HIGHER SCHOOL OF MANAGEMENT AND DIGITAL ECONOMY

HSMDE

End of cycle dissertation for the attainment of Master-Start-Up Diploma

Specialty: Governance of Information Systems

THEME:

THE INTEGRATION OF BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT.

CASE STUDY: The National Company of Geophysics (ENAGEO)

Project:

Secure Supply Path

(SSP)

Submitted by:

Miss. Naoual Malki.

Supervised by:

Mrs. Sihem Ould Said.

Mrs. Manel Merabti.

Class of: June 2024

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Dedications:

"To those who have been martyred for the land of sad oranges... and to those who have not yet been martyred." (Ghassan Kanafani, The Land of Sad Oranges).

To childhood and children, especially those who suffer from the brunt of war. To the children of Gaza in particular…my dissertation work is devoted to you.

To my first inspirations, to my heroes, to those who have given to me and continue to give without limits...To my parents, Ameur and Samia! I owe everything I have achieved and everything I hope to achieve. I am very proud to be your daughter, without you, I would not be who I am today.

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List of Abbreviations:

AR: Augmented Reality.

CDD: Communication and Development.

CIPS: The Chartered Institute of Procurement and Supply.

CPU: Central Processing Unit.

CSD: Common Services Department.

DLT: Distributed Ledger Technology.

dApps: Decentralized Applications.

EID: Electronic identification devices.

EMR: Electronic Medical Records.

ENAGEO: Enterprise Nationale de Géophysique (Algerian National Company of Geophysics).

ERP: Enterprise Resource Planning.

FAD: Finance and Accounting Department.

GVCS: Global Value Chains.

HRAD: Human Resources and Administration Department.

HSED: Health, Safety, and Environment Department.

HTD: Hydrology and Topography Department.

IoT: Internet of things.

ITID: Information Technology and Communication Department.

LAD: Legal Affairs Department.

LD: Logistics Division.

LSPS: Logistics Service Providers.

NFT: Non-Fungible Token.

P2P: Peer to Peer.

POS: Proof Of Stake.

POW: Proof Of Work.

PSD: Planning and Systems Department.

RAM: Random-Access Memory.

R&D: Research and Development.

RFID: Radio Frequency Identifier.

SCM: Supply Chain Management.

SCO: Supply Chain Officer.

S&OP: Sales and Operation Planning.

SCP: Stellar Consensus Protocol.

SED: Seismic Exploration Division.

SPD: Seismic Processing Department.

Abstract:

Blockchain technology is a distributed data management system that can be accessed easily, containing blocks that are linked in a chain to maintain tamper-proof transaction records. It differs from other databases in that it has various technological systems, such as peer-to-peer network, distributed ledger, cryptography, consensus mechanism, and smart contracts. While blockchain brings visibility, security, trust environment, and transparency to the supply chain of companies to ensure sustainability, on the other hand, blockchain innovations come together with emerging technologies to provide scalable data management, decentralized networking, automation, predictive performance, real-time traceability that significantly affect productivity and profitability.

Our study examines the potential benefits and challenges of incorporating blockchain technology into supply chain management, with ENAGEO as our case study. Through qualitative methods, including semi-structured interviews, we examine the perception of blockchain technology's impact on supply chain management among employees.

Sub-questions address employee familiarity with blockchain, the alignment of current supply chain challenges with blockchain capabilities, and organizational factors influencing integration success. Three hypotheses are formulated to test employee perceptions, pain point alignment, and organizational readiness.

The study is structured into two chapters that explore the potential of blockchain for supply chain enhancement and detail the qualitative research methodology using a descriptive and exploratory approach. By shedding light on blockchain's role in addressing supply chain challenges, this study offers insights for businesses seeking to improve their supply chain transparency, visibility, flexibility, and trust.

Keywords: Blockchain technology, supply chain management, transparency, security, smart contracts.

Résumé :

La technologie Blockchain est un système de gestion de données distribué accessible facilement, contenant des blocs qui sont liés dans une chaîne pour maintenir des enregistrements de transactions inviolables. Il diffère des autres bases de données en ce qu'il dispose de divers systèmes technologiques, tels que le réseau peer-to-peer, le grand livre distribué, la cryptographie, le mécanisme de consensus et les contrats intelligents. Alors que la blockchain apporte de la visibilité, de la sécurité, un environnement de confiance et de la transparence à la chaîne d'approvisionnement des entreprises pour assurer la durabilité, d'autre part, les innovations de la blockchain s'associent aux technologies émergentes pour fournir une gestion des données évolutive, la mise en réseau décentralisée, l'automatisation, les performances prédictives, la traçabilité en temps réel qui affectent considérablement la productivité et la rentabilité.

Notre étude examine les avantages et les défis potentiels de l'intégration de la technologie blockchain dans la gestion de la chaîne d'approvisionnement, avec ENAGEO comme étude de cas. Grâce à des méthodes qualitatives, y compris des entretiens semi-structurés, nous examinons la perception de l'impact de la technologie blockchain sur la gestion de la chaîne d'approvisionnement parmi les employés.

Les sous-questions portent sur la familiarité des employés avec la chaîne de blocs, l'harmonisation des défis actuels de la chaîne d'approvisionnement avec les capacités de la chaîne de blocs et les facteurs organisationnels qui influent sur le succès de l'intégration. Trois hypothèses sont formulées pour tester les perceptions des employés, l'alignement des points douloureux et la préparation organisationnelle.

L'étude est structurée en deux chapitres qui explorent le potentiel de la blockchain pour l'amélioration de la chaîne d'approvisionnement et détaillent la méthodologie de recherche qualitative en utilisant une approche descriptive et exploratoire. En mettant en lumière le rôle de la blockchain dans la résolution des défis de la chaîne d'approvisionnement, cette étude offre des informations aux entreprises qui cherchent à améliorer la transparence, la visibilité, la flexibilité et la confiance de leur chaîne d'approvisionnement.

Mots-clés : Technologie blockchain, gestion de la chaîne d'approvisionnement, transparence, sécurité, contrats intelligents.

ملخص:

تكنولوجيا البلوكتشين هي نظام إدارة بيانات موزع يمكن الوصول إليه بسهولة، يحتوي على كتل متصلة بسلسلة للحفاظ على سجلات المعاملات غير القابلة للتلاعب. تختلف عن قواعد البيانات الأخرى بوجود أنظمة تكنولوجية متنوعة، مثل الشبكة نظير إلى نظير، والدفتر اللامركزي الموزع، والتشفير، وآلية الاتفاق، والعقود الذكية. بينما تجلب تكنولوجيا البلوكتشين الرؤية والأمان وبيئة الثقة والشفافية إلى سلسلة التوريد للشركات لضمان الاستدامة، فإن الابتكارات في مجال البلوكتشين تأتي بالتزامن مع التقنيات الناشئة لتوفير إدارة بيانات موزعة بشكل قابل للتوسع، وشبكات متمركزة، والتشغيل التلقائي، والأداء التنبؤي، وتتبع الوقت الحقيقي التي تؤثر بشكل كبير على الإنتاجية والربحية.

دراستنا تفحص الفوائد والتحديات المحتملة لدمج تكنولوجيا البلوكتشين في إدارة سلسلة التوريد، باعتبار الشركة الوطنية للفيزياء دراسة حالة لنا. من خلال الطرق النوعية، بما في ذلك المقابلات شبه المنظمة، ندرس الإدراك لتأثير تكنولوجيا البلوكتشين على إدارة سلسلة التوريد بين الموظفين.

تتناول الأسئلة الفرعية مدى إلمام الموظفين بتكنولوجيا البلوكتشين، وتوافق التحديات الحالية في إدارة سلسلة التوريد مع قدرات تكنولوجيا البلوكتشين، والعوامل التنظيمية التي تؤثر على نجاح الدمج. تتم صياغة ثلاث فرضيات لاختبار إدراك الموظفين، وتوافق نقاط الضعف، و جاهزية الدمج.

تتكون الدراسة من فصلين يستكشفان إمكانية تحسين سلسلة التوريد من خلال تكنولوجيا البلوكتشين وتفصيل منهجية البحث النوعية باستخدام نهج وصفي واستكشافي. من خلال إلقاء الضوء على دور تكنولوجيا البلوكتشين في مواجهة تحديات سلسلة التوريد، تقدم هذه الدراسة رؤى للشركات الساعية لتحسين شفافية سلسلة التوريد ورؤيتها ومرونتها وثقتها.

كلمات مفتاحية : تكنولوجيا البلوكتشين، إدارة سلسلة التوريد، الشفافية، الأمان، العقود ذكية

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PART I:

THE INTEGRATION OF BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

General introduction

General introduction:

The competitive environment has created challenges for companies due to the changing market conditions, which have become more dynamic and demanding. Collaboration, integration, flexibility, and trust among stakeholders are crucial to supply chains in navigating this complexity. In today's competitive business environment, effective supply chain management is seen as a vital strategy for reducing costs and improving economic performance. To maintain competitiveness, supply chain management techniques must be updated to respond to emerging issues such as increased complexity, transparency standards, and flexibility requirements.

As a result, companies are actively developing information technologies to make supply chain processes more efficient. This development highlights the growing importance of incorporating new technical applications in supply chains. The common belief is that implementing modern specialized technological tools is necessary to better manage the flow of the supply chain. Despite the longstanding use of digital technology tools such as EID, RFID, and IoTs to improve efficiency in supply chain processes, challenges related to transparency, visibility, flexibility, and trust have not been fully resolved over time.

In this situation, due to its advanced technological features, blockchain seems to address the challenges we mentioned earlier. By enhancing how data is managed and protecting shared information, incorporating blockchain has the potential to enhance the security, traceability, and efficiency of the supply chain. Additionally, blockchain technology can boost collaboration and communication among those involved, resulting in cost savings and improved performance. Moreover, customer trust can grow with blockchain, as it enables the tracking of products at every step of the supply chain. Furthermore, blockchain plays a crucial role in preventing fraud, managing product data in real-time, and ensuring quality control throughout a product's entire lifecycle.

Given the reasons mentioned earlier, it is essential for businesses to take a proactive approach in adopting and incorporating blockchain technology into their supply chain operations.

The choice of this topic was not randomly made; it was inspired by Mohamed Haichour"s online article 'La blockchain, un choix stratégique pour l'industrie algérienne', which was published by Presse-Algerie. I was interested in the potential of blockchain technology highlighted in the

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article, especially its strategic implications for the Algerian industry, so I embarked on a journey to better understand this transformative technology.

As my interest in blockchain technology grew, I made a pivotal decision to focus my dissertation on exploring the integration of blockchain technology into existing systems. By conducting thorough research and engaging with experts in different fields, including supply chain management, I gained an understanding of the complexity of modern supply chains and the challenges that arise in tracking goods throughout the entire supply chain process.

The goal of this study is to introduce and encourage the adoption of blockchain technology among enterprises to enhance their supply chain operations. This initiative aims to help businesses understand the potential benefits of blockchain, addressing challenges related to transparency, visibility, flexibility, and trust. The objective is to showcase how blockchain can improve security, traceability, and efficiency in the supply chain, foster collaboration, reduce costs, and enhance overall performance.

The main research problematic can be summarized as follows:

" What are the potential benefits and challenges of integrating blockchain technology into supply chain management?"

To address this problem comprehensively, several sub-questions will guide the research:

- How familiar are employees at the National Company of Geophysics (ENAGEO) with blockchain technology, and what are their perceptions of its potential benefits and challenges for supply chain management?
- How do the current problems in supply chain management at ENAGEO relate to what blockchain technology can offer, and how might blockchain help solve these issues?
- What aspects of ENAGEO 's culture, leadership, and technology might affect the success of integrating blockchain into supply chain management?

The elements of response to the formulated problem will be provided by verifying the following hypotheses:

Hypothesis 01: Employees who are more familiar with blockchain technology will perceive greater potential benefits in its integration for supply chain management at ENAGEO.

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Hypothesis 02: The identification of specific pain points in current supply chain management processes will align with the potential capabilities of blockchain technology to address these issues effectively.

Hypothesis 03: Organizations with supportive leadership, a culture of innovation, and robust technological infrastructure will exhibit greater readiness for the integration of blockchain technology into supply chain management.

By utilizing various references such as books, online articles, doctoral research, websites, and colloquia, this research aims to provide a comprehensive understanding of the current knowledge and practices in the field. Additionally, it seeks to identify gaps that exist in the current literature, which this research aims to address.

The research will follow the descriptive, exploratory method to investigate the research problem. The qualitative study is conducted in form of semi-structured interviews approach will be utilized to gather relevant data.

line with this logic, we will attempt to address these questions by subdividing our research work into two chapters:

In the first chapter, we thoroughly examine how blockchain technology can enhance supply chain management. We start by understanding Supply Chain Management (SCM), then dive into blockchain, its history, mechanics, and applications in various industries. We discuss the benefits, challenges, and best practices for integrating blockchain into supply chain management.

In the second chapter, our attention turns to the research methodology, where we utilize a qualitative approach through semi-structured interviews. These interviews will be conducted to gather pertinent data from the National Company of Geophysics (ENAGEO).

We will find at the end of this brief a general conclusion summarizing the results obtained, as well as recommendations for the company, limitations and future perspectives.

Chapter I: Exploring Blockchain Integration in Supply Chain Management.

Supply chains are the foundation of modern commerce, bringing together manufacturers, suppliers, distributors, and retailers in an intricate manner. The desire for efficiency, transparency, and security in these networks has resulted in an increase in interest in emerging technologies, specifically blockchain. The potential of blockchain, known for its decentralized and immutable nature, is to change how we view and optimize supply chain operations. This chapter has multiple functions in exploring blockchain technology's integration in supply chain management. It provides a comprehensive overview of Supply Chain Management (SCM), dissecting its key components, information flows, complexities, and obstacles.

The review effortlessly transitions to the essential elements of blockchain, including its history, varied structures, operational mechanics, and popular platforms. Furthermore, it provides an insight into the vast array of blockchain applications across industries, leading to a deeper understanding of its potential within SCM. A focused exploration into the integration of blockchain technology within supply chain management is set to occur through this thorough examination, which explores its use cases, benefits, challenges, and best practices for successful implementation. This literature review provides a comprehensive view that illustrates the transformative potential of blockchain in revolutionizing supply chain operations.

The overarching objective of this chapter is not only to introduce the blockchain technology but also to serve as a catalyst for its adoption among Algerian companies.

Chapter I: Exploring Blockchain Integration in Supply Chain Management.

Section 1: Supply Chain Management

Supply chain management (SCM) is an important concept in modern business operations that helps companies attain efficiency, profitability, and sustainability in today's competitive landscape. **Despite *the recognition of SCM studies and applications, there stays significant confusion as to its meaning***".[1]The objective of this section is to provide clarity by providing a comprehensive overview of SCM. It explores the fundamental aspects, beginning with the definition and key components that are the backbone of supply chain operations. This includes an exploration of the intricate flow of goods, information, and finances across the supply chain network, illustrating how these elements are interconnected. As supply chains evolve, their complexity grows, presenting new challenges and obstacles that companies must navigate. This section also sheds light on these evolving complexities and the hurdles encountered within supply chains. In addition, the impact of digitization, specifically in the context of Industry 4.0, on supply chain management practices is investigated. This section reveals valuable insights into the evolving landscape of supply chain management in the era of Industry 4.0 by exploring the transformation of digital technologies in supply chain management.

1- Definition and key components of supply chain management:

In this part we will discuss the different meanings of the supply chain management and its key components.

1-1- Definition of supply chain management:

In its simplest form according to CIPS (2021) the supply chain is *"**The activities required to deliver goods or services to the consumer***"[2].

According to A. HAYES's definition (2024) "***A supply chain is a network of individuals and companies who're concerned in creating a product and delivering it to the consumer. Links***

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[1]Habib, M. M. (2024, June). Impact of integrated supply chain platforms on construction project management. In 41st International Symposium on Automation and Robotics in Construction: Supply chain management: Theory and its future perspectives. American International University - Bangladesh. https://doi.org/10.22260/ISARC2024/0050 .

[2] CIPS The Chartered Institute of Procurement and Supply. (2021). What is a supply chain? Intelligence Hub. Retrieved February 19, 2024, at 10:44 AM, from https://www.cips.org/intelligence-hub/supply-chain-management/what-is-a-supply-chain .

*on the chain start with the producers of the raw materials and end when the van delivers the finished product to the end user***"**[3].

Grimshaw (2020) says: *"**The supply chain is defined as the entire process of making and selling commercial goods, including every stage from the supply of materials and the manufacture of the goods through to their distribution and sale. Successfully dealing with supply chains is critical to any company hoping to compete*".[4]

Irina et al. (2015) state that *"**Supply Chain is a complex logistic system where raw materials are transformed into products or services and delivered to end users. The supply chain is a system that includes suppliers, logistics service providers, manufacturers, distributors and retailers, and provides material, information and financial flow between them*".[5]

Meanwhile SCM defined as:" ***The management of flow of goods as well services and includes processes involved in transforming raw materials to final products. The goal of supply chain management is to implement chains that are both efficient and economical. Supply chain management is used for controlling, shipping and distributing products. Companies can cut down on excess costs and expedite the delivery process through supply chain management*".[6]

1-2-   key components of supply chain management:

- **Planning:** Planning process are the critical to allow supply chains to operate at maximum efficiency. Proper planning allows for both inventory and operational resource levelling. Controlling supply by source planning and managing demand by demand planning allows the organization to have a better handle on cash flow and ability to meet customer needs. Data that churns from the planning process also allows companies consolidate shipments

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[3]*Hayes, A. (2024). The supply chain: From raw materials to order fulfillment. Investopedia. Retrieved February 24, 2024, at 11:21 AM, from https://www.investopedia.com/articles/investing/021015/supply-chain-raw-materials-finished-products.asp .*

[4] *Grimshaw. (2020, May 17). What is supply chain? A definitive guide. Supply Chain Digital. Retrieved February 19, 2024, at 01:51 PM, from https://supplychaindigital.com/digital-supply-chain/what-supply-chain-definitive-guide .*

[5]*Kozlenkova, I. V., Hult, G. T. M., Lund, D. J., Mena, J. A., & Kekec, P. (2015). The role of marketing channels in supply chain management. Journal of Retailing, 91(4), 586-609. https://doi.org/10.1016/j.jretai.2015.03.003 .*

[6] *Sharma, J. (2023, September 30). Difference between supply chain management and logistics management. Shiksha. Retrieved February 19, 2024, at 2:57 PM , from https://www.shiksha.com/online-courses/articles/difference-between-supply-chain-management-and-logistics-management .*

to enjoy better economies of scale and even indulge in some predictive analytics to enjoy more accurate forward-looking projections[7].

