Evolution and Trends of Business Intelligence Systems: A Systematic Mapping Study

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Abstract

Business Intelligence or *BI* can be defined as an umbrella term describing a combination of applications, infrastructures, tools, processes, best practises and methods to gather, prepare, provide and analyse data to support decision making activities in organizations. BI is noted to have ties to preceding research on similar systems, known as MIS, DSS and EIS-systems. BI is noted to have been born after requirement to answer the challenges of data gathering and turning the data into knowledge for decision-making. Early BI-development can be seen to have be affected by the development and lowering in costs of technologies in data gathering, analysis, interactivity and personal computing, as well as the introduction of spreadsheet programs in 1980s. Today, BI is noted to be the top investment-area for IT-organizations. Because of multidimensional nature and several viewpoints, it can be challenging to gain an overall view of the area. It is also noted, that a standardized framework of the different BI-related layers or aspects does not exist. The goal of this thesis is to identify which aspects can be noted central for BI, how the area has developed over time, how technological innovation has affected BI and which industries or aspects are noticed to have influenced the development most.

Systematic Mapping Study is used as the main research methodology in this thesis, together with PRISMA, which is used for a more scrutinized review during the selection process. The methods were used to review a large number of studies, gathered from academic databases using a formalized search string. The process provided with two sets of primary studies with total number of 2020 for studying the trends and central aspects in the area of BI and 1414 for studying the industries.

From the results, BI is noted to have gained popularity early 2000s, peaking in 2012–2013, while fading coming to 2016. The results show the central aspects for BI from high-level to be: strategic aspects, data warehousing methods and BI-infrastructure. From more detail, the central aspects are noted to be strategic aspects, data warehousing, BI-design aspects, real-time functionalities, visualization features, decision support, collaborative support, reporting and cloud infrastructure. The major industries influencing BI-development and research is noted to be finance and banking, healthcare, supply chain, e-commerce, manufacturing and education. Today, most notable interest is noticed in Big Data. In future, Big Data, self-service, collaboration features, visualization, user aspects and mobility are predicted as some of the rising topics. BI is noted shifting more into non-profit organizations and extending the use-context. Major changes in the area are seen to be caused by IT-base innovation, while most changes in BI may be seen to be caused by services-innovation where new industries and methods are found to utilize BI-technology.

BI is noted as a very strategic entity, consisting of data warehousing methods, different decision support methods and technologies. In the future, BI-technology will be spread into more widespread use and the lessons learnt might be valuable for the predicted revolution caused by Big Data analytics and extended data collection and analysis.

Keywords
Business Intelligence, Business Intelligence trends, Business Intelligence evolution, Business Intelligence development, Systematic Mapping Study

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Abbreviations

BI	Business Intelligence
DSS	Decision Support System
CBIS	Computer Based Information System
EIS	Executive Information System
EDP	Electronic Data Processing
DBMS	Database Management System
DWH	Data Warehouse
OLAP	Online Analytical Processing
OLTP	Online Transactional Processing
ETL	Extract Transform Load
ELT	Extract Load Transform
EAI	Enterprise Application Integration
EII	Enterprise Information Integration
IoT	Internet of Things
MDM	Master Data Management
MIS	Management Information System
ODS	Operational Data Store
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SME	Small and Medium-sized Enterprise
SOA	Service Oriented Architecture
SIS	Strategic Information System

Contents

1. Introduction

In the current information-centric age, the need for utilizing wide range of gathered and explored information to benefit different organizational activities is becoming ever more important. The process of gathering and utilizing gathered knowledge and information for decision making is becoming central for organizations, rather than in the past relying solely on past experience or knowledge of the decision maker. The current world and organizations can also be noted to become more data-centric in their nature, collecting vast amounts of data of activities, logistics, customers, transactions and their markets. Also, data today is seen as one of the most if not the most important asset in modern organizations.

In organizations information, or data is used to support different activities, most important of them presumably being to support decision making. This is a requirement which came after the automation of materials and manufacturing processes generally known as the industrial revolution (Bonczek, Holsapple & Whinston, 2014). The need for Business Intelligence (BI) or a similar information system capable in supporting decision making and problem solving through situational analysis can be considered to be one of the most important needs of a modern organization. BI can be seen to exist for organizations ever-changing business environment and has the ability to enable quick reaction to rapidly changing environments, which is seen as a key success factor and can remove guess work (Ranjan, 2012). It is often noted, that organizations require the ability to react and respond quickly to changing environments and adapt fast to appearing new situations (Turban, Aronson, Liang & Shara, 2007.) Business Intelligence today has evolved and become a very central method or tool to fulfil this central need for organizations. More accurate and wide-spread use of data collection, data processing and analysis benefits the quality of decision making and helps the organization in unambiguous way at the correct time.

To support these requirements and activities, BI has evolved through a complex process, influenced mainly by previous research on systems known as Decision Support Systems (DSS) and Management Information Systems (MIS) and Executive Information Systems (EIS). In some cases, BI can be described as the modern incarnation of a DSS or EIS- type of systems. BI's development can also be noticed to have been influenced heavily by the progress in technology development related to data storing, online analytical processing, visualization methods and the development of interactivity. Sometimes BI is also referred as a data-centric DSS-system or included as part of the DSS-spectrum, because the shift from MIS or DSS to BI is seen to be rather vague or challenging to notice. The most research done for BI has been under computer- and business science disciplines (Ee-Peng, Hsinchun & Cuoqing, 2013). These include also management science and BI-research can be seen to have been influenced by many different research areas and scholars with varying backgrounds.

The major interest towards BI can be seen to have started during the late 1980s or early 1990s. Area of BI can be seen to have evolved from main goal of delivering reports and dashboards for executives to focusing more into situational analysis on how the organization has performed in the past and how it will perform in the future (Ng, Arocena, Barbosa, Carenini, Gomes, Jou, Leung, Milios, Miller, Mylopoulos, Pottinger,

Tompa & Yu, 2013). BI can be seen to provide answers from what happened, to how, to why using a wide variety of analytical methods and tools to provide answers to organizational questions and problems.

Many different viewpoints exist for BI, on how it is generally understood, however a general viewpoint or understanding of BI does not exists. The most general view of BI, it is seen to consist of methods, tools and processes to turn collected data into knowledge and action or decision. It consists of methods and technologies to enable data collection, data manipulation and processing the data into knowledge and insights by using analytical models, reporting, dashboards, geospatial features and visualization. Previously BI was seen mostly as a managerial tool, but has later evolved to become available to support decision making in other areas of the organization. Topics which are seen important for BI are the timeliness of the support (real-time support), mobility and different visualization methods.

BI provides the promise to bring major benefits for implementing organizations. In one example of these benefits, BI can be used to predict market or customer behaviour or to find patterns. In an example, a logistics company UPS was able to save up to 8,4 million gallons of fuel by using analytics to reduce mileage on its package delivery routes using Business Intelligence analysis of historical data (Davenport & Dyché, 2013). This is one demonstration of the benefits of using data analysis to benefit an organization. Some refer the current decade that is just starting to make use of Internet of Things (IoT) and Big Data as the fourth industrial revolution or simply refer it as the next industrial revolution. As more and more data is collected and new methods are discovered to analyse and make assumptions based on the collected data to support everyday life, manufacturing and business, the next revolution is predicted to be around the corner.

From these factors, the motivation for this thesis comes from Business Intelligence's scattered research area, consisting of variety of technologies, methods and scholars with different backgrounds. Because of different influencing factors in BI, it is challenging to gain an extensive view of the research area and what terms, technologies or components are considered to be central part of BI. It can also be considered important for BI-professionals or management professionals working in IT and business need to stay informed about changes happening in the BI-industry, which is behind the organization's ability to make the correct business decisions.

Trends and changes are important to recognize, because of their ability to bring business value or entirely change existing processes in organizations. On this it has been noted, that business-innovations are often seen to be centrally linked more often to information systems innovations, than any other technology-based innovation area (Chandan & Urhuogo, 2012; Swanson, 1994). New technologies and trends in the BI-area can be noticed constantly shaping through BI-research and industry and the area is under constant evolution (Cearley, 2012). This is also why research and analysis company Gartner is constantly monitoring the changes which are happening in BI-industry and reports them in their yearly Business Intelligence Magic Quadrant, which they report which aspects of BI are observed to increasing or losing of interest in the industry (Gartner, 2007-2016).

Previous research on trends in the area of BI has found it challenging to do a literature review on BI due to the large number of literature sources, which has been caused by the research area rapidly becoming of a huge interest or hype (Moro, Cortez & Rita, 2015). Moro et al. suggest that reading of abstracts, keywords and titles could provide a feasible outcome and a view of the research field. Another literature review on Business

Intelligence research literature has been done on diffusion stages of BI using only a limited 30 primary research articles about different diffusion stages on BI-research (Côrte-Real, Ruivo & Oliveira, 2014). Searching the BI-research area, it can be concluded that an extensive mapping study on Business Intelligence trends or central aspects has not been made on BI-research literature.

It seems that there has not been an extensive research on what are considered the most important features, components or technologies of BI, or how they have evolved over time. The outcome of this thesis will be a view on how BI has evolved through time and what could be considered the major aspects and components of BI. Also industries will briefly be investigated in the area, on which industries have had the most influence for BI-development and research. Another outcome will also be a categorization of central BI-components and their contents, which is seen to be missing from BI-research.

2. Related Research

In this chapter, the related research for the thesis will be introduced. This is used to get a basic understanding of the BI-area and its history from different viewpoints. This includes a brief introduction into different definitions and interpretations known for BI, evolution and developmental history of BI and BI's connection to other research-areas. As the history of BI can be seen to have formed in very un-linear way and been influenced by many different aspects and factors, such as research on other information systems, different core-technologies and other aspects.

This chapter begins with a gathering of definitions for BI collected from different decades and years, which are used order to understand how BI has been defined and understood from different viewpoints. This is also used to understand how the definitions have changed and developed coming to this day. The definitions are combined under different decades, on which they have appeared.

After reviewing the definitions, an introduction to the history and development of BI and the relation to previous Decision Support Systems (DSS) and Management Information Systems (MIS) -research is introduced. The review of the history of BI is also divided into different timeframes, in order to study how the DSS-research area has influenced BI and later surpassed by it as the popular term used for describing information systems and methods to support decision making in organizations. This will also include describing areas and aspects where BI could be predicted to be shifting in the future.

2.1 Defining BI

Different interoperations for BI exist and are influenced by many different factors and viewpoints. BI can be defined as a principle from, as an information system tool or as collection of different technologies, depending on the viewpoint. The different viewpoints are often affected by the background of the viewer. Researchers and managers usually see BI as a process or a product. Process-view consists of methods to utilize information or intelligence to help organization survive or support it to thrive in the surrounding global economy. Product is defined as the information tool to predict the action of organization's competitors, suppliers, customers, technologies, acquisitions, markets, products, services, and the general business environment (Vedder, Vanecek, Guynes & Cappel, 1999.) BI can also be seen as a process consisting of people and different technologies, mainly consisting of data warehousing and analytics, while from some viewpoints BI consists of people, technology, tools, processes and rules (Vizgaitytė & Skyrius, 2012; Molensky, Ketter, Collins, Bloemhof & Koppel, 2010). From management viewpoint BI may also be viewed as a strategic initiative in order to benefit from collected data (strategic BI) (Gangadharan & Sqami, 2004). In IT-related encyclopaedia BI is defined as: "*an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance*." (Gartner, 2013a).

In other viewpoints BI can also be seen as a reporting, visualization, business performance management, data extraction, data transformation, data integration, statistical analysis or data mining tool depending on the viewpoint and the viewer's

professional background (Avzine, Cui, Nauck & Majeed, 2006). BI can be viewed either as a simple technological tool, or as an applied analytics system or as a tool, which integrates data warehousing together with analytical and reporting tools. For Customer Relationship Management (CRM) system experts, BI is about integration of operational front-end office applications to back-office systems, while for data warehouse experts, BI is just another term for data warehousing to support decision making activities on technology platform. Similarly, data mining statisticians see BI as a base platform for advanced data mining algorithms. All the different viewpoints tend to disagree on what a BI is, but they can be noted to share the basic assumption, that a BI is a system, which successfully integrates knowledge management, enterprise resource planning, previous decision support systems technology and data mining, but differentiates if BI is seen as a process, a product or as a combination of technologies, processes and methods which is the central viewpoint that will be used in this thesis.

A single, generalized definition for Business Intelligence does not seem to exist, similarly what has previously been noted from the preceding and related DSS-research area (Filip, Suduc & Bîzoi, 2014). The research area of BI is also very multidimensional and holistic in its form and no precise or universal understanding for BI exists to this date (Pirttimäki, 2007). The definition for BI can be seen to be influenced by the viewer's professional background, as was noted before. BI is seen to consist of several separate components and elements such as information, people, processes and technology, which are often included in the definition. It is proposed by Pirttimäki that the area of BI-research is fairly unstandardized and challenging area to understand in a generalized manner.

For BI, it has also been noted, that different terminologies cross paths with the BI. Included in BI can be different system-interpretations or terminologies such as Competitive Intelligence, Market Intelligence, Customer Intelligence, Competitor Intelligence and Strategic Intelligence, which cross path with BI-definitions, as they all focus in the same contextual idea of gathering and analysing information and data (Pirttimäki, Lönnqvist & Karjaluoto, 2006). BI is also linked to terms such as Advanced Analytics (AA) and Business Analytics (BA). Often Business Intelligence and Business Analytics are interchangeable terms and are dealt as synonyms. Terms "Business Intelligence", "Business Intelligence & Analytics" (BI&A) and "Business Analytics" can usually be summarized under the same technological umbrella (Côrte-Real, Ruivo & Oliveira, 2014).

From some opinions, there exists a clearer difference between BI and BA, but this is fairly challenging or even impossible to recognize (Elliott, 2011). BA is seen to empathizes the analytical centricity of the decision support tools, while BI focuses more in online analytical processing and data warehousing processes. In some cases, BA is seen as the new upcoming term for business cantered analytics. Elliott states, that the introduction of the new term is mostly caused by the fact, that BI-vendors, or at least new entrants in the market don't want to associate with "outdated" terminologies describing their products or services and are trying to differentiate them on the market as the "new" or next generation of technology or products. In this thesis, BI and BA are considered to exist under the same technological and terminology umbrella of BI.

From these aspects it can be concluded, that BI can be seen in very different ways. It can be seen either as a tool integrating different technologies and analytical methods under an information system, or as a process consisting of technologies and methods to support decision making activities. In this thesis, BI will be viewed generally as a combination of different aspects, mainly consisting of different technologies,

interactivity features, processes and methods rather than just data warehousing and analytics combined under an information system tool, or describing a process to support decision making. Because of the several differentiating viewpoints and competing or interfering terminologies, it has been challenging to gain an extensive view of what components or aspects are considered to be the central for BI.

Many different definitions for BI exists. Often the definitions for BI are based on basic fundamentals gained from previous DSS- and MIS-research. The most popular model behind this is on how data is turned into knowledge, to be used for decision making activities. Shown next is the typical and most known model adapted from preceding DSS-research:

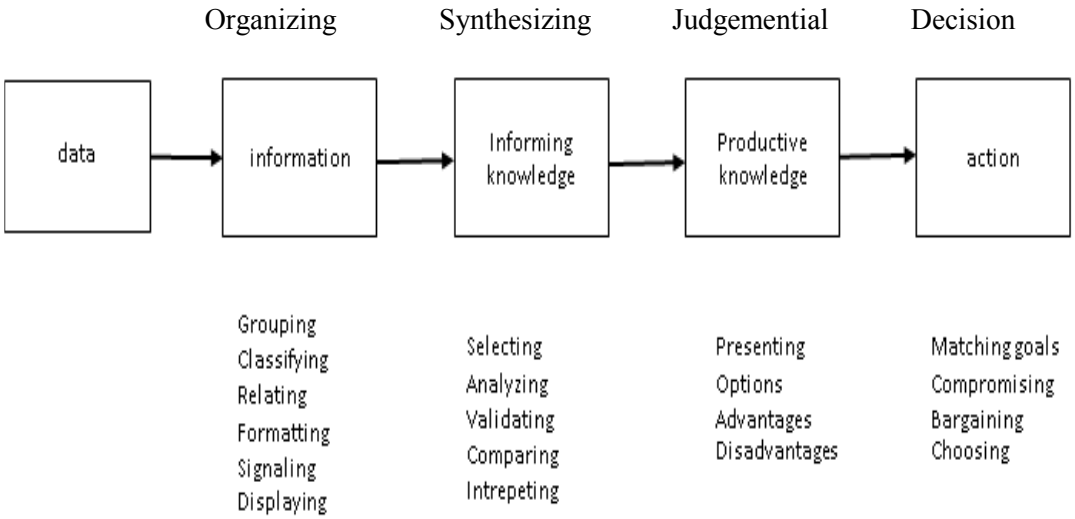


Figure 1. Value adding spectrum (Taylor, 1982)

In figure 1, a well-known model of a DSS value adding spectrum is presented showing how data is transformed from data to information, into knowledge and later action (decision) (Taylor, 1982). This is often seen to be behind much used data transformation model, which has been popular in DSS-research for decades and was later implemented to BI as well. The value adding spectrum model can also be noted to be the foundation on which many of the definitions for BI are grounded from. Many of the definition can still be seen to follow this Taylor's model showing how BI is defined through its use of information and data.

From the model, it can also be noted, that data alone is useless unless it is processed; in other words, data becomes information only after it establishes connections with set or parts of other data. After information evolves to productive knowledge, it can be used to form decisions and later used to form actions (decisions) (Taylor, 1982.) One challenge might be the challenge to acknowledge or recognize the connections between data to draw conclusions as they can be hard to notice without relevant knowledge (Barton & Court, 2012). The challenge of recognizing or noticing connections amongst the data is considered a challenge in modern BI as well, which is why different ways to make sense and prepare the data is required in BI.

The BI is usually used to compare and analyse different segments of the information to gain knowledge how to act based on collected information. One very central

requirement for business data-driven decision support systems, is that they have access to as much data as possible collected from variety of sources (Sauter, 2010). In the heart of a BI can be seen the ability to gather, prepare and analyse data, from as many sources as it is possible and to provide access to analysed knowledge at the right-time in different levels of the organization. It can also be noted, that applications or users are able to use the data to benefit the decision-making activities, only if the organization sees the central value in collecting large amounts data (Watson & Wixom, 2007). This seems to provide an understanding, that organizations should be data-centric in their nature and organizational culture in order to gain cost-benefit or value from implementing or using a BI.

Previous research has also shown, that companies and organizations, which were aggressive in the use of data, analytics and had analytics as part of their strategy, were often identified as the leaders of their represented industries (Davenport, 2006). Analytics utilized on data about pricing, customers and business processes along with employees with good set of analytical skills and choosing the most effective analytical tools are some of the key success factors recognized from utilizing BI. Today, BI is noticed to exist as the main set of tools for modern organizations and enterprises to ensure their competitiveness by utilizing their gathered data (Duan & Xu, 2012). The interest to implement and use BI in different levels of the organization and extending the use of BI into different industries has increased steadily, as more data is being collected and used to support different organizational activities and processes. The adoption rates of BI in small and medium sized organizations are lagging behind, which could possibly cause loss of competitiveness against larger and more sophisticated organizations already familiar with utilizing BI (Boonsiritomachai, McGrath, Burgess & Liu, 2016). The challenge how to provide more cost friendly approaches to start implementing BI in a more self-service way is one of the challenges for the industry, which might be one of the future topics which research will need to tackle.

Following is a collection of more definitions for BI, organized by the time of publication under different decades. Many BI-definitions follow a well-known process of turning data into actionable knowledge for supporting decision making. The changes and evolution of BI-definition between decades will also be observed using the gathered definitions.

2.1.1 BI Definitions from 1980s to 1990s

The earliest definitions provided descriptions, which defined BI mainly as a technological tool or information system appeared during mid-1980s, while the earliest definitions are even older, as noted before. From the early BI-definitions, it is noted BI is defined as a set of technologies or analytical tools used on information, managerial and social trends, in order to do more effective decisions in organizations (Ghoshal & Kim, 1986). It is defined as a tool centralizing on five tasks: collection of data, evaluation of data quality, analysis, data storing, intelligence and dissemination (Gilad & Gilad, 1986). according to Gilad and Gilad the goal of such a system is to convert raw data from environment to provide decision makers information to be used in making important strategic decisions.

From the earlier definitions of BI, it can be noticed, that the area of BI and BI-research was still in its pre-development phase and the area of BI had not gained popularity. As the area of BI was still under development and the only thing that can be noticed to connect the different definitions is the emphasis on data centricity of BI.

2.1.2 BI Definitions from 1990s to 2000s

Coming to 1990s, BI slowly became more recognized. As personal computing became a rising topic and interactivity became more important for designing information systems and applications. BI along with other information tools became started to show their importance for business organizations.

Definitions gathered from this decade see BI mainly between a process and a product. Process definitions from this decade describe BI as organizational process to systematically collect, process, analyse and distribute needed information from the external environment (Hohhof, 1994). BI can also be defined as a process on which information on customers, competitors and markets is systematically gathered by legal reasons and analysed to support decision making activities (Collins, 1997), or it can be used to predict changes in the market (Sawka, 1996). The information can then be used, according to Hohhof, to support operational and strategic issues or decision making. Another definition sees BI as a combination of a process and a product, where BI or Competitive Intelligence is used to gather information on competitors, suppliers, customers, technologies, acquisitions, markets, products and services from private and public sources to benefit the business decision making (Vedder, Vanecek, Guynes & Cappel, 1999).

From the 1990s definitions it can be seen, that BI was not yet fully formed and was interchanged with different colliding system terms at least one being Competitive Intelligence. BI was mostly defined either as a process, an information system product or combination of the both, depending on the viewpoint.

2.1.3 BI Definitions from 2000 to 2010

Coming to 2000s, BI can be seen slowly gaining recognition looking at the number of definitions, which were discovered from this period. The central importance and requirement of data collection, to support different activities, including decision making is seen to have become more evident. Also, the understanding of BI from single process-or product-viewpoint was extended, to help understand the complexity of the area. Much more variation coming from different viewpoints can be noticed from the definitions of this decade. Also “classical” views of turning data into knowledge through a process and combination of technologies exist. Howard Dresner defined BI, reflecting his earlier involvement in the research on BI and defines BI simply as a way to deliver information to end users, without needing them to be experts of the operational research (cited in Martens, 2006). This is one of the single definitions, which is bringing the user-viewpoint for BI.

