

Review

Business Intelligence: Business Evolution after Industry 4.0

Carlos Andrés Tavera Romero ^{1,*} , Jesús Hamilton Ortiz ², Osamah Ibrahim Khalaf ³ and Andrea Ríos Prado ¹

¹ COMBA R&D Laboratory, Faculty of Engineering, Universidad Santiago de Cali, Cali 76001, Colombia; andrea.rios00@usc.edu.co

² Closemobile R&D Telecommunications LS, 28070 Madrid, Spain; jesushamilton.ortiz@gmail.com

³ Al-Nahrain Nanorenewable Energy Research Center, Al-Nahrain University, Baghdad 10001, Iraq; usama.ibrahem@coie-nahrain.edu.iq

* Correspondence: carlos.tavera00@usc.edu.co; Tel.: +57-311-3348381

Abstract: Industry 4.0 is a set of technologies that companies require to promote innovation strategies and obtain a rapid response in dynamic markets. It focuses mainly on interconnectivity, digital technology, predictive analytics and machine learning to revolutionize the way companies operate and develop. Therefore, this article proposes and motivates the implementation of Industry 4.0 in organizations. Studying the state of the art and reviewing the current situation of business intelligence (BI) technology, the way it has positively impacted organizations at the economic and business level in terms of decision-making and some success stories implemented in different business, academic, social and governmental environments. Moreover, it addresses the future expected for Industry 4.0 primarily in BI and how companies should face this revolution. This article provides knowledge contribution about the current state and positive consequences of Industry 4.0, and high development in technology when implemented in the organization and the harmonization between production and intelligent digital technology.

Keywords: big data; business intelligence; industry 4.0; data analysis; digital transformation; internet of things



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1. Introduction

Business intelligence (BI) is defined as a decision-making process supported by the integration and analysis of an organization's data resources. In fact, BI plays an increasingly more critical role in several types of companies because, as information has been identified as the most valuable asset of a company, it is a fundamental resource for its development.

At present, because data constitute a new class of economic asset, similar to currency or gold [1], BI has become a challenge for information technology—Industry 4.0—as well as a very important management issue. Its importance has been especially recognized for developing analytics-based decision-making capabilities reflected in software and computer systems [2].

Business environments are becoming complex in the contour of Industry 4.0. Therefore, to provide quick responses in these dynamic markets, companies require innovations and advanced technologies [3]. In this context, technological tools, such as business intelligence (BI), are required both for processing information and for making correct decisions at corporate level. If this technological tool is implemented in an organization, it may provide several benefits such as architecture, efficient information and customer data management [4]. With this approach, companies may acquire a clearer picture of how important BI becomes in all different environments.

The highly unstable business environment, as well as the opportunities arising within the economy, require a fast and efficient decision-making process. Tracking these dynamic changes within and outside organizations while maintaining sustainable goals is indeed a challenging feat. However, this is possible because of the different modern concepts and tools available such as Industry 4.0 and BI [5].

A survey in Thailand in which 500 questionnaires were collected from those responsible for PYME, it was found that elements of Industry 4.0, such as Big Data, IoT and Smart Factory, have a positive role in promoting the implementation of information technology (IT), which contributes to sustainable business performance [6].

A study by Ślusarczyk showed that most people recognize the concept of Industry 4.0 as a great opportunity for development and improvement of competitiveness, although the state of readiness of each company to implement it varies greatly depending on the country, sector or each company [7].

Other environments are positively impacted by BI, as per 39 studies cited in Table 1. At 56%, the industrial or business environment is the most positively affected by BI from all the others, as attested by 22 studies out of the 39 reviewed. Here, the academic environment ranks second at 21% and a total of eight studies published out of the 39 reviewed. Throughout this document, the different environments in which BI exerts a total positive impact will be discussed in detail. This paper is a review of existing technologies.

Table 1. Impact from BI in certain environments.

Environment	Reference	Percentage
Academic	[2,22,25,37,39,46,47,50]	21%
Governmental	[13,23,41]	8%
Industrial	[1,3,10–12,14,24,26–28,30–35,42,44,45,48,49,54]	56%
Social	[4,5,15,29,43,53]	15%

This article motivates companies to install or implement the technologies that cover Industry 4.0, showing the state of the art and benefits that have been identified by the use of these tools that cover the concept of BI and Industry 4.0. This contribution will help small and medium-sized companies since these technologies constitute a support for their development and constant growth, making processes and operational aspects easier with intelligent digital technology.

