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Applying Blockchain in the Modern Supply Chain Management: Its Implication on Open Innovation

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Abstract: Over the past decade, the blockchain technology has been actively embraced by an increasing number of companies. Blockchain has proven its effectiveness not only in the financial sector, but also in logistics and supply chain management, and has received extensive coverage in the scientific literature. At the same time, the implementation of blockchain in logistics and supply chain management (SCM) is technically difficult and requires significant financial costs. In this regard, its distribution in countries across the world is uneven. In this study, we compare the implementation of blockchain in countries with developed (Germany) and emerging (Russia) economies. Thus, our study provides new findings and information on the similarities and differences in blockchain implementation strategies in countries with developed and emerging economies. This comparative analysis reveals country peculiarities and different approaches regarding the application of blockchain technologies. The research methodology is based on the case study method. Three economic sectors are selected for the cross-country comparative analysis: the energy, food, and pharmaceutical industries. The analysis is focused on the use of blockchain along all three parts of the supply chain: upstream, production and downstream. Using theory building through case studies, our research results reveal many similarities in blockchain implementation in Germany and Russia. They show that blockchain is actively used in all three analyzed sectors by companies in both countries. Moreover, the technology proves its effectiveness in both upstream and downstream parts of the supply chain. In both Germany and Russia, blockchain is mainly used by large businesses due to its high costs. However, there are some differences regarding the implementation process of the technology in both countries. Firstly, the state support is required for some Russian blockchain projects. Secondly, none of the Russian companies has the necessary "full range" of blockchain competencies, so all Russian projects are carried out in collaboration with other parties, primarily IT partners. Thirdly, most of the Russian blockchain projects are still local in nature and relate to the use of technology in the relationship between the specific supplier and corresponding consumers.

Keywords: blockchain; logistics; supply chain management; energy, food, and pharmaceutical industries; developed and emerging economies; case study research; cross-country comparative analysis

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1. Introduction

The changes in the industrial sector due to the progressive networking of customers, products and value chains pose strong challenges for companies, including increased customer expectations and cost pressure in production, logistics, and the supply chain [1,2]. The term Industry 4.0 summarizes digitization and the associated aspects of networked organizations and processes. The ever-increasing interconnection of procurement and sales processes is forcing companies—primarily in the industrial sector—to expand and improve their communication networks and optimize their supply chain processes [3]. The reason for this consists in the constantly increasing demand for information flows, such as the location and status of goods, cash and payment flows, and data for real-time control of production facilities and material flow systems. The Internet is considered to be the basic element of these physical network technologies.

Undoubtedly, blockchain has been over the past years one of the most hyped, hotly debated, controversial, and yet promising technologies since the inception of the Internet. The disruptive and dynamic potential of blockchain is already well heralded. Its impact and importance are more and more starting to permeate the global business environment, reaching significant enterprises that are helping boost the capabilities of the blockchain. In addition to artificial intelligence, blockchain is considered to be one of the most exciting technological developments and has long been more than just the technology behind the crypto currencies. As blockchain-based systems show significant differences in comparison to the well-known online platforms—amongst others, they are able to increase efficiency in material control based on autonomous agents and to facilitate the establishment of cross-interface data security—, the interest in adopting and implementing this new technology also in the logistics and supply chain management has increased continuously over the past years [4]. In this study, we set the goal of examining how blockchain technology provides a basis to address some of these issues.

Many papers are devoted to blockchain research in supply chain management. Some of them concern the prospects of using blockchain to ensure transparency and traceability of supply chains [5,6]. Others analyze the experience of using blockchain technologies in supply chains of various sectors of the economy [7]. Others focus on exploring the advantages and disadvantages of blockchain [8]. Although there is an increasing body of literature studying the use and benefits of the blockchain technology in supply chain, there are still no studies focusing on cross-country comparison of the experience of using blockchain in logistics and supply chain management. However, it is clear that this experience will differ significantly between developed and emerging economies. With this study we aim to close this gap in the literature.

Blockchain is an innovative technology that can dramatically improve the efficiency, transparency and verifiability of supply chains. However, its implementation is technically difficult and requires significant financial costs. In this regard, its distribution in countries across the world is uneven. The purpose of this study is to analyze the practice of implementing blockchain in logistics and supply chain management in the German and Russian economies. Our research objective is to find an answer to the following question: what are the differences and similarities between the practices of implementing blockchain technologies in developed and emerging countries?

In this study, we answer this question by using the example of Germany and Russia and compare the implementation of blockchain in countries with developed (Germany) and emerging economies (Russia). This comparative analysis reveals country peculiarities and different approaches regarding the introduction of new technologies using the blockchain example. It also shows perspective areas and industries, stages in the supply chain and specific logistics tasks for blockchain technology implementation. In addition, it describes the most effective tools for supporting the blockchain implementation in logistics and supply chain management.

