



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

**ScienceDirect**

Procedia Computer Science 121 (2017) 194–205

**Procedia**  
Computer Science

[www.elsevier.com/locate/procedia](http://www.elsevier.com/locate/procedia)

CENTERIS - International Conference on ENTERprise Information Systems / ProjMAN - International Conference on Project MANagement / HCist - International Conference on Health and Social Care Information Systems and Technologies, CENTERIS / ProjMAN / HCist 2017, 8-10 November 2017, Barcelona, Spain

## Business Intelligence and Analytics in Small and Medium-sized Enterprises: A Systematic Literature Review

Marilex Rea Llave\*

*Department of Information Systems, University of Agder, 4604 Kristiansand, Norway*

---

### Abstract

Despite much interest in business intelligence and analytics (BI&A), empirical research shows that small and medium-sized enterprises (SMEs) are still lagging behind in the proliferation of BI&A. However, there are no studies found on literature reviewing research on BI&A in SMEs. This paper collects, categorizes, synthesizes, and analyzes 62 articles related to BI&A in SMEs. The identified research topics being addressed in BI&A include: BI&A components, BI&A solutions, Mobile BI&A, Cloud BI&A, BI&A application, BI&A adoption, BI&A implementation, and BI&A benefits. Further, research gaps and directions for future research are presented to facilitate the progression of BI&A in SMEs research.

© 2017 The Authors. Published by Elsevier B.V.

Peer-review under responsibility of the scientific committee of the CENTERIS - International Conference on ENTERprise Information Systems / ProjMAN - International Conference on Project MANagement / HCist - International Conference on Health and Social Care Information Systems and Technologies.

*Keywords:* Business intelligence and analytics; SMEs; BI&A review; BI&A solutions; BI&A adoption; BI&A implementation; BI&A benefits.

---

\* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .

*E-mail address:* [marilex.r.llave@uia.no](mailto:marilex.r.llave@uia.no)

## 1. Introduction

“Small and medium-sized enterprises (SMEs) account for about 90 percent of businesses and more than 50 percent of employment worldwide according to the International Finance Corporation”<sup>1</sup> (p.1). They play a major economic and social role, and therefore, they have become a source of economic development<sup>2</sup>. Thus, the need to improve SMEs’ competitiveness worldwide is crucial. However, SMEs are typically vulnerable and not robust enough to withstand the onslaught of economic and global competition<sup>3</sup>. In order to survive, they must be able to monitor their business and use all their resources efficiently, especially information resources<sup>4</sup>.

“Business intelligence (BI) is a set of methodologies, processes, architectures, and technologies that transform the raw data into meaningful and useful information which allows users to make informed business decisions with real-time data”<sup>5</sup>. According to Yeoh<sup>6</sup> the term “business intelligence” was first coined by Luhn in 1958<sup>7</sup>. However, as Burstein and Holsapple<sup>8</sup> recalled, the term “business intelligence” was reintroduced by Howard Dresner when he defined BI as “a broad category of software and solutions for gathering, consolidating and analyzing, and providing access to data in a way that let enterprise users make better business decisions”<sup>9</sup>.

The new term business analytics (BA) emerged in the late 2000s and focused on the analytical component of BI<sup>10</sup>. Thus, business intelligence and analytics (BI&A) was used as a unified term to describe information-intensive concepts and methods for improving business decision making<sup>11</sup>. According to Gartner’s survey, BI&A appears to be the top CIO’s technological choice for increasing competitiveness in the past few years<sup>12, 13</sup>. Therefore, Chaudhuri et al stated that “Today, it is difficult to find a successful enterprise that has not leveraged BI&A technology for their business”<sup>14</sup> (p.91). Moreover, for the rest of the paper, the term BI&A is used.

Notwithstanding its importance, there is a dearth of literature on BI&A in SMEs<sup>15</sup>, as the majority of the BI&A systems are mainly adopted in large, multinational, and international enterprises and thus, the research work on BI&A has largely been focused on them<sup>16, 17</sup>. Jourdan et al<sup>18</sup> conducted a literature review on BI&A research. They collected and analyzed articles related to BI&A published from 1997 to 2006 in ten leading Information Systems (IS) journals. However, their study focused mostly on BI&A in general and not on BI&A in SMEs. An extensive literature search yielded no extant literature reviewing research on BI&A in SMEs. Therefore, the objective of this paper is to provide a comprehensive review of the literature on BI&A in SMEs. By collecting, analyzing, and synthesizing all extant literature within this domain, this review presents the current state of research topics on BI&A and reveals prospective gaps that require further research. More specifically, the following research question guides this review:

RQ: What are the research topics of BI&A in SMEs that have been addressed?

Kitchenham’s guidelines for a systematic literature review (SLR) will be applied to allow the completeness of the search to be assessed, achieve effective results, and explain them in a more intelligible manner<sup>19</sup>. This means that the research procedures of this review follow a strict sequence and well-defined methodological steps that include (1) illuminate the search strategy process, (2) identify the inclusion and exclusion criteria, (3) study the selection process, (4) study the quality assessment, and (5) use data extraction and synthesis. Subsequently, 62 articles that focus on BI&A in SMEs were selected and reviewed.

The remainder of this work is structured as follows. Section 2 outlines the research methodology procedures used to conduct this research study. Section 3 reports the SLR results, and the research question results from the reviewed articles are presented in section 4. Section 5 presents the discussion and directions for future research. Finally, section 6 concludes this research.

## 2. Research Methodology

This research comprises an SLR that was undertaken based on the guidelines proposed by Kitchenham<sup>19</sup>. The Kitchenham’s guidelines were applied due to its more structured method in informing the status of the literature. In the following sub-sections, the steps followed during the review are described.

### 2.1. Search Strategy

The search strategy consists of two stages: automatic and manual research. During the first stage, the following databases were queried: Scopus, Web of Science, IEEE Xplore, ScienceDirect, Tandfonline, ACM Digital Library,

and Emerald Insight. These online databases were selected as they were considered the most pertinent and provide the highest-impact journals and conference proceedings that cover the field of BI&A. The effectiveness of online database search rather than the defined set of journals and conferences was empirically driven by suggestions from Dieste and Padua<sup>20</sup>. The keywords used in the search encompassed BI, BA, BI&A, Business Intelligence, Business Analytics, SMEs, Small Business and Medium Business, and combination were used to identify as many related articles as possible. Once the initial data was acquired, the articles were analyzed according to the defined objectives. Thus, for storing all citations, EndNote was used to keep the results of the searches of each database, as well as to circumvent duplicate studies. In addition to automatic research, a manual search was performed to ensure that no studies were missed. Thus, all the primary studies' references were reviewed while exclusion criteria were applied. Finally, the studies obtained from this manual search were added to EndNote, which yielded the final set of primary studies.

