BUSINESS INTELLIGENCE MATURITY MODELS: OPPORTUNITIES AND RECOMMENDATIONS FOR FUTURE RINVESTIGATION - A SYSTEMATIC LITERATURE REVIEW – PART 2

MODELOS DE MADUREZ DE INTELIGENCIA DE NEGOCIOS: OPORTUNIDADES Y RECOMENDACIONES PARA FUTURAS INVESTIGACIONES – UNA REVISIÓN SISTEMÁTICA DE LITERATURA – PARTE 2

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Abstract

This research aims to show breaches and to propose prospects for the progression of the knowledge of Business Intelligence Maturity Models. In general, the prevalence of generic and descriptive features was revealed. Some gaps related to models that can be modified to specific industrial sectors were detected. This field offers great promises for new investigations and maturity models.

Keywords: Maturity models, Systematic review, Small Enterprises - SME, Business Intelligence.

Resumen

Esta investigación tiene como objetivo mostrar lagunas y proponer oportunidades para el avance en el conocimiento de los modelos de madurez de inteligencia de negocios. En general, se reveló un predominio de características genéricas y descriptivas. Se detectaron algunas lagunas relacionadas con modelos que pueden adaptarse a segmentos industriales específicos. Este campo todavía ofrece amplias posibilidades para nuevos modelos de investigación y madurez.

Palabras clave: Modelos de madurez, revisión sistemática, pequeñas empresas, inteligencia de negocios.

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Introduction

As mentioned in Yamid Fabián Hernández-Julio, Javier, Nieto-Bernal, and Romero-Prieto (2019), this article proposed the following research question - **RQ**: What research gaps presently exist and what research guidelines may be capable in the field of Enterprise Business intelligence maturity models? To answer this question above, and following the methodology used by Xavier, Naveiro, Aoussat, and Reyes (2017), the research team also proposed secondary questions as follows: **Q1**: Which research methods have been used for developing Enterprise Business intelligence maturity models? **Q2**: What are the growth and detailed level of the available Enterprise Business intelligence maturity models? **Q3**: Which research fields, sectors, or market sections have been studied and used as an application unit of Enterprise Business intelligence maturity models? **Q4**: What is the difference in content and predominant characteristics of these Enterprise Business intelligence maturity models?

The remainder of this paper is organized as follows. Section 2 discusses the research method used in this paper. Section 3 discusses the research findings and discussion of the state of art. Section 4 provides the final conclusions of this paper and proposals for future studies, and finally, the references are shown.

Research method

To develop the present work, the researchers used a descriptive methodology. The method used was exploratory. The research method used to develop this work was the systematic literature review. The complete steps were mentioned in Yamid Fabián Hernández-Julio et al. (2019).

Finding and Discussion

Classification and analysis

In this section, the outcomes of the SLR and the amalgamation of the analyzed papers will be reported.

Classification of the Business Intelligence Maturity Model

After analyzing the features of each selected researches, it was done an additional analysis of the proposed models, associated with the quality criteria presented in **¡Error! No se encuentra el origen de la referencia.** (Yamid Fabián Hernández-Julio et al., 2019; Palma, Caycedo, Guzmán, Varón y Ruíz, 2019). According to Xavier et al. (2017), this analysis was not in-depth, since the modeling procedure is flexible and depends on the capability of the modeler and due to the subjectivity on the application of the quality criteria proposed by Santos, Delamaro, and Nunes (2013).

According to the quality criteria shown in mentioned **¡Error! No se encuentra el origen de la referencia.**, the selected papers can be classified by the level of growth. Our study found that some models belong to theoretical issues (No application) or experimental ones (applied researches). As an outcome, around 47% of the models could be considered experimental; and 13% theoretical or conceptual. 33% of the selected studies were conceptual and illustrated models. 7% of the studies were a review of generic maturity models. Besides, about 70% of business intelligence maturity models are generic. 10% of the selected papers were adapted or specified to the Healthcare sector. There were other specific sectors (process and innovation performance 3%, respectively. The banking sector is represented by 3% of the selected studies (Najmi, Sepehri, & Hashemi, 2010). 10% of the works are generic models review or comparison (Fig.).

