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ABSTRACT

In today's digital age, the need for improvement in all business processes, including Supply Chain Management (SCM), is more crucial than ever before. With the rapid advancements in information and data digitalization, the adoption of information technology is an essential step for companies to gain a competitive advantage in the market. One of the most effective ways to do this is using Business Intelligence (BI) systems, which have shown to produce positive results in this process. The objective of this thesis is to run an analysis on the existing literature focusing on clarify the concepts of BI and SCM, and identify the advantages and barriers related to the use of BI systems in SCM contexts. As a result of our research, we found that the integration of those two concepts can provide an important competitive advantage for companies that arise from benefits of BI applications in SCM contexts, such as displaying real-time data using accessible visualization tools, accurate demand forecast and production plan, optimizing distribution routes and products warehousing, executing predictive analysis to minimize disruptions consequences, and many other. However, it is important to acknowledge that there is still a long way to go overcome or limit some barriers related to updating systems, making large investments, and training people involved in the processes, as well as the substantial need for an effective participation and motivation from the managers involved. This is a crucial step to ensure the effective implementation and integration of these BI systems into existing SCM processes in this fast-paced digital era. The current project will contribute not only with the academical records, but also to be a reference to support on real life business applications.

Keywords: Business Intelligence; Logistics; Supply Chain; Information Technology; Managerial Supporting Tools; Business Digitalization.

ABSTRACT

Nell'era digitale in cui stiamo vivendo, la necessità di miglioramento in tutti i processi di business, incluso il Supply Chain Management (SCM), è estremamente rilevante. Con il rapido progresso nella digitalizzazione delle informazioni e dei dati, l'adozione della tecnologia dell'informazione è un passo essenziale per le aziende per ottenere un vantaggio competitivo sul mercato. Uno dei modi più efficaci per farlo è utilizzare i sistemi di Business Intelligence (BI), che hanno dimostrato di produrre risultati positivi in questo processo. In questa tesi verrà effettuata un'analisi della letteratura esistente al fine di chiarire i concetti di BI e SCM e identificare i vantaggi e le barriere derivanti dall'applicazione dei sistemi di BI in contesti SCM. La ricerca mostra che l'integrazione di questi due concetti può fornire un importante vantaggio competitivo per le aziende che deriva dai benefici dell'utilizzo dei sistemi di BI in contesti di SCM, tra cui la visualizzazione di dati in tempo reale utilizzando strumenti di visualizzazione accessibili, previsione accurata della domanda e piano di produzione, ottimizzazione dei percorsi di distribuzione e dello stoccaggio dei prodotti, esecuzione di analisi predittive e prescrittive per ridurre al minimo le conseguenze delle interruzioni e molti altri. Tuttavia, è importante riconoscere che c'è ancora molta strada da fare per superare o limitare alcune barriere legate ad esempio all'aggiornamento dei sistemi, alla realizzazione di grandi investimenti e alla formazione delle persone coinvolte nei processi, nonché alla sostanziale necessità di un'effettiva partecipazione e motivazione da parte dei responsabili coinvolti. Si tratta di un passaggio cruciale per garantire l'effettiva implementazione e integrazione di questi sistemi di BI nei processi SCM esistenti. Questo progetto contribuisce non solo al dibattito accademico in corso su questa tematica, ma vuole essere anche un valido supporto pratico ai fini di applicazioni aziendali.

Parole-chiave: Business Intelligence; Logistica; Catena di Approvvigionamento; Supporto al Processo Decisionale; Digitalizzazione Aziendale.

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INTRODUCTION

In recent years, the global Supply Chain (SC) has become increasingly complex, with companies relying on suppliers from all over the world to provide the goods and services necessary to run their businesses, and this has created an environment of interdependence where disruptions in one part of the SC can have ripple effects throughout the entire system (Roßmann et al., 2018).

The COVID-19 pandemic is a prime example of how a disruption to the global SC can wreak damages on businesses of all sizes. As countries implemented lockdowns and travel restrictions, SCs were disrupted, leading to shortages of critical goods and services (Santhi & Muthuswamy, 2022). This highlighted the need for businesses to have contingency plans in place to deal with disruptions and ensure the continuity of their operations (Min et al., 2019).

One way to mitigate the impact of disruptions in the global SC is to leverage technology (Deepu & Ravi, 2021). By using tools such as predictive analytics, machine learning, and automation, businesses can gain insights into potential disruptions and develop contingency plans to deal with them, and this can help minimize the impact of disruptions on the SC and ensure the timely delivery of goods and services (Kaur, 2021).

The optimization of SCs through technology is an important topic that has been extensively researched in the academic literature (Sandberg et al., 2022).

Among available technologies able to generate positive impacts in SCM, BI offers solutions in order to perform real-time data analysis in an easy-to-understand way, by the usage of interactive dashboards, or it can offer also predictive analysis tools to forecasting demand, optimizing inventories level, or identifying potential SC disruptions, for instance. And these are just a few examples of the wide range of solutions offered.

In view of such a close link, the objective of this thesis is to run an analysis on the existing literature focusing on clarify the concepts of BI and SCM, and identify the advantages and barriers related to the use of BI systems in SCM contexts

The concept of BI will be introduced the first chapter of this research. It will be presented a definition of BI in three dimensions, being the concept related as a process, as a product, and as a technology. We will also be going on a journey through the historical background of BI, highlighting his relevance and benefits, and visualizing what this powerful tool has as potential future perspectives.

In the second chapter, we will explore the principles of SCM, its importance, and the key strategies and technologies used to optimize SC operations. It will be described the key definition and concepts of SCM and how a proper governance on this field is essential and beneficial to companies. The positive impact of SCM will also be highlighted in different departments in the company,

such as procurement, production, distribution, sales, sustainability, and automation, for instance.

In the third chapter we will explore the intersection of BI and SCM, and how BI might generate benefits and challenges when it is implemented within SC operations. Moreover, it will be illustrated some challenges faced by companies, and how an organized and reactive SC, supported by a BI mentality, can help them in facing crisis periods. We will dive in a whole discussion on how the future looks like on SCM and the important role BI will take on it.

We aim to demonstrate that BI tools and techniques can be used to monitor and analyze SC data, including inventory levels, supplier performance, and demand forecasting. We believe that by leveraging BI organizations can gain a better understanding of their SC and make data-driven decisions to improve efficiency and reduce costs. There will be also discussion about the challenges faced by companies on implementing BI in SCM, and it what may be the best practices for success.

With all the analysis, this thesis aim to provide the necessary information and to demonstrate the link between these two concepts and how decision makers, managers, and regular workers can benefit from using BI technologies and tools on SC processes and operations, in order to guarantee the best execution and the high level of production, services and many other aspects in a company, resulting in a

significant advantage to the company in front of their competitors in the same market.

With the conclusion of this research, we aim to delivery benefits not only to the academic community but also contribute to the practical application of these insights in the business world.

CHAPTER I

BUSINESS INTELLIGENCE: AN OVERVIEW

I.1 DEFINITION

The world evolution is given in a digital manner, with fast and life changer updates, fresh technologies being launched every single day, constantly increasing the technological needs in our life, in order to not be outdated by the new reality, which can make our day-by-day harder. In such a context, the usage of data is becoming bigger during the years, and the good manipulation of all this data is something valuable to be known (Namvar, et al., 2016).

Following this evolution, companies are dealing with higher volumes of data along their operations. On the need to manage high volumes of data, companies are used to run for software's and personnel with the capability to extract the best from those big volume of data and provide the most accurate support possible, so managers can execute their roles on decision- making (Ortiz Jr., 2010).

To support all this process of data collection, analysis and use, the concept Business Intelligence (BI) has been introduced. The concept is defined by some authors in a broader way as the result of applicating human cognitive faculties in artificial intelligence technologies to extract valuable information (Ranjan, 2012). Watson & Wixom (2007, p. 96) described that "BI is emerging as a key enabler for

increasing value and performance". Namvar, et al. (2016) definition's is that BI empowers individual and organizational sensemaking, providing management with the tools and techniques needed to produce insightful business data and make informed, impactful decisions.

Many other just use it as a "umbrella" argument to conglomerate some other aspects and tools of data analysis, as data warehousing, data mining, business analytics, and big data, for instance (Trieu, 2017). Another similar definition was presented by Shollo (2013) when he said that recent developments have integrated BI systems (formerly EIS, DSS and KMS) into a combined technology. This includes a data warehouse and related BI apps to analyze structured and unstructured data for decision-making support. Reinforcing this concept, Lokeshkumar et al. (2020) stated that "Business intelligence is an umbrella term for different business overseeing forms in view of well informed choices, which prompt to make decisions at the top level inside organizations".

An interesting definition was brought by Shollo & Kautz (2010), when they presented different perspectives from different authors, resulting in a definition of BI being considered as a product, a process, a set of technology, or a combination of these. We found this classification interesting, and now we go deeper in each dimension of this definition.

I.1.1 Business Intelligence as a Process

If the definition of BI as a process, we cand find some authors as Dekkers (2007), Golfarelli et al. (2004) and Herring (1998) who describe the process in different ways, from “The process of turning data into information and then into knowledge” (Golfarelli et al. 2004, p 1), to a continuous activity of gathering processing and analyzing data using a informatic system (Dekkers et al. 2007), and as process where significant relationships are determined from data when the information is examined through a systematic procedure (Herring, 1998).

Summarizing the definition of BI as continuous a process, Shollo and Kautz (2010) brought us the idea of a process of gathering and storing data, analyzing it and transforming into data, and finally converting it into knowledge to support decision makers on business.

I.1.2 Business Intelligence as a Product

In 2017, Fink et al. described BI as a spread-used term to classify decision support systems that disseminates adjusted organizational data to improve decisions, by collecting, analyzing, preparing and exposing the information to whom it may concerns.

From these definitions, we can add the idea of BI as a product as well. According to some authors, the product aspect of BI comes when it can be related as knowledge and relevant information that companies retains for them, from

historic records of their business, which combined with the processes above described, results in valid and useful arguments that make visible past performances and support managers choices on the future of the company (Jourdan, et al., 2008).

This definition is defended in papers from authors like Jourdan et al. (2008) and Shollo (2013), for example, who describes it as "Relevant information and knowledge describing the business environment, the organization itself, and its situation in relation to its markets, customers, competitors, and economic issues", and as "information that will allow organizations to predict the behavior of their competitors, suppliers, customers, technologies, acquisitions, markets, products and services, and the general business environment with a degree of certainty", respectively.

I.1.3 Business Intelligence as a Technology

The third definition that is worthy to be highlighted is BI as a technology. Negash (2004) start defining it as a "natural outgrowth of a series of previous systems designed to support decision making". For the author, BI is a result of a combination of different hardware and software with the fast evolution of the Internet technologies, resulting in a better and more practical way of managing and understanding data.

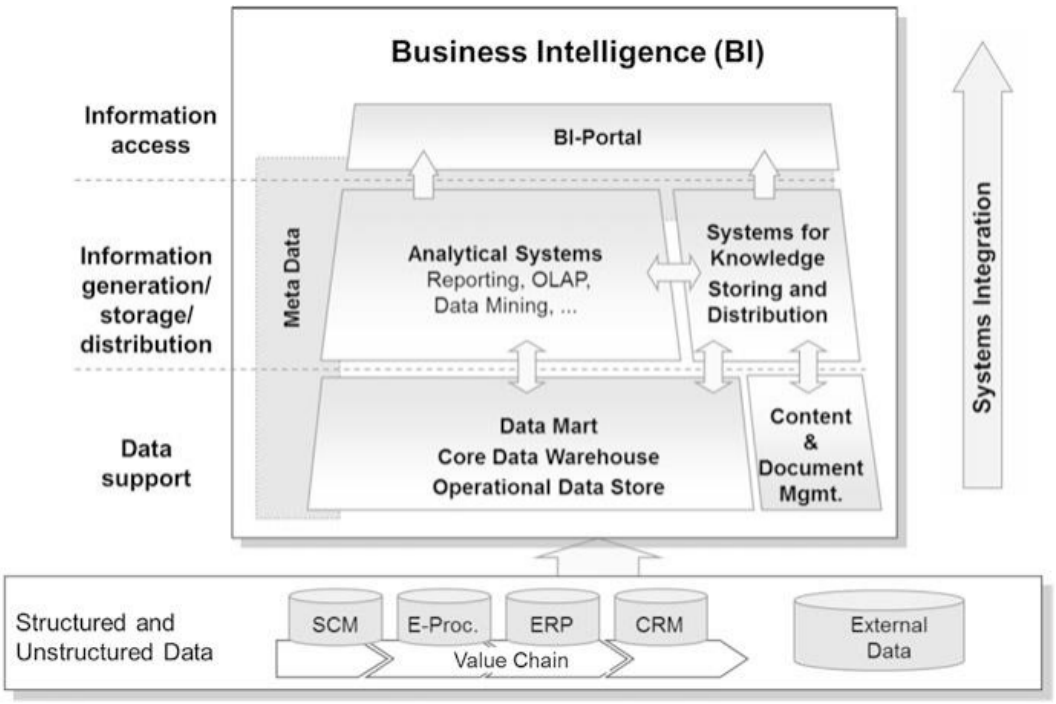
Several authors also describe BI as a technological tool, for example, Davenport (2006) said that BI embraces a huge array of processes and software

used to collect, analyze and disseminate data across different business stakeholders. For Hadhoud & Salameh (2020, p. 50) BI is "is the use of computing technologies (applications and software) to collect business data from multiple resources and analyze it then transform it into useful insights that help managers and owners to take the right actions in order to improve the business performance and meet the goals required to business success".

