



# Blockchain-Based Medication Traceability: Impact on Consumer Trust

Pedram Jamali

Dissertation written under the supervision Peter V.  
Rajsingh Ph.D.

Dissertation submitted in partial fulfilment of requirements for the  
MSc in International Management, at the Universidade Católica  
Portuguesa, 3<sup>rd</sup> January 2024

## Abstract

This Master's aims to investigate whether the implementation of blockchain technology in the pharmaceutical supply chain has an impact on consumer trust.

The recommendations of doctors or pharmacists have a major influence on consumer trust. However, these can be biased to their own advantage. Consumers do not have direct contact with pharmaceutical companies. Research suggests that key future trends for consumers are transparency and sustainability. However, consumers perceive pharmaceutical companies as being the opposite of sustainable and transparent. This has a negative impact on the customer-company relationship and trust.

Results of this research show the positive impact of blockchain traceability on consumer trust when purchasing medicines. Also, implementation of a blockchain traceability platform could empower consumers and create a commitment from pharmaceutical companies to have the same interests. It can also be seen that consumers feel less trust when purchasing their medicines in developing countries. This is partly due to the spread of counterfeit drugs. The transparency and security of the blockchain can ensure greater trust in the purchase of medicines in developing countries. However, challenges were also identified for the implementation. A large proportion of pharmaceutical end customers are older people. For them, the main challenge is technological acceptance.

**Keywords:** Blockchain, Traceability, Pharmaceutical supply chains, Consumer trust, Technology Acceptance

**Title:** Blockchain-Based Medication Traceability: Impact on Consumer Trust

**Author:** Pedram Jamali

## Sumário

Este mestrado tem como objetivo investigar se a implementação da tecnologia blockchain na cadeia de abastecimento farmacêutica tem impacto na confiança dos consumidores.

As recomendações de médicos ou farmacêuticos têm uma grande influência na confiança do consumidor. No entanto, estes podem ser tendenciosos em seu próprio benefício. Os consumidores não têm contacto direto com as empresas farmacêuticas. A investigação sugere que as principais tendências futuras para os consumidores são a transparência e a sustentabilidade. No entanto, os consumidores consideram que as empresas farmacêuticas são o oposto de sustentáveis e transparentes. Este facto tem um impacto negativo na relação cliente-empresa e na confiança.

Os resultados desta investigação mostram o impacto positivo da rastreabilidade da cadeia de blocos na confiança dos consumidores aquando da compra de medicamentos. Além disso, a implementação de uma plataforma de rastreabilidade da cadeia de blocos poderia capacitar os consumidores e criar um compromisso das empresas farmacêuticas no sentido de terem os mesmos interesses. Também se pode constatar que os consumidores sentem menos confiança quando compram os seus medicamentos nos países em desenvolvimento. Isto deve-se em parte à disseminação de medicamentos contrafeitos. A transparência e a segurança da cadeia de blocos podem garantir uma maior confiança na compra de medicamentos nos países em desenvolvimento. No entanto, também foram identificados desafios para a implementação. Uma grande parte dos clientes finais de produtos farmacêuticos são pessoas idosas. Para eles, o principal desafio é a aceitação tecnológica.

**Palavras-chave:** Cadeia de blocos, Rastreabilidade, Cadeias de abastecimento farmacêutico, Confiança do consumidor, Aceitação da tecnologia

**Título:** Rastreabilidade de medicamentos baseada em blockchain: Impacto na confiança dos consumidores

**Autor:** Pedram Jamali

## Acknowledgements

Finalizing my dissertation at Universidade Católica marks the end of an important chapter in my academic career. I am deeply grateful to the university for expanding my knowledge, mastering academic challenges, and having the opportunity to meet many international fellow students.

I would especially like to emphasize the cooperation with Peter V. Rajsingh Ph.D. His continuous commitment, support, and valuable inputs were of significant value in achieving this dissertation. He showed me how important it is to work scientifically and to communicate the results.

I would also like to thank all the experts who agreed to sacrifice their time to add value to this dissertation. I would also like to thank all those who were willing to complete the survey. Their contributions have added to the quality and depth of this dissertation.

Special thanks also go to my parents, my sister, my cousin, and my friends. Their mental support during my dissertation and my studies were a great enrichment.

## Table of Contents

|   |      |
|---|------|
| Abstract .....  | II   |
| Sumário .....   | III  |
| Acknowledgements .....                                  | IV   |
| List of Figures .....                                   | VII  |
| List of Tables.....                                     | VIII |
| List of Abbreviations.....                              | IX   |
| 1. Introduction .....                                   | 1    |
| 1.1 Relevance.....                                      | 1    |
| 1.2 Problem.....  | 1    |
| 1.3 Structure of the Thesis.....                        | 2    |
| 2. Literature Review.....                               | 2    |
| 2.1 Blockchain Technology.....                          | 2    |
| 2.2 Supply Chains of Pharmaceutical Industries .....    | 7    |
| 2.3 Drug Traceability.....                              | 9    |
| 2.4 Customer Experience in Pharma .....                 | 10   |
| 2.5 Management Theory.....                              | 11   |
| 3. Methodology .....                                    | 13   |
| 4 Survey.....   | 14   |
| 4.1 Data Collection .....                               | 14   |
| 4.2 Procedure of Survey .....                           | 14   |
| 4.3 Analysis of Survey.....                             | 15   |
| 5. Expert Interviews .....                              | 23   |
| 5.1 Data Collection .....                               | 23   |
| 5.2 Procedure of Expert Interviews .....                | 24   |
| 5.3 Analysis of Expert Interviews .....                 | 26   |
| 6. Discussion .....                                     | 30   |
| 6.1 Sustainability and transparency .....               | 30   |
| 6.2 Consumer-Pharmaceutical Industry Relationship ..... | 31   |
| 6.3 Impact of Counterfeit Drugs.....                    | 32   |
| 6.4 Technological Acceptance and Utility .....          | 33   |
| 7. Limitations .....                                    | 33   |
| 8. Recommendations for Future Research .....            | 34   |

|  |        |
|--|--------|
| 9. Conclusion.....                               | 35     |
| 10. Bibliography.....                            | 37     |
| 11. Appendices.....                              | X      |
| 11.1 Appendix A: Figures and tables .....        | X      |
| 11.2 Appendix B: Survey Overview.....            | XIII   |
| 11.3 Appendix C: Expert Interview Questions..... | XX     |
| 11.4 Appendix D: Summary Expert 1 .....          | XXI    |
| 11.5 Appendix E: Summary Expert 2.....           | XXIII  |
| 11.6 Appendix F: Summary Expert 3 .....          | XXVI   |
| 11.7 Appendix G: Summary Expert 4 .....          | XXVIII |
| 11.8 Appendix H: Summary Expert 5 .....          | XXX    |
| 11.9 Appendix I: Summary Expert 6.....           | XXXIII |

## List of Figures

|  |     |
|--|-----|
| Figure 1 Architecture of Blockchain.....                             | 4   |
| Figure 2: Characteristics of Blockchain Technology.....              | 7   |
| Figure 3 Simplification of Pharma Supply Chain.....                  | 8   |
| Figure 4 Technology Acceptance Model.....                            | 12  |
| Figure 5: Importance of Transparency in Medication Purchase.....     | 16  |
| Figure 6: Age Distribution.....                                      | 17  |
| Figure 7: Trust Change Analysis (Percentage).....                    | 18  |
| Figure 8: Counterfeit Medicine Problem for Developing Countries..... | 19  |
| Figure 9: Counterfeit Medicine Problem for Developed Countries.....  | 19  |
| Figure 10: Regression Analysis (with P-value).....                   | 20  |
| Figure 11: Correlation Test.....                                     | 22  |
| Figure 12: Importance of Sustainability in Medication Purchase.....  | X   |
| Figure 13: Trust in Medicine with or without QR Code.....            | X   |
| Figure 14: Gender Distribution.....                                  | XI  |
| Figure 15: Trust with QR Code by Age.....                            | XI  |
| Figure 16: Trust without QR Code by Age.....                         | XI  |
| Figure 17: Usability Beliefs on QR Code Feature by Age.....          | XII |
| Figure 18: Education Distribution.....                               | XII |
| Figure 19: Salary Distribution.....                                  | XII |

## List of Tables

|   |    |
|---|----|
| Table 1 Overview of Advantages and Disadvantages of Consensus Protocols ..... | 5  |
| Table 2: Overview of Blockchain Types and their Characteristics.....          | 6  |
| Table 3: List of Expert Interviews.....                                       | 26 |

## List of Abbreviations

|     |   |                                  |
|-----|---|----------------------------------|
| OEM | - | Original Equipment Manufacturers |
| DLT | - | Distributed Ledger Technology    |
| PoW | - | Proof-of-Work                    |
| PoS | - | Proof-of-Stake                   |
| PSC | - | Pharmaceutical Supply Chain      |
| IoT | - | Internet of Things               |
| AI  | - | Artificial Intelligence          |
| QR  | - | Quick Response                   |
| FDA | - | Food and Drug Administration     |
| EMA | - | European Medication Agency       |
| TAM | - | Technology Acceptance Model      |
| SET | - | Social exchange theory           |

# 1. Introduction

## 1.1 Relevance

The pharmaceutical industry faces continuous challenges regarding supply chains and obstacles that can have negative impacts on drug delivery. There are numerous regulations that determine the conditions under which medications are produced, delivered, stored, and transported (Singh et al., 2016). For example, pharmaceutical companies are subjected to risk control by the Food and Drug Administration (FDA) regulations (Marucheka et al., 2011). Pharmaceutical companies must align their supply chains with sustainability principles, and in this context, transparency and traceability of their product manufacturing become especially relevant (Bravo & Carvalho, 2015). Various trends have emerged for the future. To truly realize these for positive customer experiences and a well-functioning supply chain, it is of importance that pharma companies leverage digital technologies. This research focuses on blockchain technology and the impact of it on consumer trust. Digital technologies can be used to better manage data and provide higher transparency, where blockchain technology could offer added value to pharma by allowing secure storage of critical data on the blockchain (Francisco & Swanson, 2018). These technologies do not only provide an advantage to the pharmaceutical industry but also benefit end consumers. Furthermore, there is an increasing amount of research focused on integrating blockchain technology into the healthcare sector (Zakari et al., 2022).

## 1.2 Problem

Global supply chains of OEMs (original equipment manufacturers) in the pharmaceutical industry are characterized by high complexity. This is because pharmaceutical manufacturers, distributors, hospitals, retail pharmacies, logistics service providers, consumers, health insurers, and regulatory authorities are all involved in the supply chain (Chen et al., 2023). In addition to the exchange of materials and monetary transactions, there is a substantial exchange of data within the supply chain between suppliers and OEMs. Many OEMs have articulated the goal of producing and transporting goods in a more sustainable manner, as often noted in their reports. Studies also have shown that is also relevant for consumers to know the origins of products (Sanyal & Datta, 2011). However, achieving this and meeting consumer expectations is only possible if supply chains become more transparent. For companies, there could be numerous advantages, if important data is stored on a decentralized and immutable blockchain (Yiu, 2021). There are several challenges with this strategy, including one which is integrating blockchain technology into the present digital infrastructure of the companies. It is important

to figure out the potential advantages of using blockchain technology as well as how its features may positively impact customers' trust.

Blockchain technology is already being utilized in various industries like the Agri-food industry to store supply chain data and transactions (Park & Li, 2021). If pharmaceutical companies choose to share the history of product manufacturing with end consumers, this might create an additional layer of transparency while also posing certain challenges. In this research, we investigate the impact of blockchain in the pharmaceutical industry on consumer trust.

The goal is to answer the following research question: Does the implementation of blockchain enhance consumer trust for pharmaceutical products?

### 1.3 Structure of the Thesis

To answer this research question, we will begin by examining the existing literature, starting with an exploration of blockchain technology. Next, we will delve into the structure of the pharmaceutical industry's supply chain and the significance of sustainability and transparency within the industry.

The study design, as well as the techniques used for data collecting and analysis in a survey, will next be explained in the methodology chapter. Furthermore, expert interviews will be conducted, and the data from these interviews will be analyzed. The results chapter will document the findings from the survey, literature, and expert interviews. The study will involve questioning consumers on their existing level of consumer trust and assessing the potential beneficial impact of blockchain technology and transparency on consumer trust.

The major results, which make up the opportunities and challenges, will then be addressed in the discussion chapter. Furthermore, the limitations of this study will be discussed, along with recommendations for the future. As a final step in the investigation, the conclusion will highlight the key findings and answer the research question.

## 2. Literature Review

### 2.1 Blockchain Technology

This subchapter addresses blockchain technology. It shows the functionalities and types of blockchains. Another important aspect of this subchapter are the consensus protocols of this technology. It is important to understand blockchain technology to answer the research question.

## Functionalities of Blockchain

Blockchain is a decentralized database using distributed ledger technology (DLT) that assures users that archived information, such as certificates, remains unaltered and therefore trustworthy (Omar et al., 2021). DLT is a decentralized network, that can be used in one network. The total of all generated transactions is called ledgers and are stored decentral using blockchain technology (Sumathi et al., 2021).

With blockchain, transactions can be stored on decentralized blocks that are connected to each other and form a chain. The transactions are time-stamped and signed. In addition, transactions are cryptographically encrypted (Laurence, 2019). It is only under some circumstances possible to change information of the blocks when they are connected. By using blockchain the transaction is from one user to another user. Every participant with node of the blockchain network has a copy of the shared ledger.

Figure 1 shows a simplified representation of the blockchain architecture. This shows that all blocks are linked to each other and form a chain of transactions. All blocks contain the hash value of the previous block, which also contains the data of the transactions. The data is distributed across and managed by many different nodes, forming a decentralized system. Nodes are computers that verify transactions and maintain the blockchain (Ghag & Chitre, 2019). A hash value ensures the integrity of the blockchain. It is converted from data into an immutable hash value using a one-way hash function. If an attacker changes any information on past blocks, there is a change in the hash value and an inconsistency of the blockchain occurs. An attacker would have to change all hash values from a manipulated block to the most recent one for the blockchain participants to be unsecure, which is much more difficult to do at the same simultaneously (Dib et al., 2018).

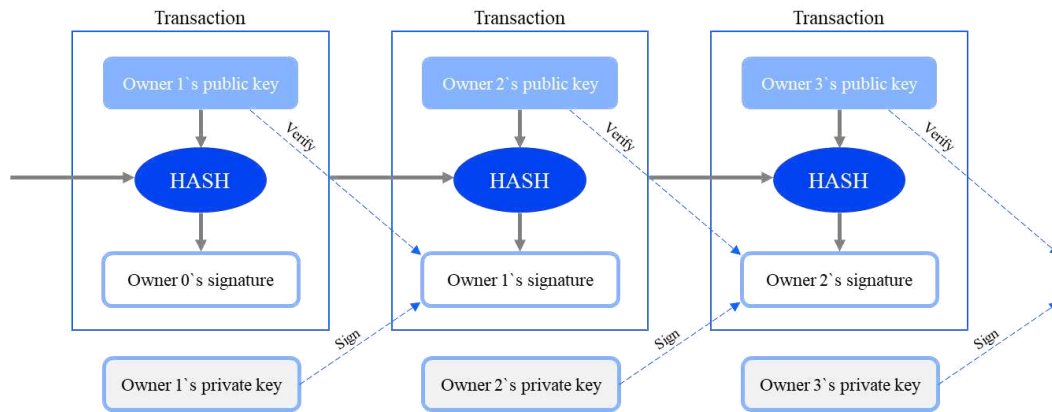


Figure 1 Architecture of Blockchain (Sumathi et al., 2021)

## Consensus Protocols

As mentioned in the previous section, transactions using blockchain work without an intermediary. Various consensus protocols can be used to validate transactions. The legitimacy of a transaction should be verified using a consensus protocol. In this subchapter, the Proof-of-Work (PoW) and Proof-of-Stake (PoS) methods are analyzed in more detail since these are the most common consensus protocols.

The **Proof-of-Work (PoW)** consensus protocol is considered the most common consensus protocol in currently operating blockchains and was used by Satoshi Nakamoto in 2009 to create the cryptocurrency Bitcoin (Gervais et al., 2016). The basic principle of PoW is that various tasks must be solved to successfully add transactions or blocks to the blockchain. In public blockchains, miners add blocks with their computing power and receive rewards for doing so, which vary depending on the blockchain protocol (Dib et al., 2018). As described in the previous chapter, this requires a cryptographic task to be solved. A lot of computing power is required to solve the task. On the other hand, it is possible to verify the correct solution very quickly. Only miners who have the entire transaction history of the blockchain used may participate in a PoW blockchain. The problem with the PoW concept is the amount of energy required to calculate the tasks. The miners compete to solve the task as quickly as possible and to be rewarded. Miners who are not the first to solve the task are not rewarded and have only consumed energy (Dib et al., 2018).