We analyze three economic sectors in which blockchain is used in both countries: food, pharmaceuticals, and energy. We also develop criteria for comparative analysis of blockchain projects in logistics and supply chain management, focusing on the size of companies that have implemented blockchain projects, forms of ownership, the need for collaboration to increase competencies in IT technologies, the scale of implementation of blockchain technology, and its place in the supply chain.

The results of our research make it possible to identify several similarities and differences in the implementation of blockchain in the logistics and supply chains of German and Russian companies. We evaluate the frequency of blockchain use in different parts of the supply chain of the analyzed sectors. The results of the study allow us to better understand the incentives and limitations of blockchain use in economies of different types, as well as draw conclusions about the demand for this technology and assumptions about its development in the future in developed and developing countries.

In this paper, we first review the relevant literature relating the blockchain technology to the supply chain. After presenting our methodological approach, we then describe the cases and make our analysis. We do this by presenting within-case descriptions, followed by cross-case comparisons. Following the analysis, we present our results, draw the key theoretical propositions, and conclude with a discussion.

2. Literature Review and Methodology

2.1. Literature Review

The advance of free trade over the past half century has led to the emergence of global value chains that cross multiple borders and link many countries around the world. Furthermore, globalization and technological advances have increased the degree of complexity of supply chains [9]. As supply chains now involve a large number of players and participants throughout the world (providers of raw materials, manufacturers, shipping and transport companies, government authorities, especially customs officials and regulators, banks, fintechs, insurance companies, insurtechs, consumers, etc.), there is an unprecedented need of coordination and cooperation arising among large numbers of stakeholders who do not necessarily trust each other [10–12]. On the one side, this dramatically increases the cost of operating these global networks and of channeling goods and services across sectors and economies around the world. According to the Global Alliance for Trade Facilitation report by the World Bank Group, International Finance Corporation, the cost of operating supply chains makes up two-thirds of the final cost of traded goods, while 7% of the global value of trade is absorbed in documentation costs alone [13].

On the other side, companies are faced with increased regulatory scrutiny, which increases their regulatory and compliance costs. Aside from that, constantly growing competition puts companies under big pressure to quickly react to supply chain issues—like defective goods or faulty products and materials—for safety and public health reasons [14]. In addition, as consumers increasingly demand sustainability, brands and suppliers must work towards fully transparent supply chains. Therefore, as the business environment is getting ever-more volatile, dynamic, and unstable, companies are increasingly turning to technological innovation in order to make their supply chains more cost-effective, socially and environmentally responsible, resilient, and responsive to customer demand and potential market disruptions [15,16].

The challenges that businesses in the supply chain management face today can be successively solved by implementing the blockchain technology. Therefore, the blockchain topic is becoming more and more popular in the scientific field. The number of research papers on blockchain in logistics and supply chain management has been constantly growing in recent years [17]. To develop our literature review on the use of blockchain in logistics and supply chain, we used the most cited publications from the Scopus database. There are four main sectors of the application of blockchain technologies in logistics: manufacturing, retail, healthcare and finance [7]. Among the main areas of blockchain application in logistics are included simplifying document flow, struggle against infringement production, ensuring product traceability along the supply chain, maintaining the Internet of things (IoT) [5], and confirming the place of origin for goods [6]. It should be noted that blockchain can successfully fight with two important negative factors of interaction between supply chain participants: opportunism and limited rationality [8].

Among the advantages of the blockchain for supply chains, three key ones were identified: increased transparency of the supply chain (eliminating unnecessary checks, developing automation of operations such as forecasting demand, monitoring assets, optimization improvements, developing cargo tracking services, monitoring the supply chains of chilled products and luxury products, and creation of additional value for customers); ensuring a secure exchange of information and strengthening trust between partners (a single pool of data accessible to all interested parties, improving the reliability of the data exchange system, developing standards for working with data throughout the supply chain, ensuring customer trust on a solid and reliable basis); improvement of operations (precise control of indicators, the possibility of identifying problems before they arise, and accelerating the supply chain) [5,7,18].

In a number of sources several key problems of introducing blockchain in the supply chain were analyzed: some distrust of the blockchain technology in a number of organizations; insufficient development of technology today; the complexity of understanding and the high cost of blockchain technology; cultural, procedural and managerial issues (cultural perception barriers, the need to change thinking and working protocols of interaction, conflicting interests, and possible resistance from some stakeholders); the need to process large amounts of data; excessive complexity of the supply chain ecosystem; lack of standards, regulatory uncertainty; the need to protect confidential information in supply chains; cyber-attacks; the use of one blockchain together with other blockchains or other systems [5,18].