- **Sourcing:** In every business, it's crucial to choose one or more suppliers who will provide the necessary goods and services for creating their products. Once suppliers are chosen, the supply chain manager is responsible for monitoring and managing these supplier relationships. This involves tasks such as ordering, receiving goods, overseeing inventory, and approving supplier payments.[8]

- **Making:** The manufacturing process can involve actual raw material to finished goods manufacturing or it can include repackaging, re-kitting, bundling, assembly, dressing, or staging. Optimizing this process is key to minimizing variance in outcomes (increase predictability of the process itself) and minimizing or eliminating non-conformance to customer requirements. The manufacturing process is almost always a space for continuous improvement even in the highest tech of automated production lines.[9]

- **Delivering:** A strong and stable delivery channel is crucial for a business. To handle unexpected increases in demand, the delivery channel must have plans in place to address common logistics challenges like port congestion or bad weather. Despite the tendency for some organizations to prioritize sales over supply chain management, it is crucial to allocate funding to improve the supply chain to meet the needs of the business effectively.[10]

- **Returning:** Returning products for various reasons is a common occurrence for customers. Damage during shipment, products not meeting quality standards, defects, products nearing expiration, or incorrect products or quantities being shipped are all possible reasons. The return process is a crucial aspect of the customer experience and is closely related to the refund process. How a business handles returns can make a big difference in how satisfied customers are with their purchases.[11]

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[7] *Globalior. (n.d.). The 5 basic components of supply chain management. Globalior. Retrieved February 22, 2024, at 9:05 AM, from* https://www.globalior.com/the-5-basic-components-of-supply-chain-management/ *.*

[8]*C&D Logistics. (n.d.). The 5 components of supply chain management. C&D Logistics. Retrieved February 22, 2024, at 10:10 AM, from* https://www.cdlogistics.ca/freight-news/the-5-components-of-supply-chain-management/ *.*
[9] *Idem*
[10] *C&D Logistics. (n.d.). The 5 components of supply chain management. C&D Logistics. Retrieved February 22, 2024, at 12:20 AM, from* https://www.cdlogistics.ca/freight-news/the-5-components-of-supply-chain-management/ *.*
[11] *Idem*

Chapter I: Exploring Blockchain Integration in Supply Chain Management.

2- The flow of information, material and financial in supply chain management:

Three essential flows are necessary for the movement and coordination of information, material, and financial throughout the entire supply chain. The efficient operation of the supply chain is dependent on these flows and they play a significant role in guaranteeing timely delivery, effective communication, and financial transactions. in this part we will see each of these flows in more detail.

2-1- Information Flow:

Information sharing is a key aspect that demonstrates collaboration in supply chain management, as stated by Li, Yan, Wang and Xia (2005)[12]. As Simatupang and Sridharan describes (2002b), information sharing is "***the ability to see private data in a partner's systems and monitor the progress of products as they pass through each process in the supply chain. This activity includes monitoring (data capturing), processing, and dissemination of customer data, end-to-end inventory status and locations, order status, costs-related data, and performance status***"[13].As per these authors, sharing information ensures that partners in the supply chain can meet demand more quickly. The flow of information within supply chain management occurs when partners share information, allowing for effective decision-making.

"Information flow is the flow of information from supplier to customer and from customer back to supplier. This flow is bi-directional, that is, it goes both direction in the supply chain".[14]

2-2- Material Flow:

According to Karsten Weiß the material flow:" ***describes the path taken by materials or products from procurement to sales within or between companies. It includes all processes and stations through which the material or product passes, such as production, storage, picking and distribution***".[15]

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[12] Li, G., Yan, H., Wang, S., & Xia, Y. (2005). Comparative analysis on value of information sharing in supply chains. *Supply Chain Management: An International Journal, 10(1), 34–46.*

[13] *Simatupang, T.M. and Sridharan, R. (2002b). Supply chain discontent: sources and remedies. Supply Chain Management: An International Journal.*

[14]*The three flows of supply chain. [online] KPA. Available at:<https://kpakpakpa.com/the-three-flows-of-supply-chain/>. [Accessed on the 20th, of February.2024 at 8:56 AM].*

[15] *Karsten Weiß: 04, Juli,2023. Material flow in production and logistics - Definition & all you need to know. [online] BEEWATEC. Available at: https://www.beewatec.com/blog/material-flow-in-production-and-logistics-how-to-optimize-your-internal-processes . [Accessed on the 20th, of February,2024 at 2:41PM].*

Based on the article by Suhaiza Zailani (January 2012):" *Many supply chain management practitioners acknowledge the significance of effectively managing material flows throughout the supply chain as a crucial strategic success factor (Rao Tummala, et al., 2006; Chin et al., 2004),According to the paper by Chin, Rao Tummala, Leung and Tang (2004), They have identified the control of seamless material flow as the focal point of optimal SCM design and practices, suggesting that supply chain performance can be enhanced through the re-engineering of material flows (Towill, Childerhouse & Disney, 2000)."[16]*

2-3-   Financial Flow:

Financial flow involves the transfer of money from the customer to the supplier. After receiving and verifying the product, the customer pays and the supplier receives the money back. Sometimes the finances flow in the opposite direction (from supplier to customer) in the form of debit[17].

After reviewing various definitions in the literature, it became clear that creating a simplified definition would help clarify the concept. Therefore, we have formulated the following definition: Material flow refers to the movement of items within a company, from production to sales. This process includes manufacturing, storing, receiving, and distributing them. Material flow management is focused on optimizing the movement of goods to ensure efficient production, minimize waste, reduce costs, and meet customer demands. It includes both the physical movement of materials and the related information flow, such as tracking inventory levels, managing orders, and coordinating shipments.

3- The complexity growth in supply chains:

The complexity of supply chains is inevitable due to changing customer needs, competitive dynamics, and advancements in technology.

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[16]*Suhaiza Zailani (January 2012). Effects of Information, Material and Financial Flows on Supply ChainPerformance: A Study of Manufacturing Companies in Malaysia. International Journal of Management Vol. 29 No. 1 Part 2 Mar 2012, pp.295.*

[17] *Know about the three flows of supply chain. Available at: https://www.linkedin.com/pulse/know-three-flows-supply-chain traxl#:~:text=Financial%20flow%20involves%20the%20movement,customer)%20in%20form%20of%20debit   . [Accessed on the 20th, of February,2024 at 3:51PM].*

Chapter I: Exploring Blockchain Integration in Supply Chain Management.

According to A.Sheel because of changing customer needs, competitive dynamics, and varying technology adoption, supply chains are becoming more complex. The supply chain involves a network of entities that move goods, services, and information. The objective of managing this complexity is to decrease expenses, enhance customer satisfaction, and gain a competitive edge.

Despite this, managing multiple business relationships and processes in uncertain environments is a challenging task. Complex systems show significant interactions, a large number of components, nonlinearity, broken symmetry, and nonholonomic constraints.[18]

Complexity is a result of changing customer requirements and businesses' desire to develop an appropriate supply chain to meet customer needs. Whether it is fashion, consumer electronics, or traditional industries such as power generation, customer preferences are changing. Agile supply chains can deliver new products every few months or new clothing styles almost every week, thanks to shorter and more responsive product lifecycles leading the way.[19]

4-   Occurring obstacles in supply chains:

To improve company performance, it is crucial to understand and overcome supply chain challenges.

According to Hudnurkar, et al., (2014) identifying and addressing the challenges and complexities within the supply chain is essential to improve a company's performance. Although integrated IT systems are essential for successful collaborations, an overreliance on technology during the beginning stages of a partnership can result in decreased performance.[20]The importance of cultural elements, particularly when it comes to how entities behave towards one another, is

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[18] *Ashutosh Sheel, 2016. Supply Chain Complexity Drivers and Its Management. IOSR Journal of Business and Management (IOSR-JBM) e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 18, Issue 1.Ver. II (Jan. 2016), PP 39-43* www.iosrjournals.org

[19]*LEE GLENDON, 2018. The Increasing Complexity of Supply Chains and the BC Professional. [Online] Risk And Resilience Hub. Available at: <The Increasing Complexity of Supply Chains and the BC Professional - Risk and Resilience Hub> [Accessed on the 22nd, of February,2024 at 07:30 AM].*

[20]*Manoj Hudnurkar, Suresh Jakhar, Urvashi Rathod ,2014. Factors Affecting Collaboration in Supply Chain: A Literature Review, Procedia - Social and Behavioral Sciences Volume 133, 15 May 2014, Pages 189-202. <https://doi.org/10.1016/j.sbspro.2014.04.184>.*

underlined by Barratt (2004)[21] and Fawcett et al. (2010)[22]. Entities may refrain from contributing their full potential to collaboration due to the fear of failing or being exploited by associates. This results in a restriction of the flow of both tangible and intangible assets and hinders the exchange of information. As stated by McCarter and Northcraft (2007), these challenges are known as 'hold-up' and 'leakage' problems.[23]The outcome is a social conflict where a partner who betrays their partner can gain a higher added value than the other party, even though the overall benefit is consistently greater in harmonious collaborations. Thus, the dilemma often lies between personal gain and shared success, as noted by Zeng and Chen (2003).[24]In order to build a harmonious supply chain relationship, it is necessary to address other culture-related challenges, such as distrust, unwillingness to divulge sensitive information, delayed payments, or the presence of third-party controlling documents that could result in manipulations or errors among associates. Resolving these issues is crucial to minimize disputes and chargebacks, as highlighted by Fawcett et al. (2010).[25]

5- Digitalization of supply chain management with industry 4.0:

Logistics has gone through significant changes over the past three decades. From being just, a reporting task for sales or manufacturing, with a focus on ensuring production line supply and customer delivery, to an independent supply chain management function, it has changed. In certain companies, a Chief Supply Chain Officer (CSO) is now in charge of this function. Supply chain management is now more focused on advanced planning processes, such as analytical demand planning or integrated sales and operations planning (S&OP). In many companies, these processes have become standard. Often, third-party Logistics Service Providers (LSPs) outsource operational

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[21]Barratt, Mark, "Understanding the Meaning of Collaboration in the Supply Chain" (2004). Management Faculty Research and Publications. 248.<https://epublications.marquette.edu/mgmt_fac/248>.

[22]Fawcett, Stanley E., Matthew A. Waller and Amydee M. Fawcett. "Elaborating a dynamic systems theory to understand collaborative inventory successes and failures." The International Journal of Logistics Management 21 (2010): 510-537.

[23]Matthew W. McCarter, Gregory B. Northcraft,2007. Happy together? : Insights and implications of viewing managed supply chains as a social dilemma. Journal of Operations Management
Volume 25, Issue 2, March 2007, Pages 498-511. <https://doi.org/10.1016/j.jom.2006.05.005>

[24]Zeng, M., & Chen, X.-P. (2003). Achieving cooperation in multiparty alliances: A social dilemma approach to partnership management. The Academy of Management Review, 28(4), 587605. https://doi.org/10.2307/30040749

[25]Fawcett, Stanley E., Matthew A. Waller and Amydee M. Fawcett. "Elaborating a dynamic systems theory to understand collaborative inventory successes and failures." The International Journal of Logistics Management 21 (2010): 510-537.

logistics. The supply chain function is now responsible for ensuring integrated operations between customers and suppliers. In this section we will discuss what's the industry 4.0 and what are its benefits for the supply chain management.

5-1- The definition of industry 4.0:

Industry 4.0 has been defined as "***a name for the current trend of automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of things, cloud computing and cognitive computing and creating the smart factory***".[26]

Industry 4.0 is a complete shift towards digitalization and automation that affects all aspects of a company, including its manufacturing processes. The industry 4.0 concept is being adopted by major international corporations, which are known for their dedication to continuous improvement and high standards in research and development, to enhance their competitiveness in the market (Marcos et al., 2017)[27].

Industry 4.0 is a way to improve manufacturing efficiency by collecting data intelligently, making correct decisions, and executing decisions without any doubts. Using the most advanced technologies will make data collection and interpretation easier. Operating ability interoperability is a 'connecting bridge' that ensures a reliable manufacturing environment in Industry 4.0. This overall consciousness gives Industry 4.0 the most important aspect of artificial intelligent functions (Qin, Liu & Grosvenor,2016)[28].

5-2- Components of Industry 4.0:

5-2-1 Horizontal Integration:

The concept of horizontal integration is that a corporation should cooperate and compete with corporations that share similar characteristics to create an efficient production system. All of

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[26]*Industry 4.0: the fourth industrial revolution. [Online]i-scoope. Available at:<https://www.i-scoop.eu/industry-4.0/>. [Accessed on the 21st, of February.2024 at 9:50AM].*

[27]*Marcos, M., Suárez, S., Marcos, M., Fernández-miranda, S. S., Marcos, M., Peralta, M. E. and Aguayo, F. The challenge of integrating Industry in the degree of Mechanical Engineering. Procedia Manufacturing 13 (1) (2017) 1229–1236.*

[28]*Qin, J., Liu, Y. and Grosvenor, R. A Categorical Framework of Manufacturing for Industry 4.0 and Beyond. Procedia CIRP, 2016, pp. 173–178.*

these companies have the ability to easily connect material, financial control, and knowledge. Therefore, new control systems and models for business may emerge (Wang et al., 2016)[29].

5-2-2 Vertical Integration:

Based on the article of Shu Ing Tay et al. (2018) vertical integration: "delivers the idea of a factory that has various informational and physical subsystems, for example like production management, actuator and sensor, value and corporate planning. It is important for the vertical integration of sensor and actuator signals along various stages of the enterprise resource planning (ERP) level to ensure high flexibility and ease to configure production lines. From this integration, the highly intelligent machines create an automated controlled system that is able to be automatically reconfigured according to the various types of products. The large amounts of data collected and processed enables the manufacturing system to be transparent (Wang et al., 2016)"[30].

5-2-3 End-To-End Engineering Integration:

From the same article of Shu Ing Tay et al. (2018) say that End-To-End engineering integration is linking all the steps from product creation to final use in a chain of activities is what end-to-end engineering integration means. It includes things like understanding what customers want, designing the product, thinking about how it will be made and eventually recycled, planning how to produce it, and keeping it working well after it's made. This integration allows for the reuse of each step for products that are similar. We can use software tools to predict how a product's design will affect how it can be made and serviced, ensuring that products can be customized to meet different needs.[31]

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[29]Wang, S., Wan, J., Li, D. and Zhang, C. Implementing Smart Factory of Industry 4.0: An Outlook, International Journal of Distributed Sensor Networks 6 (2) (2016) 1-10.
[30]Shu Ing Tay, Lee Te chuan, A.H.Nor Aziati, Ahmad Nur Aizat Ahmad (December 2018).An Overview of industry 4.0:Definition,Components,and Government Initiatives: Jour of Adv Research in Dynamical & Control Systems, Vol. 10, 14-Special Issue, 2018,pp.1382.
[31] Idem

Figure 1: Illustration of three kinds of integration and their relationship.
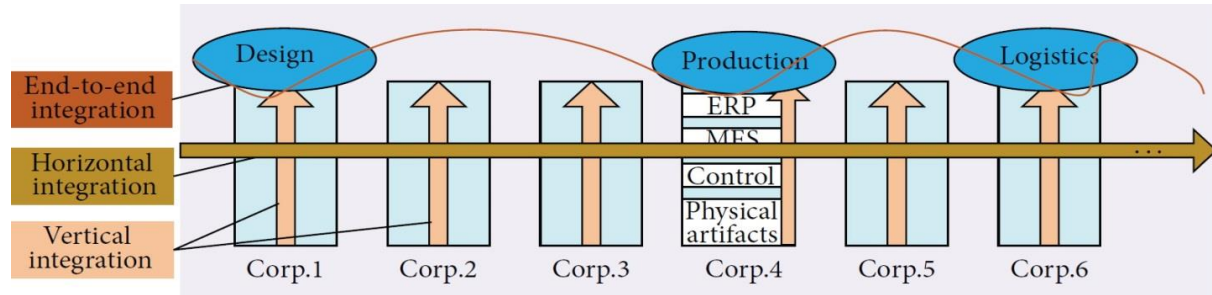
5-3- Impact of Supply Chain 4.0:

According to the world trade organization (April 2017) Supply chain organization is being reorganized due to the use of advanced technologies such as IoT, big data analytics, and autonomous robotics. Instead of the traditional linear model, where instructions move from supplier to producer to distributor to consumer and back, there's now a more integrated approach. Information flows in all directions within the supply chain. These technologies are particularly beneficial for e-commerce, but they also have the potential to improve efficiency in traditional stores. They bring significant advantages, such as cost reduction, increased responsiveness to consumer demand, more job opportunities (especially in sectors where these technologies are used), and time savings for consumers.

The impact of these technologies on the length of supply chains is not yet clear. They could shorten supply chains by bringing manufacturing back to high-income countries, reducing opportunities for developing countries in Global Value Chains (GVCs). On the other hand, they might also strengthen GVCs by cutting coordination and matching costs.[32]

According to Brettel et al. (2014) industry 4.0 technologies offer opportunities for improved synergies and enhanced optimization of activities across various areas, from research and development (R&D) to customer relations. For instance, Augmented Reality (AR) enables manufacturing workers or consumers to access expert advice even without an expert physically

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[32] World Trade Organization. (2017). Understanding Supply Chain 4.0 and its Potential Impact on Global Value Chains. Global Value Chain Development Report 2019, pp. 103-119. Retrieved from *https://doi.org/10.30875/10529e69-en*.

present. Virtualizing supply chains can also boost collaborations between companies and enable closer integration of their core strengths.[33]

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[33] Brettel, M., N. Friedrechsen, M. Keller, and M. Rosenberg. 2014. "How Virtualization, Decentralization and Network Building Change the Landscape: An Industry 4.0 Perspective in World Academy of Science, Engineering and Technology." International Journal of Information and Communication Engineering 8 (1): 37–44.

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Section 2: An overview of Blockchain Technology

Blockchain technology, which was born alongside Bitcoin, has quickly become an essential part of the digital world. It's a decentralized system that securely records transactions across multiple computers. In this section, we'll explore its key features: decentralization, security, and different types of blockchains. We'll also explain how it works and mention popular platforms like Ethereum. Finally, we'll discuss real-world uses of blockchain, from finance to healthcare.

1- **Definition and history of blockchain:**

Blockchain is a digital ledger that is shared across computers and ensures the security and decentralized record of transactions. The history of this can be traced back to the early work of Haber and Stornetta in 1991, and it was further developed with the introduction of Bitcoin by Satoshi Nakamoto in 2009. This part will provide an overview of these definitions and historical developments.

1-1- **What's Blockchain?**

A blockchain is a distributed database or ledger shared among a computer network's nodes. The role they play in cryptocurrency systems for maintaining a secure and decentralized record of transactions is their main focus, but they have other uses as well. Immutability of data in any industry can be achieved using blockchains, which is the term used to describe its inability to be altered.[34]

Blockchain is a modern technology that relies on distributed digital. The implementation of transaction ledgers is also known as "Distributed Ledger Technology".[35]Panetta has identified blockchain as a strategic technology trend for companies[36].

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[34] *Blockchain Facts: What Is It, How It works, and How It can be used. [online]. Investopedia. Available at:<Blockchain Facts: What Is It, How It Works, and How It Can Be Used (investopedia.com)>, [Accessed on the 24th, of Februrary,2024 at 08:20].*

[35]*Baidyanath Biswas, Rohit Gupta ,2019.Analysis of barriers to implement blockchain in industry and service sectors, Computers & Industrial Engineering Volume 136, October 2019, Pages 225-241, https://doi.org/10.1016/j.cie.2019.07.005.*

[36]*Kasey Panetta, October 18, 2016. Gartner's Top 10 Strategic Technology Trends for 2017. [online]. Gartner. Available at:<Gartners Top 10 Technology Trends 2017>, [Accessed on the 26th, of Februray,2024 at 08:15AM].*

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All records of transactions are stored in Blockchain. Blockchain is called a distributed ledger because the entire chain of transactions and the current list of owners can be stored through it on their computers by multiple independent users. Despite the failure of one or more computers, there is no loss of information[37].

1-2-   History of Blockchain:

As early as 1991, Stuart Haber and W. Scott Stornetta began developing the concept that would later become known as blockchain. Their goal was to produce timestamps for documents that cannot be modified by using a chain of blocks secured with cryptography. Their idea was limited by the technology of that era. Their work was improved by allowing the storage of more documents on one block, which was innovative but had limited practical applications at the time[38].

According to Biswas and Gupta (2019) the emergence of blockchain was linked to the introduction of Bitcoin[39].Satoshi Nakamoto was the inventor of Bitcoin in 2009, as Hackius and Petersen (2017) pointed out, which is a pseudonym for a mysterious individual or group of persons who still remain unidentified to the general public[40].

Richards (2019) pointed out that Bitcoin was the first natural evolution of cryptocurrency, with the primary aim of expediting financial transactions at minimal processing costs[41].