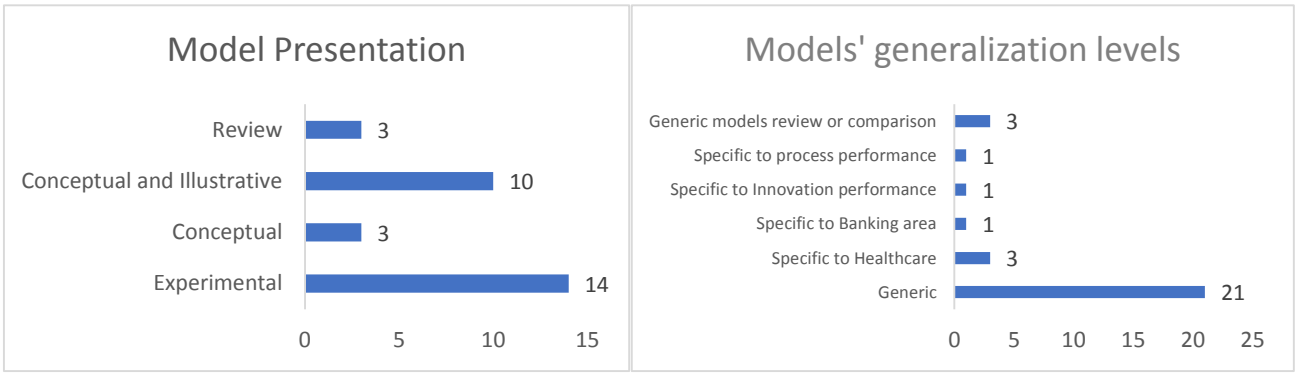

***Fig. 1**. Distribution of researches by level of growth and generalization.*

Regarding of level of detail, following the methodology proposed by Xavier et al. (2017), three categories were established (Superficial, Succinct and Complete or almost complete). The first category represents a small level of theoretic detail. It means, minimal reasoning on each of the elements and their associations, typically intrinsic to documents that have a single page restriction. The second category represents mid-level of theoretic component, where the elements and relations are founded, but deprived of many elements typically inherent to documents that have reasonable page restriction. Moreover, the third one, represents a high level of theoretic component, with all the elements and relations justifiable typically intrinsic to theses or books).

Fig**.** shows that 33% of the selected papers are complete or almost complete responding to all the quality criteria established in **¡Error! No se encuentra el origen de la referencia.** (Yamid Fabián Hernández-Julio et al., 2019). In this case, the first ten authors mentioned in **¡Error! No se encuentra el origen de la referencia.** (1-10) (Yamid Fabián Hernández-Julio et al., 2019) represent this category. 40% of the selected studies denote the succinct category. This category is represented by the next twelve authors mentioned in the table (11-22) (Yamid Fabián Hernández-Julio et al., 2019). The superficial category represents 27 % of the studies. They are characterized by the works of the last eight authors mentioned in the table (23-30) (Yamid Fabián Hernández-Julio et al., 2019).

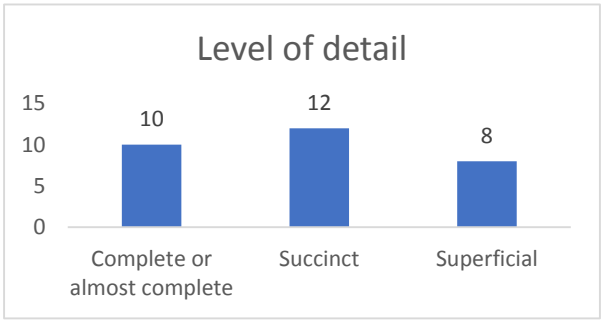

Fig. 2. Distribution of researches by level of detail.

Descriptive analysis of the Business Intelligence Maturity Model

The models of the business intelligence maturity model were analyzed separately according to their essentials and features. After this detailed examination, it was probable to isolated and categorize the 27 models into the different types of validation methods.

According to the results, it could be observed that of all the maturity models' validation methods, the most used was the survey with 21% of participation in the selected papers. Clusters analysis, Expert evaluation, focus group, and Partial Least Square appears afterward, responsible for 8% each one of them. After them, discriminant analysis, confirmatory interviews and Cronbach's alpha are responsible for 6% each. The rest of the validation methods appears with less than 3% of participation in the selected studies.

Also, it can be observed that some authors used more than one validation method. The authors who used more than three methods were (Raber, Winter, & Wortmann, 2012), (Shen, Chang, Hsu, & Chang, 2017) and (Najmi et al., 2010) responsible for 8% each one of them. The authors who used three methods to validate their maturity models were (Lukman, Hackney, Popovič, Jaklič, & Irani, 2011), (Raber, Wortmann, & Winter, 2013), (Tan, Sim, & Yeoh, 2011), (M.-H. Chuah & Wong, 2011a), (Trieu, 2013), (Brooks, El-Gayar, & Sarnikar, 2015), (Dinter, 2012), (Olszak, 2016) and (Bonner & Chae, 2016) with 6% of participation each one. The rest of the authors have less than 5% of participation. As a conclusion, from 100% of the selected studies, 70% used at least one validation method, two authors (7%) done literature reviews, and one of them (3%) made a comparison between models. It should be mentioned that 20% of the authors were did not mention because they did not validate their proposed business intelligence maturity models.

Regarding the users or participants of the respective works, the selection or recruitment criteria, number of participants, and economic sector in the assessment or validation method mentioned, it can be stated that the preferred selection criteria for the different authors about sample choosing was convenience sampling. This can be explained because this type of sampling permits selecting those available cases that accept to be included based on the opportune availability and nearness of the participants for the researcher (Otzen & Manterola, 2017; Daza, Viloria y Miranda, 2018). All participants have experience in BI or DSS or Data Warehousing. The leading selection method was the use of online surveys or paper questionnaires. The recruiting method using the LinkedIn social network is striking. This seems to be an excellent strategy to recruit expert personnel in certain areas. Other authors took advantage of academic events to conduct the surveys (Lahrmann, Marx, Winter, & Wortmann, 2011; Raber, Epple, Winter, & Rothenberger, 2016; Raber et al., 2012; Raber et al., 2013). The economic sectors were mentioned in section 4.1 (Yamid Fabián Hernández-Julio et al., 2019). Respecting the audience of the experts, prevail two kinds of audiences: practitioners and management-oriented communities. About the number of participants, the minimal number was 5 and the mentioned maximum was 171 participants in the respective case studies or focus groups to validate the respective proposed business intelligence maturity model.