Marchi et al. considered the cases of using blockchain in new energy supply chains in a country context. As examples, the experiences of Australia, Sweden, Germany, Spain, Hong Kong were considered. An analysis of the experience of these countries allowed the authors to highlight the positive aspects of using blockchain in the new energy sector: transparent, fair, reliable, environmental-friendly. However, at the same time, they speak about certain weaknesses and challenges of the blockchain technology. Among the main problems, the authors highlight scalability, regulation, privacy, invoicing, and security issues [19].

The topic of blockchain practical usage attracts not only university researchers, but also commercial and consulting companies. A number of commercial companies are actively analyzing country blockchain markets and key consumers of this technology: for example, Bitcoin in Germany or MindSmith in Russia. However, there is still no cross-country study of the experience of the blockchain technology implementation across the supply chain. At the same time, it is obvious that in connection with the above-mentioned advantages and disadvantages of the blockchain technology, the process of its implementation is uneven in different countries. In our study, we close this gap in the literature and describe what are the similarities and differences in the implementation of blockchain in the logistics and supply chains of German and Russian companies. Thus, our study will provide a comparative analysis of blockchain implementation in supply chain management in developed and emerging economies. The results of the study will make it possible to better understand the incentives and limitations of blockchain use in economies of different types, as well as draw conclusions about the demand for this technology and assumptions about its development in the future in developed and emerging countries.

2.2. Methodology

The main objective of this study is that of analyzing what are the differences and similarities between the practices of implementing blockchain technologies in developed and emerging countries, by using the case study method. Using a theory-building approach, we present in this paper ten case studies—five from Germany and five from Russia—for companies from three different sectors: food, energy, and pharmaceuticals.

We consider these sectors as being among the most relevant for both economies and have a twofold rationale for focusing on them. On the one side, these sectors are highly important for the German and, respectively, Russian economies. The energy sector is very relevant for Russian Federation's income generation for the state budget—oil and natural gas revenues account for more than one-third of the federal budget revenues—and trade balance as well. In 2017, Russia was the world's largest producer of crude oil and the second largest producer of dry natural gas [20]. As Russia plays a strategic role as an important oil and gas exporter, the Russian energy sector is of key importance to the country's economic success, as well as to the world energy markets. With its domestic pharmaceutical industry consisting of companies such as Bayer, Boehriger Ingelheim, Merck, BASF and Hoechst, Germany has a historical reputation as the world's pharmacy. With revenues of EUR

38 billion in 2015, Germany is the world's fourth largest pharmaceutical market and has a share of the global pharmaceutical market of 13.5% [21].

On the other side, the two above mentioned sectors, together with the food industry, are characterized as having some of the most complex, global supply chains across all industries. That is the reason why these sectors are given special attention, as they have proposed so far some of the most innovative and successful solutions with respect to the implementation of blockchain in the supply chain. Moreover, a detailed description of further sectors, besides these three, would have been beyond the scope and also the length of this research paper. In this study, we provide an extended comparative analysis of the adoption and implementation of the blockchain technology in these sectors in the two countries.

Case study is a popular and widely accepted research method in economics and management. Meredith have noted that the case method has three important advantages: relevance, understanding, and exploratory depth [22]. Due to these advantages, the case method is often used for theory and models development in strategic and operational management [23–26]. Ketokivi and Choi have noted a renaissance of interest in the case studies use in scientific research [27]. Over the last years, case study tools have been increasingly used in research related to logistics and supply chain management [28].

Case studies can involve either single or multiple cases, and numerous levels of analysis. In this study, we choose a multiple case approach and employ an embedded design, by using two levels of analysis within a single study: company and industry. Our study adopts a theory-building approach, meaning adopting principles of theory building based on case studies [22,29]. As we are investigating a relatively new research area, the study of such cases is considered to be appropriate. The case study data we collect is qualitative, in form of descriptive insights, observations, and information.

In this study, we adopt a theoretical sampling method and select companies with leading technological or commercial practices. Selecting some of the largest and most important companies in the three sectors means that the results and the theoretical working propositions developed in the study will apply and have practical value for other, smaller, companies as well. As at least two of the three sectors (energy and pharmaceuticals) are very capital-intensive industries, they have an oligopolistic market structure, so that identifying the most important companies becomes self-evident. Eisenhardt recommends to use four to ten cases for theory-building purposes in a proper analysis [29]. If there are less, the study might suffer from lack of generalizability, and if there are too many, it would be difficult to process the qualitative data. For this study we use ten companies. The final selection was made based on the type of use case and the innovativeness of the blockchain solution along the supply chain.

We first conduct a within-case analysis, in which we describe the use cases and conduct the analysis at the company level. We identify company's blockchain-based solution and the result of its implementation in the supply chain. Then, we conduct the cross-case comparison and show the differences and similarities between the German and Russian companies by analyzing them at an industry level. Finally, we summarize and discuss the results of within-case and cross-case analyses by deriving key characteristics and developing five comparison criteria: size of the company, form of ownership, level of collaboration with other parties, scale of implementation of the blockchain technology, and place in the supply chain. Based on this construct, we then build five research propositions and show the differences and similarities between the practices of implementing blockchain technologies in developed and emerging countries, by comparison.

