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Integrated Information Systems and Information Systems Quality: Prospects for Analysis and Emerging Trends

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ABSTRACT

Il paper propone una rassegna generale della letteratura sui sistemi informativi, sui relativi aspetti critici e sul supporto che essi possono fornire al management. Innanzitutto, esamina il ruolo svolto dai sistemi informativi integrati, con particolare riferimento ai sistemi di Enterprise Resource Planning (ERP) e di Business Intelligence (BI) e alla loro evoluzione. In secondo luogo, fornisce una definizione della qualità dei sistemi informativi e dei fattori che possono influenzarla. In terzo luogo, illustra il ruolo dell'IT/IS governance nel mantenere un adeguato livello di qualità dei sistemi informativi e di preservare il loro valore strategico. Il paper suggerisce infine delle proposizioni di ricerca che sollevano alcune questioni critiche sui sistemi informativi, sottolinea alcune tendenze emergenti nel campo dei sistemi informativi e propone delle linee di ricerca future.

The paper proposes a general review on Information Systems (IS), about their most critical aspects and their capability to support the management. At first, this study examines the role played by integrated IS, with particular regard to the Enterprise Resource Planning (ERP) and Business Intelligence (BI) systems and to their evolution. Second, the paper provides a definition of IS quality and of the factors that may influence it. Third, the paper illustrates the role of IT/IS governance in maintaining a suitable quality of IS and in preserving its strategic value. At the end, the paper suggests some research propositions which raise some critical issues about IS, highlights some emerging trends in the IS field and proposes some future research avenues.

Keywords: Information systems, Integrated information systems, Information systems quality, Enterprise Resource Planning, Business Intelligence, IT governance, Industry 4.0.

1 – Introduction

This paper provides research propositions related to the integrated Information Systems (IS) and their effects on IS quality, as emerging from the literature.

The role of integration is increasingly important for IS quality, as integration favors a better management of data and information and an improved decisional support to the companies. In the first part of the study, the integration between ERP and BI systems is observed and some emerging trends are recognized and discussed; in particular, recent trends that emerge, pertaining to the ERP systems, are: a) the possibility to adopt ERP in the form of SaaS model (Software as a Service), using the Cloud Computing technology; b) the recent and fast digital transformation, also due to the introduction of the Industry 4.0 paradigm, which strongly impact on ERP systems; c) the sustainability, which is increasingly integrated in ERP systems, especially by those companies highly interested in CSR disclosure. About BI systems, some trends emerging from the literature regard: a) the most common and recent motives that lead companies to implement a BI system; b) the emerging BI solutions, that is, the new and advanced BI tools able to provide support to companies in different ways. After highlighting the features and emerging trends related to ERP and BI systems, literature studies on IS quality are presented and the quality features of IS are showed. The attributes of ERP and BI systems are then analyzed, in order to determine if and how the two systems can contribute to fulfill the IS quality conditions. From the theoretical analysis, several IS quality issues result improved due to the features of ERP and BI systems.

The important role played by ERP and BI systems in favor of IS quality, needs to be monitored and preserved inside the company; at this regard, the final part of the research is addressed to the IT/IS governance, whose aim is to maintain aligned the business needs with the IT (and IS) resources, according to a certain maturity model.

For almost each of the abovementioned aspects, a research proposition is formulated, mainly aimed at providing new perspective of analysis and new research avenues regarding the involvement of integrated systems in several IS aspects, such as, the possible connection between system integration and competitive advantage, critical success factors of ERP in an Industry 4.0 environment, possible relationships between system integration and Cloud ERP, new factors that could change (and are already changing) ERP features and requirements, system integration as a driver of information quality and IS quality, system integration as a possible key factor of IT/IS governance framework.

The remaining of the paper is composed of the following sections: section 2, concerning the IS and the role of system integration, which illustrates the evolution of IS and presents the integration between ERP and BI systems, including the related emerging trends; section 3, which presents the IS quality features and the contribution of ERP and BI systems to IS quality; section 4, addressed to the IT/IS governance, where the main principles and aims of IT governance are explained; section 5, which presents the conclusions of the study and proposes some future researches and questions.

2 – Information Systems evolution and the role of system integration

The evolution of Information Systems (IS) may be considered an effect of the environmental changes – in technology, competition and environmental turbulence – and of the consequent new companies' needs emerged along the time (Egorov, 2017). One of the most evident effects of IS evolution consists in the IS architectures and organization structures, which have evolved from centralized to more decentralized forms (Mukherji 2002), pursuing a horizontal integration of the structural model of business, a digital integration of production processes and a vertical integration of the company production chain (Kehl, 2015). Of course, when we talk about integration of IS we may refer to a wide set of issues, all related to the integration and all involved in an integration process, such as the organization model and the human resources, the procedures, the IT tools. In this paper, we are dealing with the integration between two of the most important and strategic systems that

companies usually adopt, that is the Enterprise Resource Planning and the Business Intelligence systems; their integration, in fact, has an impact an about all the elements of the IS.

2.1 – *Integrated information systems*

Integration is one of the key processes that companies have executed to manage the higher decentralization of their technical and organization infrastructure. Applications such as Cyber-Physical System, which allow to acquire data directly from controller or enterprise manufacturing systems, such as ERP or SCM, are a clear demonstration of how companies are executing the integration process, especially when they require a reliable system which acquires various types of data, which set a seamless method of data acquisition, data management and data transferring to the central server (Vijayaraghavan et al., 2008; Lee et al. 2015).

ERP systems play a significant role in favoring information system integration, at two different levels: first, these systems are themselves the result of an integration between business processes; second, they can be furtherly integrated with other systems.

These systems can be defined as complex software that integrate business processes and related information, pertaining functional areas of business (Davenport, 2000). ERP systems have evolved from software which supported companies in Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRP II). In the '60s, only reorder point systems were developed to support managers in forecasting inventory demand on the basis of historical data. Attempts to integrate information systems started, thus, years before the birth of ERP; indeed, MRP and MRP II represent two examples of information systems integration. MRP supported managers in the integration of production planning and inventory control through a master production schedule and a bill of materials, ensuring the availability of materials needed for production and the synchronization of purchasing, manufacturing and delivery activities (Sumner 2013; Ganesh et al. 2014).

MRP evolved into MRP II, which incorporated the financial accounting system, sales planning functions and customer order processing (Somers and Nelson 2003). The main difference between MRP and MRP II is that the former is a stand-alone software, whereas MRP II is an initial example of an enterprise-level integrated system aimed at avoiding data duplication, at promoting data integrity and at providing customer feedback.

By the '90s, the first ERP systems were developed with the aim of integrating the main business functions and of aligning the business processes to the ERP software (Brown et al. 2003). For the first time, ERP systems made it possible to generate a seamless flow of information throughout the company, satisfying not only the needs of external customers but also those of internal customers (that is, information users); by doing so, it improved the effectiveness and the timeliness of the decision-making process (Ross et al. 2003; Ganesh et al. 2014).

