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# Exploring the core knowledge of business intelligence

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# Exploring the Core Knowledge of Business Intelligence

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**Abstract**

With the rapid development of data analysis, there is few research on the core knowledge of business intelligence system (BIS). In order to fill this research gap, this paper collected the 1003 articles and 31345 references from the Web of Science database, and then applied co-citation analysis and factor analysis, to analyze their core knowledge. We identified 52 highly cited articles and obtained 9 core knowledge categories in the field of BI: BI success, IT acceptance and measurement, big data analysis, data analysis and decision making, business strategy, BIS, consumer behavior, knowledge management, business adoption. Research shows that BISs are still in the growing trend and core knowledge helps researchers and managers better understand the core concepts and relevance of BI, so as to quickly discover possible research directions in this research field and useful applications in the enterprise.

## 1 Introduction

In the information era, one of the key factors affecting the success of enterprises is the capability to deal with data and information intelligently. During the past decades, BI is an important subfield, which use data analysis to get valuable information in order to support business decision making (Liang & Liu, 2018). Moreover, managers confront the challenges of big data in the contemporary enterprise management. To keep competitive advantage managers not only have effective management and operation of enterprise, but also need to make decision with changeable and uncertain problems. Thus the external big data and instant information is also another key factor for decision makers (Chang, 2018).

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With the rapid development of information and communication technology, data generates enormously in our life and enterprises. Research articles related big data and big data analysis increase quickly (Jin & Kim, 2018). More and more researchers focus on big data collection and analyses in business application and have more articles related business intelligence (Brichni et al., 2017). However, few studies focus on the core knowledge of business intelligence. In this study, we use co-citation (Small, 1973; Shiau et al., 2016) to explore the core knowledge of BI through high value articles. To achieve our goal, the following research questions arise:

- What are the high cited (value) articles in BI field?
- What are the core knowledge of BI?

With answering two research questions, our study contributes to the information system (IS) field with core knowledge of BI, help researchers get into BI quickly, and have suggestions and implications for managers of enterprises to enhance their competitive advantages. The rest of this paper is organized as followed. The next section reviews the business intelligence and co-citation analysis. Section 3 shows the research methods used in this study; Section 4 provides the results and discussion. Section 5 presents the conclusions, implications and limitations of this article.

## 2 Literature Review

### 2.1 Business Intelligence

Howard Dresner coined the term "business intelligence" in 1989 which comprises the strategies and technologies used by enterprises for the data analysis of business information. The technologies of BI include data warehousing, online analytical processing (OLAP), data mining, process mining, complex event processing, business performance management, benchmarking, text mining, predictive analytics and prescriptive analytics (Chaudhuri et al., 2011). BIS provides the capability to analyze the business information and support improving the business activities and decision making (Wixom & Watson, 2010). Managers invest and use big data (data in ERP) to perform the potential value in enterprises. They get value from BIS from investing in business intelligence, becoming business intelligence asset, and improving organizational performance (Trieu, 2017).

BIS have been used in many fields. For example, data-driven was used to analyze problems in public school, such as student achievement declines and poor youth graduation rates (Hopkins, 2011). In the enterprise business, Rehman et al. (2016) provided a framework to reduce the data transmissions between end to end in order to reduce the cost in the cloud service. Moreover, social media has become the biggest source of public opinions. Emotional analysis has great potential for application in social media texts, especially from a large number of text mining methods and social media analysis (Bo & Lee, 2008; Chau & Xu, 2012; Gruss et al., 2018; Yuan et al., 2018).

### 2.2 Co-citation Analysis

Document citation analysis is a measurement method that describes the relationship between researched objects (Small, 1973). Citation analysis is an important method for depicting scientific knowledge maps, is mainly for the analysis of cited article in published literature, and construct knowledge of a field (Shiau & Dwivedi, 2013). A high citation article reflects the peer recognition and represents key concept, method, or thought in a field (Small, 2003). High cited articles continuously have great impacts and represent high value in a research area. Articles cited together always have closer relationships in research topic, methods, or the foundation of theory. Thus, co-citation usually is used to identify the core knowledge in a field (Shiau et al., 2017). Moreover, co-citation could be used to find the internal structure in a scientific field and to identify the impacts of

group articles. For example, White & McCain (1998) presented an extensive domain analysis of a discipline — information science — in terms of its authors from 1972 through 1995. Their results showed its two sub-fields are experimental retrieval and citation analysis. Tai et al. (2014) used citation and co-citation analyses to investigate the dynamics of higher education texts and compare the status of citations between two periods of 2002-2006 and 2007-2011. Their results showed research trends changed significantly. Chang et al. (2015) used co-citation analyses for tracking the changes of research subjects in library and information science (LIS) during 4 periods (5 years each) between 1995 and 2014. The results revealed that the two subjects "information seeking and information retrieval" and "bibliometrics" are core knowledge in this field. Shiau et al. (2017) investigated social networks by co-citation methods and identified seven core factors. Their results showed that the seven core factors are measure of complex social networks, community structure, strong ties and weak ties, evolution of social networks, network structure and relationship, value concept and measurement strategies, social capital. Chandra (2018) studied the evolution of the field of entrepreneurship between 1990 and 2013 by using a combination of topic mapping, author and journal co-citation analyses and identified five topics: institutions and institutional entrepreneurship, innovation and technology management, policy and development, entrepreneurial process and opportunity, and new ventures. The co-citation analysis method provides a suitable method and means for the integration of subject knowledge. Therefore, this study chose a method of co-citation analysis to identify the core knowledge of BI.