3. Analysis

The main objective of our case study analysis is to investigate and compare the implementation of the blockchain technology in the German and Russian food, pharmaceutical, and energy sectors. After a short description of the most important challenges along the three parts of the supply chain, we present ten case studies from Germany and Russia from these three sectors. Based on these descriptive insights, we then draw theoretical propositions about the blockchain in the supply chain of the two countries, by comparison.

A supply chain consists of three main parts: upstream, production and downstream [30]. For each of these, there are several areas in which blockchain can help solve a number of important challenges like combating corrupt practices, proving good practice/authenticity, or managing complexity.

3.1. Upstream Challenges

The upstream part of the supply chain shows the relationship between the supplier, the raw materials and the supplier's supplier, including the processes for managing relationships with them. There are many different challenges along the upstream section. One of the major issues is identifying those raw materials which are obtained by using unsustainable or immoral practices like child and slave labor, exploitation of small farmers or mine workers, etc. Another challenge is that of guaranteeing that raw materials are what their providers are claiming them to be. The difficulty here is to combat fraudulent players in the supply chain by attaching reliable data about provenance and authenticity to a material and track it along the chain in order to ensure that it has not been substituted. Especially in case that materials have a large number of sources—like very many small farmers supplying agricultural products, fleets of independent fisherman supplying various types of fish, etc.—gathering and keeping track of quality information may become a very difficult task.

3.2. Production Challenges

As raw materials are transformed into finite products along the production chain—either at a single or along a chain of production facilities, in which a finite product from one facility is used as a component in the manufacturing process of a product in another one—, there are many challenges that producers may be faced with. Those players in the supply chain that purchase products higher up along the chain want to be sure that producers are providing the raw materials they are claiming them to be, or that they are compliant with industry standards and regulations regarding methods and labor practices. Production facilities meeting these standards can benefit, provided that they are able to prove the corresponding compliance with industry standards and authenticity of their products. However, this requires evidence in order to identify the products from their facility as they travel down along the chain. Furthermore, producers are usually confronted with many coordination and logistics challenges, for example, planning and coordinating the delivery of raw materials in order to prevent bottlenecks or overstocking, or to locate areas where efficiencies can be introduced.

3.3. Downstream Challenges

The downstream part of the supply chain corresponds to transporting components or finite products to their points of use or sale and so delivering them to end users (companies or consumers). Downstream can also include the "aftermarket", where finite products are resold or recycled. As transport and logistics are extremely complex, transport itself is one of the major challenges in downstream supply chains. Ensuring and proving that items and products have been handled appropriately during shipment or that they are not stolen and/or replaced by counterfeits proves to be difficult in many cases. Furthermore, shipment over long distances and across multiple jurisdictions requires tight coordination between numerous companies and authorities. For the retail and aftermarket segment, both proof of provenance and authenticity become increasingly important, as consumers want to be sure of the origin and quality of the products they buy. This is the case especially for luxury or very expensive products.

Another major challenge of the downstream supply chain is related to sustainability. Facilitating the recycling and reuse of products has become a necessity for many players in the supply chain. Research indicates that "green trade" is rising in political and economic importance and estimates a global market of $1 trillion a year for environmental goods and services [31,32]. However, the "greening" of global supply chains requires traceability and transparency. For the vast majority of consumer goods manufacturers, these two attributes do not yet characterize their supply chains [33,34].

3.4. German Case Studies

The following within-case descriptions are the result of the within-case analysis. They present the details of the ten cases—five for Germany and five for Russia—used in this study. Each case is built based on qualitative data, in form of descriptive insights, observations and information. They are compiled in a way that is as objective as possible, with minimal subjective interpretations.

Numerous companies from both Germany and Russia from various industries see blockchain as a technology with high potential for digitization. We present ten blockchain projects selected from companies from the food, energy, and pharmaceutical sectors that have a relevant position in their sector in terms of size and/or market share.

3.4.1. GS1 Germany

In order to obtain reliable information about the strengths, weaknesses and the potential of blockchain across several sectors, GS1 Germany, together with more than 35 companies from retail, industry, logistics, start-up scene, research, and several associations, carried out a pilot project in 2018 on a very specific logistics use case: the pallet exchange process between retail, logistics and industry. More than 20 well-known companies from several sectors tested, under the leadership of GS1 Germany, whether and how the exchange of euro pallets can be managed digitally, transparently and efficiently using the blockchain technology. Among these companies are Nestlé Deutschland, Unilever Deutschland, Dr. August Oetker, Kraft Foods Europe, Metro Group, European Pallet Association, Frauenhofer Institute, etc. The pallet exchange process is considered to have a great potential for optimization. The project aimed at obtaining reliable insights about blockchain, testing the extent to which blockchain can be used for providing a digital copy of the pallet note and mapping the open pallet exchange process as well.