2.2 – *Integration between ERP and Business Intelligence (BI) systems*

From the '90s on, vendors added further modules and functions to the basic ERP modules, leading to the so called "Extended ERPs", or ERP II. By the 2000s, this "extended version" of ERP was made possible also by the proliferation of the Internet (Lawton 2000), which allowed the integration of ERP with other external business modules, such as CRM (Customer Relationship Management), SCM (Supply Chain Management), APS (Advanced Planning and Scheduling), BI (Business Intelligence), and e-business capabilities (Rashid et al. 2002). Thus, the passage from ERP to ERP II has increased the integration level between applications. This passage allowed new business tools, such as application frameworks, databases, Decision Support Systems (DSS), Business Intelligence

(BI) tools and business analytics, to be integrated with ERP system, increasing considerably the business benefits (Møller 2005).

At this regard, the survey-based study of Wheller (2004) shows that: a) ERP II increases all the benefits of ERP, since resources are better managed, and b) ERP II allows the decision-making process to be supported even more effectively respect to a non-extended ERP, as the resources of the whole supply chain are made available.

The integration between ERP and other business modules provides companies with a wide variety of alternative IT solutions. The implementation of ERP and BI systems in a company plays a crucial role for supporting decisions, at least on the following issues: first, the investment in BI is considered as an incremental cost to boost and spread, within the company, the potential of the data stored in an ERP (Hoelscher 2002; Simons, 2008); second, the quality of management decisions often depends on the quality of data produced by an ERP (Calvasina et al., 2009); third, the adoption of BI systems makes ERP systems more competitive and flexible in sharing information and data for supporting decisions (Umble et al. 2003).

Integrating ERP with BI may lead to several potential benefits, as shown by Nofal and Yusof (2013), mainly concerning the control of accounting figures, the sharing of information and the consequent improvement of internal department cooperation and external relations with customers, the timeliness in accessing data and producing reports, the capacity to analyze data and forecast trends. The integration of ERP and BI is also crucial to align the process of accounting data storage, with that of accounting data analysis, as the ERP data represent one of the inputs of BI systems. Current studies on this topic are mainly focused on preliminary analysis (Aldossari et a., 2018) and on literature review (Nofal and Yusof, 2013) and only a few of researches are focused on empirical analysis of the integration between ERP and BI systems (Rouhani and Mehri, 2016). Nevertheless, current studies on the ERP-BI integration mainly aim to analyze the positive effects that some features of ERP may have on BI systems, but they do not demonstrate that the ERP-BI integration improves the competitive advantage of the companies. Few recent studies aim to find out the competitive advantage allowed by ERP and BI systems through multiple case studies (Drelichowski et al. 2016), however the correlation between ERP-BI integration and competitive advantage is still underrepresented in the literature. For this reason, the following proposition is formulated:

Proposition 1 – Integration of ERP and BI is positively associated with competitive advantage.

With regard to the integration of ERP with BI and other applications, recent studies deal with another important challenge which arises from the Industry 4.0 paradigm: the adaptation of ERP systems to the new smart factory needs. Some studies are indeed focused on the examination of challenges, opportunities and possible disadvantages of Industry 4.0 integration into ERP systems. Regarding the challenges, Gessa Perera et al. (2018) highlight that new ERP systems need to interact with Internet of Things (IoT) systems, with advanced analysis and automatic learning tools, with process automation, blockchain technologies and service-oriented architecture software. They also illustrate the area of application of each of these challenges. About disadvantages, they underline the technology dependence arising from a more intensive use of IT and new concerns about cybersecurity. On these bases, the following proposition can be formulated:

Proposition 2 – Studies on Critical Success Factors for ERP implementation should be updated in the light of Industry 4.0 paradigm.

2.3 – *Emerging trends on ERP and BI systems*

Along with the integration between ERP and BI systems, literature also shows how the technology innovation is favouring some emerging trends in the ERP and BI fields. The effects of this innovation concern each of the two systems – ERP and BI – but, at the same time, these effects may also influence, directly or indirectly, the integration between ERP and BI systems.

2.3.1 - *Emerging trends in ERP systems*

Emerging trends in ERP are mainly related to the following items:

- cloud computing;
- digital transformation;
- sustainability.

Each aspect will be described as follows according to the most recent literature, in order to make explicit the current research streams related to ERP.

2.3.1.1 - *Cloud computing*

Cloud computing belongs to the studies on ERP architecture. The innovations explained so far mainly regard the need for data and information quality, the integration of ERP with other applications, and the improvement of the decision-making process. However, more recently, technology has provided another innovation for managing ERP, which consists in purchasing the system as a service in cloud, making possible to obtain architectures allowing remote users to access the ERP system (Habadi et al. 2017).

Cloud computing is a model of computing which provides access to a shared set of IT resources, generally stored in vendor servers, by means of the Internet. These resources consist in computer processing, storage, software, and other services provided in virtualization and accessible on the basis of an as-needed logic, from any device connected to the Internet and from any location (Laudon, 2015).

Cloud computing technology is characterised by the following essential features (Mell et al. 2011):

- on-demand self-service: consumers can obtain services as needed, automatically and on their own;
- ubiquitous network access: cloud resources can be accessed through any standard Internet device;
- location-independent resource pooling: computing resources are assigned to multiple users, according to their demand. Users do not know where the computing resources are located;
- rapid elasticity: computing resources are rapidly adapted to meet changing user demand;
- measured service: cloud resource fees are proportional to the amount of resources used.

Cloud computing consists of three different types of services: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), and it can be private, public and hybrid (Elragal and El Kommos 2012).

Cloud ERP belongs to the SaaS category and allows companies to obtain ERP services in a cloud environment. The Internet has made it possible to introduce in the company's value chain many applications, which are not necessarily owned by the ERP vendors. Applications, in fact, reside on web servers to which anyone on the intranet has access using a connected device (from personal

computers to smartphones or tablets). Following this logic, access to the system and to the information does not imply extra costs, and anyone who needs information can obtain it with ease. This architecture has advantages also in extending ERP, as it easily allows for a selective access of suppliers and customers by means of extranets or the public Internet (Chaudhary 2017). Scalability, easy upgrades and mobile access are consequent advantages of this architecture.

Regarding the differences between ERP in cloud and ERP on-premises, some studies show that cloud ERP requires no capital expenditure and no maintenance costs, as opposed to on-premises ERP; furthermore, the cloud solution is more flexible and more easily accessible (Ramasamy and Periasamy 2017).

The disadvantages and concerns regarding cloud ERP are mainly related to: 1) data security (including privacy issues) and 2) integration. In terms of data security, business data is likely to be accessed from any smartphone or device, which potentially compromises data security (Chao Peng and Baptista Nunes 2009). Nevertheless, in this regard, data security is completely controlled by the vendor, as the company only uses the services but does not own the servers where data is stored, and it has no control over who may access their business data (from the vendor side) (Peng and Gala 2014). In many cases, the company does not even know where servers are geographically located and how they are protected; this lack of transparency may introduce further data privacy concerns. For these reasons, Service Level Agreements have a crucial role in defining all the conditions, guarantees, actions and remedies between vendor and customer (Lenart 2011).