The motivation for writing this article is to determine the impact of Industry 4.0 on the administrative and operational processes of all companies, regardless of their size or sector, relying on studies carried out in different countries to show the real contribution of this concept that has transformed many companies.

This article aims to motivate the implementation of Industry 4.0 and highlight the positive consequences for companies that undertake the change and technological revolution.

2. Methodology

Document selection for this paper was carried out through the following electronic sources: MDPI, IEEE, Scopus and Science Direct. These information sources were selected as a basis for being indexed and cataloged as Q1 to Q3, being pioneers in technology knowledge base and for having a lot of research. Firstly, 3689 articles were identified as the initial basis, 1354 articles and conference proceedings were selected from the journal MDPI, 1160 articles corresponding to the IEEE source, 745 were chosen by Scopus and finally 470 articles were filtered by Science Direct. After this identification, and looking for updated information, articles between 1 and 3 years of publication were selected, with this filter producing 1774 articles. Next, files that did not have Business Intelligence or similar terms were excluded, and in this process, 650 documents resulted. Finally, 44 papers were selected, that included research, case or further studies, and paper reviews on Business Intelligence, Big Data, Industry 4.0 and the Internet of Things. The process is presented in the Figure 1.

Review articles can be classified into several categories according to target, evaluation, reasoning and examination. In [8], we observed a list with the main categories and methodological aspects of search, analysis and synthesis, which is shown in Table 2.

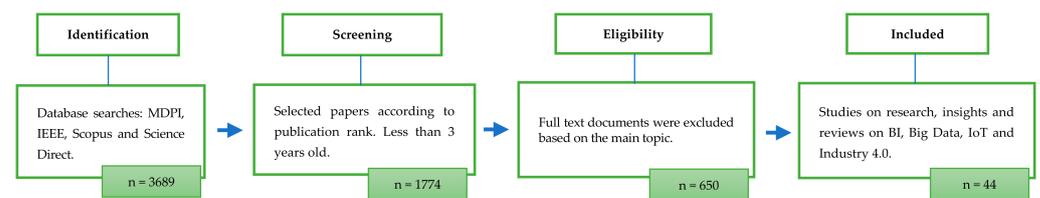


Figure 1. Paper selection process.

Table 2. Review categories and their methods.

Review Category	Target	Evaluation	Reasoning	Examination
Critical	To characterize relevant aspects	Quality estimation is not strict and it is according to contribution	Commonly narrative, maybe conceptual or chronological	Establish contribution to embody or derive
Literature	Retrieving is optional	Quality assessment is elective	Commonly narrative	Study may be chronological, conceptual, thematic, etc.
Mixed studies	Exploitation of selected studies	Evaluation with checklists	Textual or graphical means of engaging studies	Correlates or identifies absent but missing aspects
Scoping	The search depends on time or scope, possible active research	Quality estimation is not strict	Commonly tabular with some commentaries	Characterizes literature by key features; attempts to specify a review
State-of-the-art	To search current literature	Quality estimation is not strict	Commonly narrative, it can have graphics	Shows current state-of-the-art and new ideas for research
Systematic search	Exhaustive search	Quality assessment is elective	Minimal narrative, tabular summary	What is known, advice for practice and constraints

The structure and approach of this paper correspond to a state-of-the-art review as shown in Table 2. It also addresses the issue, contrasting the approaches of the different sources and proposing how these can guide future research on the subject. Regarding the synthesis methods, the document is structured by thematic points or sources, as needed [9].

3. The Impact of Business Intelligence

BI has become indispensable for strategic decision-making in companies and governments around the world. It plays an important role in business survival, in maintaining relationships with other companies, counterintelligence, goals and both short-term and long-term objectives. Moreover, the studies [10] confirm benefits from BI implementation, including improved performance, efficiency, productivity, business growth, resource planning, supplier–buyer relationship and cost reductions, which can ultimately lead to a competitive advantage [11].

Based on these studies, we classified the studies considering the different reasons that the authors of these studies were motivated to examine BI. The motivators have been classified into five different categories in which successful implementation factors is the most cited reason in the different studies with a total of 19 studies. These categories are listed in Table 3.

As per the information denoted in Table 3, organizations are faced with large datasets that cannot be used without BI as a motivator for competitive advantage [12]. For better decision-making, organizations use BI to build insights from their data. A BI solution follows a BI architecture. The uses of these technologies in all fields, including healthcare,

automotive, finance, gaming, environmental surveillance, agriculture, sports, energy management and safety, are changing the perspective at the work as well as fun levels [13]. Note that additional advancement of these technologies can contribute to developing hyper automation and hyper connectivity, leading us to the dawn of Industry 4.0. The advancement of BI is at the core of improved performance of all other technologies and the evolution of this industry.