[37]*Hirsh, S. & Alman, S. 2020. Blockchain. [online] Ala center for the future of libraries. Retrieved on 20 October 2021 by: Lazareva, Veronika. Available at:<https://ebookcentral-proquest-com.ezproxy.saimia.fi/lib/labebooks/reader.act>.*

[38] *Arnab Kar, Jun 30, 2022. History and Evolution of Blockchain. [online]. Medium. Available at:<https://medium.com/coinmonks/history-and-evolution-of-blockchain-17e5332e4a6c>, [Accessed on the 26th, of February,2024 at 9:20AM].*

[39]*Biswas, B., & Gupta, R (2019). Analysis of barriers to implement blockchain in industry and service sectors. Computers & Industrial Engineering Volume 136, October 2019, Pages 225-241. (online article available at:<https://www.sciencedirect.com/science/article/abs/pii/S0360835219303961> [Accessed on the 26th, of February,2024 at:09:40AM]).*

[40] *Niels Hackius, Moritz Petersen (2017), introduction p.4, Blockchain in Logistics and Supply Chain: Trick or Treat?, Digitalization in Supply Chain Management and Logistics Wolfgang Kersten, Thorsten Blecker and Christian M. Ringle (Eds.) ISBN 9783745043280, Oktober 2017, epubli.*
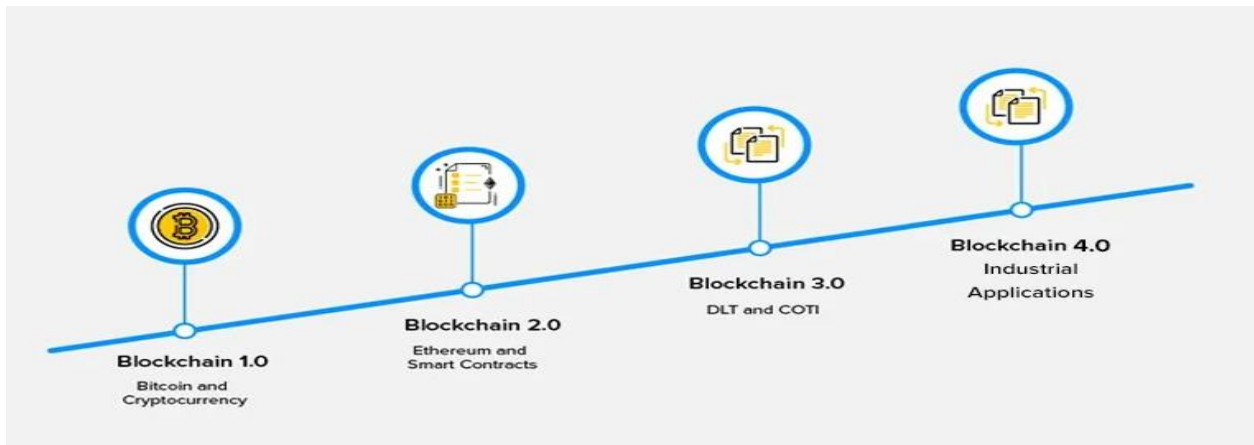
[41]*Richards, M. (2019). Disruptive Innovations: Blockchain and Spinoffs. In A. G. Pamela & A. O. Julie (Eds.), Advances in the Technology of Managing People: Contemporary Issues in Business (pp. 161-172): Emerald Publishing Limited.*

Figure 2 Timeline of blockchain.
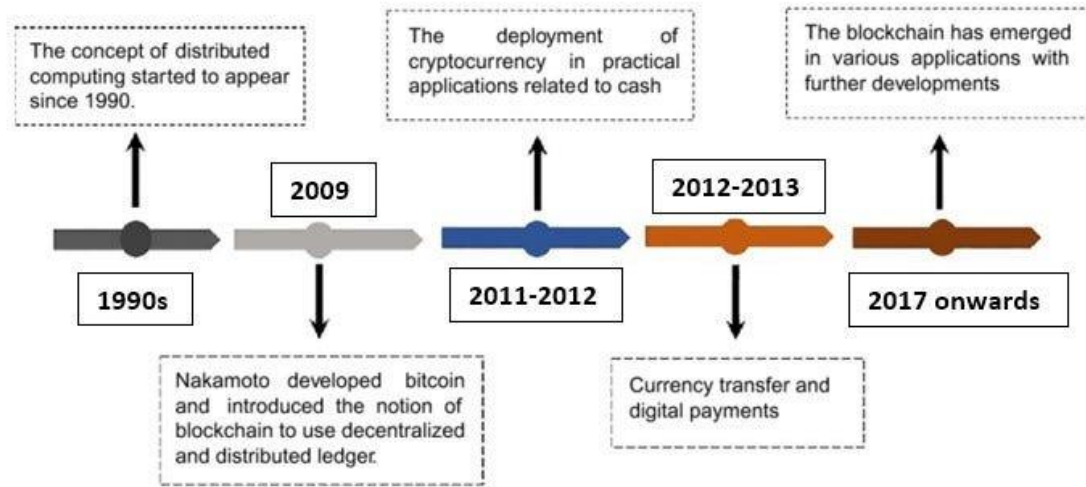
Figure 3 Evolution of blockchain.

2-   The fundamental aspects of blockchain:

In this part, we'll explore the fundamental aspects of blockchain technology. Blockchain is based on key principles that shape its functionality and reliability:

- **Immutability:** An immutable ledger is a permanent record-keeping system that is impervious to data corruption. Unlike traditional databases, where data can be altered or deleted, an immutable ledger follows the principle that once information is recorded, it remains unchangeable[42].

- **Decentralization:** Blockchain is a decentralized technology, meaning that any information stored in it functions as a unit of the entire network. Instead of a central authority, all information is shared among nodes.

  Data is managed by a decentralized network, rather than a central authority. Thus, the entire network operates on a peer-to-peer or user-to-user basis. Blockchain has been utilized by many organizations, including banks and governments, for record-keeping purposes. This not only enhances data transparency but also simplifies traceability[43].

- **Secure System:** All records in the blockchain are individually encrypted, providing an additional layer of security to the entire process on the blockchain network. Despite the absence of a central authority, it is not possible to simply add, update, or delete data on the network.

  Every piece of information on the blockchain is cryptographically hashed, giving each data point a unique identity on the network. The hash of each block is unique and the hash of the previous block is included. This cryptographic linking ensures that the blocks are connected in a secure chain. Attempting to modify the data would require changing all the hash IDs, a task that is quite impossible[44].

- **Transparency**: Each authorized member can transparently track and view the data's lifecycle, transactions, and historical records. Encrypting the private information of the involved parties is a priority, which prioritizes personal privacy[45].

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[42] *Ruholamin Haqshanas, 22 July, 2023. Immutable Ledger. [online] Techopedia. Available at :<https://www.techopedia.com/definition/immutable-ledger>,[Accessed the 26th,February,2024 at 02:45PM].*

[43] *Blockchain,4 key features of Blockchain technology, 27/02/2024. [online] Bytesoft. Available at:<https://bytesoft.vn/en/4-key-features-of-blockchain-technology>, [Accessed on the 27th, of February, 2024 at 07:40 AM].*

[44] *Features of Blockchain. [online] GeeksforGeeks, Available at:<https://www.geeksforgeeks.org/features-of-blockchain/>, [Accessed on the 27th, of February,2024 at 08:20].*

[45] *AMERA IBRAHIM, Does blockchain mean higher transparency in the financial sector? , Available at:<Does_Blockchain_mean_higher_transparency_in_the_financial_sectorlogo.pdf (accid.org)> ,[Accessed on the 27th, of February,2024 at: 08:58 AM].*

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- **Peer to Peer Network:** Decentralization is the basis of a peer-to-peer (P2P) network, which allows participants to engage in transactions without the need for a central server. Peers or nodes (typically computers) communicate directly with one another on the network without an intermediary. In contrast to the traditional client-server model, where the client makes requests and the server fulfills them, the P2P network model empowers nodes to act as both client and server, granting them equal authority to perform network tasks[46].

- **Cryptography:** Cryptography involves encrypting data, transforming a random dataset with a structured rule in such a way that it can only be reverted to its original and meaningful form by those who possess the key used during encryption[47].

- **Smart Contracts:** Nick Szabo first proposed smart contracts in 1994, and he has been rumored to be the real Satoshi Nakamoto, the anonymous Bitcoin inventor, but he has denied it. A smart contract is a self-executing program that automates the actions required in an agreement or contract. The transactions are irreversible and can be traced once completed. Smart contracts enable trusted transactions and agreements to be executed among different, anonymous parties without the necessity of a central authority, legal system, or external enforcement mechanism[48].

- **Distributed Ledger Technology (DLT):** DLT is the technological infrastructure and protocols that enable simultaneous access, validation, and record updating across a networked database. DLT is the technology blockchains are created from, and the infrastructure allows users to view any changes and who made them, reduces the need to audit data, ensures data is reliable, and only provides access to those that need it[49].

- **Consensus Mechanism:** The consensus mechanism comprises protocols that guarantee the nodes agree on which transactions are valid and which ones will be added to the blockchain. Two of the most well-known consensus mechanisms are Proof of Work and Proof of

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[46]*Digital Assets, March 20, 2023. What is a Peer-to-Peer Network in Blockchain? . [online]. CFTE. Available at:<https://blog.cfte.education/what-is-p2p-network-blockchain/> ,[Accessed on   the 27th, of February,2024 at 9:56AM].*

[47]*Kosba, A., et al. (2016)Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts.*

[48]*JAKE FRANKENFIELD, October 31, 2023. What Are Smart Contracts on the Blockchain and How They Work. [online] Investopedia. Available at :<https://www.investopedia.com/terms/s/smart-contracts.asp>, [Accessed on the 27th, of February,2024 at 2:00 PM].*

[49]* SCOTT NEVIL ,May 31, 2023. Distributed Ledger Technology (DLT): Definition and How It Works. [online] Investopedia. Available at :<https://www.investopedia.com/terms/d/distributed-ledger-technology-dlt.asp>, [Accessed on the 27th, of February 27, 2024 at 02:45PM].*

Stake[50].Nodes continuously verify and audit all transactions sent to the blockchain to prevent fraudulent activities. Consensus algorithms are used to enable a group of participants to verify and authenticate all transactions collectively instead of relying on a central authority[51].

3- Different Types of Blockchain Structures:

There are 4 types of blockchain Public, Private, Consortium, and Hybrid.

- **Public Blockchain:** Decentralization is fully supported by these blockchains. The network is open to anyone with a computer and internet, and there are no restrictions.

- Since the name is public, this blockchain is available to the public, and it is not owned by anyone.

- Participating in this public blockchain is open to anyone with an internet connection and good hardware.

- The computers in the network have copies of other nodes or blocks that are present in the network.

- Verification of transactions or records is possible on this public blockchain.

➢ Use Cases: Public blockchains are secured with proof of work or proof of stake and can be used to replace traditional financial systems. The smart contract is the most advanced aspect of this blockchain, which allows it to support decentralization. Examples of public blockchain are Bitcoin, Ethereum.[52]

- **Private Blockchain:** These blockchains are more secure than others because they are not as decentralized as public blockchains; only selected nodes are allowed to participate in the process.

- These blockchains are not as open as a public blockchain.

- Authorized users are the only ones who can access them.

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[50]*Giang-Truong Nguyen and Kyungbaek Kim, A Survey about Consensus Algorithms Used in Blockchain, Available at :<Microsoft Word - 06-(101-128) ID-21_JIPS-ME-ed(0214)-me-r1(0226)==end (volunteerscience.com)>,[Accessed on the 27th, of February 27, 2024 at 04:00PM].*

[51]*PRITESH SHAH AND DANIEL FORESTER et al. Blockchain Technology: Data Privacy Issues and Potential Mitigation Strategies, Available at :<blockchain_technology_data_privacy_issues_and_potential_mitigation_strategies_w-021-8235.pdf (davispolk.com)>,[Accessed on the 27th, of February,2024 at :4:30PM].*

[52] *Types of Blockchain. [online] GeeksforGeeks. Available at :<https://www.geeksforgeeks.org/types-of-blockchain/>, [Accessed on the 28th, of February,2024 at 07:45AM].*

- A closed network is used to operate these blockchains.

- Only a select few individuals are permitted to be a part of a network within a company or organization.

➢ Use Cases: This blockchain is a valuable asset for securing information without exposing it to the public eye with proper security and maintenance. Companies utilize them for internal auditing, voting, and asset management. An example of private blockchains is Hyperledger, Corda.[53]

- **Hybrid Blockchain:** It is the mixed content of the private and public blockchain, where some parts are controlled by some organizations and other parts are made visible as a public blockchain.

- This is a blend of both public and private blockchains.

- Both systems that require permission and those that don't require permission are in use.

- Users access information through smart contracts.

- Despite owning a hybrid blockchain, a primary entity cannot alter the transaction.

➢ Use Cases: The health care industry, government, real estate, and financial companies can benefit from this better solution. This is a solution for data that needs to be accessed publicly but needs to be safeguarded privately. Examples of Hybrid Blockchain are Ripple network and XRP token.[54]

- **Consortium Blockchain:** It is a creative approach that solves the needs of the organization. This blockchain is responsible for validating transactions and initiating or receiving them.

- It is also referred to as the Federated Blockchain.

- This method is a new way to address the organization's needs.

- There are parts that are public and others that are private.

- More than one organization is responsible for managing the blockchain in this type.

➢ Use cases: Businesses, banks, and other payment processors can benefit greatly from it. Food tracking of the organizations frequently collaborates with their sectors making it a federated solution ideal for their use. Examples of consortium Blockchain are Tender mint and Multichain.[55]

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[53] *Types of Blockchain. [online] GeeksforGeeks. Available at :https://www.geeksforgeeks.org/types-of-blockchain/ , [Accessed on the 28th, of February,2024 at 10:45AM].*
[54] *idem*
[55] *idem*

4- How blockchain works?

After reading many articles and watching videos on YouTube about the blockchain, this research is conducted to explain how the blockchain technology works:

As it was mentioned above, the Blockchain is like a shared digital ledger, spread across many computers in a network, this example to simplify how it works. Racha, Abdeljalil, and Mohammed are three siblings that manage their own lemonade stand called 'The Lemonade Ledger'. This lemonade stand will help us understand blockchain, which is like a shared digital ledger. Through their sales, it's notable to observe the security and transparency of blockchain in transactions in the table below:

Table1: How Blockchain works

Concept	Explanation
- Decentralized Ledger System:	- The siblings maintain a shared ledger called the "Lemonade Ledger." - Each sibling has their own copy. -This way, they all have the same information and can trust each other.
- Recording Transactions:	-Every time they sell lemonade, they write it in the Lemonade Ledger. - Example: Racha sells 2 cups for 2 DA, recorded as "Racha - 2 cups for 2 DA". -Similarly, Abdeljalil's 3 cups for 3 DA is noted as "Abdeljalil - 3 cups for 3 DA". - Mohammed's sale of 1 cup for 1 DA is documented as "Mohammed - 1 cup for 1 DA".
- Immutable Record keeping:	- Once something is written, it cannot be changed.

|	
	- Each sibling's copy is like a "block" of sales. - This ensures that the sales record cannot be altered later.
- Consensus:	- To make sure they match, the siblings compare their ledgers periodically. - This process, called "consensus," ensures all ledgers match. - Any differences are discussed and resolved together.
- Block Formation and Continuity:	-They commence a new page in the ledger at the end of each day. - The last sale of the day is written on the new page. - Each day's sales are linked together in this way to ensure continuity.
- Real-Time Updates:	- New sales are added to the ledger as they happen. - For example, if Racha sells 3 more cups the next day, it's added. - This keeps the ledger up-to-date with the latest transactions.

Source: Author's own work.

In summary, the example of the lemonade stand with the three siblings provides a clear illustration of blockchain technology. The 'Lemonade Ledger' they employ is similar to the decentralized nature of blockchain, where each sibling has their own identical ledger. By recording all transactions in an immutable manner, this ledger ensures transparency and trust. Regular consensus checks guarantee agreement among the siblings. Establishing a continuous chain of transactions is similar to the formation of blocks in blockchain when turning to a new page at the end of each day. Real-time updates keep the ledger current. This analogy makes the

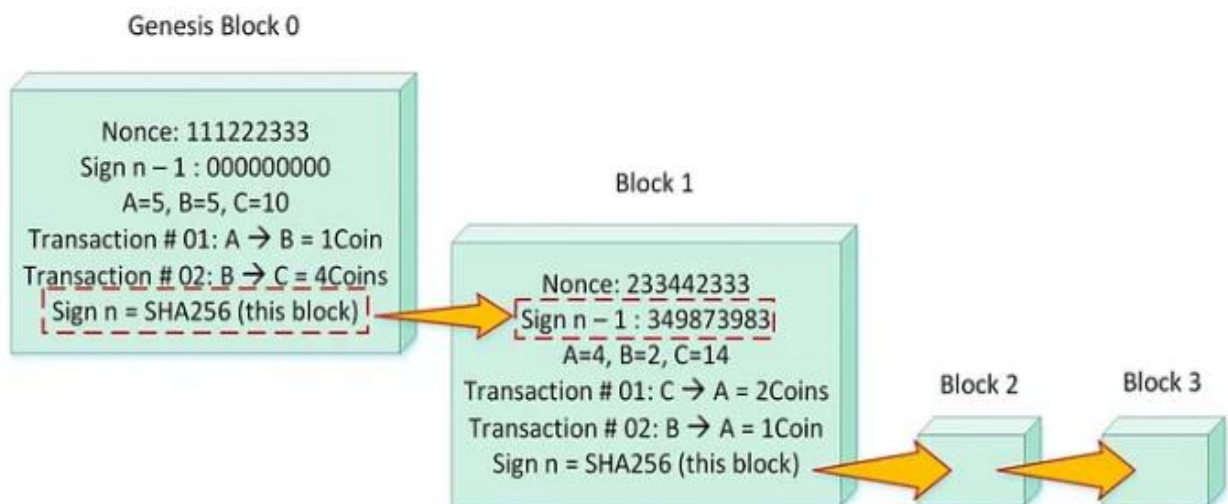complicated principles of blockchain simpler by highlighting its role as a secure, transparent, and decentralized system for recording transactions.