# 3 Methodology

In this study the web of science is selected as data source due to its well-known high quality journal database. We use the key words, "business intelligent" or "business intelligence" to search for articles published between 2000 and 2018. The authors exclude the conference, books and letters in order to keep the quality of the articles. The results are 1003 journal articles and 31345 references. Citation analysis is used to understand the citation frequency and trend in a subject within a period of time. High cited articles represent high value study. From the citation analysis, we could know the high value articles and their impacts (Tai et al., 2014; Shiau et al., 2017). Even though citation analysis reveals the high impacts articles and trend of a field, it could not show the intellect structure (core knowledge) of a field. Co-citation is a popular way to explore the intellect structure of a field through a co-cited way, a paper is cited by two articles. The more co-cited number, the closer relation. Co-citation number counts for the relations among articles and shows a symmetric matrix. With co-citation matrix, we use factor analysis to explore the core knowledge of a field (Shiau & Dwivedi, 2013).

# 4 Result and Discussion

In this study, we analyzed source articles and the cited articles. The source articles were sorted by year to show a steadily rising trend of published source articles on BI, whose number has increased from 11 in year 2000 to 131 in year 2018.

The citation analysis also used to identify the most cited articles which always represented the high valuable studies. The authors use a stepwise detection method to apply to eventually identify 52 high cited articles, whose threshold number of citations was more than 14 times. The top three journals containing the most cited articles are MIS QUARTERLY, DECISION SUPPORT SYSTEMS, and COMMUNICATIONS of the ACM.

| Factor | 1 BI success | | 2 IT acceptance and measurement | | 3 Big data analysis | |
|---|---|---|---|---|---|---|
| Article number and factor loading | Popovic et al. (2012) | 0.906 | Venkatesh et al. (2000) | 0.965 | Gandom & Haider (2015) | 0.946 |
| | Isik et al. (2013) | 0.890 | Davis et al. (1989) | 0.964 | Waller & Fawcett (2013) | 0.931 |
| | Yeoh & Koronios (2010) | 0.836 | Venkatesh & Davis (2003) | 0.942 | Chen & Zhang (2014) | 0.919 |
| | Wixom & Watson (2001) | 0.835 | Davis (1989) | 0.929 | Wamba et al. (2015) | 0.901 |
| | Watson et al. (2002) | 0.787 | Goodhue & Thompson (1995) | 0.913 | Dean & Ghemawat (2008) | 0.815 |
| | DeLone & McLean (2003) | 0.762 | Fornell & Larcker (1981) | 0.753 | McAfee & Brynjolfsson (2012) | 0.738 |
| | Wixom & Watson (2010) | 0.722 | DeLone & McLean (1992) | 0.695 | Chen et al. (2012) | 0.683 |
| | Elbashir et al. (2008) | 0.678 | Jourclan et al. (2008) | 0.538 | Davenport (2006) | 0.464 |
| | Negash (2004) | 0.642 | Kaplan & Norton (1992) | 0.514 | - | - |
| | Clark et al. (2007) | 0.641 | - | - | - | - |
| | Petrini & Pozzebon (2009) | 0.617 | - | - | - | - |
| | Watson et al. (2006) | 0.553 | - | - | - | - |
| | Wang & Strong(1996) | 0.487 | - | - | - | - |
| VE% | | 19.073 | | 15.048 | | 12.637 |
| Factor | 4 Data analysis and decision making | | 5 Business strategy | | 6 BIS | |
| Article number and factor loading | Bose (2009) | 0.841 | Barney (1991) | 0.843 | Chung et al. (2005) | 0.762 |
| | Shim (2002) | 0.821 | Teece et al. (1997) | 0.767 | Hevner et al. (2004) | 0.668 |
| | March & Hevner (2007) | 0.808 | Melville et al. (2004) | 0.601 | Webster & Watson (2002) | 0.635 |
| | Baars & Kemper (2008) | 0.735 | Podsakoff et al. (2003) | 0.587 | Luhn (1958) | 0.597 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lonnqvis & Pirttimaki (2006) | 0.712 | - | - | - | - |
| VE% | | 8.371 | | 6.239 | | 6.219 |
| Factor | 7 Consumer behavior | | 8 Knowledge management | | 9 Business adoption | |
| Article number and factor loading | Chau & Xu (2012) | 0.932 | Alavi & Leidner (2001) | 0.822 | Lavalle et al. (2011) | 0.665 |
| | Bo & Lee (2008) | 0.870 | Webster & Watson (2002) | 0.633 | Chaudhuri et al. (2011) | 0.477 |
| | Eisenhardt (1989) | 0.790 | Elbashir et al. (2013) | 0.584 | - | - |
| VE% | | 6.078 | | 4.749 | | 4.130 |