In this decade, BI is in some definitions seen either as a process or a product. In one definition, BI is defined as a process or method to improve business decision making, with information gathered from multiple sources and to support understanding of business dynamics (Wei, Xiaofei, Lei, Quanlong & Hao, 2001). In another process oriented definition, BI is defined with “Business information and business within the context of key business processes that lead to decisions and actions and which results in improved business performance"(Williams & Williams, 2007).

From product or tool viewpoint, BI is defined as tool for providing information to improve strategic and tactical decision making and turn information into knowledge (Wei at al., 2001), or it as “the tools and systems that play a key role in the strategic

planning process of the corporation" and also to help gather, store, access and analyse corporate data for decision making support" (Muntean, 2007).

From other data- and information related viewpoints, BI is defined as a system combining data gathering, data storing and knowledge management together with analytical tools to provide competitive information to planners or decision makers (Negash, 2004). Another viewpoint emphasizing the data-centricity of BI and the ability to gather data from various sources, defines it as a methodological process of transforming data from different sources into new forms to provide benefits for business-driven decision making, consisting also of tools, databases and different vendors. (Segall, 2007). In another data-centric definition from this period BI is defined as system for collecting, integrating, analysing and presenting large volumes of information for better decision support by utilizing usually front-end data warehousing, querying, reporting and analysis tools (Dayal, Castellanos, Simitsis & Wilkinson, 2009). From one related viewpoint BI is defined as the tool to help access to the right information at the right time, to make the right business decisions with analytical methods and reporting (Stackowiak, Rayman & Greenwald, 2007).

From the other viewpoints BI is defined as being neither a product nor a system, but more of an architecture and a collection of integrated operational and decision-support applications and databases (Moss & Atre, 2003), or as a strategic approach to systematically target, track, communicate and transform weak signals into actionable information or knowledge to what strategic decision-making should is based on (Rouibah & Ould-ali, 2002).

As can be noted, BI is often seen from a process, product, tool or strategic initiative viewpoint. From this period, it can be noticed, that BI is seen either from a process viewpoint, strategic viewpoint or from a tool or product viewpoint. From the definitions, it can be seen the emphasis to be in the data-centricity of and also on the strategic nature of BI. The definitions seem to show, how BI is seen from many different viewpoints, based on the viewers background. Also the "classical" views exist, which define BI as a tool to gather, integrate data and analyse it and turn it into knowledge.

2.1.4 BI Definitions 2010 Onwards

2010 onwards the changes are noticeable in the definitions, however BI is seen much more as an umbrella term combining different elements, such as technologies, methods, processes and organizational strategies to improve decision making, rather than a separate product, tool or process. The different viewpoints seem to come together and are seen forming a more synthesized definition for BI. In this period, BI is mostly seen as an umbrella term consisting of a combination of technologies, methods, processes and people, or as a data-centric tool to organize and integrate data to support decision making.

BI is defined as a system, which consists of technologies enabling monitoring and analytics activities, which enable business users to turn data into information and information into knowledge, in order to optimize decision making and manage business performance to improve profitability and competitiveness (Molensky, Ketter, Collins, Bloemhof & Koppel, 2010). Another view seeing BI as a combination of technologies and methods sees BI and analytics as an umbrella term including applications, infrastructure, tools and best practises to optimize decision making and organizational performance (Rogers, 2016). Gartner defines BI as umbrealla term, which combines

people, processes and applications or tools to organize information to access and analyse it to improve decision making and performance (Gartner, 2013b). In another generalized viewpoint, BI is defined as umbrella term for architectures, tools, databases, applications and methodologies to analyse data for managerial decision making (Turban, Sharda & Delen, 2011).

From data viewpoint, BI is defined as consisting of data architectures, technical architectures, analytic tools and methodologies (Gonzales, 2011), or BI can also be defined as the process of collecting, organizing, analysing, sharing and controlling data to provide support for organizational management functions (Lapa, Bernardino & Figueiredo, 2014). Another data-centric view of BI sees it as an application to enable organizations consolidate data from various sources, manage data quality, business processes and develop tools to use analytics through front-end applications (Wise, 2012).

From 2010 onwards, the definition has not changed noticeable from the definitions in earlier century. The change in definitions might be, because the area's complexity is understood and the definitions are getting more refined or synthesized. BI is seen in a wider context than before. The data-integration and the vague description of BI can be noted to be popular in these periods definitions.

From the more recent and refined definitions for BI, it can be noted the key components for BI to be related to data warehousing, data collecting, data integration and analysis. Also, the strategic nature and process-centricity of the systems is emphasized in many of the definitions, regardless of time frame. It can be noted that not much emphasis is put on the interactivity, user-centricity, automation or visualization in the definitions for BI.

BI is referred often as a process or a combination of information system and a process. This also depends on the timeframe, as the definitions for BI have evolved into a more synthetic definition as time has passed. In the beginning, there was much more differences noticeable among the definitions than when observing more recent definitions of BI. From the many definitions, it can be noted, that the Value adding spectrum -model seems to have remained fairly important for BI-development and research coming to this date. The definitions don't seem to vary much between timeframes, although they can be seen to have become more linear or synthetic during time, while no big changes in the definitions can be noticed in recent years.

2.2 Early History of BI and its Relation to DSS and MIS (1960–1989)

Next, the history of BI is gone through by looking at how BI has evolved over history and time. This also includes examining of preceding decision support information systems, that have had a major influence for BI development and which BI is still from some viewpoints included as part of. BI can be seen to have a long and a very un-linearly formed history, as can be noticed later.

As mentioned, the history of BI-development is very much linked to that of preceding managerial decision support systems development and research, known as Decision Support Systems (DSS), Management Information Systems (MIS) and Executive Information Systems (EIS). BI differentiates from these other systems mostly by the provided interactivity features, as well as including Online Analytical Processing (OLAP) features and other analytical functions, which are provided to the user. BI can

also be noted to be more data-centralized, than previous DSS- or MIS-systems, with capability of doing analytical tasks on collected data. BI's central goal is noted to be to extract information central for the business need and improving the managerial decision making (Gibson, Arnott & Jagielska, 2004).

The terminology describing information systems with similar goals can be noted to be varying between decades. During every decade, a distinct term seems to be used to describe an information system designed to support decision making in organizations. Currently the decision support systems in organizations are mostly referred as Business Intelligence -systems. The new appearing terms, such as Advanced Analytics (AA) or Business Analytics are starting to gain popularity. Currently, modern decision support technologies and methodolies are mostly referred as BI-systems (Poonnawat, Lehmann, Connolly, 2015).

During the 1960s the systems were referred as Electronic Data Processing Systems (EDP), which is connected to the time when data collections was just starting by collecting data from various transactional activities. After this, for a period the information system types were generally referred as Strategic Information Systems (SIS) (Samli, 1996). From the mid-1960s onwards, they were often referred as MIS or DSS-systems (Power, 2007). DSS-systems have often been categorized based on their goal or their method to support decision making. DSS is divided between the following categorizations: Personal DSS, Group Support Systems, Negotiation Support Systems, intelligent DSS, Knowledge Management-based DSS, Executive Information Systems / Business Intelligence and Data Warehousing (Arnott & Pervan, 2005).

The field of DSS-research spans for almost 40 years and BI has inherited a lot from this research area, which was influenced by researchers and scholars studying ways to support decision support through technological methods. The basic requirements and goals of a DSS have remained the same from the earliest definitions: to support the quality of decisions with combining user's experience and intuition with technology provided tools, such as visualization or analytical support tools to solve semi- and unstructured problems (Keen & Scott Morton, 1978; Averweg, 2009). The DSS have been described as "computerized interactivity based systems for connecting decision maker's intellectual resources combining with computer provided tools and features to support better quality decisions", as they were defined by pioneering researchers Keen and Scott Morton (1978). The early definitions for DSS appeared during the early 1970s and they were amongst the first information systems to be designed for the mainframe computers of the era. There still exists no clear definition for DSS, only a basic understanding what the central goal for these types of systems, which shows how turbulent this area of research has been. In some cases, it has been argued, that any system which provides decision support could be considered as a Decision Support System and that the definition of a DSS only exists as a generalizing term or as a "buzz word" (Sprague & Watson, 1996). This is fairly similar what has been mentioned about BI.

The main goal for a DSS is defined as bringing technologies and features for the use of the decision maker and to help provide better insights ensure reliability and quality of the decision. Comparing this to the goal and purpose of BI, which is to help control, identify and process vast flows of business information and process and transform it into managerial knowledge and intelligence (Lönnqvist & Pirttimäki, 2006) from where it can be noted, the BI's data-centric nature, which is answering to today's challenges connected to collecting large amounts of data which needs to be analysed using different methods.

When looking at previous research on DSS, it can be noted that the research discipline for DSS had not formed in a very linear form and seems to had also been affected by many pioneering and influential researchers coming from diverse backgrounds (Schuff, Paradice, Burstein & Power, 2011). BI can be seen to have inherited features originated from "good old ideas", which DSS-researches introduced in their developmental work during 1970s and 1980s from other information system research areas, such as knowledge management research (Power, Burstein & Shrada, 2011).

During the late 1980s when the systems were gaining more interactive features through dashboards and other features designed for managerial use, the decision support systems were briefly referred as EIS-systems. From 1990s onwards the systems were known as BI-systems, but sometimes also referred with terms such as Competitive Intelligence, Customer Intelligence and others. This can cause confusion, as the different systems have had similar objectives having been called with several different terms, depending on the observed timeframe.

Differences can be noticed between DSS-, MIS-, EIS- and EDP-systems as well. Looking at the EDP-systems, the early EDP-systems were designed mainly to process data for few organizational units, often being accounting and billing. The EDP-systems required sophisticated skills to operate the complex, expensive machinery usually located in EDP-departments. MIS on the other hand developed from Computer Based Information Systems (CBIS), that's role expanded from simple data handling to processing masses of standardized data. targeted solely for the management use to benefit from the use of collected information (Singh, 2009). DSS on the other hand, was used to focus decision support to a specific decision area from the management perspective. All the different systems seem to have evolved after the preceding system through an innovation chain over evolutionary progress (Samli, 1996). The different systems are also seen to have been targeted at different layers of the organization. Sometimes BI is be seen as a combination of reporting and personalized decision support features influenced by DSS- MIS- and EDP- systems, while gathering the interactivity and dashboard features of the EIS-systems.

BI can be seen not having evolved very far from previous DSS-systems and the borderline between the two system types has often been noted to be very thin or vague. The differences between the systems can be challenging to notice and BI can be considered as the modern incarnation or evolutionary follower of -DSS, -MIS or EIS-system. From some viewpoints, BI can be seen to have replaced the others as the main stream information system designed to support managerial decision support activities (Thomsen, 2003). Some state BI still only exist as part of DSS-systems as a Data-Driven DSS-systems, as the definitions and goals for DSS and BI can be noted to be in some cases fairly similar to BI (Power, 2009). Some see BI as an evolutionary next step from previous DSS, MIS-systems and EIS-systems, while others consider BI still as a contemporary term for EIS and not a complete replacement for the earlier system types (Arnott & Pervan, 2005). The term BI seems to have existed long enough, for it to be considered as the modern or current description used to describe a system designed to support decision making in organizations.

In essence, BI can be seen as a complex type of DSS-system, but the goal for these systems can be seen to be very similar: providing users with better quality decisions and situational awareness from outside the organization. The differences to DSS can be noticed from the choices of particular technologies and their individual application to handle decision support. Also BI is more aimed to support a more organization-wide decision support, while DSS is usually designed to address only a certain types of

problem types (Vizgaitytė & Skyrius, 2012.) BI can also be differentiated by the methods used to support decision making, offering more interactive, data-centric and using more analytical methods than preceding system types.

Interestingly, it can be noted that the definition for BI seems to be even older or have existed far longer than the other terms describing other systems (Hart, 2009). The first mention of term “Business Intelligence” in the form of a technology based tool to support decision making was made in an article, which discusses an automated system, that uses information from various sources to be processed for different individual needs. In it is stated Business Intelligence to be "*the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal*" (Luhn, 1958.)

The first mention of the term "Business Intelligence", however has appeared even earlier than this in a book how describing how an associate banker was able to act on information collected around business-environment to be used for benefit to outperform competition (Devens, 1865). Surprisingly, this very early example is able to define the current Business Intelligence systems, which is the ability to act on collected information to benefit a competitive goal, business objective or decision making activity. It also confirms, that BI can be considered to exist as a bigger entity than just a simple information system.

As a conclusion, BI’s relation to previous systems, including DSS-research and development is evident and differences between descriptions and goals between the system types is often very vague or unnoticeable. BI has sometimes been referred as a data centric Decision Support System and has inherited many central features from preceding decision support systems referred as MIS, DSS, EIS -systems. Sometimes BI is also seen as a complex DSS or as a data-centric DSS. DSS-history started in the early 1970s, but BI has been described to have been introduced even far earlier than the preceding DSS systems, the term being brought up as early as 1950s and as a non-technology related term even as early as 1865. DSS history is very similar to that of BI-research having been influenced by many research fields and different scholars with varying backgrounds. BI can be seen to have inherited a lot of the “good old ideas” from DSS-systems research, which have in turn been inherited from other research areas. The good old ideas are understood as methods and research outcomes adapted from management sciences to use information technology to support decision making by the use of unstructured, semi-structured and structured data. The BI’s similarities in many aspects to DSS are evident and BI can be seen as the modern incarnation or inheritor of the popular research area that’s been known as DSS- research.

2.3 BI Developing and Spreading into Mainstream Use (1989–present)

BI is seen to have gained popularity by the late 1980s, early 1990s or late 1990s depending on the viewpoint. The beginnings can be traced to development of data warehousing and database management, as well as the development of analytical methods. During late 1980s a huge interest for BI started at least in industrial organizations, after consultants were introducing the new “organizational innovation”, which they called the “Business Intelligence systems” (Giland & Gilad, 1986). Part of the interest was to institutionalize intelligence activities and the general interest was also to establish experiment and formalize business intelligence as part of organizational functions for the future.

The basis of processes for generalized data collecting appeared after the introduction of retail scanners for retail stores and after the introduction of barcodes during the early 1980s. Organizations discovered they had a lot of valuable data gathered about their customers, products and revenues laying around for potential strategic use (Nylund, 1999). Data warehousing was born from the need to collect and systematically organize the collected data to be used as advantage for business and strategic purposes of the organization. The basis for data warehousing and Online Analytical Processing (OLAP) were developed in the 1980s possibly for also goals to assist with their potential for business benefits (Shariat & Hightower, 2007). Other sources also state, that organizations have collected information about their competitors since the beginning of capitalism (Gilad & Gilad, 1986). Data warehousing made it possible to develop new methods and ways to analyse and model the collected data, which can be noted to be one of the major technologies, which provided BI to develop into popular use.

The need for a new kind of DSS-technology based system, which is able to provide more interactive and analytical features came during the late 1980s. EIS and BI were born under these requirements. The general popularity of BI as a research subject also rose very soon after The term Business Intelligence was brought back to major interest after Howard Dresner, an analyst working for Gartner published his research study on the topic in 1989. His definition for BI is an umbrella term of a set of technologies to help business make decisions based on facts, rather than intuition or past experience (Nylund, 1999). During this period, the technology for data collecting became available for a wider audience and also the costs for data warehousing systems and database management became lower. BI was born after being able to combine the decision supporting and reporting features of DSS-systems, with the interactivity and dashboard features of the EIS, along with advanced analytical features. The need for tool, system or method such as MIS, DSS, EIS or BI has clearly existed for several decades for organizations, which is why this area of information systems is of such huge interest for business organizations and research. It is also not surprising, that BI has become the most important area of investments for organizations or IT-department managers in the current decade (Hart, 2009; Gartner, 2015).

The systems containing interactivity before BI were known as the EIS-systems and were defined as "computerized systems that provides executives with easy access to internal and external information that is relevant to their critical success factors." (Watson, Rainer & Koh, 1991). EIS-systems also include some drill-down and analytical functionalities, information visualization properties and can be tailored for the user needs. EIS is mainly targeted for the executive level as an organizational control and monitoring technology or tool. EIS-systems were recognized as the mainstream tool for mid-sized organizations coming to the mid-1990s (Arnott & Pervan, 2005). Later the focus changed from EIS management style reporting, to enterprise-wide reporting by the introduction of BI during the late 1990s. BI includes more enhanced analytical tools have made it possible for it to move away from a simple dashboard or visualization systems designed for management use.

The early beginnings of BIs or EIS-systems can also be seen after the development of spreadsheet programs, personalization and development of graphical user interfaces among the driving technological factors. After the introduction of Lotus 1-2-3 and excel spreadsheet programs during the 1980s, when the end users got to make their own data models for business analytics, which helped to discover the potential of gathering and manipulating data (Rasmussen, Goldy & Solli, 2002). The data collection is also one of the central factors for the early development of BIs, automation and the development of data warehousing systems has supported the BIs to develop from simple reporting tools

into actionable business intelligence systems they are today (Rasmussen Goldy & Solli, 2002). Also evident is the increase in analytical features and user interaction has increased over time looking the period from 1985 to 2002. Rasmussen et al. also discuss that today, there is more data and data sources than ever before, which have been the driving forces for the development of ETL-processes and data warehousing.

The development after EIS and the evolutionary shift to BI can be seen to have been very fast-paced and BIs were heavily influenced by the capability of different analytical methods and newly appearing technologies, which supported BI to gather popularity (Arnott & Pervan, 2005). The BI we understand in its current form, however can be seen to have born during the early- to mid-1990s to satisfy manager's needs to harvest and use collected information to understand their business and to improve the decision-making processes. BI as systems can be seen to have been born from the requirement to fulfil the managers need to turn gathered data into knowledge about the organizations surrounding environments (Golfarelli, Rizzi & Cella, 2004.) During the mid-90s, BI gained more interest as a research subject. Because the requirements for more interactive, analytics and data-centralized system became evident, the area of BI became a popular research topic and subject of hype by the late 1990s. According to Golfarelli et al. the ten years of research later transformed the former bundle of naïve BI-technologies into a mainstream tool to process and extract information for decision making.

The history of BI started from the development and decrease of costs in data storing technologies during the 1980s and further development of analytical methods, such as Online Analytical Processing. Also during the 1980s spreadsheet programs, such as Lotus 1-2-3 and excel became available, which showed the advantages of data manipulation for organizations. The need to use gathered data to support decision making processes became evident during the late 1980s. This provided the foundation to develop EIS-systems, which brought out interactivity features along with managerial dashboards utilizing the collected data. BI was born after the evolution of combining EIS-features, together with DSS-features together with advanced analytical methods to be utilized with the collected data. The full popularity of BI systems fully became by the late 1990s and BI currently remains as the mainstream tool to support decision making activities using gathered internal and external data of the organization. Organizations see a clear value in BI-based technology, which is why it has remained also its position as one of the top investments for organization's IT-department for many years and also continues to grow on yearly basis.

2.4 The Future Development of BI and the Influence of Technological Innovations

The importance of data gathering and analysis has risen exponentially coming to this day. In the future, it seems the amount of data is increasing exponentially and the vast amounts of collected data is to be analysed in automatic fashion to be used to benefit every imaginable aspect of business and human life. It is evident data collection and analysis will become ever more important aspect in the future. This also means the methods and experienced gained from using and implementing BI will be utilized to benefit new areas in the future. BI can be seen to be the outcome of constant evolution. Sometimes it has been seen only as a contemporary term describing modern decision support systems and some state even that the area is not new, only adapting the old methods, as mentioned by Watson "just because it has a new name doesn't mean it is necessarily new" (Watson, 2005). Currently the BI-research is noted to be trying to

tackle the issues with quality control in industrial informatics and the need to make them more automated (Duan & Xu, 2012). This chapter tries to analyse historically what has caused shifts in BI-development and evolution and what could be predicted for the future of BI.

The area of BI-research has had to cope with rapid changes which have been happening in data and other technology landscapes (Ee-Peng, Hsinchun & Cuoqing, 2013). Also, BI itself might have been behind of some of the major innovations or disruptions, at least for organizational decision making cultures. For Business Intelligence, it can be noted that different trends and innovation subjects seem to happen in re-occurring or cyclic form and can be noted gaining momentum heavily when they gain popularity for mainstream research. This is possibly due to changes in technologies which in turn enable changes in other aspects, through combination and influence in later time (Arthur, 2011). In history of BI-research, there can be noticed timeframes when not much progress has been happening, but after the introduction of new technology such as cloud infrastructure, there have been rapid and disruptive changes how the systems are designed.

New technological trends or disruptive technologies have can provide big influence for the entire area of information systems and information technology. This has happened for moving from main frame computing, to personal computing and to internet and mobile computing. Some technologies show early promise and are adopted and implemented very quickly, while other trends or technologies vanish at same pace, because their return for investment cannot be proved during the time or are not seen of value to develop further. Digital Disruption is defined as "*an effect that changes the fundamental expectations and behaviors in a culture, market, industry or process that is caused by, or expressed through, digital capabilities, channels or assets*." (Gartner, 2013a).

Most innovation in business has been noted to be caused by quick changes caused by Information Systems used in organizations, although not often recognized or promoted. It is also evident that business innovation is increasingly depended on IS-innovation and has had a major historical connection to larger business innovation in organizations (Swansen, 1994.) Data Warehousing can be also considered as the most significant component or innovation for strategic business decision making to date (Dell'Aquila, Di Tria, Lefons & Tangorra, 2008). During the early years, development of a feasible data storing solution was extremely expensive. After the lowering in the cost of data storing methods and maintenance, the data storing became a central functional tool which enabled organizations to store critical information about their transactions, customers, markets and so on.

When looking at how innovations form for in information systems. One understanding exists, that new technologies evolve through a process of self-creation when new technologies evolve from already existing technologies. Self-creation can happen through experimentation and building by utilizing the collective of existing technologies. (Arthur, 2011). Digital innovations in IS can be described through evolution, re-occurring development loops and maturing. This is also a probable theory for to identify the source of innovation for information systems, through evolution and combination of different separate technological hierarchies.

