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Master Thesis

Big Data and Analytics in Enhancing Procurement and Supply Chain Efficiency: A Literature and Empirical Study

This thesis is submitted for the Master Degree in Business Analytics and Data Science (MBADS)

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Abstract

In the dynamically changing business environment, the role of procurement is increasingly becoming critical, a phenomenon that is particularly relevant to Greek manufacturing companies, the focal point of this master's thesis. With over six years of hands-on experience in the procurement sector, this research aims to delve into the potential of Big Data and Data Analytics to enhance procurement practices. The study consists of two main elements: a review of existing literature and an empirical investigation involving questionnaire and surveys.

The findings indicate a rising trend in the application of data analytics within procurement and supply chain operations. The level of investment in analytics varies depending on the industry and specific organizational needs. The research emphasizes the need for a well-defined data management plan that aligns with a company's overall business strategy for effective implementation. Furthermore, having the necessary resources like technology, analytical tools and expertise is vital for successfully integrating analytics into procurement. Additionally, Big Data can offer insights into the supply chain, improve risk management, and provide an edge in negotiations.

This happens because through the digital supply chain, companies are able to provide better services to customers, reduce costs and order lead times, increase trust with stakeholders in the supply chain, and ultimately enhance their position in the market.

However, the adoption of Big Data in procurement faces challenges, notably issues related to data compatibility and integration. Despite these hurdles, Big Data has substantial potential. It can aid in identifying new vendors, enhance transparency, and even offer predictive insights for better decision-making. In summary, the effective use of Big Data and analytics holds the promise of making procurement processes more efficient and strategic

Key words: Big Data, Data Analytics, Procurement, Management, Supply Chain

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1. Introduction

In today's business environment, improving procurement is essential for a company's growth and competitive edge. With over six years of experience in this field, my study is centered on Greece and combines academic research with real-world insights. This real-world information is gathered through detailed surveys involving Greek manufacturing companies. The aim is to highlight that procurement is not merely a sideline task but a core aspect of a company's overall strategy. In this context, I examine how Big Data and digital tools can modernize and enhance procurement practices.

Big Data is a buzzword that has gained significant attention. It describes a large volume of rapidly incoming information from a diverse range of sources, such as smartphones and logistical systems. While some industry leaders like have already harnessed this data in their supply chains, many other companies are yet to fully utilize its potential.

In the modern business landscape, companies are focusing more on their strengths and are increasingly outsourcing other activities. This is happening on a global scale, making procurement even more crucial. It's not just about buying necessities; it also plays a significant role in a company's overall performance. Given the substantial financial resources allocated to procurement, it's clear that utilizing data can yield meaningful advantages.

In this study, I delve into how Big Data can aid in making more informed decisions in procurement. Specifically, I explore multiple facets like supplier identification and monitoring. I've conducted with professionals in the supply sector to understand their data needs and how Big Data can meet them. I also investigate how Big Data can contribute to risk management and make procurement operations more transparent and efficient.

However, implementing Big Data comes with its own set of challenges, which I also address. With a focus on generating practical knowledge, this study not only seeks to answer academic queries but also aims to make a tangible contribution to the field. In summary, my research aims to uncover how Big Data and digital tools can revolutionize procurement practices in Greek manufacturing companies, transforming it into a more effective and strategic function.

1.1 Research gap

While existing research has examined the influence of Big Data across various facets of the supply chain, the field of procurement within this context remains notably underexplored. Most academic work has adopted a comprehensive approach to the supply chain, giving significant attention to areas such as customer demand, logistics, and manufacturing efficiency, particularly with the advent of smartphones and IoT sensors. However, procurement has not been granted the same level of scholarly focus, despite its critical financial impact on firms.

Notable scholars in the field, such as Sanders (2016), have pointed out this uneven attention. While Sanders does discuss the challenges and advantages of Big Data across the supply chain and within a firm's various functions, his coverage of procurement is cursory. Similarly, Richey et al. (2016) explore Big Data in the supply chain through case studies but only briefly touch upon procurement, although they note that the success factors, they identify are equally applicable to procurement. Weng et al. (2016) largely focus on logistics and supply chain, making only a marginal reference to procurement. Even though Sanders (2014) dedicated a chapter to Big Data in sourcing, it primarily identifies some use-cases without diving deep into the nuances of procurement. In the realm of risk management, the work of Fan et al. (2015) does incorporate supply chain perspectives but does not singularly focus on the procurement aspect.

What is glaringly evident is the lack of specialized case studies that delve into the unique challenges and opportunities presented by Big Data in the domain of procurement. Most research studies that include procurement do so as a part of a broader exploration of the supply chain, thus diluting the focused insights that could be gleaned. This absence of dedicated research has implications for purchasing professionals who might otherwise benefit from targeted findings in this field.

As a result, this Master's thesis aims to fill this discernable gap in the literature. Leveraging my six-plus years of experience in procurement, I have conducted with Greek manufacturing companies to generate empirical data. My study is designed to engage directly with purchasing professionals through dedicated case studies to uncover whether conventional insights hold true in the procurement context, or if new, specific findings emerge. By concentrating on the Greek context and blending theoretical and empirical approaches, this research seeks to contribute substantive and region-specific insights to the underdeveloped academic ¨dialogue¨ on Big Data in procurement.

1.2 Research objective and research questions

The objective of my research is to examine the practical implications of leveraging Big Data in procurement and supply chain management, with an intent to provide companies with enhanced visibility into their supply markets. I am also keen to identify the specific informational needs that supply managers possess, particularly what they hope to derive from astute data usage, as well as the kind of intelligence required for effective procurement strategies and risk minimization. To fulfill this objective, I have framed the following core research questions:

Research Question 1: What are the potential applications and requirements that companies have in the procurement domain that could be facilitated by Big Data and sophisticated analytics?

Research Question 2: What challenges and obstacles are encountered in the adoption of Big Data analytics within procurement operations?

1.3 Research methodology

The purpose of this study is to investigate the impact of new technologies and the use of Big Data and Analytics tools on the supply chain of Greek manufacturing companies. Considering that this thesis aims to explore and address several research questions fundamental to the study's purpose, quantitative analysis has been selected as the most suitable methodology to be applied.

Quantitative research methodologies, often employing questionnaires, are highly popular in social sciences. Their popularity in small-scale cross-cultural research is linked to their perceived ease of use and the access they offer to large volumes of analyzable data, even for relatively inexperienced researchers. The objective of research is to draw conclusions about a population by examining a sample from that population. This contrasts with a census, which aims to make observations that come from an entire population. Here, a 'population' refers to a group of objects in the world that the researcher is interested in, which could include individuals, families, students in a university class, and people sharing a nationality or cultural background (Young & Schartner, 2014).

1.4 Structure of the study

The first chapter serves as an introduction, outlining the subject matter while emphasizing the study's objectives and significance. The second chapter engages in a literature review, initially defining the concept of Big Data analytics and then exploring its impact on supply chain management and, subsequently, its role in procurement. The third chapter elaborates on the research methods employed, detailing the procedures for data collection and analysis. The fourth chapter unveils the study's findings. The fifth and final chapter concludes the study, summarizing the implications and acknowledging the limitations, while also suggesting avenues for future research.

2. Literature review

2.1 Data Definition

It's essential to address some fundamental questions to clarify the term 'data' and thereby enhance our overall understanding of the research.

The Oxford English Dictionary provides two definitions for 'data.' The first defines it as "facts and statistics collected together for reference or analysis." According to Arunachalam et al. (2017), this definition implies that data consists of facts and figures gathered for subsequent analysis, and these can be processed and analyzed using conventional statistical and mathematical techniques, even without the involvement of a computer.

The second definition from the Oxford Dictionary (2018) describes data as "the quantities, characters, or symbols on which operations are performed by a computer, which may be stored and transmitted in the form of electrical signals and recorded on magnetic, optical, or mechanical recording media." This definition not only encompasses 'characters' and 'symbols,' but also emphasizes that a computer is necessary for the analysis. Additionally, it addresses the various methods by which data can be transferred and stored.

Although conducting research through structured individual interviews is feasible, it's more time-intensive and potentially more expensive, questionnaires remain the most prevalent method for gathering data. They have the advantage of being relatively simple to create, which makes them a popular choice for many researchers (Lowie & Seton, 2013). Additionally, there's a wealth of pre-existing surveys that can be utilized or modified, often at no cost. These surveys can be easily digitized, facilitating their distribution to a broader audience through various channels such as direct contact, mail, or online platforms like email. Compared to oral interviews, which require transcription and coding before analysis, the data obtained from surveys is considerably easier to process and examine (Young & Schartner, 2014).

2.2 Big Data Definition

In recent times, data has become increasingly diverse, coming in multiple formats from various sources. Supply chain managers are generally familiar with structured data types, such as operational numbers and accounting metrics. This kind of qualitative data is usually converted into numerical formats, which can be easily processed by traditional database systems. Such operational data may either reside within the organization or be shared with collaborative partners.

Conversely, unstructured data, defined as data that is not pre-configured for analysis in specialized software, poses a more formidable challenge and is less frequently utilized. This category includes emails, audio and video files, social media posts, tweets, and text documents.

According to Richey Jr et al. (2016), Big Data (BD) is characterized as data that presents a challenge in terms of what to do with it. In the current age, the sheer volume and complexity of data are overwhelming, making it crucial to know how to effectively manage and use it. Whether in supply chain management, customer relationship management software, or procurement, the organization lacks unified systems to capitalize on this vast array of data. The real key to success lies in identifying what parts of this data are actually valuable, how much of it to use, and how much investment should be made in IT infrastructure to convert this data into useful information.