I.2 THE ARCHITECTURE OF BUSINESS INTELLIGENCE

The three-dimensional definition of BI is a good perspective to understand what this "system" can provide to the business and how it can be used. It is endorsed by several authors. Among them, for example, Kemper et. al (2013) presented a definition of 3 layers of BI (see Figure I.1), where the first one, on the base, is related to the data support, responsible for storing transformed and harmonized data, being it structured or unstructured. The second layer is where the tools and functionalities needed to analyze the data are. In this layer we can find the instruments needed to transform data into knowledge and to work on it until it can be shared with whom it may concerns. The third and top layer is called Information Access Layer, it is the place where the information is available for the decision-makers stakeholders, to support their actions. Normally it is related to some portal or software with accessible visual aids aimed at delivering information in an effective manner.

Figure I.1 – 3 Layers of BI architecture



Source - Kemper H. G., Rausch P., Baars H. (2013), Business intelligence and performance management: introduction, in Rausch P., Sheta A. F., Ayesh A., Business Intelligence and Performance Management: Theory, Systems and Industrial Applications, Springer, London, pp. 3-10.

Following these definitions, Hadhoud & Salameh (2020) describe the structure that embraces this technology and divided it in four components that are useful to complement the previous definitions and "implement" the proposed BI architecture.

The four components presented by the authors are: the data warehouse and it sources, business analytics tools used to enhance the raw data, a business performance management tool, and a user interface. To summarize the architectural concept of BI explained by the authors, we extract the main characteristics of each dimension presented by them, exemplifying their concept in table I.1. below.

Table I.1 – Description of 3D Business Intelligence architecture

Data Warehouse	• Centralized depository that collects and manages huge volumes of data • Use of tools to extract, transform, and load data in a standard and structured format • Consolidates data to be able to query, analyze it and create reporting
Business Analytics	• Range of applications and techniques for gathering, sorting and analyze data • Creating reports enhancing different departments of the company, to allow an overview and action taking
Business Performance Management	• Use of Key Performance Indicators (KPI) to monitor and control the performance of an organization • Expose to managers potential opportunities and threats, supporting them on actions to get it / prevent it
User Interface	• Visual part of Business Intelligence available mainly to end-users • Reports, dashboards

Source - Hadhoud, R., Salameh, W. A. (2020), How business intelligence can help you to better understand your customers. International Journal of Business Intelligence Research (IJBIR), Vol. 11 No. 1, p. 50-58.

In a brief sum-up of what does BI means, we can bring the definition of being a set of processes, products and technologies that are used by combining internal and external data data from companies with analytical tools to demonstrate

results, progresses and competitive information that can be used by planners and decision-makers on a strategic manner (Negash, 2004).

On the other hand, it is essential to remember that the human factor is also needed to BI happens. It is necessary some level of knowhow to manage all the available data, processes, and technology to extract the best from the information. We can say that, basically, BI converts data into useful information, but it is only through the human analysis that all this data and information becomes into knowledge (Negash, 2004).

But is Business Intelligence really something new that was born only with the technological advance, or does it already existed before, on what used to be a more archaic way of management? The next section will provide a brief historical evolution on this.

I.3 HISTORIC OVERVIEW AND FUTURE PERSPECTIVES

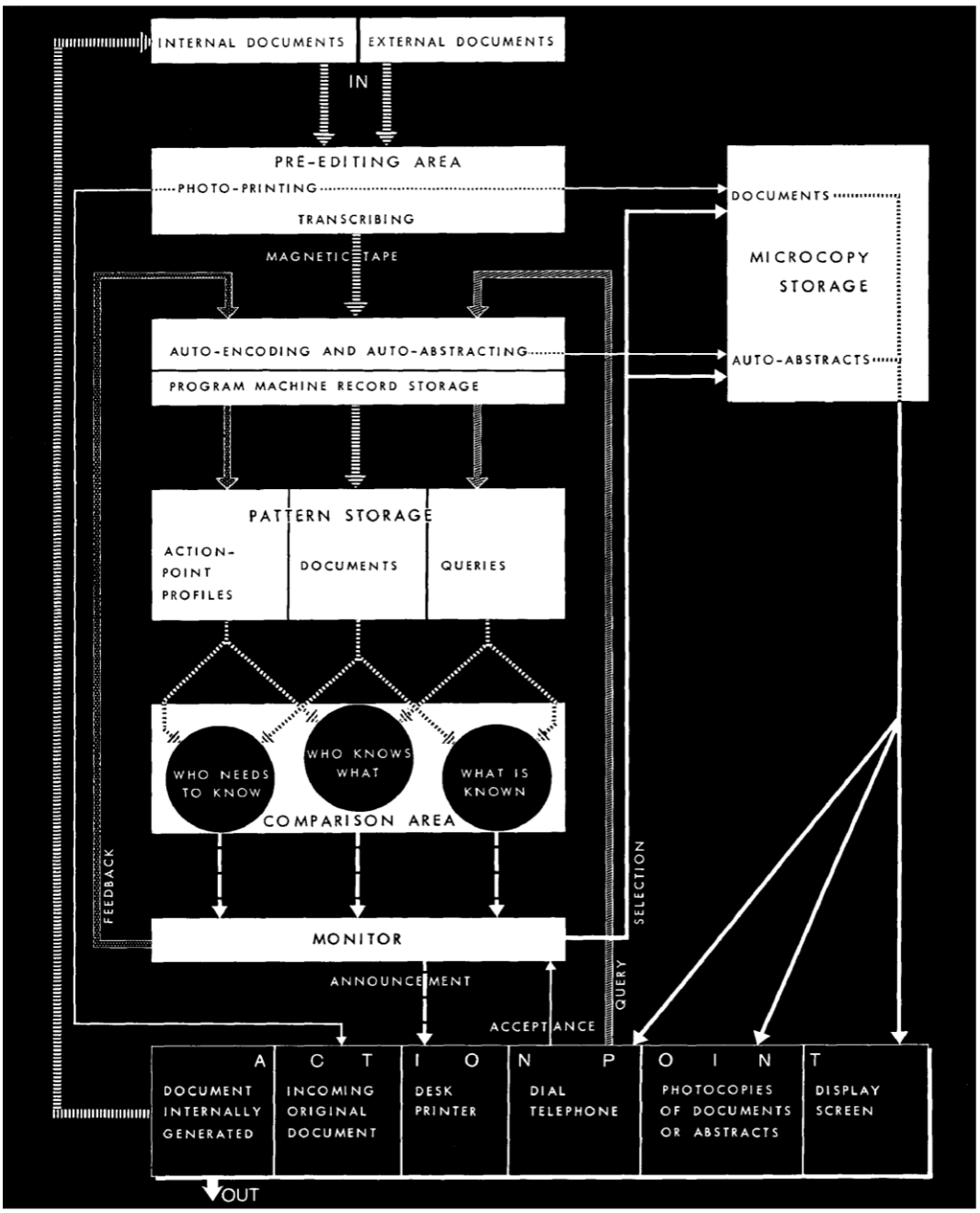
The term Business Intelligence System has one of its first appearance dated from the latest 50's. In 1958, a German scientist named Hans Peter Luhn, who worked as a researcher for the International Business Machine Corporation (IBM), wrote an article on the IBM Journal, describing the born and development of a trending integrated system capable of accept information on its original format, disseminate the data immediately to the correct place and providing information on demand (Luhn, 1958).

In his words, he first described as “An automatic system is being developed to disseminate information to the various sections of any industrial, scientific or government organization. This intelligence system will utilize data-processing machines for auto-abstracting and auto-encoding of documents and for creating interest profiles for each of the "action points" in an organization. Both incoming and internally generated documents are automatically abstracted, characterized by a word pattern, and sent automatically to appropriate action points.” (Luhn, 1958, p. 314).

It is curious to read how the whole processes of data aggregation, analysis and distribution was made back on mid 1900’s. With a limited access of technologies, the companies used to run their data analysis by using physical documents as well. Nowadays we are used with huge data sets, located on clouds, while in that time a photocopy or a printer were essential to support business decisions. Even in that way, the author predicted and projected how the integration of analogic and digital data could be integrated to better serve the business stakeholders.

On Figure I.2, we can see how Luhn (1958) described how the proposed system (BI) would be structured.

Figure I.2 – First ever scheme about Business Intelligence structure.



Source - Luhn H. P. (1958), A Business Intelligence System, IBM Journal, Vol. 2 No. 4, p. 314-319.

He dived it in functional sections, being the first one named “Document Input”, which name is self-explanatory, and is related to both digital and physical documents. Following it, a series of other passages are presented to complete the system, such as a set of configurations to recognize which are the action-points needed at the end, and how each uploaded document can be related to them. Also, the system capability to disseminates information, to allow users to accept and work on them, to filter and use only the relevant information to any related action-point, and the ability to sectorize all the info, avoiding that some users access information that are not meaningful to their decision process.

The final section would be the “Document Output”, also self-explanatory, where the system would be capable of produce the right type of document to the right requested action-point, preferably in digital format, but with the possibility of disseminating it in a physical format as well. These outputs would be precious to support decision-makers and allow other departments to execute their respective analysis on their action-points.

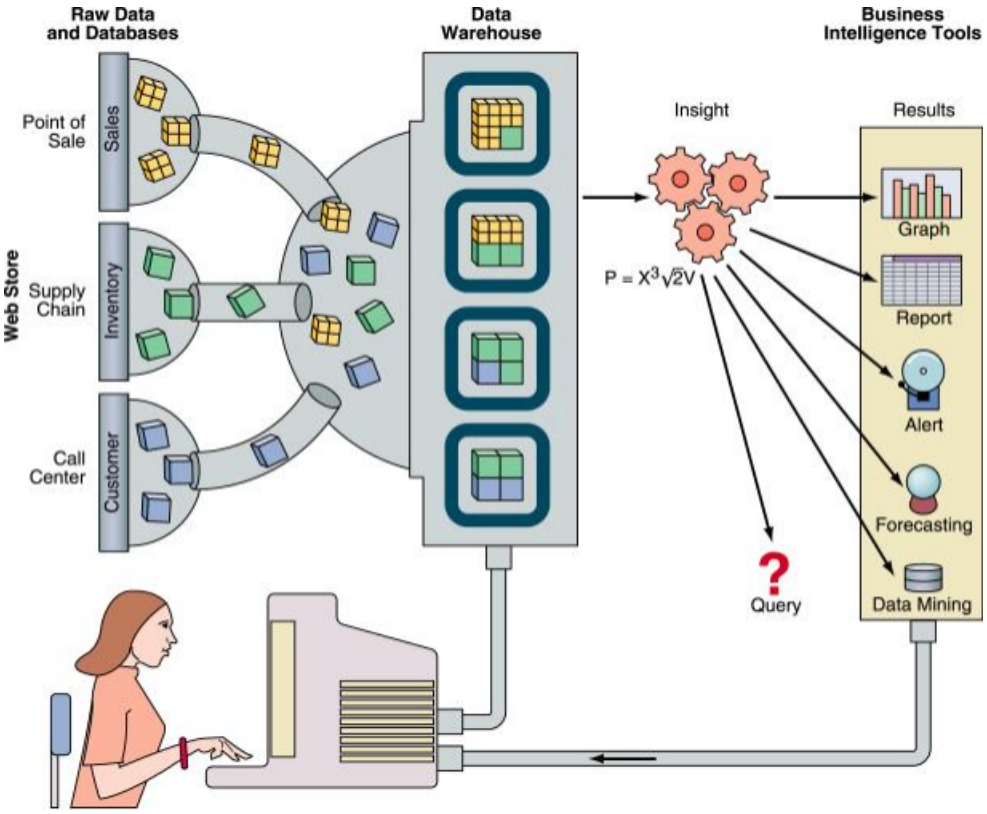
Although Luhn (1958) had already introduced the idea of BI, during the following decades the concept and functionalities of BI were developed and applied somehow by few researchers. It was only 1989 that an analyst for the Gartner Group named Howard Dresner first used the term BI to embrace concepts and methods of using mixed fact-based supporting systems, improving business decision making (Shollo &

Kautz, 2010). Afterwards, its usage became widespread in the late 1990's following the fast-paced evolution of the internet, technology, and data storage.