Innovation can also be observed through a process of emergence, growth and maturity. Innovation can be described to be a process of activities, but not always linear in nature, as it can contain several feedback loops or development cycles to achieve results of the

final innovation product or goal (Meissner & Kotsemir, 2016). Often there have existed gaps in time when a little progress has happened in development, but after a technological enabler appears, the innovation progress is accelerated very quickly. Arthur also notes, that technologies and patterns usually appear in re-occurring form during timeframe (Arthur, 2011).

New technologies may also appear after a requirement or a human need. A novel need for a purpose but they very often evolve from existing technologies that enable the wanted goal. These novel technological elements are usually made possible by existing technologies, combination, maturing and evolution of them. In this basis, according to Arthur, new technologies and trends can be explained through a "supply" of existing technologies and "demand", which is a need to fulfil a purpose or a requirement. From these combinations, innovation can happen through a combination of different technologies.

It can be noted, that past innovation research has mainly been monitoring the volume of changes in technological and organizational change connected to IT innovation (Lyytinen & Rose, 2003). This is also due to the studies of technological frames have not yet entered the mainstream IS-research. Innovation is hard to predict and the changes happening hard to monitor. When a new innovation provides means for change, the change is often very fast and in some cases causing disruption across different industries. In the following, a sample of an IS-innovation model is introduced by Lyytinen and Rose.

Table 1. Sub-categories of IT innovation, adapted from Lyytinen and Rose (2010)

IT Innovation Set	Description	Example
IT Base innovation	Base technology	DBMS, client/server computing, OODB
	Base development capacity innovation	Software Patterns, Software Component Brokering, Quality Assurance
	Base service capability innovation	Point and Click GUI, Multimedia, QoS
System Development innovation	Administrative process innovation	Maintenance departmentalization, CIO, open source development
	Technological process innovation	Systems programming, data administration, prototyping
Services innovation	Administrative process innovation	Accounting systems, EIS
	Technological process innovation	MRP, computer integrated manufacturing
	Technological services innovation	Remote customer order entry and follow-on

		customer service systems, e-commerce
	Technological integration innovation	Interorganizational information systems EDI

In table 1, a three-set model of IT-innovation is introduced. The three typical innovation channels are: system development innovations, service innovations and IT-base innovations. Systems development innovations include basic innovation happening from developing methods or processes. Service innovations include changes in the processes for support in IT as administrative core of the organization. This also includes changes that are affected by the use of IT to support business functions or processes. The third innovation change type, IT-base innovation includes changes in the IT capability and technological innovations that enables changes other types of innovations. These changes can be changes in hardware, software, services or new telecommunications capabilities. In table 1, these different innovations are divided and examples of them are shown. For BI, innovations are based mostly on service-innovations, which are mostly caused by changes in current practices or processes. As more data is gathered into BIs, more new ways to utilize the data is discovered in the process, causing service-innovations.

Today, Big Data and Internet of Things (IoT) is starting to reflect the BI-research more (Minelli, Chambers & Dhiraj, 2012). Minelli et al. describe BI as a system that centralizes its support on structured data stored in data warehouses, which have only the ability to provide single answers to a problem. Big Data has the promise to extend this by bringing up more information regarding the problem and to further reflect the complexity of the world, meaning also that even more data in unstructured format will be used for supporting decision making. According to Minelli et al. it also means that persons that are used to perfect data for their decision making might have hard time adjusting to Big Data unstructured data, which will not be perfect every time.

Big Data is often described using “three V’s, which are volume, velocity and variety, which are used in describing the nature of extensity and complexity of the data. (Russom, 2011). Some see Big Data of consisting of either four, five, seven or even ten V’s. The original simplified description for Big Data however is kept to original three V’s. The volume is to describe the size of the data and the fact that it can be sampled. The velocity is to describe the speed of the data and its real-time form. The variety is to describe the source of the data, describing it can be from different sources.

Some even refer Big Data to be the fourth industrial evolution along with Internet of Thing (IoT) or the next major step in information technology (Minelli, Chambers & Dhiraj, 2009). The revolution is expected to affect the manufacturing industry mostly, but other industries such as financial and healthcare industries might be likely affected too. Minelli, et al. also emphasize, that legacy BI and data warehousing is not going to fade away anytime soon after the discovery of Big Data. Big Data is only reflecting on the vast amounts of knowledge gathered from sensors and sources outside of the organizations and discovering new ways to make use of the vast amounts of collected data. Others refer Big Data as the BI & Analytics 3.0, which will include the analysis of data gathered from mobile, sensor and location based sources or IoT. Also, mobile and person-centric analysis will possibly become a central part for the next generation of BI. This will also highlight the requirement for data savvy managers in the future and emphasizes the challenges how to prepare education programs to the future challenges

(Chen, Chiang & Storey, 2012). This will also reflect the requirement for more advanced analytical skills to be used together with data-driven decision making amongst managers.

Currently, most users and engineers, that are using "legacy" BIs, are discovering the current systems are not able to handle the challenges of future Big Data with adequate performance (Esposito, 2015). Esposito reflects, that most industries see Big Data changing their industries in the following three years. Big Data holds competitive and profit-based expectations and is also pushing BI-research to support Big Data analytics. Also, factors and technologies such as data streaming, data architectures, real-time analytics and visualization need to evolve to support the use of Big Data according to Esposito.

The area of BI has been started by technological innovations and, which in turn may have had some influence for disruptive changes in organizational decision making cultures. Technologies often evolve through re-occurring cycles and combination of technologies. For BI, these may have been the development of data warehousing, analytical methods and interactivity among others caused by IT-base innovation. Most technological innovation caused for BI can however be seen to have been caused by services innovation, where new methods are found to make use of data collection and analysis, while spreading the technology to new industries and areas. Today, Big Data and IoT is starting to cause changes and challenges for BI, as modern Bis are not able to cope with Big Data with adequate performance. Many expect Big Data or IoT to change the different industries during the following years in a dramatic fashion and the area is providing with big promises. In the future, data gathering and analytics, as well as Big Data and Internet of Things will become more important, when designing the next generation BI or decision support systems. Some refer the next generation BI as the fourth industrial revolution or BI & Analytics 3.0. It is evident the use of the data and data analytics will spread into new areas. Big Data can already be seen to be reflecting the current BI-research. New skills will definitely be needed to tackle the complexity of the challenges provided by Big Data.

2.5 Business Intelligence Components and Layers

BI can be seen to consist of several different types of aspects and layers, some of which might be un-noticeable to the user, while some are more visible. In BI-related aspects are included activities, technologies, applications and processes to help organizations gain knowledge about their business using collected data and turning this collected information into usable information for decision making (Dell'Aquila, Di Tria, Lefons & Tangorra, 2008).

In some cases, the DSS, MIS or EIS are not yet fully forgotten as central terms used in supporting decision making and are seen the central tools of decision support technologies even today. In the following illustration by Laudon and Laudon (2006), BI infrastructure is seen as separate component, along with analytical toolset, managerial users and decision support methods. This shows how data is first brought to be stored into the data warehousing of BI from different sources, then analysed using different analytical methods and reporting functions, followed by distributing the information through managerial processes and methods. After this, the data transformed into knowledge is returned through the system for the decision making, where it is provided for the user by using different technologies and methods including dashboards, reports scorecards and so on. This illustrates the data collection, technological methods and processes to turn data into actionable knowledge for decision making purposes.

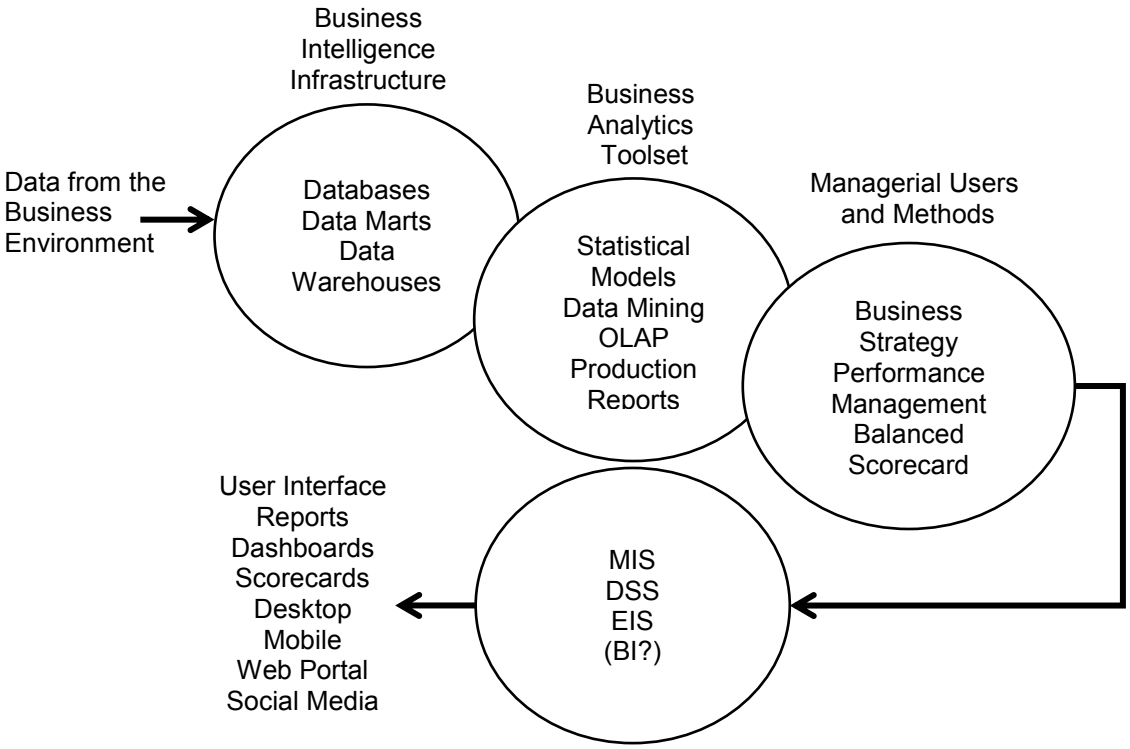


Figure 2. Business Intelligence and Analytics for Decision Support (Laudon & Laudon, 2006)

Even this model, illustrated in figure 2 has its problems, as it does not show the complexity of preparing the data including ETL-processes and other data preparation steps. Laudon and Laudon show BI solely as a data storing function, instead of a tool to turn data into accountable knowledge for decision making, from start (data storing) to the end (decision making, action). Also, it does not fully illustrate the integration of different decision support related aspects and features, such as data storing, decision process, technologies and decision support tools or how they are linked to each other. BI can be seen to have born after the development of data warehousing, personal computing, interactivity features, analytical methods, OLAP and so on and by the influence of preceding MIS- and DSS-research. BI as an entity has become more than solely a technology for storing data of this perspective. This illustration also shows the requirement for a clear categorization of different aspects related to BI, in order to study BI's relation to the whole decision making process of turning data into knowledge for decision making activities and what components are more central for BI. Coming to this day, the entire field describing decision support systems are referred to as BI (Davenport & Harris, 2007). This shows that BI is far more complicated, than maybe is sometimes understood, as it can be seen connecting the whole process from start to end including data-gathering, data preparation, decision process, to user provided visualization and methods in order to support decision making. BI is seen as a process, product or combination of these, as was noted from the earlier BI-definitions.

Different views about categorizing the central aspects about BI are available, however, a generalized categorization framework for different central components or aspects of BI does not seem exist. In order to study the area of BI, a well-founded categorization of typical BI-features and components will be required. BI can be seen consisting of different aspects or layers, most important components possibly being data warehousing, reporting, dashboards, interactivity and analytical features, which also makes BI to differentiate itself from previous DSS-, MIS- and EIS-systems as BI

includes more interactive and visualization features than the preceding DSS-, MIS- and EIS-type of systems. In the following, some viewpoints for categorising BI are introduced, in order to ain a view of how to recognize and categorize central aspects about BI.

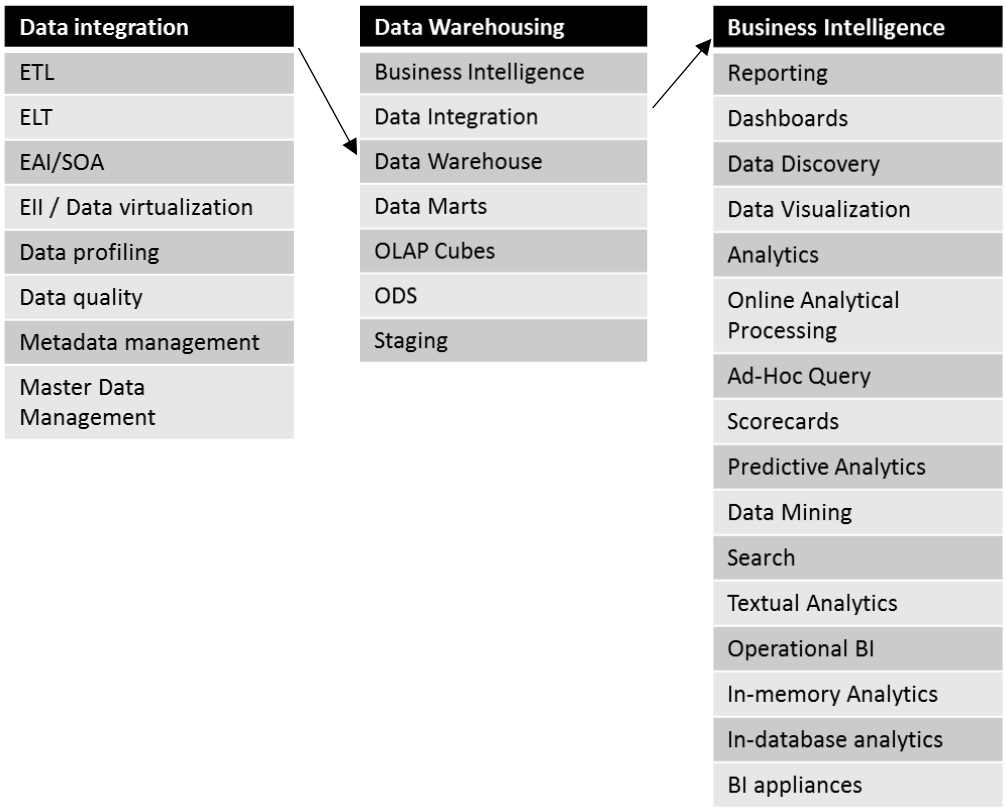


Figure 3. Categorizing BI-, DW- and DI-terminology (Sherman, 2014)

Above is a categorization view showing different aspects of a BI and their relationship and interaction between each other. Categorization seen in figure 3 divides BI into the following high level categories: Data Warehousing, Data Integration and Business Intelligence. From the figure it can be noted, that many of the categories inside high level categories are overlapping. In Sherman's view, data warehousing is divided into its own entity outside the BI, although it is physically often seen as a central aspect of a BI. Many categories are over-lapping and interacting with each other, which is in order to turn data into information and knowledge through an interactive process (Sherman, 2014).

In other cases, and from other viewpoints, BI is divided into aspects such as data warehousing, implementation, BI design and BI tools. Data warehousing is discussed as being one of six physical capability clusters of the entire IT-infrastructure, others being implementation, maintenance and best practices (strategy, design) (Rahman, Aldhaban & Akhter, 2013). From this, it can also be understood that BI can be considered to exist in the very centre of entire IT-infrastructure and the IS-spectrum.

Organizations, such as Gartner do a yearly analysis on the BI-industry's hype-cycles or in other words study of aspects, which are one rising or losing of interest. These purpose of this is to objectively compare different BI-vendors and their ability to support business decision making and analytics, looking through different aspects. Gartner describes it "*A Gartner Magic Quadrant is a culmination of research in a specific market, giving you a wide-angle view of the relative positions of the market's*

competitors." (Gartner, 2017). These are then reported in the Magic Quadrant for Business Intelligence on a yearly analysis report.

Gartner provides a categorization on BI-aspects, but the major challenge with utilizing Gartner's categorization, is that it is changed on yearly basis, based on studying how the BI-industry is changing yearly and how the hype-cycles are forming in the area. In following table 2 is introduced a categorization, that is extracted and consolidated from several years of analysis done on BI hype cycles in Gartner Magic Quadrant (Gartner, 2007-2016).

Table 2. Gartner categorization of BI-components

BI main-category	**BI sub-category**
Infrastructure	BI Platform Administration, cloud-based BI, Data Source Connectivity
Data Management	data storing, data warehouses, ETL, self-service data preparation, metadata management)
Sharing of Findings	collaboration, embedded analytics, publishing content
Information Delivery	reporting, dashboards, ad hoc query etc.
Analysis and Content Creation	Online Analytical Processing (OLAP), Predictive modeling and data mining, Interactive visualization, Search-based data discovery, Geospatial and location intelligence, Embedded Advanced Analytics, Analytic Dashboards, Interactive Visual Exploration, Mobile Exploration and Authoring, Scorecards, Prescriptive modeling, simulation and optimization
Integration	BI infrastructure, Metadata management, Development tools, collaboration, Workflow and collaboration

It can be noted, that the follow-up of different aspects utilizing consolidated categorization retrieved from Gartner's Magic Quadrant is challenging, mainly because the different BI-aspects are often moved between different main-level categories. Also, the categories are not possible to follow-up in order notice minor changes happening in BI, because also the main-level categories were noted to be changed on yearly basis by Gartner research. From this it can also be concluded that Gartner, although very popular source for BI-related analysis on the industry trends, has not provided a standardized categorization of the central aspects for BI. Gartner's categorizations are therefore not usable for studying the central aspects of BI. This highlights problem, of a basic categorization missing from the BI-industry and BI-research, which is required to study different aspects and the changes. In table 2, the categorizations consolidated from several years of Gartner Magic Quadrant for Business Intelligence will be used in later stage to form a categorisation used for later analysis in this thesis.

In order to study the central aspects and their formation through time, a new categorization will be needed. Combining these two categorizations however is possible and the terminology is used to search for primary studies later in the thesis. Different aspects can then be combined under these high-level categories. A categorization for BI synthesized from the different BI-categorizations introduced in this chapter, will be introduced later in the thesis.

2.6 Central Components of Current and for Future BI

In order to gain an overview of the BI-research area, the central aspects or layers of current, or modern BI will need to be described. The central components are needed in order to study the topics or areas that are common for BI and which aspects might have been changing in the area of BI-discipline. These are then collected for a hypothesis for this thesis. The industries having influenced the BI-industry and BI-research will also be reviewed.

When looking at the previously introduced definitions for BI, it can be noted that data warehousing along with strategic aspects have had a huge impact for Business Intelligence. Included in central aspects from the BI-definitions reviewed earlier could also be the integration features. The basic aspects for BI combined from different categorizations can be noted to be at least: data warehousing, data management, data integration, infrastructure, information delivery, analytics and content creation.

One view of the central components for a BI considered them to be OLAP, Advanced Analytics, dashboards, real-time BI and data warehouse technology (Ranjan, 2012). Another recent survey made trends provides one view of the typical aspects of a modern BI to be real-time analysis and graphical user interface (Watson, 2014). Another research which was conducted a search on news items using Google News with term “business intelligence” found the most common descriptive keywords for BI to be: automation, collaboration (collective BI) and ease of use (usability). The top features in the articles were about: detection, alerting and security (Roth, 2014.)

User aspects has always been an important research and development field for preceding DSS-research and it’s also stated to be an important design aspect for modern decision support systems development (Power, Burstein and Shrada, 2011). The role of user aspects for modern BI is unknown, as it was not brought out very often in the definitions or related research for BI.

The most recent Gartner research on BI buyer’s market shows, the current falling capabilities to be in in scorecards, predictive analytics and prescriptive analytics. The interest is increasing in geospatial and location intelligence, embedded advanced analytics, business user data mashup, embedded analytics and Big Data resources (Sallam, Tapadinhas, Parenteau, Yuen & Hostmann, 2014.) They also mention that the BI-market is in the middle of a big transformation and the growth and size of the BI-market is beating all forecasts.

As BI is involved in constant change, the future development might be challenging to predict. One source states, that self-service and distributions of self-service BI-tools to be one of the key elements to drive future success for businesses, making these aspects get more popular over time (Roger, 2016). Rogers also predicts the use of data in business provided from third party open source, internet of things (IoT), government and social media. Another source centralizes on the future and current state of BI provided by, which predicts, that for the coming years cloud and Software as a Service

(cloud BI), Web 2.0, collaborative BI, corporate performance management, predictive analytics, competitive analytics, external data processing and mobile BI to be the next most important trends for at least the small and medium sized companies' (Horakova & Skalska, 2013). From this it can be discussed the current central aspects for BI to be in the following topics:

data warehousing, dashboards, OLAP, advanced analytics, real-time features, strategic aspects, data integration, usability, collaboration, automation, alerting (reporting), advanced visualization features and security. For the future of BI, aspects such as open source, internet of things, self-service, mobile BI and cloud infrastructure are considered to be important. These also form a hypothesis for this thesi about central BI-aspects.

Looking at industries, a source reports the biggest industries utilizing BI-technology to be computers & technology, advertising / media, automotive industry, finance industry and healthcare (Watson, 2014). A review on news items using the search term "business intelligence" provided results, according to which finance, healthcare and retail industry were the most common industries utilizing BI-technology (Roth, 2014). The hypothesized industries where BI is implemented most frequently is predicted to be computer & technology, financial, retail, healthcare, media/advertising, automotive industry. These hypothesised aspects and industries will be researched later in the thesis.

3. Research Methodology

In this chapter, the research methodology and the research process is introduced. The chapter begins with defining the research method, followed by the describing of the review protocol used in the thesis.

In this thesis, the BI-research area will be investigated using systematic mapping process, together with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) -method to further select a set of primary studies for later analysis. The goal of the study is to show how the area of BI has evolved over time by studying trends as well components, which can be noted the central for the BI-context, as well as the industries involved and influencing the development of BI. The outcome of this should be able to provide answers on which aspects or components can be considered to be the most important for BI between different timeframes and a view on how BI has evolved in time, what are the major trends in the area, as well as the industries involved in influencing the development.

3.1 Research Questions

The research questions in this thesis is centralized around the goal of discovering different trends and major changes that can be observed in the area of BI and their development over time and the influence of different technologies, changes and industries. This will provide a clear view of how different trends and central aspects for BIs have formed and what are the central aspects of BI. It should also show different technological shifts have influenced the area of BIs development.

The research questions for this thesis are as follows:

RQ1: What can be considered the central components of BI, based on research literature?