## *2.2. Inclusion and exclusion*

The purpose of identifying the inclusion and exclusion criteria was to make sure that only relevant articles would be used in this study. Research articles from journals, workshops, conference proceedings, and book chapters in the English language retrieved in the online databases were considered. The articles that were either not clearly related to BI&A, not related to the research question, or had their full texts not available were eliminated. Duplicate reports of the same study were also eliminated. Further, when different versions of an article exist, only the complete version of the article was included while the others were excluded. Note that the selected studies must satisfy all the inclusion criteria and must not satisfy any exclusion criteria.

## *2.3. Quality assessment*

In addition to inclusion and exclusion criteria, assessing the quality of the primary studies was considered crucial<sup>19</sup>. The principle of the quality assessment was to assess the overall quality of the selected studies. To guide the interpretation of the findings and determine the strength of the inferences of the selected studies, the following quality assessment questions were used:

QA1: Are the research topics addressed in the paper directly related to BI&A?

QA2: Does the context of the study clearly pertain to SMEs?

## *2.4. Study selection process*

After the search was conducted, 306 articles were identified. Of these 306 articles, 127 articles were duplicates and were removed by using EndNote. The remaining 179 articles were checked based on the inclusion and exclusion criteria, then 115 articles were excluded, and 64 articles remained. Once the first stage of research was completed, the second could start. The idea of the manual search was to gain confidence in the comprehensiveness of the search results. Thus, all the 64 remaining articles' references were screened while the exclusion criteria were applied, and 17 additional articles were identified. This process of pursuing references of references is known as snowballing as suggested by Jalali and Wohlin<sup>21</sup>. Subsequently, these 17 articles were retrieved through Google Scholar and added to EndNote to produce the pre-final set of primary studies. In total, there were 81 articles. Then the quality assessment criteria were applied, and 19 articles were removed. Finally, 62 articles were identified as the final set of primary studies and formed the basis for the next steps in this review. Table 1 presents the distribution of the primary studies and their sources, before and after the selection process.

## *2.5. Data extraction and synthesis*

The process of extraction and synthesis of the collected data was performed by carefully reading each of the 62 articles pulling out related data that was managed by EndNote and MS Excel. Designing data extraction forms to accurately record the information obtained from the primary studies was the aim of this step. Consequently, Webster and Watson's<sup>22</sup> concept-centric method was used to identify the study context. The other columns, which were considered in this review, include the study title, date, research method, number of citations, and publishing location.

Table 1. Distribution of articles before and after the selection process.

Online database	Before	After
Scopus	170	39
Web of Science	38	1
IEEE Xplore	52	6
ScienceDirect	18	1
Tandfonline	8	2
ACM Digital Library	13	0
Emerald Insight	7	1
Google Scholar	(17)	12
Total	295	62

### 3. Systematic Literature Review Results

This section provides the necessary statistical results based on the selected studies before the data analysis discussion for our SLR. Thus, the publication sources, citation status, temporal review, and applied research methods are presented.

#### 3.1. Publication sources

Most primary studies were published in journals and conferences. There were few studies published in symposiums, workshops, and book chapters. The distribution of the primary studies derived from their publication sources is shown in Fig. 1(a).

#### 3.2. Citation status

Fig. 1(b) shows the overview of the citation counts of the selected studies. The citation statistics were obtained through Google Scholar and Scopus. By looking at the data presented in Fig. 1(b), 49 of the studies were cited by other sources. Among these studies, only a few had more than 30 citations while the rest of the studies had fewer than 30 citations or no citations at all. The increase in the citation rates can be expected, as the majority of the selected studies were published in recent years.

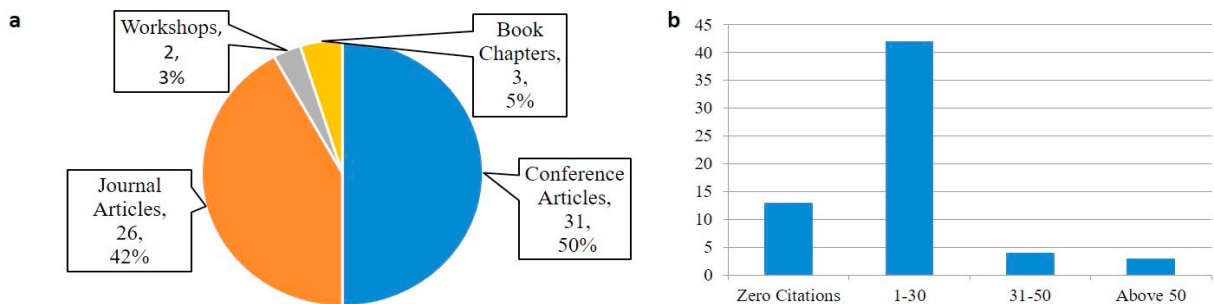


Fig. 1. (a) distribution per publication source; (b) citation count

### 3.3. Temporal review

The distribution of the final set of selected studies over the years is shown in Fig. 2(a). It is apparent that there was a significant increase in BI&A interest from 2010-2012. However, studies in 2014 slipped back to 3 in 2015. Overall, the number of studies included is low.

### 3.4. Research method

The classification of the included studies with reference to their research methods is shown in Fig. 2(b). By looking at the data presented in Fig. 2(b), it is clear to see that the research methods in the primary studies were dominated by design research, followed by case studies, surveys, interviews, field inquiries, and descriptive research. However, 42% of literature studies did not implicitly or explicitly mention which methods were applied. This suggests that the research field is still immature.