The open pallet exchange system is well-known for its non-digital nature. Virtually the whole system is paper-based and supposes lots of forms that have to be filled out by hand and manual operations. This leads to great inefficiencies, high costs and a major lack of transparency. One of the core targets of the project was the digitization of the pallet note using the blockchain technology, as this is currently part of the daily business of every truck driver. In addition, the pilot project focused on improving the existing load carrier exchange, as this is a system that involves parties who rarely know each other, where there are no standardized rules, rights, or obligations, and where there is no intermediary that monitors the exchange process.

In the first phase of the project, the participants jointly defined the load carrier as well as the project alternatives and process sequences that were to be tested. The second phase dealt with the definition of the technical system architecture and answering the question of whether a private or a public blockchain should be tested. In the third one, the simulation environment and the prototype were developed, and then a test run followed. The actual blockchain test took place in the fourth phase. The fifth and last one consisted in evaluating the results and describing the recommendations for action based on the blockchain pilot.

The project showed that the blockchain-based solution is able to provide a digital copy of the pallet note and that the open pallet exchange process can also be mapped using blockchain. Due to the consistently user-centered, agile approach, the development and adoption of the prototype by project participants went well and users confirmed good operational functionality at the front end, as well as user-friendliness, comprehensibility, and clarity.

3.4.2. GFT Technologies SE and MYTIGATE

The IT company GFT Technologies SE and the start-up MYTIGATE signed a cooperation agreement that will potentially revolutionize monitoring and tracking of pharmaceutical supply chains. MYTIGATE is the result of a project supported by the State of Hesse. The start-up aims at developing and operating a standardized, validated risk management platform for supply chain management in the pharmaceutical industry. Further partners of the cooperation agreement are the Research Consortium for Pharma Supply Chain Risk Management—which includes leading pharmaceutical and logistics companies (among others Bayer AG (Leverkusen, Germany), Boehringer Ingelheim Pharma GmbH & Co. KG (Ingelheim am Rhein, Germany), Frigo-Trans GmbH (Fußgönheim, Germany), and GEFCO Forwarding Germany GmbH (Biberach, Germany)—as well as the Fulda University of Applied Sciences and the RheinMain University of Applied Sciences.

The cooperation aims at creating a blockchain-based planning and tracking system based on distributed ledger technology. Potential customers are pharmaceutical as well as specialized logistics companies. The new pharmaceutical supply chain tracking system enables users to document the planning of drug shipments and then track them across the world in order to identify risks and monitor problems during transport. Blockchain thus allows companies to get real-time information about shipments or delays predictably in the future and helps to improve processes in the long term. This in turn leads to minimizing errors within the supply chain and reducing costs for all parties involved. Furthermore, the new technology enables both secure and transparent tracking of different shipments using a single system that can be exploited collaboratively by various pharmaceutical and logistics companies. User rights can be regulated flexibly, meaning that only predefined persons can access information about their shipments. In addition, the new planning and tracking system generates data for MYTIGATE's risk management platform, which creates key risk figures and provide information on the best routes for certain shipments.

3.4.3. Bayer AG

Bayer provides another use case from the pharmaceutical industry. At the end of May 2020, Bayer announced working on a new blockchain-based traceability platform for the delivery of drugs. The pharmaceutical giant selected the company VeChain, a branch of Bayer, as tech provider for the new blockchain-powered solution that will allow to track clinical drugs along the entire supply chain.

The system, known as CSecure, loads into a blockchain a batch number that is assigned to a specific drug. The number is then used to track the drug as it moves through the supply chain, registering timestamps and user-identification information at various route points. Due to the immutable nature of blockchain, the data cannot be changed or manipulated by any other third party [35]. CSecure is based on ToolChain, a proprietary blockchain-as-a-service (BaaS) system that allows VeChain to design and develop blockchain-powered solutions to client's specific requirements. Further information about CSecure cannot unfortunately be disclosed, as VeChain is bound by a non-disclosure agreement.

3.4.4. Bayer AG and Ant Financial

After acquiring US seeds and agrochemicals firm Monsanto in 2018, the pharmaceutical giant Bayer has been actively working on blockchain projects also in the food and agricultural sector. Ant Financial, the company behind the popular payment system Alipay, and Bayer Crop Science, the agricultural department at Bayer AG, have collaborated since September 2019 to develop a blockchain solution for the food and crop industry, which aims at providing greater transparency and improved traceability across the whole agricultural supply chain [36]. The companies signed a letter of intent to utilize blockchain technology to increase efficiency, improve the income of farmers, ensure the production of high-quality food, improve safety for food products, and aid in the digitization of agriculture. There is little information available regarding the size of the deal or the structure of the relationship. Geoff Jiang, vice president and general manager of Ant Financial's Intelligent Technology

Group, stated that "together with Bayer, our exploration of blockchain in agriculture will improve the transparency and responsiveness of its supply chain, and bring more value to consumers, farmers and the society."