RQ2: How has the area of BI evolved over time, based on research literature?

RQ3: How have technological innovations affected the development of BI?

RQ4: Which industries can be seen to have influenced BI?

The research questions are divided as following. The RQ1 is focused on gaining information on typical components of a BI and how the area of BI has evolved over time. RQ2 and RQ3 will focus on the trends and formation of trends in the area of BI. RQ4 will be focusing on different industries, which been influencing the BI-research.

3.2 Systematic Mapping Process

Systematic mapping is chosen for this thesis as the main research method. Systematic mapping method is chosen, because of its ability to study trends and ability to gain an overall view of a chosen research area. In order to answer the research questions, Systematic Mapping Study can be noted to be the most effective research method to study trends in the area of BI. The objective will be to study the trends and central components of BI, as well as how BI has evolved over time.

Systematic mapping or alternatively known as Scoping Study is a functional method for studying trends in a research area by a process of analysing existing research literature. This method has often been used in research areas where no large number of central primary studies exists (Kitchenham & Charters, 2007). Systematic Mapping study is sometimes considered to be a lightweight Systematic Literature Review (SLR), depending on the number of studies used for the process. The goal for systematic mapping study could be to gain an overview of the research area or to remove bias from gathered literature around a research area, or it can be used to research for gaps in the existing literature (Budgen, Turner, Brereton & Kitchenham, 2008). The steps to guide a mapping study is based on the process guideline by Kitcheman & Charters (2007).

The first step of the systematic mapping process is the planning stage, where the research questions are formulated and the review protocol is formed and evaluated. The goal of the planning step is to form the search strategy and the plan how the search process will be executed and implemented later in the process. The planning step will rule and influence how the rest of the systematic mapping process will be conducted and the importance of this step is vital for the robustness of the whole systematic mapping process, providing a well-documented research-process. The outcome should provide the research questions, the search strategy, the inclusion and exclusion criteria's. The process of gathering studies can be conducted on automatic searches, manual searches or by combining both search methods together, which Kitcheman and Charters recommend.

After the review protocol and planning has been formulated and evaluated, the second step is to identify the research area and continue the process to search for studies to be selected into the set of primary studies. During this step, a quality assessment of studies is to be done. The process is to collect the studies into previously generated data extraction forms using the inclusion and exclusion criteria. In this stage, the results are collected into a data extraction form, where keywording is done to determine the contribution of the publication based on keywords and abstracts.

In the third step, finally the data is extracted and synthetized to form results from the selected primary studies. The results are then reported and processed in order to provide answers to the set of pre-defined research questions.

3.3 Review Protocol

In this chapter, the process of conducting the systematic mapping process is described and evaluated. For conducting the selection of primary studies, PRISMA process will be used as part of the selection process. The process is based on the PRISMA Statement Flow Diagram (PRISMA Statement, 2009). PRISMA is defined as an iterative method for ensuring the quality of a systematic literature analysis. The PRISMA process starts with using search process from databases and by manual insertion from other sources. the remaining records are screened in more detail and the duplicates are removed. After this the full text articles are assessed for validity and the eligible ones are chosen to the qualitative and quantitative synthesis. PRISMA process can be considered as a more detailed examination method of a systematic mapping process, by including more qualitative studies and its goal is to ensure the quality of a systematic mapping process. In the following, the process adapted from systematic mapping process and PRISMA is used to gather the primary studies for this thesis. The PRISMA-method and the second phase of study-analysis is included in the process, because a more detailed assessment of the studies is needed, in order to study the different trends and notice the central BI-

aspects in a detailed level. The studies were further evaluated and categorized in more detailly during this phase.

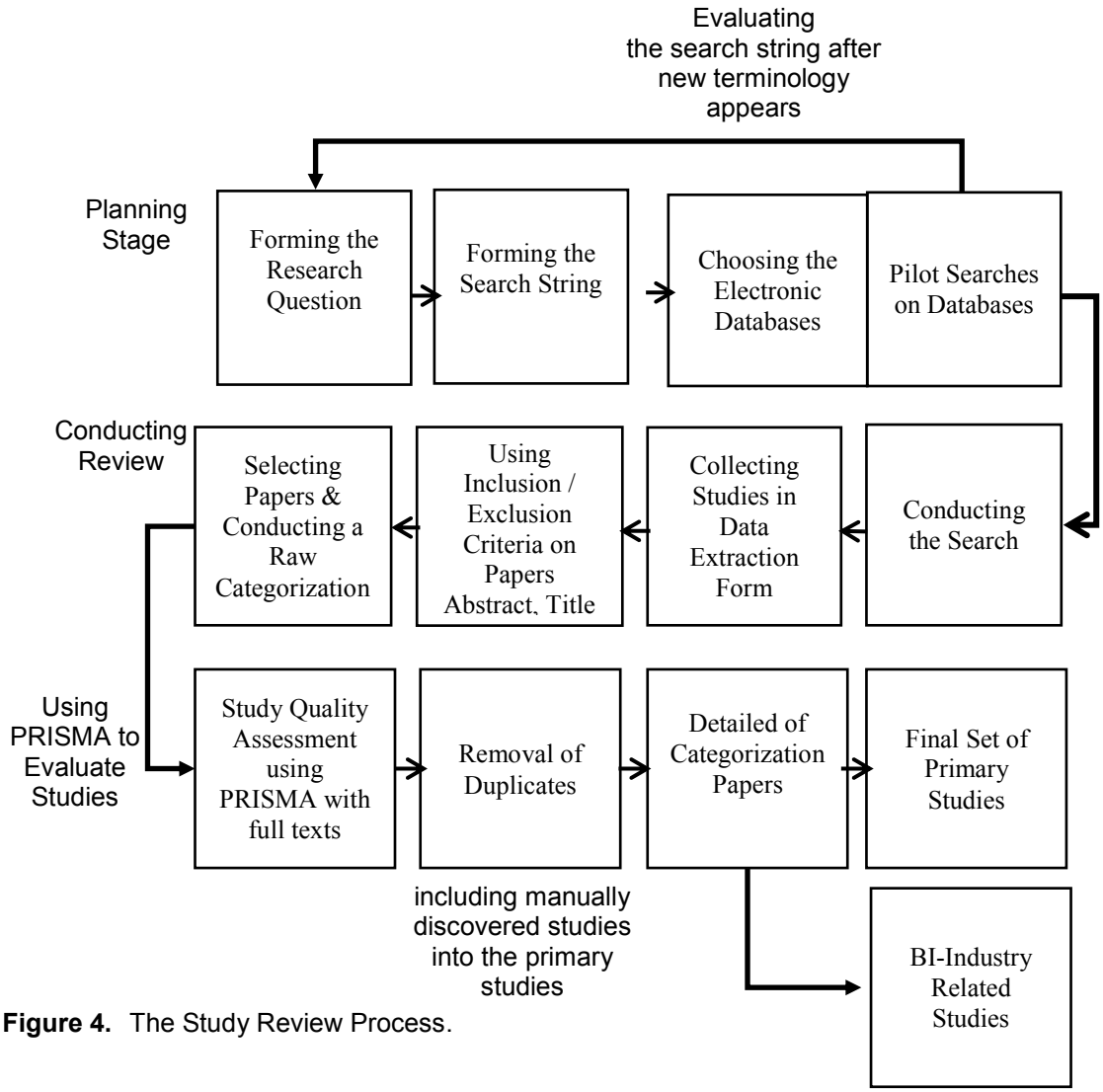


Figure 4. The Study Review Process.

The whole process used in this thesis is shown in figure 4. First, the planning stage of the mapping study is processed. In the beginning of the planning stage, the research questions are formalized. Next, the search string is generated and the academic databases are chosen to be used for the automatic search process. The inclusion and exclusion criteria is generated after this step. Next, a series of pilot searches are used to gain better knowledge of the area and test the chosen databases. During the pilot search, new terminology received is entered into the search string and the search is refined based on the testing and piloting searches.

After the planning stage, the search is conducted and the studies are collected into data extraction forms shown in appendix B. The studies are collected and evaluated using the inclusion and exclusion criteria is used into the title, abstract and keywords. Also, a raw categorization is done to the studies based on their contribution during the data collection phase.

Then the studies will be further evaluated based on PRISMA method, using full text to determine the contribution of the study. After the evaluation, duplicates are removed and the final set of studies are gathered. During this phase, more studies are excluded and more qualitative studies are included into the final set of primary studies. Also the manually discovered studies are injected into the primary studies. The detailed

categorization of papers is done and also the industry-specific papers are categorized in this phase.

The search string is generated using central terminology gathered from different sources related to BI-categorization and BI-terminology. Central terminology related to BI is gathered from several sources, such as a study by Sherman (2014) and also Gartner Magic Quadrant for Business Intelligence Platforms gathered from several years, which was shown in chapter 2.5. The terminology is gathered and separated using Boolean operators "AND" and "OR". Asterix (*), which is used to ignore conjugations in the terminology. The search string is the outcome of several iterations and the overall goal of the search string is to gain a view of the central aspects of BI, their relation to each other in number of studies, as well as to notice trends in the area of BI. The Finalized Search String formalized is:

"Business Intelligence" AND report OR alert* OR dashboard OR graph* OR visualization OR "real-time" OR "in-memory" OR "big data" OR spatial OR geospatial OR cloud OR "open source" OR "self-service" OR operational OR collaborative OR mobile OR collective OR security OR strategic OR tactic* OR automat* OR integration OR discovery OR mapping OR "data cleaning" OR decision model OR decision process OR decision making OR personalization OR usability OR user-int* OR localization OR user experience OR dynamic* OR social OR "internet of things" OR "IoT" OR prescriptive OR complex event processing OR data exploration OR "smart data discovery" OR agilit* OR offline OR embed* OR standard* OR democ**

The academic databases chosen to be used in the search were: ACM digital library, IEEE Xplore - IEEE/IEE Electronic Library, Scopus, ScienceDirect (Elsevier) and Springer. The search is mainly focused in research areas related to information processing sciences, information technology sciences, business sciences and management sciences. The results consisted of conference proceedings, journal articles and book chapters.

The inclusion and exclusion criteria for this thesis is formed with a goal to support in evaluating the quality and relevance of the research studies gathered. Before the formalization of the criteria, it was decided that the data analytics and data mining area to be excluded from the analysis. Reasons behind excluding analytics-related literature was, because during the pilot searching, it was found that studies which contained analytics related terminology often contained studies on data mining methods, analytical algorithms or analytical models, which were irrelevant to the overall results and also challenging to categorize based on their contribution or context. Also, prediction, forecasting, online analytical processing, online transactional processing and algorithms were left outside the literature review, as the study-context and contribution is mostly linked to describing the analytical methods. It was deemed a separate systematic mapping should be done on analytical methods and online analytical processing in order to study their relation to BI in more detail, but it would be resource and time consuming to include these into this thesis research. The inclusion and exclusion steps were used for the rest of the studies, resulted from the search. The main goal of the inclusion and exclusion is to discover studies mainly related to the BI-context and to remove studies,

which were unrelated to BI or the BI-research area. It is also decided, that limiting the timeframe for gathering studies is not required, as the central goal was to study the trends and evolution of BI and because also the beginning, or genesis of BI was of interest. In the following table 3, the inclusion and exclusion criteria for selecting the primary studies studying trends for this thesis is introduced:

Table 3. Inclusion, exclusion criteria for studying trends

Inclusion criteria	Exclusion criteria
Literature related primarily to Business Intelligence research area, technology closely associated to BI or has a research contribution to Business Intelligence research.	Literature not focused, or not associated to the subject area of BI, BI-related technologies or has no contribution to Business Intelligence research. Also excluded will be literature based on introducing data analytics, analytical methods, data mining, online analytical processes or mining algorithms.
Literature about Business Intelligence technology areas, except literature focusing on analytical methods data mining, or data mining algorithms.	Literature about analytical methods, data mining or data mining algorithms.
Literature published in scientific journals, conferences, workshops or in text books.	Summaries, book reviews, technical reports, secondary literature reviews (systematic mapping or systematic literature reviews), slide presentations, panel discussions or prefaces and patent documents.
Written in English language, abstract or full text available. If duplicates are found, the newest version is chosen.	Not written in English language. No abstract or full text available.

For industries studies, a separate inclusion and exclusion criteria was required. For the study set gathering industry related studies, the exclusion was different mainly in, that the analytics-related studies were included in the results, if the industry-area could be easily recognized from the article. The exclusion was a lighter version of the exclusion criteria for excluding trends literature, as it was considered that inclusion of all industry specific literature on BI would not affect the outcome or results. The studies were validated on inclusion and exclusion criteria described in the following table 4.

Table 4. Inclusion, exclusion criteria for studying industries

Inclusion criteria	Exclusion criteria
Literature focused to Business Intelligence or technology closely associated to BI or has a research contribution to Business Intelligence research.	Literature not focused, or not associated to the subject area of BI, BI-related technologies or has no contribution to Business Intelligence research.

Literature published in scientific journals, conferences, workshops or in text books	Summaries, book reviews, technical reports, secondary literature reviews (systematic mapping or systematic literature reviews), slide presentations, panel discussions or prefaces and patent documents.
Written in English language, abstract or full text available. If duplicates are found, the newest version is chosen.	Not written in English language.

After the formation of the inclusion and exclusion criteria's, a set of pilot searches are executed on different academic databases, to gain an overall view of the research area and in order to refine the search string and the search process for the different databases. The pilot searches are used to evaluate the planning stage for next step of conducting the search.

After the initial planning stage, the search is conducted using the previously chosen academic databases. The search string was used on abstract, title and introduction if possible, after during the pilot search the terms were noted to usually appear in either the introduction or abstract of the study. Search was then performed on academic databases. The search string needed to be modified for each electronic database. In most cases the search string was targeted to search mainly abstracts and keywords, as in pilot searches it was noted to provide with the most reliable results.

The results are gathered into data extraction forms, after initial review of the study. The studies are then reviewed and the quality is assessed using the inclusion and exclusion criteria and reviewed based on the title, abstract and keywords. During this, the studies are also categorized on high-level, based on the contribution and context of the study. Also, the industry-area is defined during this stage as a parallel process. After the raw-categorization, the process of collecting the first set of primary studies was finished.

After the initial process, the results were then evaluated in more detail, looking through the full text using the PRISMA method and removal of duplicates. The same inclusion and exclusion criteria was used for the more detailed scrutiny of the studies. Also, the industry was highlighted if it could be discovered from the full text into the industry-specific studies. During this stage, also the manually discovered studies were injected into the set of primary studies.

3.4 Conducting the Review

In this chapter, search conduct is gone through using the pre-defined process. In this chapter, also the results of the search process are shown. The main goal of this search process is to discover and find studies, in order to study trends which can be observed happening in the area of BI and also to notice the central components and the industries, which have been the most influential to the area of BI.

The search process is started with conducting the search on different academic databases. During the search process, the search string needed to be modified to fit the different academic databases search tools. As ACM only allows search from title, abstract or the whole article, the search was limited to only the abstract to provide a number of feasible results. This resulted in total of 314 papers gathered from ACM. For IEEE database, the search string was set on the first query area and business intelligence as the second query area. The search string was used to search the metadata of the database and provided with 880 results from the IEEE database. For ScienceDirect only

the abstracts and titles were searched to provide a feasible number of results. The search from ScienceDirect resulted in 310 results. For Springer, the search string was modified to only business intelligence after many test searches provided literature not related to BI-discipline, resulting in 428 studies. For Scopus database, the search string was searched from abstract resulting in 1756 results also being the largest set of results provided by the search.

Table 5. Initial first set of collected studies (initial set of studies).

Academic Journal	Conduct	1st set of studies
ACM digital library	Search using only "Business Intelligence" on entire articles	314
IEEE Xplore	Search used on abstracts	880
Scopus	Search used on abstracts	1756
Springer	Search using only "Business Intelligence" on entire articles	428
ScienceDirect	Search used on title, abstract and keywords	310
total		**3688**

Because of the limited resources for reviewing the studies, the search and review process was very time consuming. During the process, the results were categorized based on their contribution on a high-level. The studies were categorized based on their context between Data Warehousing and Data Preparation, BI infrastructure, Knowledge/information providing, BI Strategy, User aspects, Big Data and General BI-Research.

After the initial set of studies and inserting the manually discovered studies into the data set, the data was further analysed based on the full text, in order to further gain an idea of the contribution of the study and to further categorize them using the PRISMA. The detailed level categorization is shown in the results-section of this thesis. The same process was done for BI-industries related studies.

The first set of studies provided total of 3688 results. For industry-related studies the first set totalled in total of 2205 studies. After this, the removal of duplicates resulted in 2680 results and 1850 for industry-related set of studies. After the third step, reviewing the full text with a more scrutinized analysis provided with total of 2020 studies and 1414 studies for industry related studies providing the primary studies for further analysis. As can be noted, there exists a large number of studies related to BI and the research area is extensive, when looking at the number of studies discovered from the area.

Table 6. Set of collected studies after each phase

Phase	BI-trends	BI-industries
1st set of results (systematic mapping process, raw categorization)	3688	2205
2nd set of results (after the removal of duplicates)	2680	1850
3rd set of results (PRISMA process and inclusion, exclusion on full text)	2020	1414

The systematic mapping process was done in order to study trends and central components of BI through studying the literature which exists in the research area. Systematic mapping study was chosen because of its ability to study trends and provide an overall view of a research field. The systematic mapping process was combined together with PRISMA, in order to gain an extensive view of the overall results. PRISMA was used to further increase the quality of the systematic mapping, in order to provide more reliable results. The categorization of studies was done on two stages and was based on categorization, which needed to be conceived for this thesis. The final detail-level categorization, containing high-level and lower level categories is shown in the results.

The process was to first form the plan for the study process. At the beginning, the research questions were formed, after which the research protocol was introduced and evaluated. After the planning stage, the search was conducted based on the predefined review protocol on selected academic databases. The results, after the inclusion and exclusion stage and removal of duplicates and using more detailed analysis of full texts resulted in total of 2020 studies related to studying BI-trends and 1414 studies on BI-related industries.

4 Results

In this chapter, the results gathered from the systematic mapping study will be reviewed and analysed. First the categorization framework for BI-related literature is introduced, which was done after the initial gathering of primary studies. One of the results of this thesis is the category framework used for categorizing BI. The framework categorizing BI-related aspects was consolidated from other existing categorizations containing descriptions of aspects, technologies, terms and layers seen central for BI. The framework contains a high-level categorization and a low-level categorization, which is used to separate different components and aspects of BI.

In later stage, the different high-level aspects of BI are analysed based on this framework. Different aspects are then analysed together and separately. This should then provide an overview of how BI has evolved over time, what are the most central components of BI and how different aspects, technologies and industries have influenced the area of BI.

4.1 Categorization Framework

An extensive categorization made on different BI- aspects and -components is noted to be missing as was discussed in chapter 2.5. Gartner research provides a categorization for different aspects of BI, but does not seem to provide any standardized categorization of the different aspects. Gartner provides Gartner's Magic Quadrant for Business Intelligence, where the goal is to follow-up on different aspects of BI and their changes. This is in order to note which aspects are decreasing or gaining focus in the BI-industry. Looking at the Gartner analysis from different years, it can be noted that the categorization is changed between years, making it very challenging to follow changes between years, based on several years of Gartner's analysis on BI (Gartner, 2006-2016).

After it was noted necessary to have a clear and easily adaptable categorization of different components, technologies, layers, processes and other aspects which are central for BIs, a newly formed categorization was needed to be formed. During the data gathering phase, the literature is categorized into different BI-related categories, based on their included terminology and context. There are also several other existing categorizations describing BIs, but none of them seemed to be extensive enough to be used for the results of this thesis. The categorization formed was influenced by many existing categorizations of BI-aspects, including the Business Intelligence Stack (Evelson, 2015) and Maturity Model for Business Intelligence (Ioana, 2008) as well as BI technical architecture categories (Sherman, 2014) and the categorization consolidated in table 2 based on Gartner Magic Quadrant for Business Intelligence (Gartner, 2006-2016).

Table 7. Categorizing Framework for BI

High-level Categorization	Low-level Categorization	Description
Data Warehousing and Data Preparation	Ad Hoc Querying, Data Architecture, Data cleansing, Data quality, Data integration, Data management, Data virtualization, DWH Design, ETL design, In Memory DWH, Query Optimization	Data-related category for data storage, data management and data manipulation
BI infrastructure	Automation, cloud based BI, collaborative/ collective BI, Data Architecture, mobile BI, open source BI, real-time BI, self-service BI, strategic BI, tactical BI, operational BI	BI-architecture layer "enabling" the system to function also containing infrastructure features for increasing the support of decision making activities
Knowledge/information Providing	BI dashboard, Balanced Scorecard, Geospatial BI(GIS), Reporting and Monitoring, Visualization Methods	Providing methods to provide or present the information or knowledge to the user
BI Strategy	adaptive BI, BI design, BI strategy, implementation, open source BI, pervasive BI, standardization, success factors, vendor selection	Strategic aspects of a BI, including different factors implementing or designing a BI
User aspects	Cognitive Aspects, Decision Process & Decision Support, Localization, Personalization, Security/ Privacy, UI design, User Aspects, User Behavior, User Groups, User Interaction & Usability, User Training	User aspects of related to BI, including decision process, cognitive aspects, usability and user interaction design
Big Data	Big Data Research, Big Data Architecture, Big Data Implementation/Application, Big Data Strategy, Big Data Architecture, Internet of Things	Big Data analytics and Internet of Things related to BI-context
General BI-Research	General research on BI	Literature containing general research on BI or literature which only goal is only to describe or define BI

The categorizations were divided into seven high-level categories, which include lower-level categories consisting of different aspects which are related to the high-level categorization. The BI-categories contain the gathering of all components, technologies, terminology and different BI-aspects, that can be logically combined into a descriptive categorization of different aspects for a BI.

The BI high level categories were based on these classifications:

BI-infrastructure includes studies on **t**echnologies and parts of the system, which are needed to run and operate the BI, including legacy and cloud based BIs. Also different BI-infrastructures designed for different aspects of organizational needs (tactical, operational and strategic BI).

Big Data contains studies Big Data related aspects and research as well as literature on IoT. This category was formed to study the newly appearing aspects of Big Data.

Data Warehousing and Data Preparation contained studies related on storing, manipulating, cleansing or structuring data into usable form for decision making or later analytical purposes. Also data quality related issues are included in this layer.

