding validity and reliability.
Deploy	The model is deployed to the initial stakeholders and to an independent community.
Maintain	The model needs to be maintained to ensure its evolution.

For designing and populating MMs, different exploratory research methods and combinations of these methods are proposed. Commonly mentioned are literature analysis, Delphi & case studies, and focus groups [5, 13]. Quantitative methods are less frequently used for constructing MMs [17], as these require a sound theoretical foundation. Testing is also mostly done qualitatively. The choice of the relevant research method is influenced by the scope, stakeholders, and targeted audiences [32].

## State of the art of BI maturity models

In the following, we give a general overview of our literature search results, followed by an analysis as regards content and a methodical analysis.

### *Literature search results*

Altogether, our literature search yielded twelve different MMs of BI and closely related domains. No single MM was identified by journal search. By the examination of scholarly databases, we directly identified eight MMs. By backward search, we identified ten MMs. No additional MM has been identified by forward search. After removing doublets, twelve MMs were left. Due to reasons of inaccessibility (e. g. out of print), we had to exclude two MMs from our analysis. These are Miller [34] and Hawking, Foster, & Stein [23]. In table 5, we give an overview of the MMs.

**Table 5.** Overview of BI maturity models

Name	Ref.	Topic	Description
Watson et al. (2001)	[51]	DW	Watson et al. develop a MM for data warehousing (DW). The MM consists of three levels and nine DW specific dimensions. It was developed in a study with eight participating DW experts. The MM is based on the stages of growth concept [21], a theory describing the observation that many things change over time in sequential, predictable ways. The labels of the maturity levels, termed initiation, growth, and maturity, are not DW specific.
SAS (2004, 2009)	[22, 43]	Inf. mgt.	SAS offers the Information Evolution Model to aid companies in assessing how they use information to drive business, i.e. to outline how information is managed and utilized as a corporate asset. The MM differentiates five levels and four dimensions, which use generic labels (e.g. integrate, optimize, or innovate). For the execution of an assessment, a consulting service is needed. The MMs reliability is unclear, as the development process and the theoretical foundation are not addressed.
Eckerson (2004, 2009)	[14, 15]	BI	The BI MM by Eckerson includes six levels and seven dimensions. It uses a metaphor of human evolution from prenatal to sage to depict “the trajectory that most organizations follow when evolving their BI infrastructure [...] to a high-value, strategic utility” [15]. Its seven dimensions cover different aspects of BI, e.g. IS architecture, organizational scope, user groups, and the executives’ perception about the role of BI. The MM is the foundation for the TDWI BI benchmark report, which has been published yearly since 2006. The reliability is not addressed.
SMC (2004, 2009)	[8, 44]	BI	The BI MM by Steria Mummert Consulting (SMC) is an assessment tool to measure business, system, and organizational aspects of BI. Each of these three dimensions is partitioned into different fields of investigation. The MM consists of five levels. For the execution of a maturity assessment, a questionnaire, the so called “BI maturity audit” (BIMA) is applied. The questionnaire is the foundation for the “BIMA study”. The MM uses an object-centric maturity concept, with information being the object under consideration. The reliability of the MM is not documented.

Cates et al. (2005)	[7]	BI	The Ladder of BI (LOBI) MM by Cates et al. describes levels of maturity in effectiveness and efficiency of decision making. The LOBI MM is part of the LOBI framework, which aims at facilitating the creation of an IT plan and the design of IT architectures. Besides the MM, other key components of the LOBI framework are the balanced score card, business roles, business processes and technology, the cycle time to intelligence, and the business role intelligence analysis. The MM has six levels and three dimensions, which are not described in detail. This MM also uses an object-centric maturity concept, with information being the object under consideration, with a change to a people-centric maturity concept in higher levels.
Dataflux (2005)	[16]	Data mgt.	Dataflux presents the Enterprise Data Management MM to help “companies identify and quantify their data maturity, and assess the risks of undervalued data management practices” [16]. Furthermore, benefits and costs of moving to the next level are considered. The MM consists of four levels and four dimensions, which all use generic labels (e.g. people, process, technology and risk & reward respectively unaware, reactive, proactive, and predictive). The maturity concept is based on organizational capabilities, e.g. in stage two (labeled reactive), an organization “understands data-management problems as they occur, and comprehends that data is critical to its success.” [16] The reliability is not documented. The MM is freely available, a peculiarity for a MM from practice.
Sen et al. (2006)	[45]	DW	Sen et al. understand DW, like software development, as a process, which can be expressed in terms of components such as artifacts and workflows. Based on an exploratory study, they explore the factors influencing perceptions of DW process maturity. Drawing upon the concepts of CMM [38], they define five levels and five DW specific labeled dimensions for a DW process. The MM is available free of charge, but the assessment instrument is supposed to be future research. A forward search in the Web of Science did not give any such result.
HP (2007, 2009)	[24, 26]	BI	The HP BI MM aims at describing “the path forward as companies work toward closer alignment of business and IT organizations” [26]. The MM is based on the experiences of HP with clients across various industries. The MM differentiates five levels (with generic labels, e.g. improvement, empowerment, or transformation) and three dimensions to assess BI maturity in terms of business enablement, strategy & program management, and information management. The reliability is not documented. As the MM is targeted at HP’s (potential) clients, the MM is not available free of charge.
Gartner (2008)	[39]	BI & PM	Gartner’s BI and PM MM is a means to assess the maturity of an organization’s efforts in BI and PM and how mature these need to become to reach the business goals. The MM defines five levels (with generic labels like unaware, focused, or strategic) which are described textually. The MM does not define dimensions, but gives textual hints concerning e.g. sponsoring, organizational structure, scope of the BI initiative, and metrics. The maturity concept is object-centric. The compliance to a statement in relation to a certain object defines a progress as regards maturity. The reliability of the MM is not documented. Its application needs third-party assistance.
Teradata (2008)	[47]	BI & DW	Teradata’s BI and DW MM consists of five levels, e.g. “Reporting – What happened?” or “Predicting – What will happen?”, and two dimensions, namely data sophistication and workload complexity. The MM is meant as a means to document the as-is situation of BI and DW, which is supposed to be used as a foundation for future BI initiatives. The reliability is not documented. The MM is not available free of charge, as it is targeted at Teradata’s (potential) clients. The maturity concept is process-centric, stressing the impact of BI on the business processes.