In the early stages of practical utilization of BI, people used to execute simple reports from data warehouses, but it didn't take too long to them to realize the powerful capabilities and possibilities of BI. They started to understand that BI could go way further then they thought. For instance, they discovered new useful functions to it, such as analyzing data statistically, disseminate graphical visualization of results, collect information about previous analysis that had been done, analyzing information over time, looking at a very large volume of data, and many others (Inmon, 2013).

Later, analyzing the development of BI, an Indian researcher named Jayanthi Ranjan developed a scientific study about BI and its concepts, components, technics and benefits. The author presented a well described the use of BI as an enabler for companies to use gathered information and quickly respond to changes in an ever-changing and fast-paced business environment. Ranjan (2009) developed as well a visual to provide a basic understanding of BI (see Figure I.3). It is interesting to look on how he presented it, in comparison with the presented by Luhn (1958) almost sixty years before.

Figure I.3 – Recent version of Business Intelligence structure scheme



Source - Ranjan J. (2009), Business Intelligence: Concepts, Components, Techniques and Benefits, Journal of Theoretical and Applied Information Technology, Vol 9. No. 1, p. 64.

Although it is clear the difference between the versions, where in the latest one it is possible to see a wider usage of the technology (software and hardware), the final output is always regarding information delivered in the best way to the user, to enable them to make decisions considering a huge range of data coming from different sources and presented in a mix of available visual aids (i.e., reports, graphs, forecasting).

Ranjan (2009) also provided a sign of development of BI. BI to the masses was a topic on trend back in the latest 2000's, which many authors were mentioning as important change on the way BI was used. It consists on the idea of making BI accessible to all levels of stakeholders, and not only to those who dominates technological and statistical tools.

Still according to the author, some examples of BI for the masses are the possibility of workers to convert their knowledges via analytical intelligence to solve some business problems by using their e-mails, telephones, and internet delivered campaigns, for instance. Analyzing potential growth customers, setting more profitable rates on products sold, and detecting fraudulent behaviors are some other examples illustrated by the author.

In the same line, Ortiz Jr. (2010) also commented about the need of extending the access of the generated documents and reports to non-management employees, in order to spread the tool beyond the technical specialists. When the access to technologies and information are reduced to a small cluster of employees inside a company, the rate of return is reduced, over the large investments that are need for those systems to run.

A complementary aspect of this idea is the fact that at that point, companies were running BI systems to provide information about past performances, and the aim was to enable it to work with real-time or predictive information. "Pervasive BI" was the term used to explain the new stage of BI, where data was generated

from different sources, mostly in real time, and widely spread across different levels of workers, in a way that more people are involved providing their knowledge and supporting managers on making their decisions, without adding significant costs to the company (Ortiz Jr., 2010).

Moving further, we can now take a look on what to expect from the development of BI and what users and researchers believe are the next step of this tools.

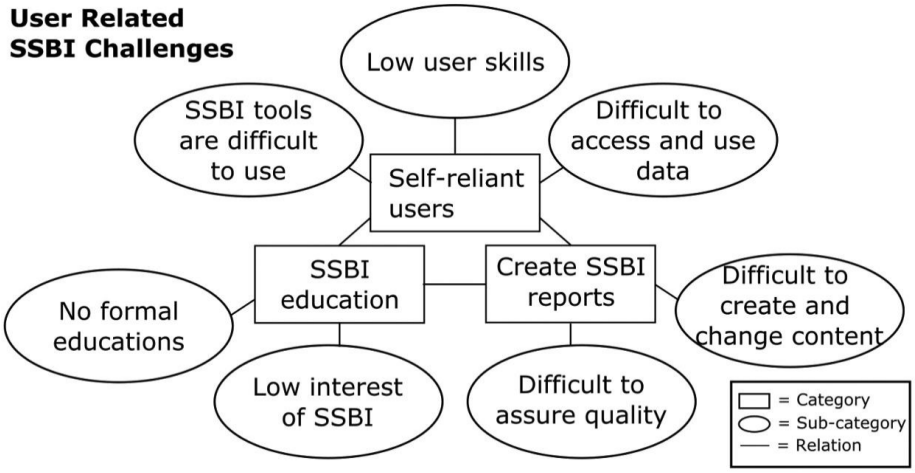
One of the trend topics about Business Intelligence is the so-called Self-Service Business Intelligence (SSBI). The idea is similar to the pervasive BI previously commented, but while in that one the focus was on start using real-time data, from different datasets and spread it to different users, the SSBI relies on the use of Artificial Intelligence (AI) and machine learning, to improve and provide an easier comprehension to everyone, including people with limited to no technical or statistical knowledge.

However, when we are dealing with people, and trying to develop accessible systems, the human factor and their boundaries become more evident, what can be a challenging factor to the evolution of the theme. Lennerholt et al. (2021) conducted a research to point the main obstacles on implementing SSBI. According to them, although implementing SSBI is really important to engage casual users and make organizations more data-driven, the whole process cannot be underestimated.

Making data sources easy to access and use, using correct data queries, defining policies for data management and governance, preparing the data for visual analytics, and controlling its distribution, integrity, and security, are few examples of challenges faced by companies and experts on spreading the utilization of BI, through a Self-Service system.

Complementing that, and moving to a user related challenges analysis, it was created a segmentation, resuming a qualitative interview, to understand what are the main barriers that companies can face on implementing new BI tools, or opening the access among non-expert users within the company (Figure I.4).

Figure I.4 – Categories and Subcategories of User Related SSBI Challenges



Source - Lennerholt, C., Van Laere, J., Söderström, E. (2021), User-related challenges of self-service business intelligence. Information Systems Management, Vol. 38 No. 4, p. 313.

It is interesting to see an overall analysis of it, and how really and simple these challenges can look for those who have a minimum understanding of data analysis or BI technology, when in the reality, the biggest part of the users is not familiar with this. If you move from a managerial office to a shift-floor, for example, you are more likely to find resistance and difficulties on spreading the new systems. So, making it in an efficient and inclusive way is also a challenge to managers who are willing to succeed on the business digitalization.

Following that, we listed the main challenges presented by the authors (see Table I.2). It can be clear that the investments cannot be focused only on buying the latest version of a software, or the most powerful data base available. Maybe more important than that are the investments made on human resources, who will be the end users of these instruments.

Table I.2 – Main challenge titles of user related SSBI challenges

Self-reliant user	
Difficult to access and use data	• Difficult to know available data sources • Difficult to locate data • Difficult to use data • Different data sources • Support is required to add data
Low user skills	• Limited competence level • Difficult to interpret report content • Limited general IT skills
SSBI tools are too difficult to use	• Difficult to use SSBI tools • Users create isolated solutions • Give the right tool to the right user
Create SSBI Reports	
Create and change content	• Difficult to create SSBI reports • Requires lots of time and manual work • Difficult to change content
Assure quality	• Difficult to assure quality of reports • Redundant reports exist • No governance of SSBI reports • Unsupported tools are used
SSBI Education	
No formal education	• No formal educations are given • Users forget how to use SSBI • Not using SSBI after education
Low interest of SSBI	• Users do not see the benefits of SSBI • Users have different technical backgrounds

Source – Lennerholt C., Van Laere J., Söderström E. (2021), User-related challenges of self-service business intelligence. Information Systems Management, Vol. 38 No. 4, pp. 309-323.

What we can resume from these information, and what has been noticed by other authors as well, is that Self-Service Business Intelligence is a great idea to make end users capable of explore data and develop BI utilities without the need of technicians intervention, however, it has not been applied on a successful way yet because of the complexity of the used tools, and the lack of interest both on end users to learn, and also on the companies on investing on development (Fink, et. al, 2017).

I.4 IMPORTANCE AND BENEFITS OF USING BUSINESS INTELLIGENCE

BI, as we saw, has been being developed and used as a powerful tool to support managers and many other stakeholders to make choices and take actions given past experiences, and projections of possible scenarios to come. We can complement the overall idea presented about BI and highlight some positive outcomes of using it in a business.

Based on historical data, BI is capable of supporting strategic decision, to show past and current performances, creating forecasts and estimating the direction the business is going, given the proposed actions. By assisting corporate performance management, applying the right application for the right operation or strategy, managing reports, and optimizing customer relations and business

activities, BI systems are responsible to provide valuable information to the right person, at the right location, at the right time and in the right format (Negash, 2004).

If we move for a Business Performance point of view, BI can provide the company several information about how they are running the business, based on the data coming from the company results. After setting its KPI's, the company can use BI tools to understand how they performed, where they could improve, or what would be the possible results if they move in a certain way or another. A few examples on what results could be bring through a BI analysis would be (Hadhoud & Salameh, 2020):

- What is the number of customers at the start, during, and at the end of a certain period?
- What kind of products aggregate more lifetime value to the customers?
- Which are the most profitable products, given margin and volume of sells?
- What is the type of your most profitable clients?
- How much is your available margin to play on acquiring new customers and still maintain your profitability?

Also, according to a research run by Hooi & Husain (2012), where they analyzed through a literature review the benefits of integrating Business Intelligence on e-commerce, the output brought by the authors about the indicated relation are that it helps on saving money and time, enable access to real time

information, significantly improving strategies planning, and helps in the decision making, with a high level of satisfaction from users of the studied organizations.

Ranjan (2009) also developed a research nominating what the use of BI can reveals and what are the benefits of it. According to her, BI shows to stakeholders how their companies are positioned in the market in comparison with competitors and what these competitors are doing, how their customers behaviors are changing, what are the market conditions, his future trends, and the capabilities of the firm to follow or not these changes. Also, from a macroeconomics point of view, how the social, political, and regulatory environmental are affecting the market.

The quoted author pointed that by using BI, the company can increase its savings eliminating lot of "guesswork", enhancing communication, and enabling businesses to better and quickly respond to changes in customer preferences, financial conditions, and supply chain operations, what we will discuss deeper following, now, in the current research.

To summarize all the concepts perceived on the literature reviewed, we prepared a table I.3 with what we consider the main benefits that companies can see when using Business Intelligence as a support tool:

Table I.3 – Summary of benefits perceived form using BI

Benefit	Description
Improves decision making	BI tools provide access to real-time data, which can help managers and executives make more informed decisions
Increases efficiency	BI can automate routine tasks and make it easier to access and analyze data, which can save time and improve productivity
Better customer insights	BI can help companies understand their customers better by providing detailed information about customer behavior and preferences
Enhances competitive advantage	BI can give companies a competitive edge by providing them with insights that can inform strategic planning and marketing efforts
Improves financial performance	BI can help companies monitor key financial metrics and identify opportunities for cost savings and revenue growth
Better risk management	BI can help companies identify and mitigate potential risks by providing visibility into key data and trends
Improves operational performance	BI can help companies optimize their operations by providing insights into key performance indicators and identifying areas for improvement

Source: The Author (2023).

Tree characteristics of BI make it possible the benefits described on the table I.3, among them, the possibility to manage diverse data namely internal an external, structural, and unstructured. The other one is based on the nature of analytics techniques, the capability to be a prescriptive and predictive supportive tool, and not merely descriptive and diagnoses analysis. The third one is the power of communication efficiently, through large range visualization techniques reports.

Regarding the possibility to manage diverse data namely internal and external, structural, and unstructured, we can bring the idea presented by Baars & Kemper (2008), where they describe the capability of BI to process both structured and unstructured data. According to them, structured data is characterized by its highly organized format, where each data element is labeled and organized into specific fields. They describe that the structure is often predefined, and the relationships between data elements are well-defined, making it easy to search, sort, filter, and analyze it using various software tools. Some examples of structured data include customer names and addresses, financial transaction records, and inventory lists.