Zhong et al. (2016, pp. 572-591) define 'Big Data' as the enormous influx of data ranging in size from Exabytes and beyond. This has broadened the technological possibilities for storing, managing, processing, interpreting, and visualizing large datasets.

The term 'Big Data' made its first appearance in the ACM digital library in October 1997, where it was used to describe a visualization challenge for systems handling large datasets within the field of computer science. Since then, both academic and industry interest in the concept has been significant. Market projections indicate that Big Data will rank among the top 10 market sectors in the coming century. Statistical forecasts suggest that by 2022, the global Big Data market could reach $118.52 billion, growing at a compound annual growth rate of 26% from 2014 to 2020 (NewsOn6.com) (Zhong et al., 2016, pp. 572-591).

The Service and Manufacturing Supply Chain Management (SM-SCM) sector has been undergoing digital transformation for an extended period. This area is rapidly evolving, and human involvement is crucial, not just in specialized fields like aeronautics but also in everyday necessities. The drive to enhance operational performance and efficiency has led to the integration of Big Data (BD). Combining SM-SCM with BD can facilitate more effective decision-making processes, especially in the utilization of natural resources. Significant investments have been made to stimulate scientists, researchers, and practitioners to delve deeper into the applications and development of Big Data and to gain a more comprehensive understanding of its potential.

Historically, the focus in SM-SCM was primarily on amassing and storing massive volumes of data, as noted by Zhong et al. (2016, pp. 572-591). However, exploiting the full potential of such large datasets has been a formidable challenge. In line with the observations made by Zhong et al. (2016, pp. 572-591), we can categorize the challenges posed by Big Data into the '5V's.' Among these, three are primary and the other two are supplementary. We will also outline the distinct features of SM-SCM.

Figure 1. *5V's of Big Data, (Surya Gutta, Analytics Vidhya)*

Volume: The quantity of data generated within the Supply Chain (SC) globally is staggering. Take, for instance, a personal care manufacturer that produces 500 data samples every 33 milliseconds, equating to 152,000 samples per second or 4 trillion samples annually. The massive inflow of data poses challenges for data collection systems and storage infrastructure.

Velocity: Rapid processing of voluminous data within the SC is crucial for timely, data-driven decision-making. The term 'velocity' refers to various aspects: the speed of data collection, the dependability of data transfer processes, efficient storage mechanisms, the quickness in extracting valuable insights, and fast algorithms for decision-making.

Variety: SC data come from a plethora of sources and in diverse formats. Emerging data types from sensors in manufacturing plants, retail locations, highways, and other facilities require a common language or protocol to convert them into a standardized format.

Verification: Not all collected data is of value. In the SC processes, there's inevitably some amount of 'bad' data. The task of separating useful from useless data should be conducted under specific security measures and authoritative oversight. While automated tools are often designed to ensure data quality, some verification processes are so complex that they pose a significant challenge.

Value: Assessing the worth of Big Data in the SC is particularly challenging. First, extracting meaningful insights from the data is hindered by issues related to volume, velocity, variety, and verification. Second, evaluating the data's impact on business processes and benefits within the SC is complex. Third, it's difficult to measure the value of extracted reports, statistical outcomes, and decision-making insights due to their broad influence on both micro and macro levels.

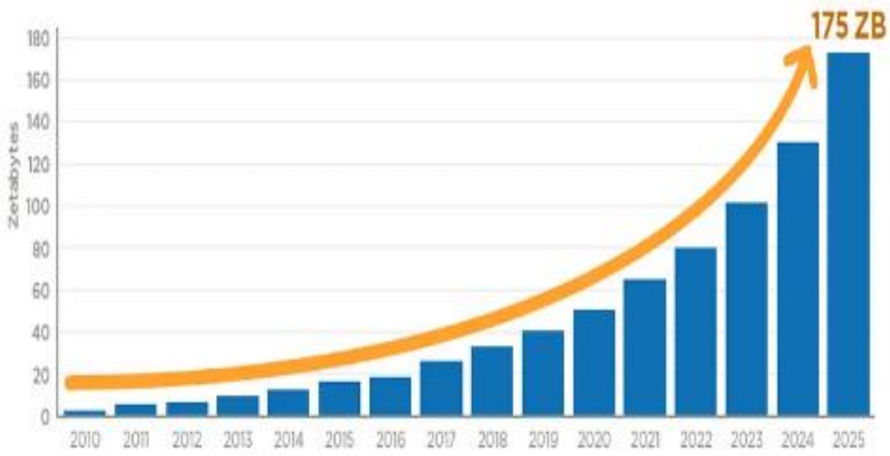

Figure 2. *Data growth prediction, Source Data from IDC Global Datasphere, Nov. 2018*

2.3 Data Sources

Data primarily resides in databases and enterprise IT systems like ERP (Enterprise Resource Planning). Internal communication channels between production and inventory systems also contribute to data streams, as seen with technologies like Radio-Frequency Identification (RFID).

Externally, data streams can come from diverse platforms, including data portals and social media sites such as Instagram, Twitter, and Facebook. The data from social media is often unstructured and continuously evolving in terms of semantics. Access to such data is usually restricted; for instance, Twitter allows only a specific volume of tweets in their data stream. Companies like DataSift provide purchasable data streams derived from these social media platforms. Other less-structured external data, like search engine trends, are often available through free APIs, such as the Google Search API. Technologies like Web Semantic (WS) and Linked Open Data (LOD) can be utilized for capturing data from external sources.

Open data platforms like Eurostat offer free access to various types of data, including political, geological, and statistical information about regions and countries. These can be accessed via open data portals, like the European Union Open Data Portal. Closed data platforms, in contrast, require purchased or licensed access to data sets.

Microsoft Azure Data Market operates as a cloud-based platform where one can find both open and closed data. The data is sourced from a variety of organizations and businesses. Another example is Factual, an open data platform established in 2009, which specializes in services like ad targeting and data mapping based on a comprehensive global location database. Data.com focuses on business data management, offering access to an extensive repository of company profiles, which can be regularly updated.

2.4 Data integrity and quality

Data integrity refers to the robustness, dependability, credibility, and completeness of a dataset, ensuring its accuracy, uniformity, and contextual relevance. It is underpinned by four central elements:

- Data Integration: Regardless of where it originates, data must be seamlessly integrated to guarantee that it is displayed promptly and accurately.
- Data Quality: For data to be actionable in decision-making, it needs to be complete, distinct, valid, up-to-date, and uniform.
- Location Intelligence: This involves the geographic aspects of data, which may include demographic information, traffic patterns, or meteorological data.
- Data Enrichment: This entails enhancing internal data by incorporating information from external sources. The addition of business, consumer, or

location-based data offers a more thorough and contextual understanding of the data for deeper analysis (O'Connor, 2020; Morrow, 2021).

- Data quality can be defined as the condition of either qualitative or quantitative information. High-quality data should satisfy the following criteria:
- Complete: The dataset should represent a significant proportion of the total data required for a particular purpose.
- Unique: The dataset should be devoid of unnecessary or duplicate entries.
- Valid: The data should align with the syntax and structure outlined by business-specific requirements.
- Timely: The data should be current enough to be useful for its intended applications.
- Consistent: Throughout the dataset, the representation of data should adhere to a uniform standard.

Failure to meet any of these standards could jeopardize the success of any initiatives reliant on data (O'Connor, 2020; Morrow, 2021).

2.5 Big Data Analytics

Big Data Analytics (BDA) refers to the comprehensive practice of investigating large and varied sets of data with the aim to reveal undisclosed patterns, undiscovered correlations, and other valuable information or insights (Rouse, 2012). This field has garnered significant attention for its capability to deliver key knowledge and actionable insights that enhance business profitability, streamline operations, and unearth new market possibilities (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2013). Primarily designed to aid businesses in their decision-making processes, BDA allows for the scrutiny of immense data volumes originating from diverse platforms such as the internet, databases, mobile phone activity, smart gadgets, and sensor-gathered information. To manage and analyze this profusion of multi-formatted data, BDA technologies consist of a fundamental core of open-source software frameworks that support the handling of large-scale data over clustered systems (Zakir, Seymour, & Berg, 2015).

Davenport and Harris (2007) highlight three essential qualities that typify organizations excelling in analytics. While basic descriptive statistics are commonly used across companies, firms vying in analytics go beyond rudimentary statistical evaluations. As per Davenport and Harris (2007), the extensive application of predictive modeling, advanced quantitative methods, and optimization techniques are critical attributes that significantly contribute to increased profits, operational efficacy, and improved decision-making. Many enterprises particularly refine their Supply Chains (SCs) to gain competitive advantages, often employing 'what-if' analysis to explore various alternatives.

The authors proceed to provide a more intricate definition of analytics, stating: 'By the term analytics we mean the extensive use of data, statistical and quantitative analysis, explanatory and predictive models and fact-based management that will lead us to drive decisions and actions. In essence, analytics is viewed as a specialized subset of Business Intelligence (BI). It includes aspects like optimization, statistical analysis, predictive modeling, and forecasting, serving either as a basis for informed decision-making or facilitating entirely autonomous choices.

The Institute for Operations Research and Management Science offered a different definition for analytics in 2014, stating it as: 'the scientific process of transforming data into insight for making better decisions.' Dr. Gorman, who has a significant background in quantitative analysis, divides analytics into three key segments:

Descriptive Analytics (events of the past):

Processes and analyzes past data.

Recognizes patterns and reports trends from sample data.

Predictive Analytics (potential future events):

Forecasts future probabilities and trends.

Detects not-so-obvious relationships that descriptive analytics might miss.