**Table 1:** Results of Factor Analysis

A factor analysis with principal component analysis (PCA), Eigenvalues greater than one, and the varimax rotation method were applied to analyze the correlation matrix from the co-citations among the 52 high cited articles. The results showed that nine factors were extracted, explaining 82.544% of the variance in the correlation matrix, which is higher than the recommended 70% of the total variance (Hsiao & Yang, 2011; Shiau et al., 2017). The nine factors were named based on the cited articles containing in these factors except for one article Agrawal et al. (1993): Table 1 lists the results of the factor analysis.

## 4.1 Business Intelligence Success

The first factor is BI success. Literature including this factor mainly discuss the principle factors affecting BI success. DeLone & McLean (2003) proposed a renewed Delone and McLean IS Success model and discuss the practicability of the renewed model in measuring electronic business system success. Elbashir et al. (2008) pointed out that the relationship between business process and organizational performance has an impact on BI success. Yeoh & Koronios (2010) developed a critical success factor (CSF) framework crucial for BI system realization and examine its applicability with a case, which aim to fill the gap between scholars and practitioners through research on CSF affecting BIS success. Popovic et al. (2012) argued that effects of maturity and culture on analytical decision making impact BI system success. Isik et al. (2013) suggested that data quality, user visit, and technical competence such as integration between BI and other systems are all essential requirements for BI success. Moreover, decision-making environment can influence relationship between BI success and technologies. Data Warehouse (DW) is one of the vital developments in IS (Watson et al. 2006). Wixom & Watson (2001) empirically examined success factors affecting DW success, and argued that management support and resource help address organization issues during DW implementation process. Though DW is of many advantages, some organizations gain higher rewards than others. Thus, Watson et al. (2002) introduced a framework, which presents how DW changes organizations and explains why there are impact differences. Negash (2004) proposed a BI framework and a potential research topic. The framework emphasizes on importance of unstructured data and discusses the necessity of BI tools developed to acquire, integrate, clean, search, analyze and delivery.

In summary, the findings show that data quality, user visit and technical competence such as integration between BI and other systems are all essential requirements for BI success (Isik et al. 2013), but decision-making environment can influence relationship between BI success and technologies. Organization factors play a vital role in determining success of BI system realization (Yeoh & Popovic 2016). Commitment from top management and shared understanding become important premise for agile values and plan-driven aspects), which arrives at the conclusion agile values are more helpful for DW/BI analysis success (Batra, 2018).

## 4.2 IT Adoption and Measurement

The second factor is IT adoption and measurement. Literature including this factor mainly discuss IT innovation tools or model development. Davis (1989) developed and examines new scales including two particular variables: perceived usefulness (PU) and perceived ease of use (PEOU). Davis et al. (1989) compared the influences of PU and PEOU on user acceptance of computer technologies. Kaplan & Norton (1992) developed a balanced scorecard, which a new performance measurement system that enable top managers understand the business quickly and comprehensively. Venkatesh & Davis (2000) developed and tested theoretical extension of technology acceptance model (TAM). This model, which is called TAM2, explains terms on social influence and cognitive instrumental process. Based on summary of prior research on TAM, (Venkatesh et al., 2003) propose a Unified Theory of Acceptance and Use of Technology (UTAUT) to study factors that influence users' cognition. Goodhue & Thompson (1995) proposed a comprehensive theoretical model and empirically test a core of the model. The model emphasizes that matching between technology and user task is important to realization of influence of technology on personal performance. DeLone & McLean (1992) proposed six key dimensions or categories of IS success: system quality, information quality, use, user satisfaction, individual impact, and organizational impact. Jourclan et al. (2008) collected, synthesized and analyzed 167 BI relevant articles in ten top IS journals from1997 to 2006. The findings show that activity level is improved generally within ten years and the emphasis is exploratory research method.

In summary, BI system has become an important tool for enterprise to make decisions timely and effectively. Nevertheless, there are many differences in quality and performance of BIS in the market. Company managers should evaluate BIS before purchase so that they can choose suitable BIS. For example, Wang et al. (2016) proposed a fuzzy comprehensive evaluation method for BI system choice based on multi-attribute group decision making.