On the other hand, unstructured or semi-structured data refer to information that doesn't fit neatly into a relational database's columns and rows. This type of data includes emails, text files, presentations, images, and videos, but can contain metadata, such as author and time of creation. This definition was presented by Elena (2011), who also sustains that developing business intelligence with unstructured or semi-structured data poses several challenges, including

accessing the data, standardizing terminology, dealing with the high volume of data, and accurately searching for information within the data. For example, simple searches may miss references to related terms and concepts.

When we talk about internal and external data, Shollo & Kautz (2010) were precise on explaining it in their research about the understanding of BI. They propose that internal data refers to data that is generated by the organization's own systems or by its employees, and it pertains to the organization's own processes, products, employees, and performance. Differently, external data is data about customers, competitors, markets, products in the market, environment, technologies, acquisitions, alliances, and suppliers, and it can be obtained from various sources such as online media, contacts outside and inside the firm, and online databases. When applied to decision-support system, the authors defend that the importance of external data can be highlighted by its impact on the industry level and the external environment level (political, economic, social, and technological).

Delving deeper into the BI capability to be a descriptive, predictive, and prescriptive supportive tool, Souza (2014), Wang et al. (2016) and Tiwari et al. (2018) highlighted the differences between the tree characteristics and the role they play in the decision-making process that will be descripted in the next paragraphs and can be visualized in the figure I.5.

Figure I.5 - Analytic techniques used in SCM

Analytics Techniques	Source	Make	Deliver	Return
Descriptive	• Supply chain mapping	• Supply chain visualization		
Predictive	• Time series methods (e.g., moving average, exponential smoothing, autoregressive models) • Linear, non-linear, and logistic regression • Data-mining techniques (e.g., cluster analysis, market basket analysis)			
Prescriptive	• Analytic hierarchy process • Game theory (e.g., auction design, contract design)	• Mixed-integer linear programming (MILP) • Non-linear programming	• Network flow algorithms • MILP • Stochastic dynamic programming	

Source: Souza G. C. (2014), Supply chain analytics. Business Horizon, Vol. 57, pp. 597.

According to them, descriptive analytics is related to the questions of what has happened, is happening, and why it is happening. By applying techniques as online analytical processing (OLAP), and with the support of visualization tools and real-time information reporting, such as Power BI, global positioning system (GPS), or radio frequency identification (RFID), managers are able to quickly identify problems and opportunities in their existing operations and take the appropriate action needed, either place replenishment and emergency orders, change transportation modes, or make adjustments to delivery schedules, for instance.

The same authors highlighted the use of predictive analytics in SC is focused on deriving demand forecasts from past data, which helps organizations understand what will be happening in the future in terms of demand for inputs, thus this information can be used to make more informed decisions about SC operations, including inventory management and production planning, employing statistical

techniques, simulation, and programming to explore data patterns and accurately predict future demand, providing reasons for the projected outcomes. Although they affirm that no statistical algorithm can predict the future with complete certainty, but the use of predictive analytics can still provide valuable insights and help organizations make more informed decisions based on data-driven insights. It can be applied across an organization, from forecasting customer behavior and purchasing patterns to identifying trends in sales activities and is a powerful tool for leveraging the value of data.

Finally, the authors illustrate the prescriptive analytics involves using data and mathematical algorithms to determine alternative decisions that can improve business performance, and look for strategies to influence using multi-criteria decision-making, optimization, and simulation techniques. However, the authors affirm that prescriptive analytics is the more complex among the other two ones, it combines descriptive and predictive analytics models with mathematical optimization models to provide decision recommendations and have the potential to impact significantly on decision-making when implemented correctly, optimizing production, scheduling, and inventorying in the SC and other areas of the business.

The last characteristic is related to the possibility of an efficient communication thanks to the wide range of data visualization tools. About this, Lousa et al. (2019) explained that data visualization is focused on the speed and

quality at which information is transferred from a machine to the human brain. They affirmed that BI tools for data visualization have data manipulation techniques that lead to the rapid perception of important information that would otherwise be difficult to observe. However, according to them, choosing the best BI tool for data visualization for an organization depends on various factors such as the organization's investment willingness, available human resources to work in a self-service mode, but the most important factor is the objective that the use of the tool will have.

Another interesting definition was presented by Jun (2020), where he sustains that data visualization is a crucial aspect of BI that involves combining enterprise data with management decisions. He says that BI systems rely on data analysis and processing at every stage, making it imperative that visualization tools provide strong support for data processing functions such as collection, integration, mining and analysis, in order to optimize the presentation of enterprise data into knowledge. The author completes his ideas by defending that, as unstructured data become increasingly important in customer and competition analysis, strengthening the ability to store, process, and analyze unstructured data has emerged as a critical development direction for the future of BI visualization. Additionally, visual predictive analysis has become an important means for enterprises to predict and present future trends.

Finally, after analyzing all the listed benefits, it is possible to say that the good use of BI, added with investments on human resources to enable end users to access it, leads the company to a certain level of competitive advantage. In other words, “BI leads to movement from data into information and from information to designed knowledge through different processes, tools and technologies and adds value to the organization. Using the obtained knowledge, the organization’s managers can opt for better decisions and operate business activities more efficiently by designing practical plans for the organization, and, consequently, they gain competitive advantage for the organization” (Eidizadeh, et. al, 2017, p. 259).

CHAPTER II

SUPPLY CHAIN MANAGEMENT: AN OVERVIEW

II.1 DEFINITION AND KEY CONCEPTS

Supply chain management (SCM) is a concept applied in every single company and kind of business, either in a small company or an international one. When there is a transaction, with a supplier and a customer, which demands any kind of activities, facilities, or processes to link the product between the parties, delivering the best value at a minimum cost, this is called supply chain management (Basu & Wright, 2008).

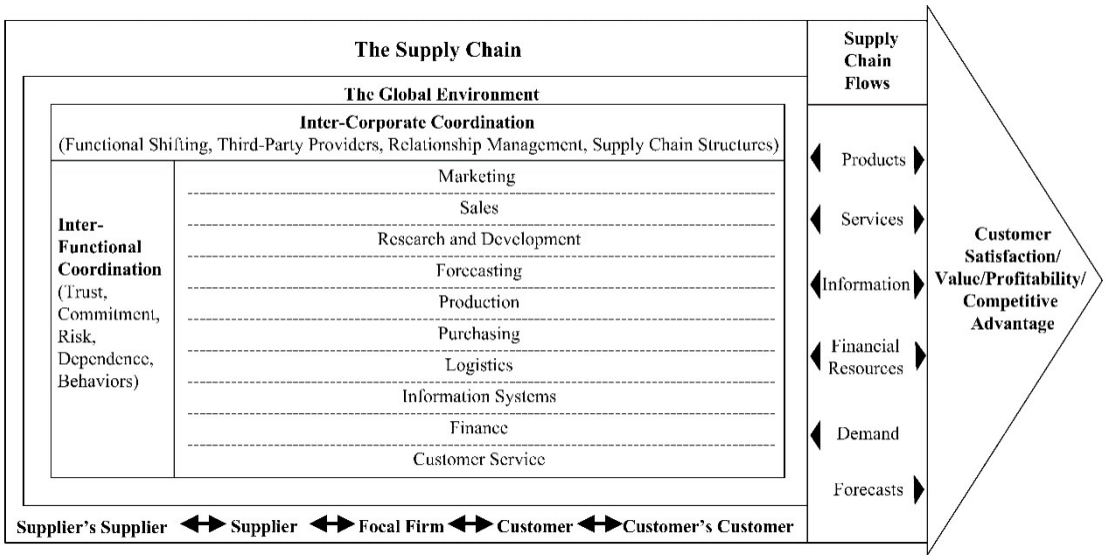
Another basic definition is that Supply Chain (SC) is a network of organizations, individuals, processes, information and resources involved in bringing a product or service from the supplier to the customer. This includes transforming raw materials into a final product and delivering it to the end-user. The various organizations in the network participate in different roles within the SC, adding value and results in the delivery of products or services to the customer (Kaina & Verma, 2018).

We can continue describing SC as a huge part of the business system, that involves many processes and stakeholders for different departments. Some other authors describe SCM as a process that enhances overseeing and organizing all

elements involved in the procurement of materials, transformation process and logistics management. This includes working closely with business partners such as suppliers, intermediaries, third-party service providers, and customers. Essentially, it brings together the management of both supply and demand within and across organizations (Ellram, et al., 2019).

Mentzer et al. (2001) created a scheme, which we can see in figure II.1, about the definition of SCM.

Figure II.1 – Supply Chain Management Scheme



Source - Mentzer J.T., DeWitt W., Keebler J.S., Min S., Nix N.W., Smith C.D., Zacharia Z.G. (2001), Defining supply chain management. *Journal of Business logistics*, Vol. 22 No.2, pp.1-25.

According to them, SCM involves coordination across multiple firms and business activities, with the goal of improving long-term performance for both individual companies and the entire SD. This encompasses the traditional business

functions of marketing, sales, R&D, forecasting, production, procurement, logistics, IT, finance, and customer service. The SC can be seen as a pipeline, with flows of products, services, financial resources, information, and demand forecasts being managed and optimized for customer value and satisfaction. This is critical for achieving competitive advantage and profitability for both individual companies and the SC as a whole.

SCM encompasses not only the management of the flow of goods, data, and finances from point of origin to final destination along the SC, but also the reverse flow of information, who provides the necessary data and feedback about the transactions, allowing companies to better prepare themselves and maintain a good level of continuity of their operations (Habib, 2011).

It is important to highlight as well that effectiveness is also part of SCM concept. Companies must focus on reaching customers' needs by providing high level of services in all levels of the business structure, as described by the following authors: "The process of planning, implementing, and controlling the operations of the SC with the purpose to satisfy customer requirements as efficiently as possible. SCM spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point-of-origin to point-of-consumption" (Martins & Pato, 2019), and: "A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The SC not only includes the manufacturer and

suppliers, but also transporters, warehouses, retailers, and customers themselves" (Chopra & Meindl, 2013).

Before moving further into the definitions of SCM, is important to make a note about the difference between the concepts of SCM and the concepts of Logistics. Although they may present some similarities, SCM and traditional logistics are distinct from each other. Logistics refers to the internal operations of a single organization, while SCM encompasses a collaborative network of companies working together to bring a product to market. While logistics focuses on procurement, distribution, maintenance, and inventory management, SCM encompasses these traditional logistics activities and also includes marketing, product development, finance, and customer service (Hugos, 2018). Also, to exemplify the difference, we can describe the difference saying that "Logistics is a planning orientation and framework that seeks to create a single plan for the flow of products and information through a business, while SCM builds upon this framework and seeks to achieve linkage and coordination between the processes of other entities of the pipeline, i.e. suppliers and customers and the organization itself" (Mukhamedjanova, 2020, p. 762).

We can see this differentiation of concepts when we move from a limited focus on logistics processes, to widespread inter-departments concern during the whole operation (Basu & Wright, 2008).

As already described, SCM embraces several activities within the business, this creates the link to a plenty of concepts linked to it, moving further now, we can start looking into the actual application of SCM, and given the huge range of possibilities. Further on this chapter, we will present the main applications and the importance of develop a SCM with excellence within companies.

II.2 IMPORTANCE OF A GOOD SUPPLY CHAIN MANAGEMENT IN BUSINESS

In the previous point we could understand that an effective SCM is crucial to the success of a company. It encompasses every stage of product creation and delivery, and a weak link in this area can result in significant financial losses.

The SC connects various departments within a company, streamlining and optimizing production and strategies, fostering better relationships with suppliers, and enhancing delivery to customers. It means also that SCM assists the business organization to compete in the dynamic international market, with a clear objective of incorporate activities across and within organizations for providing the customer value (Habib, 2011).

According to Basu & Wright (2008), from services to manufacturing, even in non-profit organizations, it is possible to see the demand for a good SCM, it is always based on providing the best solution in the best way for the end user/customer. The authors illustrate SCM in non-profit organizations allows for

quick response to unpredictable demands, and in service the SCM includes suppliers, products/services, customers, and service level agreements, and the service inventory can be informational databases, consumables, stationery, and subcontracted services. The same authors affirm manufacturing, SCM considers demand, supply, and inventory needs for each production item to deliver output efficiently to customers at the lowest cost and on time. Resuming it, in all of these types of "business", the consensus is that the focus is on providing the best solution for the final user/customer.

On the following sections, we will highlight some key areas where SCM is more commonly applied in companies and their specific definitions.