General BI & Research, which contains generalizing and BI-describing research that cannot be categorized into other layers. This category was used as category to BI-related generalized studies.

Knowledge/information providing contains studies providing the user with the processed or unprocessed information or data, such as visualization methods, reporting, dashboards etc. This is used to provide the knowledge or information for the user through different methods included in BI.

BI-strategy contains studies on BI-strategies, success models, maturity models and BI-design methods. Also BI-implementation and BI-design related studies are included in this category.

User Aspects contains studies on usability, user experience, user interface design and decision making activities. This also includes decision processes, which are related to the decision-making process of regarding the user's role in utilizing BI to form decisions.

The industries were also combined in its own categorization, shown in Appendix A. The industry-areas were gathered as a secondary object, while executing the search for primary studies. The different industries were needed to be grouped and during the discovery, some industries needed to be combined, such as banking, financing and accounting industry. The public sector was combined to contain all government related BI-studies.

The goal for the rest of the chapter is to analyse and show the results based on the gathered primary studies. The results show different BI-related aspects, their relation to each other and how they are represented in the historical timeframe of BI. Studies categorized in General Research on BI will be left outside of this analysis. In the next phase, a validation analysis on the primary studies results and a comparative search is shown.

4.2 Validation Analysis

In this chapter, the number of gathered primary studies are compared to those from a comparative search conducted on Scopus database using the term "Business Intelligence" to abstract, title and keywords for literature published between years 1994-2016. The results are then compared to those gathered into the primary studies. The goal was to validate the collected primary studies against a separate search conducted using a reliable academic database results. In figure 5, the outcome of the results for the Scopus search is shown and the results of the primary studies collected for this thesis are shown

in figure 6. Scopus was chosen because in previous search process and pilot searches it was considered to provide with the most reliable and relevant results when discovering BI-related literature using different terminology. Also the different types of publication types discovered will be analysed, collected from the set of primary studies.

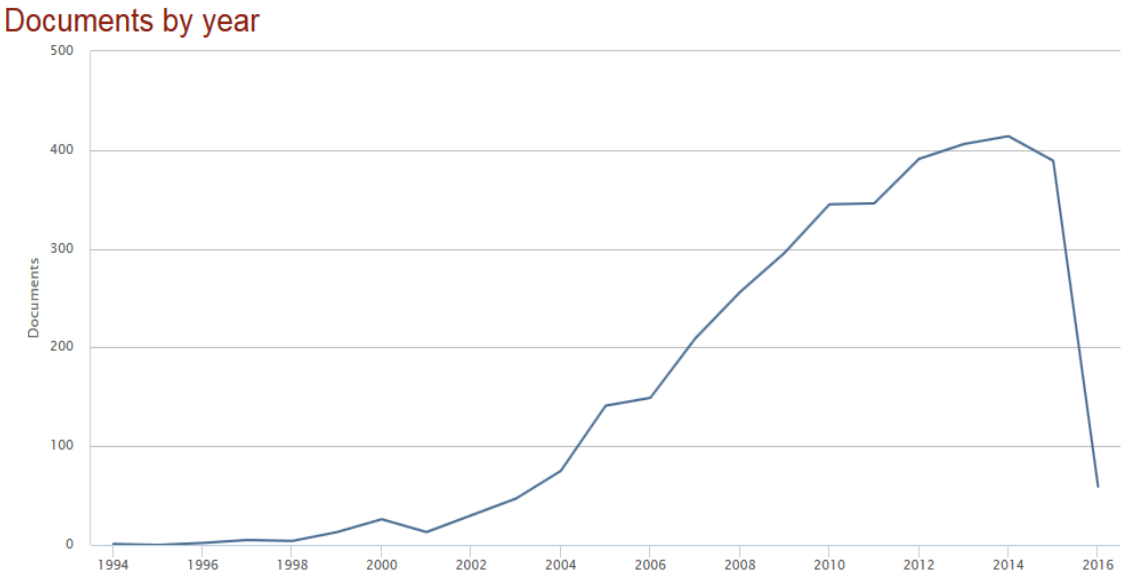


Figure 5. Result for total number of studies from Scopus search

In the following figure 6, the results from Scopus the final set of primary studies are shown in a similar fashion. The timeframe for observing the results was chosen to be the same for both sources.

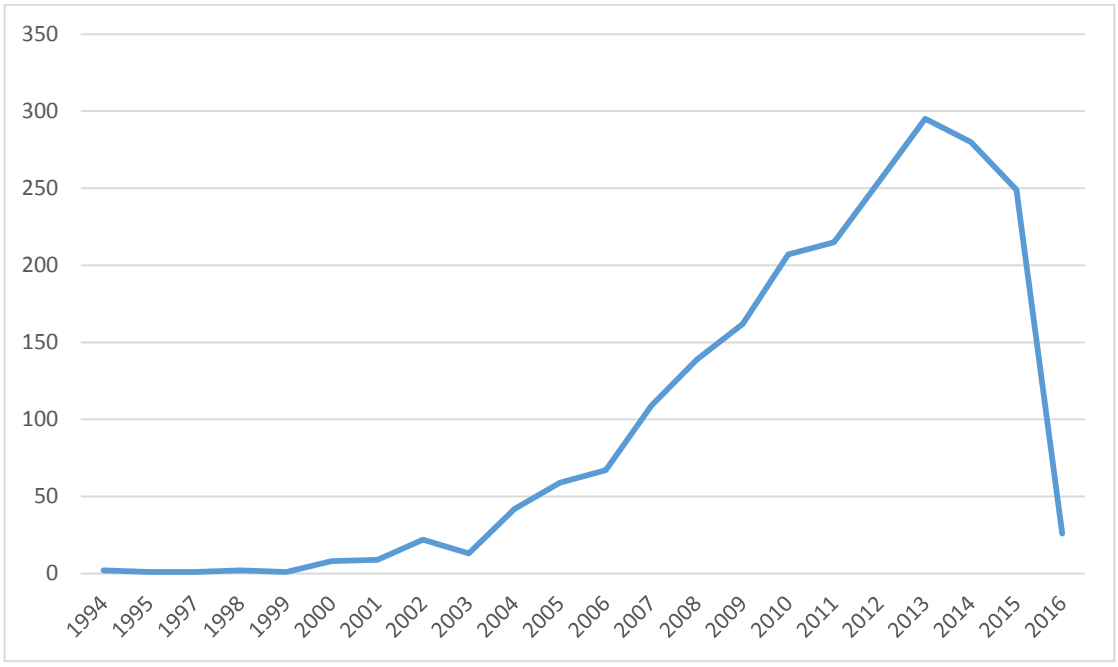


Figure 6. Result for total number of collected primary studies from data extraction.

Comparing to results of the evaluation search against the primary studies of this thesis, shows the overall number and peaking trend in literature numbers to resemble each other. Both results show to be peaking around the same time-period during 2013–2014. Based on the results, the area of Business Intelligence has quickly gained momentum

during the time period starting from 2006 and gaining its peak during the years 2013 and 2014. The overall number of Business Intelligence related literature has clearly been fading slightly for the past two years, although the illustrations doesn't show all of the literature collected from the year 2016, as the search was executed and finished before the end of the year.

From comparing these results, it can be seen that, they are comparable to each other. This also indicates that the results collected for primary studies are valid for investigating the trends in the area of BI.

Next, looking at the different publication types collected from the primary studies, in order to gain an overview of what kind of publication types are popular in the BI-research area. The results are divided between journal articles, conference papers, book chapters and short surveys.

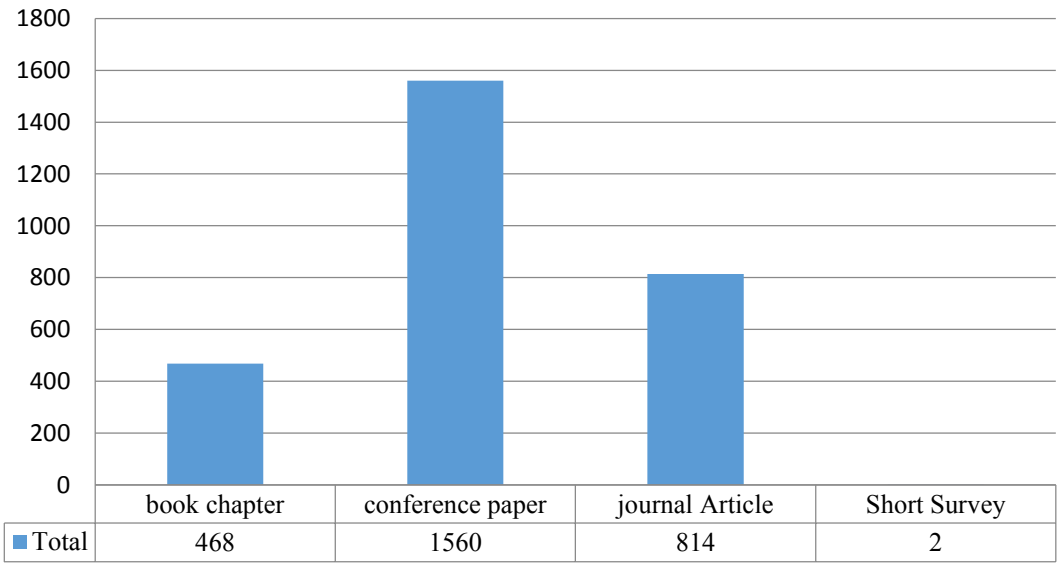


Figure 7. Publication types by number of studies

As shown in figure 7, most of the studies collected in final set of primary studies are published in conference papers, second being journal articles and third book chapters and short surveys. The huge most number of publications in conference papers shows the scientific nature of the research area, possibly influenced by different industries and other research areas reflecting BI.

4.3 Research of Primary Studies Using High-level Categories

Next the high-level categories are analysed and their relation to each other and to the average year of publication of the studies. The illustration will show how different high-level BI-categories are represented regarding the number of studies and the year of publish.

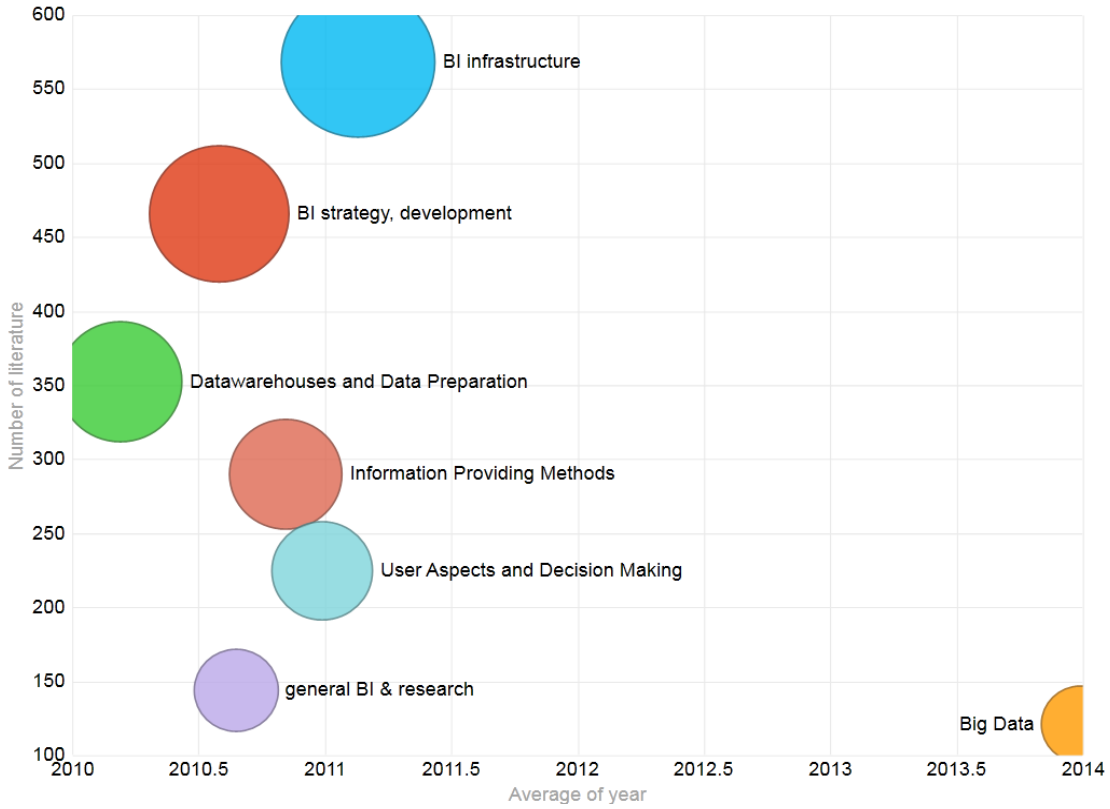


Figure 8. High level BI-categories and number of literature and average publish year.

As can be seen from the chart illustrating the relation of different high-level categories, based on the number of studies between time frames in figure 8, it shows trends are not easily recognizable when looking at the number of studies between the high-level categories. An observation, that can be noticed from the illustrations, is that Big Data seems to have gained interest much later than the other high-level aspects observed in the research area. The other areas seem to be concentrated on approximately the same time-period. From this it can be interpreted, that the Big Data research is currently heavily influencing a change in the Business Intelligence discipline. The other aspects seem to be centralized approximately between the years 2010 and 2012.

Looking at the different categories more closely, it can be noticed from figure 8 that the largest categories for BI looking from high-level are BI-infrastructure and BI-strategy and data warehousing. These categories contain the largest number of primary studies. These high-level categories are therefore considered very influential and important for BI-research.

The different high-level topics shown in figure 8 will next be later analysed in more detail. The high-level categories consist of different aspects, which are also shown in table 7. The goal is to notice differences between aspects inside the high-level categorizations and their maturation and development over time. Next looking more detailly into each high-level category of BI and the lower level categories inside. Each category is analysed separately, except for the general research studies on BI, which will be left outside of the analysis.

4.4 Big Data Category

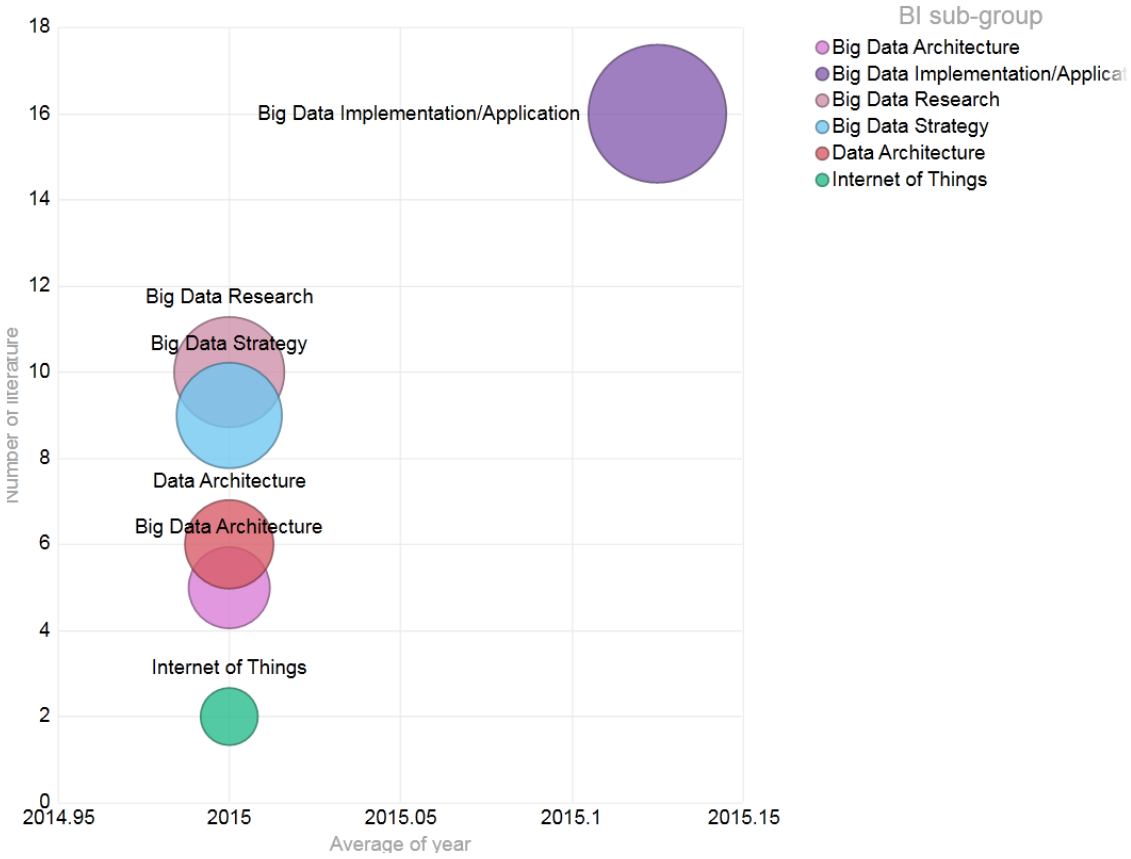


Figure 9. Big Data category and number of studies related to publish year.

Looking closely into the Big Data category, the category consists of different aspects, which are interest for Big Data research in Business Intelligence context. These are divided into general Big Data research, Big Data strategy, Big Data architecture, Big Data implementation/Application, Data Architecture and Internet of Things.

The research in this area is still fairly new or novel, or only a few years old. As noted before, it is recognized to have appeared later from other main BI-categories. For this category, only studies with their main contribution in the Big Data research and a relation to Business Intelligence research were included.

Looking at the results from figure 9, the research seems to be weighted closely to year 2015. Most of the current research is done under Big Data Implementation/Application. Rest of the research is done under general research, strategy, architecture, data architecture and internet of things and seem to be fairly evenly distributed between the lower level categories. The results show that the area of Big Data seems to be starting to formalize as a research area and it can be seen of the implementation/application studies, that Big Data is currently being studied how to implement it into legacy

Business Intelligence solutions. Internet of Things related BI-research is still fairly low in research literature numbers and does not seem to be of big interest for current research in the BI-discipline for Big Data. Big Data is noted to be a heavy influenced for current BI-research and industry.

4.5 Data Warehousing and Data Preparation

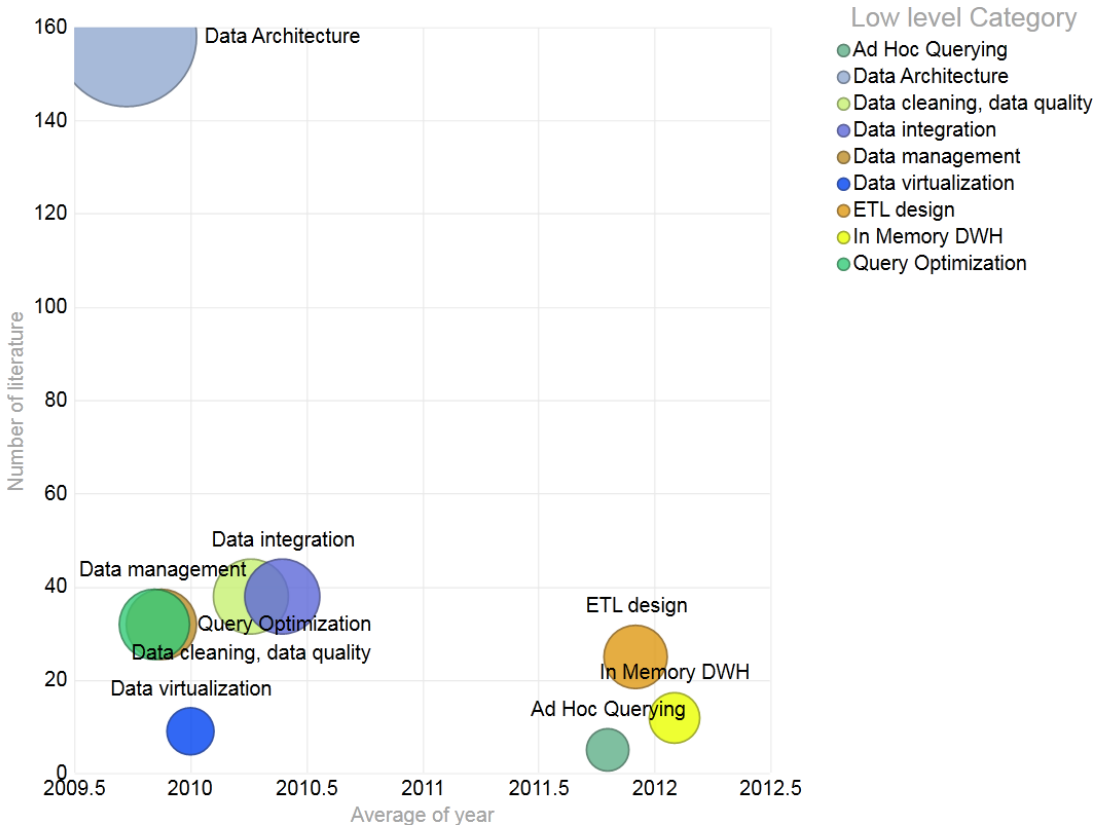


Figure 10. Data Warehousing and Data Preparation and number of studies related to publish year.

Data warehousing and data-preparation category consists of all aspects, which are related to data storing, data preparation, ETL, data cleansing, data quality or other aspects before the data is turned into information or knowledge.

Looking at the figure 10, which contains data warehouse and data providing category aspects, it can be noticed that the biggest influencers in this category are Data architecture, data integration, data cleansing or data quality, data management and query optimization. Behind them are ETL-design and data management. Newly formed areas for data warehouses are ad hoc querying, in-memory DWH. ETL design, another important aspect for BI has evolved fairly recently, averaging during year 2012.

Most of the research for data warehousing and data preparation category happened before the main peak for other BI-related studies, seen in figure 6. For data warehousing the interest seems to have peaked between years 2009 and 2011. Newly formed interest areas for this category are about in-memory queries, ETL-design and ad hoc querying, which seem to have appeared a bit later. The category seems to have lost some of major interest in BI-research area coming towards year 2016, which is clearly noticeable from the low number of literature from 2012 onwards.

