Business Intelligence Maturity Models: Information Management Perspective

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Abstract. While Business Intelligence (BI) plays a critical role for businesses in terms of organizational development and creating competitive advantages, many BI projects fail to fully deliver the features and benefits that could help organizations in their decision-making. Rather than depending on software, BI success relies on the capabilities of sensing for appropriate information, data collection, extraction, organization, analysis, and retention of information due to the large volume of information that exists.

Therefore, this paper presents a comprehensive review of existing BI maturity models and elaborates their methodical and conceptual characteristics to determine their gaps in addressing the information life-cycle concept in terms of sensing, collecting, organizing, processing, and maintaining activities. As a result, a conceptual framework is proposed from the literature analysis. The intentions are to build a BI maturity model that can be used to increase the success of BI implementation by basing it on Information Management Practice (IMP), which a model built on the information life-cycle concept.

Keywords: Business Intelligence, Maturity Model, Information Life-Cycle, Information Management Practise, Literature Review.

1 Introduction

Nowadays, Chief Information Officers (CIOs) consider BI to be the most important technological area (Raber et al., 2013; Gartner, 2013), helping them to improve performance and create competitive advantage (Chen, 2012; Vitt et al., 2002). However, Wells (2008) sees BI as the capability of an organization to predict, plan, and solve problems to help in establishing and achieving business goals; and not as being about tools, applications, data and databases.

The role of BI has changed from concentrating on technical capabilities (Wells, 2008) to contributing to strategic decision-making by focusing on the sensing activity to monitor market change in the external environment and explain early threatening signals of risk from unpredicted sources (Gilad, 2004; Frates and Sharp, 2005: 20). Based on information needs, it also contributes to deciding which information is to be exploited in order to maximize opportunities, and avoid problems before they occur (Rouibah and Ould, 2002; Grof, 1999). Furthermore, it also assists in deciding how much they want

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information sources; be they external, such as information on competitors and customers, or internal, such as operational databases (Myllarniemi et al., 2009).

In addition, while most organizations deal with the large volume of information that exists within an organizational environment, causing a big data issue, the BI role becomes important in addressing only information that is critical and accurate (Rouibah and Ould, 2002; Gromm and David, 2001). Cackett et al. (2013) state that while information management focuses on organizing the large volumes of semi-structured and unstructured data that are stored in organizations, big data capabilities have to fit with information management design in order to leverage big data in a successful way. For example, a Telecommunications Company can interact with its customers by triggering a customer's location with real data instead of putting fixed campaigns against defined target segments. However, this use of big data should be justified in terms of what new opportunities could be used regarding Price Management, Product and Offering Design, Acquisition and Retention Management, and Loyalty Management (Cackett et al., 2013).Therefore, it is important to address the organization within sensing activities in an appropriate way during BI implementation.

Nevertheless, to make BI more effective, it is important to link sensing, collecting, organizing, and maintaining information activities with organizational success. Despite the complexities in implementing BI systems in terms of sensing and other information life-cycle activities, as discussed above, there has been little empirical research into BI maturity models regarding how to identify the concepts of information life-cycle and business intelligence that can impact on the successful implementation of BI systems, and this gap in the literature is reflected in the low level of contributions on this issue to international conferences and journals. Therefore, this paper identifies gaps in existing BI maturity models (MMs) by analyzing the existing BI maturity models to highlight their shortcomings in addressing BI benchmarking variables. The analysis will also be done from an Information Management Practice (IMP) perspective to show the weaknesses of these models in terms of addressing critical information life-cycle phases.

2 Life Cycle View of Information Management

This part will discuss the information life cycle concept as well as giving a description of the IMP model and it phases and why it is used in BI as a measurement base.

2.1 Information Life Cycle Model

Information management has been defined as a set of activities that transfers through a desired sequence of phases, as each phase is dependent on the other (Kettinger and Marchand, 2011; Alavi and Leidner, 2001; Butler and Murphy, 2007).The life cycle phases have been changed with time in the literature, as most of them are inconsistent in terms of concepts and in including only four phases: collecting, organising,

processing and maintaining information (Kettinger and Marchand, 2011; Ashby, 1956; Taylor, 1968).However, the sensing phase was later included in the information management life cycle by Choo (1998) to address the activities that related to the scanning of the external environment (Kettinger and Marchand, 2011).Based on that, Kettinger and Marchand (2011) suggest an IMP model which includes sensing, collecting, organizing, processing and maintaining phases.

2.2 Information Management Practices (IMP)

The IMP model, which was built by William J. Kettinger and Donald A. Marchand in 2011, is based on a general model of information used, proposed by Choo in 1998. According to Kettinger and Marchand (2011), the IMP model is a theoretical model that is built on path dependency theory for the nature of decision-making phases, where each phase is dependent on the previous phase, and keeps independence as a concept. Moreover, both tacit and explicit knowledge concepts were taken into account in the design of the IMP model concept by focusing on the knowledge of people (Kettinger and Marchand, 2011).

The IMP model implements the growth of information life cycle approaches, and it includes five phases which represent the information management cycle of the IMP model, and they are:

1- Sensing Phase: used to detect and identify information concerning:
   A- Social, economic and political variations which could impact organizations;
   B- Innovations that are created by competitors which might influence the business;
   C- New products which satisfy customer demands and market changes;
   D- Recognition of the problems that could happen with the company's partners and suppliers.