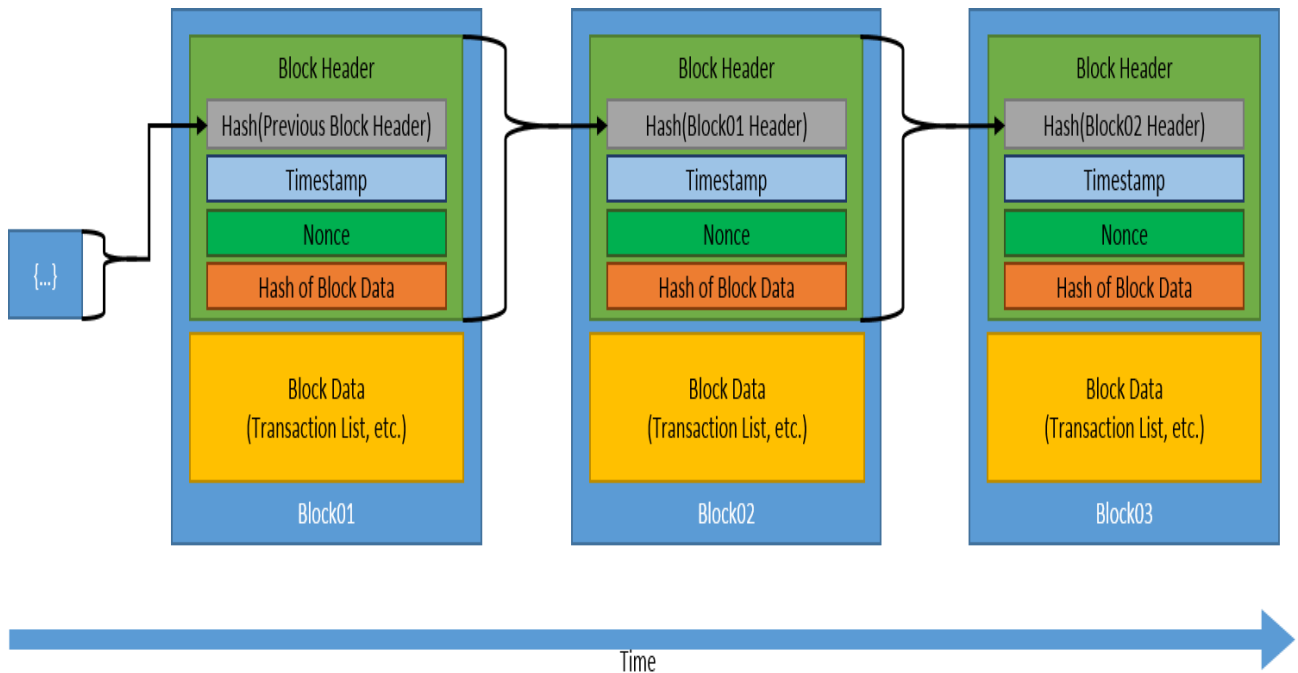**Figure 4**: How Blockchain Technology Works.
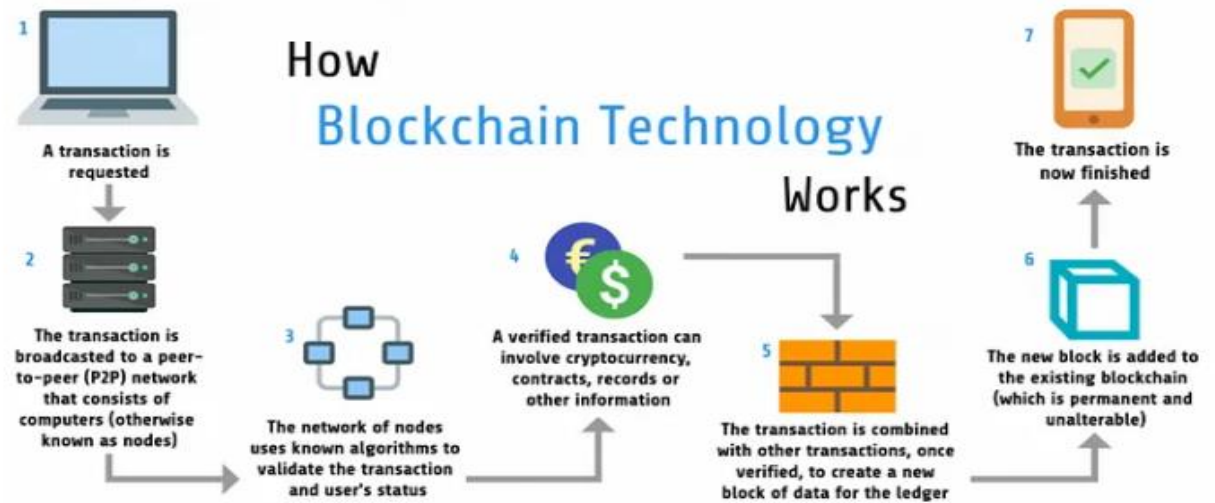
Source: Blockchain technology: | LinkedIn, *[Accessed on the 1st, of March,2024 at 07:45AM].*

Figure 5: Blockchain Transaction Example

Source: How Blockchain Technology Works(medium.com), [Accessed on the 2nd, of March,2024 at 06:45AM].

Figure 6: The Immutable Link of Cryptographic Hashes.

- Genisis Block: Block 0 or 'Day-Zero Block' is also known as the first block of the chain, which is known as the 'Genesis Block'.

- Blocks: In the blockchain database, blocks are data structures that store transaction data from a cryptocurrency blockchain permanently. A block is a list of the latest transactions that haven't been validated by the network yet. The block will be closed once the data has been validated. Then, a new block is created for new transactions to be entered into and validated.

Once written, blocks are permanent stores of records that cannot be altered or removed.[56]

-Nonce: short for "number used only once," is a random number essential for bitcoin miners. They search for this nonce to create a new block in the Bitcoin blockchain. When they successfully find

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[56] *By JAKE FRANKENFIELD Updated January 09, 2022, Reviewed by JULIUS MANSA. What Is a Block in the Crypto Blockchain, and How Does It Work? [online] Investopedia. Available at:<https://www.investopedia.com/terms/b/block-bitcoin-block.asp>, [Accessed on the 1st, of March, 2024 at 09:21AM].*

it, they earn a block reward. This nonce is crucial for the efficient operation of the Bitcoin blockchain.[57]

-Timestamp: in cryptocurrency identifies the precise moment in time when a block was mined and validated by a blockchain network. The existence of the data compiled in a blockchain transaction is confirmed through the use of a timestamp, which also refers to the moment when the transaction was encrypted.[58]

- Hash – Hashing: It is the process of encrypting any text to make it unreadable or unpredictable.

The data entered is transformed into a fixed-length output by utilizing mathematical operations. Hashing is an algorithm-based method for creating cryptographic data. In this respect, cryptographic hashes are similar to digital signatures. Both traditional and cryptographic hash functions are deterministic. As long as the input is not changed, the same hash is always output. A hash algorithm called SHA-256 is used in the Bitcoin network. (It provides 64-character output in hexadecimal).[59]

- Node: Nodes are crucial to the blockchain in crypto, as they validate transactions and keep the network secure. The term "node" in computer science refers to a device that plays a role in a larger network. In the context of crypto and blockchain, to validate and store the entire history of transactions on the network, the blockchain software is executed by a node, which is one of the computers.[60]

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[57]*By JAKE FRANKENFIELD Updated January 09, 2022, Reviewed by JULIUS MANSA. Nonce: What It Means and How It's Used in Blockchain, [online] Investopedia. Available at :<https://www.investopedia.com/terms/n/nonce.asp#:~:text=our%20editorial%20policies-,What%20Is%20the%20Nonce%3F,the%20Bitcoin%20blockchain%20running%20smoothly.> , [Accessed on the 1st of March, 2024 at 09:51].*

[58]*Decryptopedia™, Timestamp. [online] babypips. Availableat:<https://www.babypips.com/crypto/glossary/timestamp#:~:text=In%20cryptocurrency%2C%20a%20timestamp%20represents,compiled%20in%20a%20blockchain%20transaction.> , [Accessed at: the 1st of March,2024].*

[59]* Jo, Jeong Hoon, et al. (2019), A blockchain-based trusted security zone architecture, The Electronic Library Vol. 37 No. 5, 2019 pp. 796-810 © Emerald Publishing Limited 0264-0473 DOI 10.1108/EL-02-2019-0053.*

[60]*Benedict George,Updated May 11, 2023 at 11:04 a.m. PDT. What Is a Node? / [online] Coindesk. Available at:<What Is a Node? (coindesk.com)>, [Accessed on the 11th, of March, 2024 at 02:20 PM].*

5- Top Blockchain Platforms:

It is crucial to comprehend how the blockchain system will be integrated after analyzing its technical structure and how it functions. In order to take advantage of the blockchain system, what steps should one take first? Is it essential to create your own blockchain platform from the beginning? Because creating such a system would necessitate a lot of work, it is more advantageous to rely on open source blockchain platforms that have already been built.
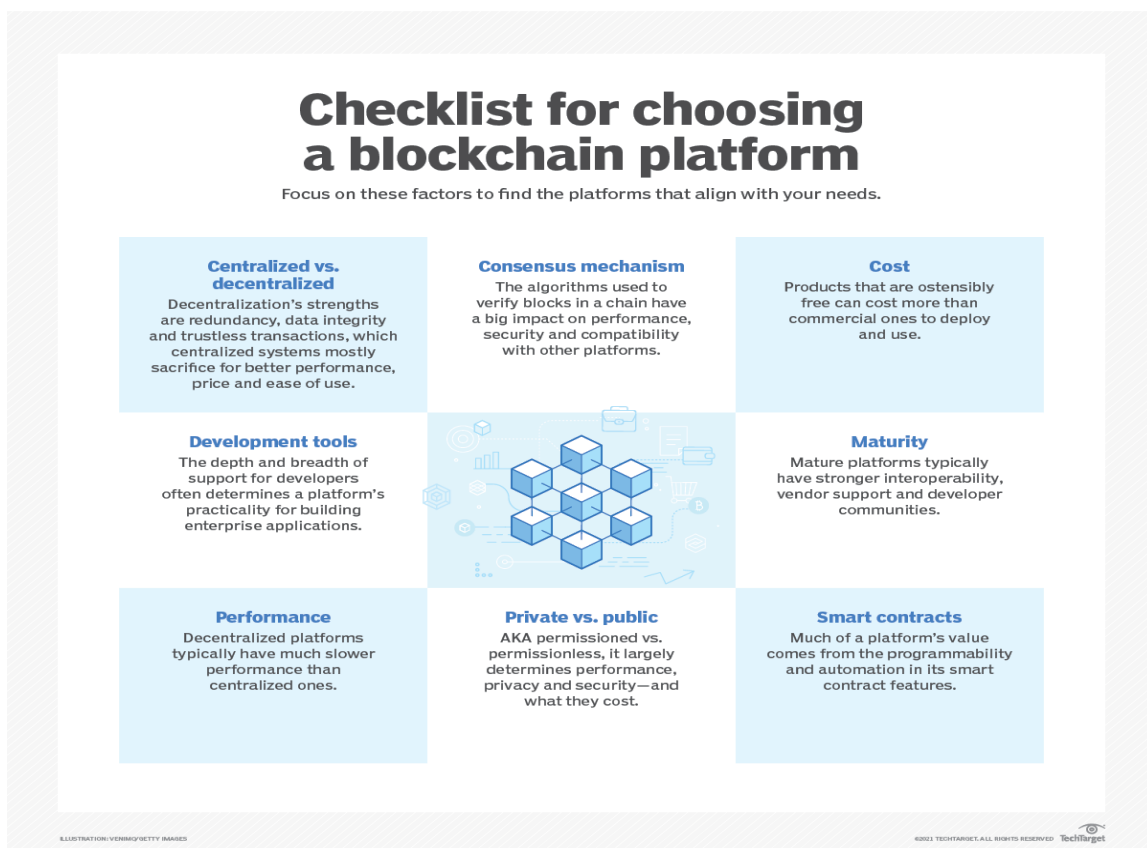
- **Ethereum:** Ethereum was created in 2013 and is one of the oldest and most established blockchain platforms. It offers a blockchain network that is completely decentralized and comparable to the Bitcoin blockchain network. According to Manders, its main strength lies in its ability to enable true decentralization and support smart contracts. The main issues it has are slow processing times and higher transaction processing costs when compared to other platforms. Apart from serving as a blockchain platform that supports enterprise applications, it also has its own cryptocurrency named Ether. Decentralized applications (dApps), such as non-fungible token (NFT) platforms and exchanges, are commonly built using the Ethereum platform. It offers a mature ecosystem for creating smart contracts using Solidity. Ethereum is expected to improve with a more efficient security mechanism, even though other blockchain networks have faster and cheaper transaction processing. The platform went from proof of work (PoW) to proof of stake (PoS), which led to a significant decrease in energy consumption.[61]

- **IBM Blockchain:** IBM Blockchain is a blockchain network that is specifically designed for businesses. The fact that it's private and decentralized means it's a popular choice for companies who don't want to take a lot of risks. The greatest benefit is that it can easily connect to enterprise cloud and older technologies, which is not an easy feat for other blockchain networks. IBM has developed tools for developers that are easy to use and can be tailored to meet specific needs. They also created a simple interface for important tasks such as creating and testing smart contracts quickly.[62]

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[61]George Lawton, Published: 12 Jan 2024. Top 9 blockchain platforms to consider in 2024 (Suseel Menon,Ethereum), [online] TechTarget. Available at: <_Top 9 Blockchain Platforms to Consider in 2024 | TechTarget_>,[Accessed on the 11th, of March, 2024 at 02:50 PM].

[62] Rakesh Mohan, IBM Blockchain, [online] TechTarget. Available at: <_Top 9 Blockchain Platforms to Consider in 2024 | TechTarget_>,[Accessed on the 12th, of March, 2024 at 04:20 AM].

- **Hyperledger Fabric:** Hyperledger Fabric is a blockchain system that is specifically designed for businesses. The integrated design makes building big applications easy. Developers have the ability to add the specific parts they need, like membership services and transaction agreements, due to its modularity. The design of this network allows only approved and credible users to join, making it safe for businesses. Companies seeking to develop robust blockchain applications choose it as their preferred option.[63]

Figure 7: Checklist for choosing a blockchain platform.

Source: https://www.techtarget.com/searchcio/feature/Top-9-blockchain-platforms-to-consider, *[Accessed on the 10th, of March,2024 at 07:45AM].*

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[63] *P. Sriramya, Golda Dilip, Performance Evaluation of Various Block Chain Platforms, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8, Issue-3S, October 2019 , <C11261083S19.pdf (ijrte.org)>, Accessed on the 12th , of March,2024 at 05:00 AM.*

- **Hyperledger Sawtooth:** Hyperledger Sawtooth is a blockchain platform that is open-source and allows businesses to create custom smart contracts without the need for extensive knowledge of the core system. It's designed for enterprise applications, focusing on secure smart contracts and distributed ledgers. Sawtooth's modularity allows for the selection of policies and algorithms that are tailored to specific business requirements. Sawtooth differentiates itself from other systems by decoupling its core from applications, which can enhance security and performance. It is capable of supporting different consensus algorithms such as PBFT and PoET and ensuring privacy with separate per missioning, safeguarding confidential information in a user-friendly way for smooth enterprise utilization.[64]

- **R3 Corda:** Corda, a blockchain platform that is open-source and developed by the R3 consortium, was originally intended for the financial sector. It uses a Pluggable Consensus technique and is built using Kotlin and Java. Corda operates in a permissioned mode, unlike many other blockchain platforms that have their own cryptocurrency. By removing costly obstacles in business processes, Corda enables institutions to conduct transactions directly using smart contracts.[65]

- **Tezos:** Tezos is an open-source platform that enables asset and application evolution through self-updates. Stakeholders have the authority to make upgrades to the core protocol, which includes modifications to the upgrade process itself. It is capable of adapting to new uses with a dynamically upgradable protocol and modular software clients. Tezos uses a PoS (Proof of Stake) consensus mechanism, enhancing efficiency compared to Bitcoin and early Ethereum versions. Developers can make improvements to the blockchain without forking by using an on-chain upgrade mechanism, which avoids the need to create a new blockchain and migrate users. In addition to improving performance, the Tezos community actively enhances the platform by expanding smart contract size limits. Additionally, they've developed tools to automate integrating NFTs into enterprise supply chains.[66]

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[64]*Hyperledger Sawtooth in Blockchain, [online] GeeksforGeeks. Available at: <Hyperledger Sawtooth in Blockchain - GeeksforGeeks>, [Accessed the 12th, of March, 2024 at 04:45 AM].*
[65]*C.rda, [online] r3. Available at:<Corda Permissioned Distributed Ledger Technology (DLT) | R3>, [Accessed the 13th, of March,2024 at 10:05AM].*
[66]*George Lawton, 12 Jan 2024, Top 9 blockchain platforms to consider in 2024, [online] TechTarget. Available at:<Top 9 Blockchain Platforms to Consider in 2024 | TechTarget>, [Accessed the 13th,of March,2024 at 10:30].*

- **EOSIO:** EOSIO is a platform that allows third-party developers to create and operate decentralized apps (dApps). EOSIO is similar to a computer in that it uses familiar computing concepts and provides resources like network bandwidth (bit transactions), CPU power (measured in microseconds), and RAM (for data storage). EOSIO's programmable smart contracts, also known as dApps, are computer programs that execute tasks when certain conditions are met, such as paying for rendered services. Furthermore, EOSIO offers tools and protocols that guarantee security, custody, and authorization for other blockchain networks, while adapting to changing regulatory requirements.[67]

- **Stellar:** Stellar is a blockchain platform that is distributed and designed for cross-asset value transfers while still requiring minimal computing and financial resources. It supports exchanges between cryptocurrencies and fiat currencies. The network allows for the creation of mobile wallets and smart devices. Stellar is distinguished by its use of the Stellar Consensus Protocol (SCP) to achieve consensus. To maintain security and integrity, the network stops until consensus is reached in case of bad behavior on nodes.[68]

6- Applications of Blockchain Technology:

The creation of cryptocurrencies, such as Bitcoin, has made blockchain technology widely known. Apart from Bitcoin, there are now more than a million cryptocurrencies in existence. The total combined value of all cryptocurrencies in the market is approximately $2.77 trillion, with Bitcoin holding a dominant share of 52.17%.[69]

There are many uses for blockchain technology in various industries. In finance, it is employed to secure and expedite transactions, enabling faster and cheaper cross-border payments. Healthcare providers use blockchain to securely store and share patient data, guarantee privacy, and improve interoperability. Supply chain management benefits from blockchain's transparency and traceability, allowing for better tracking of products from origin to destination, reducing fraud, and ensuring authenticity. Furthermore, blockchain is utilized in voting systems for the sake of secure

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[67] *By: Robyn Conti, Reviewed By: Michael Adams, updated: Apr 27, 2022, 10:48 AM, Understanding EOS & EOSIO. [online] Forbes Advisor. Available at:<Understanding EOS & EOSIO – Forbes Advisor>. [Accessed on the 13th, of March,2024 at:11:10 AM].*

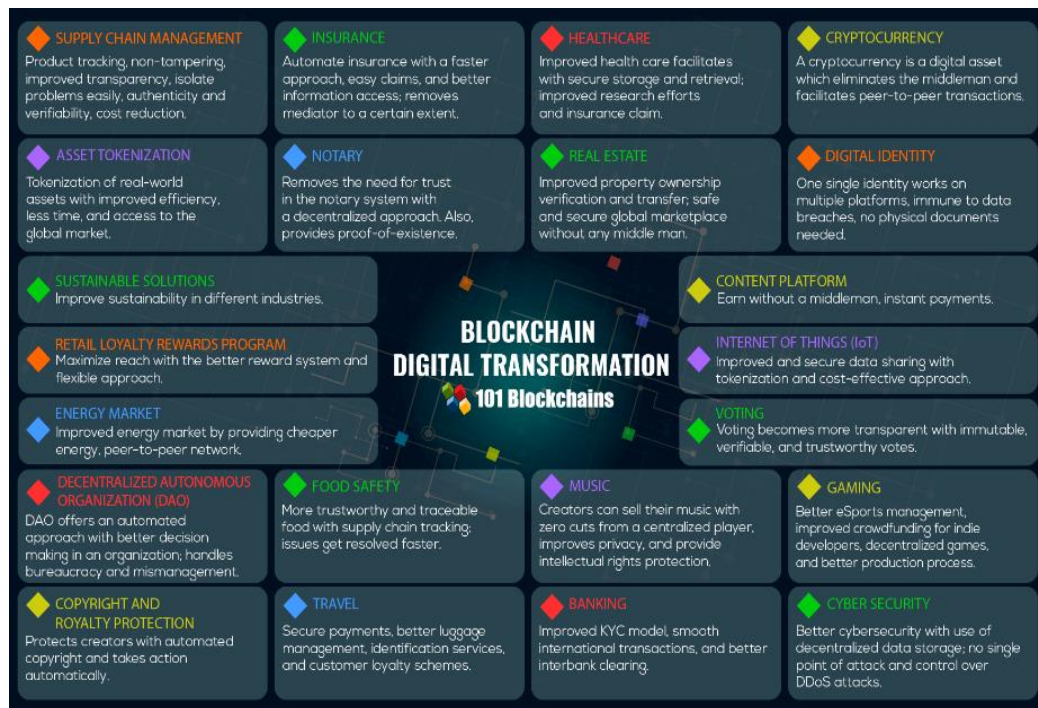[68] *Stellar. Available at:<Stellar | A Blockchain Network for Payments and Tokenization>, [Accessed on the 13th, of March,2024 at:11:30 AM].*

[69] *Today's Cryptocurrency Prices by Market Cap. [online] available at:<Cryptocurrency Prices, Charts and Market Capitalizations | CoinMarketCap>, [Accessed on the 13th, of March,2024 at:01:03PM].*

and transparent elections, in real estate for efficient property transactions, and in academia for secure credential verification. The Internet of Things (IoT) uses blockchain to connect and manage devices in a secure manner, ensuring data integrity and allowing for autonomous machine-to-machine transactions.[70]

Below is a list of the most prominent use cases of blockchain technology as illustrated in Figure8.