Regarding the second item, integration, it is quite difficult both for companies and for vendors to customise a cloud ERP and to integrate it with other applications. For their part, companies have limited control over the cloud and do not have sufficient freedom and rights to personalize a cloud ERP, whereas vendors, in trying to make integrations, would have to face the diversity of platforms and technologies used for developing applications. As a result, until now it has not been feasible for vendors to customise the ERP package and to provide a seamless integration between the system and the applications purchased by different client companies (Peng and Gala 2014). Consequently, cloud ERP seems to present more advantages in companies that have less complex information systems, or that already adopt integrated systems. Hence, the following proposition can be formulated:

Proposition 3: Benefits of cloud ERP are positively correlated with the existing system integration level of the company.

2.3.1.2 - *Digital transformation*

Besides the cloud computing issues, and partially related to them, other emerging aspects do emerge from the literature, related to the digital transformation of ERP and to the new Industry 4.0 era. ERP and other integrated systems play a crucial role in the digital transformation, given their central position as data receiver and data supplier and as "connectors" of value-added processes across companies. However, for ERP to keep producing benefits for the companies, it has to be renewed and customised to the new technologies. According to some studies, ERP systems have reached a mature level on their life-cycle (Seddon, 2005) as they are available to companies of all sizes and sectors with a wide range of options, such as cloud-based, web-based, mobile apps, on premise (Bahssas et al., 2015). The study of Panorama Consulting (2016) even considers ERP systems at the end of their life-cycle and proposes, as a solution to keep them vital for companies and strategically competitive on the market, to adapt ERP systems to new technologies and to focus the attention on users and processes. Regarding the technologies, as showed above, the Extended ERP and the trend to integrate new applications in the ERP systems is already a reality; with regard to the focus on

users and processes, some studies suggest that ERP systems should not be considered only as systems of records, but also as systems of engagements, closely interconnected with a set of user-centric systems, based on communication and collaboration (Moore, 2011; Asprion et al., 2018). This transformation seems to be required by the upcoming digital era and it is mostly due to the societal changes: digital natives, social media, mobile access along with new ways to conceive, adopt and develop IT-based business models, is affecting the approach to the technology. The entering of digital natives in the job market, with their new mindset and expectations, will probably furtherly affect the IT approach and IT-based models (Koutropoulos, 2011). Companies, in their strategic plans, should thus consider not only the investments in data management potentialities and in new technologies, but also investments in soft-factors such as user-experience and expectations, user-engagement and needs.

2.3.1.3 - *Sustainability*

The higher attention paid by stakeholders and by the laws to corporate sustainability has been an incentive for companies to embed sustainability-related information into their ERP systems, with the aim to determine specific sustainability performance indicators and to integrate the reports with this new information (Hasan et al., 2017). In this regard, some evidences arise from studies conducted on environmental sustainability: very often environmental issues are managed using tools such as spreadsheets (AMRResearch, 2010), considered rudimentary, if compared to the tools used for managing financial information (Starbuck, 2012). The recent choice of some companies, to integrate sustainability data in ERP systems, answers the current need to manage these data on a more structured, organized and systemic basis. Summarizing, companies are thus going to upgrade their Information Systems, mainly pursuing the following aims:

- meeting the increasing stakeholders' and institutions requests about sustainability, environmental issues and impacts;
- improving the ability to acquire sustainability data, so increasing the accuracy of disclosure and allowing a better sustainability assessment by rating agencies (Simmonds et al., 2018);
- aligning environmental strategy with IS strategy for achieving sustainability objectives and controlling, at the same time, the related costs (Pearlson and Saunders, 2010).

As a result, along with digital transformation, the growing attention to the sustainability requires new ERP features, capacities and expected outcomes.

Proposition 4: New factors such as digital transformation, user needs and corporate sustainability are going to change the ERP features required by the companies.

2.3.2 - *Emerging trends in BI systems*

About BI systems, two main trends are recognizable from the literature: a) the emerging companies' needs which lead companies to invest in BI; b) the emerging BI solutions. These two points are strictly connected between each other, as to satisfy some needs, certain types of software and technology are required.

2.3.2.1 - *Emerging companies' needs for BI*

About the needs which lead companies to invest in BI, we can identify the following three main drivers:

1) coercive isomorphism (DiMaggio and Powell 1983; Powell and DiMaggio 2012), related to the need to manage a growing amount of data and information. These needs can be determined by the increasingly stringent and complex management needs, and by the need to meet the

requirements of compliance with general or sectoral norms (e.g., bank regulations). The diffusion of computer technology and communication tools has greatly increased the amount of data and information that companies are able to manage daily;

2) mimetic isomorphism (Haveman 1993), related to the need to cope with an increasingly competitive, global, turbulent and disrupting environment where timeliness becomes more and more critical in responding rapidly to market demands;
3) decision-making process, associated with the need to deal with more and more complex processes (Saaty 1990; Turban et al. 2014) due to highly competitive contexts that require the increasing use of advanced information technologies and sophisticated decision-making algorithms.

As a consequence, companies need to invest in innovative BI models that can:

- meet the need of integrating and analyzing data from different applications or, more generally, from different sources;
- reduce the opacity of certain operations and business functions by increasing their transparency and sharing;
- increase the timeliness of data access and data processing;
- increase the number of users who have access to data and information while reducing the technical expertise needed;
- effectively and efficiently manage company-specific life stages (expansion of the business, mergers, acquisitions, and so forth).

To develop these capacities, companies need to have BI and information available for several business functions and areas. Therefore, the main areas where BI needs are most felt are the following: a) management information systems; b) the strategic planning; c) marketing; d) regulations and fraud detection.

About the first, companies may need to align IS to group logics, especially in Mergers and Acquisitions (M&A) operations, given the nowadays increased frequency and scope of these operations. Among the key success factors recognizable for M&A operations, many authors highlight the information systems integration (Sudarsanam 2003, Levinson 1994) and the integration of IT resources of the companies involved (McKiernan and Merali 1995; Roehl-Anderson 2013). This integration should be one of the primary objectives of M&A operations, as it would provide quality, accurate, useful and timely information (Buck-Lew et al. 1992). Furthermore, the integration of information systems improves the effectiveness of BI systems, as these analyze and process data provided by the information systems (Elbashir et al. 2008; Peters et al. 2016), and help to align the group's strategic needs with its BI needs in order to create value (Henningsson and Kettinger 2016).

In recent days, globalization has undoubtedly favored the implementation of M&A operations and therefore the need for companies to integrate, update or modify BI systems, to align them with business strategies (Sudarsanam 2003; Kasemsap, 2018).

Still in the management information system field, companies need to invest in BI also to improve internal, technical and organizational coordination, even if they are not involved in a M&A project. BI systems should provide an adequate level of user satisfaction, which can be achieved through the enhancement and integration of existing and/or new BI systems (Serumaga-Zake, 2017); but this improvement, in turn, generates the need to manage the technical issues underlying the integration. This latter mainly concerns two closely-related factors (Isik et al. 2011):

a. technical-IT integration of internal business applications, which involves data, information and people;

b. enhancement of the ability to provide the information and knowledge needed to support end-user decisions.