3.4.5. Innogy SE

Innogy SE is a German energy company focusing on renewables, grid, and infrastructure as well as retail that explores the use of blockchain technologies in all lines of business. With the blockchain-powered Digital Product Memory project, the company seeks to give every product a story such that, in the future, the exact provenance and authenticity of all products can be known.

While the global flows of goods have continuously increased over the past decades, many of the processes designed to manage these flows remain manual, paper-based, error-prone and vulnerable to fraud. That means that consumers have almost no possibility to check the trace or provenance, or verify the authenticity of the products they buy. As consumers make their choices more and more based on moral, political, and economic values, knowing all details about each individual product from the moment of inception until it reaches the end consumer becomes an increasing challenge. The main goal of the Digital Product Memory project is that of giving each product a story by facilitating the verification of authenticity and provenance, the proof of ownership, and lifecycle traceability as well. By using the blockchain technology provided by BigchainDB, it is possible to build a database of products and their entire histories so that provenance, authenticity, and ownership can be verified. BigchainDB underpins the Digital Product Memory in several ways: provides a globally accessible database to store products and their digital histories, ensures data immutability that brings trust and auditability to the records, offers high capacity and throughput for millions of sensors and products, provides query technology that enables quick retrieval product histories, and supports micropayment channels to enable machine-to-machine commerce.

3.5. Russian Case Studies

3.5.1. Magnit

Russian food retail is one of the most innovative Russian industries [37,38]. It is actively involved in the implementation of newly developed digital technologies, including blockchain [39,40]. Magnit, the Russian second largest retailer, has equipped all of its distribution centers with a blockchain system for remote temperature control and began to monitor products on the way to their stores. The innovation allows the retailer to control the freshness of goods via Internet, increase their "lifespan", as well as reduce losses by 10%. The special sensors are installed in the distribution centers lockers and in the area for goods loading into delivery vehicles. They scan the storage temperature and, in the event of deviations, send data to e-mail and mobile phone of the responsible person. The refrigerators of the company's own vehicles are also equipped with special sensors. After loading goods into trucks, additional sensors are installed in containers with products. Thus, not only the overall temperature in the truck is monitored, but also the temperature of the individual box on the way to the buyer. This is necessary in order to analyze whether a certain tare is suitable for maintaining quality or if it needs to be replaced with another. In the future, remote temperature control will be synchronized with warehouse and transport management systems.

3.5.2. Dixy

Dixy is also one of the largest Russian retailers that implements blockchain in the supply chain. Its pilot project consisted of innovative systems that ensure the availability of goods on the store shelves. The project is being developed in collaboration with OSA HP (On-Shelf-Availability Hybrid Platform). Blockchain allows supermarket employees to automatically update product information. If any of the products is out of stock or has a poor quality, supermarket employees can quickly find and manage the problem. Thus, blockchain helps retail chain stores with improving their inventory management efficiency, optimizing supplies, and increasing sales. The pilot testing showed almost 4% sales growth for retail chains and their suppliers, while inventories and financial losses associated with them decreased. Therefore, blockchain implementation intensifies cooperation in the food supply chains and benefits not only the retailers, but also their suppliers, ensuring goods availability on the shelves on the basis of real time analytics [41–43]. As a result, food retail is becoming more open and transparent for both manufacturers and suppliers.

3.5.3. Vnesheconombank

An example of blockchain implementation in the Russian medical and pharmaceutical industries is the joint project on registration and dispensing of medicines implemented by the Vnesheconombank (VEB) in collaboration with the Government of the Novgorod Region. The key goal of this project was to remove the resale of expensive drugs purchased from the budget, as well as unauthorized changes in the patient care regimens. The regional clinical hospital has also participated in the project. The hospital created a unified register of electronic prescriptions combined with the hospital's information system. Thus, the hospital departments were able to exchange information about patients, drugs availability in the warehouse, and their use. A patient could find information about the prescribed medication using a special tablet. Seven months after launching, the blockchain project saved about 12% of the drug provision budget. The project won "The Digital Peaks" competition in the "Trust and Transparency" category. This award is given to projects that enhance the transparency of the relationship between citizens and government agencies. In the future, the pilot project can be extended to other hospitals and regions of Russia as well.

3.5.4. Surgutneftegaz

A further example, this time from the energy industry, is Surgutneftegaz, a Russian oil and gas company that has successfully implemented a blockchain project. The project was implemented in collaboration with the Russian Railways and the United Metallurgical Company. In this case, the technology was applied to monitor the movement of cargo—metal pipes. The pipes supplier was the Vyksunskiy Metallurgical Plant (part of the United Metallurgical Company). The blockchain was used to monitor the movement of the pipes from the supplier to the buyer with control of all stages of the process, including shipment of pipes from the factory, their transportation, acceptance and distribution procedure, and identification of defective elements. The companies participating in the project highly appreciated its economic efficiency [44,45].