Table 3. Authors' BI research motivators.

Investigation Motivators	Reference	Percentage
Skills and qualifications	[48–52]	13%
Successful implementation factors	[3,5,23,25,27,30,31–46]	49%
Literature	[1,2,4,14,47]	13%
User satisfaction	[10,11,13,22,24]	13%
Competitive advantage	[12,15,25,28,29]	13%

The sources defined Industry 4.0 as “a concept used to describe related technological advances that provide the basis for increasing the level of digitization of industrial and business environments” [14]. Usually, when discussing the development of Industry 4.0, four key components are distinguished. The key components are shown in Figure 2 in an ascending manner as per their impact. Figure 2 was designed according to the information analyzed from [15].

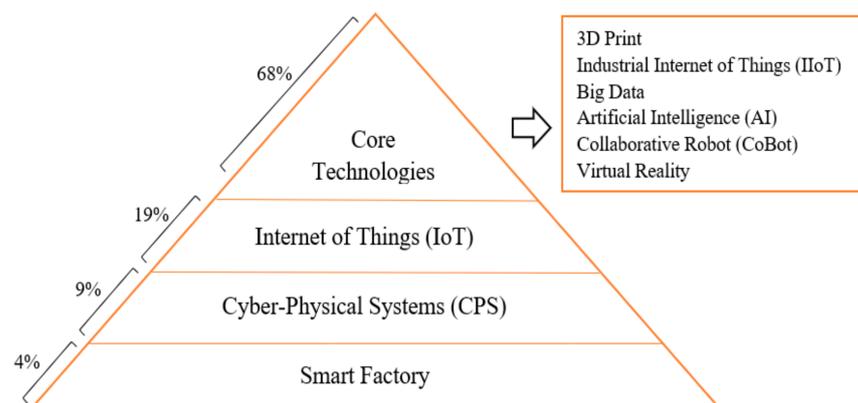


Figure 2. Industry 4.0 key components.

From the information consulted in [15] and shown in Figure 2, it is considered that Core Technologies have had a 68% impact on Industry 4.0. This 68% has been reflected in organizations with a high implementation of Big Data and Artificial Intelligence, providing organizational development and multiple advantages for the management of the main assets of the company. On the other hand, it offers predictive analytics for high-value decision making. Virtual reality and 3D printing have also worked to support training and operational processes. In other words, Industry 4.0 grows stronger every day and becomes more critical for organizations. Secondly, we have the Internet of Things, which continues to grow exponentially to position itself at the top of the key components. Cyber-physical systems and smart factories have continued to gain strength.

In Industrial Revolution 4.0, which is defined by the extensive use of different technologies in all fields, particularly on the Internet, users are required to be able to quickly access data and information to make proper decisions wherever they are [15].

Industry 4.0 is a process that generates technological transformations in the design, production and distribution of manufacturing systems and products, oriented towards automated and interconnected industrial production [16]. This has a significant impact not only on production processes, but on project management in companies [17], on the operation and future of the regions, and it is essential to understand the phenomena that take

place in the social and economic space and even in human resources [18]. Industry 4.0 has been shown to contribute to overall efficiency gains in sustainability (clean and renewable energy) [19], adaptive work environments, financial performance and innovation [20].

The era of smart factories is called “Industry 4.0.” This term was first coined at the Hannover Fair [21] in 2011. Industry 4.0 awareness and the vision of “smart factories” initially emerged because of government projects to support using Information Technologies in manufacturing [22]; therefore, it is closely linked to industrial, technological and automation operations. Moreover, as expressed by a government procurement specialist in Florida, this indicates that part of the intelligence collected by organizations should be focused on directly doing business with the government [23].

In this era of smart factories, market intelligence and BI are key to their development. Market intelligence is the cornerstone of the marketing concept; it is essential for strategic marketing planning and implementation [24]. Although the importance of market intelligence is widely accepted, the manner in which managers can ensure the generation, dissemination and responsiveness of market intelligence throughout the organization remains an ongoing challenge.

It is a challenge for company managers to identify tools that can be highly effective and have considerable impact when applying BI in their organizations. Using a survey [25], certain suitable data visualization tools were selected: Jasper Reports, Pentaho, SpagoBI, Palo/Jedox, Tableau and Qlik. Table 4 provides a comparison of these BI tools among one another [26].