4.6 Information Providing

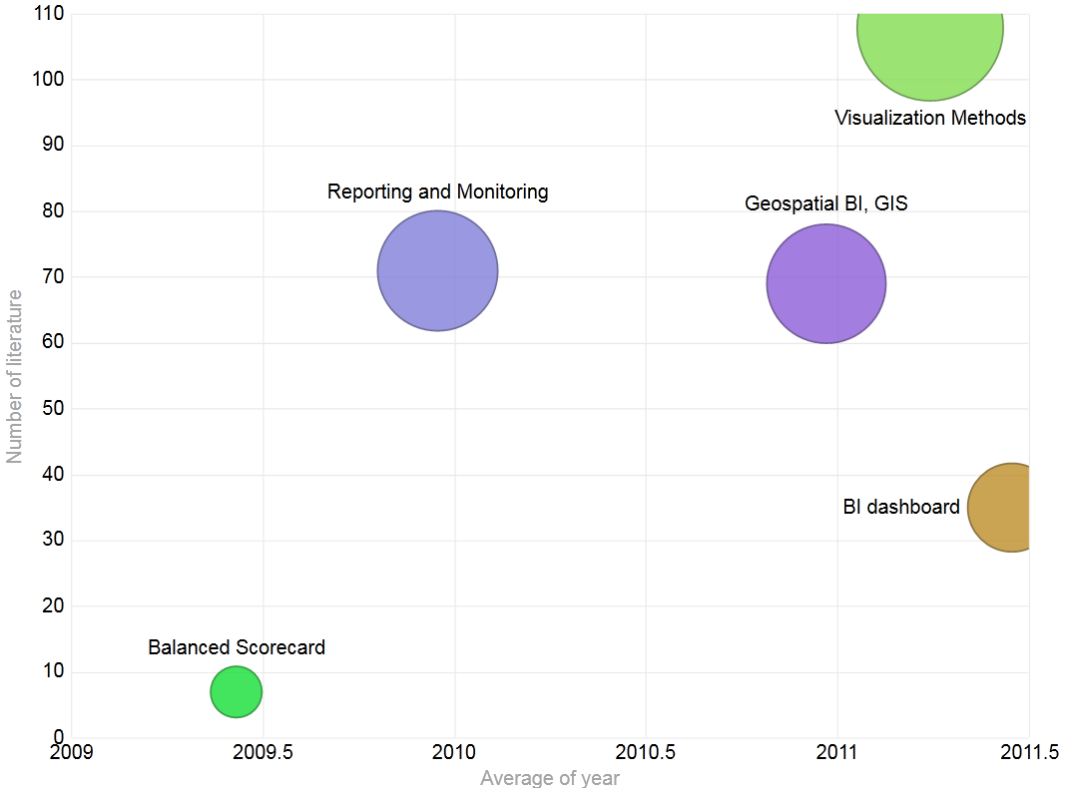


Figure 11. Information Providing and number of studies related to publish year.

The information providing category consists of different aspects that are central for providing the data turned information to the user and support decision making activity using different system-provided methods. The number of studies seem to be peaking during years 2010 and 2011, which is around the same time when all included studies related to BI have peaked.

From the above figure 11, it can be noted the visualization methods being the most common topic in this category. After that reporting, geospatial BI and BI-dashboards, lowest being balanced scorecard. Interestingly, the studies about dashboard design/utilization is the most recent research area, along with visualization methods and geospatial features. Reporting and balanced scorecards, although important for BI are fading and have been influential only during the earlier stages of BI development. Lowest area counting from all sub-categories seems to be balanced scorecards containing the lowest number of studies. From this group, geospatial features along with visualization have become the most popular. Coming to this day, the knowledge providing category does not seem to be of big interest for current time period, looking at the number of studies.

4.7 BI-infrastructure

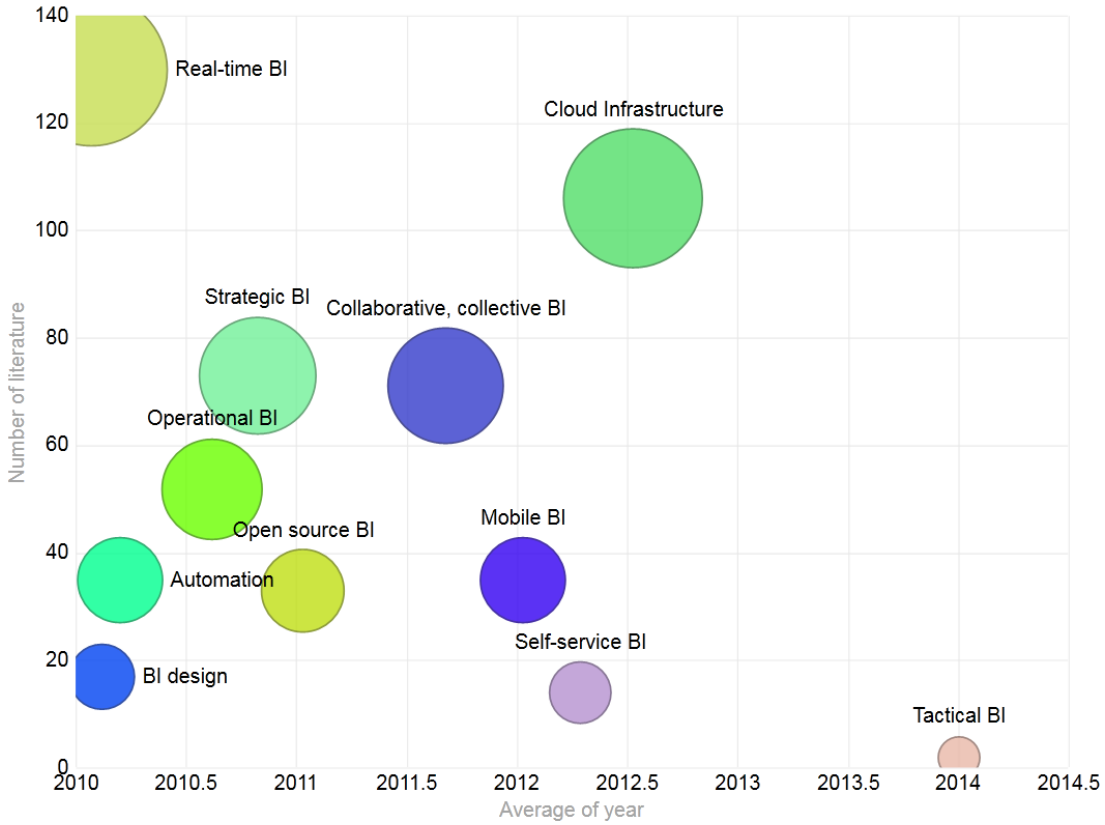


Figure 12. BI-Infrastructure and number of studies related to publish year.

BI-infrastructure category consists of technologies on which the BI is founded on or general functionality related aspects, such as collaboration, real-time, self-service or mobility features. Also included is BI designed for different organizational levels (operational, strategic and tactical). BI-infrastructure category peaked during the years in which interest in BI-based systems research was at its highest, during 2010–2013.

For BI-infrastructure, it can be seen from figure 12 that it is widely distributed between different lower level categories. What can be noted is, that the biggest interest areas are related to real-time BI, cloud based BI, collaborative BI system and strategic BI. Recently the interest has been in mobile BI, tactical BI, cloud based infrastructure and mobility features. It can be noticed how small the amount of self-service based BI is in relation to other topics. Also open source based systems seem to be fairly low in interest for BIs research in this category.

Automation for BI seems to have appeared fairly early and one would imagine this area to be more interest for current research. It shows there was a requirement to automatize BI in an early stage. Also operational BI can be noted to be of fairly big in interest, as well as strategic BI-aspects. BI can be considered to be solely strategic information system, so it's interesting to note that BI utilization is gaining more interest for operational purposes. Tactical BI however is not gaining recognizable interest. Also collaborative functionalities seem to be fairly important in the area of BI. The infrastructure aspects seem to have gained some interest coming to recent times, although this area also is centralized to earlier years. What can be noted here, is the relatively low number of self-service related studies. Cloud based infrastructure seems to have become of major interest, as a new infrastructure technology for BI.

4.8 BI-strategy

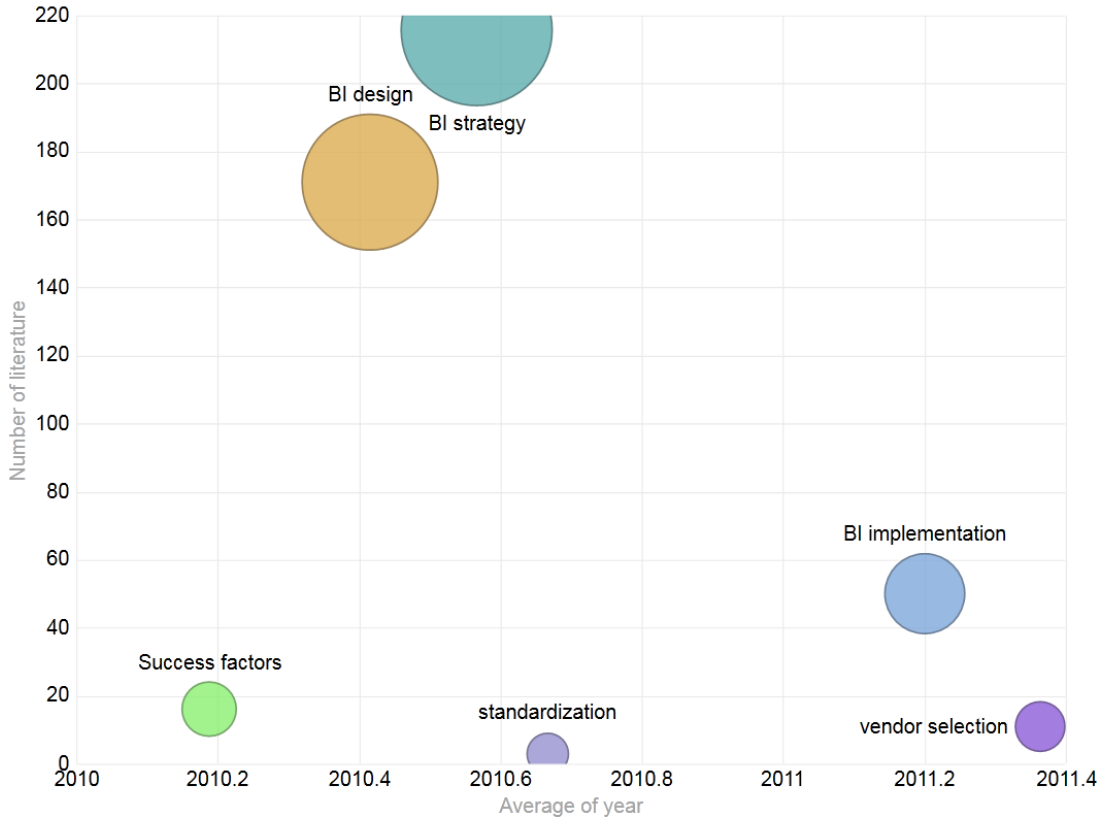


Figure 13. BI strategy category and number of studies related to publish year.

The BI-strategy category is consisted of studies related to aspects on different strategies to implement, design or develop a BI for organizational use, as well as formulation of a strategy for implementing the system to part of the organizational processes. It also consists of aspects on making BI increase its value for organizations and ensure its success factors.

From the strategy topics seen in figure 13, it can be noticed that strategy and design are the most common areas for interest. Third being implementation. The strategic aspects category is focused and has peaked between years 2010–2011, looking at the average weighting of studies in figure 13.

Overall the area is fairly scattered among smaller topics, but the key aspects on strategic issues can be noted to be differentiated from others. Aspects such as general strategy, BI design and implementation rise above others as the most popular topics in this area.

From the results, it can also be noticed, that standardization from these aspects has fairly low interest. The lack of standardization is sometimes seen as a problem for the BI, as standardization often ensures quality, efficiency and cost-effectiveness of implementing an information system. The cause may be, because the area has formed through evolution and influence of technological innovation. The large number of BI-design aspects seem to show, that the area is under constant development through evolution. Topics in this area have been of interest in BI during the whole observed timeframe of BI.

4.9 User Aspects

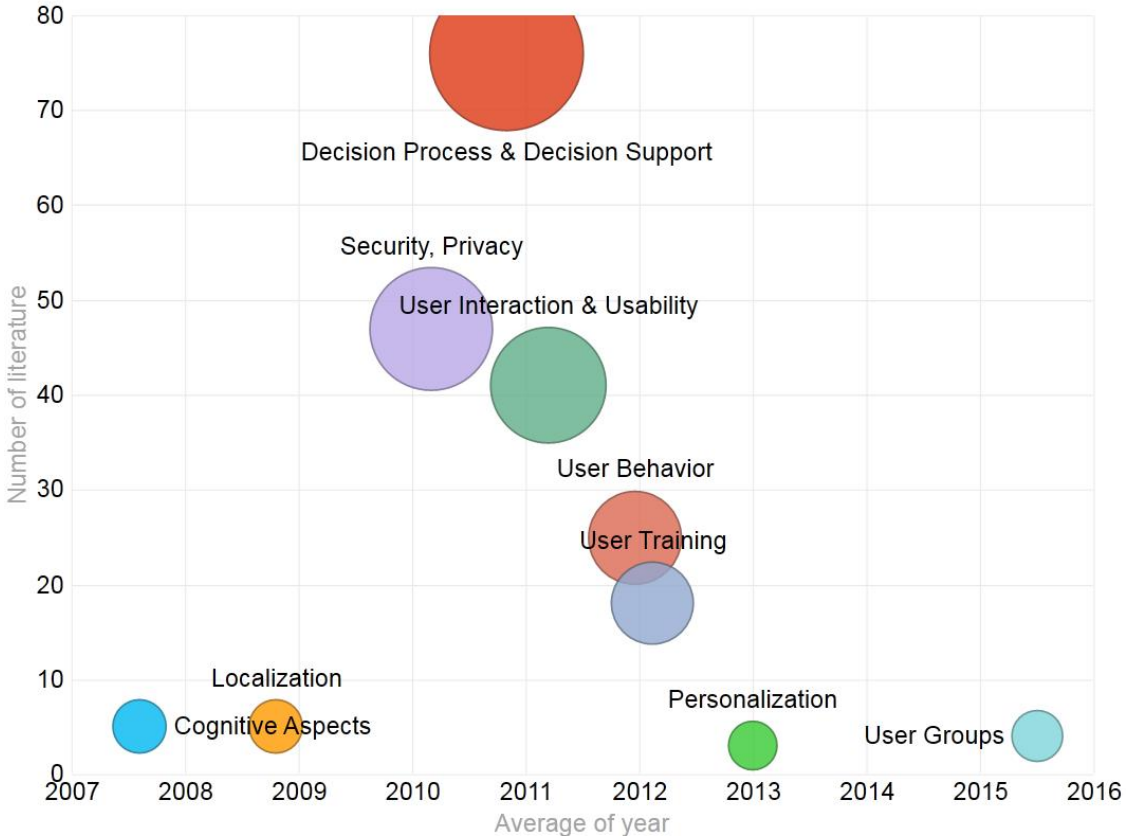


Figure 14. User Aspects and number of studies related to publish year.

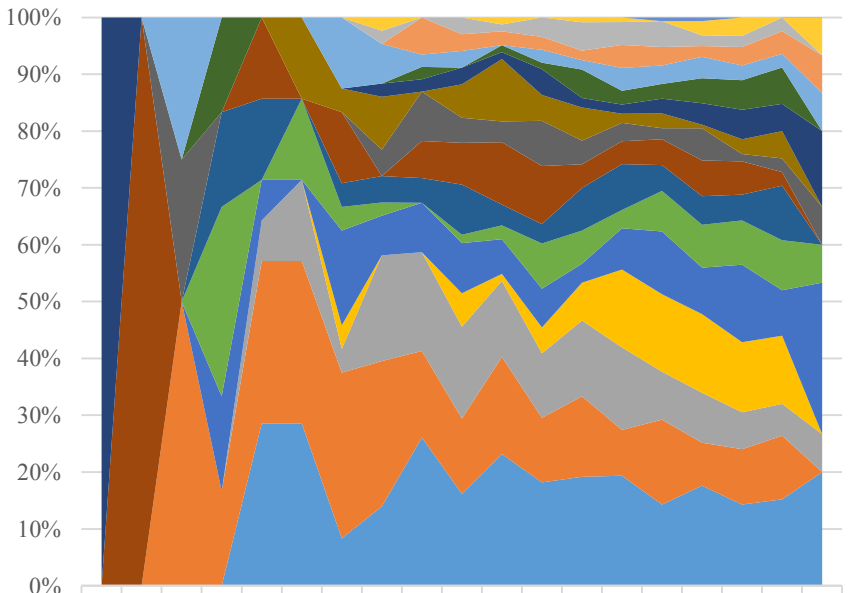
User aspects consists of all user-related aspects of a BI including usability, user interface design, personalization, ethical aspects, privacy, decision supporting models and so on. The user aspects in this category are peaked around years 2000 and 2005, as seen from figure 14.

As the mapping in figure 14 for this area shows, the biggest lower level groups are related to decision process, decision supporting, security and privacy, user interaction, user interaction, user behaviour and, user training and user interface design.

Most of the interest for user aspects seem to be on the decision process and decision support, where a lot is influenced by the preceding DSS-research. Also, security, usability and user training are some major interest on user aspects. Lower level of interest seems to be in localization, personalization, cognitive aspects or user groups of BI. This area is gaining more interest coming to current year.

4.10 Hypothesized Aspects in BI-literature

The areas and aspects which were introduced in hypothesis in chapter 2.6 as central current and future aspects for BI to be: data warehousing, dashboards, real-time features, strategic aspects, data integration, usability, collaboration, automation, alerting (reporting), advanced visualization features and security. For the future of BI, aspects such as open source, internet of things, self-service, mobile BI and cloud infrastructure are considered to be important.



	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
internet of things															1	1			
Self-service BI								1			1		1	1		4	5		1
open source BI								1		2	1	3	6	5	7	3	3	3	
BI dashboard									3	2	2	2	2	5	5	3	5	5	1
Data integration			1				3	3	1	2		2	2	5	5	6	4	3	1
Mobile BI				1					1		1	1	6	3	4	7	8	8	
User Interaction & Usability	2							1	1	2	1	4	2	2	4	6	8	6	2
Automation						1	1	4		4	9	4	7	2	4	1	4	6	
Security, Privacy			1					2	4	3	3	7	5	4	3	9	2	3	1
Reporting and Monitoring		1			2		3		3	5	9	9	5	5	7	10	9	3	
Strategic BI				1	2		1	2	2	6	3	3	9	10	7	8	7	12	
collaborative, collective BI				2		1	1	1		1	2	7	7	4	11	12	12	11	1
Visualization Methods				1	1		4	3	4	6	5	6	4	9	17	13	21	10	4
Cloud Infrastructure							1			4	1	4	8	17	21	22	19	15	
Real-time BI					1	1	1	8	8	11	11	10	16	18	13	14	10	7	1
Data Architecture			2	1	4	2	7	11	7	9	14	10	17	10	23	12	15	14	
BI strategy					4	2	2	6	12	11	19	16	23	24	22	28	22	19	3

Figure 15. Hypothesized BI-categories and number of studies (1994–2016).

In figure 15, the hypothesized current and future central topics discussed in chapter. They are collected an illustration containing studies published between years 1994–2016. The objective of this illustration is to show the hypothesized central aspects and possible future aspects for BI. As can be seen from the illustration, strategic aspects, data warehousing (data architecture), real-time BI, cloud infrastructure and visualization are noted as the top aspects of these hypothesized aspects looking at overall number of studies.

From the illustration, it can be noted, that current popular topics, which contain more number of studies in relation to others and were considered as rising topics. These aspects were: strategic aspects, data architecture, cloud infrastructure, visualization. The other minor rising aspects for BI are analysed to be in self-service, collaboration, dashboards, user interaction and mobile BI.

From the hypothesis, it can be noted that during this five-year period, features such as strategic aspects, data warehousing, real-time BI, visualization, automation and user aspects have been fairly evenly distributed on the observed timeframe, which means they can be considered fairly grounded features for BI. From the hypothesized aspects decreasing in interest seem to be aspects such as cloud infrastructure, real-time features. Areas such as internet of things, data integration, BI dashboards and mobility were still fairly low in overall number in study results. Topics including self-service BI, Internet of Things, open source BI, data integration and automation are still low in the number of results, but can be considered to gain more momentum for research interest in the future.

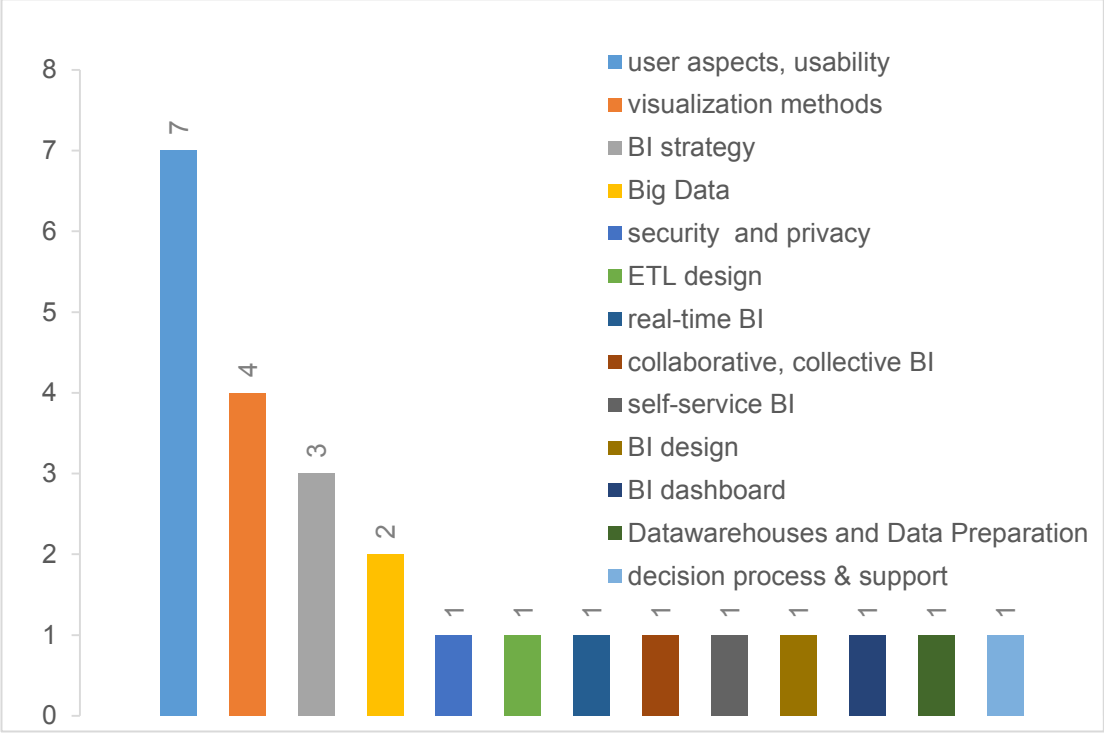


Figure 16. Studies published during the year 2016 and topic

Analysing the studies which were published only during year 2016 in figure 16 it can be noticed the most popular topics for this year to be in user aspects. After this, visualization, strategic aspects and Big Data which is noted as one of the top topics for literature published during 2016. From the hypothesized topics user aspects, visualization self-service, real-time BI, collaborative functions and are present for 2016.