3.5.5. Gazprom Neft

Gazprom Neft is one of the first companies that has launched blockchain technologies. In this blockchain-based project, the company worked together with Gazprom Neft Shelf and Gazpromneft Neft Snabzhenie. The Radio Frequency Identification (RFID) tags and satellite positioning sensors were installed on the valves purchased by the company. Consequently, the company could track the movement of valves from the supplier's plant in Veliky Novgorod to the warehouse in Murmansk. The company could track the speed and route of movement of the cargo, the number of stops on the route, and their duration. The data obtained was recorded by a smart contract using the blockchain technology. The technology was also extended to storage and transport operations for the cargo of the Prirazlomnaya platform in the Pechora Sea. Thus, the blockchain provided a link between the physical processes along the supply chain and the accompanying paperwork.

3.6. Cross-Case Comparison

The case studies described above present some of the challenges existing in the food, energy, and pharmaceuticals industries in adopting blockchain in their supply chains and show how blockchain could be used in order to solve them.

3.6.1. Food Industry: Enforcing Safety and Sustainability Standards, Improving Inventory Management Efficiency

Agriculture is one of the leading job providers worldwide and a critical sector for boosting economic growth in developing economies as well. According to the Food and Agriculture Organization of the United Nations (FAO), over 1 billion people are employed in world agriculture, representing roughly 40 percent of the global workforce [46]. For emerging economies with global market and footprint ambitions, putting into effect sustainable supply chain practices has become over the past years more and more important. In this quest for efficiency and transparency, blockchain offers the ability to integrate and manage supply chain transactions and processes in real-time, and identify and audit the provenance of goods in every link of the chain [47].

As supply chains in the food industry have become global and complex, assuring that the quality of food corresponds to what it should be is one of the major challenges producers are faced with. Transparent supply chains are thus crucial to ensuring quality and conformity with the expected standards of production (bio, fair-trade, and circular economy), meeting environmental standards, as well as combatting fraud.

Food companies both in Germany and Russia have to comply with many standards, laws, and regulations (e.g., standards for organic food labelling, fair trade labelling, regulations regarding environmental sustainability, etc.) and, in order to ensure safety, they need to be able to promptly identify irregularities in the supply chain and trace outbreaks to their source. Furthermore, consumer behavior is changing in the food industry in both countries and consumers are becoming more health-conscious and sustainability-oriented. They are thus looking for food options that are compatible with these ideals (for example, they want to know where their food comes from and how it was produced and transported).

The within-case analysis shows an important difference between the use cases food companies chose for implementing the blockchain in their supply chains. While for the two German case studies (GS1 Germany and Bayer AG and Ant Financial) blockchain projects are present in the upstream part of the food supply chain, the two Russian ones (Magnit and Dixy) show the implementation of blockchain along the downstream part. In Germany, blockchain-based platforms allow the implementation of "track and trace" resources along the entire supply chain, enabling tracing "from farm to fork". These platforms make possible to identify and prove the source of an ingredient as well as keep a record of its movements and changes along the supply chain, including environmental information. In case of contamination, such data provides extremely useful audit trails and adds efficiency to safety inspections. In contrast, blockchain pilot projects are implemented in Russia primarily in the downstream part, for ensuring the availability of goods on the shelves of food retailers. Ensuring sustainability still remains an issue, but the main objective is that of improving inventory management efficiency, optimizing food supplies, and increasing sales.

However, the within-case analysis shows also several similarities. We observe that in both countries the blockchain projects are implemented globally by large, privately-owned businesses. In addition, companies collaborate either with other companies, business associations and research institutes, or with the IT solution provider. The only exception is the case study of Bayer AG and Ant Financial, as the latter one is also the IT solution provider.

3.6.2. Energy: Performance-Based Contracts, Digital Products, and Lifecycle Traceability

Due to its size, huge complexity and fundamental importance to the whole economy, the energy sector proves to be a very good example of how blockchain technologies can be used to tackle risks and challenges all across the supply chain. The upstream oil and gas sector (exploration, extraction, and production) is usually perceived as a low-tech industry, which involves a large number of different companies at a time. After being recovered and brought to the surface, crude oil or raw natural gas needs to be shipped—via tankers or pipelines—to refineries. This is a complex process that involves numerous suppliers. Refined products (like gasoline, natural gas, jet fuel, diesel, asphalt, etc.) are then transported to their distribution centers and finally into the hands of end customers.