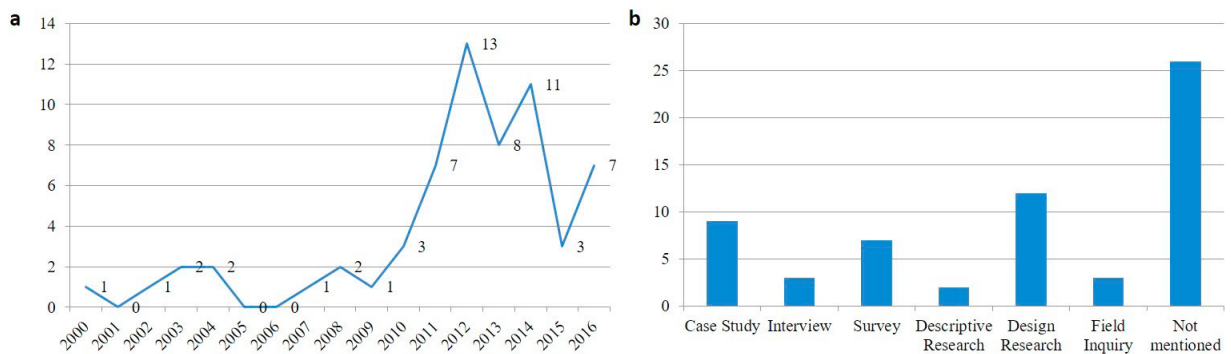


Fig. 2. (a) distribution of the primary studies throughout the years; (b) distribution per research methods

## 4. Research Question Results

After the primary studies were selected and extracted, it was possible to address the research question of this study derived from the 62 articles analyzed. The concept-centric method was applied during the data extraction and synthesis phase. The identified research topics were: BI&A Components, BI&A Solutions, Mobile BI&A, Cloud BI&A, BI&A Application, BI&A Adoption, BI&A Implementation, and BI&A Benefits, which will be further discussed in the following sub-sections. Moreover, the research topics identified are summarized in Table 2.

Table 2. Research topics identified in the study.

Research Topics	Issues	Reference articles
BI&A components	Data warehouse and reference models	[17, 24-28]
	KPIs	[27, 28]
	OLAP	[17]
	Data mining	[29, 30]
	Dashboard	[31, 32]
BI&A solutions		[17, 33-40]
Mobile BI&A		[46-53]
Cloud BI&A	SaaS frameworks, architectures, models	[45-52]
	SaaS prototype	[54, 55]
	Critical success factors	[40, 56]
	Other issues	[57-59]

BI&A application		[61]
BI&A adoption	Frameworks, maturity level, determinants, models	[15, 38, 62-65]
	Other adoption issues	[16, 66, 67]
BI&A implementation	Critical success factors	[36]
	Frameworks, development cycle, models	[67-71]
	Prototype	[39, 72-77]
	Other implementation issues	[4, 78-80]
BI&A benefits		[16, 84, 85]

#### 4.1. BI&A components

A typical BI&A system includes identification of key performance indicators (KPIs), data warehousing, data mining, OLAP, digital dashboards, and reporting through data visualization<sup>23</sup>. There are studies on data warehouse, KPIs, OLAP, data mining, and dashboard in the literature. Sharma et al<sup>24</sup> proposed Data warehousing as a Service (DaaS) as an attempt to reach a new level of BI&A. While, the actual use of data warehousing systems in 45 SMEs of the Udine district in Italy was studied through a survey analysis by Pighin and Marzona<sup>25</sup>. Grabova et al<sup>17</sup> reported the importance of data warehousing for SMEs and presented different web-based data warehouse technologies. Collaborative business systems provide a competitive advantage to companies that operate in a joint business structure. However, traditional BI&A is not designed for collaboration; therefore, Olaru and Vincini<sup>26</sup> provided a methodology for heterogeneous data warehouses to aid this shortcoming. Many SMEs refrain from adopting BI&A technology, however, reference models allow SMEs to overcome the obstacles associated with the introduction of BI&A solutions as argued by Schuetz et al<sup>27</sup>. Schütz and Schrefl<sup>28</sup> proposed a four-layered reference model for data warehouses to lower the obstacles that inhibit SMEs from adopting BI&A technology. More specifically, explicit modelling and calculated KPIs, as well as the definition of reference data marts for report building were addressed. Further, Schuetz et al<sup>27</sup> followed up a study that specifically addressed the explicit modeling of KPIs by introducing the BI&A reference modeling for data analysis (BIRD) approach.

Another BI&A component is OLAP. OLAP extracts knowledge from a data warehouse or data marts to provide navigation through data to non-expert users. However, traditional OLAP technology is cumbersome and storage costly; therefore, Grabova et al<sup>17</sup> presented a comparison of different OLAP technologies that work in the main memory and with web interfaces. BI&A based on data mining has been one of the popular and indispensable tools for identifying business opportunities in sales and for marketing new products. Cheung and Li<sup>29</sup> implemented a BI&A prototype named correlation coefficient sales data mining system (CCSDMS) and the results showed that the proposed solution provides higher accuracy, better computational effectiveness, and higher predictive power. While, Kitayama et al<sup>30</sup> presented the use of data mining techniques based on customer profile data in the power electric industry in Japan. A dashboard is an easy-to-read summary of the analysis of the information. Korczak et al<sup>31</sup> implemented an Intelligent Dashboard for Managers called InKoM. Consequently, an evaluation method based on a scorecard framework oriented toward BI&A systems and projects was presented by Dyczkowski et al<sup>32</sup> to evaluate the decision support system applied in the InKoM project.

#### 4.2. BI&A solutions

The industrial use of open source BI&A has become increasingly common. Talend OpenStudio, Mondrian Pentaho, and Pa-Lo are some of the web-based open source solutions that are suitable for SMEs according to Grabova et al<sup>17</sup>. Similarly, Bernardino<sup>33</sup> analysed seven of the most frequently used open source BI&A tools. While, Lapa et al<sup>34</sup> made a comparative analysis of the BI&A tools to assist the selection of BI&A platforms and identified the most suitable solutions for SMEs. Few papers discussed other BI&A solutions for SMEs. A study by Tutunea and Rus<sup>35</sup> identified the BI&A solutions for SMEs in the global market and in the Romanian market. Whereas, Olszak and Ziemba<sup>36</sup> identified the known BI&A systems in the Polish market. Moreover, other BI&A solutions-related issues have also been presented in the literature. Nyblom et al<sup>37</sup> proposed a simple model for BI&A performance evaluation which was

based on the case studies of eight Swedish SMEs. A study by Gibson and Arnott<sup>38</sup> explored why BI&A application are not widely used in small business. In addition, a table of BI&A system classification outlined by Mallach in 2000 was also presented in this study. Further, Khan et al<sup>39</sup> and Emam<sup>40</sup> presented a comparison between the major BI&A vendors and BI&A technologies.