**Figure 8:** Blockchain Usage – 20+ Blockchain Technology Use Cases.

Source: https://101blockchains.com/blockchain-usage/, *[Accessed on the 13th, of March,2024 at: 01:05PM].*

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[70] *Sam Daley. 35 Blockchain Applications and Real-World Use Cases. [online] Available at:<35 Top Blockchain Applications to Know for 2024 | Built In>, [Accessed on the 13th, of March,2024 at: 02:15PM].*

Section3: The integration of blockchain technology in supply chain management

Global supply chains have become complex value chains in today's world. Due to competitive concerns, the data in these chains is often limited to silos and shared sparingly. The lack of standardized formats for data exchange across organizations creates challenges due to the limited sharing. As a result, significant issues arise such as supply chain blind spots and data incompatibility. In this section, we explore how blockchain technology addresses these challenges, offering transparency, traceability, and efficiency in supply chain operations.

Figure 9 : SCM Transformation - Based on blockchain.
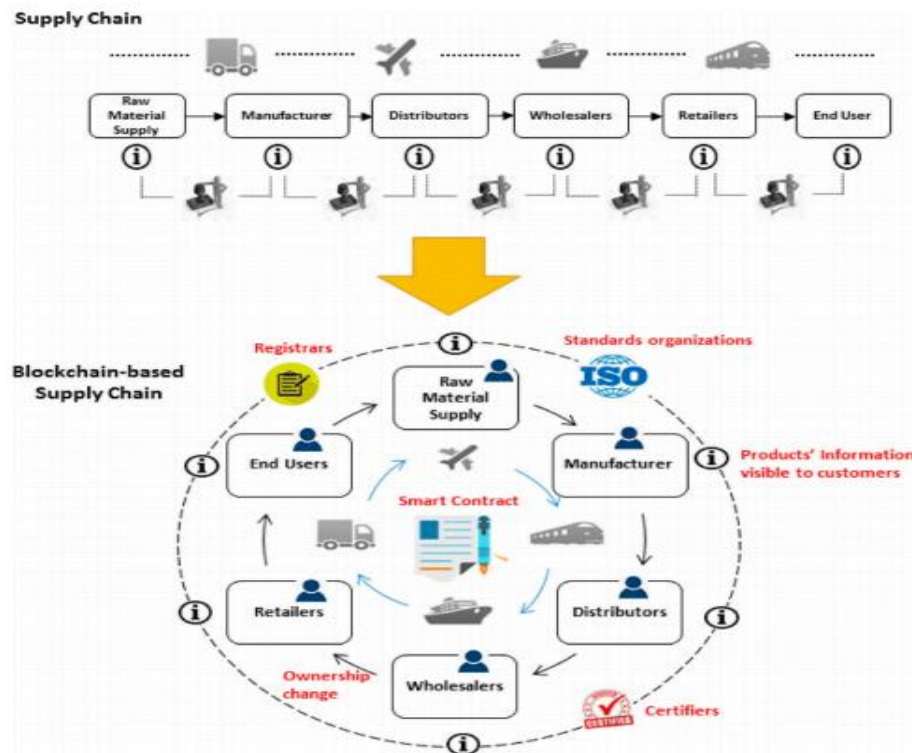
Source : Saberi et al., 2019[71]

Chapter I: Exploring Blockchain Integration in Supply Chain Management.

1- Potential use cases for blockchain technology in supply chain management:

Blockchain technology may not be the primary solution for supply chain management at this time, but businesses are increasingly utilizing it in various aspects of their operations. Here are a few examples of how blockchain is being utilized in the supply chain:

- **Transport & Logistics:**

Due to the increase in stakeholders, logistics management has become a complex activity. Adopting blockchain technology has brought several benefits to this sector, including reducing time delays, cost, and human errors. The use of smart contracts has resulted in faster transactions between companies involved in logistics activities.[72]

Table 2: Blockchain Applications in Transport and Logistics Supply Chains

Benefit	Description

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[72] *Jameela Al-Jaroodi and Nader Mohamed. Blockchain in industries: A survey, pp 5. IEEE Access, 7:36500–36515, 2019. <https://ieeexplore.ieee.org/abstract/document/8662573>. [Accessed on the 19th, of March,2024 at 01:30 AM].*

Improved Transparency	Due to the decentralized nature of Blockchain, it enhances transparency and traceability throughout the supply chain. By adding every transaction to the Blockchain, an auditable trail of all activities can be created, including relevant documentation, the movement of goods, and changes in ownership. Logistics businesses can reduce fraud in the supply chain by using this tool, which also aids in faster dispute resolution and accountability improvement.[73]
Reduced Overhead Cost	Smart contracts can automate a variety of tasks in the logistics supply chain, including compliance verification, order fulfillment, and payment processing. Smart contracts eliminate the need to rely on manual processes, intermediaries, and paperwork through automation of these tasks. The supply chain is more efficient and costs are reduced due to this streamlined approach.[74]
Data Integrity	Once recorded on the blockchain, data cannot be altered or deleted without consensus from the network participants. This ensures data integrity and prevents

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[73] *Top 5 Real-life Blockchain Use Cases in Supply Chain in 2024, [online] antier. Available at:<https://www.antiersolutions.com/top-5-real-life-blockchain-use-cases-in-supply-chain-in-2023/>, [Accessed on the 16th,of March,2024 at: 01:00 AM].*
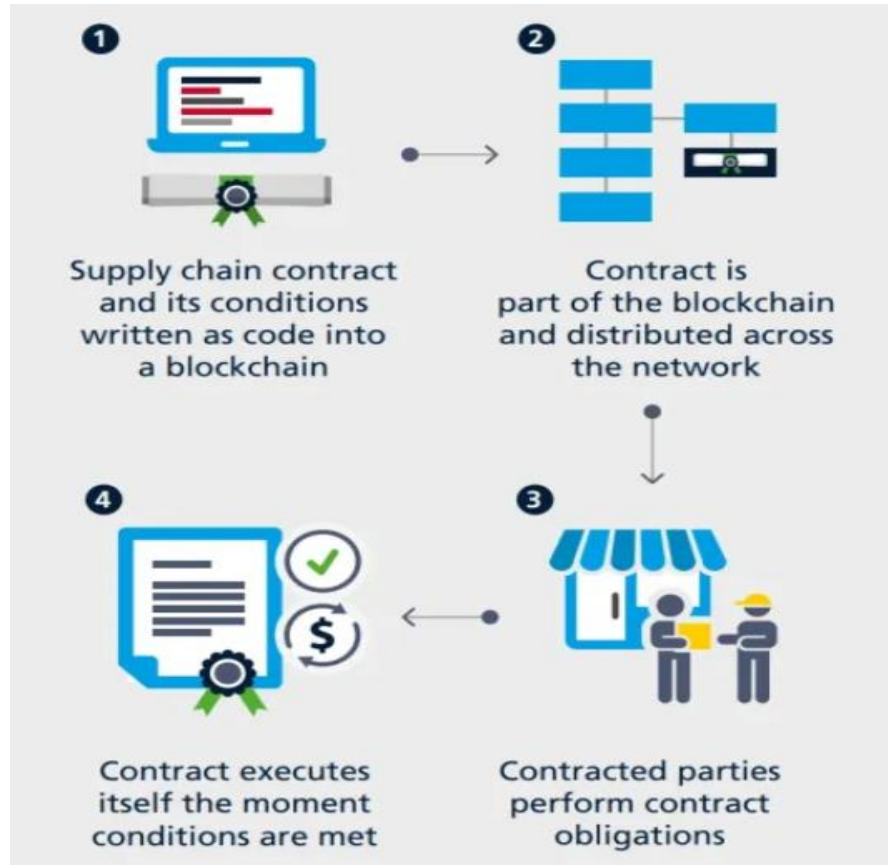[74]*Idem*

	unauthorized tampering or manipulation of supply chain information.[75]
Faster Payments Settlements	Modern business is a big data business. The activities of entrepreneurs necessitate the use of a large amount of data. The speed of money payments and transfers is crucial for the success of transactions and other operations. Blockchain is a perfect match for this need. Smart contracts allow network participants to share information in an immutable ledger, and transactions are executed quickly and securely. Additionally, smart contracts define the conditions for the transfer of corporate bonds and can establish the criteria for insurance payments.[76]
Real-Life Example	UPS(United Parcel Service).

Source: the author's own effort.

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[75] *By Rafael Vela / Jun 05, 2023, The Role of Blockchain in Supply Chain Transparency and Security, [online] LinkedIn. Available at:<https://www.linkedin.com/pulse/role-blockchain-supply-chain-transparency-security-rafael-a-vela>, [Accessed on the 16th, of March,2024 at: 02:04 PM].*

[76] *FEBRUARY 7, 2023, BENEFITS OF BLOCKCHAIN: FASTER PAYMENT PROCESSING. [online] Billdu. Available at:<https://www.billdu.com/blog/benefits-of-blockchain-faster-payment-processing/>, [Accessed the 16th, of March,2024 at:02:15 PM].*

Figure 10: How smart contracts could work in logistics.

- **Food industry:**

    The food industry has encountered obstacles such as consumers' demands to know the source of their food and concerns about food spoilage during transportation (such as the 2015 E. coli outbreak at a Chipotle Mexican Grill). This has resulted in the necessity of monitoring food at every stage of the supply chain to ensure transparency for consumers and stakeholders.[77]

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[77]*Kshetri. 1 blockchain's roles in meeting key supply chain management objectives. International Journal of information management, 39:80–89, 2018.*

Table 3: Blockchain Applications in Food industry.

Benefit	Description
Enhanced Traceability	The use of blockchain supply chain solutions allows for the traceability of food products end-to-end. The food supply chain can be monitored from the manufacturer to the end consumer, with the possibility of tracking all activities involved, such as production process, transportation details, and storage conditions. Furthermore, the food items that are impacted could be eliminated and identified from the supply chain if there is a product recall.[78]
	Food quality control procedures are implemented across food processing, manufacturing, distribution, and other stages, with automated compliance checks to ensure high food quality according to global and internal standards. usage of Blockchain technology for supply chain management in the food industry enables real-time verification and monitoring of data such as humidity, temperature, storage mediums, and more. To reduce the risk of fraud, contamination, and spoilage, it is

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[78] *Top 5 Real-life Blockchain Use Cases in Supply Chain in 2024, [online] antier. Available at:<https://www.antiersolutions.com/top-5-real-life-blockchain-use-cases-in-supply-chain-in-2023/>, [Accessed on the 17th, of March,2024 at: 11:30 AM].*

Quality Control and Food Safety	necessary to follow proper handling and storage protocols in the supply chain. In case of any deviation or discrepancy, stakeholders will receive prompt alerts, allowing for timely corrective actions.[79]
Waste Reduction	The transparency offered by blockchain in food logistics is unprecedented, due to the decentralized database structure that records transactions or information flows completely transparently. It includes crucial data like temperature, production date, and ingredients, which can be utilized to increase shelf life and reduce food waste. By analyzing the data recorded on the Blockchain, companies can pinpoint areas for improvement, decrease excess inventory, optimize logistic routes, and minimize waste. These optimizations not only result in cost savings, but also play a part in sustainability efforts by minimizing the environmental impact of the food supply chain.[80]
Real-life Example	Walmart

Source: the author's own effort.

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[79]*Hiba Haneefa, 21 July. 2023. Blockchain Technology in the Food Supply Chain. [online] LinkedIn. Available at:<*https://www.linkedin.com/pulse/blockchain-technology-food-supply-chain-hiba-haneefa*> ,[Accessed the 17th,of March,2024 at: 02:10 PM].*

[80]*Tobias Maier, 17 Nov 2023, How Blockchain Technology Can Reduce Food Waste and Address Global Hunger. [online] Sustain Ability Middle East. Available at:<*https://www.sustainabilitymenews.com/technology/how-blockchain-technology-can-reduce-food-waste-and-address-global hunger#:~:text=As%20a%20decentralized%20database%20structure,increase%20shelf%20life%20and%20reduce*>, [Accessed on the 17th,of March,2024 at: 02:30 PM].*

- **Pharmaceutical industry:**

Blockchain technology is used in healthcare for various purposes, including ensuring the security and privacy of patient data shared across systems, known as electronic medical records (EMR). The use of this technology is crucial in safeguarding sensitive medical information and maintaining patient privacy[81].Besides protecting patient data's security and privacy in healthcare, blockchain technology is also used in the pharmaceutical industry. This is used to track and trace pharmaceutical products throughout the entire supply chain. This helps maintain the integrity of the supply chain, ensure the authenticity of medications, and combat counterfeit drugs.[82]

Table 4: Blockchain Applications in Pharmaceutical industry.

Benefit	Description
Reduced Counterfeiting	The pharmaceutical industry is facing challenges in ensuring the availability of genuine drugs because of issues like ineffective supervision and counterfeit production. The global trade of counterfeit medicines costs billions every year, with developing countries being particularly vulnerable. There are various solutions that have been proposed, such as RFID tagging and image recognition, but blockchain technology stands out due to its potential to offer transparency, traceability, and data

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[81]*Jameela Al-Jaroodi and Nader Mohamed. Blockchain in industries: A survey, pp 4.*

[82]*Moulouki Reda et al.Blockchain in health supply chain management: State of art challenges and opportunities. Procedia Computer Science Volume 175, 2020, Pages 706-709. Procedia Computer Science Volume 175, 2020, Pages 706-709. Available at: <https://www.sciencedirect.com/science/article/pii/S1877050920318044>, [Accessed on the 20th, of March,2024 at: 02:20 PM].*

	immutability. The integration of blockchain can be used to combat medicine counterfeiting, enhance supply chain trust, and improve distribution efficiency. This technology has the potential to prevent malicious actors from entering the supply chain, guaranteeing the delivery of legitimate medicines to end customers and decreasing the risk of falsification, thereby enhancing patient safety.[83]
Better Drug Authentication	Various security measures are being utilized by the pharmaceutical industry to enhance drug authentication using blockchain technology. The supply chain's integrity and security are secured by using cryptographic techniques to validate transactional data blocks. Through serialization, this technology enables thorough verification checks to effectively combat counterfeit medications. The integrity of the entire supply chain is maintained and security risks are mitigated by blockchain by authenticating serial numbers. Blockchain also enhances drug traceability, prevents theft, and ensures consistent product quality. These standards are maintained by manufacturers and pharmacies through the

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[83]*Iyolita Islam, Muhammad Nazrul Islam, A blockchain based medicine production and distribution framework to prevent medicine counterfeit, Journal of King Saud University - Computer and Information Sciences Volume 36, Issue 1, January 2024, 101851.Availbale at: <https://www.sciencedirect.com/science/article/pii/S1319157823004056>, [Accessed on the 18th, of March,2024 at: 01:40 PM].*

	use of digital signatures, chain codes, and health information. By using blockchain, the authentication of high-value drugs and their integrity are ensured throughout the pharmaceutical supply chain. Furthermore, blockchain-based systems enhance the efficiency of supply chain financing by providing transparent and verifiable transaction data. Pharmaceutical companies benefit from this advancement by reducing costs and improving liquidity, resulting in more robust and reliable drug authentication.[84]
Secure Data Management	Pharmaceutical supply chains require secure data management, which involves handling sensitive information like manufacturing processes, patient data, and intellectual property. Blockchain technology provides a solution to this challenge by offering a secure and transparent platform for managing data. Blockchain allows for the encryption and storage of sensitive information in an immutable ledger, which ensures tamper-proof records. This data can be protected by implementing access controls and encryption mechanisms, which

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[84]*Sukhpreet Singh, the 3ʳᵈ, of July,2023. Leveraging Blockchain to Ensure Authenticity in Pharma Supply Chains. [online] LinkedIn, Available at: <https://www.linkedin.com/pulse/leveraging-blockchain-ensure-authenticity-pharma-supply singh#:~:text=Blockchain%20in%20Pharma%20Industry&text=Security%20measures%20are%20implemented%20through,numbers%2C%20effectively%20mitigating%20security%20threats> ,[Accessed on the 18ᵗʰ,of March,2024 at:02:50 PM].*

	only authorize authorized parties to access relevant information. This not only enhances data security, but also provides transparency and trust to stakeholders.[85]
Real-life Example	Sanofi

Source: The author's own work.

Apart from the Transport and Logistics, Food, and pharmaceutical industries, blockchain technology benefits various sectors. Brilliant Earth ensures ethical sourcing by providing transparency in its diamond supply chain. Naturipe Farms uses blockchain to provide fresher fruit delivery, which enhances food safety. BHP uses blockchain in mining to ensure responsible sourcing. In the energy sector, it tracks transactions related to renewable energy. Real estate sees blockchain as a tool for property transactions, while luxury brands are fighting counterfeiting. Blockchain is utilized in healthcare to maintain secure medical records, and entertainment uses it to track royalty. The integrity of vehicle history is guaranteed by BMW, and insurance enhances claims processing. These examples showcase blockchain's versatility in enhancing transparency, security, and efficiency across industries.

2- Benefits of Implementing Blockchain in Supply Chain Management:

Implementing blockchain technology in supply chain management can lead to various improvements and advancements. In the literature, blockchain technology is commonly identified with three main drivers: transparency, traceability, and security (e.g. Francisco & Swanson, 2018; Imeri, Feltus, Khadraoui, Agoulmine & Nicolas, 2018; Tijan et al., 2019; Treiblmaier, 2018).

- **Transparency:**

According to Apte and Petrovsky (2016) blockchain innovation is distinguished by its

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[85]*Sanjeev Kumar Dwivedi et al.Journal of Information Security and Applications Volume 54, October 2020, 102554.Available at :<https://www.sciencedirect.com/science/article/abs/pii/S2214212620301484>, [Accessed on the 18th,of March,2024 at: 11:15 PM].*

transparency, which is considered one of its primary benefits[86].It offers increased transparency in the supply chain as Francisco & Swanson (2018) mentioned[87] ,and leads to a potential major benefit of blockchain technology, for example in the logistics industry (Tijan et al., 2019)[88].The technical fact of the block having copies of all operations allows it to achieve transparency cannot be changed[89].Furthermore, the enhanced transparency is intended to boost confidence in transactions[90].these will result in building trust among the parties included in a supply chain because it provides open access to key data points it captures[91].