Another consensus protocol is **Proof-of-Stake (PoS)**. This method was introduced in 2012 to solve the problem of high energy consumption of PoW. Stake-based leader selection in PoS reduces energy consumption compared to PoW because it does not rely on computing power. It also enables faster block generation and transaction confirmation, making PoS increasingly

popular (Nguyen et al., 2019). In a blockchain PoS network, participants stake their digital assets to verify new blocks. If they try to cheat, they risk losing their entire stake. Although PoS is energy efficient in comparison with PoW, it is not resilient to attacks (Lashkari & Musilek, 2021). Table 1 shows an overview of the advantages and disadvantages of both consensus protocols.

| <b>Consensus Protocols</b> | <b>Advantage</b>  | <b>Disadvantages</b>   |
|----------------------------|---|--|
| Proof-of-Work              | <ul style="list-style-type: none"> <li>• Safe and stable, high degree of freedom of nodes</li> <li>• High degree of decentralization, open node system</li> </ul> | <ul style="list-style-type: none"> <li>• Weak scalability and low performance</li> <li>• Causing hardware equipment waste</li> </ul> |
| Proof-of-Stake             | <ul style="list-style-type: none"> <li>• Less energy</li> <li>• High degree of decentralization, open node system</li> </ul>                                      | <ul style="list-style-type: none"> <li>• Complex implementation process</li> <li>• Security breach</li> </ul>                        |

*Table 1 Overview of Advantages and Disadvantages of Consensus Protocols (Wang, et al., 2020)*

### Types of Blockchain

There are different types of blockchains, that can be implemented and used. Those blockchain types can be used in different scenarios and have not the same characteristics.

**Public blockchain** is a decentralized database to which no institution belongs. Participation in transactions is open to everybody, and the network is public. Bitcoin is a cryptocurrency and members blockchain that allows nodes to conduct transactions using the currency. Anonymous nodes and direct transactions in permissionless public blockchain networks enable fast and low-cost transactions between anonymous parties (Yaga et al., 2018). However, a major problem with public blockchains is that it is difficult to monitor users when they add information. For example, if someone uploads sensitive or incorrect data to the system, this action cannot be reversed. One advantage is that transactions can be validated and verified without the need for a trusted entity (Yang et al., 2020).

**Private blockchain** is a blockchain network with technical access restrictions. Compared to a public blockchain, a blockchain that is private has a central authority that has access-granting authority. This type of blockchain is typically used by businesses. They are exclusively

accessible to a consortium or a group of individuals who have agreed to share the ledger among themselves (Bashir, 2017). A large portion of private blockchains use PoS, which results in a lower energy requirement than with a public blockchain.

**Consortium blockchain** is applied in practice as a hybrid solution. This blockchain has a hybrid architecture and, as shown in Table 2, features characteristics of both public and private blockchains. Participation in this network is limited to a consortium of participating members (Yao et al., 2023). The database is managed by a consortium rather than a single central database. All members of the consortium who could provide access rights to the blockchain are eligible to join. A consortium blockchain is an enterprise-level ledger that does not have the challenges of developing a resource-efficient global consensus protocol as public blockchains do (Yao et al., 2023).

| Property                 | Blockchain Governance  |  |  |
|--------------------------|--|--|--|
|                          | Public   | Consortium   | Private                                |
| Governance Type          | Consensus is public  | Consensus is managed by a set of participant   | Consensus is managed by a single owner |
| Transactions Validation  | Any node (or miner)  | A list of authorized nodes (or validators)   |  |
| Consensus Algorithm      | Without permission   | With permission  |  |
| Data Immutability        | Yes, blockchain rollback is almost impossible  | Yes, but blockchain rollback is possible   |  |
| Network scalability      | High   | Low to medium (a few dozen/hundred of nodes)   |  |
| Infrastructure           | Highly-Decentralized   | Decentralized  | Distirbuted                            |
| Features                 | <ul style="list-style-type: none"> <li>• Unregulated and cross-borders</li> <li>• Anonymous identities</li> <li>• Scalable network architecture</li> </ul> | <ul style="list-style-type: none"> <li>• Applicable to highly regulated business (known identities, etc.)</li> <li>• Efficient transactions throughput</li> <li>• Better protection against external disturbances</li> </ul> |  |
| Examples of technologies | Bitcoin, Ethereum, Ripple, etc.  | HyperLedger, Ethemint, Tendermint, etc.  |  |

Table 2: Overview of Blockchain Types and their Characteristics (Dib et al., 2018)

Characteristics of Blockchains

Blockchain technology is a constantly growing technology. Nevertheless, there are certain features that define its characteristics. These characteristics are described in more detail in the following section.

**Trust** is strongly influenced by transparency, integrity of data and immutability, which is illustrated in Figure 3. Since information stored on blocks is cryptographically protected, data can be stored securely on the blockchain. The blockchain network routinely checks in with itself

every ten minutes to self-audit the ecosystem of a digital value, which reconciles transactions that happen in ten-minute intervals (Joshi et al., 2018).

Transactions on blockchain ledger are completely transparent where anyone can see the details and history of any transaction. This level of transparency is unique in blockchain technology and provides a high level of accountability and integrity to the information, ensuring that nothing is unduly altered, deceitfully added, or removed (Bhutta et al., 2021). Blockchain ensures trust through transparency, data integrity and immutability by means of a decentralized structure that prevents manipulation or failures (Seebacher & Schüritz, 2017).

Another characteristic that has already been explained in the previous chapters is the **decentralized database**. Decentralization is the dispersion of functions and controls from a central authority to all the units involved. In blockchain, a centralized authority is not available (Joshi et al., 2018).

Blockchain relies on trust mechanisms (e.g., data integrity and transparency) for a decentralized network that enables secure transactions without a trusted third party. User participation in decentralization establishes consensus, eliminating the need for a trusted third party (Seebacher & Schüritz, 2017).

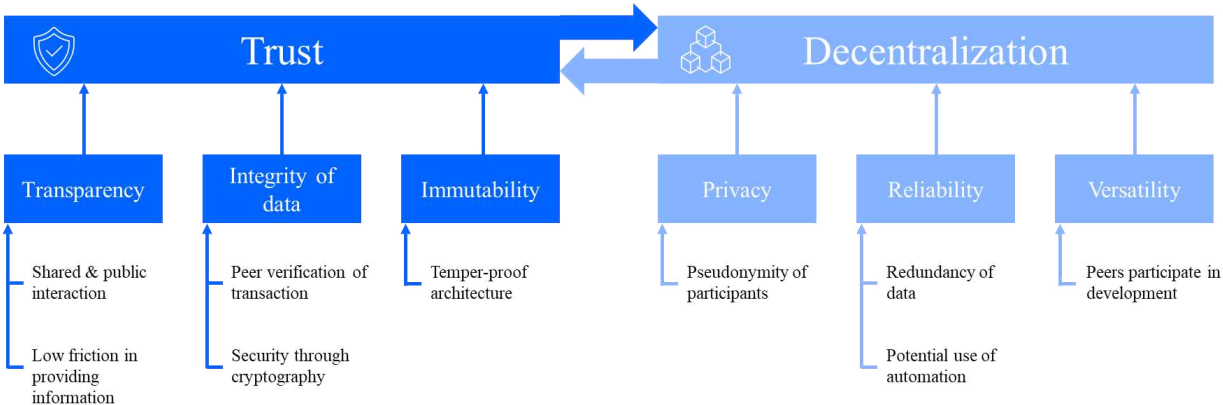


Figure 2: Characteristics of Blockchain Technology (Seebacher & Schüritz, 2017)

## 2.2 Supply Chains of Pharmaceutical Industries

This section presents a simplification of a PSC (pharmaceutical supply chains). Challenges are described and significant future trends that will affect the pharmaceutical industry's supply chain are explained. The global supply chain of pharmaceutical OEMs is associated with a high level of complexity. This supply chain is linked to a high flow of information and transactions from different suppliers.

PSC are driven by life-saving importance, high quality standards and the accessible provision of medicines. These elements are critical to ensuring that vital, high-quality medicines are available to patients when they need them (Chen et al., 2023). There are strict regulatory requirements to produce medicines. This is because the consumption of medicines is intended to improve or stabilize a person's state of health. Accordingly, transparency from the production to the supply of these medicines is crucial. Control points must ensure that high quality is available for the end consumer. Ultimately, the accessibility of medicines is necessary to ensure that consumers receive their medicines on time. The functionality of the supply chain is therefore essential to avoid bottlenecks or other challenges. Figure 3 shows a simplified representation of a PSC. The raw material suppliers provide the manufacturers who are responsible for drug production. After production, the drugs are packaged and sealed by pharmaceutical companies, whereby these processes are often outsourced to external companies. The medicines are then transported by plane, ship, or truck to the central warehouses and from there to the pharmacies, hospitals, or doctors' offices and finally to the end customer.

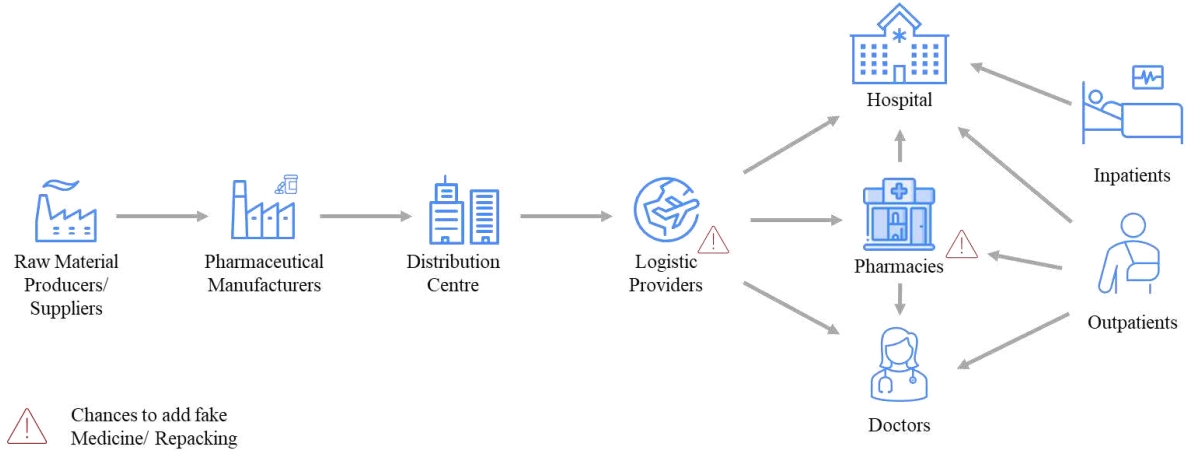


Figure 3 Simplification of Pharma Supply Chain (Subramanian et al., 2021; Szabó-Geletóczy et al., 2023)

Manufacturing of pharmaceutical products requires production, marketing, research, clinical trials, and legal regulations, which poses challenges for the supply chain in the pharmaceutical industry (Szabó-Geletóczy et al., 2023). An additional challenge is the widespread counterfeiting of drugs, which faces thousands of cases of fraud every year. This challenge is favored by a complex global network of supply chains that enables such illegal practices (Mackey & Liang, 2011). The current pharmaceutical supply chain does not provide end-to-end transparency from the manufacturer to the end consumer, which favors the emergence of substandard and counterfeit medicines on the market (Subramanian et al., 2021). In developing

countries counterfeit drugs are a major problem. The WHO states that over 50% of global drugs might be fake, mainly found in developing countries (Glass, 2014).

### Future Trends in Pharma

One major future trend is **sustainability**. The corporate goals of the major companies in the pharmaceutical industry are to produce medicines more sustainable and to distribute them within the supply chain with the lowest possible CO2 emissions (Arnum, 2022). More environmentally friendly packaging solutions and the guarantee of sustainable drug production are further goals that pharmaceutical companies are expected to consider. This is due to social pressure as well as regulatory and sustainability requirements (Paffen, 2023).

**Personalization of medicine** is another trend that could pose a challenge for the supply chain. Personalized medicine is seen as a major innovation in the pharmaceutical and life sciences industry that can significantly improve healthcare and contribute to economic growth (Eppinger & Kamprath, 2011). Due to increasing competition and customer needs, today's pharmaceutical companies are being forced to differentiate their offerings to remain successful (Rejikumar et al., 2018).

Lastly, **digital transformation** is one big trend. The pharmaceutical industry has been trying to digitalize its processes for several years now. The aim here is to connect the various systems in the supply chain. New technologies such as Internet of Things (IoT), blockchain and artificial intelligence (AI) can ensure greater transparency and efficiency in the pharma supply chain (Sharma et al., 2020). However, it is essential that all participants in the supply chain adapt their digital infrastructures, as various parties are involved in a data transaction (Preindl et al., 2020). With digital transformation, however, it is extremely important that data security is guaranteed. Otherwise, it could lead to cyber-attacks and the supply chain is jeopardized. In addition, counterfeit drugs are a major problem in the pharmaceutical supply chain if the IT infrastructure of suppliers is lacking.

### 2.3 Drug Traceability

Pharmaceutical companies have had difficulties tracking their products along their global supply chains in recent years. They have had to deal with disruptions in their supply chains due to the rise of counterfeit drugs, which has led to worldwide measures for the implementation of trace and track systems by federal agencies (Archa et al., 2018).

There are already various solutions for tracing falsified medicines in the pharmaceutical industry's supply chain (Kumar & Tripathi, 2019). Quick response (QR) codes, barcodes, Radio Frequency Identification (RFID) tags, and IoT are examples of potential technologies. To avoid counterfeiting in supply chains, these centralized systems have serious constraints regarding security, interoperability, data protection, and scalability (Benatia et al., 2018).

A fundamental responsibility of supply chain participants to guarantee patient safety and health by distributing drugs with high quality. Ensuring the traceability of medications is of utmost importance for creating interoperable solutions that meet the standards set by regulatory bodies like the FDA and the European Medication Agency (EMA) (Uddin et al., 2021).

## 2.4 Customer Experience in Pharma

Particularly when it comes to medications, customers need to have some trust in the production and secure distribution of pharmaceuticals. Maintaining a relationship of trust and confidence between the patient, healthcare provider, and pharmaceutical manufacturers is important. There is no direct relationship between end-consumers and pharmaceutical companies. Doctors and Pharmacies might influence consumers and have a great Impact of their decision making and trust. There are many reasons why doctors prescribe branded medications, such as financial concerns, personal experience, or even unethical connections with manufacturers (Mahmoud, 2016).

### Sustainability

Customers' choice for sustainability has grown in the last several years, making it a critical business problem (Sheth et al., 2020). It is important for consumers that the drugs were made in a good environment with fair working conditions and low emissions. Numerous sectors of the economy are exhibiting this trend toward sustainable manufacturing and delivery. The significance of implementing extra controls in many areas is paramount due to the requirements placed on suppliers and OEMs. For instance, the USA and the EU have implemented a multitude of rules and regulations to govern emissions and pollutants in the pharmaceutical production process (Ding, 2018).

### Quality

Satisfaction is influenced by the quality of medicine and the advice given, with these aspects reflecting the perceived trust in the pharmaceutical brand (Rejikumar, Asokan, & Kumar, 2018). There are certifications that bring with them a certain mark of quality. Due to changing

consumer habits, there has been an increase in demand for over-the-counter products such as vitamins and dietary supplements. Accordingly, collaboration in the supply chain is crucial to maintaining the quality of supply and increasing customer satisfaction (Szabó-Geletóczki et al., 2023).

### Transparency

Even if pharmaceutical companies are making their supply chain and drug production more sustainable as well as more qualitative, communication with the customer is elementary. The transparency of pharmaceutical companies is one of the most important indicators of customer mistrust (Reh et al., 2021). New technologies can be integrated into different parts of the supply chain to create transparency. This would lead to greater consumer confidence and facilitate authorization by regulatory authorities (Petty, 2018). Belén Garijo, CEO of Merck Healthcare, emphasizes in an interview with Georg Nederegger from McKinsey that the industry is striving to consolidate public trust. She emphasizes that improving credibility and increasing transparency are key measures for achieving this goal (Garijo, 2017).

## 2.5 Management Theory

The research's theoretical framework is provided through management theories in the section following.

### Technology Acceptance Model

The Technology Acceptance Model (TAM) is relevant for analyzing acceptance of the blockchain by different participants within a PSC. Davis developed the Technology Acceptance Model (TAM) in 1989 with the aim of understanding the intended behaviors of potential users in relation to the use of a technological innovation (Davis, 1989). External variables in the TAM are external influences, such as social opinions or technological features, that influence user perception (Marangunic & Granic, 2014). TAM examines factors that influence the acceptance of technologies, focusing on perceived usefulness (E) and perceived ease of use (U). Perceived usefulness is how effectively it can help individuals to achieve their goals (Chau, 1996). In contrast, perceived ease of use of information technology has an impact on customer acceptance and utilization behavior (Venkatesh, 2000). As can be seen in Figure 4, other components of TAM are the attitude towards using (A) and the behavioral intention to use (BI). Attitudes towards technology use in TAM are influenced by perceived ease of use and perceived usefulness. It is assumed that the derived intention to use is like actual behavior (actual usage)

(King & He, 2006) In this research, the TAM model offers the opportunity to investigate whether consumers are ready to accept blockchain.

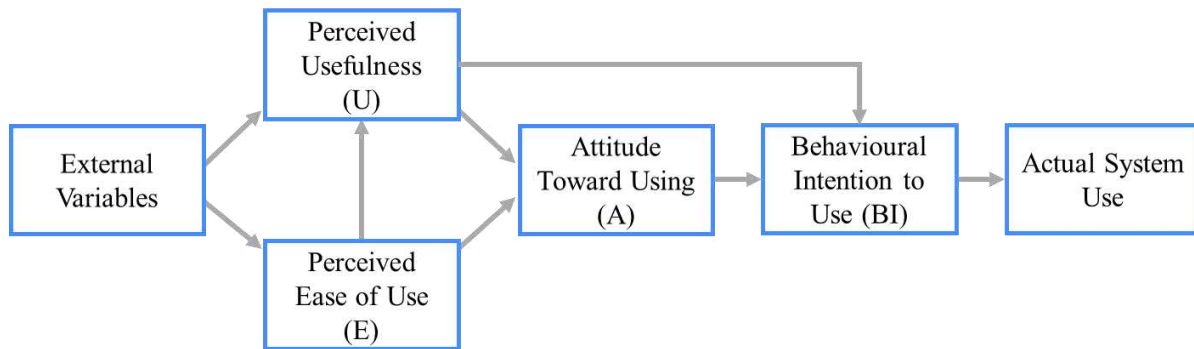


Figure 4 Technology Acceptance Model (Davis et al., 1989)

### Social Exchange Theory

Social exchange theory (SET) was developed by Homans, Blau and Emerson (Chen et al., 2023). In SET, social interactions between actors are analyzed based on trust, commitment, reciprocity, and power. According to SET there are also other determinants, that influence relationship and trust, for instance costs or revenue. In this research we will focus on trust, commitment, reciprocity, and power. These interactions are based on the voluntary exchange of values over time and generate high-quality relationships (Benitez et al., 2022).