#### *4.3. Mobile BI&A*

A mobile BI&A system is an application that can offer similar functionality as traditional BI&A. The mobile system is one of the trending topics in this domain; however, there is still little conceptual work in this field<sup>41</sup>. A study by Dubravac and Bevanda<sup>42</sup> in Croatia explored mobile BI&A adoption in 83 SMEs. The results indicated budget constraints as one of the biggest barriers in mobile BI&A adoption. Other issues were discussed in the mobile BI&A literature. Talati et al<sup>43</sup> presented a model for mobile BI&A and Motta et al<sup>44</sup> proposed a low-cost system architecture for mobile BI&A in SMEs. The core idea of both studies was to design a system based on low-cost open source technologies that would suit the different requirements of small businesses and help SMEs to achieve similar opportunities that BI&A offers to large enterprises. Further, Adeyelure et al<sup>45</sup> presented a mobile BI&A framework for SMEs in developing countries and identified problems related to the deployment of mobile BI&A.

#### *4.4. Cloud BI&A*

Cloud computing and BI&A are becoming increasingly important in gaining and maintaining a competitive edge<sup>46</sup>. Studies have discussed cloud BI&A or Software as a Service business intelligence (SaaS BI) in SMEs by proposing frameworks such as conceptual framework for cloud-based open platform analytics<sup>47</sup>, theoretical framework for cloud BI&A<sup>48</sup>, and framework for consolidated cloud BI&A<sup>49</sup>. Similarly, a study by Liyang et al<sup>50</sup> proposed a unified five-layered framework which includes: infrastructure, data service, business service, user interface service, and operational service layer. Other authors presented an application architecture for BI&A<sup>51</sup> and proposed a model for cloud BI&A to address the problems associated with traditional BI&A<sup>46, 52, 53</sup>. Ouf et al<sup>54</sup> did a follow up study by implementing a BI&A SaaS system. Moreover, Hassanien and Elragal<sup>55</sup> proposed a novel approach by using tokenization as a security mechanism to address the security issues in cloud BI&A. Their results showed that tokenization can largely replace the traditional encryption techniques toward securing BI&A data in the cloud. Other BI&A cloud-related issues have also been discussed in the literature. Agostino et al<sup>56</sup> identified the key success factors of cloud-based BI&A. Similarly, Emam<sup>40</sup> presented the most important critical success factors (CSFs) and proposed a CSF model for implementing BI&A over cloud. A study by Kazeli<sup>57</sup> presented the concepts of cloud BI&A and addressed the corresponding benefits, problems, and challenges. Deepak et al<sup>58</sup> proposed a pre-packaged configurable workflow for BI&A as a means of endearing cloud-based analytics to SMEs in developing regions. Further, Rozehnal and Tvrdivkova<sup>59</sup> studied the applicability of the BI&A SaaS model in the Czech SME segment.

#### *4.5. BI&A application*

BI&A has permeated various industries, such as retail, insurance, banking, finance and securities, telecommunications, and manufacturing<sup>60</sup>. However, few studies have been conducted on how BI&A can be applied in different industries. Through a survey analysis, Tyrychtr et al<sup>61</sup> examined the relation between 135 agricultural enterprise structures and the use of BI&A in the Czech Republic. They found that only few respondents use any type of the BI&A application although the research results showed a high probability for the potential use of BI&A among the respondents. The authors also evaluated how BI&A could be applied to assist agricultural enterprises to strengthen their production potential and technical efficiency.

#### *4.6. BI&A adoption*

In order to better understand BI&A adoption, some studies presented frameworks, maturity level, models, and adoption theories. While, other studies identified factors and determinants that affect BI&A adoption in SMEs. Boonsiritomachai et al<sup>62</sup> proposed a research framework to identify the current state of BI&A adoption in Thailand,

including the enabling factors that impact the adoption of BI&A in SMEs. The same authors continued the study by proposing different maturity levels for BI&A and identified factors that influenced BI&A adoption in Thai SMEs<sup>15</sup>. A study by Gibson and Arnott<sup>38</sup> presented a model and a table of BI&A adoption factors that affect small businesses. Puklavec et al<sup>63</sup> identified the determinants of BI&A adoption to serve as a guide through the development and testing of BI&A adoption frameworks. Similarly, Chichti et al<sup>64</sup> identified determinants of BI&A adoption within the framework of the relation between SMEs and Tunisian public organizations. Hatta et al<sup>65</sup> proposed a BI&A system adoption model for Malaysian SMEs and identified two prominent adoption models used by SMEs: diffusion of innovation (DOI) theory and technology, organization, and environment (TOE) framework.

Few BI&A adoption-related issues were discussed in the literature. A qualitative study conducted by Hill and Scott<sup>66</sup> with 11 small businesses based in Northern Ireland proposed a set of recommendations for successful BI&A adoption. While, Scholz et al<sup>16</sup> carried out an exploratory analysis to examine BI&A adoption in German SMEs to distinguish underlying constructs related to the perception of the BI&A benefits, challenges, and organizational factors. Through an empirical survey with 20 French companies, Sadok and Lesca<sup>67</sup> identified seven necessary acceptance conditions (NACs) of a BI&A model. The authors proposed to use the model to help set up an environmental intelligence system for SMEs.

#### *4.7. BI&A implementation*

Several papers discussed BI&A implementation from different angles, including presenting CSFs, frameworks, development cycle, and models. Olszak and Ziemba<sup>36</sup> conducted in-depth interviews with 20 SMEs from Upper Silesia and discovered three perspectives of CSFs in BI&A implementation: organization, process, and technology. Guarda et al<sup>68</sup> proposed a framework that demonstrates the applicability of BI&A as a driving force for SMEs. Likewise, Sohail et al<sup>69</sup> proposed a framework that provides automated data mapping, validation, and data loading from user application to offer convenience of use and effective cost saving. Raymond<sup>70</sup> proposed a conceptual and operational framework that focuses on the competitiveness of SMEs. While, Haque and Lutzer<sup>71</sup> presented a BI&A development cycle and performed a real-world functional application to demonstrate its concepts. Further, Sadok and Lesca<sup>67</sup> proposed a BI&A model based on the mobilization of corporate tacit knowledge and informal information.