2- Collecting Phase: used to collect related information, including:
   A- To make sure that the right information is provided at the right time; outlining the desires of information for employees is required;
   B- In order to prevent overloading of information, cleaning information is necessary;
   C- Key information sources should be identified;
   D- To ensure that there is accurate and complete collecting of information, training and rewarding employees should be identified.

3- Organizing Phase: used to organize the information to ensure cost-saving by minimizing efforts in locating useful data and preventing duplication; the focus is on:
   A- Indexing and classifying information for appropriate availability;
   B- Linking databases across the business units and functions within an enterprise;
   C- Training and rewarding employees for accurately and completely organizing the information for which they are responsible.

4- Processing Phase: used for analyzing data which have been organized in the previous stage; processing information includes:
   A- Only suitable information is accessed;
   B- To drive sensible decisions, databases are analyzed;
   C- People with outstanding analytical skills are hired;
   D- Making sure of the appropriate use of information to arrive at decisions; training and rewarding of employees is required in this stage;
   E- Appraisal of employees' performance should be aligned with their use of information.

5- Maintaining Phase: used for future organizational use of information, involving the following:
   A- In order to save efforts and cost, existing information which has been previously collected in one part of the organization will be used again;
   B- Databases should be updated to make sure they remain current;
   C- Continuous refreshing of data to make sure that people are using the appropriate and up-to-date information.

However, the proposed BI maturity assessment will be based on the IMP model, as it identifies the cycle of information that includes the sensing phase; to help in assessing the capabilities of information processes within the BI environment. According to Choo (2002), environmental sensing and BI reflect the same meaning as they both focus on immediate competitive situations as well as the political, social and economic factors of the external environment. In addition, to increase quality and clarity of information deal with uncertain situations, sensing phase have to be well developed as emphasis by Marchand, Kettinger, and Rollins (2002). Moreover, Rouibah and Ould (2002) put emphasis on the importance of building sensing or scanning strategies in the BI environment as BI depends on various data collection, extraction, and analysis technologies (Chen et al., 2012; Chaudhuri et al., 2011).

3 Existing BI Maturity Models

The maturity model for Business Intelligence gives support to organizations so that they have a clear perspective of their current position and what they need to do in order to reach the next phase. As Rajteric states (2010), BI maturity models (MMs) offer different strategies for development in this rapidly growing field. Bruin et al (2005) argues that the earlier research could be a good resource to get critical success factors which are required in building maturity model. Therefore, in table 1 below, the existing BI maturity models will be explored and compared to understand what key areas have been addressed by such models.

Table 1. Overview of existing BI maturity model

Model Name	Reference	Topic	Description
The BI Maturity Model	(Stock, 2013)	BI	The three main areas of the model are business enablement, information management, and strategy and program management. It uses a five-grade scale for each part (Stock, 2013). This model focuses principally on the alignment and integration by a linkage KPIs within the organization strategies as well as responsive to business environments. In addition, , it focuses on data governance and stewardship, measurement of ROI, quality of data and data management (MDM, metadata), BI programme management office (PMO) analytics skills ,sponsorship and C-level role.
Enterprise Business Intelligence Maturity Model	(Chuah and Wong, 2012)	BI	The three main areas of the Enterprise Business Intelligence Maturity Model (EBIMM) are data warehousing, information quality and knowledge process. It uses a five-grade scale for each part (Chuah and Wong, 2012). This model focuses mainly on the technical viewpoints by emphasizing the data warehouse part rather than the business side. In addition, the documentation of this model is not well established. This model focusing on data and metrics alignment between departments, alignment between KM process and department level (individuals, Department, Enterprise, Extended enterprise), data management policy and information quality conditions, technical programme skills, redundancy of data and management of metadata issues.
Impact-Oriented BI MM	Lahrmann et al (2011)	BI	BI capabilities, BI practices, BI IT, organizational support, individual use, organizational use, individual impact and organizational impact are the main areas of the Impact-Oriented BI maturity model, which uses a five-grade scale for each part (Lahrmann et al., 2011). The Impact-Oriented BI maturity model is a theoretical BI model that based on the IS impact measurement model which created by Gable et al. (2008).In addition, the model is based on comparisons between ten existing BI maturity models, data warehousing, information management, and data management. This model focuses on business requirements methodology, data governance, cost effective development and operations, technical and social capabilities, organizational support, technical architecture and analytical tools, data quality , and data integration.

Table 1. (*continued*)