With reference to the first point, obtaining a satisfactory level of integration between the business applications has become increasingly complex over time, given the high heterogeneity of databases, information platforms, software and interfaces. Furthermore, the advent of the Internet has brought new problems related to public communications, communications security and interoperability, i.e., the ability of systems to interact reliably with other systems (Hérault et al. 2005; Zacharewicz et al., 2017).

To cope with these complexities and to foster a link between business applications, middleware solutions were designed, which consist in software systems and interfaces that act as mediators among a lot of different applications (Serain 2002; Bieberstein 2006).

With regard to point b), namely, the ability of the system to provide decision support to end-users, it is still thanks to the integration (and the updating) of the systems that the decision makers can meet this need. In addition to allowing very different applications to interact, the integration of the systems also makes it possible to unify information and data management systems, thus improving the alignment of information flows with business needs (Markus 2000).

2.3.2.2 - *Emerging BI solutions*

The integration of the systems allows for the provision of "unified" information which supports managerial decision-making (Mendoza et al. 2006). In addition to providing "unified" information, an effective decision support to end-users also requires the adoption of data mining and knowledge discovery tools to transform data into knowledge; in doing so, these tools allow management to obtain insights and to make interpretations regarding a vast amount of data (Shim et al. 2002; Chou et al. 2014).

The need to have a BI system is perceived even more intensely when information is critical and impacts the decision-making process (Woodside 2011). Companies' needs for BI to support decisions can be explored under two main aspects:

- technological, based on data and tools available for data analysis;
- informational, associated with the specific business-related decision-making needs.

Regarding the technological aspect, companies' needs for data processing tools have evolved in line with the evolution of data complexity. Consequently, these needs have led to an evolution in BI tools (Chen et al. 2012). According to this interpretation, the needs for BI can be correlated with the types of data that managers need to analyze. The more structured is the data – that is, the more it comes from corporate databases and management systems – the more companies will effectively use BI tools such as data warehousing, Extracting, Transforming and Loading technologies (ETL), On-Line Analytical Processing (OLAP) and reporting, which allow them to extrapolate useful information through statistical analyses such as regression, segmentation and clustering, and to visualize information using multidimensional tools such as scorecards and dashboards (Chen et al. 2012). The implementation of BI systems inevitably responds to the need to obtain data and information that support the decision-making process, especially in our times, when the environmental turbulence is increased respect to the past (especially in certain industries), and consequently, the need for a rapid information-decision-action (and feedback) cycle is the most felt. At this regard, new BI systems are mainly used to collect data, evaluate their validity and reliability, analyze, store and processing them, disseminate and communicate information (Turban et al. 2014).

What is changing in this era of Internet 4.0 are the source where data comes from (see, for example, Internet of Things, where data comes from smart devices; Web 2.0 and Web 3.0, where data comes from social media and web sources), the ways data are collected (see Data Warehouse and Big Data), the way data are used (see for example the machine learning), stored (see Cloud Computing), analyzed and processed (see the business analytics, or the more recent Big Data

Analytics) and the technologies used for communication and dissemination (see, for example, Social media, Mobile communication, Web applications). Furthermore, BI tools needed by companies may change according to the nature and to the characteristics of the data. For example, if the data to be analyzed comes from the web in very large amounts and is not structured, companies will need Big Data and Web 2.0 tools, which would allow managers to analyze large amounts of data – such as, sites, social media, forums, blogs, and online resources in general. These tools, through advanced analyses, can provide a measurement of relevant aspects, such as online user activity (through web analytics and web intelligence tools), the frequency of use of certain terms (text mining, web mining), and the "moods" emerging from the text analysis (tone analysis, sentiment analysis, sensitivity analysis) (O'Reilly 2009; O'Reilly and Battelle 2009; Chen et al. 2012). According to the literature, many of these activities are made possible by the Web 3.0 tools, which represent an evolution of Web 2.0 and include: a) the possibility to convert the Web into a database, making content accessible by several non-browser applications; b) the leveraging of artificial intelligence technologies; c) the Semantic web; d) the Geospatial Web; e) the web where people do not (only) publish content for other people, but build applications that people can interact with (Patel, 2013; Singh et al., 2011). Web 3.0 has furtherly evolved into Web 4.0, which is based on a symbiotic interaction between humans and machines, and some authors are already dealing with Web 5.0, which are technologies that operate with the feelings of the user (Tekdal et al. 2018).

Companies that rely particularly on innovative tools may perceive, more than other firms, the need for BI tools that have recently begun to spread on the market, such as the Internet of Things (IoT) and the related mobile web applications (Da Xu et al. 2014; Palattella et al. 2016; Peters et al. 2016). However, also other companies, which do not rely particularly on innovative tools, may benefit from these latter, especially if managers are able to align these tools to the business strategy. In the IoT technology, the internet is not limited to the use of computers or smartphones, but also to interlinked objects such as smart automobiles, watches, jewelry, glasses, among others, which involve a connection through sensitive, automated and integrated functions. The business opportunities provided by these technologies mainly concern the marketing functions: for example, analytics tools integrated into IoT devices allow companies to monitor the data provided by customers' smart devices, to observe their behavior and trace patterns useful for strategic marketing offers (Remondes and Afonso, 2019).

Even if the evolution of technology goes on, it is important for companies to understand which BI tools and IT innovations are the most suitable for them. This is especially true, considering that BI needs very often depend on the specific decision-making requirements that managers must meet. Hence, investing in BI requires a preliminary identification of the company's real technical and informational needs to ensure that the new BI resources are not acquired just for a mere upgrade of processing capabilities, which neglect the alignment of technology to the business. Following this idea, the need for BI tools depends on the type of business activity, the industry, the complexity of the internal processes and the external environment. In other words, it depends on all those elements that contribute to creating the problems and, consequently, on the type of decision support needed to solve them (Moss and Atre 2003). Therefore, before adopting new tools and advanced applications, companies should: a) recognize their current problems, the decisional support needed and the extant alignment of their BI tools with business strategy; b) understand how new BI tools and applications could be useful for their problems, how and at which conditions these innovations could be integrated in the business model and which competitive opportunities BI tools would bring about.

This is a well-known concept in the field of BI maturity models: the main aim of these models is to allow companies to assess their BI technologies, by understanding what the BI maturity level of their system is, and by ascertaining the coherence between BI maturity and company maturity.

Furthermore, maturity models support companies in comparing their system with those of competitors, in recognizing possible weak points in their BI system, and in identifying possible improvement strategies to achieve a certain maturity level (Tan et al. 2011). Therefore, the passage from one level to another is generally dictated by strategic alignment needs.

The maturity models also support the understanding of critical success factors for BI implementation, since, according to Hawking and Sellitto (2010), success factors may vary depending on the life stage of BI in which the company is involved. Similarly, Dinter et al. (2011) suggest that a lifecycle-oriented approach allows companies to anticipate potential project risks in a timely fashion and to identify possible interventions in the early implementation stage.

The need for BI investments can also be perceived by companies that already adopt BI systems to support key business processes. Companies of this type recognize a considerable strategic value for BI systems, and they are generally the most inclined to invest in new BI solutions, since they wish to derive the maximum possible value (Marjanovic 2010).