II.2.1 Procurement

This area involves the sourcing and purchasing of raw materials, parts, and components that are used in the production of goods. It includes activities such as supplier selection, negotiation, and contract management. Actually, from a SCM point of view, procurement involves more than just acquiring a product. The primary goal is to have the necessary materials readily available for production, processing, storage, and retail. This means having the right product, at the right time, at the right price, in the right place. There is also a relationship factor linked to this concept. For some crucial products, for example, the best approach is to build strong partnerships with suppliers, and for suppliers to proactively create

relationships with customers, looking forward on building alliances and long-term relationships, that will provide the whole chain some competitive advantage (Basu & Wright, 2008).

II.2.2 Production, Planning and Control

In this area, SCM is about managing of the production process, including the scheduling and coordination of production activities, inventory management, and quality control. In other words, and according to Hugos (2018), managers face the challenge of balancing responsiveness and efficiency SCM in production decisions. An abundance of excess capacity allows for greater flexibility and prompt adjustments to fluctuating product demand. Conversely, facilities operating at full capacity struggle to adapt to demand changes. Excess capacity incurs cost and yields no revenue as it remains unused, leading to lower efficiency.

II.2.3 Distribution and Logistics

This involves the movement of goods from the point of origin to the point of consumption, including transportation, warehousing, and distribution. It also includes the management of logistics service providers, such as third-party logistics providers (Hugos, 2018)

According to Mukhamedjanova (2020), the establishment of a SC relies on the selection of logistics channels that link the supplier and consumer of the material flow, when the final composition of participants is not determined until

specific organizations are chosen to become part of the SC, effectively transforming the logistics into a functioning tool. This selection process involves considerations such as the participation of intermediaries, the number of them, their operating conditions, transportation methods, and the choice of carriers, warehouses, insurance companies, and more.

The Author also mention that it is important to remember that the choice of the SC has a significant impact on the cost of the material flow and the options available are dependent on the size of entities providing logistics services and the quality of the infrastructure.

II.2.4 Sales and Operations Planning

In this area, a good coordination of sales, marketing, and operations activities, creates an alignment among all the business, in order to match supply and demand, and to ensure that customer demand is met in a timely and efficient manner, without leaving behind the good relationship with the supplier through an efficient inter-organizational information system (Thomé et al., 2011)

There are many positive outcomes for a company when sales and operation planning are running within a good SCM basis, where improvements to the process can be done by implementing a comprehensive and integrated planning process that balances sales and operations, providing a more accurate and synchronized view of the business. There are a few positive outputs for this good SCM, such as a shorter

lead time for customers, a decrease in stock-outs or back-orders, lower inventory levels, and improved responsiveness to changes in demand and supply disruptions (Goh & Eldridge, 2019).

To complement this concept, Basu & Wright (2008) presented the idea that within the operations planning, there are some existing techniques, such as the materials requirement planning (MRP), that calculate the quantity and timing of materials needed based on bills of material, inventory, production schedule, and resource availability. According to them, it all starts with a business plan, is created based on sales estimates, leading to an operations plan covering materials and resources, where a regular communication is an important tool to keep the plan in line with updates to the business plan.

II.2.5 Sustainability and Risk Management

This involves the management of environmental, social, and ethical issues throughout the SC, as well as the identification and management of risks such as natural disasters, pandemics, and geopolitical instability.

The United Nations defined sustainability as development that satisfies current needs without hindering future generations from fulfilling their own needs. This definition emphasizes the distinction between "needs" and "limitations," a crucial aspect in sustainability discussions (Martins & Pato, 2019).

Giving the previous definition and considering also that the global economy's growth has accelerated environmental deterioration due to overconsumption and overproduction, SCM has an important role on developing conducts to minimize those impacts on our environment. Both consumers and producers, through unsustainable practices, contribute to socio-environmental problems. SC can improve their performance by motivating consumer behavior toward green consumption, which motivates producers to change operations (Taghikhah et al., 2019).

According to research developed by Koberg & Longoni (2019), a sustainable SCM balances profitability with the impact of a company's operations on the environment and society. It involves managing flows and considering sustainable development goals from all three dimensions. Sustainability outcomes include adopting environmentally and socially responsible practices and achieving environmental, social, or economic performance, such as pollution control, environmental management systems, compliance with labor laws, adoption of social standards, and certifications like different ISO's.

The risk management perspective fits on SCM when there is the need for create a reliable and efficient SC. It goes from ensuring a good flow of the chain (transportation, warehousing, distribution, and so on), until ensuring the compliance from suppliers and customers when related to sustainability and all the other required legislation. The SCM plays a crucial role in managing the firm's supply

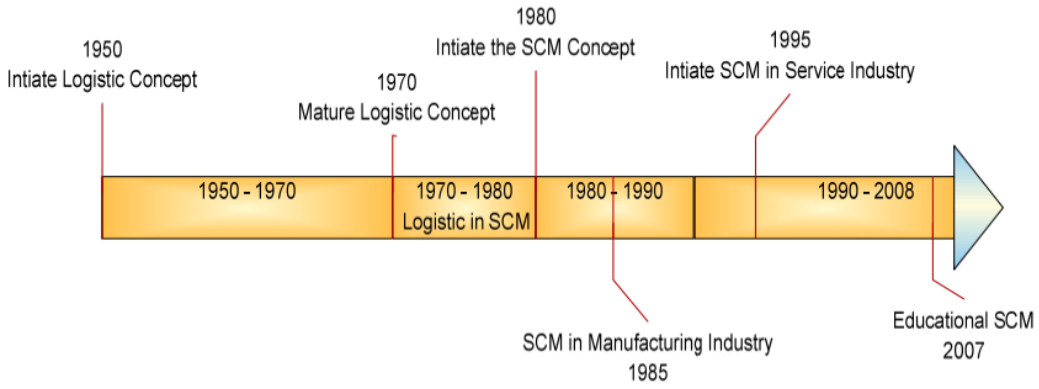
network and resources and defining the origin of raw materials and products. Hence, it is important to find innovative, responsible suppliers who can provide sustainable and legal solutions, following all the policymaker's regulations existing for each kind of business (Lintukangas et al., 2016).

II.3 HISTORICAL EVOLUTION AND FUTURE PERSPECTIVES

SCM has a long history dating back to ancient civilizations when people started to produce and trade goods. These ideas of logistics management where very related to military conduct. During the ancient Greek and Roman empires there were the knowns as "logistics", military officials responsible for supplying and distributing resources and services, played a crucial role in determining the outcome of wars. Also, during World War II, the efficiency of the logistics systems of the United States and its allies proved decisive, with their ability to supply troops with necessary resources at the right time and place. This led to the development of new and advanced military logistics techniques, marking the evolution of logistics as both an art and a science (Farahani et al., 2011).

Back in time, Napoleon, a master strategist and skilled general, recognized the importance of an efficient SC when he famously said, "An army marches on its stomach." This shows that he understood that unless soldiers are fed, and satisfied, an army cannot move forward (Hugos, 2018).

Figure II.2 – Timeline of SCM research and development



Source - Habib M., Jungthirapanich C. (2008), An Integrated Framework for Research and Education Supply Chain for the Universities. In: Proceedings of the *4th IEEE International Conference on Management of Innovation and Technology,* Bangkok, 24 September, 2008.

However, the formal concept of SCM as we know it today evolved relatively recently. In the early 20th century, businesses began to focus on efficiency and productivity, which led to the development of new management techniques. As we can see in figure II.2, although the concept of logistics and SCM were developed mostly inside the manufacturing industry, over the years it has evolved drastically and in a high speed until it reaches other industries, extending it until the educational system, as a means for strategic planning in tertiary education (Habib & Jungthirapanich, 2008).

In 1958, Forrester recognized that management is close to a major breakthrough in comprehending the connection between the success of industrial companies and the interplay between the flows of information, materials, money,

manpower, and capital equipment. The interlocking nature of these five flow systems, which can amplify each other and bring about change and fluctuation, will serve as the foundation for predicting the consequences of decisions, policies, organizational structures, and investment decisions.

Moving to the earlies 80's, the intense global competition in the textile and apparel industry led to the formation of a local council in the USA, whom, in response to SC challenges, conducted in 1985 an analysis to understand that problem. The study revealed a 66-week long SC with 40 weeks spent in warehouses or transit, leading to significant losses for the industry. This led to the development of a strategy called Quick Response (QR), where retailers and suppliers collaborate to respond more efficiently to consumer needs through shared information. It consisted on applying some technics in the process as standardization of information and investments on technological improvements, what would then lead to maximize profitability by making informed decisions based on sales data and incorporating marketing information (Lummus & Vokurka, 1999).

In the 90's, in order to follow the fast-paced evolution of competition among industries, and to match the need for integration between different fields of a business, the concept of SCM became more popular and known across the literature. Drucker & Marciariello (1999, p. 19) said that "It is crucial for management to gather information from outside the organization to be effective. Many transformative changes in enterprises come from outside their specific

industry. This information is not solely stored in an industry's computers. Building data networks and knowledge management systems that connect databases and provide direct access to relevant information across the global supply chain is also crucial."

Still in the 1990's, several industry groups have formed to study SCM, providing practitioners with "best practices" guidelines. With more than 300 members from some of the world's largest manufacturers and supported by a consortium of businesses, non-profit groups, and academic institutions, they developed the study in order to improve and standardize communication and business processes in manufacturing SCs, primarily for small and medium-sized businesses (Lummus & Vokurka, 1999).

The same authors also presented some examples of the companies that were part of this group of development, and their actions on implementing the SCM idea on their operations, such as:

- **Walmart**:

The company started its SC initiative by collaborating with key manufacturers. The manufacturers manage the company's warehouse inventory of their products through Vendor Managed Inventory (VMI) and are expected to provide near 100% order fulfillment rates. Other large retailers such as KMart have also implemented similar VMI programs.

- **Whirlpool:**

In 1992, the appliance manufacturer initiated its SC implementation with a team of executives and the vision of being linked in a short cycle response mode to the customer. The company created a new vice-president of logistics position, formed cross-functional teams, entered into single-source agreements with reliable suppliers, and implemented EDI communication to improve SCM. This resulted in improved product availability (90-95%), reduced inventories (15-20%), and shortened lead times (as low as five days).

- **Georgia-Pacific**

The company started implementing SCM practices in its decentralized operations. Before this, traffic managers in each division managed inbound and outbound shipments, leading to fragmented shipping priorities and dissatisfaction among internal and external customers. To solve it, a centralized division was created to coordinate and streamline the distribution process, resulting in annual savings of $20 million through reduced freight costs and other logistics improvements.

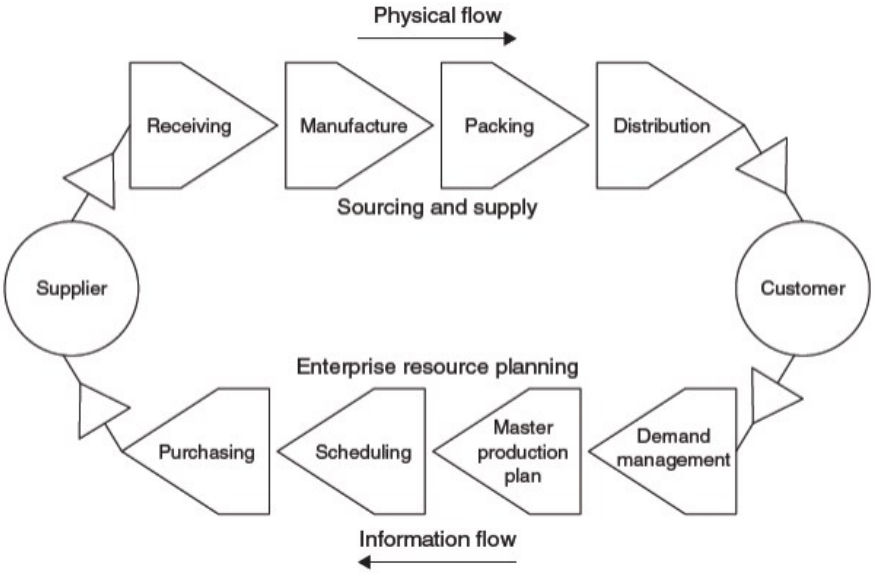
- **Hewlett-Packard**

In the early 1990s, the computer components manufacturer linked its distribution and manufacturing activities in the computer terminal business. This implementation involved changes in the physical distribution of the product and the introduction of a new Distribution Requirements Planning (DRP) system. The DRP

system integrates customer orders with forecasts, serving as the starting point of the SC.