American SAP User Group	Hawking et al (2010)	BI	Information analytics, governance, standards processes, and application Architecture are the main areas of this Business Intelligence Development Model, which uses a six-grade scale for each part .According to Hawking et al. (2010), this model was published only for SAP customers; as a result, there is no literature which has discussed and analysed this model critically. However, this model focuses on KPIs, and on the importance of building an alignment between business needs and KPIs in order to drive a standardised view of business performance (Hawking et al, 2010). In terms of BI benchmarking indicator, this model focuses on identification and use of KPIs and analytics. Moreover, it focuses on the BI Competency Centre (BICC), standards and processes of BI, architecture needed for BI application.
Business Intelligence Development Model (BIDM)	Sacu and Spruit (2010)	BI	Temporal characteristics, data Characteristics, decision Insights, output Insights, BI-Process Approaches, Semantics, User, Implementation people, process and technology are the main areas of focus of the Business Intelligence Development Model, which uses a six-grade scale for each part (Sacu and Spruit , 2010). Chuah and Wong (2010) criticize the Business Intelligence Development Model as it is not well documented and lacks a well-defined evaluation. In addition, the model focuses on the technical side more than on the business side. However, this model focusing on data and analysis in terms of refreshing period data focus, and action type. In addition, it focuses implementation type, at department level or enterprise-wide, culture and whether it is a closed loop environment, type of analysis tools at each level, data type, data sources, and granularity level.
TERADATA'S BI and DW maturity model	Miller et al (2009)	BI	Business alignment, architecture practices, performance systems management, BI/decision support, business analytics, data management, data acquisition/integration, business continuity, communication/ training, program and project management are the main areas of Teradata's BI MM, which uses a six-grade scale for each part (Miller et al, 2009).TERADATA'S maturity model is considered to be a process-centric model emphasizing mainly the influence of BI on the business processes (Lahrmann et al.,2010). Moreover, the model focuses on the as-is situation of BI and DW and the consistency of the model is not documented (Lahrmann et al., 2010). However, this model focusing on analytic vision, business alignment, project management methodology and data warehouse agility. In addition, it focuses on data governance and stewardship, measurement of ROI, training on the data model to know how to address data and interpret it, data Acquisition and Integration techniques, quality of data, and data management (MDM, metadata).

Table 1. (*continued*)

TDWI's Business Intelligence Maturity Model	(Eckerson, 2009)	BI	Scope, Funding, Sponsorship, Data, Value, Architecture, Development and Delivery are the eight main parts that are used for evaluation in this model, with a five-grade scale for each part .Eckerson (2007) also states that a top-down approach is used in TDWI's BI MM. However, this model focuses on the technical viewpoints by putting emphasis on the data warehouse part, and the business viewpoint could be improved with regard to the organizational and cultural vision (Chuah and Wong, 2011). In addition, the model put emphasis on creating standards for developing BI functionality: Cost-benefits; Sponsorship (CFO, CEO, BI Project, etc.), and Culture by addressing the field of analytics, whether by monitoring business events or delivering paper reports, or by addressing the technical infrastructure through emphasis on analytical tools and data architecture.
Hewlett Package Business Intelligence Maturity Model	(HP,2009)	BI	The HP maturity model covers the dimensions of business enablement, information technology, strategy, and programme management, with a five-grade scale for each part (HP, 2009). As this model focuses mainly on project management and alignment of business aspects, the data warehousing and analytical aspects have not been included which, as Chuah and Wong (2011) note, they should have been. In addition, Lahrmann et al. (2010) state that a HP maturity model is not reliable as it is not documented. However, the model put emphasis on business alignment, BI programme management office (PMO) and BICC., governance, analytics skills ,sponsorship and C-level role, technical infrastructure and quality of data.
BI MM Steria Mummert Consulting (SMC)	SMC (2009)	BI	SMC is an IT consulting company in Germany, and their Enterprise Data Management Maturity Model has three main areas of focus: process, organization, and technology, using a five-grade scale for each part (Chamoni & Gluchowski 2004; Schulze et al. 2009; Neumann, 2009). However, Lahrmann et al (2010) state that the model is not reliable as it is not documented. In terms of BI benchmarking variables, this model focusing on strategic alignment, analytical saturation, and business relevance, BI organisational structure (Project, dedicated Bi-organizes, etc.),cost-effective strategy ,IT architecture needed for BI, and data management (data marts, data warehouse, etc.)
Gartner Maturity Model for Business Intelligence and	(Rayner and Schlegel ,2008)	BI/PM	People, processes and metrics or technology are the main three areas of Gartner's Maturity Model, which uses a five-grade scale for each part (Rayner et al. 2008). However, Rajteric (2010) notes that the method used to evaluate the maturity level is not well-defined as it is based on an individual maturity level classification rather than on IT employees' or business users' classifications. Nevertheless, these authors point out that this model focuses on the business viewpoints rather than on the technical view (Chuah and Wong, 2011). Moreover, the strategic

Table 1. (*continued*)

Performance Management			vision and plan for implementing BI projects are filed to be integrated (Hostmann et al, 2006; Rajteric, 2010). However, this model emphasising the alignment between BI and performance management strategies and business goals, BI competency centre, data policies; capabilities to support policy management and data quality; sponsorship whether from the IT or business side, incentives and the creation of opportunities; enterprise architecture, and data consistency.
SAS Information Evolution Model	(SAS,2009)	IM	People, process, culture and infrastructure are the four main areas of the SAS Maturity Model, which uses a five-grade scale for each part. This model is mainly focused on the information management approach, and its reliability is not well documented (Lahrmann et al., 2010). It uses the IEM assessment process to move from one level to another by conducting five steps; determining the current IEM level, gap analysis, recommendation, roadmaps and action plan, and presentation of findings. In terms of BI benchmarking variables, this model focusing on the alignment between human capital, internal processes, culture, and infrastructure aspects. In addition, it focusing on BICC implementation, information skills, training, fact-based decisions and sharing information between units , and information architecture
Business Intelligence Maturity Hierarchy	(Deng,2007)	BI	The Business Intelligence Maturity Hierarchy model uses the knowledge management field as its main area, and it uses a four-grade scale for each part (Deng 2007). It focus on knowledge management field mainly and on technical point of view such as efficiency of reporting, analysis and data-warehousing(Rajteric ,2010).However, the evaluation standards of maturity levels are not defined appropriately (Chuah and Wong, 2010) In terms of BI benchmarking variables, this model focus on Return on investment strategy, experience perception, technical and tools infrastructure, data quality, and integration of data.
Analytical Capability Maturity Model	(Davenport and Harries, 2007)	Analytic	The three main areas of the Analytical Capability Maturity Model are organization, human, and technology; and it uses a five-grade scale for each part (Davenport and Harries, 2007). This model is based on competing in analytics strategy as it emphasises managing analytics with IT processes, governance principles, and analytical architecture, with a focus on consistent, good quality data (Aho, 2010). In addition, the model is based on four pillars: unique strategic capability, high level management support, enterprise-wide analytics, and large-scale motivation (Davenport and Harries, 2007). In term of BI benchmarking variables, this model focuses on insight into customers, markets, and competitor. In addition, it focuses on analytical competencies, executive management support, analytical culture weather if it fact-based culture or test and learning culture, hardware and