3 – Information Systems quality

BI and ERP systems are two key elements of IS and when they are well integrated, they benefit the company in several ways. An effective IS integration is considered by the literature as a success factor for a wide range of functions, such as for achieving successful operations of mergers and acquisitions (Giacomazzi et al., 1997), for allowing and complementing the integration of business processes (Ross et al., 2006), for extending the IS to other applications (CRM, SCM, etc.). Therefore, IS integration plays an important role in affecting the quality of an enterprise IS. However, for IS integration to be beneficial, it is important to understand and create the conditions which make a quality IS.

3.1 – *Quality of IS: a multidimensional issue*

The attention paid to IS quality has gradually increased over time, given the role played by IS in providing information to management. From data acquisition and elaboration to the communication of information, several components are involved, since the information system consists of a set of technical resources, data, people and procedures which interact to produce information and to generate knowledge (Wijnhoven 2009; Kroenke and Boyle 2016). Therefore, the quality of IS needs to be assessed through a multidimensional measure, or through frameworks which take into account the whole set of components (DeLone and McLean 1992), identifying the most critical aspects of IS quality that can affect the business (Gorla et al. 2010).

The literature provides numerous studies aimed at analyzing how the quality of IS could be obtained and measured under different perspectives and using different methods. The initial studies focused attention mainly on user satisfaction and system use (Ginzberg 1981; Srinivasan 1985). Following the idea that productivity in the computer context is related to the sense of satisfaction in using the computer services, some studies measured user satisfaction through a list of factors identified through a review of the literature (Bailey and Pearson 1983; King and Epstein 1983), while others focused on the users' attitude towards the changes introduced by a system – specifically, by DSS – to the work environment (Barki and Huff 1985). Barki and Huff discovered that satisfaction is higher when DSSs bring changes to the work environment as opposed to when they do not result in substantial changes. Later studies examined service quality as a driver for IS quality; service quality refers to the fact that computer users are satisfied only if their expectations meet their perception of the quality they are getting (Pitt et al. 1995); the concept is thus very similar to that of user satisfaction.

Another study, based on an extensive survey conducted on a sample of 465 data warehouse users from seven companies, developed a model based on nine determinants of quality in an IT environment, four focused on the output of the system (i.e., the information quality), and five addressed to the information processing system needed to produce the output (i.e., the system quality) (Nelson et al. 2005). It is interesting to note that, according to the authors, information quality – consisting in the accuracy, completeness, currency and format of information – has a significant role in explaining information system quality – consisting in the accessibility of the system, its reliability, response time, flexibility and integration; these nine determinants are also predictive of the general information and system quality in data warehouse contexts.

Aspects	**Improvement after ERP adoption**
Information system integration	From stand-alone systems to integrated systems
Internal coordination	Improvement of the coordination among business functions
Database integration	ERP allows data to have the same meaning across the company
Maintenance	From a costly maintenance of single separate systems, to a maintenance which affects multiple integrated systems
Interfaces	From separate and non-integrated interfaces between systems to common interfaces across the company
Information	From redundant, inconsistent information, to consistent and real-time information
Information system architecture	ERP introduces a client-server model, more effective than legacy systems
Business processes	From incompatible processes to consistent processes aligned with an information model
Applications	From several different applications to single applications for managing business functions

Table 1 – ERP benefits to the information system (Source: adapted from Sumner 2013)

Similarly, other studies identified the characteristics that give high quality to an information system. The literature review conducted by De Lone and McLean (1992) identified six factors considered critical for IS quality: a) system quality, intended as the information processing system

itself; b) information quality, that is, accuracy, timeliness, reliability, completeness, relevance, precision and currency; c) information use; d) user satisfaction; e) individual impact; f) organizational impact. After about twenty years, De Lone and McLean updated their study, proposing other determinants that can affect information system success, divided into four categories: task, user, project, organization (Petter et al. 2013). As we can observe, measuring quality always takes into account several aspects, confirming that IS quality is a multidimensional issue.

Further confirm comes from more recent literature, which shows there is no single determinant which can, on its own, explain the quality or the success of the information system; instead, it is necessary to include variables pertaining to the several integrated aspects characterizing IS, such as hardware and software quality, service quality, information quality, communication quality, while also considering that different, or more specific needs can arise depending on the business and on the evolution of technology (Xu et al. 2013; Bessa et al. 2016).

Thus, we can point out that IS quality is a multidimensional *and* contingent issue. Among all the dimensions affecting the IS quality, in this paper we examine the role of ERP and BI systems, as they play a significant role in several IS quality dimensions: ERP systems have major impacts on business process integration, and, consequently, on data quality and information quality, on individuals and organization (see Table 1 for a more detailed list); BI systems have main impacts on data processing quality, on the information use (consisting, for example, in the decision-making process), on reporting and communication quality; both ERP and BI systems have impact on software and service quality.

3.2 – *ERP and BI for IS quality*

3.2.1 - *ERP for IS quality*

The implementation of an effective ERP has many implications for the information system, considering that ERP is defined by the literature as an information system itself (Sheu et al. 2003; Li and Olorunniwo 2008; Parthasarathy 2012; Esendemirli et al. 2015).

3.2.1.1 - *Business process integration*

The greatest benefit of ERP implementation is the reduction of business process complexity, since ERP aims at integrating business functions, data and processes along the value chain (Karimi et al. 2007). In most cases, a successful ERP implementation requires a preventive Business Process Reengineering (BPR) which aims at revising and optimizing the business processes (Broadbent et al. 1999; Palaniswamy and Frank 2000; Fui-Hoon Nah et al. 2001). BPR developed in companies with a high business process complexity has more of an impact and is more expensive because of the difficulty in carrying out standardization (Schäfermeyer et al. 2012). In this regard, Karimi et al. (2007) observe that "*the higher a firm's business process complexity, the higher the radicalness of its ERP implementation as a result of its potential to enable fundamental and radical changes in the firm's business processes and their outcomes*" (Karimi et al. 2007: 107). We can consequently deduce that the higher the business process complexity, the higher the business impact (and risk of failure) of ERP implementation. In fact, the literature confirms that the benefits of ERP on IS can depend on the quality of BPR (Bingi et al. 1999) and that one of the motivations that lead companies to implement an ERP is to obtain business process standardization (Al-Mashari et al. 2003).