To emphasize it, as we already saw, the idea of viewing the SC as a single, integrated flow across all business functions is relatively recent. Previously, SC activities were seen as separate, specialized functions such as purchasing, planning, scheduling, manufacturing, and distribution. SCM now views the flow of materials and information as a single process, transcending traditional functional boundaries (Sarkis, 2012). In the past, information flow was managed by the commercial division while material conversion was the responsibility of the manufacturing or technical division. With an integrated SC approach, responsibility for all aspects of supply now lies with operations management or SC management (Basu & Wright, 2008). We can see these flows on the following figure II.3.

Figure II.3 – Supply Chain Management Flow



Source – Basu R., Wright J. N. (2008), *Total Supply Chain Management*, first edition, Butterworth-Heinemann, Oxford, OX.

When we move the focus to the present and future of SCM, it is inevitable not to consider technological evolution. Min et al. (2019) summarizes the present and future of this tool by stating that, since the beginning of the concept of SCM, and even with the technological advances and the brutal changes in the market trend, SCM is still strategic in its nature, its purpose is still to create value to the customer, and its core is still about interorganizational collaboration. And according to them, for now and for the future (besides the informatization and digital evolution as already seen), instead of asking "what is the ideal SC for companies," it is more important to consider "what is the optimal SC for customers." In a digital and sustainable economy, there is no one-size-fits-all approach to managed SCs or inter-

company partnerships. Instead, we should anticipate the evolution of various SC configurations and partnership models that continuously cater to customers in the best possible way. In the next section, it will be highlighted more in depth how SCM is going to be affected by digitalization and automation.

II.4 TOWARDS DIGITALIZATION AND AUTOMATION IN SUPPLY CHAIN MANAGEMENT

Digitalization and automation involve the use of digital technologies such as big data, predictive analytics, artificial intelligence, and the internet of things (IoT) to improve decision-making, automate processes, and increase SC visibility.

Coyle et al. (2016) presented in their book how technology has greatly impacted SCM, facilitating change and transforming processes for companies. According to them, some of the outputs of this digitalization are as follows:

- It changed the dynamics of the marketplace by enabling 24/7 connectivity and instant access to information through the Internet and search engines like Google.
- It has been noticed that social networks such as Facebook and Twitter are increasingly affecting SC through their impact on customer demand and fast information transfers.
- Companies are able to use social media to gather demand-related information for improved forecasting and marketing.

- Cloud computing is revolutionizing information systems and allowing individuals and smaller organizations to access the world's knowledge for collaboration in SC.
- It has enabled outsourcing to less-developed countries and increased collaboration and market opportunities globally.
- Companies like Uber and Airbnb have been created and disrupted their respective markets due to technology.

Information technology also supports internal operations and inter-company collaboration in the SC. By sharing data via high-speed networks and databases, companies can improve SCM and their own positions. Effective use of this technology is crucial for a company's success. Information systems have three main functions: data capture/communication, storage/retrieval, and manipulation/reporting. The specific combination of functions depends on the job requirements of the system, and those used for SCM are a combination of these three functions (Hugos, 2018).

Technologies for sharing and analyzing information in the SC are abundant. It's up to managers to determine which to employ and how to incorporate them into their SC operations. According to Chopra & Meindl (2013), a few examples of these technologies include:

- ERP (Enterprise Resource Planning)
- CRM (Customer Relationship Management)

- APS (Advanced Planning and Scheduling)
- MES (Manufacturing Execution Systems)
- WMS (Warehouse Management Systems)
- Transportation Scheduling Systems
- Inventory Management Systems
- Transportation Planning Systems
- Procurement Systems
- Demand Planning Systems

It is not possible to talk about digitalization and automation in SCM without going thru the Artificial Intelligence (AI) aspect. We can briefly talk about it introducing the research made by Toorajipour et al. (2021), where they run a systematic literature review and realized that AI has a natural fit in SCM, where large amounts of data and agile decision-making are present. AI can be used for big data analysis and decision support systems, optimizing networks, and improving orchestration. Interactive decision-making systems can further improve AI capabilities and help transition operations from reactive to proactive and manual to autonomous. Advances in computer chip technology and tracking are also essential for widespread use of AI in the SCM.

Following the automation and digitalization topic, it is important to introduce the usage of BI in the SCM. About this subject, Dughi (2022) said that the effective management of SC is critical for companies, as it can account for up

to half the value of their products or services. Poor management leads to persistent issues, such as decreased market resilience, efficiency, inventory, and financial performance. By mapping and monitoring the flow of goods, businesses can gain insight into the SC and anticipate potential concerns.

The author mentioned above still lists some benefits offered by utilizing BI tools in SCM, including easy data collection and sharing for remote teams, real-time data analysis, low upfront and total ownership costs, improved collaboration, customizable for users, and the ability for non-technical users to create interactive reports and dashboards (Dughi, 2022).

In the next chapter, it will be explored deeply the correlation between BI and SCM, which is the main goal of this study.

CHAPTER III

BUSINESS INTELLIGENCE IN SUPPLY CHAIN MANAGEMENT

The "relationship" between BI and SCM is a topic discussed already since the earlies 2000's, when Sahay and Ranjan (2008) said that most companies were interested in investing in BI systems, despite significant investments in ERP, SCM, and CRM systems over the precedent decade. They justify saying that those systems may not capture the necessary information to achieve a competitive advantage. According to them, every business needs quick and appropriate access to information to make operational decisions, such as marketing seasonal merchandise or providing personalized recommendations to customers. Smarter business processes, powered by BI, can significantly impact the bottom line and add value to any organization.

In the field of SCM, many activities benefit from real-time monitoring of operational data. BI tools allow for the improvement of activities such as demand forecasting, pricing determination, distribution planning, supplier selection, SC design and reengineering, uncertainty and risk mitigation, increased capacity and responsiveness, as well as greater accuracy in decision-making (Toorajipour et al., 2021).

In many cases, the importance of using IT, including BI, to achieve success in logistics activities was highlighted, as well as the need for integration among all participants in the SC. That means that understanding external factors that impact

the market in which they operate plays a crucial role in predicting market behavior, as well as in the responsiveness that suppliers and distributors must have to react to unexpected events and uncertainties, cooperating for an efficient SCM (Tozin & Amaro, 2022).

Further in this chapter, we are going to understand recent problems faced by companies on running their SC, and how they benefit from BI and data analysis tools.

III.1 RECENT CHALLENGES ON SCM FACED BY COMPANIES

Recently, the COVID-19 pandemic has presented a major threat to public health, leading many countries to implement partial shutdowns of their economies in order to prevent the spread of infections. These actions have caused widespread disruptions in both global and local supply chains, impacting all kind of materials and services supplying, which could make worsen the situation (Guan et al., 2020). For instance, when the health medicines and the food supply chain were affected, the impact on people's resistance to the virus was compromised. To fight against these disruptions, and restore these supply chains to their prior levels, fast and assertive actions were needed (Mahajah & Tomar, 2021).

Santhi & Muthuswamy (2022) ran a study to understand how technology can be useful to overcome periods like the one we recently faced. Based on to their study, while it can be challenging to anticipate the extent of disruptions during global events, leveraging Industry 4.0 technologies, including BI, can provide

supply chains with the flexibility, visibility, and durability needed to be adequately prepared.

Unforeseen events can disrupt the supply chain, causing significant impacts, and in order to respond effectively and seize opportunities, organizations with access to BI should have the capability to anticipate changes and adjust their operations, but this requires integrating business processes within and outside the firm (Obidat et al., 2023).

In the following topics, we will be discussing how the already presented topics of BI and SCM can merge in order to reach the best solution to a company. We will also see what are the barriers that could make this arrangement, so in future managerial applications, this concepts can be analyzed and avoided.

III.2 BENEFITS OF USING BI SYSTEMS IN SCM CONTEXTS

III.2.1 Demand Forecast e Accurate Production Planning

BI can support production by integrating data from diverse sources, analyzing it from multiple viewpoints, and transforming it into actionable knowledge. SCM systems offer an integrated environment for producers to obtain reliable and timely information, enabling smart decision-making and improving enterprise competitiveness. Hence, by leveraging BI tools, companies can optimize their supply chain operations and production efficiency, and this, in turn, helps them

make better decisions, enhancing their competitiveness in the market (Rabelo & Pereira-Klen, 2002)

The combination of big data and BI has the potential to bring significant benefits to the logistics industry. For carriers, the use of big data and BI can lead to improved delivery times by considering variables such as weather, driver characteristics, and time of day and date. For manufacturers, the use of big data and BI can enable early responses to extremely negative or positive customer feedback. For retailers, big data and BI can provide valuable customer sentiment data and facilitate the use of mobile devices in stores (Waller & Fawcett, 2013).

Nguyen et al. (2017) have presented a research offering many insights into capturing real-time demand changes. The authors sustain that both BI and big data analytics can play a role in detecting demand behaviors and improving the accuracy of demand forecasting, also, another way that it can be applied in demand management is by shaping demand to match production and logistics capacity, doing it by making available data from different sources (internal and external), in an accessible visualization, within different levels of stakeholders.

From a customer point of view, BI tools and platforms are vital intermediaries in the evolving business landscape, connecting businesses' offerings with customer needs in a digital, data-driven environment. Their practices are centered on transparency and built on top of existing operational efficiencies. The influence of BI and others recent kinds of technologies in the expansion of new technological

business models is on the rise, with a growing emphasis on efficiently matching supply with demand in the most convenient manner (Kumar et al., 2021).

With the rise of technology that tracks materials and products, the accuracy of production planning in industries applying digital concepts is greatly improved. Real-time tracking of material flows such as inbound and outbound at a sales point enables a more precise understanding of demand patterns. This can lead to a reduction or elimination of deterministic production planning as material flows are tracked with greater precision. When a product is sold or consumed at a point in the supply chain, all relevant stakeholders are immediately notified and adjust their production accordingly to meet current demand. This helps to prevent or mitigate "bullwhip-effects" since all parties have access to the same real-time information. These notifications can be easily spread within all the stakeholders with the utilization of BI tools, capable of reach different levels of decision makers (Hofmann & Rusch, 2017).

Fu & Chien (2019) developed a study where they have created a way to predict demand for components in the manufacturing industry using a combination of data analysis, artificial and BI. The method was tested and proved to be more accurate than industrial practical models, time-series and machine learning models, that are dominant currently. The findings suggest that using this technological approach can help improve demand forecasting in the supply chain, leading to more efficient production and a competitive advantage for companies.

III.2.2 Warehousing and distribution management

In order to achieve a competitive advantage, enterprises must view inventory management as a crucial tool for efficient order fulfillment and stock replenishment planning. This helps optimize the utilization of assets and ensures timely and appropriate supply to meet market demands. By effectively aligning orders with fluctuations in customer demands and smoothly adjusting product planning, these enterprises can maintain or gain market share against their competitors (Naeini et al., 2019).

BI is expected to lower the information processing requirements by improving forecast accuracy and reducing inventory slack. Some researchers believe safety stocks will be minimal as BI leads to more dynamic and adaptive supply chains, However, they may still be necessary due to residual risk of unpredictable demand patterns. More efficient warehousing, just-in-time supply chains, and demand-driven production are also expected outcomes (Roßmann, et al., 2018).

Govindan et al. (2022) discusses how manufacturers can improve their warehousing operations through the use of advanced technologies. They said that by utilizing horizontal integration with customers and suppliers, manufacturers can gather more accurate information to optimize their warehouse resources, which can reduce inefficiencies and costs. According to the authors, different tools embraced on BI definition can be used to provide real-time user interfaces, to create digital

picking lists to help warehouse employees find objects faster and more accurately, implement systems that can track and manage inventory, and analyze data for proactive building management. They sustain that these technologies collectively fall under the umbrella of BI, which enables manufacturers to be more agile and responsive to customers' needs.

At this point, it is still relevant to discuss distribution center operations, where good communication and transparency in data lead to better operational efficiency and, consequently, better results in logistics operations. This has a positive impact through reduced costs and losses (Nguyen et al., 2017).

BI tools can enhance cargo control processes by integrating data from different sources, applying data analytics techniques to analyze data, providing real-time monitoring of cargo and shipment, tracking and measuring performance metrics, and presenting data in a user-friendly and interactive way, as consequence, by utilizing BI tools, cargo control processes can benefit from better decision-making, operational efficiency, and reduced costs (Václav, et al., 2021).