Several authors implemented BI&A systems that were discussed in the literature. Bajo et al<sup>72</sup> implemented a multi-agent system for innovative web BI&A tools. Iqbal et al<sup>73</sup> developed a prototype using an expert system method that suited Indonesian SMEs' characteristics. Moreover, Campos et al<sup>74</sup> presented the design and programming details of the BI&A system named Eagle. While, Baransel and Baransel<sup>75</sup> proposed the bilişimBI and reported its outstanding features. A recent study by Devi and Priya<sup>76</sup> developed a BI&A solution using open source technologies for Sriram Industries and Sriram Wire Products. Arrieta et al<sup>77</sup> implemented an advanced BI&A system methodology specifically tailored for SMEs in the machine-tool sector. Similarly, Khan et al<sup>39</sup> proposed a web support system for BI&A and demonstrated the convenience of its use and effective cost savings.

Other implementation-related issues were discussed in the literature. Horakova and Skalska<sup>78</sup> presented how BI&A can be built in a small company. While Bergeron<sup>79</sup> went further and conducted a study on BI&A implementation in SMEs and large enterprises, as well as the cultural sector and argued that BI&A requires a holistic approach. Raj et al<sup>4</sup> examined the challenges in BI&A implementation within an SME in the United Kingdom and discussed how these challenges can be overcome. Further, Gil and Sousa<sup>80</sup> developed a method for a successful BI&A implementation using performance indicators based on business activities.

#### *4.8. BI&A benefits*

Several studies can be found in the literature regarding the multiple benefits of business intelligence, for example, faster and easier access to information<sup>81</sup>, savings in IT infrastructure cost<sup>82</sup>, and greater customer satisfaction<sup>83</sup>. However, only three studies have discussed BI&A benefits for SMEs in the literature. First, a study by Hočevár and Jaklič<sup>84</sup> assessed the potential benefits of BI&A in an SME called Melamin. They argued that the first and most common purpose of benefits evaluation is to demonstrate that BI&A is worth the investment. Second, Lueg and Lu<sup>85</sup> illustrated how standard BI&A solutions can help SMEs to increase their efficiency in budgeting within short time frames. They performed a case study in a Danish SME to demonstrate the most pressing problems in budgeting



efficiency and proposed a model for future research. Lastly, Scholz<sup>16</sup> presented important BI&A benefits for SMEs.

## 5. Discussion and Future Research Avenues

This study presented an overview of publications on BI&A in SMEs through a systematic literature review of studies published between 2000 and 2016. 62 articles met the inclusion criteria, however, 26 articles did not clearly define which research methods were applied. This is an indication of an immature research field, and calls for more empirical research on BI&A. The subsequent discussion presents research gaps and future research avenues.

The various BI&A components presented can form different BI&A technologies and tools. Before developing a BI&A system, having a detailed understanding of these various components can lead to a solid architecture design for a successful implementation. According to Schuetz et al<sup>27</sup>, many SMEs refrain from adopting BI&A technology, but reference models allow these SMEs to overcome the obstacles associated with the introduction of BI&A solutions. Therefore, further research should address the development of additional reference models for BI&A components.

The mature set of BI&A open source solutions presented in this study offers most areas of BI&A functionality. Therefore, it has become a solid option for any organization, especially SMEs, to achieve and surpass their BI&A needs. Studies on what opportunities that open source BI&A can offer to SMEs would be a useful avenue for future research.

Mobile phones have become an integral part of enterprises, especially SMEs, due to their communication and computing capabilities. The ability to access services ubiquitously on the move is truly remarkable. However, there are important aspects that need further attention, such as, deployment methods, information display and interaction, information exploration, context awareness, offline mode exploration, rich application functionality, and multiple device support. Moreover, an explicit focus on leveraging mobile security capabilities, delivering secure authentication, Virtual Private Network (VPN) and Hypertext Transfer Protocol Secure (HTTPS) support, and application sandboxing for BI&A developers is vital. Therefore, more studies in this area could help avoid user frustration and promote BI&A adoption.

In addition to open source solutions, cloud BI&A was also considered a low-cost licensed alternative solution for SMEs. Although factors, frameworks, and models have been presented to address successful implementation of cloud BI&A in the literature, no empirical studies have shown its benefits. The cloud is a good option; however, SMEs' reluctance to enter the cloud due to issues of security and control, particularly ownership, is still an obstacle. Thus, future studies should focus on these issues.

BI&A when done right can deliver knowledge, efficiency, better and timelier decisions, and profit to almost any organization. In the area of BI&A application, the studies are often about traditional manufacturing SMEs employing BI&A. Studies on BI&A applications in other types of industries are also needed. Such studies may yield different research findings and help make BI&A more mainstream in SMEs.

Understanding what BI&A is, why one would apply it, and the corresponding benefits are significant in adopting BI&A across the enterprise. Although some studies examined BI&A adoption determinants and theories, not enough studies extend the knowledge regarding SMEs' readiness for BI&A adoption. Such knowledge can be valuable for owner managers or senior management to become more proactive in promoting BI&A. Additionally, more empirical studies on determinants and barriers in BI&A adoption would be valuable.

Several frameworks and models have emerged to provide guidance in terms of identifying factors that support successful BI&A implementation. However, there was no clear definition of success. In addition, how BI&A solutions are used has not been extensively studied relative to the benefits realized. Further, the need to deliver significant return on investment (ROI) has not yet been fully discussed, as well as how to minimize the total cost of ownership (TCO).

BI&A benefits are often greater than what appears at first sight. Similar to large organizations, SMEs' most-sought outcome for BI&A is to make better decisions, according to Howard Dresner<sup>86</sup>. Surprisingly, only one study focused on BI&A benefits within SMEs. According to Gibson et al<sup>9</sup>, there has been limited academic research on benefits evaluation of BI&A. Therefore, further studies on assessing and evaluating benefits of BI&A is important.