Regarding remain of the main characteristics of the business intelligence maturity model, we found the key process areas, dimensions and levels. In this study, we are going to mention those categories that were more frequently assessed or mentioned in the selected papers, it means, technologies, process, organizational processes, people/workforce and knowledge management (Lahrmann et al., 2011; Raber et al., 2012).

Table 1. Key process area or dimension characteristics.

People		
Maturity Model Dimension	**Maturity Model KPA**	**Components**
Data WareHousing Stage of Growth – DWH SoG (Brooks et al., 2015). Gartner´s (Côrte-Real, Neto, & Neves, 2012; M.-H. Chuah & Wong, 2011a, 2011b, 2013; Hribar Rajterič, 2010; Olszak, 2013, 2016; Ong, Siew, & Wong, 2011; Russell, Haddad, Bruni, & Granger, 2010; Tavallaei, Shokohyar, Moosavi, & Sarfi, 2015). Dataflux (Brooks, El-Gayar, & Sarnikar, 2013; Brooks et al., 2015). Business Intelligence Development Model - BIDM (Sacu & Spruit, 2010)	Ladder of Business Intelligence - LOBI (M.-H. Chuah & Wong, 2011b, 2013; Olszak, 2013, 2016; Tavallaei et al., 2015). Capability Maturity Model for BI - CMM (Brooks et al., 2015; Raber et al., 2012). Enterprise Business Intelligence Maturity Model - EBI2M (Brooks et al., 2015; M.-H. Chuah & Wong, 2011a, 2013; M. H. Chuah & Wong, 2014). AMR Research BI/Performance Management MM – AMR (M.-H. Chuah & Wong, 2011b, 2013; Hribar Rajterič, 2010; Olszak, 2013, 2016). Dataflux (Brooks et al., 2013, 2015). Healthcare BI (Brooks et al., 2015).	People skills (Brooks et al., 2015; Lahrmann et al., 2011; Olszak, 2016; Ong et al., 2011; Tavallaei et al., 2015). Project management (Brooks et al., 2015). Responsibility and Flexibility (Hribar Rajterič, 2010). Theoretical foundation (Brooks et al., 2015; Lahrmann et al., 2011; Raber et al., 2012; Raber et al., 2013). Change Management (Brooks et al., 2015; M.-H. Chuah & Wong, 2011a, 2013; Olszak, 2016; Ong et al., 2011).
Technology		
BI Maturity Model - biMM (Vukšić, Bach, Grublješič, Jaklić, & Stjepić, 2017). Gartner's. Service-Oriented BI MM - SOBIMM (Prieto-Morales, Meneses-Villegas, & Vega-Zepeda, 2015; Prieto Morales, Meneses Villegas, & Vega Zepeda, 2015; Tavallaei et al., 2015). Logica (Côrte-Real et al., 2012). BI Infrastructure Maturity Model – BIIMM (Tavallaei et al., 2015). Malaysian Organizational BI – MOBI (Lih & Hwa, 2013; Ong et al., 2011). Dataflux Economic transitional BI MM (Lukman et al., 2011) EBI2M. BIDM.	CMM for BI. LOBI. Dataflux. Healthcare BI. AMR.	Metadata management (M.-H. Chuah & Wong, 2011a; Ong et al., 2011). Dashboards (Lukman et al., 2011; Olszak, 2013). Technical architectures and Information design (Dinter, 2012). Interactive reports, Standalone databases, Data consistency, and Transactional systems, static reports (Lukman et al., 2011). Hardware, Software (Tavallaei et al., 2015). Network (Prieto-Morales et al., 2015; Tavallaei et al., 2015). Data quality (Brooks et al., 2015; Lukman et al., 2011; Ong et al., 2011; Trieu, 2013). Technical flexibility and Quality (Tavallaei et al., 2015). OLAP (Online analytical Processing tool) (Lukman et al., 2011; Najmi et al., 2010; Ong et al., 2011). Data management, Reporting and analysis (Ong et al., 2011). Data warehousing (M.-H. Chuah, 2010; M.-H. Chuah & Wong, 2011a, 2013; Lahrmann et al., 2011; Lukman et al., 2011; Najmi et al., 2010; Olszak, 2016; Ong et al., 2011; Raber et al., 2012; Raber et al., 2013; Spruit & Sacu, 2015). Extract-Transform-Load (ETL) (Najmi et al., 2010; Ong et al., 2011; Spruit & Sacu, 2015).