Table 4. BI Tools and application analysis.

S. No.	BI Tool	Applications
1	Tableau	Data visualization products
2	Cognos	Performance management products
3	Sisense	Analyzes and visualizes big data sets and ideal tool for building interactive dashboards
4	SAP Business Objects	Real-time Business Intelligence
5	Microsoft Power BI	Interactive visualizations with self-service business intelligence capabilities
6	Domo	SaaS
7	Pentaho	Data integration, business analytics and big data
8	Klipfolio	Building real time business dashboards
9	Dundas BI	Data visualization
10	Necto	Business Intelligence

The information generated via different reports is fed by source databases (such as social networks and news websites that can be heterogeneous in practice) [27]. These collections bring about the difficulties of managing and organizing complete information and they have been optimized using different algorithms to achieve the best decisions for companies. One of the multiple algorithms is submitted through a study [28] that discussed the implementation path and configuration of the reinforcement learning model in a big data scenario. Then, it uses the relevant background of the zero-inventory case and the current zero-inventory situation. Subsequently, the specific application of the reinforced learning method in BI is validated through an assessment with zero-inventory application cases in companies using the Qlearning algorithm. In this manner, the authors proved that an enhanced learning method can be used to solve certain practical problems.

A study suggests that organizations are increasingly expecting their employees to make data-driven decisions to gain competitive advantages [29]. This expectation requires greater flexibility and faster decision-making support. Classic BI standard reporting

often cannot sufficiently meet these demands. The use of Self-Service BI (SSBI) software has provided increased flexibility, and thus has been instrumental in meeting these new demands. Consequently, this software can help reduce the workload of the IT department and free up resources for other activities.

However, the implementation of SSBI software alone does not necessarily lead to a better BI environment. It has already been determined that, to realize the full potential of a BI environment, a change in culture and behavior is necessary.

4. BI Implementation Today

In today's economy, intangible assets have gained considerable appreciation. Therefore, an important part of business value, such as the IP strategy, plays an essential role in defining, creating and maintaining a winning business strategy. This allows the creation of value and the strengthening of the multiple aspects of a strategy [30].

As a strategy, BI goes hand in hand with competitive intelligence (CI). Because of their multiple advantages, both make up an interesting pair for organizations. CI is based on scanning and monitoring information that significantly influences the market [31]. In this perspective, the development of CI tools provides organizational individuals with the most appropriate conditions for facing challenges. CI generates analyzed data and information that can be integrated into organizational business.

However, the BI and Analytics (BI&A) operational combination has emerged as a new approach to value production data in real time, thus favoring companies in their managerial decisions [32]. Big Data create value and exhibit transformation potential in the organization and for process improvement.

In accordance with these concepts, the applications and implementations of BI in the different organizational environments will be detailed, thus demonstrating its valuable contribution. A case to be highlighted is a BI application for an industrial and food company in which information from various database sources is arranged to provide objective and vital information for the company to visualize its weaknesses and strengths [33]. This study seeks to gather enough evidence for integrating information through BI technology, which would allow management to make more assertive and effective decisions that will benefit the aims of different organizations. Moreover, there is the case study of the largest fertilizer manufacturing company in Indonesia [34], which implemented BI in its business activities. This study discusses the vital role that BI plays in the process of providing relevant information based on accurate data available in a BI application.

Another implementation was conducted at two Mexican companies [35] where the adoption of a BI platform is reviewed. The results from this study revealed that the response of these organizations is based on information management because this information is generated and shared through historical data. For these reasons, the company is deemed as having reached a high level of maturity, which fosters a culture in the standard management of information. This data governance provided the company with capabilities to successfully meet market requirements and therefore guarantee its survival [36].

Another case study, but this time in an academic environment, describes the implementation of BI in libraries [37]. The application of BI technology is presented as a case study where libraries overcome the limitations of their existing reporting module using the BISIS library system. During the development of a data warehouse model, both user requirements for reports in BISIS and existing transactional databases are assessed. Based on that analysis [38], three data storage models were proposed:

- A Model Describing Data in the Library Collection:

A dimensional model of the BISIS data warehouse used for analytically processing the data included in the library collection.

- A Model Describing Library Circulation Data:

A dimensional model of the BISIS data warehouse used for analytically processing library circulation data.

- A Model Describing Member Data:

A dimensional model of the BISIS data warehouse used for analytically processing member data.

In addition to these models, examples of reports generated using an OLAP tool are provided. BISIS users can perform business analysis in a more user-friendly and interactive manner because these reports are not limited to predefined report templates. Librarians can easily generate customized reports tailored to specific library requirements.