## 4.3 Big Data Analysis

The third factor is big data analysis. Literature including this factor mainly discuss big data related concepts, methods and technologies. Waller & Fawcett (2013) argued data science, predictive analysis, and big data would change supply chain design and management. Wamba et al. (2015) proposed an interpretation framework for analyzing big data definition and application. They also provided a universal taxonomy, which helps broaden the understanding of big data and its role in capturing business value. Chen & Zhang (2014) described a close-up view of big data, including big data application, big data opportunity and challenge, as well as the most advanced technologies we apply to address big data issues. MapReduce is a programming model and a relevant implementation for processing and generating large scale data sets that can be adapted to a variety of real-world tasks. Users specify computations through map and reduce functions. And the system automatically computes in parallel among large machine clusters at underlying runtime, processes machine errors, and schedules inter-machine communication to effectively utilize the network and disks (Dean & Ghemawat, 2008). Chen et al. (2012) divided BI and analysis into three levels: BI & A 1.0, BI & A 2.0

and BI＆A 3.0, and made definitions and descriptions according to their major features and functions. Davenport (2006) argued companies need not only an accumulation of technology and massive stores of data, but also a heavy investment in the formulation of company wide strategies for managing the data in order to compete in the quantitative field.

In summary, big data is much more powerful than prior analysis. Mangers can measure and manage data more accurately than ever before, and make better decisions (McAfee & Brynjolfsson, 2012). Drawing on the results of system evaluation and case study, Wamba et al. (2015) proposed an interpretation framework and analyzes the definition and application of big data. The findings shows that big data can indeed help knowledge co-creation, which in turn can sufficiently guide evidence-based, effective and efficient decision-making and thus obtain better business returns (Acharya et al., 2018).

## 4.4 Data Analysis Support Decision

The fourth factor is data analysis support decision. Literature including this factor mainly discuss how to manage data and support decisions. Through advanced analytics-driven data analyses, enterprises can have a complete and 360-degree view of their operations and customers. Then, they obtain insight from these analyses to guide, optimize and automate their decisions for successful realization of their organization objectives. Data, text, and web mining technologies are among the key factors that make advanced analysis possible. Bose (2009) studied how to use the three mining technologies, as well as issues related to their effective implementation and management. Shim et al. (2002) discussed the development of DSS, as well as issues related to its definition, application, and influence. Then, it provides four strong decision support tools, including DW, online application processing (OLPA), data mining, and web-based DSS. Baars & Kemper (2008) developed an integrated BI framework to manage structured and unstructured data. Lonnqvist & Pirttimaki (2006) identified and evaluated measurement methods for two different purpose: identify BI value and manage BI processes within management organizations.

In summary, Decision support, which is a traditional management concept, plays an important role in organizational competitiveness or survival (Rouhani et al., 2016; Safwan et al., 2016), and the key to successfully support management decision depends on timely and intelligible high quality information (March & Hevner, 2007). BI is usually used as a collective name for large scale DSS within organizations (Arnott et al., 2017). BI supports efficient identification of problems and opportunities, key decision making, strategy formulation, implementation, and evaluation.

## 4.5 Enterprise Strategy

The fifth factor is enterprise strategy. Literature including this factor mainly discuss the influence of BI on enterprise strategy. Barney (1991) analyzed the potential of multiple enterprise resources to generate sustainable competitive advantages, and studied the relationship between enterprise resources and sustainable competitive advantages. Teece et al. (1997) discussed the relationship between dynamic capabilities and strategy management. Melville et al. (2004) developed an IT business value model based on resource-based view. Podsakoff et al. (2003) studied method biases in behavioral sciences and provide recommendations

In summary, the advent of BIS have increased the ability of organizations to collect and analyse data to support decisions. Shollo & Galliers (2016) developed a conceptual framework of organizational knowledge based on a synthesis of the literature, and use this as a framework to investigate how BIS facilitate knowledge in a case organization. The company's BI strategy included

elements that directly addressed governance and resource management, business technology alignment, innovation and skills capability (Hawking & Sellitto, 2017).

## 4.6 Business Intelligence System

The sixth factor is BIS. Literature including this factor mainly discuss the function of BIS. In order to handle enormous data flows in uncertain economic environments nowadays, enterprise has already adopted BIS widely that provide internal and external information for stakeholders at all work levels in decision schemes. Chung et al. (2005) proposed a visual framework for knowledge discovery on the web. This framework integrates web mining, clustering, and visualization technology to support effective intellectual inquiry. Hevner et al. (2004) described the performance of design science research in IS through a concise conceptual framework and a clear guideline in order to comprehend, execute and access research. Watson & Wixom (2007) argued BI includes two major active flows: data input and data output. Luhn (1958) developed an automatic system that can spread information to any department of industry, science or government organization. This intelligence system would use data processing machines to automatically extract and encode documents, and create interest configuration files for each action point in the organization.

In summary, in order to handle enormous data flows in uncertain economic environments nowadays, enterprise has adopted BIS widely that provide internal and external information for stakeholders at all work levels in decision schemes. Although BI technologies have been developing, the capabilities to apply BI technology have been indispensable resources for enterprises to operate in complex, uncertain, and dynamic business environment nowadays. Business Intelligence System Effectiveness (BISE) can be used to predict models and rules for pioneering work. For enterprises, effectively managing critical attributes that determine BISE to develop prediction models with a set of rules for self-evaluation of the effectiveness of BI solutions is necessary to improve BI implementation and ensure its success (Han et al., 2016; Weng et al., 2016).