Prescriptive Analytics (optimal outcomes based on various conditions):

Suggests new operational methods.

Aims for specific business goals.

Accounts for multiple constraints.

While there are similarities between this categorization and the definition by Davenport et al. (2010), Gorman (2012) specifically emphasizes the importance of prescriptive and predictive analytics for those skilled in quantitative methodologies. IBM, moreover, introduces Social Media Analytics, which deals with non-transactional data generated from platforms like Facebook, Instagram, Twitter, and WhatsApp. IBM also outlines Entity Analytics, aimed at collating and categorizing data from identical entities (Dietrich et al. 2014).

SAS, an internationally acclaimed software development firm, markets itself as an analytics solution provider. SAS's Analytics software suite includes features such as (SAS 2013):

Predictive analytics and data mining: For creating descriptive and predictive models.

Data visualization: To enhance analytics efficacy via dynamic visualization.

Forecasting, econometrics, and time series: For predicting future outcomes based on historical data.

Model management and monitoring: To better deploy, create, and manage analytical models.

Operations research: Utilizes optimization and simulation for optimal results.

Quality improvement: Focuses on quality control over time.

Statistics: Utilizes statistical analysis to inform decision-making.

Text analytics: Extracts value from unstructured data sets.

With continually advancing computing power, more organizations are leveraging Big Data (BD) for analytics, substantiating Davenport’s (2006) claim that significant value can be harvested from data analysis. Enterprises employing Big Data Analytics (BDA) are leading their sectors, building their foundations on effective data collection, analysis, and implementation. Indeed, an analytics approach can substantially improve a company's competitive edge and profitability. As Dietrich et al. (2014) state: 'People respond to facts. Rational people will make rational decisions if you present them with the right data.'

In both the public sector and complex private industries, decision-makers are grappling not just with large amounts of data but also with multifaceted challenges. Utilizing Business Analytics (BA) for Big Data analysis allows for more nuanced and informed decision-making.

2.6 Business analytics and Big Data analytics

Holsapple et al (2014) propose a framework to define business analytics, comprising several building blocks. Let's break them down for a better understanding:

Movement:

The first block is the "Movement," which refers to an organizational culture that prioritizes analytics. In this culture, evidence is not an optional extra but the core basis for decision-making. This evidence-based approach encourages creativity, collaboration, and a realistic understanding of issues. The challenge lies in establishing and sustaining this culture, complete with Key Performance Indicators (KPIs) that measure its effectiveness.

Collection of Practices and Technologies:

The second block encompasses the techniques and technologies used for evidence-based operations to derive knowledge for decision-making. While this block can exist independently of the "Movement," it is often less effective without a supportive culture. This is typically the facet by which most people identify business analytics.

Transformational Process:

This stage involves translating the gathered evidence into actionable insights. Here, the capabilities of business analytics come into play, including the use of various statistical techniques and three types of analytics: descriptive, predictive, and prescriptive. Applications of these capabilities can include analyzing competitors' strategies, parsing big data for relevant messages, and optimizing processes.

Decisional Paradigm:

This block deals with how business analytics fits into the overall decision-making schema within an organization. Here, the compatibility of the analytics-driven approach with other decision-making paradigms is assessed. Proper alignment of these paradigms is crucial to avoid misuse and maximize utility.

Holsapple et al (2014) suggest that the end goal of business analytics is to offer a competitive edge by aiding strategic decision-making. However, they also caution that simply possessing big data analytics technology doesn't automatically confer this advantage. The real value comes from high-quality data and the algorithms used to analyze it. For this reason, managerial buy-in and proper guidelines for technology implementation are essential (Chan et al, 2014).

Data Analytics vs. Big Data

Data analytics can often be simplistically envisioned as spreadsheet-based statistical analysis or some Excel automation. Big Data analytics, however, involves handling enormous databases that require specialized technologies for statistical analysis, data mining, and machine learning algorithms. Advanced methods such as clustering, classification, and regression analysis can be conducted on a larger scale, and optimization algorithms are more easily applicable (Chen et al, 2012).

In summary, the framework by Holsapple et al (2014) serves as a holistic guide to understanding the complex layers of business analytics, emphasizing the necessity of a supportive culture, advanced techniques, transformation processes, and aligned decision-making paradigms for the effective application of business analytics.

2.7 Tools for Big Data Analytics

In today's data-driven landscape, the need for robust tools to manage, analyze, and visualize big data has never been more critical. Organizations face numerous challenges when it comes to storing, cleaning, and mining vast amounts of data. To address these challenges, a range of specialized tools have been developed. The following is an overview of various data storage and management tools, along with utilities for data cleaning, mining, analysis, and visualization.

Introduction to Data Storage and Management Tools

Managing and storing large volumes of data, commonly known as "Big Data," is a significant challenge for data-centric organizations. To handle these complex tasks, modern solutions like Hadoop, Cloudera, MongoDB, and Talend are employed.

Hadoop: This open-source software is designed for distributed storage of large datasets across multiple computers. Hadoop offers significant storage capacity, enhanced processing capabilities, and supports unlimited virtual tasks. Effective implementation, however, requires a thorough understanding of Java.

Cloudera: As an adjunct to Hadoop, Cloudera provides additional enterprise-level functionalities. It plays a crucial role in safeguarding sensitive data.

MongoDB: This versatile database system can handle an array of data types, ranging from structured to unstructured. MongoDB notably decreases operational overhead by up to 95% and enhances storage efficiency through its WiredTiger engine.

Talend: Talend specializes in extensive data management solutions for businesses of all types, employing the concept of Master Data Management (MDM) to ensure data quality and integrity.

Data Cleaning Tools: Before analysis, data must be purified, especially if derived from web sources. Tools like Open Refine and Data Cleaner are adept at this.

Open Refine: This user-friendly software is particularly effective for cleaning up unstructured data.

Data Cleaner: Focused on preparing data for visualization, Data Cleaner converts raw information into a structured format.

Data Mining Tools: For intelligent predictive analytics and decision-making, solutions like Rapid Miner, IBM SPSS Modeler, and Oracle Data Mining are available.

Rapid Miner: Known for its user-friendly graphical interface, Rapid Miner excels in predictive analytics. It also allows custom algorithm integration.

IBM SPSS Modeler: Primarily suited for large-scale enterprises, this tool offers a gamut of functionalities, including text analytics and decision support.

Oracle Data Mining: This tool provides comprehensive predictive analytics features and is particularly helpful for data scientists and analysts.

Data Analysis Tools: BigML stands out for its efficiency in data pattern analysis and also features a predictive analytics component.

Data Visualization Tools: Tableau, Silk, Carto DB, Chartio, and Plot.ly are vital in making large and complex data sets easily understandable.

Tableau, Silk, Carto DB, Chartio, Plot.ly: These tools offer a variety of features for data visualization, from real-time data rendering to complex dashboard creation.

Additional Tools: Other utilities like Blockspring, Pentaho, as well as languages like R programming and Python, offer various aspects of data integration. Import.io is especially useful for data collection.

In summary, a myriad of tools is available to meet the different needs in the data management pipeline, making it easier for organizations to handle the challenges of today's data-centric world.

2.8 Big Data enabled decision-making models

Increasingly, decision-making processes in supply chain management (SC), manufacturing, and service sectors are relying on insights derived from Big Data (BD). However, a 2015 survey revealed that 55% of participants felt that Big Data decision models were not given strategic importance at the upper echelons of their organizations (Jin et al., 2015). Often, traditional data mining techniques are repackaged or enhanced and then labeled as Big Data-driven decision models. Such methods are typically inadequate for handling the specific challenges that arise in service, manufacturing, and supply chain management. Several issues need addressing in this context:

First, decision-making models require data to generate solutions for a variety of purposes, including strategic, operational, and analytical objectives. However, when dealing with massive amounts of data, these models can take a considerable amount of time to compute.

Second, existing data-driven decision models lack criteria for evaluating their effectiveness and efficiency. Comparisons with other models or solutions may not be appropriate for Big Data scenarios.

Third, most decision-making models target specific issues, and generalized models capable of solving multiple objectives are rarely seen. However, in conjunction with Big Data, it's possible to develop multifunctional models.

Emerging models and decision-making mechanisms present an opportunity to overcome these challenges. On one hand, these new models can fully leverage Big Data by mining various types of information, which can then be converted into parameters for optimal decision-making. On the other hand, they are designed to quickly arrive at optimal solutions. These models are adaptable to both specific and multi-objective problem-solving, utilizing different Big Data-driven techniques. Additionally, historical data can be incorporated into evaluation criteria for quantitative verification.

The future of Big Data-driven decision models seems to be headed in two promising directions:

Self-learning models: Upcoming models will have the capacity for self-improvement by learning from vast amounts of Big Data. Techniques like Deep Machine Learning (DML) will be integrated, allowing the models to have continuous learning capabilities. This will enable the development and diversification of new models based on learnings from varied data types.

Smart Decision-Maker: Future models will not function in isolation but will collaborate through hierarchical or parallel structures. With built-in learning mechanisms, these models will evolve into intelligent decision-making systems capable of accurately selecting data parameters, rapidly generating solutions, and thoroughly evaluating outcomes.

In summary, although current Big Data-driven decision-making models face challenges in areas like evaluation criteria and computational time, emerging models and techniques promise to provide more effective and efficient solutions. The focus is on developing multifunctional models that are not just problem-specific but can address multiple objectives and can also evolve to become more intelligent over time.