More studies in this domain will increase understanding of the value of BI&A and how these systems are utilized to create intelligence. In addition, capturing the value of BI&A can open different perspectives as it requires SMEs to go beyond the technical implementation. BI&A technologies and applications in other industries are still at a nascent stage of development. To make BI&A more mainstream for SMEs, issues such as establishing standards and

governance, safeguarding security, guaranteeing privacy, usability, and flexibility, and continually improving the technologies need further attention. Moreover, the several challenges highlighted above must be addressed. Finally, it would be beneficial to present empirical success and failure reports to understand the disparate capabilities of BI&A available, to assist SMEs in circumventing common pitfalls during implementation periods, and to facilitate the selection of BI&A solutions.

## 6. Conclusion

This study provides a comprehensive literature review of BI&A in SMEs. Most studies focused on frameworks, architectures, models, critical success factors, determinants, and barriers that affect the implementation and adoption of BI&A. This provides promising evidence for the contribution to practitioners that can guide them in their future projects. For BI&A vendors, this can help to improve their BI&A solutions, for example, offering improved usability, integration into other systems, and ease of deployment.

For researchers, this study identified research topics, research gaps, and several important directions for future research in this field. More specifically, there is an opportunity for studies that explicitly focus on (a) the development of reference models, (b) benefit evaluation, assessment, and realization (c) the factors that influence adoption and implementation (e.g., TCO, ROI, and security issues), and (d) different uses of BI&A in various business fields and industries. Furthermore, cloud-based and mobile-based BI&A solutions are promising application areas for SMEs.

This study suffers from some limitations. Even though the paper has conducted a very thorough review of the literature, I note however, that I cannot guarantee to have captured all the materials in this area.

## References

1. IFC. *IFC and Small and Medium Enterprises* 2012 [cited 2016 November]; Available from: [http://www.ifc.org/wps/wcm/connect/277d1680486a831abec2fff995bd23db/AM11IFC+IssueBrief\\_SME.pdf?MOD=AJPERES](http://www.ifc.org/wps/wcm/connect/277d1680486a831abec2fff995bd23db/AM11IFC+IssueBrief_SME.pdf?MOD=AJPERES).
2. Olszak, C.M. and E. Ziemia, The conceptual model of a web learning portal for small and medium sized enterprises. *Issues in Informing Science and Information Technology*, 2008. 5: p. 335-351.
3. Ngah, R., I. Abd Wahab, and Z. Salleh, The Sustainable Competitive Advantage of Small and Medium Enterprises (SMEs) with Intellectual Capital, Knowledge Management and Innovative Intelligence: Building a Conceptual Framework. *Advanced Science Letters*, 2015. 21(5): p. 1325-1328.
4. Raj, R., S.H.S. Wong, and A.J. Beaumont. Business intelligence solution for an SME: a case study. in *Proceedings of the 8th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2016)*. 2016.
5. Forrester. *Boris Evelson Topic Overview: Business Intelligence*. 2008 [cited 2017 April 18]; Available from: <https://www.forrester.com/report/Topic+Overview+Business+Intelligence/-/E-RES39218>.
6. Yeoh, W., *Critical Success Factors for Implementation of Business Intelligence Systems in Engineering Asset Management Organizations*. 2008.
7. Luhn, H.P., A business intelligence system. *IBM Journal of Research and Development*, 1958. 2(4): p. 314-319.
8. Burstein, F. and C. Holsapple, *Handbook on decision support systems 2: variations*. 2008: Springer Science & Business Media.
9. Gibson, M., et al. Evaluating the intangible benefits of business intelligence: Review & research agenda. in *Proceedings of the 2004 IFIP International Conference on Decision Support Systems (DSS2004): Decision Support in an Uncertain and Complex World*. 2004. Citeseer.
10. Chen, H., R.H.L. Chiang, and V.C. Storey, Business Intelligence and Analytics: From Big Data to Big Impact. *Mis Quarterly*, 2012. 36(4): p. 1165-1188.
11. Chiang, R.H., P. Goes, and E.A. Stohr, Business intelligence and analytics education, and program development: A unique opportunity for the information systems discipline. *ACM Transactions on Management Information Systems (TMIS)*, 2012. 3(3): p. 12.
12. *Flipping to Digital Leadership, Insights from the 2015 Gartner CIO Agenda Report*. 2015.
13. *Gartner: BI & Analytics Top Priority for CIOs in 2016*. 2016 [cited 2017 April 25]; Available from: <https://solutionsreview.com/business-intelligence/gartner-bi-analytics-top-priority-for-cios-in-2016/>.
14. Chaudhuri, S., U. Dayal, and V. Narasayya, An overview of business intelligence technology. *Communications of the ACM*, 2011. 54(8): p. 88-98.
15. Boonsiritomachai, W., G.M. McGrath, and S. Burgess, Exploring business intelligence and its depth of maturity in Thai SMEs. *Cogent Business & Management*, 2016. 3(1): p. 1220663.
16. Scholz, P., et al. Benefits and Challenges of Business Intelligence Adoption in Small and Medium-Sized Enterprises. in *18th European Conference on Information Systems, ECIS 2010*. 2010. Citeseer.
17. Grabova, O., et al., Business intelligence for small and middle-sized enterprises. *ACM SIGMOD Record*, 2010. 39(2): p. 39-50.
18. Jourdan, Z., R.K. Rainer, and T.E. Marshall, Business intelligence: An analysis of the literature 1. *Information Systems Management*, 2008. 25(2): p. 121-131.
19. Kitchenham, B., Procedures for performing systematic reviews. *Keele, UK, Keele University*, 2004. 33(2004): p. 1-26.
20. Dieste, O. and A.G. Padua. Developing Search Strategies for Detecting Relevant Experiments for Systematic Reviews. in *First International Symposium on Empirical Software Engineering and Measurement (ESEM 2007)*. 2007.