## 4.7 Consumer Behavior

The seventh factor is consumer behavior. Literature including this factor mainly discuss the emotion analysis of costumers using social software and their interactions. With the growing popularity of opinion-rich resources such as online review sites and personal blogs and other opinion rich resource, people's comments and information-rich consumer community may become the gold mine of BI, which brings great opportunities for academic research and business application. Chau & Xu, (2012) proposed a framework for gathering BI from blogs by automatically collecting and analyzing blog contents and bloggers' interaction networks to analyze consumer behavior and mining effective information. Bo & Lee (2008) summarized evaluative text and issues regarding privacy, manipulation, and economic to address the new challenges raised by sentiment-aware applications. Eisenhardt (1989) described a process that introduces case study into theory from specific research questions to final result. Some features of the process, such as problem definition and construct validation, are similar to hypothesis-testing research. Other features, such as case analysis and replication logic, are unique to the inductive, case-oriented process.

In summary, using social software and their interactions, we can study consumer behavior and improve the level of marketing decision-making. Bollen et al. (2011) predicted consumer emotions based on Twitter platform. One can also analyze unstructured text on Facebook using text mining (He et al., 2013). Furthermore, the value of social media competitive analysis and text mining can be used as efficient technology strength to extract business value from vast available social media data (Kurnia a& Suharjito, 2018).

## 4.8 Knowledge Management

The eighth factor is knowledge management. Literature including this factor mainly discuss the importance of knowledge management that can create value for enterprises. In the information era, knowledge has become a major source of wealth. The vital task of organizations and individuals is to manage knowledge. Knowledge management can enable organizations and individuals to be more competitive and make better decisions. Alavi & Leidner (2001) reviewed and explained literature on knowledge management in different domains, looked at identifying important research domain, focused on the potential role of IT in organization knowledge management. Webster & Watson (2002) presented information on how to write a literature review in the field of IS, noting that there are only a few published review articles in this field. Elbashir et al. (2013) argued that knowledge sharing and assimilation can improve business value of BI.

In summary, enterprises that develop and possess excellent knowledge management capabilities can better manage external knowledge and combine it with internal knowledge (Elbashir et al., 2013; Ferraris et al., 2017). But among external factors that influence open innovation (OI), knowledge management ability has a direct impact on OI (Isabel et al., 2017).

## 4.9 Business Intelligence Technology Adoption

The ninth factor is BI technology adoption. Literature including this factor mainly discuss the application of BI technology. Lavalle et al. (2011) discussed how data-driven management and analyses help public school system in Gwinnett County, Atlanta, Georgia determine education risk students' performance that can predict its success most accurately. Chaudhuri et al. (2011) pointed out that BI has a viable prospect in research and industry domain. Data collection has become increasing easy. Large databases have become more popular. Text data is also used as a valuable source of BI. The change of hardware technology is influencing backend architectures of large DW.

In summary, BI technologies are active in academia and business. Data collection is getting much easier. Text data are seen as precious resource for BI. The change of hardware such as the cost reduce of main storage and internal storage is influencing backend architectures of large DW. Thus BI software still faces many technology challenges and opportunities (Chaudhuri et al., 2011). For instance, to apply BI system in logistic model of hospital supply, disposition and distribution in order to handle the key problem in hospital logistics BI systems and improve work flows of hospital logistics management (Liu et al., 2017).

## 5 Conclusion

BI is a set of methodologies, processes, architectures, and technologies that transform raw data into meaningful and useful information in order to identify new opportunities and implementing an effective strategy for enterprises to have more competitive advantage. The aim of this study is to explore the core knowledge of BI. Data collected from Web of Science are 1003 journal articles and 31345 references. We identify 52 high cited article and group into 9 core factors. They are: 1) BI success, 2) IT acceptance and measurement, 3) big data analysis, 4) data analysis and decision making, 5) business strategy, 6) BIS, 7) consumer behavior, 8）knowledge management, 9）business adoption. The trend of BI study is still growing and getting more attention of researchers. With more advanced technology emerged, such as internet of things and artificial intelligence, BI will be more intelligent and play critical role in business decision making.

# 6 Implications and Limitations

In an evolving research, it is important to understand core issues. Through the understanding of core knowledge, researchers will have a better understanding of BI. For academics, our results provide high values and nine factors of BI articles. Researchers may save enormous time to realize the core issues of BI, explore more unsolved problems, and create more valuable BI studies. For practitioners, managers may know more how to use BI knowledge to improve operation of enterprise operation. BIS provides data analysis in time. Managers make better decisions through high quality data analysis to help enterprise confront crises, create new business opportunity, and develop new business model to enhance the competitive advantage in the global economy. Our results have some limitations. First, co-citation suffers the time lag problem. The new important article may not show up due to the factor of time. Second, we use factor analysis to explore the core issues. Different methods may have different results. Future studies may use other methods to explore and compare with our results. Finally, for an evolving research, it always changes in different time period. Future studies may explore and compare the different period time of BI articles in order to know the different core knowledge from time to time.