- **Traceability:**

According to Kshetri (2018); Pal and Kant (2019) traceability and provenance have recently become more important for the supply chain. The aim of this focus is to ensure that industries and customers relying on the supply chain are confident in the sustainability of their products and processes. Although it is common for logistics operators to track packages accurately during transportation stages nowadays, this level of precision is often lost or not possible at all stages of supply chains because of their multilingual, complex, and interorganizational nature.[92]

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[86] *Shireesh Apte, Nikolai Petrovsky, September 24, 2016. Will blockchain technology revolutionize excipient supply chain management? . International Journal of Pharmaceutical Excipients, Vol. 7, Issue 3, 2016September 24, 2016 EDT. Available at:<https://jefc.scholasticahq.com/article/910-will-blockchain-technology-revolutionize-excipient-supply-chain-management> ,[Accessed on the 20th,of March,2024 at: 06:20 PM].*

[87]*Kristoffer Francisco and David Swanson, 5 January 2018, The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency. Available at :<https://www.mdpi.com/2305-6290/2/1/2>, [Accessed on the 21st, of March,2024 at: 00:35 AM].*

[88]*Tijan, E., Aksentijević, S., Ivanić, K., & Jardas, M. ,2019, Blockchain Technology Implementation in Logistics. Sustainability, MDPI, vol. 11(4), pages 1-13, February. Available at:<https://ideas.repec.org/a/gam/jsusta/v11y2019i4p1185-d208586.html> ,[Accessed on the 21st,of March, 2024 at: 00:49 AM].*

[89] *Minhaj Ahmad Khan, Khaled Salah, May 2018. IoT security: Review, blockchain solutions, and open challenges. Future Generation Computer Systems Volume 82, May 2018, Pages 395-411. Available at:<https://www.sciencedirect.com/science/article/abs/pii/S0167739X17315765>, [Accessed on the 21st, of March, 2024 at: 01:41 Am].*

[90]*Eljazzar, M. M., Amr, M. A., Kassem, S. S., & Ezzat, M. 2018). Merging supply chain and blockchain technologies. In: 28th International Conference for Management of Technology-Managing Technology for Inclusive and Sustainable Growth, 224-228. Available at:<https://arxiv.org/ftp/arxiv/papers/1804/1804.04149.pdf>, [Accessed on the 21st, of March,2024 at: 02:02 AM].*

[91] *Cem Dilmegani, January 2024. Blockchain in Supply Chain: Benefits & Top Use Cases in 2024. [online] AIMultiple. Available at:<https://research.aimultiple.com/blockchain-in-supply-chain/>, [Accessed on the 21st, of March,2024 at: 02:15 AM].*

[92] *Pedro Azevedo, Jorge Gomes, Mário Romão. Supply chain traceability using blockchain. Operations Management Research (2023) 16:1359–1381https://doi.org/10.1007/s12063-023-00359-y, [Accessed the 21st, of March,2024 at:02:13 PM].*

Chapter I: Exploring Blockchain Integration in Supply Chain Management.

Currently, the most common use of blockchain in supply chains involves verifying the origin of a product (such as its place, time, and manufacturer) and providing details about its journey from the origin to the end consumer. Traceability and visibility have always been crucial factors in delivering top-notch logistical services to customers. The ability to provide information on a product's origins, manufacturer, transportation details, and current location is highly valuable to customers and offers a significant competitive edge to companies. These details enable better planning and synchronization of customer processes, leading to further operational optimizations.[93]

Every physical product can have a digital 'passport' that confirms its authenticity and origin with the help of provenance solutions.[94]Using blockchain permits verified supply chain members to upload and read information on blockchain, and final consumers can easily access all relevant product information online, in-store, or on-pack.

- **Security:**

As cybercrime and supply chain complexity increase, Blockchain provides additional security by creating immutable records. Tijan et al. (2019) state that blockchain innovations are contributing to the improvement of security measures. Data stored on a blockchain is cryptographically secure, making it resistant to tampering, hacking, or unauthorized access.[95] Supply chain management benefits greatly from this aspect because businesses can rely on the accuracy and integrity of the information received. Furthermore, as Larry Sherrod (2023) points out, the decentralized nature of blockchain eliminates the risk of a single point of failure, thereby enhancing overall data security. The decentralized and consensus-oriented nature of blockchain[96], as stated by Kshetri (2017),

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[93]Davor Dujak and Domagoj Sajter, 2018. Blockchain Applications in Supply Chain. Available at :<*Blockchain Applications in Supply Chain | SpringerLink*>, [Accessed on the 21st, of March,2024 at: 02:43 PM].

[94] *Herzberg, B. (2015). Blockchain: The solution for transparency in product supply chains. [online] Provenance. Available at:<Blockchain: the solution for transparency in product supply chains | Provenance | Provenance>, [Accessed on the 22nd, of March,2024 at: 03:00 PM].*

[95]*Tijan, E., Aksentijević, S., Ivanić, K., & Jardas, M. ,2019, Blockchain Technology Implementation in Logistics. Sustainability, MDPI, vol. 11(4), pages 1-13, February. Available at:<https://ideas.repec.org/a/gam/jsusta/v11y2019i4p1185-d208586.html>, [Accessed the 22nd, of March 2024 at:10:40 PM].*

[96]*Larry Sherrod, Juin 2023. The Benefits of Using Blockchain for Supply Chain Compliance. [online] LinkedIn. Available at:<https://www.linkedin.com/pulse/benefits-using-blockchain-supply-chain-compliance-larry-sherrod>, [Accessed the 22nd, of March,2024 at: 10:56 PM].*

assures that each partner is responsible for their role in transactions, even in rapidly expanding networks, which prevents potential conflicts[97].

In summary, blockchain technology provides enhanced security measures despite the challenges of cybercrime and supply chain complexity, which makes it an invaluable asset in guaranteeing the integrity and reliability of supply chain data.

This research paper only mentions the main three advantages of blockchain in supply chain management, but there are many potential benefits mentioned in academic literature and reputable websites. It is acknowledged that it reduces costs by streamlining processes and eliminating middlemen, as well as improving efficiency and transaction speeds. Blockchain's unchangeable records and smart contracts also improve financial transactions' accuracy, decreasing errors and related costs. Additionally, it fosters trust among stakeholders, promotes collaboration by sharing data, and provides real-time supply chain visibility. Numerous reliable sources have highlighted the significant role played by blockchain in modernizing and optimizing supply chain operations.

3- Challenges and Limitations of Blockchain in Supply Chain Management:

Although blockchain technology has many potential advantages for supply chain management, there are also several challenges and limitations that need to be taken into consideration:

- **High implementation cost:**

At first, the acquisition and implementation of new technologies can be very costly, according to Heilig, Lalla-Ruiz, and Voß (2017)[98]. Rohleder (2019) states that the training required for employees to handle these changes is both expensive and necessary[99]. Furthermore,

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[97]*Nir Kshetri,2017. Blockchain's roles in strengthening cybersecurity and protecting privacy, Telecommunications Policy Volume 41, Issue 10, November 2017, Pages 1027-1038. Available at:<https://www.sciencedirect.com/science/article/abs/pii/S0308596117302483>, [Accessed the 22nd, of March,2024 at: 10:58 PM].*

[98]*Leonard Heilig,Eduardo Lalla-Ruiz1 ,Stefan Voß (2017). Digital transformation in maritime ports: analysis and a game theoretic framework. Available at:<https://link.springer.com/article/10.1007/s11066-017-9122-x>, [Accessed on the 25th, of March,2024 at: 11:55 AM].*

[99] *Rohleder, B. (2019). Digitalization of logistics. [Online] Bitkom. Available at: https://www.bitkom.org/sites/default/files/2019-06/bitkom- charts_digitalisierung_der_logistik_03_06_2019 [Accessed on the 20th, of March ,2024 at : 05:30 PM].*

Veera Budhi (2022) mentions that blockchain is costlier than a conventional database. Businesses need proper planning and execution to integrate blockchain into their processes[100].

- **Lack of Knowledge for blockchain implementation:**

Rugeviciute and Mehrpouya (2019) concluded that the most significant obstacles to blockchain-governed projects include a lack of comprehension, a reluctance to comprehend its complexity, security challenges, and a lack of institutional structures for rules and knowledge production[101]. According to Korpela et al. (2017), there is a lack of knowledge and tools for implementing blockchain technology[102]. The absence of consistent standardization was noted by Fridgen, Radszuwill, Urbach, and Utz (2018), which means that companies are left with unclear guidance on how to efficiently manage the technology[103]. Sternberg and Baruffaldi (2018) emphasized that a stable environment can provide some compensation for the incomplete knowledge of the long-term success of the implementation[104].

- **The absence of technological access:**

According to Saberi at al. lacking technology access is frequently a significant issue in a supply chain (Saberi et al., 2019)[105]. To enhance the value of a digital supply chain, it is

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[100]*Veera Budhi (2022). Advantages And Disadvantages Of Blockchain Technology. [online] Forbes. Available at :<https://www.forbes.com/sites/forbestechcouncil/2022/10/20/advantages-and-disadvantages-of-blockchain-technology/?sh=2547cfb03453>, [Accessed the 25th, of March,2024 at: 1:01PM].*

[101] *Rugeviciute, A., & Mehrpouya, A. (2019). Blockchain, a panacea for development accountability? A study of the barriers and enablers for blockchain's adoption by development aid organizations. Available at:<https://www.frontiersin.org/articles/10.3389/fbloc.2019.00015/full>, [Accessed on the 25th, of March,2024 at: 03:15 PM].*

[102]*Korpela, K., Hallikas, J., & Dahlberg, T. (2017). Digital supply chain transformation toward blockchain integration. In: Proceedings of the 50th Hawaii International Conference on System Sciences. 3936-3943.<https://scholarspace.manoa.hawaii.edu/server/api/core/bitstreams/57742ac0-0713-4cd4-b355-d921a3bbff7c/content>, [Accessed on the 25th, of March,2024 at: 03:20 PM].*

[103]*Gilbert Fridgen, Sven Radszuwill, Nils Urbach, Lena Utz (2018). Cross-Organizational Workflow Management Using Blockchain Technology – Towards Applicability, Auditability, and Automation. In: Proceedings of the 51st Hawaii International Conference on System Sciences, 3507-3516.<https://www.fim-rc.de/Paperbibliothek/Veroeffentlicht/696/wi-696.pdf>, [Accessed on the 25th, of March,2024 at: 03:35 PM].*

[104]*Henrik Sternberg, Giulia Baruffaldi (2018). Chains in chains: Logic and Challenges of Blockchains in Supply Chains, In: 51st Hawaii International Conference on System Sciences. 3936-3943.<https://portal.research.lu.se/en/publications/chains-in-chains-logic-and-challenges-of-blockchains-in-supply-ch>, [Accessed the 25th,of March,2024 at :03:45 PM].*

[105]*Sara Saberi, Mahtab Kouhizadeh, Joseph Sarkis & Lejia Shen (2019). Blockchain technology and its relationships to sustainable supply chain management. Blockchain technology and its relationships to sustainable supply chain management, International Journal of Production Research, 57:7, 2117-2135, DOI: 10.1080/00207543.2018.1533261. < https://doi.org/10.1080/00207543.2018.1533261>.*

essential that all participants in the supply chain have access to the necessary information and use the same method or technology (Apte & Petrovsky, 2016)[106]. Due to the various possibilities offered by various enterprises, this cannot be accomplished. Korpela et al.,suggests that not all companies can afford the high establishment costs (Korpela et al.2017)[107].

- **Integration with Existing Systems:**

Harman Puri (2023) on Medium explains that integrating blockchain into existing systems is challenging due to numerous challenges. While legacy systems are centralized and operated by a single authority, blockchains such as Anryton are decentralized and distribute control among a network of peers. The difference is that legacy systems maintain data under one organization's control, while blockchain disperses data ownership, resulting in better data control and governance[108].Additionally, he points out that integrating blockchain into existing systems is challenging due to technological incompatibility, such as different data structures and performance issues. The growth of data volumes and network expansion, as well as security paradigm shifts, are all contributing to scalability concerns and key management challenges[109].Integrating this technology into current systems can be a complex and time-consuming process, especially for companies with multiple legacy systems. As a result, most organizations need enough time and resources to ensure that their systems are seamlessly linked to the blockchain[110].

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[106]*Shireesh Apte, Nikolai Petrovsky, September 24, 2016. Will blockchain technology revolutionize excipient supply chain management? . International Journal of Pharmaceutical Excipients, Vol. 7, Issue 3, 2016 September 24, 2016 EDT. Available at:<https://jefc.scholasticahq.com/article/910-will-blockchain-technology-revolutionize-excipient-supply-chain-management> ,[Accessed the 2nd ,of April,2024 at: 01:58 AM].*

[107]*Korpela, K., Hallikas, J., & Dahlberg, T. (2017). Digital supply chain transformation toward blockchain integration. In: Proceedings of the 50th Hawaii International Conference on System Sciences. 3936-3943. <https://scholarspace.manoa.hawaii.edu/server/api/core/bitstreams/57742ac0-0713-4cd4-b355-d921a3bbff7c/content>, [Accessed the 2nd, of April,2024 at: 02:02 AM].*

[108]*Harman Puri, Oct 26, 2023, Challenges in Integrating Blockchain into Legacy Systems. [online] Medium. Available at:<https://medium.com/anryton-media/challenges-in-integrating-blockchain-into-legacy-systems-1d60fbc44563>, [Accessed the 2nd, of April,2024 at: 03:30 PM].*

[109]*Idem*

[110]*Günthner, MARCH 16, 2023, The Role of Blockchain in Supply Chain Management (SCM). [online] Paltron. Available at:<https://www.paltron.com/insights-en/the-role-of-blockchain-in-supply-chain-management-scm#toc-section-3>, [Accessed the 2nd,of March,2024 at: 03:58 PM].*

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- **Cybersecurity and Data Privacy Concerns:**

Businesses must be vigilant about security risks associated with blockchain technology, as stated by Josef Günthner. Malicious actors have the ability to exploit vulnerabilities to compromise data and networks despite the distributed ledger's inherent security[111]. Additionally, according to Conte et al. the transparency of the blockchain poses a risk to data privacy, potentially exposing sensitive information if proper precautions are not taken. While blockchain's immutability is a strength, it cannot completely prevent forgery and falsification of data, which may lead to security lapses (Conte de Leon et al. 2017)[112]. The human element adds an additional layer of risk, as Saberi et al. point out. Individuals may inadvertently introduce incorrect data when interacting with blockchain technology, as Saberi et al. (2019)[113].

- **Legal considerations and regulations:**

According to recent research, blockchain technology's regulatory framework is still relatively new, resulting in considerable uncertainty in various jurisdictions. Companies considering adoption face legal and regulatory risks due to this uncertainty. It is important for organizations to be vigilant for any regulatory changes that could affect their use of blockchain[114].The integration of blockchain technology into supply chains is faced with significant obstacles due to legal aspects and laws. Supply chains are globally interconnected in the context of globalization, resulting in a complex legal environment with numerous actors and laws (Wang et al., 2019a)[115]. According to many research papers the challenge is further compounded by the absence of clear legal guidelines that specifically address the use of blockchain technology. This uncertainty can cause challenges with

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[111]Idem

[112]Daniel Conte de Leon, Antonius Q. Stalick, Ananth A. Jillepalli, Michael A. Haney, Frederick T. Sheldon,2017, Blockchain: properties and misconceptions, Asia Pacific Journal of Innovation and Entrepreneurship, Vol. 11 Issue: 3, pp.286-300, https://doi.org/10.1108/APJIE-12-2017-034.

[113]Sara Saberi, Mahtab Kouhizadeh, Joseph Sarkis & Lejia Shen (2019). Blockchain technology and its relationships to sustainable supply chain management. Blockchain technology and its relationships to sustainable supply chain management, International Journal of Production Research, 57:7, 2117-2135, DOI: 10.1080/00207543.2018.1533261. < https://doi.org/10.1080/00207543.2018.1533261>.

[114]Josef Günthner, MARCH 16, 2023, The Role of Blockchain in Supply Chain Management (SCM). [online] Paltron. Available at:<*https://www.paltron.com/insights-en/the-role-of-blockchain-in-supply-chain-management-scm#toc-section-3*>, [Accessed the 04th,of March,2024 at: 06:48 AM].

[115]Wang, Yingli, Han, Jeong Hugh and Beynon-Davies, Paul (2019). Understanding blockchain technology for future supply chains: a systematic literature review and research agenda. Supply Chain Management: *An International Journal 2 4 (1), pp.62-84.10.110 8/SCM-03-2018-014 8.<https://orca.cardiff.ac.uk/id/eprint/115569/1/_system_appendPDF_proof_hi.pdf>.*

implementation and create an obstacle outside (Poszler et al., 2019[116]; Seebacher & Schüritz, 2019[117]).

4- Best Practices for Successful Implementation of Blockchain in Supply Chain Management:

Even with challenges, blockchain technology can be successfully implemented in supply chain management. We will look at the strategies and methodologies that organizations can use to successfully integrate blockchain technology into their supply chain operations in this part.

- **Identify Key Use Cases:**

Josef Günthner in Paltron (2023) states that identifying the key use cases that will provide the most value for your supply chain is crucial before implementing blockchain technology[118]. According to Deep Dave, the identification of the use case is crucial as it ensures that the blockchain solution effectively tackles specific challenges. Without a clear use case, resources may be wasted on unsuitable applications, leading to inefficiencies. Setting the scope, objectives, and success metrics ensures alignment with business goals and stakeholder needs[119].It is important to identify the specific problem you want to solve before utilizing blockchain. Blockchain is not suitable for every situation, so take into account factors such as the number and type of participants, the level of trust between them, the frequency of transactions, and the requirement for transparency.

Also, take into account the regulatory requirements and costs. Defining the project's goals and setting key indicators is crucial to measure success.[120]

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[116]*Poszler, F., Ritter, A.-C., & Welpe, I. (2019). Blockchain startups in the logistics industry: The technology´s potential to disrupt business models and supply chains. Logistik Im Wandel Der Zeit – Von Der Produktionssteuerung Zu Vernetzten Supply Chains, 567–584. doi:10.1007/978-3-658-25412-4_26.*

[117]*Seebacher, Stefan and Schüritz, Ronny, (2019). "BLOCKCHAIN – JUST ANOTHER IT IMPLEMENTATION? A COMPARISON OF BLOCKCHAIN AND INTERORGANIZATIONAL INFORMATION SYSTEMS". In Proceedings of the 27th European Conference on Information Systems (ECIS), Stockholm & Uppsala, Sweden, June 8-14, 2019. ISBN 978-1-7336325-0-8 Research Papers. <https://aisel.aisnet.org/ecis2019_rp/124>.*

[118]*Josef Günthner, MARCH 16, 2023, The Role of Blockchain in Supply Chain Management (SCM). [online] Paltron. Available at:<https://www.paltron.com/insights-en/the-role-of-blockchain-in-supply-chain-management-scm#toc-section-3>, [Accessed the 09th,of April,2024 at: 01:00 AM].*

[119]*James Canterbury,Deep Dave, Konstantin Nikolaev. What are the best practices for using blockchain insupply chain management? [online] LinkedIn. Available at:<https://www.linkedin.com/advice/3/what-best-practices-using-blockchain-supply-chain-management?lang=en>. [Accessed the 9th, of April,2024 at 01:35 AM].*

[120]*Idem*

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- **Choose the right platform:**

After reviewing many researches, we came to this conclusion, After the specific use case is identified, the next step is to select the appropriate blockchain platform. Public, private, or hybrid are three different types, each with unique features and trade-offs. Public blockchains can be both open and decentralized, but they may have scalability and privacy issues. Closed and centralized private blockchains have the potential to offer higher performance and security. Hybrid blockchains combine elements of both, but may face obstacles in interoperability and governance. Comparing technical aspects such as consensus mechanisms, programming languages, smart contract support, data storage, and network architecture is crucial.