To enhance normal and reverse logistics, organizations can use BI tools, such as data mining, machine learning, and predictive analytics, to analyze returned products and provide accurate and timely information. This integration of BI in the logistics system enables greater control over the distribution channels of returned products, resulting in a complete closed-loop logistics system, what can become conducive to the effective operation of the entire system. Additionally, it is a

positive solution when adding some others IT tools to work together with BI in order to track returned products and evaluate their value and overall cost (Rejeb, et al., 2020).

III.2.3 Communication and collaboration between parties

Managing knowledge assets is critical for modern SCM. Following this idea Ribeiro et al. (2019) stated that BI tools can help facilitate open communication and knowledge networks, improving competitiveness and overall SC efficiency. According to them, however, open networks also present a significant challenge in protecting commercial interests. They say that leveraging BI to provide the right information to the right people can significantly enhance productivity, and they keep defending that organizations need to focus on managing knowledge assets, using BI to facilitate open communication, implementing an effective data storage and mining system to enhance inter-business relations and protect commercial interests and maximize productivity.

A collaborative SCM rely on the sharing and integration of data from external partners to aid in decision-making processes, according to Wang et al. (2016). The authors sustain that this integration of external data with internal decision-making processes can be seen as a form of BI, as it allows companies to gather and analyze relevant data to make informed decisions and achieve better supply chain integration. Additionally, they suggest that the use of formal

quantitative methodologies and sensitivity analysis further supports the application of BI principles in the context of SC collaboration.

A BI network can benefit SCM by facilitating the sharing of business information between companies operating in the same SC or market. This can help users to monitor inter-company processes and accurately control markets. The core idea of this network is to enable users to access and analyze shared data quickly and efficiently through specific queries, which can be processed on the data warehouses of each involved peer, allowing more effective and efficient SCM through improved information sharing and analysis, leading to better decision-making and business performance (Rizzi, 2012).

Although the collaboration and communication withing parties in the SC can bring enormous benefits it is expensive and challenging as well, according to Krmac (2011). The author believes that successful SCM integration requires trust and a shared strategy, with effective management of alliances, data, and information systems being essential, what turns to be collaborative effort that requires investment. The author also says that, despite the challenges, an integrated supply chain can improve operational efficiency, reduce costs, and enhance competitiveness.

Reinforcing this aspect, Tongzhu et al. (2017) agreed on saying that a collaborative BI enables enterprise managers to view data and knowledge in a cooperative manner, it can help SCM on promoting business collaboration,

improving logistics management, reducing costs, and increasing service quality. They also suggest that by transforming enterprise data into shared insights, collaborative BI can help SC managers make better decisions and achieve their goals more effectively.

III.2.4 Supply chain agility and responsiveness

As rapidly as technology advances, it is imperative that we respond to disruptions and unpredictable events with equal speed. The analysis of data has been demonstrated to be a vital tool in anticipating and managing these critical moments (Rejeb, et al., 2020). While it can be challenging to predict the extent of disruptions during global events, it is feasible to be prepared by utilizing tools and technologies (including BI) that can provide the supply chain with agility, transparency, and resilience (Santhi & Muthuswamy, 2022).

Obidat et al. (2023) run a research on how the agility of supply chains are affected by using BI. The study found that BI managerial, cultural, and technical competences have a significant positive impact on supply chain agility. According to them, organizations should aim to cultivate a culture that values information and knowledge, maintain a strong BI infrastructure, and provide staff with the necessary training. Management and employees should continuously gather and analyze information, make decisions based on reliable and verified data, and collaborate with partners to build trust. The objective of these actions is to ensure that

information and knowledge are efficiently managed in real-time to support agile supply chain operations.

The International Journal of Supply Chain Management published a research developed in 2021 to demonstrate the positive impact of using BI to make SCM more agile. After running a survey and compare with old publications, they stated that “Business intelligence competence has a significant influence on supply chain responsiveness and agile performance. In short, these findings of this study presented business intelligence are strongly affecting the responsiveness of the supply chain and the agile performance in the logistics industry. Therefore, increasing business intelligence competence of the company will enhance the performance of the company response speed and agile performance” (Kaur, 2021, p. 47).

Giannakis et al. (2019) defend that within the various BI tools and sources, the "dashboards" presentations offer a powerful data visualization that provides a comprehensive and easy-to-understand overview of the current state of the supply chain. They continue saying that by consolidating a wide range of analytics, including metrics, KPIs, and performance scorecards onto a single screen, users can quickly and proactively identify trends and exceptions as they happen, so, this real-time monitoring provides organizations a competitive advantage by enabling them to respond rapidly to any issues that arise, ensuring their supply chain operates smoothly and efficiently.

Therefore, as already mentioned, BI focuses on business analysis and offers a unique advantage of being easily accessible and user-friendly for managers and directors from different areas and departments. Gonçales Filho & da Silva (2021) suggest that through BI, organizations can continually broaden their understanding of the business and market, stay vigilant of market changes, monitor competitors, and identify new opportunities in their field of operation, being agile and responding changes with quickness.

III.2.5 Improvements and efficiency on productivity and logistics

Managing data properly impacts logistic movements of material shipments and receipts. Business productivity can also benefit from the use of BI tools. IT integrated into production through data disclosure, storage, and sharing influences the decisions made by managers, resulting in better execution in the manufacturing process, with a focus on cost reduction and improvement of production processes (Naeini et al., 2019).

To understand how companies can reach these results, Jin & Kim (2018) developed a research with practical application of BI tools in courier companies. As a result, they realized that efficiency in the business logistics can be enhanced by analyzing big data and applying BI, because the key to deriving value from big data is in how the data is utilized and transformed into valuable information. According to them, BI and big data should be integrated into the management

decision support system as a whole, and by leveraging big data and BI, enterprises can increase productivity, maintain market share, and ensure sustainable growth and competitiveness.

When data is properly analyzed, organizations can gain valuable insights into their operations, which can lead to improvements in production performance, and it means that BI becomes a critical tool for businesses looking to stay competitive in today's fast-paced, data-driven environment, resulting in improvement in efficiency and effectiveness not only on production, but in all levels of the organization (Kaur, 2021).

Pistikopoulos et al. (2021) describe that minimizing costs, reducing utilities consumption, and optimizing stock levels are some of the goals pursued within productions and logistics operations, and to achieve these goals, BI techniques play a key role, especially when dealing with batch processes where the presence of multipurpose resources calls for their optimized usage while exploring operations flexibility to deal with the production of several competing product recipes. Additionally, they said that those tools are capable of improving complex SC, incorporating and refining the activities on a set of interrelated entities responsible for the sourcing, production, and distribution of a large set of products.

Studying the benefits of BI in the lean aspect of production and logistics, Lizotte-Latendresse & Beauregard (2018) pointed that self-service BI can help to improve manufacturing organizations in several ways. First, it can enable faster and

more informed decision-making by providing real-time data and insights to employees across all levels of the organization. Second, self-service BI can help identify opportunities for process improvement and waste reduction, which are key tenets of lean production. Finally, by promoting data literacy and a culture of continuous improvement, self-service BI can help drive organizational change and promote a more agile and adaptable production and logistics environment.

III.2.6 Innovation ability

As already mentioned, one of the benefits from BI tools is the ability of provide up-to-date information to support decision making. When there is the use of an integrated forecast with temporal aggregation, is possible to support demand management for flexible decision making and supply chain innovation, and this can empower developing countries and companies to innovate their supply chains and compete globally, leading to the implementation of intellectual development strategies and upgrading of their industry (Fu & Chien, 2019).

Gonçales Filho & da Silva (2021) developed a research to analyze the influence of IT, and its similar, on SCM. The authors realized that effective data management is crucial for successful SCM and is also a key aspect of BI. According to them, with BI, managers can easily understand their organization's operations, monitor market trends, identify opportunities in their industry, and by leveraging the insights provided by BI, companies can make informed decisions, improve their

overall performance, and stay ahead of the curve in an increasingly competitive marketplace. Thus, implementing IT systems for data management enables companies to make innovation inevitable, a critical factor in modern SCM.

According to Shanti and Muthuswamy (2022), while successful supply chain strategies such as offshoring manufacturing to low-cost countries, minimal inventory management, and just-in-time production have been effective, they can fail during unforeseen events like pandemics, wars, and natural disasters. However, they sustain that advanced Industry 4.0 technologies like AI, Internet of Things (IoT), Big Data Analytics and BI, for example, offer companies an opportunity to achieve the highest level of operational efficiency, agility, innovation, and customer service, transforming their supply chains into digital ones. To them, with these technologies, industries can overcome the limitations of traditional supply chain strategies and navigate through uncertain times with greater resilience and success.

When studying how big data can enhance SCM innovation, Tan et al. (2015) presented a new infrastructure that offers better and more comprehensive support for BI than previous data mining or others deduction graph models. They proposed a model capable of linking different abilities, giving a complete picture of the company's capabilities for strategic analysis. According to them, it is a reliable method of identifying and measuring the connections needed to use the available data. They also affirm that by using these BI and big data infrastructures,

managers can create models for SC operations and product development and use the outcomes to help with supply operations strategy and innovation.

III.2.7 Improving sustainability of operations

Many companies face sustainability issues in their operations, so the use of a good database and BI systems can significantly contribute to analyzing the weak points in the supply chain processes, providing support material for decision-making that aims to increase operations and mitigate the damage they may cause to the environment. Responsibility for sustainability in SCM can ensure long-lasting and profitable operations while also ensuring the organization's good reputation, giving them a significant competitive advantage over their competitor (Kara & Firat, 2016).

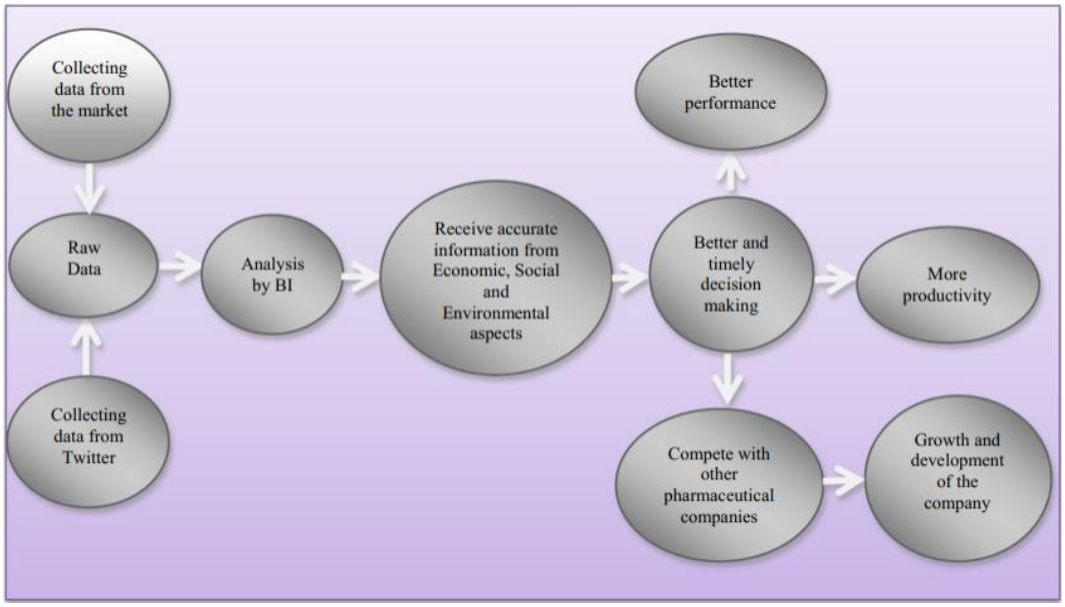
The amount of data being generated and exchanged in logistics supply chains is continuously growing, and this has led market participants to focus on extracting high-quality information from this data to make informed management decisions, so all this information is now considered a strategic asset that needs to be integrated into logistics activities to meet the analytical needs of supply chain participants. Thus, business analytics and intelligence have emerged as a new trend in the modern economy and an effective tool for achieving ongoing sustainable development in the supply chain. By utilizing BI, companies can optimize costs and

minimize losses, including those of a material or temporary nature (Evtodieva et al., 2019).

Seddigh et al. (2021) developed an analysis on the correlation between BI and sustainable supply chain. According to them, BI is a valuable tool for developing a sustainable supply chain, by analyzing raw data, companies can understand their operations better, leading to increased productivity and competitiveness. They follow stating that BI can unintentionally promote sustainability even in companies that do not prioritize it, however, the decision-makers' knowledge of sustainability and commitment to its principles are critical to the supply chain's sustainability.