## Content analysis

In order to analyze the content of the BI MMs, we examined the dimensions of the MMs in several discussion sessions. As such an examination is subjective by nature, a standardized process for content analysis (conceptualization, codebook creation, coding, refinement, & reliability check) was used, thereby helping to ensure the necessary rigor in the classification process [37].

We examined the dimensions and the underlying constructs (e.g. sub-dimensions, measures). Thereby, we matched synonyms. As an example, Cates et al. [7] use the term “Technology” and HP [26] uses the term “IT”, both actually addressing a similar aspect. Special attention was paid to homonymy (i.e. when similar dimension labels suggest the addressing of a similar aspect, but actually mean something different) and to the level of detail of the dimensions of the models (e.g. “culture” vs. DW size). The outcome is a catalogue of BI maturity dimensions, which should cover all aspects as outlined by the examined BI MMs in a distinctive manner (cf. table 6).

**Table 6.** Analysis as regards content: unified, distinct dimensions of BI maturity models

Dimension	Description	Watson et al.	SAS	Eckerson	SMC	Cates et al.	Dataflux	Sen et al.	HP	Gartner	Teradata	$\Sigma$
Applications	Kinds of (analytical) applications in use, e.g. data mining, OLAP, or reporting	■		■	■				■	■	■	6
Architecture	Overall structure of e.g. source sys., platform, integration infrastructure, and appl.	■		■				■				3
Behavior	Prevailing analytic decision culture in the org. (i.e. fact-based decision making)		■	■				■		■		4
Change	Controlling and tracking of changes over time	■	■					■				3
Data	# of subject areas, the data model(s) used, and the quality and quantity of data	■				■	■	■		■	■	6
Efficiency	Ratio of resource input compared to resource output	■										1
Impact	Individual impact and org. impact	■		■			■		■	■	■	6
Infrastructure	Components of the integration infrastructure, e.g. data bases, application servers		■	■	■		■	■	■			6
Org. structure	Characteristics, structure, and placement of the BI organization in the overall org.				■					■		2
Processes	Degree to which BI-related activities are performed		■		■		■					3
Staff	Experience, skills, and specialization of the BI staff	■										1
Strategy	Strategic alignment of BI, e.g. on corporate, business, or IT objectives								■			1
Users	Types, numbers, and locations of the BI users	■	■		■	■	■					5

Looking at the dimensions as depicted in table 6, the following statements can be made. Overall, classic IT topics, e.g. applications, data, and infrastructure, are highly present, while other topics like costs, organizational structures, staff, and strategy are rarely addressed (i.e. only in one, respectively two models). As high costs are not bad per se (i.e. if the benefit is also high), costs and benefits should be examined together [51]. Furthermore, other resource measures might be interesting to allow an exhaustive assessment of efficiency. Therefore, the inclusion of efficiency as a generic measure of outcome-oriented use of resources might be favorable, which includes e.g. financial and human resources. A bit surprising is the fact that organizational structure and strategy are rarely addressed, as BI organization (e.g. BI competency centers) and BI strategy (e.g. strategic alignment) are two topics highly present in current IS literature [18, 48]. With regard to people, users and staff are differentiated. Five models address users, but only one model explicitly addresses staff. A differentiation between BI and IT staff might be helpful – we were not able to identify such a distinction in the examined models. No single model makes a differentiation between different process types (i.e. core, management, and support processes [42]). Therefore, the examination of processes and their maturity might need further attention. Finally, the aspect of change is addressed by three models. Topics like change and requirements management might need further attention, as these might help to better align the BI activities to the overall needs.