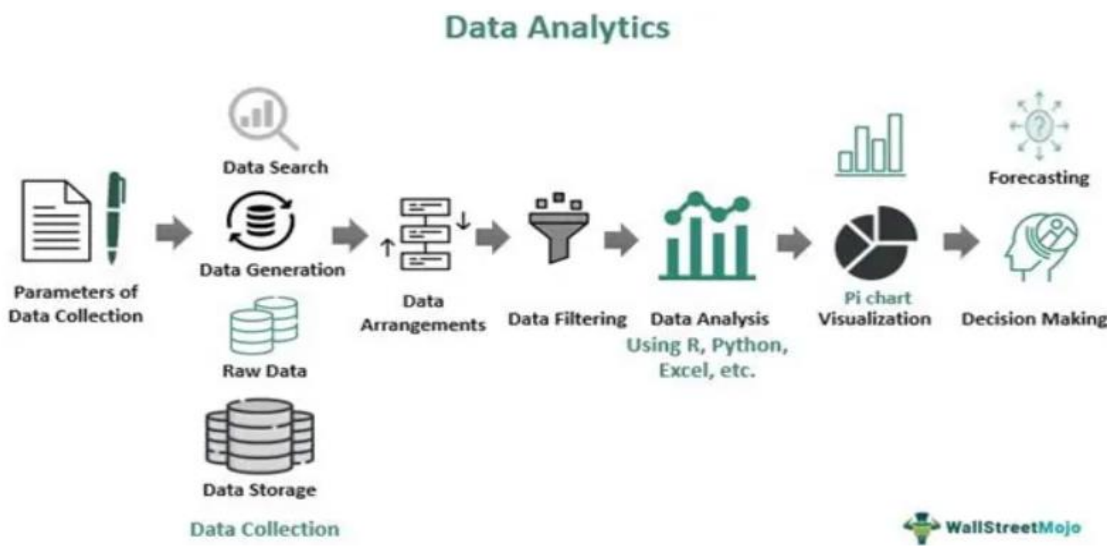

Figure 3, *Data Analytics Decision Making (Wallstreet Mojo)*

2.9 Definition of Supply Chain

According to Chopra and Meindl (2016), a supply chain comprises all parties involved in fulfilling a customer's request. These parties can be involved either directly or indirectly, and the supply chain encompasses not only manufacturers and suppliers but also transporters, warehouses, retailers, and customers. Moreover, a supply chain involves a continuous flow of information, products, and capital among different stages. Commonly, the term "supply chain" is understood as the movement of products or supplies between suppliers, manufacturers, distributors, retailers, and customers along the chain.

However, it is crucial to also to include the flow of information and capital (Chopra & Meindl, 2016). Corominas et al. (2015) state that a supply chain is a network comprised of collaborative units to provide products or services to customers and end-users. The term "network" implies that supply chains have a more complex structure and that flows among the units are an integral part of the supply chain (Corominas et al., 2015). Furthermore, the proper design of a supply chain depends as much on customer needs as it does on the roles of the different involved units (Chopra & Meindl, 2016). According to Chopra and Meindl (2016), the objective of a supply chain for an organization should be the creation of the maximum possible total value.

Given that the thesis is on Big Data and Analytics in the field of Procurement, this foundational understanding of supply chains serves as the groundwork on which you could layer discussions about the impact of data analytics in optimizing and streamlining these complex networks. From real-time data analytics in inventory management to predictive analytics in demand forecasting, Big Data tools could offer unprecedented efficiencies and capabilities in procurement processes, thereby enhancing the "maximum possible total value" that a well-designed supply chain aims to achieve.

Chopra and Meindl's definition of the value in the supply chain is crucial, as it draws attention to the difference between the perceived value by the customer and the overall cost of the supply chain. Businesses constantly juggle between customer expectations and operational efficiencies. For instance, offering faster deliveries could enhance the perceived value, but it will also ratchet up logistical costs. Conversely, reducing these costs may affect customer satisfaction negatively, thereby reducing the perceived value of the final product or service.

The literature by Lambert et al., and also the works of Caescu and Dumitru, are instrumental in laying out the layers and complexities involved in a typical supply chain. Businesses do not function in isolation; they are part of a larger ecosystem that includes suppliers, manufacturers, transport agencies, and customers. Even a single decision, like switching to a supplier who offers cheaper but lower-quality raw materials, can reverberate across the entire supply chain and ultimately influence customer perception.

Chopra and Meindl's (2007) definition encapsulate the functional diversity involved in fulfilling a customer request. From R&D and marketing to distribution and customer service, every function in an organization plays a role. Additionally, Chen and Paulraj's work adds another layer by emphasizing the flow of information, which is often as critical as the flow of materials.

To summarize all the above, supply chain management is not merely an operational concern; it's a strategic imperative. Balancing costs with customer satisfaction is tricky, as both can be at odds with each other. Also, organizations must realize that their actions have ripple effects across the entire ecosystem, affecting suppliers and customers alike. It involves a multi-stage, multi-geographical, and multi-functional set of activities that organizations must manage efficiently and effectively.

2.10 Procurement

The term "procurement" is often interpreted in various ways depending on the academic or industry perspective. Rooted in the broader activities of acquiring goods and services, the notion of procurement has evolved significantly over the years. It's now seen not just as a function but as a strategic operation that contributes to a business's overall revenue and operational effectiveness. The core essence of procurement, which involves a company exchanging payment for goods, services, or rights, remains central to its definition (Lamming, 1993; Weele, 2010).

Around three decades ago, Lamming (1993) pointed out that the role of procurement was becoming increasingly strategic, tasked with ensuring that the most appropriate external resources are matched to specific organizational needs. This idea was later elaborated by Cox and Lamming (1997) as "external resource management," highlighting the myriad strategies that can be used to navigate external assets such as suppliers and their respective markets. The focus here is on a holistic management approach to the supplier landscape that also takes into account the end-user's requirements.

According to van Weele (2010), the definition of "procurement" is: "Procurement is the oversight of a company's external assets to ensure the acquisition of essential goods, services, abilities, and information for effectively carrying out the company's primary and auxiliary roles, under conditions most beneficial to the organization."

Iloranta and Pajunen-Muhonen (2008) define "procurement" as: "Procurement is the control of an organization's outside resources. The functioning, upkeep, governance, and growth of an organization call for a diverse set of products and services, as well as different expertise and knowledge from external sources. Procurement aims to capitalize on opportunities in the supplier market to meet the end-user's needs in a manner that optimizes the overall business value."

2.11 Procurement organizations

The landscape of procurement has dramatically changed in recent years, becoming a multi-faceted function that goes beyond simple acquisition tasks. This transformation can be dissected into strategic, tactical, and operational facets, each with distinct roles and activities. These shifts have been propelled by various factors such as globalization, advancements in technology, and changes in management thinking. Given this context, let's delve into these dimensions.

Procurement is generally categorized into three main types of activities: strategic, tactical, and operational. Strategic procurement lays heavy emphasis on the planning, development of activities, selection and evaluation of suppliers, establishing partnerships, and forecasting. Tactical procurement, by contrast, focuses more on activities like contract negotiations and budget allocation. Meanwhile, operational procurement handles routine tasks like order placement, invoice review, and monitoring deliveries. This modern understanding of procurement's diversified roles owes much to changes in organizational structures and industry dynamics (Huuhka, 2019; Weele, 2010; Iloranta, 2008).

Globalization has been pinpointed as one of the pivotal catalysts that have fueled procurement's evolution, particularly during the years 1970 to 2000. The international competitive landscape has intensified, making countries like China and South-East Asian nations attractive bases for production due to their lower operational costs. Furthermore, shifts in consumer behavior and shortened product life cycles have contributed to the harmonization of global markets.

The role of technology cannot be understated. Developments in Information and Communication Technologies (ICT) have revolutionized the way businesses and their associates operate. The rise of Enterprise Resource Planning (ERP) systems has broadened the availability of information, making data management a critical competitive advantage for many organizations. This has had a significant impact, especially in the industrial and service sectors, with many players in the logistics sector leveraging ICT to gain global market positions (Huuhka, 2019).

Lastly, the growing strategic importance of procurement in organizational success has also been shaped by various management theories and approaches. Ideas like benchmarking, supply chain management, supplier classification and development, total quality management, and lean and just-in-time production methods have all contributed to the complex, multifaceted role procurement now plays in modern businesses.

2.12 Industry 4.0

The concept of Industry 4.0 has emerged as a revolutionary force reshaping the landscape of manufacturing and supply chain management. This transformation isn't merely an extension of digital technology into these domains, but rather a comprehensive integration of various facets such as automation, machine learning, and data analytics.

Industry 4.0 is characterized by its emphasis on 'connectivity,' 'automation,' 'machine learning,' and the utilization of 'real-time data.' Companies in the realms of manufacturing and supply chain are keen to harness the potential of Industry 4.0, often referred to as 'intelligent manufacturing,' to upgrade their physical processes. This new phase amalgamates conventional manufacturing with modern digital technology, data analytics, and machine learning, resulting in a unified and interconnected operational ecosystem. Key elements like automation and readily available data facilitate 'flexible planning,' enabled by instantaneous information sharing and superior data analytics. The ultimate aim of Industry 4.0 transcends mere technological upgrades for operational efficiency; it aspires to fundamentally transform the manner in which businesses function and grow.

2.13 Data-analytics in the field of procurement

The role of data analytics in procurement is becoming increasingly significant for organizational decision-making. This technology offers not only efficiency but also strategic insights for businesses, fundamentally altering traditional procurement practices. Here's a nuanced look at how data analytics and digital technologies like Industry 4.0 are reshaping the landscape of procurement and supply chain management.