The above-mentioned authors created a visual flow to understand how BI system enables managers to make efficient and effective decisions and respond quickly to changes in the supply chain, which we can see in figure III.1. They agreed that as a result to the positive outcomes, business executives can be persuaded to adopt the BI system, making it an essential asset for any company.

Figure III. 1 – Impact of BI in SCM



Source: Seddigh, M. R., Shokouhyar, S., & Loghmani, F. (2022). Approaching towards sustainable supply chain under the spotlight of business intelligence. Annals of Operations Research, p.23.

Following these definitions, Wang et al. (2016) defined that sustainable SC involves using business analytics to collect, analyze, and disseminate sustainability-related data for effective decision-making, and collaboration with suppliers and customers is key to better managing risks and improving organizational sustainability. In that way, sustainable SCM enables efficient analysis and evaluation of economic, environmental, and social issues to support forecasting and decision-making. Thus, strategic goals, transparency, and risk management are essential building blocks of sustainable a SCM, being data analysis and BI tools necessary to securely collect, cleanse, analyze, and distribute information across functions and processes.

III.3 BARRIERS FOR USING BI SYSTEMS IN SCM CONTEXTS

There are many researches pointing the existing barriers on implementing BI on companies. Moktadir et al. (2019), for example, ran a Delphi research with practical applications, and pointed four main barriers existing on implementing BI, specifically on SCM. According to them, companies are increasingly embracing big data analytics tools to gain insights and inform decision-making based on BI. Despite its benefits, there are numerous obstacles to implementing it in supply chains.

The four main barriers described by the author are data, technology, expertise and organizational problems, with some subproblems in each one. We found this and interesting division, and further on, we will move deeper in all of them.

III.3.1 Data

According to Jha et al. (2020) research, effective data management is crucial for building BI capabilities, in their research, SCM executives identified data quality as a critical aspect affecting BI development. According to them the companies without proper data management struggled to develop its capabilities, facing some traditional data issues such as missing or incorrect data, and resulting in unsuccessful investments, on the other hand, companies that appointed a data manager were able to store and manage large data warehouses, ensuring data quality

and volume, providing better insights into processes, improving planning, and reducing costs. They affirm these companies were better prepared to mine and analyze data for BI, leading to improved marketing capabilities and overhauls of production processes.

Another problem raised by SC managers and experts is related to data security and privacy. Some companies have their concerns about sharing information and make it available on a technological field, mainly the small and medium enterprises (SMEs) (Horakova & Skalska, 2013). Moktadir et al. (2019, p. 1070) reinforce this problem saying that "Most manufacturers do not want to share their data through the internet. It is a large task to analyze the actual nature of data. Hence, this barrier should be minimized by formulating cooperative policies between manufacturers, between suppliers, between manufacturers and buyers, and between manufacturers and policy makers".

In a specific study on data quality in warehousing and BI, Debbarma et al. (2013) said that data quality is one of the biggest barriers on logistics and SCM management. According to them, data quality refers to key measures such as completeness, consistency, validity, integrity, conformity, and accuracy of the information, and these measures determine if the data is understandable, relevant, and accurate. They defend that ensuring that data is consistent, valid, and adheres to certain standards is crucial for accuracy. Then, completeness refers to both mandatory and optional data availability, integrity ensures that data remains

unaltered from creation to reception, and accuracy checks for the accurate representation of real-world values.

Summarizing the negative impact that low-quality data can cause on the company and in the application of BI tools, Marshall & De la Harpe (2009, p. 10) say that “Users tended to believe the data that resided in the operational system as it represented the place of data origin. When users doubted the trust worthiness of the data reflected in the BI reports, they would likely seek the truth at source, which would not only affect business' confidence in BI, but also made a decision-making process challenging”.

III.3.2 Technology

One of the major challenges that companies face in adopting sustainable SC practices and leveraging technology for sustainable development is the lack of technological capabilities, which is a pressing issue that hinders the implementation of sustainability-oriented innovation in the SC (De Jesus & Mendonça, 2018). In addition to technological barriers, another significant challenge is the resistance to change and the lack of awareness and understanding of the benefits of implementing BI tools. Companies often struggle to recognize the value of adopting BI solutions and integrating them into their operations, which is a critical barrier that must be addressed to overcome the technological limitations and ensure sustainable development (Gupta et al., 2020)

Developing IT infrastructure for BI and big data analytics requires significant investments in hardware and software to support real-time analysis of vast amounts of data (Jha et al., 2020). While cloud and heterogeneous computing architectures are often seen as promising solutions for big data, they can fail technically or economically when processing large data volumes. Thus, these technologies may not be sufficient to prevent data processing bottlenecks resulting from the use of big data in BI (Alharthi et al., 2017).

Bag et al. (2022) reinforce this idea saying that one of the obstacles to implementing BI in sustainable SC is the lack of infrastructure readiness, they say that both the physical systems and software need to be implemented effectively for the smooth running of BI programs, otherwise, the process of collecting, storing, and processing data can be challenging due to infrastructure un-readiness.

Moktadir et al. (2019) said, according to their research among SC managers, that the main problems related to the technological barrier, are the lack of infrastructural facilities (infrastructure, software and hardware), lack of availability of data analysis and BI tools (huge demand for new tools), and lack of interest in implementing advanced technology (from a managerial perspective, new companies are more likely to invest on it).

Although the investment on these technologies is a sensitive decision that SC managers should do in order to achieve high level of competitiveness, is notable

that nowadays is hard to find a company that reached a good success without leveraged and invested in BI and analytical tools to their operations (Llave, 2019).

III.3.3 Competences

Following the list of obstacles to implementing a BI system in SCM, we found the factor related to the expertise or skill of the human resources involved in the process, and the high investment costs to cover all stakeholders in this system. Lack of personnel with IT skills, high investment costs, difficulty in financing, and a lack of investigations carried out in this area are some of the sub-factors related to this barrier, and since companies always are looking for reducing costs, a considerable part of them do not want to invest in BI tools and training, what becomes a key barrier to its development (Moktadir et al., 2019).

Lack of data analytics skills among existing employees may increase data entry errors that could result in placing information in the wrong record, losing valuable information, and limiting the value a business can derive from the data that it captures, and, to make things worse, some organizations decided to not have the technology to recognize and recover missing or erroneous data, in order to minimize costs (Alharthi et al., 2017).

Sivarajah et al. (2017) have identified several challenges related to big data and BI, including difficulties in understanding the concept, deciding what data to collect, privacy concerns, and ethical considerations. Building a solution for it can

be costly due to expensive hardware equipment and software tools, even with the use of cloud computing. Furthermore, to sort through data, so that valuable information can be constructed, human analysis is often required. According to them, while the computing technologies required to facilitate these data are keeping pace, the human expertise and talents business leaders require to leverage BD are lagging behind, proving to be a big challenge.

Additionally, the above-mentioned authors believe that for the BI system to be effective, it must be user-friendly and accessible to all users, which can be achieved through staff training and design. It is also important to consider the cost of implementing a BI system, which should include not only the technology but also the establishment of a project team, technical and substantive support, change management, employee training, as well as maintenance and future development of the system, because without accounting for these costs, a business risks investing in a powerful tool that may go unused.

III.3.4 Organizational barriers

The organizational-related barrier can be described in some sub-barriers, such as the lack of a data-sharing policy among organizations, inadequate training facilities, time constraints, and the closed mindset regarding big data.

According to Moktadir et al. (2019), time constraints is the most significant of them. They affirm that manufacturers typically aim to minimize

production, delivery, and other relevant times during the manufacturing process. As a result, time constraints are a significant issue when using BI and big data, since it requires significant amounts of time to analyze large datasets due to the complexity of data integration, privacy, and variety. It is critical to analyze data to achieve better performance in the global market, and industrial managers should allow for reasonable amounts of time to analyze data to improve market performance.

Regarding the lack of data-sharing among companies, Alharthi et al. (2017) found that having data sharing policies is crucial for business development and BDA tool adoption. This highlights the need for decision-makers to establish cooperation policies among manufacturers. As such, manufacturing companies must prioritize the development of their data sharing policies or mechanisms.

Researching about the capabilities of BI in SCM, Jha et al. (2020) agreed that regular and appropriate training programs are crucial for the success of businesses, especially when it comes to incorporating BI and big data tools. They believe that by facilitating such training programs, IT personnel can acquire the necessary knowledge and competency to use BI, ultimately helping companies to perform better in the global market. According to the authors, however, the lack of skilled resources in certain locations can be a challenge for companies to enhance their technology capabilities, when smaller cities may face difficulty in finding individuals with the necessary skill set. Additionally, retraining existing employees and investing in dedicated data structures can also be a challenge, requiring

additional funding and resources, what defines the barrier of inadequate training facilities.

It is undeniable that to stay competitive in an ever-changing market, companies focused on SCM need to use new technologies. In line with this idea, Fink et al. (2022) say that, despite that, established companies may struggle to develop new and innovative technologies in-house, so they often turn to external suppliers.

Olszak & Ziemba (2012) remind us about the need to keep investing in these technologies. They say that in order for a BI system to remain relevant and useful, it requires continuous development and adaptation to new challenges and expectations and failing to do so can result in the system becoming outdated and ultimately being discarded. The problem is that these suppliers are often reluctant to invest in new technology, since the use of BDA tools may make stakeholders reluctant due to the potential need for significant investment and additional effort that is not yet fully understood. In the end, as Moktadir et al. (2019, p. 1071) say, “Business success largely depends on the mindsets of decision makers, and industrial managers must understand the benefits of adopting big data and BI tools in the long term”.

Besides technical and financial limitations, there is also the resistance aspect. People tend to resist adopting new technologies because it can lead to changes in the company's workforce and warehouse operations, and also it may

somehow frustrate employees who must change the way they perform their routine tasks (Sharma & Khanna, 2020). Although there is a huge popularity of BI technologies within the industry, many organizations are hesitant to invest in them due to manager's behavior, organizational issues and a lack of clarity in understanding their potential benefits, which clearly moves in the opposite sense of today's evolution (Raut et al., 2021).

CONCLUSIONS

The objective of this thesis was to run an analysis on the existing literature focusing on clarify the concepts of BI and SCM, and identify the advantages and barriers in related to the use of BI systems in SCM contexts.

The analysis has shown that the use of BI in SCM can be an effective tool for improving various aspects of the SC. BI has provided significant benefits such as accurate demand forecasting, improved production planning, better management of warehousing and distribution, enhanced communication, and collaboration between parties, increased SCM agility and responsiveness, improved productivity and logistics efficiency, and the promotion of innovation and sustainability in operations.

One of the most significant benefits of using BI in SCM is the ability to forecast demand accurately. This helps to optimize inventory levels, reduce waste, and improve customer satisfaction. Accurate production planning is also essential to ensure that resources are allocated efficiently, leading to cost savings, improved productivity, and timely delivery.

It was possible to conclude that BI can also help in the effective management of warehousing and distribution, leading to enhanced operational efficiency and reduced costs. Improved communication and collaboration between

parties in the SC operations can help to avoid bottlenecks, reduce delays, and improve overall responsiveness, leading to a more agile and efficient SCM.

In addition, BI technology can help improve communication and collaboration between different parties involved in the SC operations. By sharing data and insights in real-time, suppliers, transporters, and customers can work together to optimize the flow of goods and services and ensure timely delivery.

However, despite the many benefits of BI in SCM, several barriers need to be overcome or limited. Data-related challenges such as data quality, data governance, and data integration can hinder the effective use of BI in SCM. Technological-related challenges such as the lack of integration between legacy systems can also be a significant barrier to implementing BI solutions. Competence-related challenges, such as a lack of skilled personnel to produce, manage and interpret information on SC operations provided by BI systems, can also be a barrier. Organizational-related challenges such as resistance to change and lack of buy-in from senior management can also pose significant obstacles.

In conclusion, the use of BI in SCM offers significant benefits in terms of improving the efficiency and effectiveness of SC operations. If properly applied, updated and with the right investments, BI can become a powerful game-changer tool for a company, providing a huge competitive advantage on their SCM in face of competitors. However, overcoming or limiting the various barriers is crucial to ensure that the full benefits of BI can be realized. Therefore, it is necessary to

address data-related, technological-related, competence-related, and organizational-related challenges to leverage the full potential of BI in SCM.

Finally, this study has been done based on a theoretical review. Therefore, for future research, it is suggested to perform an empirical investigation through case studies to explore how benefits and challenges unfold in companies that have adopted BI systems to execute SC operations.

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