In certain situations, it is important to build **trust** quickly and fulfill the expectations of different stakeholders in a short space of time to establish a long-term relationship (Hanna et al., 2023). Trust is of great importance in a social exchange process.

**Commitment** also plays a fundamental role in SET. All actors should strive for a common goal in the long term and be committed to achieving it. If a lack of commitment on the part of the various actors is sensed, this can have a negative impact on the relationship (Lambe et al., 2008).

**Reciprocity** strengthens the relationship between the different actors. It also is a basis for a social exchange process and promotes trust in the relationship. There is a reciprocal exchange of resources between different actors and the relationship is bidirectional (Gouldner, 1960).

**Power** can also have a strong influence on the relationships between the different actors and influence decision-making. Actors who have more power in the relationship can exploit it. There is a relative dependency to achieve the goal of the interest groups. However, power

relations can change for a variety of reasons. Within SET, power and equity have both gained an increasing amount of attention (Cook & Emerson, 1978).

### 3. Methodology

With the aim of investigating how blockchain technology can enhance trust in the pharmaceutical supply chain, this master's thesis utilizes a multifaceted study design. After reviewing relevant literature, our research design includes a survey and expert interviews to answer the research question.

#### Expert Interviews

To analyze the complex details of the use of blockchain technology, particularly in the areas of consumer trust, pharmaceuticals, and supply chain management, interviews were conducted with experts from these industries. These experts were selected carefully to ensure a broad range of views and specific expertise in the interviews. The questions were designed to highlight both the technical and social aspects of using blockchain traceability in the PSC. Expert interviews were done by a semi-structured interview method.

To enable a detailed investigation, the interviews were recorded and transcribed. Qualitative methods were used, a thematic analysis was conducted, and key terms were identified to gain a deep understanding of the obstacles, advantages, and overall impact of blockchain on consumer trust. Most importantly, the findings from the literature review and consumer surveys were assessed and validated by using these expert interviews as a triangulation research method.

#### Survey

Additionally, a quantitative survey was conducted to the expert interviews to measure consumer trust in pharmaceuticals with blockchain as an additional feature. The intent was to identify which variables could influence consumer trust. The purpose of this survey was to find out how consumers feel about blockchain technology in this situation and to explore their preferences and concerns.

To gain a broad understanding of the different opinions and experiences, we distributed the survey online to reach a wide and demographically diverse group of participants. The data collected was analyzed using a statistical analysis that included descriptive statistics and correlation analysis to identify relationships.

## Integration of Methods

The research methodology relied strongly on a combination of literature review, surveys, and expert interviews. Both, the technical knowledge from the interviews and the customer feedback from the surveys were included to obtain a balanced view. The application of this triangulation approach not only served to confirm our research question, but also underpinned the findings from the literature review. Incorporating these methods allowed us to gain a holistic view of the potential of blockchain to improve trust in consumer in the pharmaceutical industry.

The results were justified and reflected the perceptions of literature, experts and consumers based on this detailed investigation of the topic. These different methods strengthened our research and provided a holistic view of the impact of blockchain on consumer behavior.

## 4 Survey

### 4.1 Data Collection

To create a high-quality survey, questions were formulated considering the analyzed literature and management theories. The aim of the survey was to analyze the consumer's trust towards the pharmaceutical industry, blockchain and medicines.

The sample for this survey comprised 140 participants who had previous experience of buying medicines in pharmacies. This group represents a diverse composition, including people from different age groups and educational backgrounds.

The survey was distributed through various channels, including LinkedIn, Facebook groups, and WhatsApp. Participants were invited to take part through invitations.

The Qualtrics platform was used to create the survey and collect data. This sample provides a solid basis for investigating the impact of blockchain on trust in pharmaceutical products and allows representative conclusions for the master thesis. The analysis of this survey was done with the programming language R.

### 4.2 Procedure of Survey

The survey was conducted with 140 participants to gain insights on various information about consumers. Participants were asked 30 questions including general information about themselves, their opinion on the transparency and sustainability of pharma companies and their views on the integration of blockchain services (QR code) in the pharmaceutical industry.

The structure of our survey was as followed. At the beginning of the survey, participants had to provide information about their gender, age and education. The purpose was to find out whether these variables had an influence on trust in pharmaceutical products. This was followed by a series of questions aimed to find out what the current level of trust in the pharmaceutical industry was, and what their attitudes towards technology were. The idea was to measure customer acceptance of technology. Participants also had to state how they felt about sustainability and transparency. Participants were then given a scenario in which they were presented a medical product with blockchain traceability. The medicine with the blockchain service was presented to consumers along with the benefits it offers. They then had to rate their trust level in the blockchain product compared to the conventional pharmaceutical product. Finally, participants were asked to indicate their origin. You had the opportunity to evaluate both drugs in five different trust levels. Our appendix provides an overview of the questions and the structure of the survey (Appendix B).

Aim of this survey is to investigate potential changes in consumer trust derived from introducing a blockchain service in the pharmaceutical industry. Consumers are able to scan a QR code (with blockchain traceability) to access detailed information stored in a blockchain on sustainability and quality of a product. Our aim is to evaluate whether the implementation of such blockchain services correlates with an increase in consumer trust.

### 4.3 Analysis of Survey

The descriptive analysis includes an examination of variables, like age, education or gender. Variables are compared with each other to identify patterns. The aim is to gain insights into customer behavior, particularly with regard to trust in the blockchain feature. Furthermore, customer preferences presented in the literature will also be analyzed.

#### Importance of Sustainability and Transparency in Medication Purchase

Most of respondents rated sustainability in pharmacy to be ‘to a certain extent’ or ‘very’ important. In contrast, they believed that pharmaceutical companies tend to prioritize sustainability somewhat or not at all in production and delivery. Figure 12 (Appendix A) illustrates consumer importance of sustainability in purchasing drugs. Similar to sustainability, it can also be seen that transparency is important to consumers. It can be seen in Figure 5, that majority of participants stated that transparency was important to them ‘to a certain extent’. On the other hand, consumers believed that pharma companies view transparency as ‘somewhat’ to ‘not at all’ important

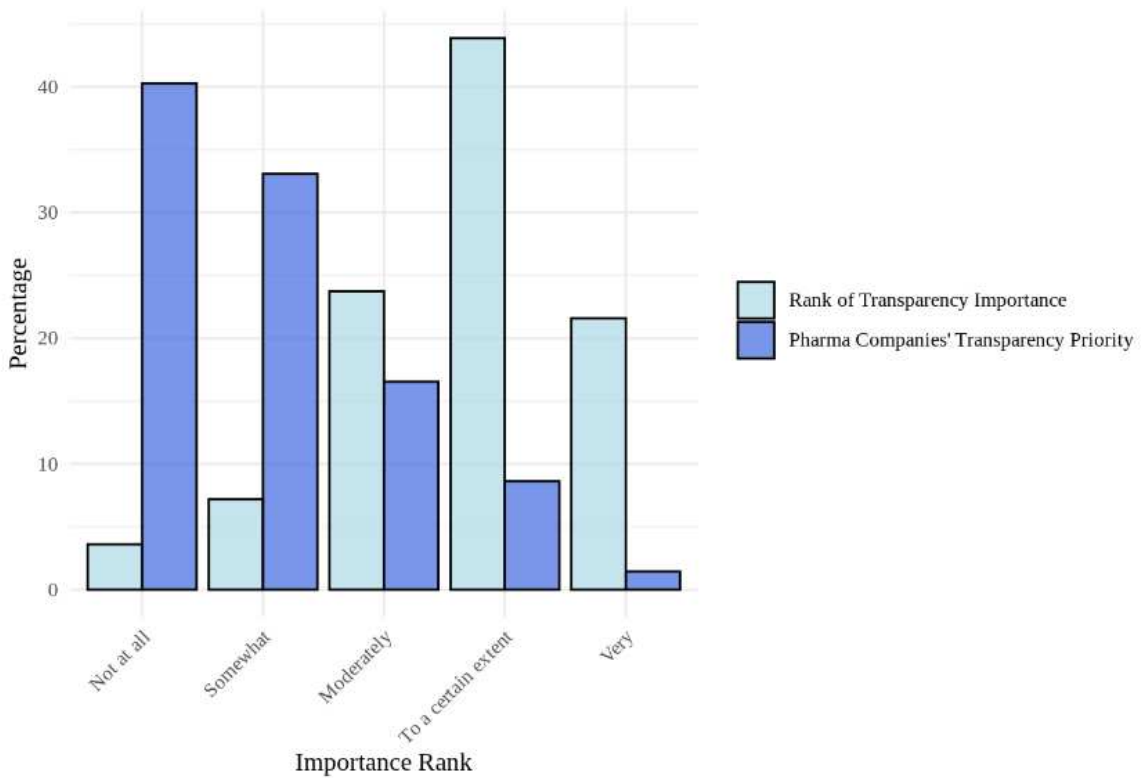


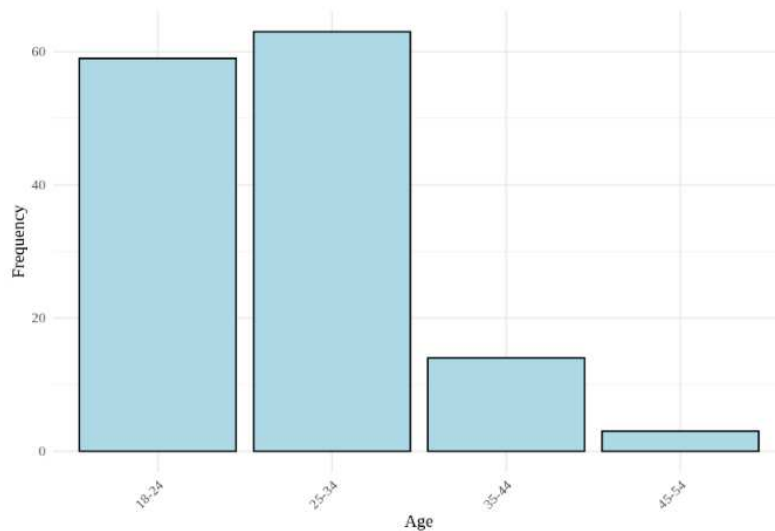
Figure 5: Importance of Transparency in Medication Purchase

### Trust in Medicine with or without QR Code

The majority of participants indicated that they had ‘moderate’ to ‘somewhat’ trust in medication that does not have a QR code. Participants stated that they had greater confidence in the medicine with the QR code. A total of 80% of participants stated that they had ‘to a certain extent’ to ‘very’ much confidence in the medicine with the QR code. Accordingly, the participants had more trust overall in the medicine with the blockchain traceability. However, it is very important to consider the age structure of the participants. Figure 13 (Appendix A) illustrates the result of trust in both drugs.

### Analysis on Gender and Age

The majority of the participants who completed this survey were men. They outnumbered the female participants by a ratio of more than two to one. Figure 14 (Appendix A) illustrates the gender distribution of this survey. It was also evident from Figure 6 that most participants were in the 18-24 and 25-34 age groups. Only a small number of individuals belonged to age groups 35-44 and 45-54. Accordingly, some of the results of the survey may focus more on the age groups between 18-34 and are not representative of other age groups. There were no participants older than 54.



*Figure 6: Age Distribution*

### Trust in Medicine without and with QR Code by Age

Across all age groups, a majority expressed trust in medicine without QR codes, with a tendency to ‘somewhat’ and ‘moderately’. The comparison of trust clustered by age groups in medicine with and without QR code is illustrated in Figure 15 and Figure 16 (Appendix A). Most individuals had more trust in medicine with QR codes, most of them had trust ‘to a certain extent’ and ‘very’ strongly. There was a clear preference for some degree, especially in the 18-24 age group. It was clear that all age groups had more trust in medicine with the QR code.

### Usability Beliefs on QR Code Feature by Age

Participants in the survey stated that they believed that medications with a QR code are usable ‘to a certain extent’. Apart from the 45-54 age group, this was seen in all other age groups. This was less when compared to the actual trust of the medication with a QR code and indicated that most consumers had some concerns about the usability of the feature. The distribution is illustrated in Figure 17 (Appendix A).

### Analysis on Education and Salary

As can be seen in Figure 18 (Appendix A), the survey was mostly completed by participants with a ‘Bachelor Degree’ and ‘Master Degree or Higher’. In most of the networks and groups where the survey was published, there were participants with an academic background who were students.

Most participants in the survey were in the salary category of less than €20,000 per year. There were a few participants that earned more than €80,000 per year. The distribution of salary structures can be explained by the fact that most of the participants in the survey were between 18-34 years old. This clear distribution is illustrated in Figure 19 (Appendix A).

Change in Trust from without QR to with QR

Figure 7 presents the behavior of trust levels between medications with and without QR codes. Trust levels are measured according to how much consumers trusted the pharmaceutical product with the QR code in direct comparison with the product without the QR code. Participants in the survey had the opportunity to choose between the following trust levels: ‘Not at all’, ‘Somewhat’, ‘Moderately’, ‘To a certain extent’, ‘Very’. The illustration shows that, among the participants, 31,9% felt a level-one increase of trust if the blockchain features were implemented. There was a two-level increase in trust of 29,7%. A three-level increase of 10,9% was perceived. However, just 5,8% of participants reported a one-level decrease using the QR code, whereas 20,3% of participants reported no changes at all. Survey respondents were more likely to trust the medication with the QR code.

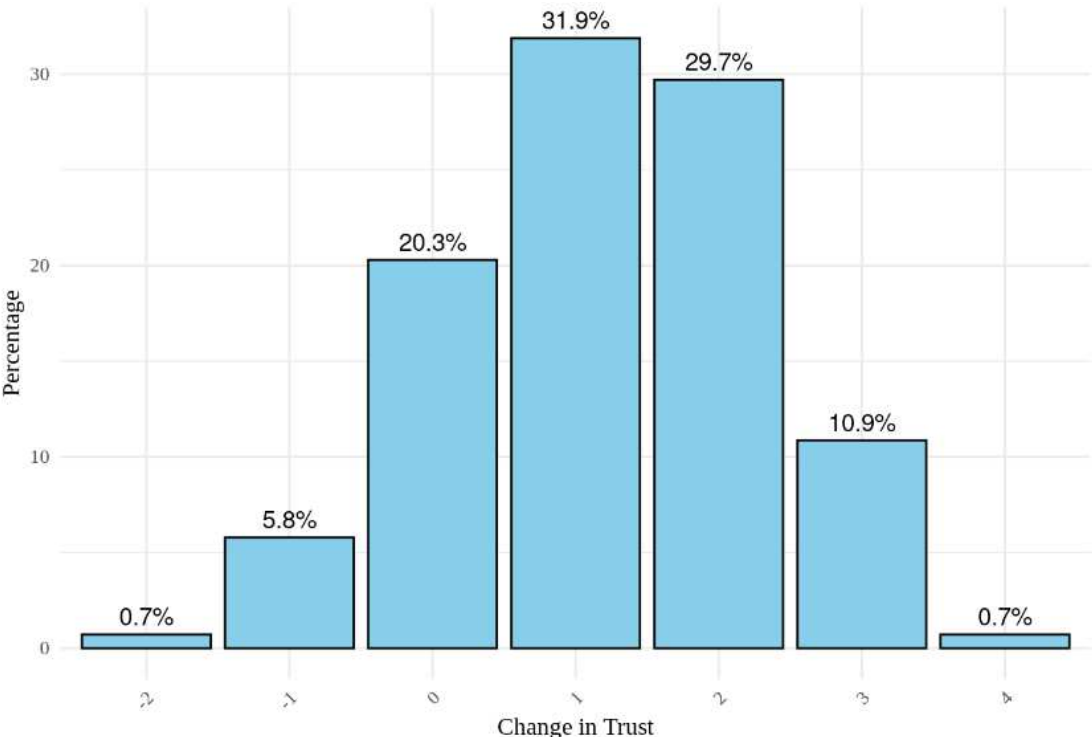


Figure 7: Trust Change Analysis (Percentage)

Counterfeit drugs in developed countries and developing countries

Customers were asked if they believed that counterfeit medicines were a problem in both developed and developing countries. This question was posed to determine whether consumers had a lower level of trust in different areas. Based on Figures 8 and 9, consumers generally only felt ‘somewhat’ that counterfeit medicine is an issue in developed countries. However, this pattern was not seen in developing countries. Figure 8 demonstrated that consumers tended to believe ‘to a certain extent’ to ‘very’, that counterfeit drugs are a problem for developing nations. This indicated that consumer might have less trust in purchasing drugs in developing countries.