		Master data management (M.-H. Chuah & Wong, 2011a, 2013; Ong et al., 2011; Tan et al., 2011). Data Integration (Lukman et al., 2011; Trieu, 2013). Data Architecture (Brooks et al., 2015; Dinter, 2012). Theoretical foundation. Data mining methodologies (Lukman et al., 2011; Najmi et al., 2010; Prieto-Morales et al., 2015). Analytical tools (Bonner & Chae, 2016; Brooks et al., 2015; M.-H. Chuah & Wong, 2011a, 2013; Lukman et al., 2011; Olszak, 2013, 2016; Ong et al., 2011; Raber et al., 2013; Tan et al., 2011; Vukšić et al., 2017).
Organizational processes		
SOBIMM biMM	Healthcare BI CMM for BI Dataflux	Processes (M.-H. Chuah & Wong, 2011b; Dinter, 2012; Hribar Rajterič, 2010). Strategy (Dinter, 2012; Raber et al., 2013). Vision and BI strategy, Learning organization, Management engagement and Support (Brooks et al., 2015). Theoretical foundation. Knowledge management (Brooks et al., 2015; M.-H. Chuah, 2010; M.-H. Chuah & Wong, 2011a, 2013; Olszak, 2013; Prieto-Morales et al., 2015). Profitability (Dinter, 2012; Tavallaei et al., 2015). Business expertise (business service, credibility, leadership processes and organization value) (Prieto Morales et al., 2015; Tavallaei et al., 2015).
Process		
Guía Metodológica para Mejorar BI - GMM-BI (Prieto-Morales et al., 2015). MOBI. BIDM	LOBI EBI2M.	Data governance (Brooks et al., 2015). Structure and rules (Tavallaei et al., 2015). Implementation (Ong et al., 2011; Raber et al., 2012). Metadata management. Data management. Master data management. Change Management (Brooks et al., 2015; M.-H. Chuah & Wong, 2011a, 2013; Olszak, 2016; Ong et al., 2011).
Knowledge management		
BI Maturity Hierarchy – BIMH (M.-H. Chuah & Wong, 2011a, 2011b; Hribar Rajterič, 2010; Olszak, 2013, 2016). EBIMM (M.-H. Chuah, 2010).	EBI2M	Learning organization (Brooks et al., 2015). Intellectual capital (Prieto-Morales et al., 2015).

From the table above, we can highlight the following:

1. Gartner's maturity model was the most cited in the selected papers regarding the established parameters.

2. According to the ATLAS.ti software, the most quoted maturity model with different parameters to those established in the table, was TDWI.

3. Regarding maturity models covering at least three main components are LOBI, Healthcare BI, EBI2M, BIDM, and Dataflux.

4. Within the People category, People skills and Change Management were the most mentioned components in the selected works. The first one, according to Tavallaei et al. (2015) is the most essential and vital property of every organization. Quality and human resource aptitudes are the most critical issues for the administrations to subsist and life. The clever human resource makes a challenging organization. The second one, Change Management refers that BI involves perpetual development and adaptation to new challenges and opportunities for the organizations (Olszak, 2016), for that reason, organizations would need to have organized change management processes for ensuring that standardized events are applied to every new project or a new change in a systematic way (Ong et al., 2011).

5. In the Technology category, the Data warehouse and analytical tools were the most quoted components. This indicates the importance of these components within BI. The first component belongs to DWH SoG, TDWI, and EBIMM dimensions and as a key process area, belongs to EBI2M, Economic BI, MOBI, and Iranian banking BI MM (Najmi et al., 2010). The second component, according to Lukman et al. (2011) includes the many tools that could be used for producing, analyzing, and delivering information. Howson (2007) mentions to these tools as front-end tools, specifically interactive reporting tools, Online Analytical Processing (OLAP), analytical applications, data mining tools, and dashboards. To Watson (2013), these tools can be categorized as descriptive, prognostic, or prescriptive. According to (Olszak, 2016), the most significant contain Extraction, Transformation and Load tools, data cleaning, OLAP, online transaction processing (OLTP), predictive modeling and data mining, text mining and web mining, exponential random graph models (ERGMs), search-based applications, real-time BI, in-memory databases, NoSQL, dashboards, and interactive visualization tools.

6. The Theoretical component foundation is located within the categories of People and Technology. This is because this component becomes a critical factor in the implementation of BI (Brooks et al., 2015). For the case of both categories (people and Technology), the most representative theoretical basis would be the socio-technical theory (Brooks et al., 2015), this could be worked with Kernel theories, among them, cognitive fit theory, task-technology fit theory, diffusion of innovation theory, and the IS success model (Delone & McLean, 2003). Most of the selected maturity models do not provide a theoretical foundation based on these theories (Raber et al., 2016).

Regarding the theoretical foundation on the methodologies or approaches used for the elaboration of maturity models, the following can be found: *Design Science Research Methodology*, *grounded-theory*, *and Inductive Design approach*. The objective of the first approach is to advance problem-solving competences by making artifacts such as concepts, models, approaches, and instantiations (Hevner, March, Park, & Ram, 2004). According to Brooks et al. (2015), a maturity model could be considered an object for solving a business problem; in this case, business intelligence maturity. This approach was used by Spruit and Sacu (2015), Dinter (2012) and Brooks et al. (2015). The purpose of the second approach study is developing a theory for a process from data from participants who have experienced the process (Crewell, 2013). According to the same author, it is a suitable investigation method when there are no accessible models for a process, or the available models are incomplete or define examples other than the one that the researcher is interested in. This approach was used by Olszak (2016). The third approach objectives for generating meanings from the data set collected to recognize patterns and associations for building a theory. Nevertheless, the inductive approach does not prevent the researcher from using the remaining theory to express the research question to be explored (Saunders, Lewis, & Thornhill, 2012). This approach was used by Raber et al. (2013).