Another academic study [39] introduced a BI framework design for data visualization and its associated text narration. The key idea is to display an image as a response to the reading position in the text area and vice versa because an image can express an idea better than text. Still, the interpretation of the displayed information sometimes leads to a lack of communication between the author and readers because an image can have multiple interesting characteristics and readers can perceive the author's point of view at different angles. To convey points of interest to readers without reducing the effectiveness of the text, synergy is required between the imaged displayed and the corresponding text narration. This aim was achieved via a BI framework [40].

Examples of BI implementations were reported at the government level. The study conducted an analysis based on a BI system at a bank to identify areas where value may be added [41]. The results of this study demonstrated the positive effect from technology resources in the process of adopting this technology and the importance of effective results. As per all these cases described above, it is possible to conclude that the dissemination of data in real time between companies, given the availability of adequate analytical tools and methods, can have a significant impact on any company. These findings are reinforced in a case study conducted in Hungary on the Industry 4.0 phenomenon [42].

5. Future Research Issues

Sustainable development and the circular economy are two important issues for business development and market competition. The programs seeking to integrate sustainability with industrial activities include the reconfiguration of production processes to reduce their impact on the natural system, the development of new eco-sustainable products and the redesign of the business model [43]. The use of information and management support tools is at the core of company digitization assessments. One study examined integrated enterprise resource planning (ERP) systems and business intelligence (BI) tools, which had been used independently of each other when migrating to industry 4.0 technology [44]. Centralized functions such as research and development, asset optimization, corporate planning (strategy, investment planning, finance) and supply chain, along with any other functions, provide significant business value. The integration of these functions across Industry 4.0 offers significant business value, providing strategic and operational benefits. The resulting main digital transformation objectives are listed in Figure 3.

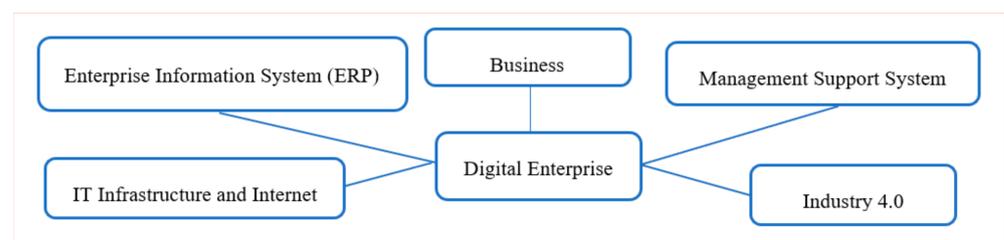


Figure 3. Digital transformation goals.

Another relevant Digital Transformation objective is specified in the study conducted by Zafary [45], which denotes the value of integrating information systems and ERP in successful BI implementations. The results of this study provide an opportunity for other researchers to implement a cost optimization approach.

If we continue reviewing the digital transformation process for BI, in the age of Industry 4.0, highly automated industries have been created by advanced digital technologies such as Internet of Things, Big Data analytics and data visualization [46]. These recent technologies have been extensively used in industries as dashboards, a BI tool that provides analytical data insights to corporate executives and business managers for decision making regarding system and process performance optimization [47].

Figure 4 shows certain Industry 4.0 technologies as an industry framework with core technologies.

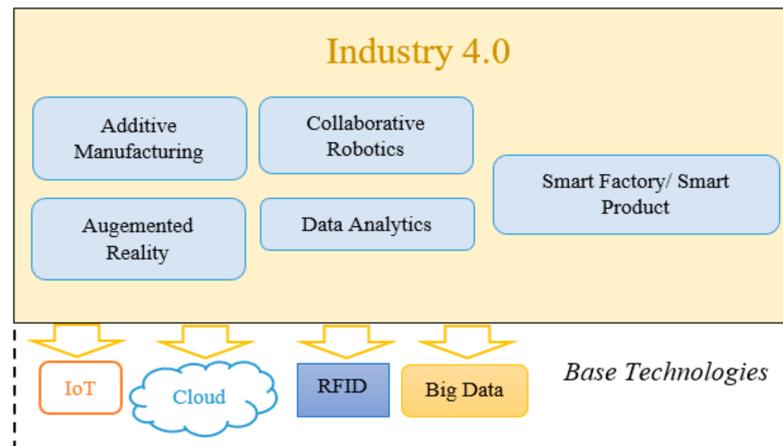


Figure 4. Industry 4.0 framework with core technologies.