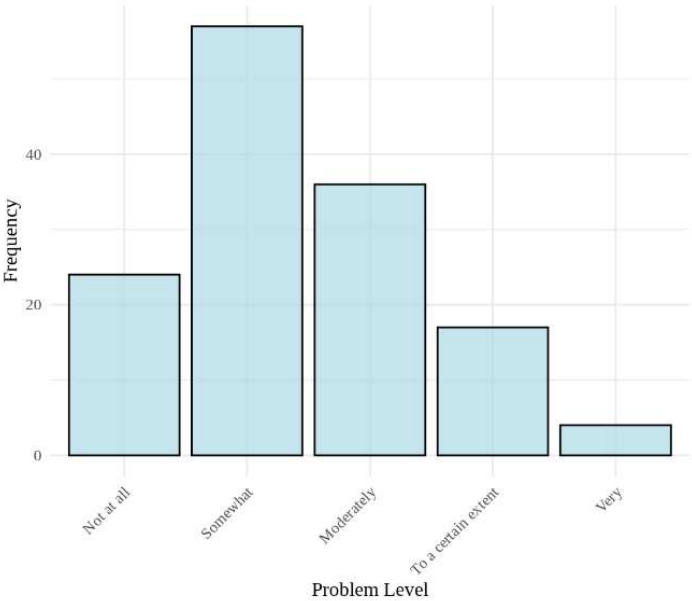


Figure 8: Counterfeit Medicine Problem for Developing Countries

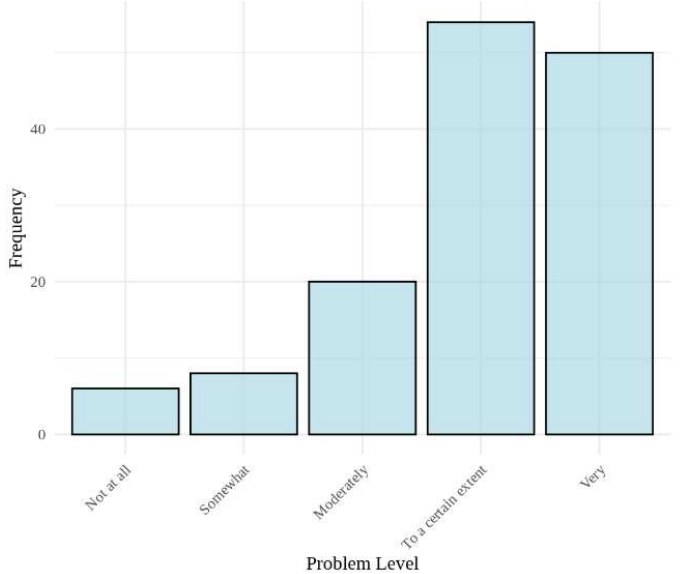


Figure 9: Counterfeit Medicine Problem for Developed Countries

## Regression Analysis (with P-value)

A regression analysis was conducted to obtain a detailed analysis of the survey. The variables shown in Figure 10 were taken into account and analyzed in more detail. Figure shows the different p-values, which evaluate the significance of the regression. A statistical correlation can be seen if the p-value is below 0.05 (Rice, 1989). This regression model shows the relationship between the individual variables and how they influenced each other. We take into account both our dependent variables and our independent variables (trust) when performing this regression analysis.

|   | Age        | Education   | Salary     | Please rank the importance of sustainability when purchasing your medication. | Please rank the importance of transparency when purchasing your medication. | Do you have trust in Medicine with QR Code? | Do you have trust in Medicine without QR Code? |
|---|------------|-------------|------------|---|---|---|--|
| Do you have trust in Medicine with QR Code?   | 0.08111789 | 0.008115625 | 0.0742837  | 0.04409448  | 0.007538799   | 0   | 0.0137503                                      |
| Do you have trust in Medicine without QR Code?  | 0.459947   | 0.2550745   | 0.5162845  | 0.001946351   | 0.1496831   | 0.0137503                                   | 0  |
| Do you believe this add on feature would be usable?   | 0.6536823  | 0.2337933   | 0.7241581  | 0.002739012   | 6.037547e-05  | 8.448093e-05                                | 0.0009033229                                   |
| Do you believe that this feature could have a positive impact on transparency and sustainability? | 0.7925263  | 0.004853176 | 0.2722351  | 0.0008880924  | 3.552063e-05  | 1.872508e-05                                | 0.02232292                                     |
| Please rate your likelihood of paying a premium for such pharmaceutical products.                 | 0.1453691  | 0.02672561  | 0.03431553 | 7.42433e-09   | 0.003262576   | 1.375322e-06                                | 5.406471e-06                                   |

Figure 10: Regression Analysis (with P-value)

Based on the p-values, we can see that there are significant linear relationships between some variables. These are the relationships that we will take into account for our research:

### Relation of Trust in Medicine without QR Code and Importance of Medicine Sustainability

There was a correlation with a p-value of 0.0019 between the variables Trust in medicine with QR code and Importance of Medicine Sustainability. This correlation indicates that people who believed sustainability is relevant also might have a high level of trust in medicines without a QR code.

### Relation of Trust in Medicine with QR Code and Importance of Medicine Transparency

With a p-value of 0.044, there was a strong correlation between the variables trust in medicine with QR code and importance of medicine sustainability for customers. This relationship also

indicates that individuals who trusted medicine with QR code more also tended to prioritize sustainability.

#### *Relation of Trust in Medicine with QR Code and Importance of Medicine Transparency*

With a p-value of 0.0075, there was also a significant relationship between trust in medicines with a QR code and the importance attached to traceability. This implies that individuals who had more trust in medicines with a QR code also might value traceability more.

#### *Relation of Education Level and Trust in Medicine with QR Code*

An interesting finding ( $p = 0.0081$ ) emerged, revealing a linear relationship between education level and trust in medicine with QR code. More educated people may have greater trust in medicine that has a QR code.

#### *Relation of Usability of Add-on Feature and Transparency Importance*

A significant relationship with a p-value of 0.0000845 was observed between the perceived usability of the add-on feature and the importance assigned to transparency in medicine. This indicates that individuals who believed in the usability of the feature are more willing to emphasize transparency in pharmaceutical products.

#### *Relation of Trust in Medicine with QR Code and Salary*

Another relationship with a p-value of 0,0138 with a relationship was between the variables trust in Medicine with QR code and salary levels. Individuals who belonged to a higher salary category tended to have an increased trust in medicine with QR Code.

### **Correlation Test**

Additionally, a correlation analysis was carried out. This aimed to identify which variables correlated positively and negatively with one another. Figure 11 shows the results of this correlation analysis. The correlation coefficients are presented and are used to evaluate the significance of their correlations. The correlation coefficients range from -1 to 1. Values closer to 1 or -1 indicate a stronger linear relationship, while values closer to 0 suggest a weaker or no linear association (Taylor, 1990). The purpose of correlation analysis was to measure the strength and direction of linear relationships between pairs of variables to gain insight into their interdependence.

|   | Age         | Education   | Salary     | Please rank the importance of sustainability when purchasing your medication. | Please rank the importance of transparency when purchasing your medication. | Do you have trust in Medicine with QR Code? | Do you have trust in Medicine without QR Code? |
|---|-------------|-------------|------------|---|---|---|--|
| Do you have trust in Medicine with QR Code?   | 0.1490045   | 0.2245044   | 0.1524349  | 0.1716614   | 0.2265558   | 1   | 0.2093013                                      |
| Do you have trust in Medicine without QR Code?  | -0.06341572 | -0.09753836 | -0.0557175 | -0.2615178  | -0.1232895  | 0.2093013                                   | 1  |
| Do you believe this add on feature would be usable?   | 0.0385281   | 0.1020176   | 0.03031025 | 0.2531386   | 0.3346148   | 0.3283173                                   | -0.2794263                                     |
| Do you believe that this feature could have a positive impact on transparency and sustainability? | 0.02259338  | 0.2384667   | 0.09411043 | 0.2798097   | 0.3442898   | 0.3555586                                   | -0.1944063                                     |
| Please rate your likelihood of paying a premium for such pharmaceutical products.                 | 0.1246      | 0.1886156   | 0.1803159  | 0.4675101   | 0.2487411   | 0.3975768                                   | -0.3762781                                     |

Figure 11: Correlation Test

Using the correlation coefficients obtained from the analysis, we can determine that statistically significant relationships exist within certain combinations of variables. These are relevant relationships for research:

Correlation of Trust in Medicine with QR Code and Education

Individuals with higher education levels tended to have a positive correlation with trust in medicine featuring QR codes (correlation = 0.2245). This suggests that as education levels increase, there is a tendency for an elevated trust in medicine with QR codes.

Correlation of Trust in Medicine without QR Code and Sustainability Importance

A notable negative correlation was observed between trust in medicine without QR code and the importance placed on sustainability (correlation = -0.2615). This implied that individuals who have less trust in medicine without QR codes may prioritize sustainability more.

Correlation of Usability Belief and Transparency Importance

The usability belief of the add-on feature demonstrated a strong positive correlation with the importance assigned to transparency in medicine (correlation = 0.3346). This suggested that individuals who believed the feature is usable were more likely to emphasize transparency in pharmaceutical products.

### *Correlation of Belief in Feature Impact and Transparency/Sustainability*

Individuals who believed that the QR code feature could positively impact transparency and sustainability exhibited positive correlations with both transparency (correlation = 0.3443) and sustainability (correlation = 0.2798). Those who perceived a positive impact on transparency and sustainability were more likely to trust in the usability of the function.

### *Correlation of Premium Payment Likelihood and Sustainability Ranking*

There was a positive correlation between the variables likelihood of paying a premium for pharmaceutical products and the ranking of sustainability importance with a correlation of 0,4675. Individuals who ranked sustainability as very important were more likely to have a willingness to pay a premium for pharmaceutical products.

### *Correlation of Trust in Medicine and Premium Payment Likelihood*

Trust in medicine with a QR code (correlation = 0.3976) and trust in medicine without QR code (correlation = -0.3763) both exhibited correlations with the likelihood of paying a premium. Individuals with higher levels of trust in medicine with QR codes may also have an increased likelihood of paying a premium for pharmaceutical products. Conversely, those with higher trust in medicine without QR codes may show a decreased likelihood of paying a premium for such products.

### *Correlation of Premium Payment Likelihood and Salary*

With a value of 0.1803 there was a positive correlation between the likelihood of paying a premium and a higher salary. This implied that individuals with higher salaries may be more inclined to consider paying a premium for pharmaceutical products.

## 5. Expert Interviews

### 5.1 Data Collection

This chapter serves as a supplementary component of the methodology, with the objective of gathering further insights regarding the ramifications of blockchain on PSC and its influence on the consumer experience. Expert interviews play an essential part in the acquisition of primary data as they provide comprehensive and profound understandings of the subject's intricacies. The purpose of conducting expert interviews was to obtain a diverse range of viewpoints from individuals who are experts in the respective field. These findings will be combined with the results obtained from the survey.

Expert interviews are essential due to the master's thesis's intricacy and distinctiveness. It is feasible to collect high-quality data for a thorough examination by analyzing the experiences and knowledge of industry specialists. Every interview was carried out in a virtual environment, granting the participants flexibility. A duration of 30 to 60 minutes was allocated for each interview to provide enough time for prospective in-depth discussions with the experts. To assure confidentiality, each interview was recorded, transcribed, and anonymized. For the purpose to identify appropriate specialists, an extensive network of professionals with publications in the pharmaceutical supply chain, blockchain, or supply chain consulting was contacted via email, LinkedIn, Xing, and well-established professional communities. To conduct every interview, Microsoft Teams was utilized.

A total of six interviews were undertaken, with the participants being divided into three distinct expert groups: supply chain consulting experts, pharmaceutical industry experts, and blockchain experts. Two interviews represented each industry. The expert interviews involved the selection of participants who possessed knowledge in the fields of pharmaceutical supply chain (PSC) and/or blockchain technology. Numerous selection criteria were considered:

Professional Experience: Experts who have an extensive professional background and have had touchpoint in their career with blockchain. This expert group might consist of researchers, managers, or supply chain directors who are actively involved in supply chain projects.

Industry Diversity: The interviewees represent a wide range of knowledge. Our goal was it to get different perspectives about our specific topic. Therefore, we have decided to also interview Supply Chain Experts.

## 5.2 Procedure of Expert Interviews

We provided the experts with a scenario to begin each interview to ensure our conversation would have a starting point. Also, our aim was to compare results of expert interviews with our finding of the survey. We presented our experts with the following scenario:

*Consumers can use their smartphones to scan the QR codes on medicine packages. Important data regarding resources, carbon dioxide emissions, and transactions are openly shared on a publicly available blockchain, ensuring transparency for suppliers as well as consumers. Furthermore, this information is protected by cryptographic measures.*

All the questions asked in the interviews were designed to obtain specific ideas and views from the experts:

1. **Analyzing Consumer Advantages:** We inquired, "How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?" The aim of this question was to study the different views of experts on consumer advantages if blockchain would be implemented.
2. **Identifying Industry Challenges:** The question, "What are the challenges in global pharmaceutical supply chains?" to comprehend current problems that could have an impact on a global Supply Chain.
3. **The Significance of Transparency:** We investigated, "How crucial is transparency within the pharmaceutical supply chain, and why?" Our intention was to identify the degree of correlation between expert opinions and our survey results on the importance of transparency.
4. **Sustainability and Transparency:** The experts were asked, "How can this feature support sustainability and transparency in the pharmaceutical products?" to evaluate the potential impact of blockchain on these important sustainability and transparency issues.
5. **Customer Trust Dynamics:** To investigate regional differences in customer trust, we presented, "Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?" We used this to compare the results of our survey with this as well.
6. **Assessing the practicality of implementation:** The inquiry, "Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?" with the goal of gaining useful understanding of the viability and difficulties of blockchain deployment.
7. **Assessing Usefulness:** We inquired, "How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?" to find out if experts thought this technology would have practical use.
8. **Trust Enhancement via Blockchain:** The specialists were questioned "Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?" to compare with our survey findings.
9. **Consumer Willingness to Pay:** We asked, to comprehend the economic ramifications, "Do you think Consumers would pay more for this add-on feature, why would they pay more?" Determining the possible market impact was also aided by this.
10. **Examining Business-Consumer Relationships:** The objective of the question, "How would you evaluate the relationship between pharmaceutical companies and their

consumers?" was to understand the relationships between Pharma Companies and their Customers.

11. **Evaluating Technology Acceptance:** Finally, we asked, "How do you think is the technology acceptance of this feature among consumers and within the pharmaceutical industry?" to consider the Technology Acceptance Model and the findings from our survey.

### 5.3 Analysis of Expert Interviews

The following table shows how many experts were interviewed and which industry those experts come from. The positions of experts in their companies are also illustrated in Table 3.

| <b>Number of Experts</b> | <b>Branch of Expert</b> | <b>Expert's Position in Company</b>  |
|--------------------------|-------------------------|--|
| Expert 1                 | Pharma                  | Senior manager for supply chain transformation at a leading pharmaceutical company |
| Expert 2                 | Pharma                  | Digital lead supply chain & logistics in an international pharmaceutical company   |
| Expert 3                 | Blockchain              | Founder and CEO of a blockchain technology company                                 |
| Expert 4                 | Blockchain              | Blockchain expert and holds a leadership position                                  |
| Expert 5                 | Supply chain consulting | Manager for supply chain management at a global consulting firm                    |
| Expert 6                 | Supply chain consulting | Blockchain specialist and consultant for digital transformation in supply chain    |

*Table 3: List of Expert Interviews*

1. *How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?*

The experts interviewed stated that blockchain technology could bring some advantages for consumers. Expert 6 said that consumers could have greater transparency through track and trace systems. For example, they could see where their products come from. Overall, Experts 1,3,4,5 and 6 stated that consumers could benefit from the transparency offered by a blockchain. Expert 4 explained that this transparency could lead to consumers receiving higher quality products and that product shortages could be minimized. Expert 2 mentioned that blockchain

could have some benefits, but doubts whether the technology is relevant for pharma customers. Overall, five out of six experts stated that the implementation of blockchain could have an advantage for customers.

*2. What are the challenges in global pharmaceutical supply chains?*

In response to the question dealing with challenges in the global supply chain, Experts 1, 2, 3, 4, 5 stated that the main challenges in the global pharma supply chain are the strict regulations that exist in the different countries. Expert 3 explained that pharmaceutical companies are obliged to observe the constantly changing regulations, otherwise they must pay fines. According to Expert 5, there are specific regulations that must be monitored when transporting medicines that are kept under refrigeration. Expert 2 explained that communication and data management with suppliers could be a challenge for pharma OEMs. Five experts saw regulations as a major problem in the pharma supply chain.

*3. How crucial is transparency within the pharmaceutical supply chain, and why?*

When it comes to the relevance of transparency in the PSC, all Experts agreed that transparency is of immense importance. Expert 2 stated that greater transparency has a positive impact on regulatory compliance and customer trust. According to Expert 5, there is also a trend in various industries where transparency is becoming increasingly important for consumers over time. All Experts agreed on this question and confirmed the relevance of transparency within supply chains.

*4. How can this feature support sustainability and transparency in the pharmaceutical products?*

The experts were then asked whether the QR code blockchain feature, which was also presented in the survey, can support sustainability and transparency in pharmaceutical products. Experts rated the support of the feature differently. Experts 1 and 2 recognized the potential for increasing transparency. However, Expert 1 expressed concern that there are other technologies that are already being used to achieve a higher level of transparency and sustainability. Experts 2, 4 and 5 agreed that blockchain can improve traceability in the supply chain. From the interview with Expert 3, it was shown that a combination of AI and blockchain can be used to reduce waste. Experts 4 and 6 emphasized that there could be advantages in supplier monitoring to behave more sustainably. It can be concluded that all Experts, except for Expert 1, saw advantages for transparency and sustainability when using the feature.