7. In the category Organization processes, knowledge management was the most mentioned in the selected papers. In this case, it means that the company should accumulate the knowledge produced in the bases to use it to its benefit (Prieto-Morales et al., 2015). Knowledge is defined as "information consisting of organized data and facts. It consists of truths, beliefs, perspectives, concepts, judgments, expectations, methodologies, and know-how" (Davenport, 1996). In (Prieto-Morales et al., 2015), the organization can recognize processes, being appreciated for the company for registering the learned lessons. At that point, an organized method is presented to obtain the knowledge produced by the learned lessons. Later, the documented knowledge is guided to the human resource performing similar activities. This component is related to intellectual capital and the knowledge base (Prieto-Morales et al., 2015). The last one can be referred to as "an organized repository of information, which includes concepts, data, standards, and specifications for effective knowledge management. This repository can collect, organize, share, and search information" (Krishnan, 2013).

8. In the Process category, the most mentioned component was Change Management. This topic was already mentioned in item number 4.

Regarding to the maturity models' levels, these are representative states of maturity of the object that is assessed. Each level should have a set of distinct features (practices, measures or activities per dimension) that are empirically testable (Nolan, 1973). The results show that some models had their foundational base in those levels names proposed by the Software Engineering Institute (SEI) (2010) through the concept of Capability Maturity Model – CMM. However, some authors adapted or changed the names of the original levels. W. Humphrey proposed the concept of CMM in 1986 as a model of maturity capability focused on best practices for the software development process (Prieto Morales et al., 2015). Similarly, it can be defined as a process improvement method that delivers a recommendation across a project, a division or a whole organization as well as a quality process (Schwalbe, 2013). The rest of the authors used other names for every level.

1. BIIMM and SOBIMM have the same maturity levels (Initial, Immature, Controlled, Managed and Mature). EBIM, MOBI, DWCMM, EBIMM have the Software Capability Maturity Model' names (Paulk, 1993) at their respective levels (Initial, Repeatable, Defined, Managed, and Optimizing). Iranian banking, EBI2M and Healthcare BI have the original CMMI levels names (Initial, Managed, Defined, Quantitatively Managed and Optimizing). For its part, CMM for BI changed all CMM original levels names.
2. Of all maturity models' levels, only an 8% of them have six levels (LOBI and BIDM). Most of them (58%) have five levels, 21% of them have four levels, and the rest (13%) have three levels. Some maturity models did not mention any levels. These results are in concordance with the statements of Fraser, Moultrie, and Gregory (2002).
3. 100% of the maturity models' names present a descriptor for each level (names). However, not all maturity models present several components which might or might not be present in each model proposed by (Fraser et al., 2002), it means, a generic explanation or summary of the features of each level as a whole, or, a description of each activity as it might be done at each maturity level.

Below are descriptions of the maturity levels discussed above. Levels 1 and 5 will be exposed. The names of the maturity models that are not mentioned did not have any description within the selected papers:

LEVEL 1 Descriptions

"Reacting": organizations rely on desktop tools and ad-hoc queries performed by individuals (Hribar Rajterič, 2010). "Data": an organization at this level collects, cleans, normalizes and preserves data from different sources consistent. The aim at this phase is to establish integrated, clean and high-quality data. This is an initial point for introducing DW and BI (Hribar Rajterič, 2010). "Initiate" is characterized by a high degree of decentralism with virtually no standardization efforts, representing an early and undeveloped state of BI. In more detail, the BI organization, responsibilities, and sponsorship are decentralized, rendering standardization initiatives nearly unsuitable. From a technical point of view, the BI infrastructure is previously operated centrally and basic skills as ad-hoc analyses are providing (Raber et al., 2012). "Conception": conception Phase started with the acquisition of off-the-shelf tools to meet a demand for improved information diversity and reporting. At conception, business intelligence is loosely structured (Russell et al., 2010). "Immature organizations" The poor information quality is moderately a consequence of the absenteeism of advanced technological infrastructure, especially front-end tools, which would serve the information needs of business users (Lukman et al., 2011). "Initial": in this level, there is no process area, and processes are chaotic (M.-H. Chuah & Wong, 2011a). Process unpredictable, poorly controlled, and reactive (Najmi et al., 2010). There are no consciousness of any information quality (IQ) issues. Therefore no attempts are made to assess or improve information quality. The organization acts in response only when information quality problems occur (Tan et al., 2011). "Unaware": the first level is frequently labeled as "information anarchy." It means that data are incomplete, incorrect, or inconsistent, and the organization does not have defined metrics. The uses of reporting tools are limited (Olszak, 2016). "Individual Information": according to Dinter (2012), at the first phase, analytical information is collected using isolated, clumsy queries. Neither there is a systematic methodology nor are technical competences of BI tools exploited. Therefore, many inadequacies like redundancies, heterogeneity, missing transparency, and high manual efforts characterize this stage. Organizational structures and processes, dedicated to BI, do not (yet) exist.

LEVEL 5 descriptions:

"Pervasive": BI plays a persistent role in all areas of the business and corporate culture. BI provides flexibility for familiarizing with fast business changes and information demand. The users have access to information and analysis needed for creating business value and persuading business performance. The usage of BI is accessible to customers, suppliers, and other business partners (Olszak, 2016). "Optimizing": is the level where organizations establish structures for continuous improvement (M.-H. Chuah & Wong, 2011a). There is ongoing inventiveness for improving the processing of information quality problems. The hub is fully joined into the application system environment. The organization concentrates on continuous analytics assessment and improvement (Tan et al., 2011). "Optimized": focus on process improvement (Dayan & Evans, 2006). "Perpetuate": this stage of maturity needs a complete BI strategy to be specified and frequently updated. Besides, BI performance management and pro-active data quality management need to be established (Raber et al., 2012).