# References

Acharya, A., Singh, S. K., Pereira, V. & Singh, P. (2018). Big Data, Knowledge Co-Creation and Decision Making in Fashion Industry. *International Journal of Information Management* (42), pp. 90-101.

Alavi, M. & Leidner, D. E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly* (25:1), pp. 107-136.

Arnott, D., Lizama, F. & Song, Y. T. (2017). Patterns of Business Intelligence Systems Use in Organizations. *Decision Support Systems* (97), pp. 58-68.

Baars, H. & Kemper, H.-G. (2008). Management Support with Structured and Unstructured Data - an Integrated Business Intelligence Framework. *Information Systems Management* (25:2), pp. 132-148.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management* (17:1), p. 3-10.

Batra, D. (2018). Agile Values or Plan-Driven Aspects: Which Factor Contributes More toward the Success of Data Warehousing, Business Intelligence, and Analytics Project Development?. *Journal of Systems and Software* (146), pp. 249-262.

Bo, P. & Lee, L. (2008). Opinion Mining and Sentiment Analysis. *Foundations and Trends in Information Retrieval* (2:1-2), pp. 1-135.

Bollen, J., Mao, H. & Zeng, X. (2011). Twitter Mood Predicts the Stock Market. Journal of Computational Science (2:1), pp. 1-8.

Bose, R. (2009). Advanced Analytics: Opportunities and Challenges. *Industrial Management & Data Systems* (109:1-2), pp. 155-172.

Brichni, M., Dupuy-Chessa, S., Gzara, L., Mandran, N. & Jeannet, C. (2017). Bi4bi: A Continuous Evaluation System for Business Intelligence Systems. *Expert Systems with Applications* (76), pp. 97-112.

Chandra, Y. (2018). Mapping the Evolution of Entrepreneurship as a Field of Research (1990-2013): A Scientometric Analysis. *Plos One* (13:1), p. 24.

Chang, B. J. (2018). Agile Business Intelligence: Combining Big Data and Business Intelligence to Responsive Decision Model. *Journal of Internet Technology* (19:6), pp. 1699-1706.

Chang, Y. W., Huang, M. H. & Lin, C. W. (2015). Evolution of Research Subjects in Library and Information Science Based on Keyword, Bibliographical Coupling, and Co-Citation Analyses. *Scientometrics* (105:3), pp. 2071-2087.

Chau, M. & Xu, J. (2012). Business Intelligence in Blogs: Understanding Consumer Interactions and Communities. *MIS Quarterly* (36:4), pp. 1189-1216.

Chaudhuri, S., Dayal, U. & Narasayya, V. (2011). An Overview of Business Intelligence Technology. *Communications of the ACM* (54:8), pp. 88-98.

Chen, C. L. P. & Zhang, C. Y. (2014). Data-Intensive Applications, Challenges, Techniques and Technologies: A Survey on Big Data. *Information Sciences* (275), pp. 314-347.

Chen, H. C., Chiang, R. H. L. & Storey, V. C. (2012). Business intelligence and analytics: from big data to big impact. *MIS Quarterly* (*36*:4), pp. 1165-1188.

Chung, W., Chen, H. & Nunamaker, J. F. (2005). A Visual Framework for Knowledge Discovery on the Web: An Empirical Study of Business Intelligence Exploration. *Journal of Management Information Systems* (21:4), pp. 57-84.

Clark, T. D., Jr., Jones, M. C. & Armstrong, C. P. (2007). The Dynamic Structure of Management Support Systems: Theory Development, Research Focus, and Direction. *Mis Quarterly* (31:3), pp. 579-615.

Davenport, T. H. (2006). Competing on Analytics. *Harvard Business Review* (84:1), pp. 98-107.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *Management Information Systems Quarterly* (13:3), pp. 319-340.

Davis, F. D., Bagozzi, R. P. & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science* (35:8), pp. 982-1003.

Dean, J. & Ghemawat, S. (2008). Mapreduce: Simplified Data Processing on Large Clusters. *Communications of the ACM* (51:1), pp. 107-113.

DeLone, W. H. & McLean, E. R. (1992). Information Systems Success: The Quest for the Dependent Variable. *Information Systems Research* (3:1), pp. 60-95.

DeLone, W. H. & McLean, E. R. (2003). The Delone and Mclean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems* (19:4), pp. 9-30.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Academy of Management Review* (14:4), pp. 532-550.

Elbashir, M. Z., Collier, P. A. & Davern, M. J. (2008). Measuring the Effects of Business Intelligence Systems: The Relationship between Business Process and Organizational Performance. *International Journal of Accounting Information Systems* (9:3), pp. 135-153.

Elbashir, M. Z., Collier, P. A., Sutton, S. G., Davern, M. J. & Leech, S. A. (2013). Enhancing the Business Value of Business Intelligence: The Role of Shared Knowledge and Assimilation. *Journal of Information Systems* (27:2), pp. 87-105.

Ferraris, A., Santoro, G. & Dezi, L. (2017). How Mnc's Subsidiaries May Improve Their Innovative Performance? The Role of External Sources and Knowledge Management Capabilities. *Journal of Knowledge Management* (21:3), pp. 540-552.