5. *Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?*

Regarding the question whether the level of consumer confidence when purchasing medicines is different in industrialized and developing countries, the answers of the experts differed. Based on the interviews with Experts 1 and 5, there was a higher level of consumer trust in industrialized countries, as there are more regulations there. In addition, they stated that counterfeit medicines are in fact more common there. Experts 3 and 4 also saw a difference and said that consumers might have distrust in developing countries. In the interview with Expert 6, he emphasized that this lack of regulations affects the quality of the medicines and that it is difficult to buy medicines that are in stock. Expert 2 differentiated between consumers from industrialized countries and people who live in developing countries. Expert 2 said that people from developing countries do not feel any distrust and emphasizes that the products are of the same quality regardless of the region. All Experts except Expert 2 stated that regulations and controls in industrialized countries strengthen consumer trust, while many counterfeit products are in circulation in developing countries.

6. *Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?*

When summarizing the results of the question of whether there are challenges in implementing the blockchain feature, there are several common views shared by the experts. Expert 1 emphasized the complexity of integrating the technology into the entire supply chain and adds that this would only be feasible at high cost. Expert 2 agreed and added that implementation must also result in benefits for pharmaceutical companies. Expert 3 also mentioned that raw material suppliers may not have the financial resources. Experts 4 and 5 stated that there must be an understanding of the benefits of the feature during implementation and that it could be difficult if participants in the supply chain network do not have a well-developed IT infrastructure. Expert 6 added that external companies such as IBM need to be added as such projects require know-how. All experts mentioned the challenge of integrating all participants in the blockchain network.

7. *How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?*

Some Experts disagreed on how they assess the practical utility of the feature for consumers. Expert 1 saw no practical utility at all for consumers in developed countries and added that it could be interesting for consumers in developing countries. Experts 2 and 3 did not see any utility of the feature for older people either. They stated that it could be usable by younger people and tech enthusiasts. Expert 4 explained that the feature could be useful and that there are already practical examples and research going in this direction. Experts 5 and 6 said it could be useful for consumers because of the security and transparency. Overall, it can be stated that Expert 1 did not find the feature useful, Experts 2 and 3 found it partially useful and Experts 4, 5 and 6 found it useful.

*8. Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?*

When asked if a blockchain traceability feature might increase consumer trust, all Experts who responded to the question agreed that it would influence trust. However, Expert 1 added that he thought consumers already had a good level for trust of pharma companies with a brand, that represents their quality. Expert 3 said that the effect of higher trust can already be seen in the financial sector with Bitcoin. Experts 4 and 5 also assumed an increase in trust and explain that it is of greater importance that consumers have a certain understanding of blockchain traceability and understand the benefits that this technology offers them. Experts 2 and 6 also believed that there could be an increase in consumer confidence. It can be stated that all Experts assume that there could be an increase in consumer confidence when this technology is implemented.

*9. Do you think Consumers would pay more for this add-on feature, why would they pay more?*

Experts disagreed on whether consumers would pay more for the blockchain feature. Experts 1 and 2 do not assume that consumers would pay more. They suggested that a small customer segment would be willing to pay more. Expert 4 added that it was possible that many people might be willing to pay extra. Experts 5 and 6 would both pay more, especially if they were in developing countries and want a certain level of security. Consumers are willing to pay more, said Expert 6, particularly when it comes to medicine. According to Expert 3, consumers may find this technology to be more valuable, especially in developing nations where they might be willing to pay a higher price. The Experts disagreed on whether consumers would pay more.

*10. How would you evaluate the relationship between pharmaceutical companies and their consumers?*

When evaluating the relationship between pharma and customers, there were also differences among the experts. Experts 1 and 2 said that there is a solid relationship. Expert 1 added that this can be seen in the sales figures of recent years and explains that pharmaceutical companies have no direct contact with their customers, but that this is the task of pharmaceutical wholesalers. Expert 3 described the relationship as ambivalent and explains that it depends on the drug being purchased. The Expert added that people tend to think lobbying is mainly responsible for how often certain medicine will be recommended. As a result, the Experts said that there is a solid relationship. Experts 4, 5 and 6 stated that there is no direct relationship between the end consumer and the pharmaceutical company, and that the relationship is influenced by intermediaries.

*How do you think is the technology acceptance of this feature among consumers?*

On the last question, whether consumers would accept this feature. There is also minimal disagreement among the experts. Expert 1 was unsure whether customers will accept it. Based on the interview with Expert 2, acceptance could be high, as consumers only must scan a QR code. Experts 1, 4 and 6 believed acceptance depends on the user friendliness of the program. In addition, Experts 4 and 5, 6 stated that acceptance changes positively over time and that clear customer communication regarding the benefits is crucial. Expert 3 said there will be a high level of acceptance, especially among younger and tech-savvy people. It can be said that all experts were certain that, under certain conditions, there will be customer acceptance of this technology.

## 6. Discussion

### 6.1 Sustainability and transparency

Consumers have a general trust in pharmaceutical products, but also have a clear desire for more transparency and sustainability. This indicates that sustainability is seen by consumers as a trend that is increasingly important for improving the customer experience. However, most survey participants believed that sustainability and transparency are not very important for pharmaceutical companies (Chapter 4.3).

Experts confirmed the importance of transparency. All experts stated that transparency plays an important role in the PSC. Expert 2 stated that greater transparency has a positive influence

on regulatory compliance and customer trust. According to Expert 5, there is also a trend in various industries where transparency is becoming increasingly important for consumers over time. The views of Experts 4 and 6 highlighted the potential benefits of supplier monitoring for more environmentally friendly behavior. Both experts saw benefits for sustainability and transparency regarding the usage of the feature. The transparency that a blockchain provides could be advantageous for consumers overall, according to five expert interviews. Product shortages could be reduced, and consumers could receive higher-quality products because of this transparency, according to one expert. In the expert interviews, it also emerged that a major challenge is global PSC regulations and transparency across all supply chain processes.

The implementation of a public blockchain with the PoS mechanism could offer significant benefits for pharma companies and customers. This would make the blockchain energy efficient and sustainable. Improving data integrity within the supply chain would not only increase the efficiency of the blockchain, but also its sustainability. This would be an important step towards a more energy-efficient and environmentally friendly technology. It is also in line with the corporate goals published in many of the pharmaceutical group's corporate and sustainability reports (Chapter 2.2). One of the characteristics of blockchain is the transparency and decentralization of the information that is stored.

## 6.2 Consumer-Pharmaceutical Industry Relationship

The results of the survey indicated the complex relationship between consumers and the pharmaceutical industry. The survey results showed that consumers placed a high importance on sustainability and transparency and had greater trust in the medicine with the blockchain traceability feature. Accordingly, it can be concluded that the consideration of the trends sustainability and transparency have an influence on consumer trust. The analysis of the survey revealed that customers tended to rate pharmaceutical companies in such a way that neither transparency nor sustainability was relevant to them.

The expert interviews revealed that most experts stated that there is no direct relationship between pharmaceutical companies and the customer. Pharmaceutical companies are only responsible for the distribution of medicines and do not supply their end customers directly. On the other hand, one expert explained that people tend to think that lobbying is the main reason why a certain medicine is recommended so often. Another expert also stated that it is important for pharmaceutical companies to be transparent.

Taking the SET into account, commitment is of high importance for the relationship between consumer and pharmaceutical company. Consumers have the impression that it is not important for pharmaceutical companies to act transparently and sustainably, which has a negative effect on trust and commitment. It would be beneficial if pharmaceutical companies give consumers the impression that they have the same preferences in the production and distribution of their products. A blockchain traceability feature would enable this. In addition, such a feature could make consumers feel involved and it would be good for consumer engagement. This is also an important indicator for consumers and would make customers feel more empowered. Which is also beneficial for trust building according to SET. It can be concluded that blockchain in this context offers a promising opportunity to positively influence the image of pharmaceutical companies and therefore also influences consumer trust.

### 6.3 Impact of Counterfeit Drugs

Since PSC is highly complex, and it is a challenge to monitor all processes and regulations, fake medicines could occur in the supply chain. The results indicated that consumers from developed countries had less confidence in buying medicines from developing countries (Chapter 4.3).

In the expert interviews, we were able to identify that this is due to the low level of transparency and the different regulations (Chapter 5.3). It is also a challenge for consumers in developing countries to access high-quality products. However, one expert stated that she assumes that only people from developed countries feel distrust in developing countries. It should be mentioned that most of the survey participants are from Germany, which could be the reason for mistrust.

The literature also showed that the number of counterfeit medicines in developed countries are high (Glass, 2014). This could lead to consumers taking them and experiencing serious problems. The introduction of a blockchain traceability feature could provide additional added value for consumers. If consumers can view all important information regarding production and distribution transparency, this will have a positive effect on their trust. As stated in the literature review, the blocks in the blockchain are cryptographically secured. Accordingly, changing the transaction data to introduce counterfeit drugs would require too many resources. Greater transparency would therefore have a positive impact on the safety of the drugs and protect potential consumers. This would enhance trust among consumers from industrialized countries who want to purchase medicines in developing countries.

## 6.4 Technological Acceptance and Utility

Technological acceptance and the actual benefits depend on different factors. Various cultures and countries have different levels of acceptance towards introduction of new technologies (Straub et al., 1997). The effectiveness of blockchain functions is influenced by different levels of trust. These can vary depending on the region and consumer confidence in pharmaceutical companies and new technologies. Accordingly, it is important to take these cultural differences into account during a global introduction to increase acceptance.

Given that the survey analyzed that transparency and sustainability play a key role for consumers, it can be deduced there are benefits. This blockchain feature could also provide a significant benefit for people from developing countries to ensure that their medicines are of an appropriate quality, but the most important aspect is user-friendliness, so that consumers can benefit from this technology. Here, the experts mentioned the challenge of reaching the main target group of older people. A user-friendly interface is essential for the feature to have any actual benefit to increase trust. Technological acceptance and utility are dependent on the communication of the feature. Consumers need to understand the benefits of the feature. According to the survey, there is a correlation between technology acceptance and education.

## 7. Limitations

Data collection and analysis were significantly affected by the time restrictions of this study. Due to the limited time frame, the sample size for the survey was comparatively small, which limited the overall validity and representativeness of the findings. In particular, the high proportion of participants from European regions, which consisted mainly of younger individuals, therefore, might have affected the range of viewpoints represented, leading to a demographic bias and regional imbalance in the results.

In addition, the complex and specialized nature of blockchain technology in the pharmaceutical sector was an obstacle. The limited accessibility and scope of relevant literature affected the literature reviews comprehensiveness. In addition, the complex nature of the topic made it difficult to conduct an in-depth investigation of all relevant aspects within the given structure.

The required length of the paper, which varied between 8,000 and 13,000 words, limited the depth of analysis that could be provided on specific topics. As a result, emphasis was placed on the most important elements, potentially neglecting other relevant topics that should be considered and thoroughly investigated.

It would be recommended to conduct additional research based on the key findings of this study. To this end, the expert interviews and surveys could be more in-depth and diverse, and the scope of the surveys could be expanded. A more extensive and diverse literature review and a larger and more diverse sample could contribute significantly to improving the results and expanding the applicability of the research findings.

## 8. Recommendations for Future Research

### Consideration of Cultural Differences

Given the variation in pharmaceutical industry regulations across countries and the potential prevalence of counterfeit medications in certain regions, an essential area of future research is the examination of consumer perception with a regional focus. An area of particular emphasis could be the examination of consumer trust in developing nations.

Additionally, user-friendliness and acceptance may differ between countries. For instance, technological acceptability in Switzerland may vary in comparison to that of countries such as (Straub et al., 1997). This allows for the investigation of regional adoption and utilization of blockchain technologies in greater depth.

In addition to examining regional differences between consumers, it is possible to analyze whether different segments have different characteristics when adopting blockchain traceability. Conducting an analysis to determine whether the implementation of blockchain technology could yield greater benefits for specific segments, such as premium products or frequently counterfeited medications, would be rather intriguing. By adopting a differentiated approach, valuable insights may be gained regarding the specific implementation and enhancement of blockchain solutions across distinct pharmaceutical industry market segments.

### Additional Study Regarding the Standardized Model

A thorough and in-depth meta-analysis that looks at different types and methods of blockchain protocols, existing projects, and other things could reveal very useful information. Finding blockchain solutions that fit well with the requirements of pharmaceutical companies could be one of the primary objectives of this research. Not only should pharmaceutical companies be looked at closely, but so should the businesses that supply them. Creating a standardized model for a company like that would be a purpose of this study. This kind of model could be used as an in-depth guide for integrating blockchain technologies into the pharmacy industry in an

approach that functions effectively and is easy to understand. By putting in place clear regulations and norms, this would make supply chains safer and more transparent. Additionally, it could be helpful to test how useful this feature is by conducting real-world experiments for both customers and businesses.

### Profitability Assessment

Pharmaceutical customers were the focus of the research. To determine if incorporating blockchain technology for pharmaceutical OEMs and their suppliers is economically feasible, more research may be necessary. Both pharmaceutical experts were concerned about the feasibility of implementing this technology for pharmaceutical companies. As a result, a full profitability study is necessary because putting a blockchain network into action along the whole supply chain might be challenging. One option for a pilot project would be to examine how a certain medication is implemented and assess how it affects demand. The impact on supply should also be considered to avoid bottlenecks during implementation. This kind of study could find out if and how blockchain technology improves the efficiency of the supply chain and lowers the number of counterfeit drugs.

To obtain more information and reduce risk, more expensive drugs or frequently counterfeited drugs could initially be provided as part of a pilot project. Pharmaceutical companies could test blockchain technology on parts of their products by doing so, instead of having to totally restructure their supply chains. This research would lead to important conclusions about the long-term financial benefits and improvements to supply chains that blockchain technology provides.

## 9. Conclusion

In conclusion, it can be stated that blockchain traceability has an influence on consumer trust when purchasing pharmaceutical goods. However, this influence varied and is dependent on several circumstances. The results of the survey suggested that the trends of sustainability and transparency are gaining in importance for consumers. Participants who believed Transparency and Sustainability were important also tended to have more trust in the medicine with QR code. These findings were confirmed by the literature review and the expert interviews. The PSC is characterized by a high degree of complexity and a wide variety of regulations. It is also challenging to maintain an overview. Implementing blockchain traceability could ensure greater transparency for both consumers and pharmaceutical OEMs. It would also have a

positive impact on the relationship between customers and pharmaceutical companies. In the expert interviews and in the literature review, we discovered that it is important for pharmaceutical companies to ensure transparency. However, this does not correspond with the views of consumers. A large proportion of survey participants stated that transparency and sustainability are not relevant for pharmaceutical companies. This conflict of interest has a negative impact on trust in pharmaceutical companies. It is important to note that pharmacies and doctors are also responsible for consumer trust. However, this conflict of interest could be minimized if a blockchain traceability tool is developed, as consumers would be able to decide on their own and gain more power over their own product decisions. According to SET by Homans, Blau and Emerson, this would have a positive impact on the relationship and increase trust. Consumers could also observe that there is a commitment from the pharmaceutical industry to transparency and compliance during implementation, which also has a positive influence on consumer confidence. Since counterfeit drugs are a problem in developing countries, the advantages of transparency and decentralization (security) of blockchain can also offer customers there a benefit. In this case, consumers have more confidence in purchasing their medicines. However, there are also some challenges that have a negative impact on consumer confidence. One of these challenges is technological acceptance. Senior consumers are the main consumers of medication. It will be difficult to communicate the benefits of the feature and basic understanding to this consumer segment. Age groups 18-24 and 25-34 were the main respondents to the online survey. There were no results from participants older than 54. This must be considered when implementing and considering this research. Nevertheless, there is a trend in consumer desire for transcendence and indulgence. This trend will continue to grow in importance. Blockchain traceability in PSC is one way to respond to the trend and have a positive impact on the consumer behavior and increase consumer trust of future consumers.