In conclusion, regardless of the different names given to the respective levels, they have similar characteristics on the description of the necessary components of the business intelligence maturity models (dimensions, key process areas, data, analytical tools, change management, among others). Different conclusions can be that higher levels should be of more excellent utility than lower levels (Brooks et al., 2015). According to the previous statement, higher-level functionality

should include predictive data mining and predictive analytics (Bellazzi & Zupan, 2008), as proposed by Olszak (2016), Howson (2007), and Watson (2013).

After categorizing the selected documents and their projected models, to answer the research questions, the outcomes were analyzed together. Through this analysis, some breaches and opportunities for future investigation can be projected.

Answer to the research questions

Q1: *Which approaches, and research methods have been used to develop Enterprise Business intelligence maturity models – EBIMMs?*

Most of the selected studies had a qualitative approach, being conceptual models and surveys the most used methods, more than half with national coverage. The location of the studies application was more representative in Malaysia, Switzerland, and Slovenia. The concentration of applied studies was in Europe. The most commonly used for approach for the elaboration of maturity models was the Design Science Research Methodology.

Q2*: What is the development and detailing level of the published Enterprise Business intelligence maturity models?*

The primary two databases that providing the maximum number of EBIMMs were the IEEE Xplore Digital library and Scopus. The main form of models' publication is through conference proceedings, with great emphasis on the first database. These conferences were held around the world. The other form of models' publications is through scientific journals with an emphasis on Information Systems Management. According to these results, this feature may be associated with the circumstance that almost half of the selected papers are classified in the succinct and complete or almost complete categories due to the inherent moderate pages limitation. It is worth mentioning that in this work, no books or master's and doctoral thesis were consulted.

Regarding the models' presentations, most models indicated descriptive characteristics and almost half of the selected papers are considered experimental. Conceptual and illustrative models appear afterward. From this fact, it appears that the rest of the models need a more significant application for the validation of the selected models through new investigation. Using quantitative approaches such as surveys (most used validation method - **¡Error! No se encuentra el origen de la referencia.**) could be developed, reaching a more excellent geographical coverage, going beyond national borders, thus increasing the field of action of the selected models (Xavier et al., 2017).

Even though almost half of the selected models were experimental, the most of them had a high level of generalization (generic); only a few are explicit to some sector industry or company. A benefit of a generic BI maturity model is that it can be used for any sphere, but a disadvantage is that unique or highly significant information needs of a specific domain, may not be addressed in detail (Brooks et al., 2015). Most of these maturity models have their origins in practice and are scarcely documented. Thus the respective construction processes have not been published or are poorly documented (Côrte-Real et al., 2012). Also, the documentation of several maturity models was not well defined, and they do not offer any guidelines or surveys for evaluating maturity levels. If the companies want to distinguish careful business intelligence maturity levels, they must use multiple models and that it is time-consuming. For the reasons above, adapted or specific business intelligence maturity models must be developed, tested, and validated (Xavier et al., 2017) with good documentation and access to understanding (Hribar Rajterič, 2010).

***Q4**: Which research fields, sectors, or market segments have been studied and used as an application unit of Enterprise Business intelligence maturity models?*

Of the generic experimental models, the research fields and segments with the more significant application was Services Industries (telecommunications, banking, insurance, financial, services, marketing, consulting, among other market segments). Other maturity models enclosed a group of different businesses of diverse sectors (non-services: manufacturing, construction, logistics, automotive, among others) regions. This fact could be explained because the services industry focuses more on refining products and services for their customers, and non-services industries focus on improving processes for the production and distribution of their products and services (M. H. Chuah & Wong, 2014; Lih & Hwa, 2013). Generally, organizations from service industries achieved a higher mean score in the maturity models than the non-service industries. BI is often associated with service industries, especially the financial and healthcare industries (Lih & Hwa, 2013).

***Q5**: What is the difference in content and predominant features of these Enterprise Business intelligence maturity models?*

After a comprehensive analysis, it was conceivable to separate and categorize the models according to the models' approaches. Almost half of the selected models could be characterized as conceptual models and surveys, respectively. Case studies appear afterward. Some of the maturity models are characterized as a framework, comparative and literature review.

A framework can be labeled as a set of mechanisms and independent structures that have a predefined connection (Pree, Fontoura, & Rumpe, 2001). Frameworks simplify the understanding and communication among members that may have diverse viewpoints in a specific situation (Odeh & Kamm, 2003). These frameworks belong to the conceptual and illustrative category.

In the comparative study, Prieto Morales et al. (2015) presented a quantitative and qualitative methods to determine similarities among five maturity models (M.-H. Chuah & Wong, 2011a; Eckerson, 2007; Huffman & Whitman, 2011; Shaaban, Helmy, Khedr, & Nasr, 2011; Tan et al., 2011). The method of study of similarities and standards (MESME) and the technique of data envelopment analysis (DEA) was used to characterize them. The results show that with this method and technique application, it can be inferred that existing maturity models in BI have different approaches, among them culture, systems or data, processes, data warehousing or services. Most of these models are oriented to a dimension. According to the authors, TDWI has three similarities with the EBIM model (Tan et al., 2011). For the other models, no similarities were identified between them.