3.2.1.2 - *Data quality*

Because information systems produce information and knowledge starting from data and using processing capabilities, the quality of information is related to the quality of the entire data

elaboration process: if the information system allows companies to acquire and store high quality data (with the support of high quality hardware), then the processing system will generate high quality information (with the support of high quality software). This, in turn, will effectively support the decision-making process, providing a high service quality. These considerations are recognizable in a wide stream of studies on the role of data and information in improving the quality of information systems (Redman and Blanton 1997; Pipino et al. 2002; Xu et al. 2002; Madnick et al. 2009). Studies on the impact of data and information quality have been carried out to promote positive impacts and provide disincentives to negative ones. Poor data quality, in fact, could make the retrieval of business records more difficult thereby not allowing the right information to be provided to the right stakeholder. This misalignment could be even more critical in the performance management field: as underlined by Redman (Redman 1998), poor data quality can compromise the achievement of strategic and tactical objectives. Other studies demonstrate that the quality of the decision-making process depends on the quality of data produced by the information system (Fisher et al. 2003; Calvasina et al. 2009) and on the coherence between data architecture and business architecture (Vasile and Mirela 2008). Studies on data quality also involve the Enterprise Architecture and the IT governance frameworks, both aimed at aligning IS with the business objectives on a strategic level (Schekkerman 2004; Weill and Ross 2004; Caserio 2017; Caserio and Trucco 2018). This is evidence of how important data and information quality have become, and it explains why companies are investing in IT, in IS solutions such as ERP and BI systems and in integration of IS.

3.2.1.3 - *Information quality*

Another benefit that the ERP can bring to IS quality is the improvement of information quality. Given the importance recognized by companies and scholars of the quality of information, the attention paid to the circumstances that may improve information quality has gradually increased. ERP systems directly and indirectly support information quality: for example, they lead to the integrity of the system and permit users to insert data only once (Xu et al. 2002; Uwizeyemungu and Raymond 2005).

The literature confirms that companies implement ERP systems in order to resolve information problems related to the legacy systems; in fact, poor productivity and performance are connected to the poor quality of information, specifically to the fragmentation of information (Davenport 1998; Rajagopal 2002).

ERP systems reduce data integration problems as follows (Markus and Tanis 2000; Rajagopal 2002; Karimi et al. 2007): by eliminating multiple data entry and concomitant errors; by simplifying the data analysis; by managing, integrating and sharing data related to products, services and business activities that create value.

Data integration improvement allows information to be consistent, thus ensuring that two (or more) separate systems do not generate two (or more) different versions of the same information. Data integration allows each decision maker in the company, and in each subsidiary, to receive the same information, so speeding up the decision-making process (Shanks et al. 2003) and managers can exchange views on problems and business issues, even when the subsidiaries are located at a great distance.

As confirmation of this, the relational database on which ERP systems are built makes information representative throughout the company, which is even more perceived when a company migrates from legacy systems to an ERP system. In fact, legacy systems are built on separate subsystems, and thus the same data is located in several sources, thereby generating problems of information inconsistency. The resulting lack of integration makes it difficult for a

subsystem to access data stored in another subsystem and makes the communication between different subsystems very problematic (Xu et al. 2002).

3.2.1.4 - *Organization*

In addition to business process complexity, organizational factors play a critical role in examining the potential benefits of ERP for information systems quality. Employees are a component of information systems, as well as being the end users of ERP; thus, to obtain information system benefits from an ERP implementation, people should accept the ERP and recognize its usefulness and support for their tasks. Therefore, as suggested by many authors, ERP benefits IS when top management provides its support (Grover and Segars 1996) and mediates between technology and business requirements, resolving eventual conflicts of interest among stakeholders. The alignment between the ERP and the organizational objectives and needs is another critical condition that enables the ERP to improve the IS quality (Cline and Guynes 2001; Gefen and Ragowsky 2005).

3.2.2 - *BI for IS quality*

Most of the benefits of BI on IS quality are already discussed above, when dealing with BI solutions. However, some BI system features deserve a closer look, such as the capacity of BI systems to improve the data processing quality, to support the decision-making process and the communication and reporting quality.

3.2.2.1 - *BI for data processing quality*

Regarding the BI systems impacts on data processing quality, the implementation of BI systems inevitably responds to the need to obtain data and information that support the decision-making process. Literature shows that the main phases of a BI system are (Gilad and Gilad 1986; Turban et al. 2014): collection of data; evaluation of the validity and reliability of the data; data analysis; data storing and processing; dissemination and communication.

Following this path, raw data will be converted into information and therefore into knowledge, which is useful in providing decision makers with the appropriate support for their strategic choices. For example, BI systems can support companies interested in analyzing trends and historical data, in creating forecasts and conducting scenario analysis (Hribar Rajterič 2010).

3.2.2.2 - *BI for decision-making quality*

Data processing quality is strictly connected to the decision support provided by BI systems and, in turn, the decision support depends on the specific needs of the company. The study by Mackenzie et al. (2006) is in line with this idea: the authors distinguish the Decision Support Systems (DSSs) according to the decision-making needs the company has to satisfy, recognizing two types of DSSs:

a. substantive systems, which provide support for the resolution of specific kinds of problems and the management of specific decisions through processing, calculation and design capabilities;
b. procedural systems, which instead provide support for the assessment of the consequences of a decision.

Substantive systems will be implemented by companies that need an "operational" decision-making support, and thus an aid in understanding how to reach a certain goal that is already known (Checkland 1981). This type of support is based on providing the decision maker with a set of alternatives, mostly based on mathematical calculations and simulations.

On the other hand, procedural systems will be adopted by companies that need to understand why a specific action is required, or to look for the best alternative that could solve a particular problem. In these systems – unlike the previous ones – the problems to be solved are not known in

advance and are generally strategic, unstructured and not well-documented (Rosenhead and Mingers 2001; Mackenzie et al. 2006).

BI systems can also support decisions on strategic planning issues, such as: a) the monitoring of weak environment signals; b) the consequent alignment of the business model to the environmental changes; c) the support of planning and control activities.

About the first point, BI can help companies to face with the environmental changes, by rapidly and effectively providing the information needed to support the decision-making process. From this perspective, BI tools can support companies in analyzing unstructured problems, typically associated with environmental turbulence. These problems have gradually been perceived since the 1970s, when the environmental complexity began to affect corporate decisions more intensely (Malaska et al. 1984; Bradfield et al. 2005). At this regard, BI tools can support decision-making process in the following ways:

- providing better monitoring of the external environment and recognition of weak change signals (Rud 2009);
- making possible re-evaluations of the adopted business model (Giesen et al. 2010);
- identifying and monitoring, over time, the drivers which affect economic and financial results (Mitchell and Bruckner Coles 2004);
- creating alternative scenarios for solving complex problems (Lindgren and Bandhold 2009);
- obtaining a quick and coordinated decision-making process (Laszlo and Laugel 2000).

With regard to the first point, we have to point out that external information, useful for analyzing the external environment and for supporting decisions, may be available only in certain limited periods of time. Furthermore, the external environment consists of several forces and conditions related to the industry, the market and the economic system, therefore, some information could be not easy to measure. Thus, the external environment analysis supported by BI systems is usually based on the principles of SWOT analysis, which identifies the strengths, the weaknesses, the opportunities and the threats that characterize the company and its environment (Hunger and Wheelen 2010). Within a turbulent environmental system, BI can effectively support managers in identifying environmental elements that have changed, in recognizing which elements have a direct influence on business processes and which ones, instead, do not engender any modification of the business model (Carpenter and Sanders 2006).