Table 1. (*continued*)

			software architecture and IT infrastructural issues, quality of data, data integration, and data architecture.
Infrastructure Optimization Maturity Model	(Microsoft , 2007)	BI	This model was built by Microsoft, with its main areas of focus being: efficiency of reporting, analysis, and data warehouse; and uses a four-grade scale for each part (Microsoft, 2007; Kašnik, 2008; Rajteric, 2010). However, Rajteric (2010) states that the Infrastructure Optimization Maturity Model is inadequate for the business intelligence field as it focuses mainly on the products and technologies for commercial purposes; in addition, the assessment criteria for individual maturity levels are not well defined. In term of BI benchmarking variables, this model focuses on IT costs and business value, culture by focusing on collaboration between employees and mobility of BI, IT infrastructure such as SQL Server Analysis Services, data mining, data warehousing, data types and integration.
Enterprise Data Management Maturity Model	(Fisher,2007)	DM	People, process, technology, risk and reward are the three main areas of the Enterprise Data Management Maturity Model, which uses a four-grade scale for each part .In addition; Fisher (2007) mentioned that the Enterprise Data Management Maturity Model focuses on the maturity of an organization with regard to how data is managed. While Lahrmann et al. (2010) state that the Enterprise Data Management Maturity Model is good in addresses and assesses the risks of data, as well as considering a cost-benefits strategy for moving to the next level; but the model is not reliable as it represents a practice mode. However, this model focuses on deploying the roles, responsibilities, and policies to the acquirement, maintenance, and dissemination of data. Moreover, it focuses on employees' technical skills, sponsorship, data management tools across the organization, and data quality monitoring.

Table 1. (*continued*)

Business information maturity model	(William and William, 2007)	IM	The two main areas of model are information focus and return on investment (ROI); and it uses a three-grade scale for each part. (William and William, 2007). In addition, the main success factors have been used in the model are alignment and governance, leverage and delivery; BI strategic position, BI portfolio management, partnership between business units and IT, information and analysis usage culture, process of improving business culture, process of establishing decision culture, and technical readiness of BI/DW (William and William , 2007). According to Rajteric (2010), the model shows a new perspective on maturity that could add value to the business intelligence maturity assessment domain, as it is assessed from the cultural perspective. Moreover, William and William (2007) used the information culture of organizations as an assessment tool for achieving high business efficiency. In addition, the model is considered by Rajteric (2010) to be well-documented as it shows a full description for each level with a list of questions which help in performing a self-evaluation. However, the technical side of TDWI has been used in this model to cover the technical requirements for BI as the authors are TDWI business partners (Rajteric, 2010) In terms of BI benchmarking variables, this model focusing on the way that information requirements are defined, organizational processes that are in place for using information, cost/benefits of changing an organization culture, and fact-based decision processes.
Data Warehousing Process Maturity	(Sen et al.,2006)	DM	The areas of focus in this model are data quality, alignment of architecture, change management, organizational readiness, and data warehouse size with six-grade scale for each part .The model is incomplete and future work has been considered by the author (Lahrmann et al., 2010). In term of BI benchmarking variables, this model focuses on data definition and business rules, technical skills of data warehouse, training to improve technical skills, culture by rewarding fact-based decisions and sharing information. In addition, it focusing on BI applications and IT infrastructure aspects (telecommunication, operating system, etc.) in alignment with data warehouse, data quality, and data warehouse size and architecture. However, as this model focus mainly on DM, it addresses issues like reliability of data and data warehouse size and architecture without considering business side.
AMR Research's Business Intelligence/Performance Management	(Hagerty, 2006)	BI/PM	The three main dimensions of the model are technology, people, process; and it uses a four-grade scale for each part (Hagerty, 2006). According to Rajteric (2010), the model focuses more on performance management than BI, as Hagerty (2006) sees Performance Management as a natural growth of Business Intelligence. Additionally, Kasabian (2007) mentions that BI is considered to be a means of transport by enabling more actual information delivery. However, Rajteric (2010) states that the analysis of this model seems to be difficult due to a lack of available documentation

Table 1. (*continued*)