## 10. Bibliography

- Archa, Alangot, B., & Achuthan, K. (2018). Trace and Track: Enhanced Pharma Supply Chain Infrastructure to Prevent Fraud. *International Conference on Ubiquitous Communications and Network Computing (218)* (pp. 189-195). SpringerLink.
- Arnum, P. V. (2022, January 20). *Big Pharma and Sustainability: Tracking Companies' Goals*. Retrieved from DCAT: <https://www.dcatvci.org/features/big-pharma-and-sustainability-tracking-companies-goals/>
- Bashir, I. (2017). *Mastering Blockchain*. Birmingham: Packt Publishing.
- Benatia, M. A., Remadna, A., Baudry, D., Halftermeyer, P., & Delalin, H. (2018). QR-Code Enabled Product Traceability System: A Big Data Perspective. *International Conference on Manufacturing Research*, 323 - 328. <https://doi.org/10.3233/978-1-61499-902-7-323>
- Benitez, G. B., Ayala, N. F., & Frank, A. G. (2022). *The Digital Supply Chain - How can SMEs participate successfully in Industry 4.0 ecosystems?* Elsevier. <https://doi.org/10.1016/B978-0-323-91614-1.00019-8>
- Bhutta, M. N., Khwaja, A. A., Nadeem, A., Ahmad, H. F., Khan, M. K., Hanif, M. A., . . . Cao, Y. (2021). A Survey on Blockchain Technology: Evolution, Architecture and Security. *IEEE*, 9, 61048 - 61073. <https://doi.org/10.1109/ACCESS.2021.3072849>
- Bravo, A. M., & Carvalho, J. C. (2015). Challenging times to pharmaceutical supply chains towards sustainability: a case study application. *International Journal of Procurement Management (IJPM)*, 8(1), 126-140. <https://doi.org/10.1504/IJPM.2015.066292>
- Chau, P. Y. (1996). An Empirical Assessment of a Modified Technology Acceptance Model. *Journal of Management Information Systems*, 13(2), 185-204. <https://doi.org/10.1080/07421222.1996.11518128>
- Chen, X., He, C., Chen, Y., & Xie, Z. (2023). Internet of Things (IoT)–blockchain-enabled pharmaceutical supply chain resilience in the post-pandemic era. *Frontiers of Engineering Management*, 10, 82-95. <https://doi.org/10.1007/s42524-022-0233-1>

- Cook, K. S., & Emerson, R. M. (1978). Power, Equity and Commitment in Exchange Networks. *American Sociological Review*, 43(5), 721-739.  
<https://doi.org/10.2307/2094546>
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), 319-340. Retrieved from  
<https://doi.org/10.2307/249008>
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, 35(8), 982-1003. <https://doi.org/10.2307/2632151>
- Dib, O., Brousmiche, K.-L., Durand, A., Thea, E., & Hamida, E. B. (2018). Consortium Blockchains: Overview, Applications and Challenges. *International Journal on Advances in Telecommunications*, 11 (1,2), 51-64.
- Ding, B. (2018). Pharma Industry 4.0: literature review and research opportunities in sustainable pharmaceutical supply chains. *Process Safety and Environmental Protection*, 119, 115-130. <https://doi.org/10.1016/j.psep.2018.06.031>
- Eppinger, E., & Kamprath, M. (2011). Sustainable Business Model Innovation in Personalized Medicine. *R&D, Sustainability & Innovation* (pp. 1-11). Linköping, Sweden: R&D Management Conference. Retrieved from  
<https://ssrn.com/abstract=1978400>
- Francisco, K., & Swanson, D. (2018). The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency. *Department of Marketing & Logistics*, 2(1), 1-13. <https://doi.org/10.3390/logistics2010002>
- Garijo, B. (2017, August 4). Building trust-based relationships in pharma. (G. Nederegger, Interviewer) McKinsey. Retrieved from <https://www.mckinsey.com/industries/life-sciences/our-insights/building-trust-based-relationships-in-pharma>
- Gervais, A., Karame, G. O., Wüst, K., Glykantzis, V., Ritzdorf, H., & Capkun, S. (2016). On the Security and Performance of Proof of Work Blockchains. *CCS '16: Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security* (pp. 3-16). Vienna: ETH Zürich. Retrieved from <https://eprint.iacr.org/2016/555.pdf>

- Ghag, O. M., & Chitre, V. (2019). Blockchain: Comparative Analysis of Public and Private networks. *Conference: International Conferences on Advances in Mathematics, Engineering and Technology*, 6, pp. 13-20. Patna, India: JETIR. Retrieved from <https://www.jetir.org/view?paper=JETIRDC06003>
- Glass, B. D. (2014). Counterfeit drugs and medical devices in developing countries. *Research and Reports in Tropical Medicine*, 5, 11-22. <https://doi.org/10.2147/RRTM.S39354>
- Gouldner, A. W. (1960). The Norm of Reciprocity: A Preliminary Statement. *American Sociological Review*, 25(2), 161-178. <https://doi.org/10.2307/2092623>
- Hanna, B., Xu, G., Wang, X., & Hossain, J. (2023). Blockchain-enabled humanitarian supply chain management: sustainability and responsibility. In K. Mathiyazhagan, V. R. Sreedharan, D. Mathivathanan, & V. S. M, *Blockchain in a Volatile-Uncertain-Complex-Ambiguous World* (pp. 251-276). Elsevier. <https://doi.org/10.1016/B978-0-323-89963-5.00001-0>
- Joshi, A. P., Han, M., & Wang, Y. (2018). A Survey on Security and Privacy Issues of Blockchain Technology. *Mathematical Foundations of Computing*, 1(2), 121- 147. <https://doi.org/10.3934/mfc.2018007>
- King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management*, 43(6), 740–755. <https://doi.org/10.1016/j.im.2006.05.003>
- Kumar, R., & Tripathi, R. (2019). Traceability of counterfeit medicine supply chain through Blockchain. *11th International Conference on Communication Systems & Networks* (pp. 568-570). Bengaluru, India: IEEE. <https://doi.org/10.1109/comsnets.2019.8711418>
- Lambe, C. J., Wittmann, C. M., & Spekman, R. E. (2008). Social Exchange Theory and Research on Business-to-Business Relational Exchange. *Journal of Business-to-Business Marketing*, 8(3), 1-36. [https://doi.org/10.1300/J033v08n03\\_01](https://doi.org/10.1300/J033v08n03_01)
- Lashkari, B., & Musilek, P. (2021). A Comprehensive Review of Blockchain Consensus Mechanisms. *IEEE Access*, 9, 43620 - 43652. <https://doi.org/10.1109/access.2021.3065880>

- Laurence, T. (2019). *Introduction to blockchain technology - The many faces of blockchain technology in the 21st century*. Van Haren Publishing.
- Mackey, T. K., & Liang, B. A. (2011). The Global Counterfeit Drug Trade: Patient Safety and Public Health Risks. *Journal of Pharmaceutical Sciences*, *100*(11), 4571-4579.  
<https://doi.org/10.1002/jps.22679>
- Mahmoud, A. M. (2016). Consumer trust and physician prescription of branded medicines: an exploratory study. *International Journal of Pharmaceutical and Healthcare Marketing*, *10*(3), 285-301. <https://doi.org/10.1108/ijphm-05-2015-0017>
- Marangunic, N., & Granic, A. (2014). Technology acceptance model: a literature review from 1986 to 2013. *Universal Access in the Information Society*, *14*(1), 81–95.  
<https://doi.org/10.1007/s10209-014-0348-1>
- Marucheka, A., Greis, N., Menac, C., & Cai, L. (2011). Product safety and security in the global supply chain: Issues, challenges and research opportunities. *Journal of Operations Management*, *29*(7-8), 707-720. <https://doi.org/10.1016/j.jom.2011.06.007>
- Nguyen, C. T., Hoang, D. T., Nguyen, D. N., Niyato, D., Nguyen, H. T., & Dutkiewicz, E. (2019). Proof-of-Stake Consensus Mechanisms for Future Blockchain Networks: Fundamentals, Applications and Opportunities. *IEEE Access*, *7*, 85727 - 85745.  
<https://doi.org/10.1109/access.2019.2925010>
- Omar, A., Ashraf, J., Atik, K., & Ahmed, A. (2021). A Comparative Study: Blockchain Technology Utilization Benefits, Challenges and Functionalities. *IEEE*, *9*, 12730 - 12749. <https://doi.org/10.1109/access.2021.3050241>
- Paffen, R. (2023, November 03). Sustainability in the pharmaceuticals and life sciences industry. PwC. Retrieved from <https://www.pwc.de/en/sustainability/sustainability-in-the-pharmaceuticals-and-life-sciences-industry.html>
- Park, A., & Li, H. (2021). The Effect of Blockchain Technology on Supply Chain Sustainability Performances. *Sustainability*, *13*(4), 1-18.  
<https://doi.org/10.3390/su13041726>

- Petty, C. (2018, February 27). *Gartner Top 8 Supply Chain Technology Trends for 2018*. Retrieved from Gartner: <https://www.gartner.com/smarterwithgartner/gartner-top-8-supply-chain-technology-trends-for-2018>
- Preindl, R., Nikolopoulos, K., & Litsiou, K. (2020). Transformation strategies for the supply chain: the impact of industry 4.0 and digital transformation. *Supply Chain Forum: An International Journal*, 21(1), 26-34. <https://doi.org/10.1080/16258312.2020.1716633>
- Reh, G., Ronte, H., Gupta, L., & Varia, H. (2021, May 06). Overcoming biopharma's trust deficit - Why people mistrust the biopharma industry—and what to do about it. Deloitte. Retrieved from <https://www2.deloitte.com/xe/en/insights/industry/life-sciences/trust-in-biopharmaceutical-companies-covid.html>
- Rejikumar, G., Asokan, A. A., & Kumar, G. V. (2018). Pharmaceutical Marketing: Directions for Customer Orientation. *Research Journal of Pharmacy and Technology*, 11, 3283-3289. <https://doi.org/10.5958/0974-360X.2018.00604.2>
- Rice, W. R. (1989). Analyzing Tables of Statistical Tests. *Evolution*, 43(1), 223-225. <https://doi.org/10.1111/j.1558-5646.1989.tb04220.x>
- Sanyal, S. N., & Datta, S. K. (2011). The effect of country of origin on brand equity: an empirical study on generic drugs. *Journal of Product & Brand Management*, 20(2), 130-140. <https://doi.org/10.1108/10610421111121125>
- Seebacher, S., & Schüritz, R. (2017). Blockchain Technology as an Enabler of Service Systems: A Structured Literature Review. *International Conference on Exploring Services Science* (pp. 12-23). Lecture Notes in Business Information Processing. [https://doi.org/10.1007/978-3-319-56925-3\\_2](https://doi.org/10.1007/978-3-319-56925-3_2)
- Sharma, A., Kaur, J., & Singh, I. (2020). Internet of Things (IoT) in Pharmaceutical Manufacturing, Warehousing, and Supply Chain Management. *SN Computer Science*, 1(4), 1-10. <https://doi.org/10.1007/s42979-020-00248-2>
- Sheth, J. N., Sethia, N. K., & Srinivas, S. (2020). Mindful consumption: a customer-centric approach to sustainability. *Journal of the Academy of Marketing Science*, 39(1), 21-39. <https://doi.org/10.1007/s11747-010-0216-3>

- Singh, R. K., Kumar, R., & Kumar, P. (2016). Strategic issues in pharmaceutical supply chains: a review. *International Journal of Pharmaceutical and Healthcare Marketing*, 10(3), 1-24. <https://doi.org/10.1108/ijphm-10-2015-0050>
- Straub, D., Keil, M., & Brenner, W. (1997). Testing the technology acceptance model across cultures: A three country study. *Information & Management*, 33(1), 1-11. [https://doi.org/10.1016/s0378-7206\(97\)00026-8](https://doi.org/10.1016/s0378-7206(97)00026-8)
- Subramanian, G., Sreekantanthampy, A., Valbosco, N., & Ramnani, B. (2021). Crypto Pharmacy – Digital Medicine: A Mobile Application Integrated With Hybrid Blockchain to Tackle the Issues in Pharma Supply Chain. *IEEE Open Journal of the Computer Society*, 2, 26-37. <https://doi.org/10.1109/ojcs.2021.3049330>
- Sumathi, D., Poongodi, T., Balusamy, B., Himani, B., & P, F. K. (2021). *Convergence of Blockchain Technology and E-Business: Concepts, Applications, and Case Studies*. Boca Raton: CRC Press. <https://doi.org/10.1201/9781003048107>
- Szabó-Geletóczki, R., Kozma, T., & Pónusz, M. (2023). Market Changes in the Pharmaceutical Industry. *Acta Universitatis Sapientiae European and Regional Studies*, 22(1), 50-72. <https://doi.org/10.2478/auseur-2022-0009>
- Taylor, R. (1990). Interpretation of the Correlation Coefficient: A Basic Review. *Journal of Diagnostic Medical Sonography*, 6(1), 35-39. <https://doi.org/10.1177/875647939000600106>
- Uddin, M., Salah, K., Jayaraman, R., Pesic, S., & Ellahham, S. (2021). Blockchain for drug traceability: Architectures and open challenges. *Health Informatics Journal*, 27(2), 1-15. <https://doi.org/10.1177/14604582211011228>
- Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model. *Information Systems Research*, 11(4), 342-365. <https://doi.org/10.1287/isre.11.4.342.11872>
- Wang, Q., Huang, J., Wang, S., Chen, Y., Zhang, P., & He, L. (2020). A Comparative Study of Blockchain Consensus Algorithms. *Journal of Physics: Conference Series*, 1437(012007), 1-7. <https://doi.org/10.1088/1742-6596/1437/1/012007>

- Yaga, D., Mell, P., Roby, N., & Scarfone, K. (2018). *Blockchain Technology Overview*. National Institute of Standards and Technology Internal Report, 8203. <https://doi.org/https://doi.org/10.6028/NIST.IR.8202>
- Yang, R., Wakefield, R., Lyu, S., Jayasuriya, S., Han, F., Yi, X., . . . Chen, S. (2020). Public and private blockchain in construction business process and information integration. *Automation in Construction, 118*, 1-21. <https://doi.org/10.1016/j.autcon.2020.103276>
- Yao, W., Deek, F. P., Murimi, R., & Wang, G. (2023). SoK: A Taxonomy for Critical Analysis of Consensus Mechanisms in Consortium Blockchain. *IEEE, 11*, 79572 - 79587. <https://doi.org/10.1109/ACCESS.2023.3298675>
- Yiu, N. C. (2021). Decentralizing Supply Chain Anti-Counterfeiting and Traceability Systems Using Blockchain Technology. *Future Internet, 13*(4), 1-33. <https://doi.org/10.3390/fi13040084>
- Zakari, N., Al-Razgan, M., Alsaadi, A., Alshareef, H., Saigh, H. A., Alashaikh, L., . . . Alotaibi, S. (2022). Blockchain technology in the pharmaceutical industry: a systematic review. *PeerJ Computer Science, 1*-26. <https://doi.org/10.7717/peerj-cs.840>