The literature review shows that the greatest of the models do not cover the entire area of Business Intelligence, but they instead focus on a specific point of view and area of the problem domain. Outcomes show that by using maturity models, only a short period is needed for one to discover the areas within the institution that need unique, more intensive attention and work (Hribar Rajterič, 2010). Among the results, the greatest of them do not consider all issues affecting BI. Some of BI maturity models focus on the technical aspect and some of the models focus on a business point of view (M.-H. Chuah & Wong, 2011b).

Regarding other predominant characteristics, the most used data collection technique in the applied studies was the questionnaire. Clusters analysis, Expert evaluation, focus group and Partial Least Square appears afterward as maturity models' validation methods. Almost half of the studies who used questionnaires used a Likert scale. The majority of the selected models were generic.

Some maturity models were adapted to specific sectors. The preferred selection criteria for the different authors for sample choosing was convenience sampling. All participants of the studies had experience in BI or DSS or Data Warehousing.

Regarding People category, People skills and Change Management were the most mentioned components in the selected works. The last one was also most mentioned in the Process category. The Data warehouse and analytical tools were the most quoted components in the technology category. A data warehouse is an instrument for the centralized storing of data so that this data can be analyzed in various manners. However, for diverse motives, such as an absence of technical know-how, several organizations still do not use a data warehouse (Lukman et al., 2011). In Organization processes, knowledge management was the most mentioned in the selected papers. In the level category, most of the MMs have five levels. The primary foundational base for the name or classification of the levels in the respective maturity models is CMMI levels.

The results show a trend in models dedicated to assessing the Business Intelligence maturity in Medium and Large enterprises in service and non-service industries. According to Lih and Hwa (2013) and (Raber et al., 2013), in Service Industries focus more on technology and outcome dimensions, while non-service industries focus more on technology and organizational dimensions. This could be attributed to the alteration in quality enhancement plans (Lih & Hwa, 2013). In general, greatest competences are easier for implementing for large companies in the first maturity levels, whereas small and medium-sized companies do not finish the evolution in the first levels (Raber et al., 2013).

Gaps and opportunities for future investigation

In this section, we are going to expose our findings of this topic according to the research questions above.

Regarding the research area, content, and predominant features: as we said previously, the results show a trend in the modeling of BI maturity in Medium and large companies. In the selected articles where they applied model validation through different techniques, micro and small companies did not have much participation. The validation models' sectors were the service industry (tertiary sector) and the non-service industry (secondary sector). Among the selected models, the primary sector was not much consideration for the validation; only one work mentioned a primary sector (plantation). On the other hand, the quaternary sector did not have any representation within the companies that participated in the case studies. Therefore, for future researches, these sectors could be considered.

Some of these models are focused on technology and outcome dimensions. According to (M. H. Chuah & Wong, 2014), the majority of the models do not focus the business intelligence as a whole, which some of the maturity models emphasis the technical aspect and some of the maturity models emphasis on the business point of view. Continuing with the idea of the author, some models only concentrate on the data warehousing and analytical tools, while others only concentrate on other components like process, organizational processes, etc. In that sense, in front of the proposal of a new maturity model, a balance must be sought between its main components.

Regarding the sectors, according to the nature of the holders of property rights, it can be mentioned that most cases were validated in private organizations. Only one study worked with public and private banking organizations. Therefore, there is a gap regarding the application of maturity models in public sector companies.

Most of the authors of the selected articles belong to Higher Education institutions throughout the world. It means that it is the academic community that is proposing business

intelligence, maturity models. At the same time, there are also models created by the practitioners' communities. The ideal would be joining the two communities (academic and practitioner) and try to standardize one or several maturity models with the aim of companies having a common reference.

Regarding to the theoretical foundation, this describes if the model is explicitly based on accepted (design) theories (Biberoglu & Haddad, 2002). Brooks et al. (2015) stated that the maturity procedures should suggest theory by demonstrating social and technical subsystems, and by incorporating key process areas and dimensions, which include people, technology, and organizational processes. In the selected works, socio-technical, kernel and stage of growth theories were used. In this sense, most of the works have lacked in the theoretical foundation, which makes it difficult the understanding the underlying maturity concept and relationships between the different parts of a maturity model (Lahrmann et al., 2011; Raber et al., 2012; Cardona, Lamadrid y Brito, 2018;). Therefore, it is recommended to use a theoretical foundation related to the thematic that helps to understand the relationships between the model components. Because most of the papers used surveys, case studies, and interviews, we recommend the use of the grounded-theory, whose purpose is to develop a theory for a process from data from participants who have experienced the process (Creswell & Poth, 2017). According to the author, it is a suitable research technique when there are no available models of a process or the available models are incomplete or describe samples other than the one that the researcher is interested in (Babarskiene & Gaiduk, 2018; Creswell & Poth, 2017).