Maturity Model			as it is produced by Consultant Company. While Chuah and Wong (2010) criticize this model because it is focused on a balanced scorecard methodology rather than BI, they also point out that the criteria of evaluation are not clear as there is no questionnaire to evaluate maturity levels. However, this model focuses on mapping key performance indicators (KPIs) with organizational strategies. In addition, it focuses on project based aspects, whether multi-department, or single consistent views of the enterprise. Moreover it addresses sponsorship, culture by focusing on performance management as a cultural philosophy, incentives, and data source type.
Ladder of business intelligence	(Cates et al.,2005)	BI	Technology, process and people are the three main areas of the Ladder Maturity Model which work in synchronization using a six-grade scale for each part (Cates et al., 2005). According to Cates et al. (2010), the synchronization of work between technology, process and people leads to two main aspects. First of all, it guides intelligent business to be proactive rather than reactive in addressing problems and improving business processes. Secondly, it allows innovation at every level of the organization so that it is in advance of its competitors. However, Chuah and Wong (2010) criticize the Ladder model as it is not well documented and its maturity levels are not well defined. In addition, the model has been built from a technical point of view, and this means that it is incomplete in terms of BI characteristics. However, this model focusing on information analysis, the process needed, data needed; and frequency of information needed. In addition, it emphasising on IT governance charts and PMO roles, IT governance, sponsorship and business roles (CFO, VP, etc.) technical infrastructure and tools, and data quality and the existence of sources.
Data warehousing stages of growth	(Watson et al., 2001)	DW	The nine main dimensions of the DW maturity model are: data, architecture, stability of the production environment, warehouse staff and users, impact on users' skills and jobs, applications, costs and benefits, and organizational impacts. Each part has a three-grade scale of initiation, growth, and maturity (Watson et al., 2001). The stage of growth theory is used to build the data warehousing stages of growth model. However, the model emphasising benefits associated with data warehouse and costs, the experience and specialization of the warehouse staff, the kinds of applications that utilize warehouse data, and structure of marts and warehouses.

As noted in overview of existing BI MM, there is a small number of maturity models that are information management based; for example, Business information maturity model, which was built by William and William (2007), and SAS Information Evolution Model, which was built by SAS (2009). However, neither of them were complete models because they are not addressing whole information life cycle process in terms of sensing, collecting, organizing, processing, and maintaining. Moreover, while the BI Maturity Model which built by Stock (2013) uses information management as key area, the focus was only on organizing and processing phases rather than use whole information life cycle. In addition, most of the existing BI MMs lack empirical tests as they do not deep enough in terms of addressing BI dimensions, or the key process and assessment levels. However, three main socio-technical aspects of business intelligence maturity model have been proposed in this study according to their importance for BI as has been mentioned in some of the relevant literature, and those are: organizational, human, and technical aspects. Furthermore, the assume that no BI MMs concentrate on the information life cycle, an important part of BI implementation, means that there are shortcomings which need to be overcome. Next section will address these issues by completed content analysis of existing BI maturity models.

4 Content Analysis

Content analysis has been defined by Stone et al. (1966) as "(…) any research technique for making inferences by systematically and objectively identifying specified characteristics within text". Prasad (2008) addressed six main steps for completing content analyses; start with designing of the research objectives or questions, selection of content , developing content themes, completing units of analysis, preparing a pilot testing, and analyzing the collected data.

As mentioned previously, Brooks et al (2013) criticizes key process of existing BI maturity models, which is used in many BI maturity models, because not included technology, people, and organizational processes. However, to build new maturity model levels, top-down approach can be used, by address definitions and dimensions first (Bruin et al ,2005). In same regard, Steenbergen et al (2009) emphasis on the importance of top down method as it is more suitable for new field. Therefore, this part will examine the BI dimensions which have been addressed in exiting BI maturity models, as well as the IMP phases. The main unit analyses of content analysis among current MMs (organizational, human, and technology dimensions) will be examined by completing two main phases. In the first phase, all synonyms of terms of BI dimensions and benchmarking variables of current BI MMs have been addressed with their current definitions (See Appendix A). In the second phase, an alternative expression has been used to change the names of the dimensions and benchmarking variables (See Appendix A). Finally, the content analysis of those BI MMs is carried out to (Table 2).

4.1 BI Dimensions and Their Definitions

Lahrmann et al (2010) mentioned that there is homonymy and synonyms of terms in BI maturity models; as example HP maturity model use "IT" term while Cates et al.(2005) use the term "Technology" . By looking at the definition of dimensions and

benchmarking variables, it is clear that there is a different definition for the same construct in BI maturity models. For example, the human dimension has been defined by Curtis et al. (2010) as "the level of knowledge, skills, and process abilities available for performing an organization's business activities". Cates et al. (2010) define people without differentiating between knowledge and skills by saying that "an intelligent business employs human intelligence to its fullest capacity". In addition, Fisher (2007) addresses people generally by focusing on the type of employee and their contribution to business activities in this way: "who is involved and what contributions must they make". To solve this issue, one definition has been used as an alternative expression, in order to conduct the content analysis of BI maturity models in a successful manner. Therefore, it is important to have alternative expression to the dimensions and benchmarking variables in the existing BI maturity models to carry out comparison between them in appropriate way. The definition of dimensions and variables has been given by used existing BI maturity models authors (See Appendix A), to help us to define the alternative expression. However, many of the existing BI maturity models have not addressed definitions of their variables as most of them practitioner models. Within three basic dimensions (organizational, human, technology), ten matching benchmarking variables of current BI MMs have been founded as shown in table 2 in next section.

4.2 Content Analysis of BI Maturity Models

In this part, content analysis has been carried out for twenty BI MMs in order to examine the BI dimensions which have been addressed (Table 2) in exiting BI maturity models to be used in next step in methodical analysis of IMP model.