When choosing a platform, James Canterbury emphasizes the importance of considering future planning. Although private blockchains are perfect for experimentation, they have limitations when it comes to scalability. As their size increases, they may face privacy and security challenges similar to those of public networks. Running private networks can be expensive unless they are small-scale.[121]For example Healthcare requires the right blockchain platform to be chosen. Private blockchains may be a better choice for securing patient data because of their enhanced security and controlled access, which ensures HIPAA compliance. A hybrid solution could be the perfect solution for cross-hospital data sharing, providing both accessibility and privacy. Prioritizing patient confidentiality is crucial when evaluating blockchain platforms.[122]

- **Determine the Consensus Mechanism:**

A consensus mechanism was defined on MongoDB's platform that is employed to create trust, security, and agreement in a decentralized network. It enables a decentralized network to reach "consensus" on the state of the blockchain and proceed in harmony. Different mechanisms operate on different principles to achieve this. Proof of work (PoW) and proof of stake (PoS) are the most common. Furthermore, there are other methods like proof of authority (utilized in private or permissioned networks) and consortium (also referred to as federated or semi-private). The

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[121]*James Canterbury. What are the best practices for using blockchain in supply chain management? [online] LinkedIn. Available at:<https://www.linkedin.com/advice/3/what-best-practices-using-blockchain-supply-chain-management?lang=en>. [Accessed the 10th, of April,2024 at 01:35 AM].*

[122]Deep Dave. What are the best practices for using blockchain in supply chain management? [online] LinkedIn. Available at:<https://www.linkedin.com/advice/3/what-best-practices-using-blockchain-supply-chain-management?lang=en>. [Accessed the 10th, of April,2024 at 01:35 AM].

importance of these mechanisms lies in making sure that decentralized systems are both functional and have integrity.[123]

- **Design the data model:**

Determine the data structures and types of data that will be recorded on the blockchain. Identify the level of data privacy and security needed and create tools for encryption, access control, and identity management.[124]

"*Data models are important for a given use case, but defining the perfect data model is the number one reason for projects to get slowed down. You have to accept that data models will change over time, and therefor you don't need to let perfect get in the way of good.*

Also, very little data should ever be stored on chain, we just store hashes and pointers to where the data is stored. If you write smart contracts that require data to trigger certain logic, that will need to be carefully defined and you are probably better off leveraging an oracle network for that.

Finally for supply chain specifically, we need to start thinking about 'product oriented' data models, as opposed the typical 'process oriented' data models we have today"[125].

- **Follow Security Best Practices:**

As it was mentioned on Paltron by Josef Günthner[126], and on TechTarget by Jessica Groopman[127], it is crucial to protect data privacy and security when implementing blockchain in supply chain management. To safeguard sensitive information, companies must follow best practices, which include strong encryption, access control measures, and regular security checks.

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[123]Blockchain Implementation Guide. [online] MongoDB. Available at:<*https://www.mongodb.com/databases/blockchain-implementation*>, [Accessed the 13th, of April, 2024 at 01:10 PM].

[124]RIDHAM MODI. HOW TO DESIGN A BLOCKCHAIN APPLICATION ARCHITECTURE? , [online] highen. Available at:<*How to design a blockchain application architecture? (highenfintech.com)*>. [Accessed the 13th, of April,2024 at 02:30 PM].

[125]*James Canterbury. What are the best practices for using blockchain in supply chain management? [online] LinkedIn. Available at:<https://www.linkedin.com/advice/3/what-best-practices-using-blockchain-supply-chain-management?lang=en>. [Accessed the 10th, of April,2024 at 01:35 AM].*

[126]*Josef Günthner, MARCH 16, 2023, The Role of Blockchain in Supply Chain Management (SCM). [online] Paltron. Available at:<https://www.paltron.com/insights-en/the-role-of-blockchain-in-supply-chain-management-scm#toc-section-3>, [Accessed the 12th,of April,2024 at: 07:15 PM].*

[127] *Jessica Groopman, 08 Jun 2023, How to secure blockchain: 10 best practices. [online] TechTarget. Available at:<https://www.techtarget.com/searchsecurity/tip/8-best-practices-for-blockchain-security>. [Accessed the 12th, of April,2024 at: 07:17 PM].*

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Despite the fact that core blockchain technologies are often hidden from end-user view, applications and identity management systems are susceptible to attacks such as phishing. To reduce risks, it is crucial to have universal best practices that consist of two-factor authentication, trusted sender and recipient lists, strong private key management, regular security updates, knowledge of custodial services, utilizing cold wallet storage, and implementing robust network security measures like zero-trust architecture and VPNs. To protect blockchain applications and data interactions, these practices are a must.

- **Collaborate with stakeholders:**

"*Blockchain is a team sport - it only works if enough of the ecosystem is involved - this implies that enough of the ecosystem gains value from it to make their participation worthwhile (forcing a sector to use a blockchain for compliance purposes is almost always a bad idea).*

Different ecosystem members will be motivated by different use cases, which is why thinking of the blockchain as a foundation and not a fit-for-purpose solution is so important".[128]

Collaborating with partners is necessary to implement blockchain in supply chain management. Sharing information is crucial because partners encounter similar challenges such as security and legal issues. Engaging stakeholders like suppliers, manufacturers, and regulators is essential. The objective is to convey the advantages of blockchain, address concerns, and establish a transparent governance structure. In order to encourage participation and compliance, incentives are necessary.

- **Monitor performance:**

Ensure that the application's performance, security, and user feedback are regularly monitored. Address any problems, make necessary updates or enhancements, and adjust the architecture as necessary to adapt to changing requirements or emerging technologies.[129]

Companies can effectively integrate blockchain technology into their supply chains and realize its numerous potential advantages by following best practices. The implementation process

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[128]*James Canterbury. What are the best practices for using blockchain in supply chain management? [online] LinkedIn. Available at:<https://www.linkedin.com/advice/3/what-best-practices-using-blockchain-supply-chain-management?lang=en>. [Accessed the 10th, of April,2024 at 01:35 AM].*
[129]*RIDHAM MODI. HOW TO DESIGN A BLOCKCHAIN APPLICATION ARCHITECTURE? , [online] highen. Available at:<How to design a blockchain application architecture? (highenfintech.com)>. [Accessed the 13th, of April,2024 at 02:57 PM].*

requires the assistance of appropriate technology partners or professionals. Their expertise can ensure the success of their blockchain investments, resulting in lasting value and benefits.

Conclusion:

In conclusion, supply chains are the backbone of modern commerce, connecting manufacturers, suppliers, distributors, and retailers. The rising demand for efficiency, transparency, and security has sparked interest in emerging technologies like blockchain. This chapter has explored Supply Chain Management (SCM) and its complexities, along with the basics of blockchain technology. It has outlined the potential benefits of integrating blockchain into SCM, such as improved transparency and efficiency. However, challenges like scalability and interoperability exist. Despite these, blockchain holds promise for transforming supply chain operations. The goal is not only to introduce blockchain but also to encourage its adoption among Algerian companies for enhanced supply chain management.

Chapter II: Methodology and Research Approach

This chapter entails the methodological approach to answer the main research question and associated sub questions. The first part of this chapter outlines the Presentation of the National Company of Geophysics, followed by research methodology. Lastly, we analyze the results we got.

Section 1: Presentation of the National Company of Geophysics

This section elaborates the description of the National Company of Geophysics and its characteristics, then we will move on to the description of the logistical direction.

1- Presentation of the National Company of Geophysics (ENAGEO):

1-1- General Presentation of E.NA.GEO:

National company of Geophysics (E.NA.GEO), a subsidiary of the oil group SONATRACH, is the leading provider in oil exploration. It has a social capital of 30.000.000.000 Algerian Dinars (DA) and a highly qualified workforce (900 engineers and post-graduates among 6,500 employees). ENAGEO has been QHSE certified since 2006 (ISO 9001, ISO 14001, and ISO 45001), and it has the advantage of engaging in an activity that represents the first step in the oil industrial process. With over 40 years of experience in the field of hydrocarbon exploration through seismic reflection, one of the most widely used methods worldwide, it holds a leading position in the national oil exploration market.

E.NA.GEO's international reputation, experience, and expertise have been gained through various projects carried out abroad, particularly in Tunisia, Niger, Mali, and Libya.

1-2- History of the company:

E.NA.GEO was established in August 1981 (Decree 81-172 of 01/08/1981), from:

- ALGEO, which was a joint venture between SONATRACH and TELEDYNE (an American company) since March 1st, 1967;
- From the geophysical department and the topography service of the Petroleum Works Directorate (DTP) of SONATRACH;
- From SONATRACH's seismic processing service;

Chapter II: Methodology and Research Approach

Under the supervision of the Ministry of Energy and Mines until February 1989, it then acquired the status of an autonomous company whose shareholders are the three participation funds:

- Mines, Hydrocarbons, and Hydraulic: 40%;
- Agro-food Industries: 30%;
- Chemistry, Petrochemistry, and Pharmacy: 30%.

In 1998, after the replacement of the participation funds with Holdings, SONATRACH acquired 51% of the capital of E.NA.GEO, which then became the property of:

- SONATRACH Parapetroleum Services Holding (SPP): 51%;
- TRAVEN Energy Works Participation Management Company (SGP-TRAVEN): 49%.

Since 2005, it has been a 100% subsidiary of SONATRACH.

1-3- Activity sector and activities of E.NA.GEO:

1-3-1- Field of activity:

E.NA.GEO is responsible for conducting geophysical exploration activities located upstream of the oil extraction process. This activity is part of the oilfield services sector, encompassing all companies involved in the exploration, study, and construction required for exploiting deposits. Therefore, the primary activity of the company involves conducting exploration and research studies for hydrocarbons and other mineral substances, utilizing geophysical methods, particularly seismic reflection. This encompasses the acquisition, recording, processing, and interpretation of subsurface reactions to artificially induced vibrations by seismic vibrators.

1-3-2- Main Activities:

a) Acquisition of Seismic Data:

E.NA.GEO has over 40 years of experience in hydrocarbon exploration through seismic reflection, one of the most widely used methods in Algeria and globally. Highly qualified engineers and technicians have enabled the company to achieve perfect mastery of state-of-the-art recording

equipment (telemetric laboratories with a large number of channels, vibroseismic, GPS positioning) used in 2D and 3D seismic acquisition. The company has 16 seismic teams.

b) Seismic Data Processing:

E.NA.GEO has two computing centers, the first located in Ouled Fayet, Algiers province, and the second, operational since the second half of 2006, located in Boumerdes. These two centers are undergoing expansion to meet the seismic data processing needs of Sonatrach and Associates and are overseen by highly experienced geophysicists with over 20 years of experience.

c) Interpretation and Reservoir Evaluation:

E.NA.GEO also has a sub-division responsible for seismic interpretation, evaluation (geological and geophysical), and conducting studies directly related to reservoir characterization. This structure will enable the company in the near future to develop its human, material, and expertise capacities to offer its clients integrated solutions in the field of reservoir characterization.

1-3-3-Additional Activities:

- Hydraulic Drilling,
- General Geophysics (Well Seismic, Electrical Prospecting, Gravimetry, and Magnetometry),
- Topography Works,
- Geotechnics.

1-4-   Information about the company:

1-4-1- Address:

- PO Box 140, Industrial Zone
- Hassi-Messaoud
- Ouargla 30500 / Algeria

1-4-2- Contact:

- Phone number: +213 (0) 29 79 77 00
- Fax: +213 (0) 29 79 72 12
- Email: communication@enageo.com

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- Website: https://www.enageo.com/

Figure 11: ENAGEO's logo.

Source: https://enageo.com/

2- Organizational Mode of E.NA.GEO:

In order to carry out its missions successfully, the National Geophysics Company has organized itself as follows:

- **General Management:**

The general management is the sole entity responsible for the strategy and development of the Company. It exercises hierarchical and functional authority over all departments and units.

- **Production Units:**

They differ from support units in their operational nature and objectives. They are represented as follows:

a) **Seismic Exploration Division (SED):** It primarily operates in the field of hydrocarbon exploration through seismic reflection, one of the most commonly used methods worldwide. It employs both 2D and 3D seismic acquisition techniques and has 15 seismic teams (missions) with its own resources.

b) **Seismic Processing Department (SPD):** It handles the computer processing of seismic data obtained in the field by seismic research teams. It is also responsible for producing maps of the surveyed regions and preparing the data interpretation report, aiming to delineate areas favorable for hydrocarbon accumulation.

c) **Hydrology & Topography Department (HTD):** It has around ten light and medium drilling rigs, capable of drilling up to 800 meters deep. It also conducts geotechnical and topographical studies

- **Support Units:**

They provide supplies and support in various management areas to the operational units in achieving their objectives.

a) **Logistics Division (LD):** Ensures the satisfaction of the operational departments' and other company structures' needs in terms of:
➢ Logistics (food and accommodation);
➢ Equipment and rolling stock maintenance;
➢ Supply of equipment and consumable materials.

b) **Health, Safety, and Environment Department (HSE):** Its mission is to develop and implement the company's policy regarding Safety, Health, and Environment, in compliance with national and international standards and laws.

c) **Finance and Accounting Department (FAD):** Its role is to ensure the availability and optimal management of financial resources necessary for the Company's operations, as well as to safeguard its interests.

d) **Planning & Systems Department (PSD):** It handles the following tasks:
➢ Coordinates the company's planning process;
➢ Designs management systems and ensures their implementation;
➢ Evaluates the achievement of management objectives and policies;
➢ Monitors the use of resources;
➢ Ensures the accuracy and regularity of procedures with financial and accounting implications for the company's operations, in accordance with current rules and legislation.

e) **Human Resources & Administration Department (HRAD):** Its role is to initiate and promote dynamic management of the company's human resources within the framework of national policies and rules, reconciling the company's objectives and policies with the individual aspirations of the staff.

f) **Communication and Development Department (CDD):** It is primarily responsible for communication within the company in its broadest sense, but also, and above all, for

research and development activities. These works, particularly in the field of reservoir characterization, have enabled the company to file four (04) patents that will enhance its portfolio of activities.

g) **Information Technology and ICT Department (ITID):** Its main scope of action is the computerization of management processes and the development of communication networks within the company. It defines the medium and long-term objectives of IT developments in the company and ensures the availability of equipment and software in use.

h) **Common Services Department (CSD):** Besides managing the common services in North Boumerdes and OFA (Ouled Fayet), CSD is responsible for coordinating and providing administrative and logistical support to the activities of DTS and DCDEV.

i) **Legal Affairs Department (LAD):** It ensures compliance with national and international regulations and decrees in all company activities, as well as safeguarding its interests.

j) **Audit Department:** Ensures the accuracy of information and the regularity of procedures with financial and accounting implications for the company's operations, in accordance with current rules and instructions.

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2-2- General Organizational Chart of ENAGEO:

Figure 12: ENAGEO's Organizational Chart
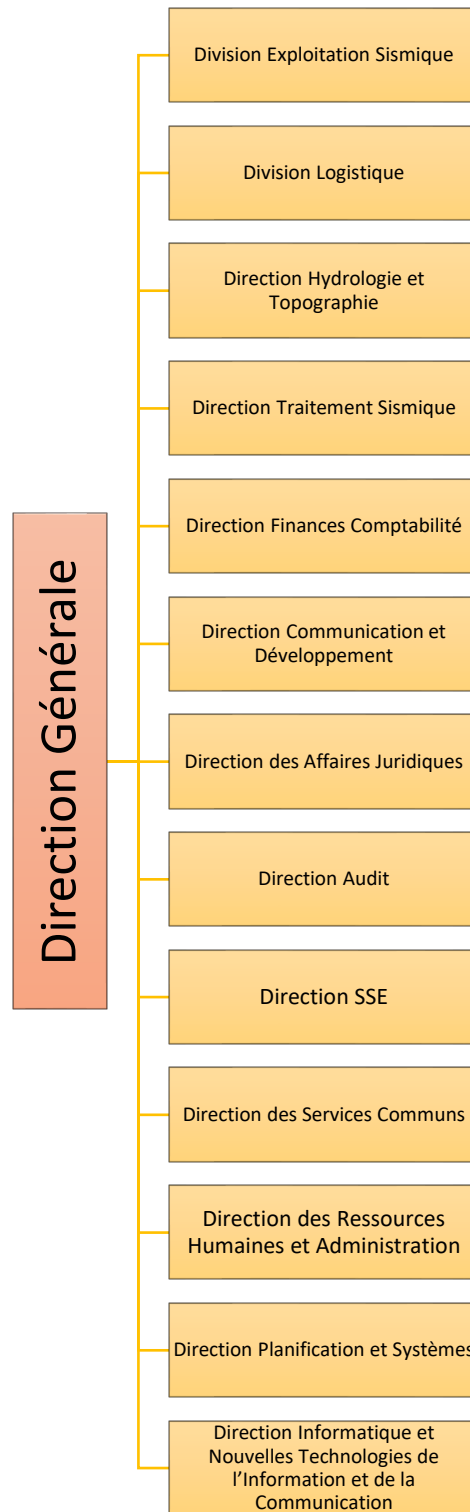
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Section2: Research Methodology

In this section, we will present the research process, which includes research purposes, methodologies, and data collection. The methodological choices are determined by the research problem and dissertation questions, as stated at the beginning of the dissertation. The purpose of this methodology section is to explain why the author's research approaches and thesis goals matter, which allows readers to assess the research's scope and limitations.

1-1-   Research Purpose:

Singh (2019) stated that the research purpose is a statement that clarifies why the investigation is being conducted or what the primary objective of the examination is[130]. The purpose of research may be to distinguish or describe an idea, explain or predict a situation, or propose a solution for a situation that demonstrates the type of focus to be directed[131]. (Hill, Campiglia, Beckingham and Brandes, 1974).

The purpose of this master dissertation is exploratory, delving into an area that has not been previously studied to uncover uncharted dimensions of the issue. Exploratory studies are particularly useful when the exact nature of a phenomenon is not well understood, aiming to establish a broad understanding of it rather than provide conclusive answers. They serve as preliminary research, laying the groundwork for more definitive studies in the future. With their adaptable nature, exploratory studies allow for shifts in direction as new insights are discovered. In line with this exploratory approach, this study employs a qualitative methodology, blending exploratory and descriptive methods. Initially, the dissertation seeks to gain a solid understanding of the benefits and limitations of blockchain in supply chain management. Through exploratory research, insights into this topic will be uncovered. Subsequently, adopting a descriptive approach, the study will focus on ENAGEO to examine the potential of integrating blockchain technology into their supply chain management. The primary goal is to gather useful knowledge for companies and individuals interested in the topic, emphasizing an exploratory approach to uncover new

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[130]*Singh, S., 2019. Purpose and Process of Research. Methodological Issues in Management Research: Advances, Challenges, and the Way Ahead, pp.27-36.*
[131]*Hill, R., Campiglia, H., Beckingham, P. and Brandes, B., 1974. ACT, achievement competence training. Philadelphia: Humanizing Learning Program, Research for Better Schools.*

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perspectives and insights. Additionally, recognizing the novelty of the topic in Algeria, this study aims to introduce and encourage businesses in the region to adopt blockchain technology.

1-2-   Research Method:

The author has the ability to choose based on their basic knowledge of what a qualitative or quantitative method is. Since the purpose of this dissertation is exploratory, the research methodology employed is qualitative. This qualitative approach will enable us to establish models and data categories based on our understanding and interpretations A quantitative method will not allow us to verify our hypotheses because the statistics in this sector in Algeria are very limited and recent, and as a result, blockchain technology is not yet adopted in Algerian business.

Qualitative research can be defined as "*the study of the nature of phenomena", containing "their quality, different manifestations, the context in which they appear or the perspectives from which they can be perceived*", yet not including "*their range, frequency and place in an objectively determined chain of cause and effect*" (Philipsen and Vernooy-Dassen, 2004)[132].

Qualitative research captures the opinions and viewpoints of study participants as they emerge from the real world. (Yin, 2016)[133].

Research guides recommend using qualitative research to learn why issues need to be addressed, analyze events, and describe activities. This method is suitable for the author to acquire sufficient knowledge and information to fulfill the aims of this paper.