Fornell, C. & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research (JMR)* (18:1), pp. 39-50.

Goodhue, D. L. & Thompson, R. L. (1995). Task-Technology Fit and Individual Performance. *MIS Quarterly* (19:2), pp. 213-236.

Gruss, R., Abrahams, A. S., Fan, W. G. & Wang, G. A. (2018). By the Numbers: The Magic of Numerical Intelligence in Text Analytic Systems. *Decision Support Systems* (113), pp. 86-98.

Han, Y. M., Shen, C. S. & Farn, C. K. (2016). Determinants of Continued Usage of Pervasive Business Intelligence Systems. *Information Development* (32:3), pp. 424-439.

Hawking, P. & Sellitto, C. (2017). A Fast-Moving Consumer Goods Company and Business Intelligence Strategy Development. *International Journal of Enterprise Information Systems* (13:2), pp. 22-33.

He, W., Zha, S. H. & Li, L. (2013). Social Media Competitive Analysis and Text Mining: A Case Study in the Pizza Industry. *International Journal of Information Management* (33:3), pp. 464-472.

Hevner, A. R., March, S. T., Park, J. & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly* (28:1), pp. 75-105.

Hopkins, M. S. (2011). Big Data, Analytics and the Path from Insights to Value. *MIT Sloan Management Review* (52:2), pp. 21-22.

Isabel, M. C., Pedro, S. A. & Carayannis, E. G. (2017). On the Path Towards Open Innovation: Assessing the Role of Knowledge Management Capability and Environmental Dynamism in Smes. *Journal of Knowledge Management* (21:3), pp. 553-570.

Isik, O., Jones, M. C. & Sidorova, A. (2013). Business Intelligence Success: The Roles of Bi Capabilities and Decision Environments. *Information & Management* (50:1), pp. 13-23.

Jin, D. H. & Kim, H. J. (2018). Integrated Understanding of Big Data, Big Data Analysis, and Business Intelligence: A Case Study of Logistics. *Sustainability* (10:10), p. 15.

Jourclan, Z., Rainer, R. K. & Marshall, T. E. (2008). Business Intelligence: An Analysis of the Literature. *Information Systems Management* (25:2), pp. 121-131.

Kaplan, R. S. & Norton, D. P. (1992). The Balanced Scorecard--Measures That Drive Performance. *Harvard Business Review* (70:1), pp. 71-79.

Kurnia, P. F. & Suharjito. (2018). Business Intelligence Model to Analyze Social Media Information. *Procedia Computer Science* (135), pp. 5-14.

Lavalle, S., Lesser, E., Shockley, R., Hopkins, M. S. & Kruschwitz, N. (2011). Big Data, Analytics and the Path from Insights to Value. *MIT Sloan Management Review* (52:2), pp. 21-32.

Liang, T. P. & Liu, Y. H. (2018). Research Landscape of Business Intelligence and Big Data Analytics: A Bibliometrics Study. *Expert Systems with Applications* (111), pp. 2-10.

Liu, T. Z., Shen, A. Z., Hu, X. J., Tong, G. X. & Gu, W. (2017). The Application of Collaborative Business Intelligence Technology in the Hospital Spd Logistics Management Model. *Iranian Journal of Public Health* (46:6), pp. 744-754.

Lonnqvist, A. & Pirttimaki, V. (2006). The Measurement of Business Intelligence. *Information Systems Management* (23:1), pp. 32-40.

Luhn, H. P. (1958). A Business Intelligence System. *IBM Journal of Research and Development* (2:4), pp. 314-319.

March, S. T. & Hevner, A. R. (2007). Integrated Decision Support Systems: A Data Warehousing Perspective. *Decision Support Systems* (43:3), pp. 1031-1043.

McAfee, A. & Brynjolfsson, E. (2012). Strategy & Competition Big Data: The Management Revolution. *Harvard Business Review* (90:10), pp. 60-66.

Melville, N., Kraemer, K. & Gurbaxani, V. (2004). Review: Information Technology and Organizational Performance: An Integrative Model of It Business Value. *MIS Quarterly* (28:2), pp. 283-322.

Negash, S. (2004). Business Intelligence. *Communications of the Association for Information Systems* (13), pp. 177-195.

Petrini, M. & Pozzebon, M. (2009). Managing Sustainability with the Support of Business Intelligence: Integrating Socio-Environmental Indicators and Organisational Context. *Journal of Strategic Information Systems* (18:4), pp. 178-191.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y. & Podsakoff, N. P. (2003). Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. *Journal of Applied Psychology* (88:5), pp. 879-903.

Popovic, A., Hackney, R., Coelho, P. S. & Jaklic, J. (2012). Towards Business Intelligence Systems Success: Effects of Maturity and Culture on Analytical Decision Making. *Decision Support Systems* (54:1), pp. 729-739.

Rouhani, S., Ashrafi, A., Ravasan, A. Z. & Afshari, S. (2016). The Impact Model of Business Intelligence on Decision Support and Organizational Benefits. *Journal of Enterprise Information Management* (29:1), pp. 19-50.