About the second point – pertaining to the alignment of business model to the environmental changes – an effective BI system would play a crucial role for companies, as it would provide environmental turbulence signals necessary to evaluate a possible revision of the business model. In addition to anticipate potential changes in the external environment, BI tools can also support companies in aligning their business model to the environmental changes, as BI tools can help manager in these following activities (Alkhafaji 2011):

- understanding whether the alignment between the business model and the environment has been achieved (or is happening) effectively;
- verifying if there are any inconsistencies between the desired change and the actual change;
- providing alternatives that enhance alignment, minimizing the negative effects of external pressures.

One of the most relevant supports provided by BI systems is the continuous monitoring of the ongoing process of alignment between the business model and the new, changed environmental conditions. BI allows companies both to monitor external information that most likely will affect the business model and to monitor the internal key variables that are most sensitive to external

influences. A BI system capable of managing such continuous monitoring and controls provides undoubted benefits to business management, as it permits periodic reviews of strategic objectives and the alignment of business processes with environmental changes. Because business processes are often a response to environmental turbulence, continuous monitoring of these processes must necessarily be coordinated with the constant monitoring of the external environment. Therefore, BI systems allow to monitor the external signals of change, to assess the adherence of the business model to the mutable environmental conditions, to promptly reveal any discrepancy.

On an opposite position, some studies argue that traditional BI tools, as part of strategic planning, are likely to undermine the strategic adaptability of the company (Laszlo and Laugel 2000). This strategic adaptability should be supported by an equally adaptable BI infrastructure, or by adaptive BI tools (Bäck 2002). These systems inherit the features of expert systems and belong to the field of machine learning, which examines the ability to provide software with the capacity to learn without a specific programming. The goals of traditional BI systems are to access data from a variety of sources, transform them into information and, through data mining algorithms, into knowledge that supports decision-making. The knowledge is made available to the decision makers through user-friendly interfaces. Unlike these traditional systems, adaptive BI not only provides support for decisions but is also able to recognize the best decisions to take on the basis of the knowledge available (Michalewicz et al. 2006). Therefore, in addition to transforming the data into information and information into knowledge, these systems elaborate the knowledge through optimization models and predictive algorithms, proposing decisions that are continuously updated based on the data and knowledge acquired in input.

With regard to the third point – the support of BI to planning and control – BI tools can support business management in several ways:

- by providing in-depth data mining, which enables companies to acquire non-detectable knowledge (Bose and Mahapatra 2001);
- by creating forecasts based on historical trends (Liebowitz 2006);
- by acquiring and processing data in a timely fashion and visualizing it through multidimensional reporting systems (Chen et al. 2012);
- by providing scenarios, simulating the effects of possible future decisions (Bradfield et al. 2005).

In addition to the support provided to the strategic level, BI systems are also helpful in enhancing the planning and control activities performed by firms, through business applications that include scorecards, dashboards, customer analytics and supply chain analytics (Williams and Williams 2010).

With regard to planning and control activities, the main support provided by BI systems is to improve the effectiveness of Corporate Performance Management, which mainly consists in resource management, cost accounting, financial planning and budgeting (Howard 2003; Williams and Williams 2010; Elbashir et al. 2011). BI tools provide powerful capabilities which support planning, cybernetic controls, and administrative and reward/compensation controls (Elbashir et al. 2011). According to Malmi and Brown's definition (2008), cybernetic controls provide quantitative measures for activities and processes, fix performance standards, and provide feedback on the business goals, assessing variances between goals and results. Planning controls, instead, designate functional area goals, establish standards for assessing the business function results, and assure alignment between the various functional goals throughout the company. Reward/compensation controls seek to motivate the individuals, thereby increasing their performance.

BI tools also help to monitor, scan and interpret the collected information. For example, BI tools allow firms to perform financial simulations, what-if analyses and scenario analysis before defining strategic (and tactical) goals (Aronson et al. 2005; Marchi and Caserio 2010).

The importance of BI tools for planning and control activities is also confirmed by some empirical studies: a survey conducted by Olszak (2016), along with other case study analyses (Chaudhary 2004; Hawking et al. 2008; Davenport et al. 2010; Olszak 2015), reveal that BI systems are useful for:

- supporting demand forecasting;
- informing about the realization of enterprise goals;
- increasing the effectiveness of strategic, tactical and operational planning;
- improving the quality of information related to trends and the realization of plans;
- providing analyses of deviations from the realization of plans.

The benefits of BI for planning and control activities are sometimes neither directly measurable nor explicit. This happens when the improved strategic decisions and the increased information quality due to the adoption of BI tools allow managers to prevent losses, without the possibility of quantifying the effects (Pranjić 2011).

3.2.2.3 - *BI for communication and reporting quality*

In addition to acquiring data and information needed to gain decision support, BI systems enhance the communicative companies' skills (Rud 2009). BI tools can be used to improve the frequency, clarity and timeliness of communication, in doing so contributing to the increasing of the IS quality. Naturally, some specific factors may affect the type of support provided by BI systems, such as:

- the type of business activity;
- the number of sectors and/or markets in which the company operates;
- the structure of the reporting system;
- the maturity model of BI.

Regarding the first point, some companies may adopt tools useful for promoting internal real-time collaboration, setting up collaborative teams that can discuss and share ideas and solutions for several issues (Rud 2009). The type of business activity can also lead companies to prefer BI systems for synchronous communication or asynchronous communication: the first fulfills the need for quick comparison between the interested parties (both internal and external), while the latter is generally suitable for the resolution of less urgent problems (Coleman and Levine 2008). As for the second point, a high number of sectors and/or markets in which the company operates may cause information overload, which could bring about a loss in decision-making accuracy, and low-quality and delayed communications (Rud 2009). In these cases, companies would need a high-quality information system which requires both an integrated transaction system (e.g. ERP systems) and a BI system well-aligned with business goals (Patel and Hancock 2005; Caserio and Trucco 2016).

Concerning the third point, communication and collaboration can be improved by the BI systems through the implementation of reporting systems which allow to select, represent and communicate only the most relevant data, dividing it into multidimensional views. To enhance the reporting system, BI tools can provide advanced multidimensional solutions (Wiese, 2009), such as personalized Key Performance Indicators (KPIs) and scorecards, that generate reports for performance measurement, control and monitoring.

Furthermore, the availability of timely and accurate information and data positively affect both cost management and the reporting system (Rud 2009). In fact, BI systems are able to produce, from the underlying enterprise databases, a wide range of pre-specified reports useful for supporting planning and control activities (Elbashir et al. 2011).

Regarding the fourth point, the need for an upgrade in BI could be influenced by the maturity of BI and that of the company: in fact, according to the literature on the maturity model of BI systems – used to describe, explain and evaluate the life cycle of Business Intelligence – for a BI system

upgrade to produce the benefits expected, the equilibrium between the level of maturity of BI and the level of maturity of the company has to be maintained (Lahrmann et al. 2010). Therefore, the support of BI system to the IS quality may depend on the moment in which BI is acquired or upgraded: a company could postpone or anticipate its purchase according to the condition of equilibrium (or disequilibrium) between the BI and the company maturity level.

As we can see from the above paragraphs, almost all the key factors which affect the information quality and the IS quality can be found in the ERP and BI systems; when these two systems are well integrated, we can expect a general improvement of IS quality. Consequently, we can formulate the following proposition:

Proposition 5: The integration of BI and ERP systems is positively correlated with the quality of information and with the quality of Information System.