Table 2. Analysis Content: BI Maturity Models

BI Maturity Model / BI benchmarking Variables	**Organizational**				**Human**				**Technical**	
	Analytical processes	**organization structure**	**Governance**	**Cost-benefits**	**Skills**	**Training**	**Sponsorship**	**Culture**	**Technical infrastructure/ Tools**	**Data**
The BI Maturity Model (Stock, 2013)	■	■	■	■	■		■		■	■
Enterprise Business Intelligence Maturity Model (Chuah, and Wong,2012)	■	■	■		■					■
Impact-Oriented BI MM Lahrmann et al (2011)	■		■	■	■		■		■	
American SAP User Group (ASUG) (Hawking et al ,2010)	■	■	■						■	
Business Intelligence Development Model (BIDM) (Sacu and Spruit ,2010)	■	■						■	■	■
TERADATA'S BI and DW maturity model (Miller et al ,2009)	■		■	■		■			■	■

Table 2. (*continued*)

TDWI's Business Intelligence Maturity Model (Eckerson,2009)	■	■	■	■			■	■	■	■
Hewlett Package Business Intelligence Maturity Model (HP,2009)	■	■	■		■.		■		■	■
BI MM Steria Mummert Consulting (SMC ,2009)	■	■		■					■	■
Gartner Maturity Model for Business Intelligence and Performance Management (Rayner and Schlegel ,2008)	■	■	■			■	■	■	■	■
SAS Information Evolution Model (SAS,2009)	■	■			■	■		■		■
Business Intelligence Maturity Hierarchy (Deng,2007)				■	■				■	■
Analytical Capability Maturity Model (Davenport and Harries,2007)	■.				■	■	■	■	■	■
Infrastructure Optimization Maturity Model (Microsoft, 2007)				■				■	■	■
Enterprise Data Management Maturity Model (Fisher,2007)			■		■		■		■	■
Business intelligence maturity model (William and William, 2007)	■		■	■				■		
Data Warehousing Process Maturity (Sen et al.,2006)			■		■	■		■	■	■
AMR Research's Business Intelligence/Performance Management Maturity Model (Hagerty, 2006)	■	■					■	■	■	■
Ladder of business intelligence (Cates et al.,2005)	■	■	■				■		■	■
Data warehousing stages of growth (Watson et al., 2009)				■	■				■	■
Σ	**14**	**10**	**12**	**9**	**10**	**5**	**9**	**9**	**17**	**17**

As shown in the analysis section, none of the BI maturity models have applied all the dimensions and benchmarking variables of BI. While some of them focus on organizational factors, such as the HP and Gartner maturity models, the others focus mainly on technical factors. Examples of these are TDWI, Data warehousing stages of growth, and the Ladder maturity model. Human factors like skills, training and culture are addressed only by a few of these models, such as the Analytical Capability maturity model and the impact oriented maturity model. However, although some of them address many factors, the way in which they do so does not seem to be

appropriate. An example of this is the governance factor, which is addressed by the TERADATA maturity model in terms of architecture governance, while the HP and Impact oriented maturity models address it in terms of data governance.

Moreover, some BI maturity models address factors by providing in-depth details while others do not. A case in point is the analytical process factor, addressed by some maturity models by refer to internal environment process without addressing the external environment for that, as does the AMR maturity model, which addresses that by mentioning linking KPIs with organizational strategies without addressing benchmarking variables of customers, markets, and competitors as Analytical Capability Maturity Model. However, next section will address methodical analysis of IMP model in order to link those factors which have been used in existing BI MMs with IMP model.

5 Methodical Analysis

In this part, methodical analysis has been carried out for twenty BI MMs in order to examine the BI dimensions within IMP phase's .The classification of analysis is based on phases of IMP phases, and those are, sensing, collecting, organizing, processing, and maintaining. To complete this task, content analysis procedures have been carried out.

Table 3. IMP Analysis of BI Maturity Models

Maturity Model / IMP phases	IMP phases				
	Sensing	***Collecting***	***Organising***	***Processing***	***Maintaining***
The BI Maturity Model (Stock, 2013)	■		■	■	
Enterprise Business Intelligence Maturity Model (Chuah and Wong, 2012)			■		
Impact-Oriented BI MM (Lahrmann et al ,2011)			■	■	
American SAP User Group (ASUG) (Hawking et al ,2010)				■	
Business Intelligence Development Model (BIDM) Sacu and Spruit (2010)		■		■	
TERADATA'S BI and DW maturity model (Miller et al ,2009)	■		■		■
TDWI's Business Intelligence Maturity Model (Eckerson,2009)	■	■		■	
Hewlett Package Business Intelligence Maturity Model (HP,2009)	■	■	■	■	
BI MM Steria Mummert Consulting (SMC ,(2009)			■	■	
Gartner Maturity Model for Business Intelligence and Performance Management (Rayner and Schlegel ,2008)	■				

Table 3. (*continued*)

SAS Information Evolution Model (SAS,2009)	■	■	■		
Business Intelligence Maturity Hierarchy (Deng,2007)				■	
Analytical Capability Maturity Model (Davenport and Harries,2007)	■	■			
Infrastructure Optimization Maturity Model (Microsoft, 2007)		■	■	■	
Enterprise Data Management Maturity Model (Fisher,2007)		■	■		
Business information maturity model (William and William, 2007)	■				
Data Warehousing Process Maturity (Sen et al.,2006)			■		
AMR Research's Business Intelligence /Performance Management Maturity Model (Hagerty, 2006)		■		■	
Ladder of business intelligence (Cates et al.,2005)	■	■			
Data warehousing stages of growth (Watson et al., 2001)			■		■
Σ	**9**	**9**	**11**	**10**	**2**