21. Jalali, S. and C. Wohlin. Systematic literature studies: database searches vs. backward snowballing. in *Proceedings of the ACM-IEEE international symposium on Empirical software engineering and measurement*. 2012. ACM.
22. Webster, J. and R.T. Watson, Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, 2002. **26**(2): p. 13-23.
23. Ranjan, J., Business intelligence: Concepts, components, techniques and benefits. *Journal of Theoretical and Applied Information Technology*, 2009. **9**(1): p. 60-70.
24. Sharma, Y., R. Nasri, and K. Askand. Building a data warehousing infrastructure based on service oriented architecture. in *International Conference on Cloud Computing Technologies, Applications and Management (ICCCTAM), 2012* 2012. IEEE.
25. Pighin, M. and A. Marzona. Data value in decision process: Survey on decision support system in small and medium enterprises. in *MIPRO, 2012 Proceedings of the 35th International Convention*. 2012. IEEE.
26. Olaru, M.-O. and M. Vincini, Integrating Multidimensional Information for the Benefit of Collaborative Enterprises. *Journal of Digital Information Management*, 2014. **12**(4): p. 255-266.
27. Schuetz, C.G., et al., Reference Modeling for Data Analysis: The BIRD Approach. *International Journal of Cooperative Information Systems*, 2016. **25**(02): p. 1650006.
28. Schütz, C. and M. Schrefl. Customization of Domain-Specific Reference Models for Data Warehouses. in *Enterprise Distributed Object Computing Conference (EDOC), 2014 IEEE 18th International*. 2014. IEEE.
29. Cheung, C.F. and F.L. Li, A quantitative correlation coefficient mining method for business intelligence in small and medium enterprises of trading business. *Expert Systems with Applications*, 2012. **39**(7): p. 6279-6291.
30. Kitayama, M., R. Matsubara, and Y. Izui. Application of data mining to customer profile analysis in the power electric industry. in *Proceedings of the IEEE Power Engineering Society Transmission and Distribution Conference*. 2002.
31. Korczak, J., H. Dudyecz, and M. Dyczkowski. Intelligent dashboard for SME managers. Architecture and functions. in *Federated Conference on Computer Science and Information Systems (FedCSIS), 2012* 2012. IEEE.
32. Dyczkowski, M., J. Korczak, and H. Dudyecz. Multi-criteria evaluation of the intelligent dashboard for SME managers based on scorecard framework. in *Federated Conference on Computer Science and Information Systems (FedCSIS), 2014* 2014.
33. Bernardino, J., Emerging business intelligence technologies for SMEs, in *Handbook of Research on Enterprise 2.0: Technological, Social, and Organizational Dimensions*. 2013. p. 1-28.
34. Lapa, J., J. Bernardino, and A. Figueiredo. A comparative analysis of open source business intelligence platforms. in *Proceedings of the International Conference on Information Systems and Design of Communication*. 2014. ACM.
35. Tutunea, M.F. and R.V. Rus, Business Intelligence Solutions for SME's. *Procedia Economics and Finance*, 2012. **3**: p. 865-870.
36. Olszak, C.M. and E. Ziemba, Critical success factors for implementing business intelligence systems in small and medium enterprises on the example of upper Silesia, Poland. *Interdisciplinary Journal of Information, Knowledge, and Management*, 2012. **7**: p. 129-150.
37. Nyblom, M., et al., An evaluation of business intelligence software systems in SMEs - a case study. *Journal of Intelligence Studies in Business*, 2012. **2**(2): p. 51-57.
38. Gibson, M. and D. Arnott. Business Intelligence for Small Business: Assessment, Framework & Agenda. in *Pacific Asia Conference on Information Systems PACIS 2003 Proceedings*. 2003.
39. Khan, M.K., et al., Web Support System for Business Intelligence in Small and Medium Enterprises. *Wireless Personal Communications*, 2014. **76**(3): p. 535-548.
40. Emam, A.Z. Critical Success Factors Model for Business Intelligent over ERP Cloud. in *International Conference on IT Convergence and Security (ICITCS) 2013* 2013. IEEE.
41. Brockmann, T., et al. User Acceptance of Mobile Business Intelligence Services. in *Network-Based Information Systems (NBIS), 2012 15th International Conference on*. 2012.
42. Dubravac, I. and V. Bevanda. Mobile business intelligence adoption (case of croatian SMEs). in *ACM International Conference Proceeding Series*. 2015.
43. Talati, S., G. McRobbie, and K. Watt. Developing business intelligence for Small and Medium Sized Enterprises using mobile technology. in *International Conference on Information Society, i-Society 2012*. 2012.
44. Motta, G., et al., Delivering knowledge to the mobile enterprise implementation solutions for a mobile business intelligence, in *Smart Organizations and Smart Artifacts*. 2014, Springer. p. 115-123.
45. Adeyelu, T.S., B.M. Kalema, and K.J. Bwalya. Development of Mobile Business Intelligence framework for small and medium enterprises in developing countries: Case study of South Africa and Nigeria. in *Computational and Business Intelligence (ISCBI), 2016 4th International Symposium on*. 2016. IEEE.
46. Ouf, S. and M. Nasr. Business intelligence in the cloud. in *Communication Software and Networks (ICCSN), 2011 IEEE 3rd International Conference on*. 2011. IEEE.
47. Hiziroglu, A. and H.İ. Cebeci, A Conceptual Framework of a Cloud-Based Customer Analytics Tool for Retail SMEs. *Periodicals of Engineering and Natural Sciences (PEN)*, 2013. **1**(2).
48. Gash, D., T. Ariyachandra, and M. Frolick, Looking to the clouds for business intelligence. *Journal of Internet Commerce*, 2011. **10**(4): p. 261-269.
49. Muriithi, G. and J. Kotzé. A conceptual framework for delivering cost effective business intelligence solutions as a service. in *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference*. 2013. ACM.
50. Liyang, T., et al. A conceptual framework for business intelligence as a service (SaaS BI). in *Proceedings - 4th International Conference on Intelligent Computation Technology and Automation, ICICTA 2011*. 2011.
51. Fu, T. Research on business intelligence pattern based on the BaaS. in *International Symposium on Intelligent Information Technology Application Workshops, 2008. IITAW'08*. 2008. IEEE.
52. Khan, S., et al. Business intelligence in the cloud: A case of Pakistan. in *CCIS2011 - Proceedings: 2011 IEEE International Conference on Cloud Computing and Intelligence Systems*. 2011.
53. Sheikh, R.A., SaaS BI: Sustainable business intelligence solution for SMB's. *International Journal of Research in Finance & Marketing*, 2011. **1**(3): p. 1-11.
54. Ouf, S., et al. Business intelligence software as a service (SAAS). in *IEEE 3rd International Conference on Communication Software and*