4 – IS/IT Governance and Strategic Information System

Given the importance of a quality IS and given the relevance of the alignment between business model and external environment, in addition to the alignment between company's maturity and BI model maturity, it is evident that the "management" of IS and IT has a strategic value. To understand when and how the business model has to be adapted to the environmental changes, a company needs to monitor the external conditions (as explained above), and this implies the provision of a BI system able to provide this information. At the same time, directors need to know why, when and how upgrade BI systems, according to the maturity of the company – which means that directors have to keep aligned the BI maturity with the company maturity to obtain the benefits from BI systems on the business model.

Many other decisions take into account the IS resources, for example when the decision regards the purchasing of an ERP or a BI system, or the integration of new applications with the extant systems. Maintaining an IS aligned with the business needs is thus a strategic decision which should be taken on a long-term period. This is one of the main functions of the IS/IT governance.

IT governance is one of the most important factors that allows companies to generate business value from IT investments (Weill and Ross, 2004). Major literature on IT governance shows definitions expressed under different perspectives, as the IT governance has several determinants, such as business strategy, business governance, firm size, information-intensity, environment stability, business competency (Peterson, 2004). These definitions arise from the shared acknowledgment that the notion of a single homogeneous IT function is now obsolete (Van Grembergen et al. 2004) as the IT is widely distributed in organizations and requires a holistic definition that includes actors, responsibilities, decision-making process and activities related to IT.

On the basis of such a holistic vision, many authors define IT governance as the pattern and the locus of authority for key IT activities (Sambamurthy and Zmud, 2000; Luftman, 1996). Other studies define IT governance as the locus of responsibility for IT functions (Brown and Magill, 1994; Boynton et al. 1992) and still others attribute more emphasis to the role of top management. For example, IT Governance Institute (2003) considers IT governance as "*the responsibility of the board of directors and executive management. It is an integral part of enterprise governance and consists of the leadership and organisational structures and processes that ensure that the organisation's IT sustains and extends the organisation's strategies and objectives*". A similar point of view is expressed by Grembergen (2004) who states that IT governance is the organizational capacity of board, executive management and IT management to control the design and the implementation of IT strategy, ensuring the fusion of business and IT.

From the above general definitions, it is possible to understand that all the issues involved in IT governance are relevant for the successful management of IT (and IS) resources and activities. Given the importance of IT governance in the success of IT investments, several frameworks have been proposed by academic and non-academic literature, summarized by Grembergen (2004) and Caserio (2017). The aims of these frameworks, in general, are to provide best practices on how to organize the governance of IT inside the company (e.g. centralized or decentralized), how to plan IT services, how to acquire the most suitable IT solutions for the company, how to align business needs with IT services (according to a certain maturity model), how to deliver the IT services and how to monitor and assess the IT system performance (Lainhart, 2000; Iden and Eikebrokk, 2014).

The major shared opinions emerging from the literature analysis on the IT governance frameworks are that IT governance is a senior management responsibility and that the alignment of business strategy and IT resources is one of the most important goals and critical success factor for IT governance effectiveness.

As highlighted in the present study, also the integration between ERP and other applications, including Business Intelligence, is one of the key elements to take into account when an IT governance framework has to be defined and applied into a company. As a consequence, it is possible to formulate the following proposition:

Proposition 6: Integration between ERP, BI and other applications is another important key factor to be considered in an IT/IS governance framework.

4.1 – *Conclusions and future research*

The information era we are living, the hypercompetition and the globalization have increased the need of companies to invest in IT and IS capacities. Nowadays, companies of any size use integrated systems such as ERP (for larger companies) or light ERP (for small-medium sized companies) or the newest Cloud ERP (which allow even lower costs) to better manage the transactional business data. Consequently, also the BI systems have spread considerably, as they allow companies to convert business data into knowledge, so creating competitive advantage and supporting decision-making process. IT/IS governance frameworks are thought to help companies in organizing the responsibilities for the IT resources, the locus of authority for critical IT activities, to strategically plan the IT/IS policies. These frameworks support companies in generating business value from IT investments, especially when the IT resources are critical for the business success.

In this paper, the role of integrated systems has been examined, with a particular reference to ERP and BI systems, considered by the literature as the most important elements of an enterprise information system; subsequently, the features of IS quality have been examined highlighting the role played by the ERP and BI systems in favoring IS quality, especially considering the emerging trends in ERP and BI. At the end, the aims of IT/IS governance are presented as means to maintain a high-quality level of IS and IT.

Each issue is provided with one or more research propositions, formulated to suggest new research ideas on the addressed topics, i.e., on the role of system integration in favoring competitive advantage, on the need for new CSFs studies on ERP in view of Industry 4.0 paradigm, on the possible relationships between cloud ERP and system integration, on the new factors that may change ERP features, on the role of system integration in improving IS quality and, for this reason, on the need to embed system integration in IT/IS governance framework.

In addition to these propositions, and consistently with them, some questions may be proposed for future researches. For example, regarding the purchasing, the integration and the upgrading of ERP and BI, one could wonder how the returns on these investments are measurable and whether

there are some differences in the return on investments when the purchasing regards ERP (hard, light or Cloud) or BI systems. It would be also interesting to investigate the impacts of Cloud ERP implementation on the business processes: does cloud ERP affect (or require) the standardization and integration of business processes just like a traditional ERP? Is a Cloud ERP most suitable for a certain type of companies – e.g. for Small-Medium Enterprises (SMEs) – or it can be adopted by companies of every size with the same benefits? Furthermore, given the wide spreading of Cloud ERPs, it would be interesting to examine which are the critical success (and failure) factors for their implementation and if Cloud ERPs are more suitable than traditional ERPs for being integrated with BI systems.

About Industry 4.0, automation is touching a huge amount of purposes. Also ERP systems are involved in Industry 4.0 applications; for example, in the inventory management field, it is possible to integrate a self-driving vehicle used for material handling (such as automatic load and internal movements) into the features of an ERP system, which sends a signal to the loading dock and automatically assigns a work order when the materials are loaded (Gariepy et al. 2018). As it was expected, a good part of the literature on Industry 4.0 deals with industrial issues, such as, smart factory, smart manufacturing, smart product, smart cities (Lu, 2017), in addition to issues related to BI systems (Big Data in particular). However, Industry 4.0 has also financial and economic impacts on companies, such as the predictable increase of technical fixed costs and the consequent higher importance of strategic planning. Furthermore, Industry 4.0 opens new research avenues in the field of the competitive advantage and business model development, as new technologies provide new opportunities to companies of several sectors. Further researches on Industry 4.0 could be useful to shed light on the effects of Industry 4.0 on the entrepreneurial formula, as well as on the costs and benefits that Industry 4.0 leads to. It would also be interesting to investigate the business model of SMEs and big smart factories and their respective ability to adapt to environmental changes. The approach to Industry 4.0 by SMEs could be another interesting study perspective, considering the several opportunities that Industry 4.0 seems to provide.

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