# 11. Appendices

## 11.1 Appendix A: Figures and tables

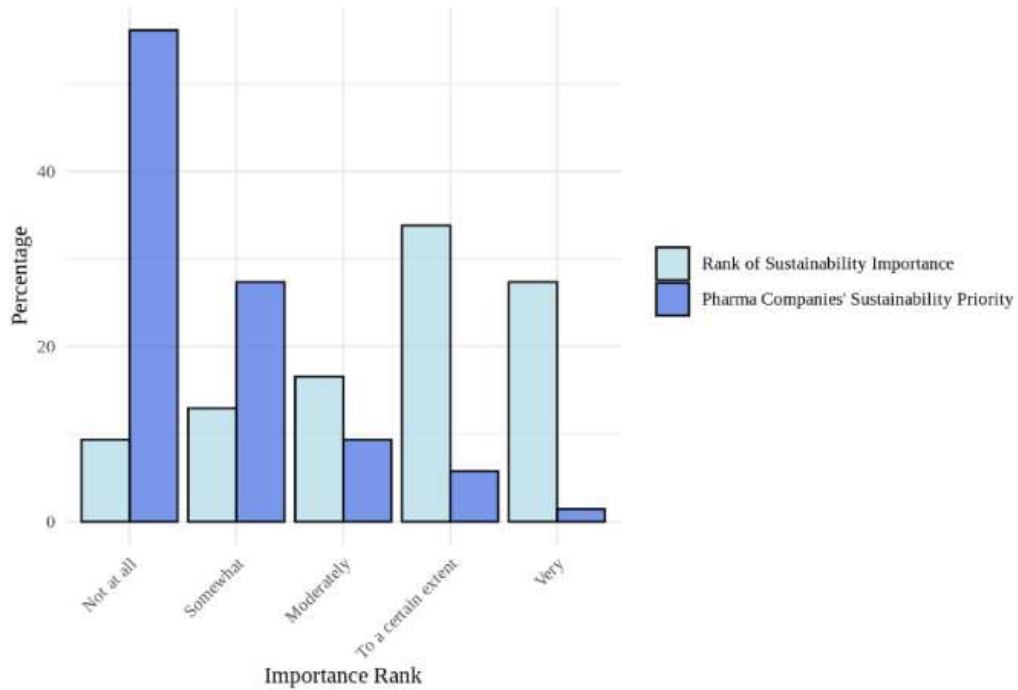


Figure 12: Importance of Sustainability in Medication Purchase

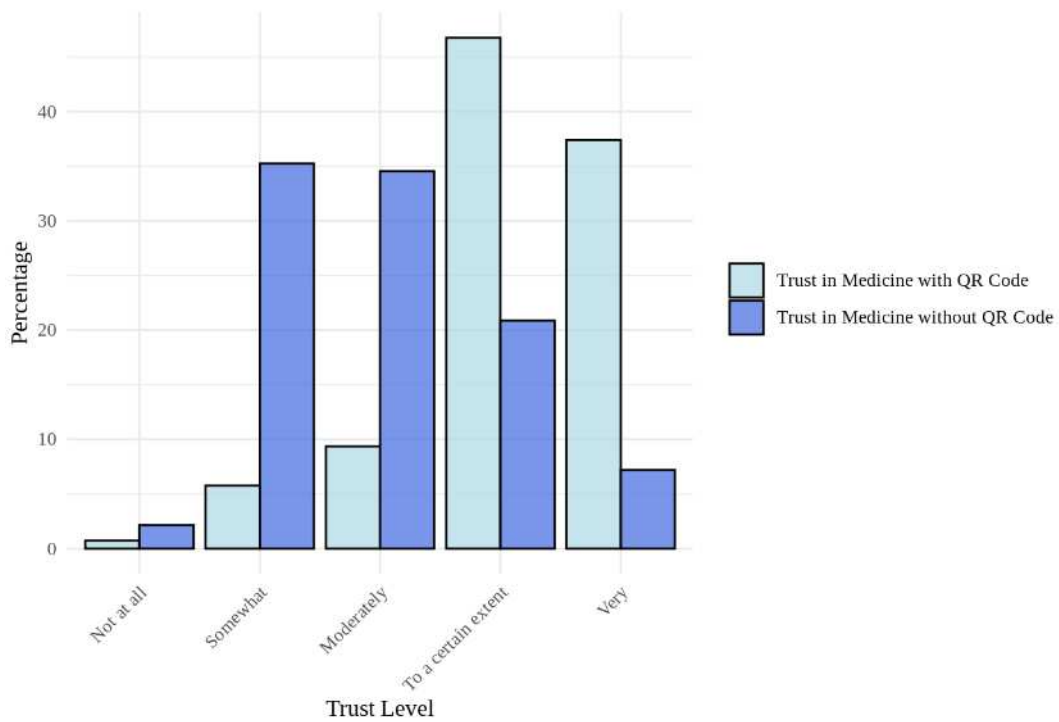


Figure 13: Trust in Medicine with or without QR Code

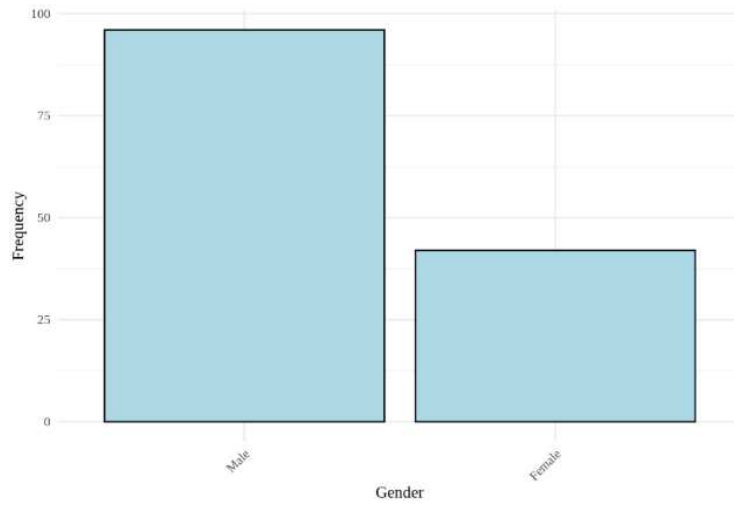


Figure 14: Gender Distribution

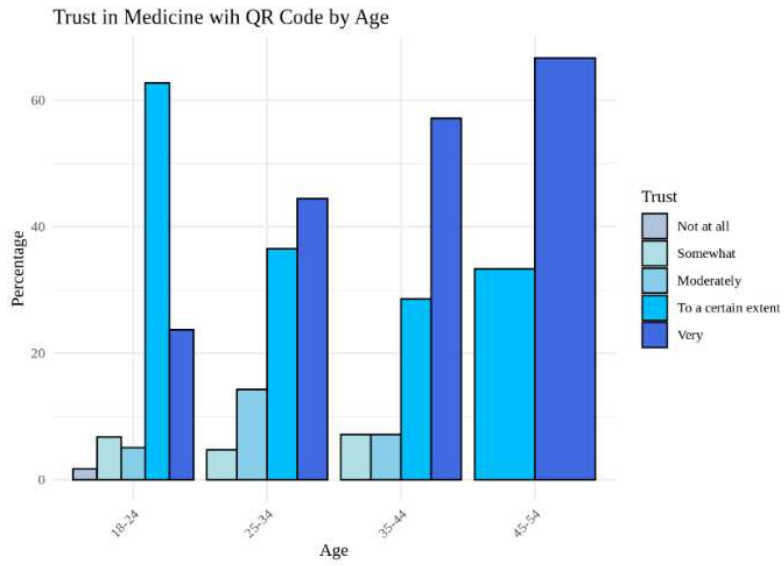


Figure 15: Trust with QR Code by Age

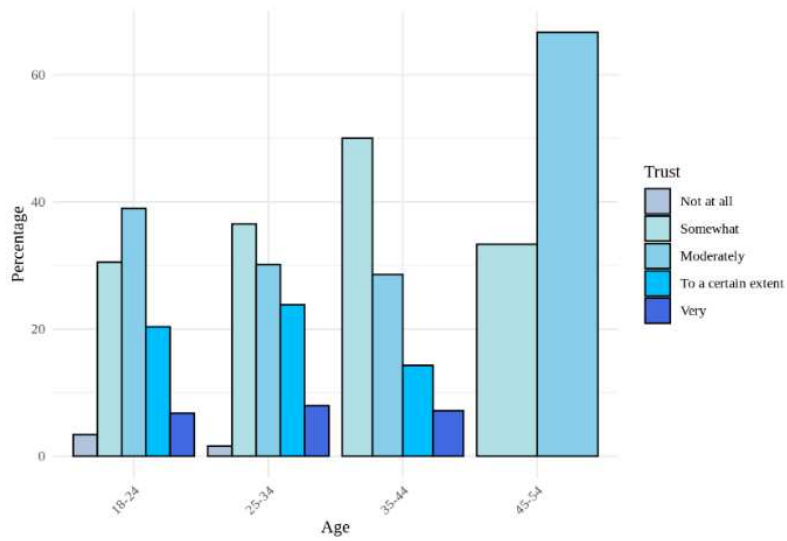


Figure 16: Trust without QR Code by Age

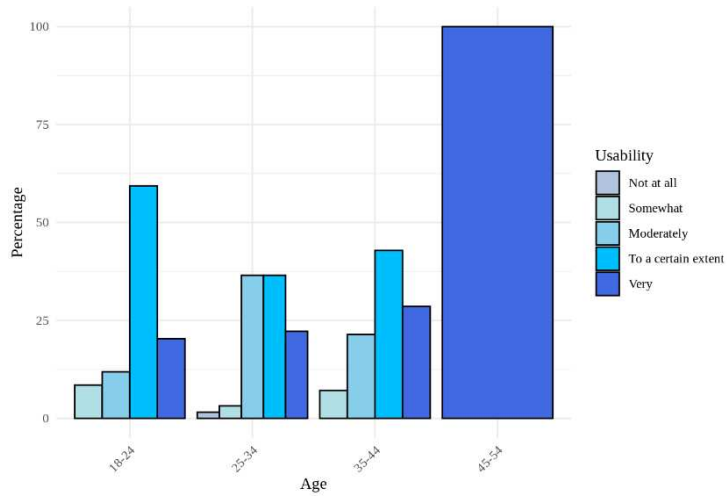


Figure 17: Usability Beliefs on QR Code Feature by Age

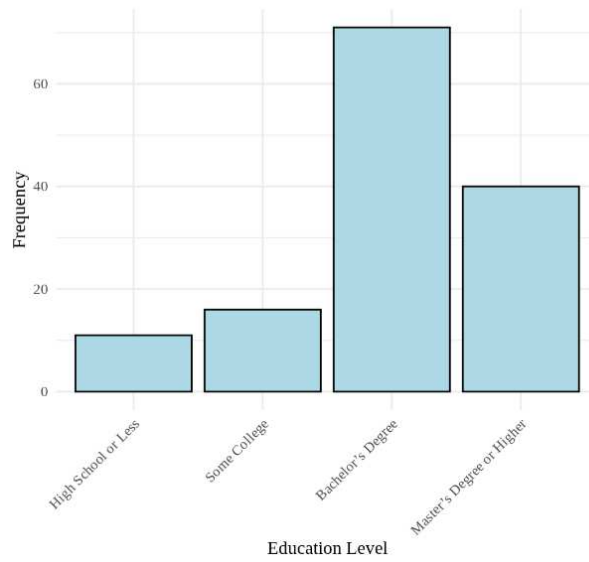


Figure 18: Education Distribution

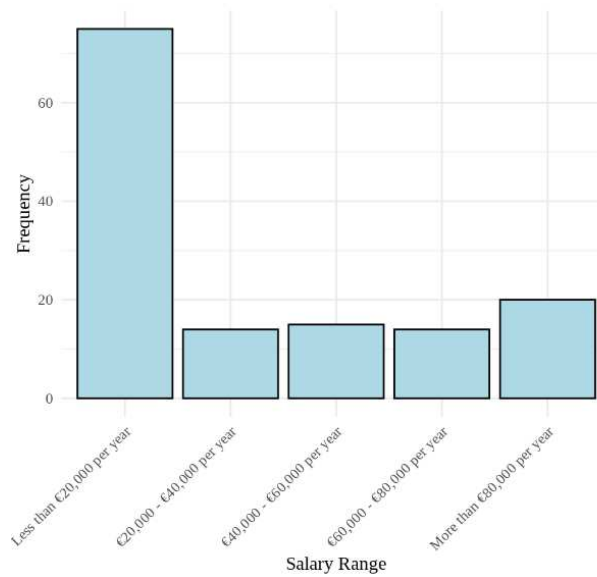


Figure 19: Salary Distribution

## 11.2 Appendix B: Survey Overview

12/28/23, 3:57 AM

Qualtrics Survey Software

### Introduction

Dear Participant,

Thank you for joining my study, part of my Master's thesis in International Management at the Católica Lisbon School of Economics. Your perspectives on how blockchain influences consumer trust in pharmaceuticals are crucial.

This survey will take approximately 5 minutes to complete. Completing this survey ensures that your insights contribute confidentially to valuable research. Participation is voluntary, and your choice not to participate is respected.

For questions or comments, contact me at [s-pjamali@ucp.pt](mailto:s-pjamali@ucp.pt).

Your time and insights are highly valued. Thank you for participating.

Pedram Jamali

---

Welcome to my blockchain study!

Blockchain, a revolutionary decentralized ledger, has the potential to transform pharmaceutical supply chains. This survey explores the benefits of blockchain, focusing on your perceptions of its impact on consumer trust.

Imagine transparent medication traceability, empowering you with real-time information on authenticity, sustainability, and quality. Your insights are invaluable in revealing the transformative impact of blockchain on trust in the pharmaceutical industry.

Thank you for being a part of this exploration!

### Section 1: Demographics

What is your age?

- Under 18
- 18-24
- 25-34

- 35-44
- 45-54
- 55-64
- 65 or older

What is your gender?

- Male
- Female
- Non-binary
- Prefer not to say

What is your highest level of education?

- High School or Less
- Some College
- Bachelor's Degree
- Master's Degree or Higher

## Block 1

### Section 2: Introduction

How familiar are you with the concept of blockchain technology?

- Not at all
- Somewhat
- Moderately
- To a certain extent
- Very

Have you ever heard of or used blockchain technology in the context of pharmaceutical product traceability?

- Yes
- No

Please rate on a scale from 1 (not at all) to 5 (very).

|  | Not at all            | Somewhat              | Moderately            | To a certain extent   | Very                  |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Do you think that pharmaceutical products are of inferior quality?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Do you believe that problems in the supply chain could arise due to information flow issues?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Do you believe that digital technologies can improve the customer experience?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Would you say that counterfeit medicines could be a problem in industrialized countries?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Would you say that counterfeit medicines could be a problem in developing countries?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Do you believe that a secured platform that can be accessed by everyone, from production to the customer, is beneficial in terms of product quality? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Block 2**

**Section 3: Customer Experience**

How often do you use medications?

- Rarely (Once a year or less)
- Occasionally (Several times a year)
- Monthly (Once a month)
- Weekly (Once a week)
- Daily (Every day)

Choose Option X if you pay attention

- Option X
- Option Y
- Option Z

Please rate on a scale from 1 (not at all) to 5 (very).

|  | Not at all            | Somewhat              | Moderately            | To a certain extent   | Very                  |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| How important is knowing the source and traceability of pharmaceutical products to you when making a purchase decision?            | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| How often have you encountered concerns or doubts about the authenticity or quality of pharmaceutical products?                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Please rank the importance of sustainability when purchasing your medication.  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| To what extent do you think pharmaceutical companies prioritize sustainability, from production to the delivery of their products? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Please rank the importance of transparency when purchasing your medication.  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| To what extent do you think pharmaceutical companies prioritize transparency, from production to the delivery of their products?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

|   |                       |                       |                       |                       |                       |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|   | Not at all            | Somewhat              | Moderately            | To a certain extent   | Very                  |
| To what extent do pharmaceutical companies wield influence in their relationships with customers? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Block 3**

**Section 4: Scenario**

You purchase a medication at a pharmacy. The salesperson informs you that by scanning a QR code, you can access all information from the production site to the delivery of the medication. This includes details about the production location, available sustainability certificates, and comprehensive information about the quality of the medication. You can be confident that the information displayed in the system is verified and accurate.

Now, you are faced with a choice between two medications. Medication 1 is equipped with a scannable QR code, allowing you to transparently access all details. Medication 2 does not have a QR code, but the pharmacist assures you that it is also effective.

The price range for this type of medication is, on average, between 40 and 70 euros. The reason for this is the costly manufacturing process, and the resources used must meet high-quality standards.

How much would you be willing to pay?

|                                    |   |    |    |    |    |    |    |    |    |    |    |
|------------------------------------|---|----|----|----|----|----|----|----|----|----|----|
|                                    | 30  | 36 | 42 | 48 | 54 | 60 | 66 | 72 | 78 | 84 | 90 |
| Value in Euros (€)                 |   |    |    |    |    |    |    |    |    |    |    |
| Medicine with scannable QR code    | <input style="width: 100%; height: 20px;" type="text"/> |    |    |    |    |    |    |    |    |    |    |
| Medicine without scannable QR code | <input style="width: 100%; height: 20px;" type="text"/> |    |    |    |    |    |    |    |    |    |    |

Please respond to the following questions, indicating 1 for very unlikely and 5 for very likely.

|   | Not at all            | Somewhat              | Moderately            | To a certain extent   | Very                  |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Do you have trust in Medicine 1?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Do you have trust in Medicine 2?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Do you believe this add on feature would be usable?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Do you believe that this feature could have a positive impact on transparency and sustainability? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Do you believe this add on feature would be usable for older people?                              | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Please rate your likelihood of paying a premium for such pharmaceutical products.                 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Block 4**

**Section 5: Additional Comments**

What is your nationality?

- Germany
- Austria
- France
- Portugal
- Other

What is your salary?

- Less than €20,000 per year
- €20,000 - €40,000 per year
- €40,000 - €60,000 per year
- €60,000 - €80,000 per year
- More than €80,000 per year

Please share any additional comments or thoughts you have about pharmaceutical product traceability and customer trust

Powered by Qualtrics

### 11.3 Appendix C: Expert Interview Questions

*Assumption: “Assume consumers can scan QR codes on medication packaging with their smartphones. Key information about materials, emissions, and transactions are transparently published on a public blockchain accessible to both suppliers and customers and are cryptographically protected.”*

#### 1. Customer Benefits from Implementing Blockchain

Question: “How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?”

#### 2. Challenges in Global Pharmaceutical Supply Chains

Question: “What are the challenges in global pharmaceutical supply chains?”

#### 3. Importance of Transparency in the Pharmaceutical Supply Chain

Question: “How crucial is transparency within the pharmaceutical supply chain, and why?”

#### 4. Blockchain Impact on Sustainability and Transparency in Pharma Products

Question: “How can this feature support sustainability and transparency in the pharmaceutical products?”

#### 5. Trust in Pharmaceuticals: Developing vs. Industrialized Countries

Question: “Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?”

#### 6. Challenges in Implementing Additional Features

Question: “Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?”

#### 7. Utility of the Add-on Feature for Customers

Question: “How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?”

#### 8. Impact of Add-On Features on Consumer Trust

Question: “Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?”

#### 9. Higher Pricing for because of higher trust

Question: “Do you think Consumers would pay more for this add-on feature, why would they pay more?”

#### 10. Relationship Between Pharma Companies and Consumers

Question: “How would you evaluate the relationship between pharmaceutical companies and their consumers?”

#### 11. Technology Acceptance of Blockchain Feature

Question: “How would you assess the acceptance of the technology for this feature among consumers?”