### ***Methodical analysis***

The methodical analysis is based on a classification scheme [33], which uses three different dimensions to describe the general model attributes, the MM design, and the MM use. Altogether, the three dimensions contain 16 attributes by which a MM can be characterized. As some of these attributes describe rather specific aspects which are not needed in the context of this work and other, potentially useful attributes, are missing, we use a slightly modified set of attributes. For a detailed description of the attributes, we refer to section 2.2 and to [33].

To analyze the identified BI MMs methodically, we examined each model's characteristics and classified it on the basis of the above mentioned scheme. As such a classification is also subjective by nature, we again adhere to a standardized process for content analysis to ensure a rigorous classification process [37]. Table 7 provides the results of the methodical analysis of the MMs.

Based on table 7, we interpret the results of the methodical analysis as follows. Most of the models do have a clear BI focus, but the more current models by Gartner and by Teradata combine the topic of BI with PM and DW. As both of these models are from practical origin, this might suggest that some research effort should be put into this kind of models. As regards the origin, there is a good mix of models from academia, from practice, and from a grey zone in between. The most common maturity concept is object-centric, closely followed by people-centricity. Five models use a maturity concept which is either people-, process-, or object-centric. The other models use a mixed maturity concept. In many cases, the compo-



sition of the models remains unclear. Especially the models of practical origin are not documented well and the composition is not revealed. In regard to reliability, a MM can be verified, i.e. the model is described and specified with sufficient accuracy by the model designer, and validated, i.e. the model accurately represents the real world from a usage perspective. For only four models, the reliability could be verified (e.g. as the model is based on empirical data), but for the remaining six models, the reliability stayed unclear. No hints were given in the models documentation how the model was constructed, how and if its content was validated or verified, and what its underlying theory is. An important aspect of reliability from a methodical perspective is the theoretical foundation [32]. The theoretical foundation describes if the model is explicitly based on accepted (design) theories [6]. Only one model is theory-based: Watson et al. [51] refer to the stages of growth approach [20]. Thus, we support previous statements that many models suffer from a poor theoretical foundation [6]. The most common method of application is the assistance by a third-party, followed by a self-assessment. No model uses the method of application by certified practitioners. These might be hints, that a) the models from practical origin are used as acquisition instruments and that b) no single model has reached the state of a standard, so that certifications are available, as this is, for example, the case with CMMI [38].

**Table 7.** Methodical analysis of BI maturity models

Name	Origin		Mat. concept			Composition				Reliability			Explicitly theory-based	Appl. method		
	Academic	Practice	People	Process	Object	Grid	Questionnaire	CMM-like	Unclear	Validated	Verified	Unclear		Self-assessment	Third-party assisted	Certified practitioners
Watson et al.	■		■	■	■	■					■		■	■		
SAS		■	■	■	■				■			■			■	
Eckerson		■	■		■		■					■		■		
SMC	■	■			■		■				■				■	
Cates et al.	■	■	■		■				■		■				■	
Dataflux		■	■			■						■			■	
Sen et al.	■			■			■	■			■			■		
HP		■	■						■			■			■	
Gartner		■			■				■			■			■	
Teradata		■		■	■				■			■			■	
Σ	4	8	6	4	7	2	3	1	5	0	4	6	1	3	7	0

## Conclusion

In this paper, we gave an overview of BI MMs. We documented the state of the art of BI MMs and compared them from a content perspective and a methodical perspective. Concluding, our findings show that future research should pay special attention to the theoretical foundation, the explication of the underlying maturity concept, and the comprehensiveness of BI MMs.

The theoretical foundation describes if the model is explicitly based on accepted (design) theories [6]. Only one model is theory-based: Watson et al. [51] refer to the stages of growth approach [20]. An explicated theoretical foundation helps to understand how the different parts of the MMs influence each other. Due to the missing theoretical foundation in most of the analyzed models, the links between BI maturity, BI impact, and organizational success stayed quite unclear. The maturity concept outlines the fundamental understanding of BI maturity. The most common maturity concept is object-centric (e.g. from no explicit architecture to an enterprise data warehouse (DW) on the highest levels of BI maturity), closely followed by people-centricity. Five models use a maturity concept which is either people-, process-, or object-centric. The other models use a mixed maturity concept. A methodically sound BI MM should explicate its maturity concept in order to be clear what exactly is measured and what the MM's purpose is. Regarding the comprehensiveness of the BI MM content, our results show that classic IT topics, e.g. applications, data, and infrastructure, are highly present, while other topics like efficiency, organizational structures, staff, and strategy are rarely addressed. A bit surprising is the fact that organizational structure and strategy are rarely addressed, as BI organization (e.g. BI competency centers) and BI strategy (e.g. strategic alignment) are two topics highly present in current IS literature [18, 48]. With regard to people, users and staff are differentiated. Five models address users, but only one model explicitly addresses staff. A comprehensive BI MM should integrate all these and further, eventually in current BI MMs neglected aspects.

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