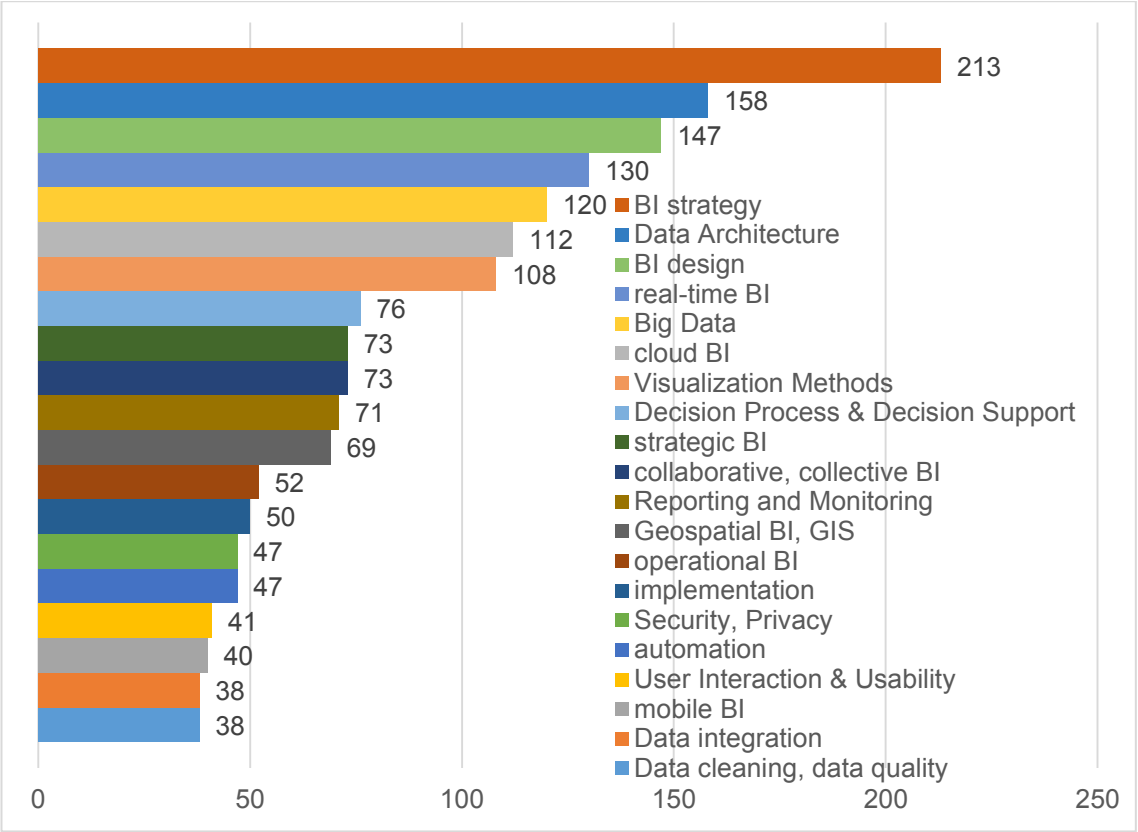


Figure 17. Top-20 aspects of a BI 1994–2016

From figure 17, looking more detailly into top-20 aspects collected from the entire gathered set of primary studies it can be seen that strategic aspects, data architecture, BI design, real-time features, Big Data, cloud infrastructure, visualization methods, decision process were some of the most common aspects for BI-research. Surprisingly, some new aspects such as cloud infrastructure and mobile BI are presented in the top-20 aspects, which seems to indicate how important they have become for the development of modern BI. Self-service aspects, although they can be considered important, are not present in these gathered the top features for BI. From the results, it can also be noted, that surprisingly little focus has been placed on reporting functionalities, self-service BI and automation, although these topics can be considered as very general features and important assets for modern BI's. From these, reporting functionalities can be noticed to be decreasing, while mobile BI is just starting to gain some interest as can be seen from figure 15.

Looking at figure 17, where all aspects in BI sub-categories are included. The top-20 collected aspects show, that they seem to be fairly similar to those introduced in the hypothesized topics, that are presented in figure 14. The top topics on BI, seem to reflect the importance of data warehousing and data preparation, strategic aspects of BI, BI-design aspects and real-time functionalities for BI. Also Big Data is seen as surprisingly large topic in the overall results, which shows how much promise it can be seen to have for BI-development.

Looking at the different aspects from lower level-level, it can be concluded that the central aspects for BI regardless of time are data related aspects in data warehousing, strategic aspects and design aspects. Other aspects such as real-time BI, cloud infrastructure, visualization features, collaborative features, decision support, reporting were some of the other central topics for BI. Other hypothesised aspects such as open

source, internet of things and BI-dashboards were not of interest currently and have not gained momentum yet to be of interest for the future. Other topics, such as Big Data were surprisingly noticeable presented in the overall top-20 results, while aspects such as dashboards were not included and the topics about data integration were rather low. Next the trends are observed more closely looking at shifts happening in the area of BI through collected primary studies.

4.11 Trends in the Area of BI

The trends in the area should be observable through analysing the number collected primary studies between different aspects. This should also provide answers to research questions RQ1 and RQ2.

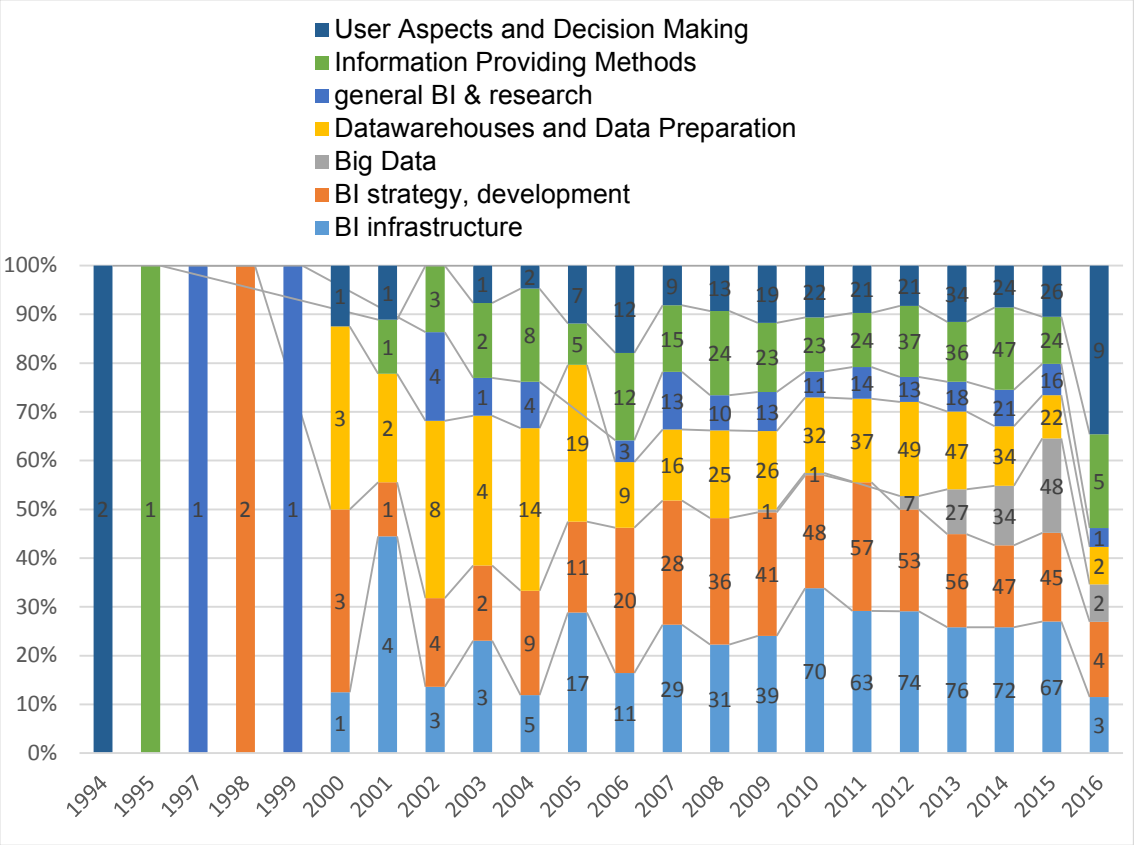


Figure 18. High-level BI-categories and number of studies between publishing years (1994–2016).

During the years 1994–2002 it can be noted, that the most of the topics during this period were based on strategic and data –based research, while all the areas were presented except for Big Data research. During this time, the overall number of studies was still fairly low. In period 2002–2005, the biggest interest for research was in data warehousing and data preparation as well as information providing and infrastructure and BI-strategy aspects. 2005–2010 the interests were rather evenly based between the layers. Strategic aspects being the major area for interest. During this time, also the user aspects started to gain interest in the BI-research area. 2010–2015 the different topic areas were more evenly distributed. The biggest influencers were in BI-infrastructure and BI-strategy and development. Rest of the topic areas were rather evenly based. During this time, approximately after 2012 Big Data entered the research and with a heavy implication for further BI-research. After this period, Big Data research can be

considered an important part of the business intelligence research discipline among with the other.

Comparing the results for BI, in order to gain better view in trends and changes in the area over a longer period of time, as seen in figure 18. The most common topics during the entire time period of collected primary studies (1994–2016) can be noticed to be related to themes, such as of data warehousing and data preparation, BI strategy, BI design. What can be noted is the huge impact of Big Data related research to BI-discipline, which can be clearly noticeable from the overall number of results. The studies related around Big Data are centralized on a three-year period (2012–2015). While some other categorized aspects of BI might be fading, Big Data is gaining more momentum as a current hot topic for today's research in business intelligence.

Looking at what timeframe most of research is based from figures 18, the research is concentrated during the time period between years 2010–2014. When looking at this period, the aspects, which have had the most influence can be seen to be BI Infrastructure, data warehousing/data preparation and BI-strategy. This also correlates with the validation done in figure 6 which shows the research to be peaking during years 2013–2014.

Looking in figure 18, the central importance of data warehousing and data manipulation topic is also evident, looking at the overall number of results. Also, the BI-infrastructure and -strategy aspects seem to be fairly dominant for BI-research. Information providing methods, user aspects and Big Data are not yet in major role for BI-research, although they have gained more interest coming to recent years. The large number of strategic aspects, shows the strategic importance of BI and its connection to managerial processes of organizations.

From figure 18, it can also be noticed, that there have been some changes or shifts between different topic areas between the years. What can be noted, is the stable number of studies related to areas of BI-infrastructure, BI-strategy and data warehouses or data preparation throughout the years, but it can also be noticed that data warehousing and data preparation area has been of central interest in the past for BI, although this topic has slowly been slowly fading down. This can be explained with the effects of introduction of cloud-based architectures and software as a service distribution models for applications, which may have caused the interest in older data warehousing methods to lower of interest at least at some noticeable level.

The different categories seen to be become more evenly distributed coming to current year, which seems to show, that the area of BI is becoming more synthetized as was noted also from the definitions for BI. When new technologies become of interest, such has happened with Big Data, the research area is reshaped by the new technology if technology is disruptive enough in its nature. There is further evidence of this happening before caused also by cloud based infrastructure, which has changed the interest from previous data warehousing to cloud based infrastructure. In order to notice little changes, all the lower level categories will also be shortly analysed, to notice any differences to previous results.

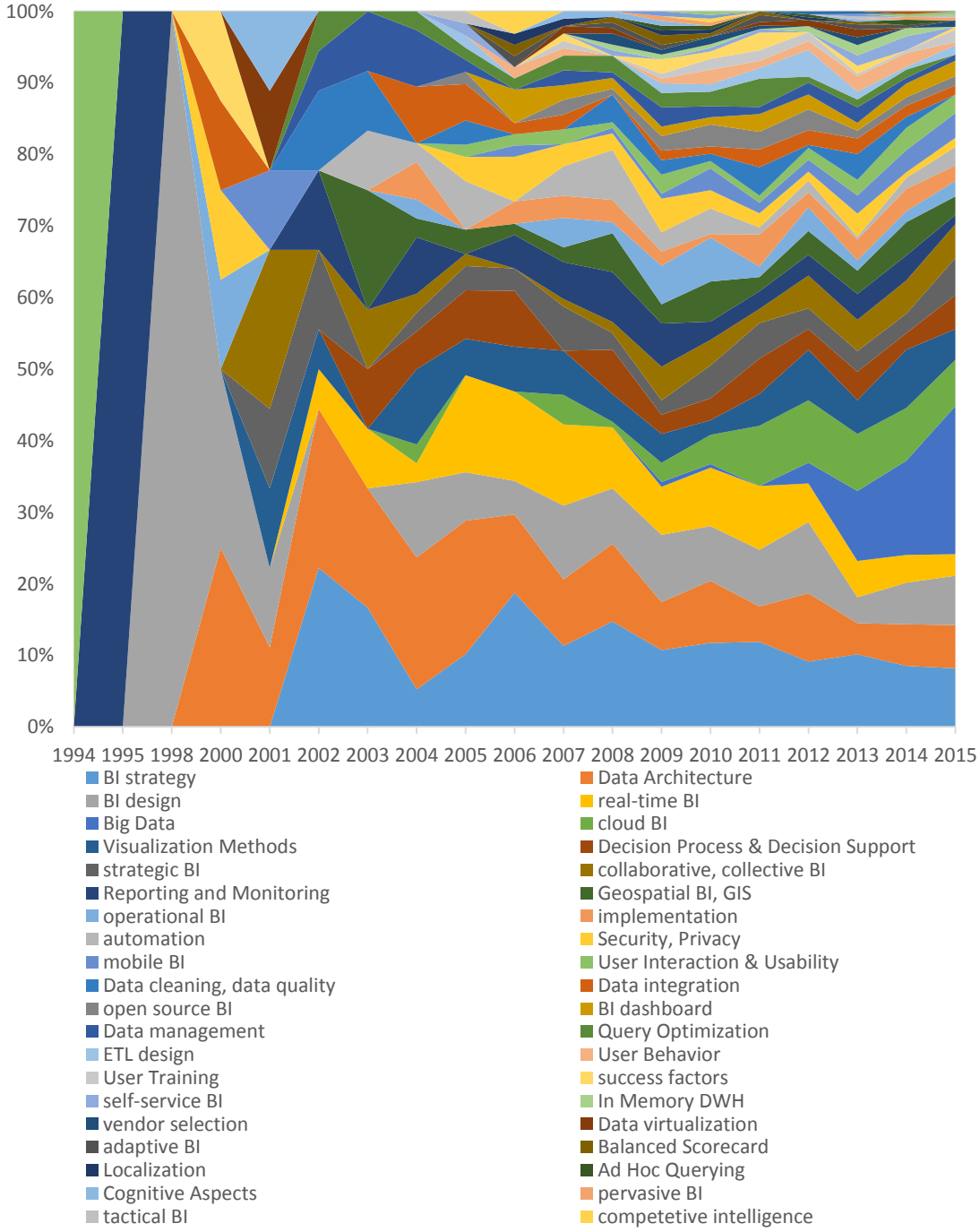


Figure 19. Top lower level features and reflect to overall number of studies (1994–2015).

In figure 19, the topics with most studies are located at the bottom in illustration and at the top of the listed aspects in the legend below the illustration. Looking at the different topics in more detailed level, using the lower level categorizations shown in figure 19, the topics which seem to be rising aspects are user aspects, strategic aspects, Big Data, security, mobility, collaborative features, visualization methods and cloud infrastructure. From researching the lower level aspects, it was discovered, that the current hot topics were Big Data, cloud infrastructure, BI-strategy, visualization, user aspects and collaboration features. Others were self-service support, security and collaborative BI.

Aspects which are surprisingly low in BI can be seen to be dashboards, automation and self-service related aspects. Also, geospatial visualization can be noted to be one important area, which is fairly low in overall number of results. It can be noted, that topics such as data warehousing, BI-design, real-time BI and reporting features have lost a lot of interest coming to 2016, as can be seen in figure 19 comparing them to the overall number of results coming to this year.

The yearly decline of in interest in data warehousing could be analysed to be caused by there now being enough research on this area and also because of new technologies affecting this area, such as cloud infrastructure. Also currently, the focus of research might be moving more into making better use of the vast amounts of collected data in organizations, using different methods such as visualization, collaborative functions, interactivity or analytics.

Trends and differences between years are noticeable from the illustration. Trends which can be noticed to have the biggest change through the years is for example data warehouses and data preparation, which has slowly been fading through the years and when coming to the year 2016. This area seems to have been of big interest and peaking during years 2001-2004. Also from this illustration it can be noted the fast-pace and big influence of the Big Data related BI-research, as well as cloud based infrastructure which have gained more influence on overall BIs research from 2011 toward 2016. Big Data's rising to one of current hot topics was an expected result, if looking the hype-cycles of this topic in other research areas as well. Other current influential topics, that can be picked of this illustration are the user aspects and the infrastructure and the strategic aspects of BIs.

From figure 19 it can be seen, the trend coming to current year seems to be shifting towards Big Data, mobility, cloud based infrastructures, user aspects/usability and visualization, internet of things, strategic BI and collaborative BI. From these topics, the most influential are Big Data related research and cloud infrastructure.

Concluding it can be seen that Business Intelligence has some grounded research areas which show stability in the number of collected results. Some of these features can be included to be data warehousing, BI-strategy, BI-design and visualization features. Other minor aspects increasing were real-time BI, collaborative BI, cloud infrastructure, geospatial BI. Aspects such as user aspects, Big Data research, strategic aspects, visualization and other areas such as self-service BI can be seen to be increasing in interest for the research as can be noted from figure 21. Areas which are decreasing in interest are data warehousing, reporting and monitoring, real-time BI, and BI in organizational levels. From the results, it can also be noticed the heavy impact of Big Data research, which is seen heavily influencing the research area.

From results, it can also be seen the strategic nature of a BI, where BI can be considered more of a strategic initiative or a process, rather than just a simplistic information system to support decision making. The basic building blocks of a BI, can be seen to include data storing method, strategy, method to analyse and manipulate the collected data and provide the outcomes for the user through a medium of interactivity or visualization features in real-time.

4.12 Industries Influencing Business Intelligence

Next the industries, which can be seen to have affected and influenced BI are reviewed using the second set of collected primary studies. For this, the second set of primary studies is used, which was collected about industries influencing BI. The analysis should provide answers regarding RQ4. A general assumption is, that the industries that are most common are also the industries which influence the development of BIs. Studying the overall number of different industries and also using the timeframe as a reference, should provide a view on which are the most important industries regarding BI's development and what industries can be seen currently influencing BI.

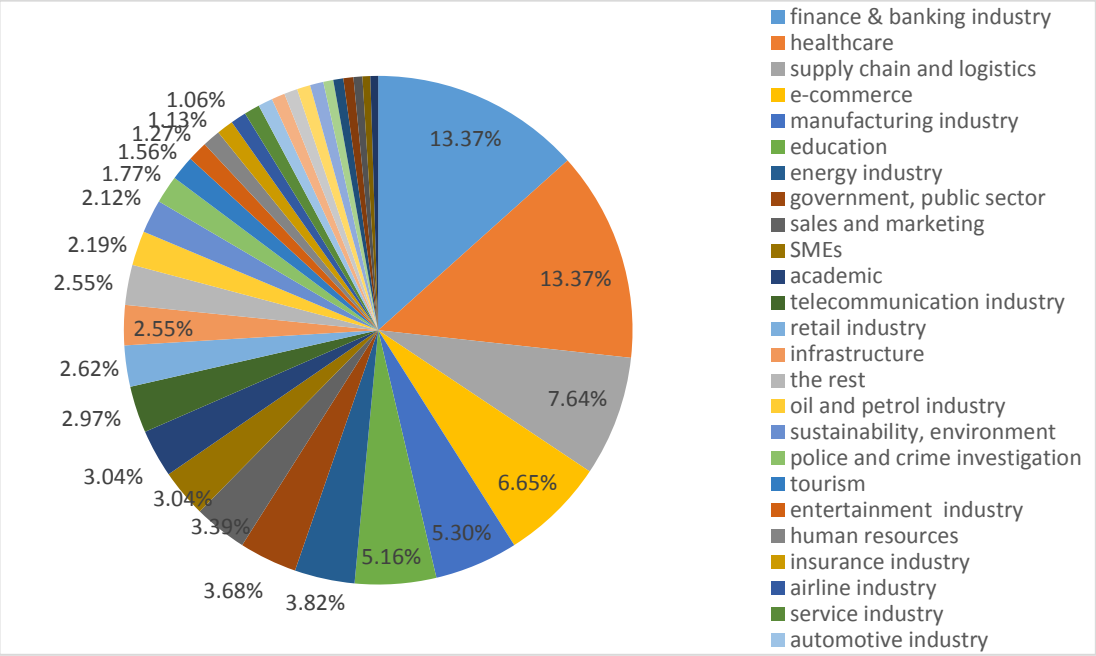


Figure 20. Most common industries influencing BI 1998-2016.

As can be seen from figure 20 the top-10 industries implementing and influencing the development according to this were finance and banking industry, healthcare, supply chain, e-commerce, manufacturing industry, education, energy industry, government and public sector, sales & marketing and Small and Medium Sized Enterprises (SMEs).