A study conducted in Dubai on adopting the new advances of Industry 4.0 [48] reveals the critical role marketing teams play when influencing the decisions to adopt said technology and achieve results. This study concludes that adopting the revolutionary Industry 4.0 technologies may generate a high level of unemployment, but both Millennials and Gen Z have a greater competitive advantage in this technology. The results make it unequivocally clear in all respects that certain issues of this technology remain a notable area of concern. For example, large global companies usually understand innovations and procedures faster, and SMEs are lagging behind because of the weight of speculation [49].

This could be considered as a prediction for the near future of organizations. BI and ERP have become key for business activities and a requirement for the later phases of industrialization. For instance, an Industry 4.0-compliant ERP system is able to fully integrate with manufacturing execution systems [49], put the puzzle pieces together and provide a unified view of business operations that allows companies to better manage and improve industrial processes. A joint BI and ERP implementation is reflected in a study performed in China [50]. This study assesses the background, related technologies and the existence of demand controls in BI projects. The BI project is an analysis of business data generated by ERP, and it will serve as an important tool for leaders to assess the current situation of the company, make forecasts and plan future decisions [51]. Therefore, business intelligence (BI) and enterprise resource planning (ERP) have become key issues for business activities and a requirement for later phases of industrialization. They have also been recognized as important in decision-making by building an analytical capacity and providing a holistic framework for technical systems in production, quality management, predictive modeling and maintenance, simulation techniques, etc. [52].

At present, the acquisition, development and retention of human resources is of strategic importance [53]. Companies send the best and brightest expats to foster their development and guide the development of local talent who may eventually replace expats. From this perspective, domain-specific job offers can be considered as an indicator for analyzing and understanding competencies. Considering the requirement for a qualified BI workforce in the near future, an empirical study was conducted [54] on job offers to assess basic skills. The results from this study can provide valuable information:

- For businesses: In identifying a qualified BI workforce and integrating new analytical processes into ongoing industry policies.
- For BI professionals: In the evaluation and improvement of their own skills.
- For academic institutions: In planning BI programs and curricula as per industry requirements.

6. Data Privacy and Security Approaches through AI Approaches for Business Evolution

Companies handle a lot of decentralized information, and with the arrival of Industry 4.0 and business evolution, it is required to have a complete, available, private and confidential repository. Six articles were reviewed showing the effect of the implementation of information technology from the technological point of view through Artificial Intelligence, Business Intelligence, IoT and Cloud Computing. A summary is shown in Table 5.

Table 5. Concepts of information technology implementation.

Reference	Concept
[55]	The Internet of Things (IoT) has produced a large flow of data and services, which has changed the access control paradigm from a fixed desktop environment to dynamic environments in the cloud. This contributes to the reduction of administrative and computational expenses.
[56]	Security and privacy are two important requirements. Big Data security refers to the use of Big Data to implement solutions that increase the reliability and security of a distributed system. Big Data privacy, instead, focuses on protection of Big Data against unauthorized use.
[57]	Cloud computing has become a major research topic by generating multiple benefits for businesses. Therefore, it has become necessary to offer Business Intelligence (BI) to companies through the Internet as a solution.
[58]	Global economic crisis focuses the information technology industry on productivity. Cloud Computing is one of the instruments that can bring efficiency to an organization.
[59]	Business intelligence systems use information technology to manage structured and unstructured data that comes from various sources. Cloud computing services enhance legacy BI systems and applications with cost-effective scalability and flexibility.
[60]	More advanced organizational interactions have led to changes in the way that business is done. Newer forms of collaboration, such as Business Process as a Service (BPaaS), allow different partners to leverage business intelligence within organizations.

The implementation of the technologies that cover Industry 4.0 allows to improve the information of the companies, with a focus on privacy and security.

7. Conclusions

In brief, this study concludes that technologies such as big data, BI and the Internet of Things are actual development pillars for companies because they support companies in terms of decision-making, forecasting and corporate economy. If these technologies are in turn supported by effective leadership and training, development would be even greater.

Moreover, this study evidenced that implementing these technologies fosters company success when coupled with the proper use of their primary asset, which is information. Furthermore, BI technology helps a company to achieve their primary business objectives.

This study highlights the importance that the integration of ERP, IoT and BI technologies acquires, contributing to growth in all organizational aspects, beginning with changes at the operational level and concluding with a decisive basis for managerial decision making.

In the near future, the implementation of these technologies will be promoted in smaller companies, thus strengthening their economy and constituting an indispensable support for their development.

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