- Networks (ICCSN), 2011.* 2011. IEEE.
55. Hassanien, E.-D.H. and A. Elragal. Business intelligence in cloud computing: A tokenization approach. in *Proceedings of the 7th IADIS International Conference Information Systems 2014, IS 2014.* 2014.
  56. Agostino, A., K.S. Soilen, and B. Gerritsen. Cloud solution in Business Intelligence for SMEs—vendor and customer perspectives. *Journal of Intelligence Studies in Business*, 2013. **3**(3).
  57. Kazeli, H. Cloud Business Intelligence. in *Business Information Systems Workshops.* 2014. Springer.
  58. Deepak, P., P.M. Deshpande, and K. Murthy. Configurable and Extensible Multi-flows for Providing Analytics as a Service on the Cloud. in *2012 Annual Service Research Innovation Institute Global Conference.* 2012. IEEE.
  59. Rozehnal, P. and M. Tvrđikova. Cooperation of academic and commercial sphere during the implementation of BI by the means of SaaS. in *Proceedings of the ITI 2012 34th International Conference on Information Technology Interfaces (ITI).* 2012. IEEE.
  60. Olszak, C.M. and E. Ziemba. Business intelligence systems in the holistic infrastructure development supporting decision-making in organisations. *Interdisciplinary Journal of Information, Knowledge, and Management*, 2006. **1**(1): p. 47-57.
  61. Tyrychtr, J., M. Ulman, and V. Vostrovský. Evaluation of the state of the business intelligence among small czech farms. *Agricultural Economics*, 2015. **61**(2): p. 63-71.
  62. Boonsiritomachai, W., M. McGrath, and S. Burgess. A research framework for the adoption of Business Intelligence by Small and Medium-sized enterprises. in *Small Enterprise Association of Australia and New Zealand 27th Annual Seanz Conference.* 2014.
  63. Puklavec, B., T. Oliveira, and A. Popovic. Unpacking Business Intelligence Systems Adoption Determinants: An Exploratory Study of Small and Medium Enterprises. *Economic and Business Review for Central and South-Eastern Europe*, 2014. **16**(2): p. 185.
  64. Chichti, F.T., A. Besbes, and I. Benzammel. The impact of contextual factors on business intelligence. in *International Conference on Digital Economy (ICDEc).* 2016. IEEE.
  65. Hatta, N.N.M., et al., Business intelligence system adoption theories in SMES: A literature review. *ARPN Journal of Engineering and Applied Sciences*, 2015. **10**(23): p. 18165-18174.
  66. Hill, J. and T. Scott. A consideration of the roles of business intelligence and e-business in management and marketing decision making in knowledge-based and high-tech start-ups. *Qualitative Market Research: An International Journal*, 2004. **7**(1): p. 48-57.
  67. Sadok, M. and H. Lesca. A business intelligence model for SMEs based on tacit knowledge. in *Innovation and Knowledge Management in Twin Track Economies Challenges and Solutions - Proceedings of the 11th International Business Information Management Association Conference, IBIMA 2009.* 2009.
  68. Guarda, T., et al., Business intelligence as a competitive advantage for SMEs. *International Journal of Trade, Economics and Finance*, 2013. **4**(4): p. 187.
  69. Sohail, M., et al., Developing Business Intelligence Framework to Automate Data Mapping, Validation, and Data Loading from User Application. *International Journal of Computer Theory and Engineering*, 2012. **4**(5): p. 847.
  70. Raymond, L., Globalization, the knowledge economy, and competitiveness: a business intelligence framework for the development of SMES. *Journal of American Academy of Business*, 2003. **3**: p. 260-269.
  71. Haque, W. and E.M. Lutzer. Intelligent analytics for business education. in *Proceedings of the IASTED International Conference on Technology for Education, TE 2011.* 2011.
  72. Bajo, J., et al., A multi-agent system for web-based risk management in small and medium business. *Expert Systems with Applications*, 2012. **39**(8): p. 6921-6931.
  73. Iqbal, M., et al., PAKAR-UKM - expert system for SMEs using dynamic knowledge base. *ARPN Journal of Engineering and Applied Sciences*, 2014. **9**(12): p. 2441-2447.
  74. Campos, P., et al. Cross-media user interfaces for controlling the enterprise : The eagle integrated system. in *ICEIS 2007 - 9th International Conference on Enterprise Information Systems, Proceedings.* 2007.
  75. Baransel, A.E. and C. Baransel. Architecturing Business Intelligence for SMEs. in *36th IEEE Annual International Computer Software and Applications Conference, COMPSAC 2012.* 2012.
  76. Devi, M.N. and A. Priya. Invoicing and analytics for small and micro manufacturing enterprises. in *International Conference on Recent Trends in Information Technology (ICRTIT), 2016* 2016. IEEE.
  77. Arrieta, J.A., A. Azkarate, and N. Aranguren. Advanced Business Intelligence System Adapted to SMEs, Within a Defined Product Life-Cycle Management Frame. in *ICE Conference.* 2004.
  78. Horakova, M. and H. Skalska. Business Intelligence and Implementation in a Small Enterprise. *Journal of systems integration*, 2013. **4**(2): p. 50.
  79. Bergeron, P., Regional business intelligence: The view from Canada. *Journal of Information Science*, 2000. **26**(3): p. 153-160.
  80. Gil, M.M. and D.N. Sousa. Using key performance indicators to facilitate the strategy implementation and business process improvement in SME's. in *ICEIS 2010 - Proceedings of the 12th International Conference on Enterprise Information Systems.* 2010.
  81. Gangadharan, G.R. and S.N. Swami. Business intelligence systems: design and implementation strategies. in *Information Technology Interfaces, 2004. 26th International Conference on.* 2004.
  82. Watson, H.J. and B.H. Wixom. The current state of business intelligence. *Computer*, 2007. **40**(9): p. 96-99.
  83. Lönnqvist, A. and V. Pirttimäki. The measurement of business intelligence. *Information systems management*, 2006. **23**(1): p. 32.
  84. Hočevár, B. and J. Jaklič. Assessing benefits of business intelligence systems—a case study. *Management: Journal of Contemporary Management Issues*, 2008. **13**(2 (Special issue)): p. 87-119.
  85. Lueg, R. and S. Lu. How to improve efficiency in budgeting-The case of business intelligence in SMEs. *European Journal of Management*, 2013. **13**(2): p. 109-120.
  86. Dresner, H. *Dresner Study Details Small and Mid-Sized Enterprise Use of Business Intelligence.* 2014 [cited 2016 November]; Available from: <http://sandhill.com/article/dresner-study-details-small-and-mid-sized-enterprise-use-of-business-intelligence/>.