Qualitative analysis takes the context into account and is based on the idea that contextual realities and individual experiences are varied. With such small numbers, we cannot analyze the context effectively. However, a qualitative method will help us understand and explorethe potential for adopting blockchain technology in Algerian business, especially for managing their supply chains. "*Exploration in management involves discovering or deepening our*

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[132]*Philipsen, H. and Vernooy-Dassen, M., 2004. Qualitative research: useful, indispensable and challenging. General practitioner and Science, 47 (10), pp. 288-292.*
[133]*Yin, R. K. (2016). Qualitative research from start to finish (2nd ed.). The Guilford Press.*

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understanding of a structure or a functioning system to serve two main goals: seeking explanation (and prediction) and seeking understanding" (Florence Allard-Poesi et al.2014)[134].

1-3-   Data Collection:

Data collection is a method that is systematic in gathering observations or measurements to address relevant challenges and generate results (Bhandari, 2021)[135]. In research, there are two types of data classification: primary and secondary data. The source of primary data is the source, while secondary data is information that has already been gathered by others and is available for use (Formplus Blog, 2021)[136].

In a qualitative case study, data can be collected in various ways by combining different sources and methods. This approach ensures that the phenomenon is examined through multiple lenses rather than a single perspective. Examples of data sources include interviews, documentation, direct observations, physical artifacts, and participant observations. However, collecting an overwhelming amount of data can be risky, as organizing and managing it may become too challenging (Baxter and Jack, 2008)[137].

The best way to collect data for this research is through interviews, as they help understand people's opinions on the matter and answer research questions. Semi-structured interviews are used as the primary data collection method in this study to obtain more comprehensive information from people about the potential of integrating blockchain technology in supply chain management in Algerian companies.

An interview is a discussion between two people that can generate a substantial amount of data, depending on the duration. Three kinds of interviews exist: structured, unstructured, and semi-structured. Structured interviews have the advantage of providing short answers, which simplifies the analysis process. Structured interviews allow for standardization and are particularly useful for large-scale research. An unstructured interview is like an open discussion on a particular topic,

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[134]*Florence Allard-Poesi, Jacques Angot, Philippe Baumard, Antoine Blanc, Manuel Cartier, Sandra Charreire,Barthélemy Chollet,Carole Donada , Carole Drucker-Godard,. Florence Durieux, and Sylvie Ehlinger, Dunod, Paris, 2014 5 rue Laromiguière, 75005 Paris www.dunod.comISBN 978-2-10-071109-3.*

[135]*Bhandari, P. (2021, July 7) An Introduction to Correlational Research. Scribbr. https://www.scribbr.com/methodology/correlational-research/*

[136]*Formplus Blog. (2020). Descriptive Research Designs: Types, Examples & Methods.*

[137]*Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers.* The Qualitative Report*, 13(4), 544-559.* *https://doi.org/10.46743/2160-3715/2008.1573*.

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where the researcher allows interviewees to present their own ideas. In semi-structured interviews, the questions have a clear set of topics that need to be addressed, but they can be adjusted based on the placement, phrasing, and structure [138].

The semi-structured interview method was selected because it enables the asking of clarifying questions, which are not permitted by other methods. The researcher can choose the themes for semi-structured interviews, but they can also ask new questions during the interview process (Hirsjärvi et al., 2004)[139]. Theme interviews allow for both open discussion and pre-planned research questions. Keeping the discussion on track is essential for the researcher if it starts to diverge from the intended themes.

Regarding the data collection, three software engineers specializing in logistics, procurement, and supply chain were interviewed because they possess in-depth knowledge of supply chain processes. The interviewees received the invitation face-to-face. Each interview was scheduled for one hour, but all lasted more than that. All the interviews were conducted face-to-face. To relieve the tension of formality, interviewees were occasionally asked about their position, and the discussion was kept informal, especially at the beginning of the interview.

➢ **Elaboration of the interview guide:**

Our interview guide (see appendix) contains 6 questions:

These questions are subdivided into 3 axes, each of which is related to a research hypothesis:

Axis 1: Employee Familiarity with Blockchain.

Axis 2: Current Pain Points in Supply Chain Management.

Axis 3: Organizational Readiness for Blockchain Integration.

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[138]Draper, A. & Swift, J.A. 2011, "Qualitative research in nutrition and dietetics: Data collection issues", Journal of human nutrition and dietetics, vol. 24, no. 1, pp. 3-12.
[139]Hirsjärvi, S., Remes, P. & Sajavaara, P. 2004, "No title", Tutki ja kirjoita.Helsinki: Tammi.

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Section 3: Data analysis and Results

This section will present the results obtained from our qualitative study. In the beginning, it will explain the method employed to generate results based on the interview content. Our next step will be to give a detailed explanation and analyses the results using the developed analysis grids.

1- Development of the interview guide:

The interview guide (see Appendix 1) is a valuable tool that enables us to exchange and progress our investigation. It includes the themes on which the sub-questions are based. By doing this, the responses become more targeted and precise, which further simplifies the analysis. The analysis requires comparing the content of the interviews. Our guide's themes were defined using our theoretical framework as inspiration. We identified 3 axes, which are as follows:

Axis 1: Employee Familiarity with Blockchain:

The aim of this axis is to evaluate the level of knowledge and comprehension that employees at the National Company of Geophysics (ENAGEO) have concerning blockchain technology. It focuses on their knowledge, perceptions, and insights regarding the potential integration of blockchain into supply chain management. This is a crucial first step in evaluating the feasibility and readiness for blockchain adoption within the company. The theme is explored through straightforward, semi-open questions to encourage detailed responses without constraining the interviewees. The questions aim to cover the following points:

- Understanding employees' basic knowledge of blockchain technology.
- Assessing their perceptions of the potential benefits of blockchain for supply chain management.
- Identifying perceived challenges and obstacles to blockchain adoption.
- Exploring their insights into how blockchain might transform current supply chain processes.

Axis 2: Current Pain Points in Supply Chain Management:

The purpose of this axis is to identify the major challenges and inefficiencies that are facing the current supply chain management processes at the National Company of Geophysics (ENAGEO). Evaluating how blockchain technology might offer solutions requires understanding these pain

points. By focusing on specific issues, we can better assess the potential impact of blockchain on improving supply chain operations. The theme is explored by asking simple, semi-open questions to encourage detailed responses without restricting the interviewees. The questions aim to cover the following points:

- Identifying the key challenges and inefficiencies in the existing supply chain processes.
- Understanding the specific areas where improvements are needed.
- Gathering insights on how blockchain technology could address these issues.
- Exploring employees' perspectives on the practical benefits of blockchain in solving current problems.

Axis 3: Organizational Readiness for Blockchain Integration:

The objective of this axis is to assess the readiness of the National Company of Geophysics (ENAGEO) to incorporate blockchain technology into its supply chain management. It aims to assess the internal factors that could influence the successful adoption of blockchain, such as leadership support, organizational culture, and technological infrastructure. Identifying potential facilitators and barriers to blockchain implementation is possible by understanding these factors and determining the necessary steps to prepare the organization for this technological shift. The theme is explored through straightforward, semi-open questions to encourage detailed responses and facilitate a comprehensive analysis.

- Assessing the level of support from the leadership team for blockchain integration.
- Determining if the organization's culture encourages innovation and technological advancements.
- Evaluating the current state of technological infrastructure and its readiness to incorporate blockchain.

2- Presentation of Findings:

This part comprises the presenting of the findings resulting from this study. Data is presented in one stage, based on the results of the semi-structured interviews, with a qualitative approach.

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➢ **Axis 1: Employee Familiarity with Blockchain:**

Question 1: How would you describe your understanding of blockchain technology and its potential applications in supply chain management?

1) Mr. X, software engineer (2D) at ENAGEO Hassi Messoud, responsible for maintaining and developing logistics applications, including inventory management, asset management, CMMS, and procurement systems:

   - *"Blockchain securely records transactions for the supply chain, and improves traceability".*

2) Mr. Y, software engineer at ENAGEO Hassi Messoud (3D), responsible for maintaining and developing logistics applications, including inventory management, asset management, CMMS, and procurement systems:

- *"In our enterprise applications, cryptographic technology is frequently employed in the authentication layer using tokens, such as JSON Web Tokens (JWT)".*

3) Mr. Z, Project Manager with expertise in IT and experience in conducting project management, works at ENAGEO Boumerdes, and has been on a mission in Hassi Messaoud:

- *"Enterprise systems often utilize cryptographic methods for their authentication layer, commonly incorporating tokens like Tokens (JWT)".*

Question 2: In your opinion, what are the potential benefits and challenges of integrating blockchain technology into our supply chain management processes?

1) Mr. X:

- *"Blockchain improves traceability and reduces supply chain fraud, but its integration can be costly and complex, requiring staff training".*

2) Mr. Y:

- *"Implementing blockchain can enhance our company by providing robust control over the supply cycle, saving time, ensuring accurate production control, minimizing costs, improving demand forecasting, fostering collaboration, boosting project performance, and enhancing reputation and*

customer satisfaction. For challenges we *have integration complexity, high initial costs, scalability issues, ensuring data privacy, and potential resistance from stakeholders and partners*."

3) Mr. Z:

- *"Implementing blockchain technology could significantly enhance our company by providing robust control over the supply cycle and saving time through increased efficiency. It ensures accurate production control, minimizes business costs, and maintains a secure stock to reserve production capacity. Additionally, blockchain can improve demand forecasting, foster collaboration and trust among different partners, and enhance project performance in terms of cost, quality, and deadlines. Ultimately, this leads to a better company reputation and higher customer satisfaction."*

> ➢ **Axis 2: Current Pain Points in Supply Chain Management:**

Question 3: What are the primary challenges or inefficiencies you encounter in your current supply chain management processes?

1) Mr. X:

- *"The main challenges are lack of traceability, human error, late delivery and inefficient inventory management"*.

2) Mr. Y:

- *"The lengthy contract negotiation process with various suppliers, lack of traceability."*

3) Mr. Z:

- *"In our supply chain, we face challenges such as the slow contract process with different suppliers, the risk of unsuccessful tenders, and underestimated forecasts."*

Question 4: How do you think blockchain technology could potentially address or improve these challenges?

1) Mr. X:
-   *"Blockchain could improve traceability, reduce human error, speed up deliveries and optimize inventory management with transparent and secure data"*.

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2) Mr. Y:

- *"Blockchain technology could improve the time of contracts by automating and streamlining contract processes through smart contracts. It also offers better traceability of operations within the supply chain by providing a transparent and immutable ledger, ensuring all transactions are accurately recorded."*

3) Mr. Z:

- *"Blockchain could: - Improve the time of contracts (purchases, services, services, etc.)*
- *Better traceability of the various operations that enter the supply chain*
- *Securing the procurement process (no disclosure of information about published offers to suppliers)."*

➢ **Axis 3: Organizational Readiness for Blockchain Integration:**

Question 5: From your perspective, what factors within your organization (e.g., leadership support, culture, technological infrastructure) might facilitate or hinder the successful integration of blockchain technology into our supply chain management?

1) Mr. X:

- *"Factors facilitating integration are management support and a culture open to innovation. Barriers may include outdated technology infrastructure and resistance to change among staff".*

2) Mr. Y:

- *"Our internally developed ERP, managing procurement, inventory, and investment, could be significantly enhanced by blockchain technology. It would improve our modern infrastructure, including LAN and satellite networks, and aid our remote data acquisition equipment, such as geophones and IoT devices. Furthermore, as we implement RFID technology to identify and track assets, blockchain could offer a secure and unchangeable record of all asset-related activities, ensuring greater accuracy and security."*

3) Mr. Z:

- *"Existence of an internally developed and deployed ERP that covers procurement management, inventory management and investment management (goods and equipment)*

- *Modern infrastructure (LAN and satellite networks to construction sites and data centers);*

- Modern remote data acquisition equipment (geophones, IOT technology, processing lab).

A project to acquire and integrate equipment using RFID technology is underway to identify and locate all the company's assets".

Question 6: What steps or resources do you believe would be necessary to prepare our organization for the adoption of blockchain technology in our supply chain management practices?

1) Mr. X:

- *"Investment in staff training, updating technology infrastructure, management support and partnerships with blockchain experts".*

2) Mr. Y:

- *"Modeling all supply chain-related business processes, and obtaining sponsorship for this adaptation project from General Management."*

3) Mr. Z:

- *"Necessary steps:*

- *- Modeling of all business processes related to the supply chain with BPMN2*

- *- Registration of a project to adapt ERP functionalities in order to integrate Blockchain technology*

- *- Sponsorship of the adaptation project by General Management."*

3- Interpretation of findings:

This section provides an analysis of the data gathered from the interviews. The findings are organized into three axes: Employee Familiarity with Blockchain, Current Pain Points in Supply Chain Management, and Organizational Readiness for Blockchain Integration. Each axis offers insights into the respondents' knowledge, perceived challenges, and the potential for blockchain technology to enhance ENAGEO's supply chain processes.

➢ **Axis 1: Employee Familiarity with Blockchain:**

Our sample at ENAGEO has varying levels of familiarity with blockchain technology. While all recognize its potential for improving traceability and securing transactions, the understanding ranges from general applications to specific cryptographic methods used in current systems. The perceived benefits are consistent, focusing on efficiency, control, and

collaboration, but challenges such as integration complexity, costs, and training needs are also acknowledged.

> **Axis 2: Current Pain Points in Supply Chain Management:**

The primary challenges in ENAGEO's supply chain management include traceability issues, inefficiencies in contract processes, human error, and inaccurate forecasts. Blockchain is seen as a solution to these problems by improving traceability, automating contract processes, reducing human error, and securing data. The consistent recognition of blockchain's potential across different respondents indicates a strong alignment between current pain points and blockchain capabilities.

> **Axis 3: Organizational Readiness for Blockchain Integration:**

ENAGEO exhibits several factors that can facilitate the successful integration of blockchain technology, including management support, an innovative culture, and modern infrastructure. However, barriers such as outdated technology and resistance to change must be addressed. Preparing for blockchain integration will require comprehensive steps, including process modeling, ERP adaptation, staff training, and securing leadership support. The organization's existing technological initiatives, such as RFID integration, provide a strong foundation for adopting blockchain.

Conclusion:

In conclusion, the research methodology outlined in this section effectively supports the exploratory nature of this study, aiming to uncover the potential of blockchain technology in supply chain management, particularly within the context of the National Company of Geophysics (ENAGEO). The primary research goal is to generate new insights and lay the groundwork for future studies on blockchain's impact on supply chains in Algeria.

The choice of a qualitative research approach aligns well with the exploratory purpose, given the nascent state of blockchain adoption in the region. This methodology allows for an in-depth understanding of complex phenomena, such as employee familiarity with blockchain, current supply chain pain points, and organizational readiness for technological integration. Through semi-

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structured interviews with key employees, the study captures a range of perspectives and detailed insights that are crucial for a comprehensive analysis.

The data collection process, primarily based on semi-structured interviews, provides a rich dataset, offering nuanced views and detailed responses that quantitative methods might overlook. The structured yet flexible nature of these interviews ensures that while key themes are consistently explored, there is room for participants to express their unique insights and experiences.

A more critical examination of blockchain's limitations and the specific conditions under which it can effectively benefit ENAGEO is essential. Not all blockchain solutions may be applicable in this case study's context, and distinguishing these nuances is crucial. For instance, while blockchain has the potential to improve traceability and reduce fraud, its integration may be costly and complex, requiring significant investment in staff training and technological infrastructure. Additionally, potential resistance from stakeholders and scalability issues must be carefully considered.

Overall, this methodology section underscores the importance of qualitative research in understanding and exploring the potential adoption of blockchain technology in supply chains. It sets a solid foundation for the subsequent analysis and findings, ensuring that the research objectives are met through systematic and thorough investigation. This approach not only addresses the research questions effectively but also highlights the broader implications for businesses in Algeria considering blockchain integration.

General Conclusion

General Conclusion:

In this research, we explored the potential benefits and challenges of integrating blockchain technology into supply chain management (SCM), focusing on the National Company of Geophysics (ENAGEO). The competitive environment has created numerous challenges for companies, requiring effective supply chain management to reduce costs and improve economic performance. Modern supply chains demand updated techniques to handle emerging issues like complexity, transparency, and flexibility.

Our literature review provided a detailed examination of SCM and blockchain technology. Our exploration of blockchain's potential for SCM was focused on improving data management, securing shared information, and fostering collaboration among stakeholders. These capabilities are particularly relevant to addressing the persistent issues of transparency, traceability, and efficiency in supply chains.

To carry out this research, we adopted a qualitative approach, utilizing semi-structured interviews with ENAGEO employees. According to our findings, those who were more familiar with blockchain technology perceived greater potential benefits for its integration into supply chain management. Additionally, our research identified specific pain points in ENAGEO's current supply chain processes, confirming the second hypothesis that blockchain technology could effectively address these issues.

According to the study, supportive leadership, innovation culture, and robust technological infrastructure are necessary for successful integration of blockchain technology. Our third hypothesis is supported by this, suggesting that organizations with these characteristics are more ready to adopt blockchain.

Although there are obvious benefits, the research highlighted the obstacles to adopting blockchain, such as its current immaturity, costs, functionality issues, and privacy and data ownership concerns. Addressing these challenges is crucial for realizing the full potential of blockchain in SCM.

To sum up, this study affirms the strategic value of integrating blockchain technology to improve transparency, efficiency, and teamwork in supply chains. The study provides valuable insight on how blockchain can transform supply chain operations, and it provides guidance for

General Conclusion

companies like ENAGEO to improve performance and maintain competitiveness. Future research has the potential to examine the practical differences between different blockchain forms and their specific SCM applications.

However, this research is not without limitations. The study is based on a qualitative approach and focuses on a single company, which may not be generalizable. The rapid development of blockchain technology can lead to outdated findings. The absence of a quantitative component makes it difficult to measure the impact of blockchain integration on specific performance metrics.

Future research could address these limitations by incorporating a mixed-methods approach, combining qualitative and quantitative data to provide a more comprehensive analysis. Additionally, studies could explore the practical differences between various blockchain forms, such as public, private, and consortium blockchains, and their specific applications in SCM. Detailed case studies and pilot projects within different industries and company sizes could provide deeper insights into the challenges and benefits of blockchain integration.

It is crucial to examine the long-term impacts of blockchain technology on supply chain performance and explore strategies for overcoming identified challenges. Research can look into the role that regulatory frameworks and standards play in facilitating or hindering blockchain adoption in supply chains.

In conclusion, this dissertation emphasizes the strategic importance of adopting blockchain technology to enhance transparency, efficiency, and collaboration in supply chains. By providing valuable insights into how blockchain can transform supply chain operations, the study offers guidance for Algerian companies to improve performance and maintain competitiveness. Future research will be crucial in gaining a better understanding and making use of blockchain technology to meet the evolving needs of modern supply chains.

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Appendices:

Interview Guide:

Axis 1: Employee Familiarity with Blockchain

Question 1: How would you describe your understanding of blockchain technology and its potential applications in supply chain management?

Question 2: In your opinion, what are the potential benefits and challenges of integrating blockchain technology into your supply chain management processes?

Axis 2: Current Pain Points in Supply Chain Management

Question 3: What are the primary challenges or inefficiencies you encounter in your current supply chain management processes?

Question 4: How do you think blockchain technology could potentially address or improve these challenges?

Axis 3: Organizational Readiness for Blockchain Integration

Question 5: From your perspective, what factors within your organization (e.g., leadership support, culture, technological infrastructure) might facilitate or hinder the successful integration of blockchain technology into our supply chain management?

Question 6: What steps or resources do you believe would be necessary to prepare your organization for the adoption of blockchain technology in your supply chain management practices?

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