By looking at the comparisons between existing BIMMs in terms of IMP phases, as shown in Table 3, it is clear that none of the BI Maturity Models have applied all the IMP phases. A few of them focus on the sensing phase by addressing external environment issues as defined in the IMP Model. For example, the Analytical Capability Maturity Model focuses mainly on the sensing phase in terms of addressing benchmarking variables of customers, markets, and competitors as well as building deep strategic insights, while the AMR Maturity Model addresses the internal environment side, by emphasizing the importance of linking KPIs with organizational strategies. Furthermore, the SAP Maturity Model addresses the internal environment by focusing mainly on performance management and how to build active KPIs that address business needs; however, it does not focus on the external environment as IMP does. However, the BI Maturity Model, which was built by Stock (2013), addresses both environments successfully.

Additionally, while the SAS Maturity Model addresses the sensing phase by focusing on market alignment and efficiency of driving the performance, including the importance of culture and the human aspects in driving organization objectives and understanding the environmental benchmarking, it successfully addresses some of the important variables of the sensing phase. In contrast, the TDWI addresses the sensing phase by emphasizing the importance of managing expected risks and executive-level visions, either by driving the business or monitor processes without a focus on the methodology for the analytical process, or the skills and knowledge that are needed for this phase. In addition, while the Ladder Maturity Model addresses sensing by focusing on the importance of the industry's best practice research, the information needed to answer questions, information analysis in terms of which information, processes and frequencies are required, and the need to be proactive rather than reactive in enhancing business processes, it does not address the required skills and training for that.

In regard to the collecting phase, the Ladder MM focuses on data sources and the quality that is needed to generate information. In contrast, the HP and the TDWI

Maturity Models focus on unstructured content to be integrated with structured data which could help to find new sources of data that can help to provide organizations with their information needs and be used for more influential analysis. Moreover, the Infrastructure Optimization Maturity Model and the Business Intelligence Development Model address the collecting phase by focusing on the data type, be it structured, semi-structured or unstructured; on the data sources, be they files and database, RSS or web based; and on granularity level. In addition, the governance issue in the collecting phase has been addressed by the Enterprise Data Management Maturity Model by focusing on roles, responsibilities, and policies for the data collection phase, while not addressing the training aspect as the IMP Model did.

In the organizing phase, the TDWI addresses the phase by focusing on the management of data architecture, be it data marts, data warehouses, or enterprise data warehouses, whereas the Enterprise Data Management Maturity Model addresses the metadata environment and maintaining metadata for corporate data structures. In addition, the organizing phase has been addressed by Gartner by focusing on data governance and the existence of BICC which emphasizes BI issues such as business metadata and data assurance. Furthermore, the organizing phase has been addressed by the SAS Maturity Model which focuses on information architecture to deliver information consistently.

In addition, as Data Warehousing Process Maturity focuses mainly on the data warehouse aspect from the technical side, the organizing phase has been addressed by focusing on the reliability of data, data warehouse size and architecture. Additionally, it addresses the organizing phase by including the importance of training and rewarding staff. Moreover, the Enterprise Data Management Maturity Model focuses mainly on the organizing phase by focusing on the technology, policies, and rules that are needed for data management. In addition, it includes the reward aspect to be used as a benefit for data management although it does not address the training aspect as the IMP model did. However, this model focuses mainly on data management rather than BI. Therefore, it has addressed the organizing phase successfully but not the sensing and processing phases.

Regarding the processing phase, the HP and TDWI Maturity Models have addressed the phase by putting emphasis on processing data methods, in monthly reports, interactive reports, dashboards, or embedded analytics. The Data Warehousing Process Maturity Model, meanwhile, addresses the processing phase by focusing on the processing of historical and current data. Moreover, it discusses culture issues, such as rewarding for collaboration, sharing information, and fact-based decision making. In addition, the processing phase has been addressed by the Business Intelligence Development Model by focusing on the culture of processing, and on the processing methods used in the organization, whether they are standard reporting, ad-hoc analysis, trends analysis, data mining, or predictive modelling. Furthermore, the processing phase has been addressed by Impact-Oriented BI MM which focuses on analytic purposes, be they forecasting or operational processes. Also, the Business Intelligence Maturity Hierarchy Model has successfully addressed the processing phase by focusing on experience and types of process at each level, whether they are KPIs at the information level, or cause analysis and what-if analysis at the knowledge level. However, as this model focuses mainly on knowledge management, it has successfully addressed the processing phase by focusing on types of process at each level, but does not address the training, and culture that are needed to complete this phase appropriately.

Finally, the DW Maturity Model and the TERADATA Maturity Model are the only models that address the maintaining phase. While the DW Maturity Model addresses the maintaining phase by recognizing the processes for maintaining, the stability of the production environment and increasing the warehouse, the TERADATA Maturity Model addresses it by putting a focus on business continuity, availability, recoverability, and data protection. However, training needs in maintaining or analytics have not been addressed by either of them.

6 Conceptual Framework Development

This paper has presented IMP as a model which addresses information life cycle phases and the BI dimension with benchmarking variables that are commonly used in current BI maturity models. Figure 2 below represents the themes and factors found in the literature analysis to be implicated in the adoption of a BI assessment model.