Regarding the validation or assessment methods, despite the existence of different model validation methods, some authors did not perform this process for the respective proposed maturity models. Some authors did so to a lesser or greater extent. For some authors, the number of methods used can be low because an essential aspect of competitive intelligence within organizations is being evaluated. In this case, it is recommended to use at least three or more validation approaches (qualitative and quantitative) in the case of proposing new BI maturity models. In this aspect, because the models were tested only in a few cases, it is not possible to generalize the findings to any given similar situation. For that reason, we recommend that the number of participants is representative at the local, regional, national or international levels, depending on the capacity of the new proposed maturity model.

In the case of the BI maturity models' documentation, most of them are not well defined and poorly documented. Some of them have been developed based on empirical data, but no complete details about the construction process have been published because of the moderate page's limitation. In this case, we recommend mentioning in a new BI maturity model proposal the original research thesis or document where the reader can get the complete documentation.

In other words, by putting all these shortcomings together, it can be stated that most of the existing maturity models have a lack of transparency, comprehensiveness, systematization, appropriate assessment tools, and the lack of empirical data (Dinter, 2012).

Regarding the generalization level: at this point, the number of generic maturity models found attracts attention. This feature can be considered an advantage because it has excellent coverage of knowledge of the BI field. However, at the same time, it could be considered a disadvantage because the different economic sectors are treated in the same way. That is, a small and medium enterprise cannot be compared to a large company. A service company is not equal to a non-service company. A private company is not the same as a public-sector company (with or without profit). Because there are few specific to different segments' maturity models, the research team considers that the framework proposed by (Brooks et al., 2015) represents an opportunity for

the development of new business intelligence maturity models aimed at a specific domain with their (s) respective market segment (s). At the same time, it will be collaborating with the validation of this framework. Another existing framework is proposed by (Prieto-Morales et al., 2015), whose purpose is to measure, analyze, plan, and implement BI maturity improvements in an organization for a given key process area (KPA). This framework is useful for those areas that need to be improved.

Regarding the detail level: Books, theses, and dissertations were not analyzed. Therefore, in the selected papers, most of the analyzed models have succinct and superficial levels, some of them with no conclusive grounds. In this case, it is an opportunity for doctoral and master's students to refer their works. It means that in the event of final publication (journal article, conference proceeding) mention the original research thesis where readers can get the complete construction process for the replicability (Warning: this recommendation could represent a violation of the principle of blind review by the journals). In case that the doctoral thesis or masters' dissertation becomes a research book, the methodology used in the study should be fully described.

Regarding the development level: the level of development of the existing maturity models allows opportunities such as: first, to try to validate the proposed conceptual models that have not yet been validated by the authors, second, to have the opportunity to develop new BI maturity models adapted to specific segments not studied, such as construction, primary economic sector, automotive, military, naval, public enterprises, all quaternary economic sector, among others, and validate them through the framework proposed by Brooks et al. (2015).

Conclusions

The main objective of this work was to identify, evaluate, and analyze the primary source of information, to respond to a specific research question about the field of Business Intelligence maturity models. Therefore, it was conceivable to highlight as gaps and capable opportunities for future investigation in the field of BI maturity models:

- BI MMs literature shows that most of the selected models do not cover the complete domain (BI), only covers some specific parts of it or only one BI point of view. In this case, a maturity model will always include some subjective impact;
- Many of the analyzed models focus on the integration of the organization, people, and technology. As a recommendation, for the new proposals for business intelligence maturity models, these three aspects should be considered;
- There are few adapted BI maturity models to some economic segments. Thus, there are opportunities to create and validate new maturity models according to the framework proposed by (Brooks et al., 2015);
- Few are mature models of BI with a high level of detail (complete). Therefore, the possibilities of working on proposals for new models of maturity for business intelligence in the different economic segments mentioned above are increased. This opportunity would be for masters or doctoral students of higher education institutions around the world. This would achieve greater visibility through their publications and their original works (research or academic books, journal article or conference proceedings);
- Some economic segments have not been studied yet, such as the primary, quaternary, public sector, among others.
- Some organizations underestimate the soft skills, e.g., culture-based on facts and knowledge, trust, human resources management, or managing analytical/creativity people. For that reason,

an opportunity for future research has the people skills within the new proposal of maturity models.

- From the selected models, outcomes show that most significant the companies are not gotten the highest maturity levels independently of the model.
- There are few adapted BI maturity models to Micro and small enterprises. Thus, there are opportunities to create and validate new maturity models according to the framework proposed by (Brooks et al., 2015) for this sector.
- Within the analytical tools mentioned in the selected articles, no computational intelligence tools were found. Therefore, this is an opportunity to create frameworks to develop business intelligence based on computational intelligence (Y. F. Hernández-Julio, Paba, Narváez, Hernández, & Bernal, 2017).

For developing this work, the main challenge was to find validated maturity models by the scientific community. On the one hand, most of the mentioned models in this work belong to conference proceedings, that is, in some cases, the rigor of the articles' validation data is less than those of a scientific journal. At conferences, most reviews are done by masters or doctoral students. In journals, the reviews are carried out by academic staff with doctoral training (usually) and with a long career in the specific knowledge field. This revision is doubly blind; that is, it is performed by two unknown pairs.

On the other hand, some of the selected articles belong to journals that were not indexed in all databases. Therefore, the quality criteria varied depending on the selected indexed databases. Another challenge was to find the complete models' documentation. Most of the information about the BI maturity models were collected using grounded theory through the software ATLAS.ti.

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