### 11.4 Appendix D: Summary Expert 1

#### 1. Question: “How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?”

*With this kind of technology, they can have a transparent platform, so I see how there would be some advantages. However, I am unsure if pharmaceutical OEMs could use any better technologies.*

#### 2. Question: “What are the challenges in global pharmaceutical supply chains?”

*Different raw materials are used to make different products. It might be difficult to track down each source. Furthermore, there are many regulations in the supply chain, making it an extremely complex supply chain.*

#### 3. Question: “How crucial is transparency within the pharmaceutical supply chain, and why?”

*Very important because regulations impacting the supply chain. In addition to establishing confidence and ensuring patient safety, it's important to comply to the regulations. We take responsibility for the health of people, which is why we value transparency in our products so highly.*

4. Question: “How can this feature support sustainability and transparency in the pharmaceutical products?”

*It may be advantageous for the industry. I know that other technologies also have a major impact on this industry. Consumers won't understand the meaning of blockchain technology or its features. especially those customers who are less tech savvy or older. Other technologies are already being used by us to guarantee sustainability and transparency. Why should blockchain be relevant for our consumers?*

5. Question: “Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?”

*Without a doubt. In my opinion, the trust for the efficacy and legitimacy of a certain medication is very high in industrialized countries. In developing countries on the other hand, issues including the growing number of counterfeit pharmaceuticals, fake labels and altered expiration dates have an impact of the trustworthiness of the product. But I also think that this is the main issue for medication sold on the black market and nonofficial distributors.*

6. Question: “Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?”

*To be honest, I see quite a few challenges for the implementation of this technology. It is a challenge to get every single participant of a complex supply chain, spanning multiple countries and cultures, to implement this technology without skipping any step in the supply chain. Since the transparency is only given if every step of the whole process is documented and verified, starting at the sourcing of raw materials, continuing with the production of the medication, up to the final distribution. I do think that all this is possible, but I cannot imagine how this could be implemented without adding a high cost for production and consumers. And the added cost makes this product less appealing than competing products, especially in developing countries where this feature would bring the most benefit.*

7. Question: “How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?”

*Honestly, I do not see any practical utility for of this technology for customers in developed countries. Developing countries on the other hand, could benefit from this feature as mentioned before.*

8. Question: “Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?”

*Sure, blockchain traceability may have a positive impact on customer trust. Customers could increase their trust about the quality and safety of their prescriptions by offering a record of the medical goods journey. However, I think the current trust of consumers is already high in company’s brands, that are associated with good quality.*

9. Question: “Do you think Consumers would pay more for this add-on feature, why would they pay more?”

*I do not think that Consumers are willing to pay more for this feature. I assume that only few people will pay a premium price for this feature. They are more likely to get consultant by a pharmacist or doctor. This would be a lot more convenience for our customers. Especially older people that do not understand the benefits of this feature.*

10. Question: “How would you evaluate the relationship between pharmaceutical companies and their consumers?”

*The relationship is good. You must consider that our main consumers are distributors such as pharmaceutical wholesalers. They then distribute our medicines. I assume that you mean trust with the end consumer. The number of products we sell has been constantly growing since the Covid-19 pandemic. Accordingly, I assume that the relationship is quite good.*

11. Question: “How would you assess the acceptance of the technology for this feature among consumers?”

*I'm not sure how the acceptance will be. Acceptance will depend heavily on the simplicity of the feature. I don't think users will understand the benefits of this feature. All they see is a user interface with information on it. To be able to evaluate the acceptance of this technology, it would be useful to first concretize the idea in detail.*

## 11.5 Appendix E: Summary Expert 2

1. Question: “How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?”

*It sounds like blockchain could bring some benefits. However, I feel that experts would need to look on it and work on a solution. I do have some doubts about whether this will be so relevant for customers.*

2. Question: “What are the challenges in global pharmaceutical supply chains?”

*An important communication difficulty in the supply chain is getting information from raw material suppliers to the final consumer. Another challenge to overcome is the existence of stringent restrictions. Those regulations change over time, and it is quite difficult to monitor those and stay compliant.*

3. Question: “How crucial is transparency within the pharmaceutical supply chain, and why?”

*Transparency is important for regulatory compliance and customer trust. If transparency can improve the trust and show the quality of our products it is of course more important to focus on that and improve it.*

4. Question: “How can this feature support sustainability and transparency in the pharmaceutical products?”

*I am not sure how it can support sustainability. Maybe when it comes to including the whole supply chain and showing where everything comes from – this is getting more important every day. But in case of transparency, I believe that by being able to scan the QR code and looking at the whole supply chain and as I mention where everything comes from, this will increase transparency for consumers that care about it.*

5. Question: “Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?”

*I believe there are differences when people from developed countries purchase drugs in developing countries. I don't think this applies to those who come from developing countries. The goods we sell in less developed countries have the same quality. Our products are under strict rules and regulations.*

6. Question: “Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?”

*The challenge will be to implement it in existing systems. And of course, looking at it from a pharmaceutical perspective my main question is how much this will cost. There must be a need for us to invest our money in it and gain benefit from it.*

7. Question: “How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?”

*Millennials and Gen Zs are probably more open to use that. Or tech enthusiast in general. But I am honestly not sure about others. Especially elderly people will probably not see a need for that or struggle when using it.*

8. Question: “Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?”

*Similar to what I said before, I think this could increase the trust. Companies could benefit when they do their due diligence. We should also consider that there are different technologies that can be used. I am not sure if blockchain is the right one.*

9. Question: “Do you think Consumers would pay more for this add-on feature, why would they pay more?”

*Maybe younger generations or people who are super cautious about and interested in everything. It could be like some of the coffee products nowadays where you’re able to track where the product is coming from. But this is also only for a certain kind of people. I am not sure if this is going to be interesting for everyone and especially if that many people will pay for it.*

10. Question: “How would you evaluate the relationship between pharmaceutical companies and their consumers?”

*Based on the supply of secure and efficient drugs, the relationship is typically solid. This is why the questions should be asked if this feature could enhance it much more. I assume it also depends on the brand of the company. In Germany most of the people have a high level of trust.*

11. Question: “How would you assess the acceptance of the technology for this feature among consumers?”

*The acceptance will in my understanding be high since they'll be able to scan the QR code or ignore it. Nothing much will change for the customers. I am not sure if there will be an acceptance for older people. I am sure this would be the biggest challenge.*

## 11.6 Appendix F: Summary Expert 3

1. Question: “How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?”

*I believe there are many ways for customers to benefit from the implementation of blockchain. One benefit is for sure the transparency of this feature. This isn't only regarding counterfeit medicine but also medicine where the best before day is adjusted to be able to sell medicine for a longer period of time.*

2. Question: “What are the challenges in global pharmaceutical supply chains?”

*Regulatory issues are certainly challenges that pharmaceutical companies have to deal with. This could be a major challenge, especially with the large number of transactions. If pharmaceutical companies do not comply with the certain regulations, they could face penalties. Apart from this, the lack of transparency is certainly also a challenge in complex supply chains.*

3. Question: “How crucial is transparency within the pharmaceutical supply chain, and why?”

*Transparency is always crucial, especially in the health industry, and it is becoming more crucial every day. We can see that customers are more interested to find out where certain products are coming from, and I am sure that with proper digital tools and technologies everyone in the supply chain is able to benefit from it immensely.*

4. Question: “How can this feature support sustainability and transparency in the pharmaceutical products?”

*Especially nowadays it would be possible to also use AI to find out how to distribute the medicine best and allocate it depending on the needs, one example is looking at the COVID vaccines which went above the date and had to be thrown away. If we would be able to reduce the waste in this area, this would already be a huge success.*

5. Question: “Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?”

*Yes, 100%. While I would argue that we do have much better regulations in the Global North, I assume – also from what I read – that the Global South is struggling more with counterfeit medicines and distrust. Trust would definitely be increased with this kind of solution.*

6. Question: “Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?”

*I see the main challenge in bringing all respective parties to the table and implementing a solution which fits all and is cost efficient. The context also depends, since certain companies would have more budget available for these kind of efforts while others would probably face other challenges. One example would be looking at the Global North and the Global South. It would be crucial to look at the needs and to find technologies which fit and meet the needs for the solution best.*

7. Question: “How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?”

*The usage depends highly on the target group. I assume young people who are digitally more literate would be able and interested to scan the QR code. Others, probably older customers, would probably be less interested or able to use the feature. I would suggest that this will be piloted somewhere with an experiment to find out how practical this would be.*

8. Question: “Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?”

*Blockchain technology already proved that trust was enhanced in various areas. The whole idea of blockchain is to increase the trackability and increase the trust, in the beginning especially for the financial sector with Bitcoin, and nowadays also in various other areas where you'd like to prove that the existing data is unmanipulable.*

9. Question: “Do you think Consumers would pay more for this add-on feature, why would they pay more?”

*I guess this depends mainly on the pain points. I believe there are a few people that would be willing to pay more for the feature. This however must be in balance with the competitive price. But in countries where trust is low, I am sure consumers would be happy to pay more just to be sure what they are buying in the end.*

10. Question: “How would you evaluate the relationship between pharmaceutical companies and their consumers?”

*I feel the relationship is ambivalent. In my circle I would say that the trust in pharmaceutical companies is rather high when it is about the medicine which is bought. Apart from that, people tend to think lobbying is mainly responsible for how often certain medicine will be recommended.*

11. Question: “How would you assess the acceptance of the technology for this feature among consumers?”

*I feel the relationship is ambivalent. In my circle I would say that the trust in pharmaceutical companies is rather high when it is about the medicine which is bought. Apart from that, people tend to think lobbying is mainly responsible for how often certain medicine will be recommended.*

## 11.7 Appendix G: Summary Expert 4

1. Question: “How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?”

*Blockchain technology offers consumers and the pharmaceutical industry transparency and ensures that data is stored securely. This could also influence the quality of the products. Consumers can also obtain information about their products in real time. The blockchain technology can be used in various areas of the supply chain and automate processes. It could therefore also protect against potential product shortages.*

2. Question: “What are the challenges in global pharmaceutical supply chains?”

*I have to be honest and admit that I am not very familiar with the pharmaceutical supply chain. Companies with global supply chains often have the issue that their products must go through duties and certain regulations. These regulations can also change over time. Also, communication within pharmaceutical supply chains could be a major challenge.*

3. Question: “How crucial is transparency within the pharmaceutical supply chain, and why?”

*Data quality and data management play a major role for such large companies. Transparency is necessary to ensure security and trust in the supply chain. Pharmaceutical companies must ensure that all transactions are stored and can be tracked. Blockchain technology can offer*

*great benefits here. I am sure that transparency will become increasingly important and relevant. At least this can be seen in other industries.*

4. Question: “How can this feature support sustainability and transparency in the pharmaceutical products?”

*One of the features of blockchain is the great transparency it offers. This feature could also be of great value when monitoring suppliers in their complex supply chain. In a complex supply chain, blockchain is an effective instrument that could be used to monitor suppliers to make sure they are acting in a sustainable way. I am sure that this technology has a lot of potential and will be seen more often in industries in the future.*

5. Question: “Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?”

*Personally, I don't like taking pharmaceutical products. I take them only when I need to. In general, my confidence is not very high. However, I know many people who take medication without hesitation. However, I think that the quality of medication in developing countries is lower because there may be different regulations. If we look at the trust in purchasing in developing countries, there could be a lot of uncertainties.*

6. Question: “Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?”

*Integration into the existing IT infrastructure is the most difficult part. All participants in this additional function need to understand the value that can be created. But I am sure that the implementation can be successful, and that consumers and companies will recognize the great value of transparency.*

7. Question: “How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?”

*I am quite sure that the implementation of the feature can be beneficial for users. As far as I know, there are already studies and application examples that are researching a similar feature in pharma. Blockchain offers users a security and authenticity of their medication that no other technology offers.*

8. Question: “Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?”

*As I said before, blockchain is known as a transparent, secure and decentralized network. I am sure that the implementation of this feature will lead to more trust among consumers of medicines. But it is crucial that consumers have an understanding of the security and transparency offered to them by this technology.*

9. Question: “Do you think Consumers would pay more for this add-on feature, why would they pay more?”

*Personally, I still wouldn't buy the products. But I am sure a lot of people would pay more for it. I think this feature will only make a difference if we know that the information in the blockchain is valid and monitored by third parties. Otherwise, the pharmaceutical companies could change the information if they implement a private blockchain.*

10. Question: “How would you evaluate the relationship between pharmaceutical companies and their consumers?”

*I don't think there is a direct relationship between them. The pharmaceutical companies produce the medicines for their customers and the pharmacies sell them. Personally, I have little trust in pharmaceutical companies. But if companies offer good medicines at fair prices and talk openly about risks, then they can build a good relationship with their customers.*

11. Question: “How would you assess the acceptance of the technology for this feature among consumers?”

*Consumer acceptance will increase as the benefits of this function become clear and companies implement it in a user-friendly way. It is very important to communicate the increased security and transparency of the feature. Consumers will not accept a technology if they don't understand it.*

## 11.8 Appendix H: Summary Expert 5

1. Question: “How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?”

*Customers can greatly benefit from the transparency that blockchain technology can provide. I believe that transparency is a significant and prevalent trend seen across numerous industries,*

*holding great importance. In addition, Blockchain has the potential to enhance security in storing transaction data. I am sure that it also has an influence on product quality by ensuring that the product's quality is validated.*

2. Question: “What are the challenges in global pharmaceutical supply chains?”

*In my previous project, we saw that data management is a big challenge. Especially when we need data from 3PL or 4PL. The problem with poor data management is that it can lead to problems in the pharma supply chain. For example, warehouse costs can increase. Some products need to be transported in compliance with temperature requirements, otherwise the product could be damaged. It is difficult to get an overview of the global supply chain for pharmaceutical companies and an overview of their regulations.*

3. Question: “How crucial is transparency within the pharmaceutical supply chain, and why?”

*It is very important. It is not only important for customers but also for the Companies to have an overview of the processes in the Supply Chain. Otherwise, companies might get penalties, when they don't consider any regulations.*

4. Question: “How can this feature support sustainability and transparency in the pharmaceutical products?”

*I believe that this feature has the potential to significantly enhance transparency and sustainability by closely monitoring the whole lifespan of the product. For instance, it may provide authenticated information on the source of resources, ensuring that they are acquired in an ethical and sustainable manner. If this function is well incorporated, it has the potential to provide several advantages for customers.*

5. Question: “Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?”

*There is actually a big difference, which is mostly caused by things like the fact that high-quality drugs might be limited, and fake drugs are common in some places. A general lack of trust may exist after what happened during COVID-19. However, if consumers would go to a pharmacy in an industrialized country, I assume they would have a higher level of trust compared to in developing countries.*

6. Question: “Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?”

*Adding this feature will not be easy for several reasons. If a pharmaceutical company wants to add this feature to their supply chain, everyone else in the chain must follow. They might have trouble with this if they don't have the right IT infrastructure. It's possible to make it happen, but drug companies need other businesses to help them figure out the best way to do it.*

7. Question: “How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?”

*As I said before, this function could be useful, especially for people who aren't sure where the goods came from. People in developing nations who want to be sure the medicine is real could use this function to feel safer. A good strategy to realize this idea could have a great benefit on consumer.*

8. Question: “Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?”

*Transparency is one of the things that makes Blockchain unique. When this feature is put into use, I'm sure that people who buy medicines will trust it more. Even though everyone in the Blockchain must agree that the info in it is correct. For people who know what a blockchain is, this technology could make them trust businesses more. I think that most people don't know what it means, which is a shame.*

9. Question: “Do you think Consumers would pay more for this add-on feature, why would they pay more?”

*I would be willing to pay more for this benefit. When I'm in a developing country and need drugs, it would make me feel safer. Simply because of the transparency, I would pay a higher price. I'm sure that the amount of trust in Germany relies on the people who use the tool and that a lot of them see benefits if it works. It is important to make sure that these benefits are offered to all customers, not just those who can pay more.*

10. Question: “How would you evaluate the relationship between pharmaceutical companies and their consumers?”

*I believe the relationship between drug companies and people who use their products is complicated. Research and development, government agencies that protect customers, and high drug costs are all parts of this relationship. Doctors and pharmacists' opinions also play a big role in how confident customers are.*

11. Question: “How would you assess the acceptance of the technology for this feature among consumers?”

*I think that over time, more people are going to accept it. There needs to be clear communication about the benefits of this technology, though. It's also important that the app is very easy to use so that even older people who aren't good with technology can do it. Getting rid of doctors and pharmacists influence will be challenging.*

### 11.9 Appendix I: Summary Expert 6

1. Question: “How can customers benefit from the implementation of blockchain in the pharmaceutical supply chain?”

*People can gain from the blockchain's transparency. In various areas of the supply chain, blockchain technology can be used. Smart contracts can be used to simplify even the processes related to a transaction. People can also find out where their drugs come from with track and trace technology.*

2. Question: “What are the challenges in global pharmaceutical supply chains?”

*It is challenging to make sure that the medications are of good quality when the supply chains are so complex. One more thing that could be challenging is keeping certain medications cool. Logistics are also very hard to handle because the medications are brought in from different countries and need to be kept in particular ways.*

3. Question: “How crucial is transparency within the pharmaceutical supply chain, and why?”

*Transparency is very important. As I have just mentioned, many different companies from different countries are involved in the pharma supply chain. Greater transparency is very important in such complex supply chains to save costs and be compliant.*

4. Question: “How can this feature support sustainability and transparency in the pharmaceutical products?”

*Without a doubt, this feature is beneficial for the sustainability and transparency of medicine. The most important data can be viewed, and pharmaceutical companies could also position themselves more sustainably. It enables the monitoring of product ethical sourcing as well as environmental consequences.*

5. Question: “Do you think the level of consumer trust in purchasing pharmaceuticals differs between developing and industrialized countries?”

*I am very sure that there are different levels of trust. In industrialized countries, there are often strict controls and regulations that have a positive influence on consumer trust. This increases chances of not taking high-quality medicines in developing countries, or even coming across counterfeit medicines.*

6. Question: “Could you discuss any potential obstacles or challenges in implementing this additional feature in the pharmaceutical context?”

*Getting new technology to work with the processes that are already in place is the greatest challenge. It is very important that external organizations like IBM or consulting firms be involved in this case so that a strategy can be made to make the project a success. IBM, for example, has completed a number of large blockchain projects in the past and knows how to manage this.*

7. Question: “How do you assess the practical utility of this add-on feature for consumers in the pharmaceutical sector?”

*Consumers have access to the whole record and can be sure that the medications they buy are real. This makes Consumers safer and gives them greater authority. With that in mind, I think the tool can really add value if it is made accessible for people to use.*

8. Question: “Do you believe the addition of blockchain traceability will enhance consumer trust in pharmaceutical products?”

*I truly believe transparency has a big effect on consumer confidence. Especially, because pharma products can increase/ decrease their health and might have a major impact on their life. People could be prevented from getting counterfeit medicines, especially in places where regulations aren't as strict. With blockchain, people can be more certain that the medicines they buy are real and made properly.*

9. Question: “Do you think Consumers would pay more for this add-on feature, why would they pay more?”

*If people knew for sure that the other product would be of a certain quality, they would definitely be willing to pay more for it. People are likely to be able to pay more, especially for medicines.*

10. Question: “How would you evaluate the relationship between pharmaceutical companies and their consumers?”

*Unfortunately, I don't know much about how people communicate with pharma businesses. I believe, that the relationship only exists with intermediaries. Doctors and pharmacists act as a sort of middleman between the companies and the customers, earning their trust in the medications.*

11. Question: “How would you assess the acceptance of the technology for this feature among consumers?”

*As I have already mentioned, it is very important to implement the feature in a user-friendly way. It is also important that pharma companies manage to communicate the new technology to consumer. In my experience, it makes most sense to test it in a pilot project and then extend it to certain segments.*