Leveraging 'data-analytics,' procurement divisions can gain more independence and greater authority in making choices. This results in a more transparent and quicker decision-making process, benefiting companies in reaching their objectives (Bizclick, 2022). While there are various analytic tools available for businesses, the core idea remains consistent—a 'data-driven' methodology for resolving issues related to supply management (Heidari, 2018). Organizations aim to balance low cost, high quality, and minimal risk by capitalizing on procurement opportunities to produce increasingly customized products (Huuhka, 2019).

Common concerns in this field include managing budgets and expenditures, reducing costs, handling suppliers, cost modeling, category market insights, supplier evaluations, innovation led by procurement, market tactics, mitigating supply chain risks, and boosting stakeholder value (Monczka et al., 2016). To tackle these issues, a suite of technological solutions, termed as 'procurement technology,' is essential. These technologies aggregate data from multiple sources like ERP systems, internet, procure-to-pay systems, Contract Management Systems (CMS), and third-party providers, subsequently analyzing and presenting actionable information to users. Research has shown a clear link between overcoming challenges related to digitalization and improved overall performance, assessed in terms of process efficiency and dynamic capabilities.

Consultancy reports suggest minimal issues with the adoption of Industry 4.0 technologies. Around a third of German manufacturing firms have adapted their procurement practices in response to Industry 4.0, influencing various sub-processes within the procurement cycle (Pellengahr et al., 2016). To maintain competitiveness, a focus on the 'digitalization' of procurement procedures is recommended (Bals et al., 2019). The use of 'data-analytics' is crucial for coordinating complex supply chains, which consist of large sets of varied data concerning the business and its operations (Bals et al., 2019).

Analytics and 'Big Data' can help strategize procurement by assessing supply market trends and suppliers, formulating sourcing strategies, and preempting supply disruptions (Bals, 2019). Effective 'data-driven' decision-making at an organizational level requires seamless information flow and the transformation of data into actionable insights, which is possible only when analytics capabilities are aligned with the business strategy (Aryal et al., 2018; Akter et al., 2016). 'Digitization' offers multiple competitive benefits, including automation and effective data usage. Various procurement systems facilitate this by providing easy access to consistent, accurate, and unified information (Hallikas et al., 2021). Consequently, both the development and execution of procurement strategies rely heavily on integrated processes and 'data-analytics.

2.14 Impact on procurement

In the modern business landscape, analytics plays an increasingly critical role in the domain of procurement, especially given the evolution of sourcing from a basic purchasing function to a more strategic role. Businesses have recognized that they cannot afford to let the sourcing function operate in isolation; rather, it must be centralized and integrated with other business functions due to its complexity and broad scope. The application of analytics to sourcing is thus not straightforward but multi-faceted.

Sanders (2014) has outlined various ways in which Big Data can impact sourcing, which include enhancing order processing, achieving standardization, facilitating visualization, enabling rapid and multiple scenario analyses, achieving cost savings, providing a predictive edge, fostering co-creation, and risk management. One of the immediate benefits of applying Big Data is the acceleration of order processing through seamless customer interfaces, thereby increasing customer satisfaction. Big Data complements Electronic Data Interchange (EDI) systems to automate and monitor logistics, inventory, and warehousing in real-time, reducing costs and speeding up the 'order to cash' and 'procure to pay' cycles.

Automation also contributes to standardizing procurement processes, which is crucial for global sourcing. This standardization transforms disparate parts of the global supply chain into a single, integrated system. Big Data further aids in the development and improvement of applications by providing powerful visualization tools. These tools help in aggregating data into visual formats like images, diagrams, or animations, making the data easier to interpret and use for 'what-if' and scenario analyses.

Additionally, Big Data analytics facilitates rapid querying capabilities, providing an edge for predictive forecasting. This capability is particularly useful for Total Cost of Ownership (TCO) assessments, adding layers of complexity to data views, such as location-based and category-based filters. The centralized nature of modern procurement operations allows for greater collaboration between design, supply chain, and other departments, which is crucial for cost-saving measures and planning.

Uncertainty in sourcing can arise from various factors like supply scarcity, performance variation, and market volatility. Big Data helps tackle these uncertainties by offering predictive analytics and scenario planning, thereby enhancing 'dynamic capabilities' as per the frameworks provided by Teece et al (1997) and Pavlou and El Sawy (2011). These capabilities include sensing, learning, integrating, and coordinating resources in response to changing environments.

Co-creation, a contemporary business model focus, also benefits from Big Data by facilitating shared information across a supply chain, leading to higher quality end-products that are produced more efficiently and at lower cost. However, the application of analytics in risk management still has room for growth. Sanders suggests the use of advanced metrics like supplier resiliency scores instead of basic metrics to assess risks. These metrics take into account several risk factors like facility location and backup production sites. Publicly available data, like news and social media, can also be leveraged for identifying potential risks.

Ethical concerns, such as child labor and human trafficking, are other key areas where Big Data analytics can offer solutions. By monitoring social media discussions and other publicly available information, high-risk areas can be identified and verified through more reliable sources. With globalization and lean production methods, supply chain risks have increased, making predictive analytics even more essential for risk mitigation and contingency planning.

In summary, as sourcing transitions from a purely transactional function to a strategic role, the application of analytics has evolved in complexity. Big Data plays an increasingly critical role in enhancing operational efficiency, achieving cost savings, promoting collaboration, managing risks, and even addressing ethical concerns. Its role is crucial in equipping firms with the dynamic capabilities needed to adapt and thrive in today's fast-paced, uncertain business environment.

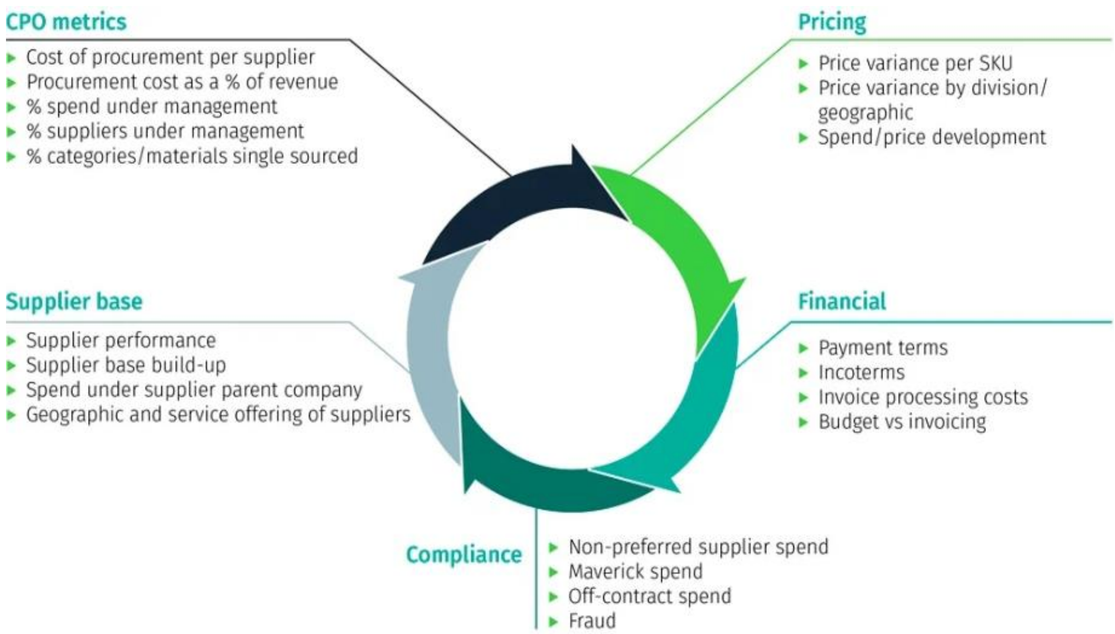

Figure 4, *What Procurement Data to Analyze (https://www.thesmartcube.com/)*

2.15 Multifaceted Applications of Big Data Analytics in Supply Chain Management

Big Data Analytics (BDA) has a versatile role across the entire spectrum of Supply Chain Management (SCM), transmitting information between different functions. However, the effectiveness of this data integration depends on its accuracy, completeness, consistency, and timeliness, as outlined by Hazen et al. (2014). For instance, within marketing, BDA processes consumer demand data captured at Point of Sale (PoS), while in transportation, data from GPS devices is utilized. Additionally, RFID technology is used for tracking inventory, and Electronic Data Interchange (EDI) automates purchase orders to vendors.

In a **marketing context**, companies are leveraging large data sets to gain real-time insights into customer behavior (Jüttner et al., 2010). These insights come from sophisticated analysis of various data sources like social media, mobile apps, and loyalty programs, which also aid in sentiment analysis. Similarly, the cloud and electronic PoS systems, along with machine-generated data, facilitate the tracking of sales across multiple channels. Butner (2008) argues that there should be a better integration of customer feedback into SCM systems. Advances in technology have made it increasingly feasible to access, scrutinize, and comprehend customer data, including gauging social behavior patterns (Shmueli et al., 2014).

On the **procurement front**, the challenges often arise from complex, global purchasing strategies that involve many transactions. A close alignment with internal financial reporting has led to an emphasis on visibility into spending data. Yet, Ainsworth (2014) points out that data related to external spending are often retrospective, inconsistently categorized, and not well-integrated with internal costs, which could form a significant portion of company expenses. Moreover, business documents like purchase orders, shipping notices, and invoices, which are often semi-structured, need to be fully integrated into the system via EDI (Still et al., 2011).

In **warehouse management**, technologies like RFID have revolutionized inventory management. The use of IoT and extended sensors has contributed to the automation and efficiency of tracking and managing inventory. These sensors not only provide real-time shelf availability data but also integrate with traditional stock-keeping unit (SKU) levels and Bills of Materials (BOMs).