It was hypothesized, that the most common industries would be computers and telecom industry, media, automotive, retail, finance and healthcare industries. It seems that the assumptions in hypothesis were only partially correct. From the hypothesis, presented in chapter 2.6 retail, healthcare and finance industries proved to be close to the results analysed from studying the primary studies on industries. Retail industry can be understood in different ways, as for example e-commerce and SME's can be in some cases understood from retail industry perspectives. The categorization may differ from the original source. Telecommunications and computers industry was combined under telecommunication industry in the primary studies, which are shown in Appendix A. Most important industries, or the top-5 industries gathered from results in figure 22 can be noticed to be healthcare, supply chain and logistics, e-commerce, manufacturing and education. After this the number of results are evenly based between the other industry-areas.

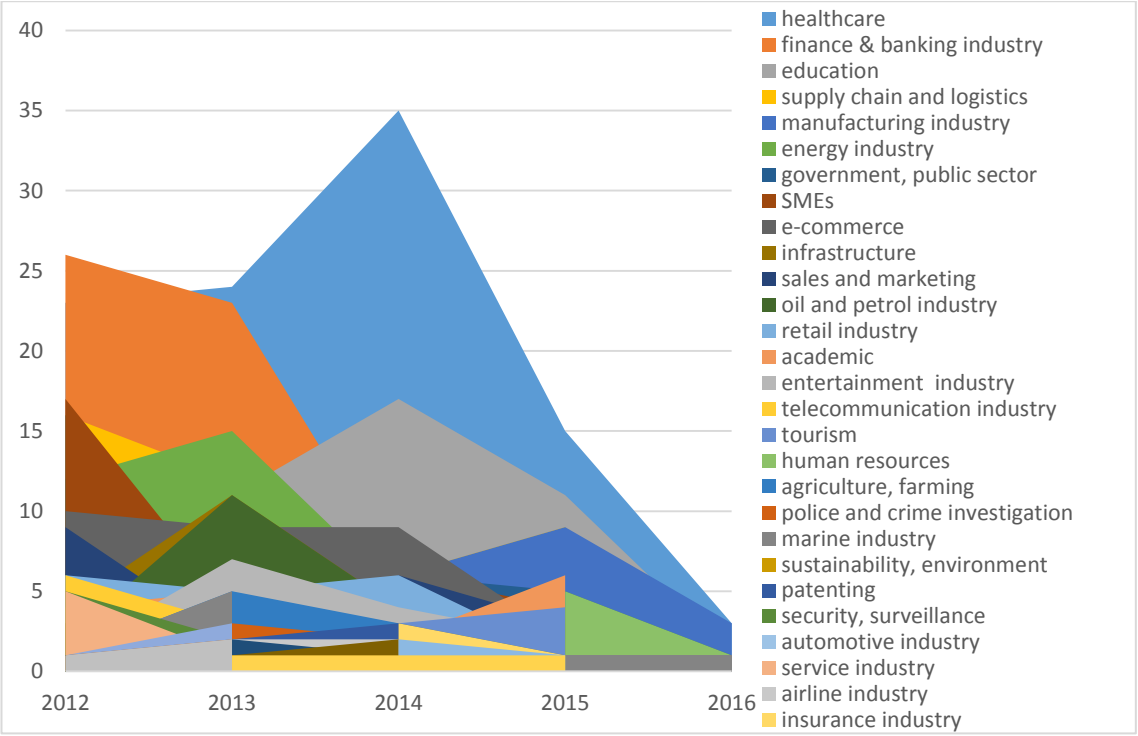


Figure 21. Top industries for BI in last five years (2012-2016).

Including timeframe in the analysis, it can be noted that healthcare peaked later than the finance and banking industry. Also, education has appeared only recently to steady its position as one of the top industries affecting current BI-research. It can be noted, that BI is moving more towards public sector industries and supporting organizations, away from the solely business use of BI-related technology. Also, SMEs are gaining interest for BI, as the systems are slowly scaling down to be used by smaller organizations in the market. In the past, development and implementation of BI was very expensive and available only for the larger enterprises. Today, this has very much changed and BI-technology is helping smaller players in the markets to gain competitive advantage of utilizing BI.

Looking at the trends in figure 21 during 1998-2016, healthcare seems to be gaining more interest for BI, as well as increase in education. Also, manufacturing, public sector and other non-profiting industries such as human resources are gaining interest for BI-research. Healthcare, finance and banking industry see influencing BI, regardless of timeframe. E-commerce can be seen being of a huge interest for the 2000-2004 period. Also finance and banking industry has gained similar big interest in BI-research during 2008-2013.

Concluding from the results, it can be concluded, that the hypothesized influencing industries were presumed to be healthcare industry, finance industry, advertising, retail industry, computer & technology industry and automotive industry. From the results in figure 19, the biggest industries in number of results and influencing BI-research can be seen to be finance & banking industry, healthcare, supply chain, e-commerce, manufacturing and education. From figure 20 it can be noted that currently, finance and banking industry, e-commerce, healthcare, education and manufacturing has had the largest influence for last five years for BI-development. Healthcare, manufacturing, education and public sector organizations are the industry-areas currently influencing the BI-development. Notable is also, that BI is spreading more towards public sector

and support organizations and industries areas, as well as more into the use of SMEs and smaller organizations in the markets.

5 Discussion

This chapter acts as a discussion based on the analysis and is based on the primary studies results gathered on BI for this thesis. The research questions will be answered using the analysis provided in the results section of chapter 4.

The role of analytics related aspects are unknown, which causes a limitation for the results. A secondary study on the analytical aspects might be in order, to study their contribution and influence towards central BI-aspects and trends in BI. Also the relationship of MIS, DSS and other closely connected research-areas of BI, could have been an interesting subject for further study.

RQ1 What can be considered the central aspects of BI, based on research literature?

The components or aspects, that can be considered central for BI looking from high-level seem to be: BI-infrastructure, strategic aspects and data warehousing. These are some of the most important aspects for BI, regardless of time.

When looking into more detail, aspects such as strategic aspects, data architecture, BI-design, real-time BI, cloud BI and visualization are some of the most central topics for BIs. Also Big Data is getting more central for BI, comparing it to the overall number of results on this topic. From the results it can be noted, that aspects such as dashboards, user interaction, self-service features are not heavily presented in the overall results, although these can be considered as some of the most important aspects for modern BI.

Topics such as decision process support, collaborative support, geospatial features, reporting, implementation, security, automation, user interaction were features which were also central for BI, but not at the top of the most central aspects.

RQ2: How has the area of BI evolved over time, based on research literature?

From related research, it was discussed, that the area of BI has started after the evolution of DSS and EIS, combining different methods and technologies, to form a new type of system or method in supporting decision making. A requirement became after the development and decreasing in cost of data storing technologies and methods, during the 1980s. Also the development of spreadsheet programs, such as Lotus 123 and Excel showed organizations the need for a more advanced way to gather, manipulate and analyse data. More data was being gathered in organizations and the collected data needed to be analysed, turned to knowledge and distributed for the users. The area has since risen to a top-investment priority coming to recent years.

On basis of analysed primary studies, BI has evolved through different technologies and methodologies, which have seemingly affected on the research of the area. Looking at the overall results in chapter 4.2, the area seems to have slowly gained momentum from mid-1990s and gaining heavy interest during the mid-2000s. According to the results, the area has peaked during years 2013 and 2014, regarding the gathered number of studies in the area. Coming to this day, the decline in number of studies has been surprisingly noticeable, maybe caused by some other research area gaining the interest, such as big data or advanced analytics. A new term might also be coming to slowly

replace BI, such as Advanced Analytics or Business Analytics, as has been noticed happening before.

During the analysed timeframe, a lot of effort has been put to develop data storing and data manipulation methods, strategic aspects and BI-design. Not much has changed in the area, although Big Data as a topic has risen to a huge interest for recent years. Different lower level aspects can be seen shifting between the years, usually slowly gaining momentum and then fading back. Today, the different aspects can be noted to have become more evenly distributed between all the aspects, as was noted from the results and no dominant area can be seen in recent years. For the early important area, data providing methods the studies peaked between 2010 and 2013. At this time, also information providing methods were gained slowly more research interest, along with strategic aspects of BIs. Infrastructure related studies came after this after gaining momentum, mainly caused by the influential impact of cloud computing appearing during this period.

Currently, the information providing and user aspects are gaining more interest than before. the interest can be seen moving away from traditional data warehousing into cloud-based infrastructures and also more into other areas. It is also plausible, that the requirements for visualizing and presenting information is becoming more important factor for current research, but also because the data storing methods are starting to get mature enough for extensive data collection to be used for analysing the data and supporting the user. It can be noted, that user aspects and visualization methods for BIs have not been of central focus before, but are getting more important than before, looking from the number of results. Also areas such, as self-service, mobility along with topics related to supporting the BI-user are aspects, which can be seen on the rise currently. These aspects are increase flexibility of the decision making.

RQ3: How have technological innovations affected the development of BI?

As the trends can be seen to have been caused by technological innovation, this is presumed to be behind the development and evolution of BI. As noted in the realated research, there exists three forms of technological innovations. IT-base innovations, system development innovation and services innovation, which are shown in more detail in chapter 2.4.

For BI-discipline, the whole area can be seen to have initiated after an IT-base innovation, such as data storing methods, database management systems or after the development of online analytical methods. These factors have also gained popularity after lowering in costs to implement. BI might have also been caused by the development of interactivity, visual methods and the revolution of personal computing during the mid-1980s to early 1990s, during which time also the modern BI is seen to have been born.

During the development cloud based infrastructure or software as a service can be seen one of the it-base innovations happening during the time. Cloud infrastructure appeared after 2010 and changed many information system business- and service models indefinitely. These IT-base innovation types happen rarely and are caused by new technology, which has enough disruptive force to change a whole area or service. Currently Big Data can be seen as a major IT-base innovation, which is causing change for BI. Most developments in the area of BI can be seen to have happened by services innovation, where new service models are found out from existing resources. This has happened often for BI, as new methods to utilize collected data is found out. This also

happens when the BI-technology is extending to new industries, where new ways to utilize existing methods in BI are discovered.

RQ4: Which industries can be seen to have influenced BI?

Looking at the results from chapter 4.12, industries which can be seen having most influence for BI were: finance and banking industry, healthcare, supply chain or logistics, e-commerce, manufacturing and education. BI-research is gaining momentum in healthcare research and education. Research on public sector and governmental use of BI-technology is noted to be on the rise. Currently BI is influenced by banking and finance industry, healthcare, education, e-commerce and manufacturing. Rising are also human resources and marine industry.

BI can be seen to be moving away from solely business utilization, towards non-profit, public sector, or support organizations. It can also be noticed, that BI is extending to the reach of smaller organizations and BI is no longer available only for the larger organizations in the market. This will ensure competitiveness of also the smaller organizations and in best cases smaller organizations might gain market share by utilizing BI-technology against much larger and slowly moving organizations.

6. Conclusions

Looking at the large number of studies related to BI, it is challenging to gain a general view of the research area and topic. The research area can be seen influenced by different technologies, other research fields and different researchers with varying backgrounds. It can also be considered challenging to discover the central aspects of BI and what kind of developmental phases, or trends have been happening in the BI-discipline. BI has evolved through a complex evolutionary process influenced by many different factors on the way to being the important factor in supporting business organizations it is today. BI can be seen to have been influenced by different scholars from different backgrounds including business, organizational and managerial research as well as information systems and information technology.

Because the multidimensional and un-linear field of BI-research a generalized view of the central aspects and trends was needed. In order to better understand the area of Business Intelligence, an overall view of the research area was needed in order to understand the future needs and how to solve future problems and requirements. BI is not seen to be fully ready for the new revolutionary age of Big Data and its performance requirements. As BI can be noted to have been born after the development of data warehousing technologies and methods, Big Data often described using volume, velocity and variety is currently causing challenges for the BI-industry. BI might need to re-discover past research to help it survive the new challenges with ever-expanding data challenges. Also the education of next-generation of data-driven managers and personnel might help to support future challenges, as they are more familiar with using knowledge tools, than their own intuition when comparing to their predecessors. A systematic mapping study together with PRISMA was used to gather a set of primary studies in order to get understanding of the central aspects and also to study how BI has been influenced by different, technologies, aspects and industries over time.

BI is one of the key-tools or technologies used to ensure profitability or competitiveness of a business organization. BI has also been noted the top investment-area for companies' IT-organizations for several sequential years. Also, it has been researched before, that organizations which incorporate BI or analytics into their decision-making processes are often leaders of their own industry-area. The top industries implementing BI were discovered to be finance and banking industry, healthcare and supply chain. Small and medium sized enterprises have also started to slowly gain more interest in BI, which shows the BI is starting to democratize and be used in smaller organizations, than before. It has also been noticed, that the movement from purely business-utilization of BI-technologies to public sector, support organizations and even non-profit organizations has been increasing, possibly caused by the new trend to bring data-gathering and analytics to every possible context of human life. It has been noted how BI-related methods and technologies have already been brought into sports, healthcare, marketing and the potential use cases are expanding yearly.

In the definitions, BI is defined often through the model of turning data into information and to knowledge. From the definitions it was noted, that modern BI is generally defined as an umbrella term, which combines data warehousing, strategic aspects, visualization and analytics methods with other information providing layers to support managerial or business decision making. BI is still seen mainly as a combination of

technologies or as a process, depending on the viewpoint and the viewers background. From some viewpoints, BI is seen mostly as a strategic initiative or as part of a process to provide methods to turn data into knowledge, rather than a separate information system or tool to gather and analyse data to support better quality decision making.

The area of BI can be seen to have developed after the data-storing methods, spreadsheet programs and analytical methods were developed, which have been central for the early phase development of BI. BI has been also influenced by preceding information systems research areas, which have also been designed towards the same goal of supporting managerial decision making. The almost 40-years spanning research-areas, which saw beginning during the 1960s of MIS and DSS are seen to have had huge influence for BI-development and research. The influence of DSS and MIS might be noticed mostly in the decision support methods and possibly in the understanding and theories how data is turned into knowledge or in how decisions are formed by utilizing information technology. BI has also sometimes referred as the data-driven DSS, combining data, interaction and analytics to general DSS-functionalities.

A clear distinction of different aspects related to BI does not seem to exist. As BI is seen from many different viewpoints, it is challenging to gain an overall view to span all the aspects. It is noted, that a yearly analysis on the hype-cycles of BI is done by Gartner Research, but it does not provide a standardized categorization of different aspects related to BI. The different aspects in the area are challenging to follow-up, after they are changed based on the hype-cycles. Gartner's magic quadrant for business intelligence is centrally meant for the industry to compare different BI-vendors and analyse new functionalities or technologies, which are seen entering in the BI-discipline.

From studying the field, BI can be considered very unstandardized in many ways. This is possibly caused by BI evolving in a very cyclic form, implementing new technologies and methods as it has kept evolving. The evolution in BI can be seen to be re-occurring, where existing technologies are re-appearing in cyclic form and are also combining to form new ways for BI to support decision making activities. Also many of the changes and development are caused by service innovations, where new ways are found to utilize existing data, or the existing methods are extended to new areas or industries. Disruptive IT-base innovations in BI have been mostly from infrastructure changes and Big Data.

In this thesis, a new categorization framework was formed, where BI was divided into six high-level categories containing different aspects related to each category. The categorization was heavily influenced by collecting different categorizations and consolidating ten years of Garner's Magic Quadrant results into a single category, seen in chapter 2.5. The categories introduced were: Data Warehousing and Data Preparation, BI infrastructure, Knowledge/information Providing, BI Strategy and development, User aspects and Big Data.

From analysing the central aspects, it was noted, that BI-infrastructure containing mostly technology to support the BI and support the decision maker were the most common categories regardless of time. Also BI strategy, data warehousing and data preparation methods were common. At least data-warehousing methods were seen to be important for the early phases of BI-development, later replaced by infrastructural and strategic aspects, including BI-design. The most central aspects for BI looking in more detail were also analysed to be BI strategy, data architecture, BI-design, real-time BI, Big Data, cloud infrastructure, visualization methods and decision support. Therefore BI

can be also analyzed to be fairly data-centralized and strategic in its nature, consisting of different user targeted features for decision support.

The main components for BI gathered from the results in this thesis can be considered to be data warehousing, strategic aspects, BI-design aspects, visualization features, real-time features, decision support features, reporting and collaborative features. Aspects such as Big Data, self-service, visualization and user aspects seem to popular aspects currently or can be noted to be gaining popularity for future. Topics considered important for future, such as Internet of Things or open source are not yet of big interest. Historically important aspects, such as reporting, dashboards and data warehousing can be seen to be losing of some interest coming to today, being mostly replaced with cloud infrastructures and software as a service models. Surprisingly little interest has been put on automation, self-service, user-aspects and self-service features in BI-related studies.

The understanding of what are they central-components, what development has happened in the past and where the BI's area is shifting to is essential for any BI-professional or user of BI to follow. In order to ensure competitiveness, lot of resources are invested into analytical methods and data gathering tools. Gartner's Magic Quadrant shows how important following of different aspects of BI is. However, the aspects are changed based on the market needs, causing challenges to understand the area of BI from in a wider context and following up on different aspects changing in BI. Also the missing of a standardized categorization of BI-aspects seems to be evident, which was shown in this thesis and was the reason why a new categorization was formalized to form an understanding of the central BI-components, aspects, technologies and layers. BI-technology also noticed to be extending to wider usage, than before including healthcare, public sector and non-profit or support organizations, solely from business use which can be seen extending the goals to use BI even further.

After following how the area of BI has shifted before, might help one to understand how to solve future problems using BI, by looking how past challenges have been met by bringing new methods or technologies to BI. The development in BI is evolutionary and once in a while a disruptive technological innovation or method is causing major changes in BI, while most development and changes are noticed to be caused by refining or combination of existing technologies or by discovering of new ways to utilize existing BI-technologies or -methods. For the future, Big Data and the utilization of more data for analytical purposes or decision making seems to be evident. The new requirements mainly caused by Big Data and by utilizing data from more unstructured sources will require faster data processing, self-service, user-centricity, more advanced visualization features and new analytical methods or artificial intelligence, which will be needed in order to survive the challenges of having more data available for the decision-making process. More user-cantered design of BI, development of more collaborative features, automation or artificial intelligence might be needed to tackle the future challenges, as some of these aspects were not seen to be of central importance for BI-related research.

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Appendix A. Industry Areas Implementing BI

Industry area
ACADEMIC
AGRICULTURE, FARMING
AIRLINE INDUSTRY
AUTOMOTIVE INDUSTRY
CHEMICAL INDUSTRY
CONSTRUCTION INDUSTRY
DISASTER RECOVERY
E-COMMERCE
EDUCATION
ENERGY INDUSTRY
ENGINEERING
ENTERTAINMENT INDUSTRY
FINANCE & BANKING INDUSTRY
FRAUD DETECTION
GOVERNMENT, PUBLIC SECTOR
HEALTHCARE
HUMAN RESOURCES
INFRASTRUCTURE
INNOVATION SUPPORT
INSURANCE INDUSTRY
INTERNET SERVICE PROVIDER
LIBRARY
MANUFACTURING INDUSTRY
MARINE INDUSTRY
MINING INDUSTRY
NEWS INDUSTRY
NON-PROFIT ORGANIZATIONS
OIL AND PETROL INDUSTRY
PATENTING
PEOPLE TRANSPORT
POLICE AND CRIME INVESTIGATION
POLITICS
RETAIL INDUSTRY
SALES AND MARKETING
SECURITY, SURVEILLANCE
SERVICE INDUSTRY
SMES SPACE INDUSTRY
SPORT INDUSTRY
SUPPLY CHAIN AND LOGISTICS
SUSTAINABILITY, ENVIRONMENT
TELECOMMUNICATION INDUSTRY
TOURISM
WEATHER FORECASTING

Industry	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
healthcare	1	1	2	1	1	1	2	4	7	10	15	14	30	23	24	35	15	3
finance & banking industry						10	1	4	3	4	41	26	35	26	23	6	10	
supply chain and logistics				1	1	3	5	2	2	10	26	5	10	16	12	6	9	
e-commerce		3	2	7	2	2	6	3	4	7	11	10	7	10	9	9	2	
manufacturing industry		1					1	3	5	2	14	5	6	9	11	6	9	3
education								1		3	9	7	6	7	11	17	11	1
energy industry				1				2	4	1	5	4	2	12	15	5	2	1
government, public sector				1			1		3	3	3	3	6	16	4	6	5	1
sales and marketing			1				1	2	1	3	6	7	6	9	2	6	3	1
SMEs										2	3	4	3	17	4	6	4	
academic								2		4	8	5	7	4	5	2	6	
telecommunication industry		1				4	1	3	1	2	5	7	5	6	3	3		1
retail industry							2		1	4	4	6	2	6	5	6	1	
infrastructure								1	1	1	4	6		4	11	4	3	1
oil and petrol industry								1	2	2	3	2	2	2	11	4	2	
sustainability, environment								2	1	2	5	7	5	3	2	2	1	
police and crime investigation							3	2	1	1	2	6	1	3	3	2	1	
tourism										2	3	1	3	2	4	3	4	
entertainment industry									1			1	2	1	7	4	2	
human resources										1	1	1	2	2	3		5	1
insurance industry								1	1	2	2	1	3	1		3	1	
airline industry						1		1		3	1	1	2	1	2	2		
service industry								1		2		4	1	5	1			
automotive industry							1		1	2	1	2		1	2		3	

patenting						1		2	2	1	2	3	1		
marine industry						1		2	1	1	5		1	1	
agriculture, farming						1		1		1	5	3	1		
security, surveillance					1	1		2	1	5	2				
construction industry				1	1		2		1	1	3				
fraud detection			1	3			1		1	3					
metal industry		1			1	1	1	1		1	2	1			
internet service provider						2	2		1	1	2				
space industry			1	2				1		2			1		
disaster recovery						1	3			1	2				
sport industry							1			1	1		2		
innovation support									1			3			
people transport									1	1	1		1		
mining industry		1		1					1		1				
news industry			1									2	1		
chemical industry											1	2			
library											1	1	1		
weather forecasting							1	1				1			
engineering						1				1			1		
politics									2						
non-profit organizations													1		

Appendix B. Data Extraction Form

High Level-Categorization /Industry	Medium Level - Categorization	Author(s)	Year Published	name of the publication	Published in	Source Type	Notes
Main category	Secondary categorization	author(s) name	publication year	title of the article	Publisher name	Journal, conference paper, book chapter	Short notes on content of the study