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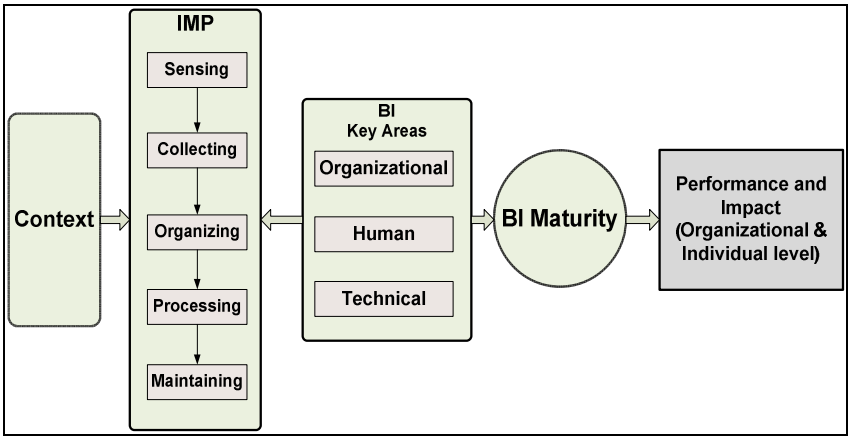

Fig. 1. Conceptual Framework of BI assessment

7 Conclusion and Future Work

In this paper, information life-cycle and Information Management Practice (IMP) have been introduced as new perspectives that are critical for successful BI implementation. Description of an information life-cycle concept and an IMP model has been given. Then, an overview of existing BI MMs has been documented, and compared from a content and IMP model perspective. According to the analysis result, this paper concludes with a conceptual framework link between the information life-cycle, BI capabilities, and organizational performance maturity which will be a base for new BI maturity model future work.

As shown in the analysis section, none of the BI maturity models have applied all the dimensions and benchmarking variables of BI; nor have they addressed all phases of the IMP model. While the existing IMP model addressed only a few BI

benchmarking variables, none of the BI maturity models have applied all the IMP phases. Some of them try to implement the sensing phase in an accurate way, while the others focus mainly on the organizing, processing or maintaining phase the latter only being applied by two models.

Therefore, in order to have a comprehensive BI model that can help in implementing BI, what seems to be important is the maturity assessment which is based on a theoretically derived model of an information life-cycle. This can act as a guide, and help in overcoming the challenges of implementing successful BI by critically determining the impact of the main BI benchmarking factors to be included in any future model.

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Appendix A

Dim/ Variables		**Business Intelligence(BI) Dimension / Variables definition**	
		Resource	***Our Definition***
Organizational	**Organizational**	(Ong et al, 2011 :4)	How an organization is structured to support BI related business processes and which activities of coordinating and managing the BI environment are being carried out.
	Analytical processes	(Devonport, 2007: 114); (Ferris, 2008:8); (Cates et al, 2007:9 ; Fisher, 2007:1); Lahrmann et al, 2010 :7); (Ong et al, 2011 :4)	Address activities of business processes in how to solve analytical problems or transforming vision into competitive advantages.
	organization structure	(Ong et al, 2011 :4); (Lahrmann et al, 2010 :7) Adapted from (Watson, 2001 :45); (Devonport, 1997 :69)	Structure of organization in which units take control and manage the elements of information.
	Cost-benefits	(Watson, 2001 :45); (Hocevar and Jaklic, 2009); (William and William, 2007:201); (William and William, 2007:22)	The costs and benefits of information associated with the BI
	Governance	(Weill, Ross ,2004-b); (William and William, 2007:77); (Ong et al (2011 :5)	Organize approach of principles, practices, and procedures.

Human	**Human**	(Curtis et al, 2010); (Cates et al (2010); (Fisher, 2007 :1); (Lahrmann et al, 2010:7)	Level of knowledge, intelligence, skills, and process abilities of Who is involved and contributes.
	Culture	(Devonport, 2007: 114);(Ferris (,2008:8) ;(Lahrmann et al, 2010 :7)	Criteria that are used to address how organizations maintain the BI environment (i.e. fact-based decision-making)
	Training	(Ong et al ,2011 :4)	Criteria that are used to address how an organization acquires the necessary BI skills and competencies to support business goals.
	Analytic Skills and knowledge	(Brink,2003); (Devonport, 2007: 114); (Ferris, 2008:8) ;(Ong et al, 2011); (William and William, 2007:109)	Necessary BI competencies which depend on experience, interests, task complexity, and productivity that ensure that its BI requirements are built and delivered to users, and are effectively identified, validated, prioritized, and managed.
	Sponsorship	(Devonport, 2007: 114); (Ferris, 2008:8) ;(TDWI, 2007:5)	Level of management that engages support, and commits to BI programme.
Technology	**Technology**	(Ong et al ,2011 :5); (Cates et al, 2007:9); (Fisher, 2007:1); (Devonport, 2007: 114); (Ferris, 2008:8)	Investments in technology and uses of various BI tools and architectures to use the right information to enable effective decision-making, communication and collaboration.
	Tools and Technical infrastructure	(Sen and Sinha, 2005): (William and William, 2007:78) ; (Lahrmann et al, 2010 :7)	Platforms, standard tools, and technologies that will be used to allow BI implementation.
	Data architecture	(Watson, 2001 :45) ; (Lahrmann et al, 2010 :7); (TDWI, 2007:6); (TDWI, 2007:5); (McGovern et al, 2004)	Criteria that are used to address how data are persisted, managed, and utilized within an organization which include structure of marts and warehouses