When it comes **to transportation**, classic Operational Research (OR) models that utilize static data inputs like origin and destination (OND), transportation costs, and logistics network design are being augmented by real-time data. This dynamic data includes variables like current traffic conditions, weather influences, and real-time costs for alternative shipping methods, as well as crowd-sourced delivery networks. As a result, there is a notable increase in the speed at which transportation data can be processed and utilized for decision-making.

2.16 Big Data Analytics in Procurement and Supply Chain Efficiency

Integrating analytics into procurement involves a deep understanding of the sourcing function, which has evolved from a simple purchasing process to a strategic operation. Given that a significant part of a company's revenue is allocated to sourcing, it's increasingly seen as a centralized function that needs to communicate with other departments rather than operating in isolation. Accordingly, the application of analytics to sourcing has grown more intricate. Sanders (2014) discusses the effects of Big Data on various aspects of sourcing, such as order processing, standardization, visualization, and predictive capabilities, among others.

Speed in order processing is a key factor in customer satisfaction, and Big Data can enhance this through efficient customer interface and electronic data interchange (EDI). Companies like IBM have broken down this process into two parts: order-to-cash and procure-to-pay cycles. Automation further streamlines and standardizes these processes, facilitating global sourcing and integrating disparate parts of the supply chain into a cohesive system (Sanders, 2014).

Big Data analytics also excels in enabling the development of new applications by offering visualization tools for large datasets. This capability helps in combining diverse data sources, such as market information, to conduct various scenario analyses, which was previously a laborious task.

Scenario analysis, enhanced by Big Data's rapid query capabilities, helps managers anticipate future conditions and make informed decisions. The analytics offer various dimensions and filters to gain a total cost of ownership (TCO) perspective on costs and procurement challenges, providing a competitive edge.

Centralized procurement encourages collaboration among different functions within a company. This collaboration is easier to achieve with Big Data, which enables better coordination between designers and suppliers to reduce costs. Furthermore, Big Data aids in collaborative planning, forecasting, and replenishment (CPFR), allowing for a broader engagement of stakeholders.

Uncertainty in sourcing may arise from various factors like supply scarcity or currency fluctuations. Big Data helps mitigate these uncertainties by offering predictive analytics and scenario planning, building upon dynamic capabilities as outlined by various researchers. These capabilities include sensing, learning, integration, and coordination, which aid not only in forecasting but also in risk management.

Co-creation is becoming increasingly popular, facilitated by Big Data allowing information sharing across the entire supply chain. This results in higher-quality end products, achieved more efficiently and cost-effectively.

Risk management in sourcing is another crucial area where analytics can play a significant role, although current approaches are still underdeveloped according to Sanders (2014). He suggests a supplier resiliency score that considers multiple risk factors, complemented by data from news and social media channels for identifying potential risks.

Moreover, with regard to ethical concerns like child labor and human trafficking, Big Data analytics can identify high-risk areas and alert companies to potential problems, which is especially critical for global supply chains. In an era of lean production and minimal inventory, analytics can offer predictive insights and contingency planning to mitigate the impact of supply disruptions.

In summary, the integration of Big Data analytics into procurement is complex but offers numerous advantages, from process automation and standardization to predictive capabilities and risk management, ultimately contributing to a more effective and efficient supply chain.

2.17 Challenges to utilize data-analytics in procurement effectively

Fact-based decision-making in the context of procurement analytics demands expertise in data management and analysis. The former entails technical challenges such as data storage, processing, and governance, while the latter calls for a specialized workforce. The principal hurdle in developing procurement analytics lies in data management capabilities, with specific issues around data accuracy, timeliness, and governance. The challenge is compounded by the dispersed nature of data across various systems (Rafati & Poels, 2015).

Rafati & Poels (2015) outline five key challenges in merging procurement with data analytics. The first is the scattered nature of procurement data across different enterprise systems, leading to a lack of integration. The second is data complexity, as not all procurement and supplier information may be digitally accessible. The third issue is the amalgamation of various data types like contracts, supplier information, and costs, without a unified platform to manage them. The fourth is an organizational shortcoming in tools and skillsets to handle this data. The fifth challenge lies in data visualization, which is essential for making data interpretable and thus useful for drawing reliable conclusions.

Alongside these specific issues, broader challenges exist concerning data ownership and privacy within global supply chains, which usually involve multiple stakeholders. Data sharing may be impeded by concerns over privacy loss and diminishing competitive edge, necessitating a centralized system for universal access (Wang et al., 2015).

Surajit (2016) points out a significant barrier in the lack of qualified personnel capable of handling Big Data analytics. This shortfall has implications for recruitment and training, emphasizing the need for close collaboration between procurement and HR departments, as noted by Connaughton & Sawchuk (2014) in their study for the Hackett Group, a NASDAQ-listed strategic consultancy specializing in research and benchmarking.

To enhance supply chain performance, integrating data analytics into procurement processes is essential. Yet, a distinct strategy for this integration is crucial and entails a commitment of resources and investment from the company (Lamba & Singh 2017). Shamim et al. (2018) also underscore challenges related to organizational leadership, effective use of talent, cultural readiness, and technology management as key factors affecting the successful implementation of data analytics in procurement.

3. Research methodology

3.1 Case selection and data collection

Questionnaires are often used to determine things such as historical and demographic details of the participants (age, biological sex, nationality, income) by noting behaviors, expressing attitudes, and stating opinions to determine real knowledge about something. For the purposes of my own work, a structured questionnaire was created, which consists of questions that already exist in other questionnaires of similar studies (Hajar & Hadi, 2020, Patterson et al., 2003, Attaran, 2020, Alabdali et al., 2022). The questionnaire that was used was brief in order to not tire the participants and not to require much time, as the size and duration of filling it out can be a decisive factor for encouraging or discouraging participants.

Additionally, the questionnaire included only closed-ended questions, which were based on graded scales using the five-point Likert scale. According to this scale, the lowest score corresponds to the answer 'Strongly Disagree,' and the highest score corresponds to the answer

'Strongly Agree.' The questionnaire was also anonymous and did not collect personal information from the participants. More specifically, the questionnaire consists of two sections. The first section contains questions related to the demographic characteristics of the participants, while the second section contains questions concerning the application of new technologies in the supply chain. Particularly, the first part consists of five demographic questions, while the second part consists of 14 questions that examine whether new technologies are being used in the management of the supply chain in the participants' companies and what the participants' views are on the advantages that may arise from the application of these new technologies.

3.2 Research Sample

The concept of a "sample" refers to a group of people, objects, or elements taken from a larger population for measurement. To obtain accurate results, sampling is performed. Sampling is defined as the process of selecting a sample from an individual or from a larger population group for a specific type of research purpose (Negida & Elfil, 2016). Samples are used to draw conclusions about populations. Collecting data from samples is easier because it is practical, cost-effective, convenient, and manageable (Leeuw et al., 2008).

The sample for this particular study is a convenience sample, consisting of 70 participants who work in various sectors of the economy and have different demographic characteristics, which are analyzed in the following chapter. Specifically, the questionnaire was addressed to employees of Greek companies belonging to various industries without targeting any of the three specific sectors (primary, secondary, tertiary). The employees come from all hierarchical levels of a company (employees, middle and senior management). The reason for choosing a sample with different demographic characteristics is to avoid the risk of expressing only the opinions of a group of people with specific homogeneous characteristics and drawing conclusions that do not align with the objective view of all employees of a company.

Additionally, 70 employees responded to the completion of the questionnaire, while the distribution was done in more than one way during the time period from June 1, 2023, to June 30, 2023. In more detail, it was sent personally via email or message to acquaintances and also with the help of the LinkedIn social networking platform to employees of companies, with a response rate calculated at 39% as 45 out of 115 responded. Finally, the completion of it was done remotely, and the analysis was carried out with the help of the Microsoft Excel program.

4. Analysis and results

4.1 Analysis of the Results of Demographic Variables

The analysis with the demographic characteristics, we observe that **Table 1**, which follows, shows the results regarding the gender of the participants in the research. It turns out that out of the 70 participants, 37 (52.8%) are men and 33 are women (47.2%)."

This text introduces a section that discusses the demographic distribution of participants based on gender in your research, likely part of the methodology or results section for your Master's Degree Thesis in Big Data and Analytics in the field of Procurement.

Table 1. Gender

	Frequency	Percent %	Cumulative percent %
Man	37	52,8	52,8
Woman	33	47,2	100
Total	**70**	**100**	

The **Table 2** that follows shows the results related to the age of the participants in the study. From the analysis, it emerges that the majority of the participants, specifically 67.1% (47 individuals), are in the age group of 23-28 years. Additionally, 11 individuals (15.7%) belong to the age group of 29-35 years. Furthermore, we observe that in the age group of 36-45 years there are 2 participants (2.9%). A percentage equal to 4.3% (3 individuals) of the participants are younger than 22 years, and 3 individuals (4.3%) belong to the age group of 46-55 years. Finally, 4 participants (5.7%) belong to the age group of 56-60 years

Table 2. Age

	Frequency	Percent %	Cumulative percent %
<22	3	4,3	4,3
23-28	47	67,1	71,4
29-35	11	15,7	87,1
36-45	2	2,9	90
46-55	3	4,3	94,3
56-60	4	5,7	100
Total	**70**	**100**	

The next demographic variable, **Table 3** refers to the work experience of the employees, who, as mentioned above, come from all levels of the hierarchy, from employees to senior executives, namely line production managers and Logistics service managers. The following table shows that 25 individuals (35.7%) have up to 5 years of work experience. Additionally, 7.1% (5 individuals) have 11-15 years of work experience, while 30% (21 individuals) state that they have been working for 2-5 years. Furthermore, 3 individuals (4.3%) indicate that they have 21-25 years of work experience, and only 4 individuals (5.7%) have been working for more than 26 years. Finally, there are also 12 participants (17.1%) who claim to have been working for 6-10 years.