Safwan, E. R., Meredith, R. & Burstein, F. (2016). Business Intelligence (Bi) System Evolution: A Case in a Healthcare Institution. *Journal of Decision Systems* (25:suppl.1), pp. 463-475.

Shiau, W. L. & Dwivedi, Y. K. (2013). Citation and Co-Citation Analysis to Identify Core and Emerging Knowledge in Electronic Commerce Research. *Scientometrics* (94:3), pp. 1317-1337.

Shiau, W. L., Dwivedi, Y. K. & Yang, H. S. (2017). Co-Citation and Cluster Analyses of Extant Literature on Social Networks. *International Journal of Information Management* (37:5), pp. 390-399.

Shim, J. P., Warkentin, M., Courtney, J. F., Power, D. J., Sharda, R. & Carlsson, C. (2002). Past, Present, and Future of Decision Support Technology. *Decision Support Systems* (33:2), pp. 111-126.

Shollo, A. & Galliers, R. D. (2016). Towards an Understanding of the Role of Business Intelligence Systems in Organisational Knowing. *Information Systems Journal* (26:4), pp. 339-367.

Small, H. (1973). Co‑Citation in the Scientific Literature: A New Measure of the Relationship between Two Documents. *Journal of the American Society for Information Science* (24:4), pp. 265-269.

Tai, C. H., Lee, C. W. & Lee, Y. (2014). Citation Analysis of Higher Education Texts in Selected Databases: A Comparison between 2002-2006 and 2007-2011. *International Journal of Engineering and Technology* (5:2), pp. 306-310.

Teece, D. J., Pisano, G. & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal* (18:7), pp. 509-533.

Trieu, V. H. (2017). Getting Value from Business Intelligence Systems: A Review and Research Agenda. *Decision Support Systems* (93), pp. 111-124.

Venkatesh, V. & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science* (46:2), p. 186.

Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly* (27:3), pp. 425-478.

Waller, M. A. & Fawcett, S. E. (2013). Data Science, Predictive Analytics, and Big Data: A Revolution That Will Transform Supply Chain Design and Management. *Journal of Business Logistics* (34:2), pp. 77-84.

Wamba, S. F., Akter, S., Edwards, A., Chopin, G. & Gnanzou, D. (2015). How 'Big Data' Can Make Big Impact: Findings from a Systematic Review and a Longitudinal Case Study. *International Journal of Production Economics* (165), pp. 234-246.

Wang, C. T., Cai, X. F. & Li, B. W. (2016). Fuzzy Comprehensive Evaluation Based on Multi-Attribute Group Decision Making for Business Intelligence System. *Journal of Intelligent & Fuzzy Systems* (31:4), pp. 2203-2212.

Wang, R. Y. & Strong, D. M. (1996). Beyond Accuracy: What Data Quality Means to Data Consumers. *Journal of Management Information Systems* (12:4), pp. 5-33.

Watson, H. J., Goodhue, D. L. & Wixom, B. H. (2002). The Benefits of Data Warehousing: Why Some Organizations Realize Exceptional Payoffs. *Information & Management* (39:6), pp. 491-502.

Watson, H. J. & Wixom, B. H. (2007). The Current State of Business Intellegence. *Computer* (40:9), pp. 96-99.

Watson, H. J., Wixom, B. H., Hoffer, J. A., Anderson-Lehman, R. & Reynolds, A. M. (2006). Real-Time Business Intelligence: Best Practices at Continental Airlines. *Information Systems Management* (23:1), pp. 7-18.

Webster, J. & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly* (26:2), pp. XIII-XXIII.

Weng, S. S., Yang, M. H., Koo, T. L. & Hsiao, P. I. (2016). Modeling the Prediction of Business Intelligence System Effectiveness. *Springerplus* (5:1), p. 737.

White, H. D. & McCain, K. W. (1998). Visualizing a Discipline: An Author Co-Citation Analysis of Information Science, 1972-1995. *Journal of the American Society for Information Science* (49:4), pp. 327-355.

Wixom, B. & Watson, H. (2010). The Bl-Based Organization," *International Journal of Business Intelligence Research* (1:1), pp. 13-28.

Wixom, B. H. & Watson, H. J. (2001). An Empirical Investigation of the Factors Affecting Data Warehousing Success. *MIS Quarterly* (25:1), pp. 17-41.

Yeoh, W. & Koronios, A. (2010). Critical Success Factors for Business Intelligence Systems. *Journal of Computer Information Systems* (50:3), pp. 23-32.

Yeoh, W. & Popovic, A. (2016). Extending the Understanding of Critical Success Factors for Implementing Business Intelligence Systems. *Journal of the Association for Information Science and Technology* (67:1), pp. 134-147.

Yuan, H., Xu, W., Li, Q. & Lau, R. (2018). Topic Sentiment Mining for Sales Performance Prediction in E-Commerce. *Annals of Operations Research* (270:1-2), pp. 553-576.