Table 3. Working Experience

	Frequency	Percent %	Cumulative percent %
<1	25	35,7	35,7
(11-25)	5	7,1	42,9
(2-5)	21	30	72,9

(21-25)	3	4,3	77,1
26+	4	5,7	82,9
(6-10)	12	17,1	100
Total	**70**	**100**	

The next **Table 4** refers to the education of the participants in the study. Based on the analysis of the responses, we observe that most individuals, specifically 53 out of the 70 participants (75.7%), are graduates of higher education institutions (AEI/TEI), while 7 individuals (10%) have completed secondary education. Additionally, 10 individuals (14.3%) hold a postgraduate degree.

Table 4. Education

	Frequency	Percent %	Cumulative percent %
Institution or Collage Graduation	53	75,7	75,7
Secondary education	7	10	85,7
Postgraduate	10	14,3	100
Total	**70**	**100**	

The last demographic variable refers to the position individuals hold in the hierarchy. We observe that 8 individuals or 11.4% are senior executives. Another 6 individuals (8.6%) are middle management, and 49 individuals or 70% are employees. Finally, there are 7 individuals (10%) who state that they hold a different position from the ones mentioned.

Table 5. Position company's hierarchy

	Frequency	Percent %	Cumulative percent %
Other	7	10	10
Senior	8	11,4	21,4
Middle	6	8,6	30
Staff Employee	49	70	100
Total	**70**	**100**	

These demographics are crucial for understanding how data analytics and Big Data are being adopted and utilized across different age groups, experience levels, and hierarchical positions in procurement. They offer a comprehensive view, ensuring that the study's findings and recommendations are broadly applicable.

The majority of the participants are young (ages 23-28) and in employee-level positions, indicating that the perceptions and experiences of those most closely involved in the procurement process are being captured. The inclusion of senior and middle management adds strategic and operational perspectives. In terms of work experience, a good mix is observed, ranging from newcomers to those with more than 26 years in the field. Lastly, educational background is predominantly at the tertiary level, adding a layer of specialization to the data.

4.2 Analysis of Results Regarding the Impact of Big Data and Analytics on the Supply Chain, especially in the Procurement

According to **Table 6** that follows and the analysis of responses to the question "Our company adopts new business processes based on technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID)," we observe that 42 individuals (60%) agree with this opinion, and 7 individuals (10%) fully agree. Furthermore, there are 9 participants (12.9%) who remain neutral, while 9 individuals (12.9%) strongly disagree, and 3 individuals (4.3%) simply disagree.

Table 6. Our company adopts new business processes based on technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID)

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	9	12.9	12.9
Disagree	3	4.3	17,1
Neither Agree nor Disagree	9	12,9	30
Agree	42	60	90
Totally Agree	7	10	100
Total	**70**	**100**	

Table 7 presented below illustrates the respondents' opinions to the question, "Does our company incorporate digital technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID)?" From the responses, it is evident that the majority, specifically 39 individuals (55.7%), agree with this perspective, and 9 individuals (12.9%) fully agree. Additionally, 10 individuals (14.3%) remain neutral and do not clearly express their opinion, while finally there are 3 individuals (4.3%) who disagree, along with another 9 individuals (12.9%) who strongly disagree.

Table 7. Our company incorporates digital technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID).

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	9	12.9	12.9
Disagree	3	4.3	17.1
Neither Agree nor Disagree	10	14,3	31,4
Agree	39	55,7	87,1
Totally Agree	9	12,9	100
Total	**70**	**100**	

At Question 8, **Table 8** "Our business activities are geared towards the use of digital technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID)," we observe that 48 individuals (68.6%) agree with this perspective, while 2 participants (2.9%) fully agree. Additionally, there are 11 individuals (15.7%) who remain neutral, and finally, 9 individuals (12.9%) disagree completely.

Table 8. Our business activities are geared towards the use of digital technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID).

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	9	12,9	12,9
Neither Agree nor Disagree	11	15,7	28,6
Agree	48	68,6	97,1
Totally Agree	2	2,9	100
Total	**70**	**100**	

Table 9 subsequently analyzes the responses of the participants regarding the question, "Our company selects the most suitable supplier through the information system." From the responses, it is evident that 27 individuals (38.6%) agree with this perspective, and 13 individuals (18.6%) fully agree. Additionally, 22 participants (31.4%) remain neutral as they do not openly express their opinion. Finally, out of the 70 participants, 7 individuals (10%) strongly disagree with this opinion, and only one individual (1.4%) disagree.

Table 9. Our company selects the most suitable supplier through the information system

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	7	10	10
Disagree	1	1,4	11,4
Neither Agree nor Disagree	22	31,4	42,9
Agree	27	38,6	81,4
Totally Agree	13	18,6	100
Total	**70**	**100**	

Next, **Table 10** demonstrates that in response to the question, "Our company gathers information related to demand and procurement through the information system," 32 individuals (45.7%) agree with this perspective, and 17 individuals (24.3%) fully agree. Additionally, 14 individuals (20%) remain neutral, while 5 individuals (7.1%) state that they strongly disagree, and only 2 individuals (2.9%) disagree.

Table 10. Our company gathers information related to demand and procurement through the information system

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	5	7,1	7,1
Disagree	2	2,9	10
Neither Agree nor Disagree	14	20	30
Agree	32	45,7	75,7
Totally Agree	17	24,3	100
Total	**70**	**100**	

Subsequently, **Table 11** reveals that 35 participants (50%) support the idea that the company they work for publishes its requirements or policies through the information system, while 5 individuals (7.1%) fully agree. Furthermore, there are 19 respondents (27.1%) who are unsure and thus adopt a neutral stance. Finally, there are 8 individuals (11.4%) who disagree, along with another 3 participants (4.3%) who strongly disagree.

Table 11. Our company publishes its requirements or company policies through the information system.

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	3	4,3	4,3
Disagree	8	11,4	15,7
Neither Agree nor Disagree	19	27,1	42,9
Agree	35	50	92,9
Totally Agree	5	7,1	100

Total	**70**	**100**	

Regarding the question of **Table 12** "Our company notifies the supplier upon the arrival of a procurement through the information system," it is evident that most individuals, specifically 36 participants (51.4%), agree with this perspective, and 6 individuals (8.6%) fully agree. Furthermore, 17 respondents (24.3%) remain neutral, while 9 individuals (12.9%) disagree completely, and an additional 2 individuals (2.9%) disagree.

Table 12. Our company notifies the supplier upon the arrival of a procurement through the information system

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	9	12,9	12,9
Disagree	2	2,9	15,7
Neither Agree nor Disagree	17	24,3	40
Agree	36	51,4	91,4
Totally Agree	6	8,6	100
Total	**70**	**100**	

Subsequently, **Table 13** analyzes the responses of the participants regarding the question, "Our company stores information from previous purchases in electronic format and Data Bases." From the responses, it is evident that 43 individuals (61.4%) agree with this perspective, and 22 individuals (31.4%) fully agree. Additionally, 4 participants (5.7%) remain neutral as they do not clearly express their opinion. Finally, only one individual (1.4%) appears to disagree with this opinion.

Table 13. Our company stores information from previous purchases in electronic format and Data Bases

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	1	1,4	1,4
Neither Agree nor Disagree	4	5,7	7,1
Agree	43	61,4	68,6
Totally Agree	22	31,4	100
Total	**70**	**100**	

Regarding the question "Our company creates a database related to procurements and utilizes it in the purchasing process," it is evident that the majority of individuals, specifically 38 participants (54.3%), agree with this perspective, and another 22 individuals (31.4%) fully agree. Additionally, 7 respondents (10%) remain neutral, while 1 individual (2.9%) disagrees, and only one individual (1.4%) strongly disagrees with this opinion.

Table 14. Our company creates a database related to procurements and utilizes it in the purchasing process

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	1	1,4	1,4
Disagree	2	2,9	4,3
Neither Agree nor Disagree	7	10	14,3
Agree	38	54,3	68,6
Totally Agree	22	31,4	100
Total	**70**	**100**	

Table 15 below analyzes the respondents' answers regarding the question "Your company evaluate supplier performance based on past purchasing information in the information system?" From the responses, it is evident that 30 individuals (42.9%) agree with this viewpoint, and 18 individuals (25.7%) fully agree. Additionally, 15 participants (21.4%) remain neutral as they do not clearly express their opinion. Finally, 4 respondents (4.3%) out of the 70 participants disagree with this opinion, and another 3 individuals (4.3%) disagree completely.

Table 15. Your company evaluate supplier performance based on past purchasing information in the information system

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	3	4,3	4,3
Disagree	4	5,7	10
Neither Agree nor Disagree	15	21,4	31,4
Agree	30	42,9	74,3
Totally Agree	18	25,7	100
Total	**70**	**100**	

Regarding the question of **Table 16** "Your supply chain have a competitive advantage in terms of the efficiency of procurement processes, in terms of using Data Analytcs tools" it is evident that the majority of individuals, specifically 46 participants (65.7%), agree with this viewpoint, and 7 individuals (10%) fully agree. Furthermore, 11 respondents (15.7%) remain neutral, while finally, 6 individuals (8.6%) disagree and consider that the supply chain does not possess a competitive advantage.

Table 16. Your supply chain have a competitive advantage in terms of the efficiency of procurement processes, in terms of using Data Analytcs tools

	Frequency	Percent %	Cumulative percent %
Strongly Disagree	6	8,6	8,6
Neither Agree nor Disagree	11	15,7	24,3
Agree	46	65,7	90
Totally Agree	7	10	100
Total	**70**	**100**	

Table 17 below, analyzes the respondents' answers regarding the question "Our supply chain has a competitive advantage in terms of the effectiveness of procurement processes" From the responses, it is evident that 4 individuals (5.7%) disagree completely with this viewpoint, and an additional 2 individuals (2.9%) disagree. Furthermore, 20 participants (28.6%) remain neutral as they do not clearly express their opinion. Finally, 34 respondents (48.6%) out of the 70 participants agree with this opinion, and another 10 individuals (14.3%) fully agree.

Table 17. Our supply chain has a competitive advantage in terms of the effectiveness of procurement processes

	Frequency	Percent %	Cumulative percent %
Disagree	4	5,7	5,7
Strongly Disagree	2	2,9	8,6
Neither Agree nor Disagree	20	28,6	37,1

Agree	34	48,6	85,7
Totally Agree	10	14,3	100
Total	**70**	**100**	

Table 18 presented below illustrates the responses of the respondents regarding the question "Our supply chain has a competitive advantage due to the differentiation of procurement processes" From the responses, it becomes apparent that 4 individuals (5.7%) disagree with this particular viewpoint, and an additional 8 individuals (11.4%) disagree completely. Furthermore, 23 participants (32.9%) remain neutral. Ultimately, 31 respondents (44.3%) out of the total 70 agree with this opinion, and another 4 individuals (5.7%) fully agree.

Table 18. Our supply chain has a competitive advantage due to the differentiation of procurement processes?

	Frequency	Percent %	Cumulative percent %
Disagree	8	11,4	11,4
Strongly Disagree	4	5,7	17,1
Neither Agree nor Disagree	23	32,9	50
Agree	31	44,3	94,3
Totally Agree	4	5,7	100
Total	**70**	**100**	

Lastly, in relation to the question of **Table 19** "Our supply chain have a competitive advantage in terms of reputation for exceptional procurement operations," it is evident that 31 individuals (44.3%) agree with this viewpoint, and 10 individuals (14.3%) fully agree. Furthermore, we observe that 23 participants (32.9%) remain neutral. Lastly, there is an opposing viewpoint as 6 individuals (8.6%) out of the 70 individuals disagree completely.

Table 19. Our supply chain has a competitive advantage in terms of reputation for exceptional procurement operations

	Frequency	Percent %	Cumulative percent %
Disagree	6	8,6	8,6
Neither Agree nor Disagree	23	32,9	41,4
Agree	31	44,3	85,7
Totally Agree	10	14,3	100
Total	**70**	**100**	

5. Conclusions and Recommendations

5.1 Conclusions

The purpose of this study was to explore the impact of using new technologies and the utilization and usefulness of Big Data and Analytics in the supply chain. For this purpose, both literature review and empirical research were employed. Beginning with the conclusions drawn from the literature review, it became evident that the fourth industrial revolution, also known as Industry 4.0, is taking place and leading to the creation of a fully interconnected ecosystem within different operational areas of an enterprise. Organizations are reshaping their strategies to move towards fully integrated boundaries and to become fully transparent in their business practices, including supply chain management, which is now one of the decisive success factors for organizations (Khajavi et al. 2015).

Continuing, it should be noted that although the field of Data Analytics in the supply chain has evolved and progressed in research, the research landscape still remains insufficient and requires further significance and analysis. Thus, I attempted to contribute to the enhancement of the existing literature through primary data. For this reason, we conducted empirical research from which the following valuable conclusions emerged. Specifically, it was found that the use of new technologies in the supply chain leads to processes and activities that enhance customer satisfaction.

In more detail, from the analysis of the research, it was observed that most companies are incorporating digital technologies such as Big Data, analytical data, cloud, automation (robotics), and radio frequency identification (RFID) based on the perspective of the majority of participants (68.6%). These companies are also adopting new business processes based on these specific technologies. These findings are consistent with the literature and studies such as Agrifoglio et al. (2017) and Xu et al. (2018), which find that RFID and cloud computing technologies create value in the supply chain, and Buyukozkan & Go9er (2018), who emphasize the creation of self-optimized production systems to proactively respond to the constantly changing nature of markets.

From the empirical research, it was demonstrated that the majority of participants agree that through the information system, they are capable of selecting the most suitable supplier, a viewpoint supported by McDonald et al. (2004). Furthermore, we found that the supply chain of most companies has a competitive advantage in terms of efficiency and effectiveness of procurement processes, according to the opinions of 53 and 44 participants, respectively. This perspective aligns with that of Porter & Heppelmann (2015), who argue that the successive connectivity through the digitization of the supply chain and the extraction of information through Data Analytics can bring businesses to a position of competitive advantage by allowing them to respond more effectively to changing customer needs.

Additionally, it's worth noting that the majority of companies, specifically 8 out of 10, create a database related to procurement and utilize it in the purchasing process to achieve flexibility and cost reduction through strategic decisions, simultaneously generating greater value. This fact is confirmed by Khajavi et al. (2015) as an advantage within the context of this digital transformation and the opportunities provided to companies by the fourth industrial revolution.

From the research, it also emerged that participants seem to recognize the benefits of digital transformation, which aligns with Alick et al. (2017), who assert that digital technologies can provide companies with a significant competitive advantage. However, a notable division among participants is apparent, as not all exclusively associate their competitive advantage with the differentiation of procurement processes through digital transformation.

According to Kache & Seuring (2017), significant opportunities for the supply chain arise from digitization, such as increased information availability, visibility, and transparency throughout the supply chain through real-time access and control of information end-to-end, consolidation, collaboration, and efficient inventory management. These conclusions are mirrored in the results of this particular research, as the majority of respondents support the idea that their company gathers information related to demand and procurement through the information system to achieve competitive advantage.

In summary, it was found necessary to digitize the supply chain in order to remain competitive. It was observed that the digitization of supply chains can enhance the competitive position of companies and promote commitment and collaboration among involved parties. Furthermore, from the empirical analysis, it was revealed that the responsiveness of the supply chain will increase as a result of the increased scalability provided by digitization. However, it's important to note that not all companies need to reach the same level of maturity in digitization to achieve similar added value and performance.

The findings of this study provide recommendations and implications regarding the digitization of supply chains, derived from companies belonging to various sectors. As such, they can be used as indicators for businesses, especially since product specifications are not the primary focus of supply chain digitization. Additionally, these findings can serve as an argument for understanding why businesses should digitize their supply chain.

5.2 Constraints and Suggestions for Future Research

This study explored the use and utility of Big Data and Analytics in the supply chain, specifically in procurement. It involved conducting descriptive analysis of secondary data from articles and analyzing primary data through descriptive statistical analysis from the conducted research. However, it's important to note that the time period of this study is limited. Therefore, it is suggested that further empirical research be conducted on this topic, focusing on the impact of technology usage in the supply chain over a longer timeframe.

Additionally, this study did not focus on a specific sector; instead, participants from various industries were involved. Consequently, conducting a study within specific sectors that examines and analyzes similarities and differences in supply chain digitization based on industry activities would be of great interest. This would shed light on how companies belonging to different sectors are impacted differently by digital transformation.

Furthermore, considering that this field is rapidly evolving due to constant technological advancements, a comparison could be made between supply chains that have embraced new technologies and data analytics and those that haven't. This could provide insights into the effectiveness of supply chains before and after the adoption of these technologies, as well as monitoring and analyzing trends.

Lastly, a comparison could be made between two supply chains that have both adopted these new technologies but are utilizing them at different levels within their logistics operations. This comparison could optimize the use of these technologies in logistics, ultimately leading to operational excellence.

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Questionnaire

DEMOGRAPHIC CHARACTERISTICS

1) Gender:

• Male

• Female

2) Age:

• <22

• 23-28

• 29-35

• 36-45

• 46-55

• 56-60

• 61+

3) Years of Work Experience:

• <1

• 2-5

• 6-10

• 11-15

• 16-20

• 21-25

• 26+

4) Education:

• Secondary Education

• University/Technical College Graduate

• Postgraduate Degree

• Doctorate

• Other

5) Position in Company Hierarchy:

• Employee

• Middle Manager

• Senior Manager

• Other

BIG DATA IN SULLPLY CHAIN AND PROCUREMENT:

6) Our company adopts new business processes based on technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID).

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

7) Our company incorporates digital technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID).

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

8) Our business activities are oriented towards using digital technologies such as big data, analytics, cloud, automation (robotics), and radio frequency identification (RFID).

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

9) Our company selects the most suitable supplier through the information system.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

10) Our company gathers information about demand and procurement through the information system.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

11) Our company publishes its requirements or rules through the information system.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

12) Our company notifies the supplier upon the arrival of a procurement through the information system.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

13) Our company stores information about previous purchases in electronic format.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

14) Our company creates a database regarding procurements and utilizes it in the purchasing process.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

15) Our company evaluates supplier performance based on previous purchasing information in the information system.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

16) Our supply chain has a competitive advantage in terms of the efficiency of procurement processes.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

17) Our supply chain has a competitive advantage in terms of the effectiveness of procurement processes.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

18) Our supply chain has a competitive advantage due to the differentiation of procurement processes.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree

19) Our supply chain has a competitive advantage in terms of reputation for exceptional procurement operations.

• Strongly disagree

• Disagree

• Neither agree nor disagree

• Agree

• Strongly agree