The energy supply chain is considered to be well behind in terms of digitalization. Blockchain could be employed in many different ways all along its parts. For example, blockchain-based identities, signatures, and documents could be used in order to prove, record, and store the identities and credentials of workers either on wells, in refineries, or when inspecting pipelines. This is of great importance, as error rates while recording data are estimated to reach levels as high as 25 to 30%. While blockchain cannot reduce error rates, by providing transparency—including information on who entered data and when—it can detect potential outliers and increase the accuracy level of data. This will result in having more reliable records about who did what and when that, coupled with evidence of the quality of work, can greatly simplify invoicing by allowing for performance-based contracts. Furthermore, automatic payments can be triggered by using smart contracts, also on the blockchain. This could significantly decrease the time it takes for payments to be made, to the benefit of contractors. Blockchain-based attestations of work could also potentially simplify dispute reconciliation.

The German and Russian energy case studies presented in this paper exhibit some common characteristics, but mostly differences. All companies have as major objective the digitalization of certain energy products and the projects are implemented solely by large businesses. For the Russian cases studies, the blockchain is applied for tracking and monitoring specific energy products (metal pipes), needed only in the upstream part of the energy supply chain. The technology is used for monitoring and controlling the movement of the pipes along the entire upstream stage. Due to the special features of this product, the successful implementation of the project depends greatly on the collaboration with the carrier, in this case Russian Railways. In contrast, the German energy company Innogy targets a complete digitalization, in terms of both number of products and content of each product, along the entire supply chain, from the moment of inception up to the end consumer. By using the blockchain, each individual product becomes a digital one and receives a digital history, such that everything—from provenance, through authenticity, and up to ownership—can be verified.

The main difference between the companies in the two countries lies in their form of ownership, which influences the scale of implementation of the projects as well. Energy is a strategic sector, being among the most capital intensive and complex industries, with perhaps the most demanding requirements for long-term corporate planning and capital allocation outside of major government-led infrastructure investment. While the German company (Innogy SE) is a private one, the two Russian companies (Surgutneftegaz and Gazprom Neft) are state-owned. This is explained by the mere nature of the business: as oil and gas are natural resources, companies operating in this sector are state-owned and managed by the Russian state.

3.6.3. Pharmaceuticals: Combating Counterfeiting, Improving Traceability, and Simplifying Compliance

As an industry with highly complex, global supply chains, the major challenge the pharmaceuticals industry is faced with is safety. Among other things, fighting counterfeit products and checking abuse in its supply chain stand in the forefront of industry's concerns. According to the World Health Organization (WHO), estimated 10% of drugs consumed in developing countries are substandard or counterfeit. There are several regulatory responses to this problem. In the European Union, the Falsified Medicines Directive (Directive 2011/62/EU) was published on 1 July 2011, and applies since 2 January 2013. This Directive introduces harmonized European measures for fighting medicine falsifications and ensures that medicines are safe and trade in medicines is rigorously controlled. The directive asks every manufacturer to comply with obligatory safety features by registering a unique identifier and an anti-tampering device of each package containing pills and drugs in a central repository and recording every movement of the packages there [48].

The blockchain technology could solve many challenges the pharmaceuticals industry is confronted with. As a drug moves along the supply chain, the transactions can be recorded on a blockchain-based platform, thereby providing a distributed provenance ledger. As a result, this will make it harder for counterfeit drugs to be introduced into the supply chain and distributed to consumers. Furthermore, by using smart IoT devices, companies can monitor pharmaceuticals throughout the entire supply chain. Temperature, humidity and other factors can also be recorded using smart devices along the supply chain life-cycle. This means not only ensuring quality, but increasing transparency and traceability as well.

In both German (GFT Technologies SE & MYTIGATE and Bayer AG) and Russian (Vnesheconombank) case studies companies are characterized by similar objectives: by implementing the blockchain technology, they aim to get a more efficient planning of drug shipments and a better traceability of pharmaceutical products as well. The blockchain-based tracking system allows companies to identify risks and transparently track and better solve problems occurring across various levels in the supply chain.

A further similarity between the two countries is the fact that the projects are sustained and funded by state institutions. A number of German universities collaborate with pharmaceutical and IT companies for developing blockchain-based traceability platforms. In Russia, regional government and hospitals are involved in the development of projects.

While the objective is very similar, the stage in the supply chain at which blockchain projects are implemented is different in the two countries. German companies are focusing primarily on the upstream level of the pharmaceutical supply chain, while the Russian ones more on the downstream level.

4. Results and Discussion: Blockchain in the Modern Supply Chain Management and Open Innovation

4.1. Results: Blockchain in the Modern Supply Chain Management

In this study, we have presented an analysis of the blockchain technologies in the supply chains of Germany and Russia. Our comparative analysis covered three of the most popular sectors that are actively introducing blockchain into their supply chains: energy, food production and trade, and pharmaceutical industries. The results of the case-based comparative analysis of blockchain implementation in German and Russian companies from three sectors are presented in Table 1. For better showing the results of the within-case and cross-case analyses at both the company and industry level, we derived and defined five criteria for comparison: company size, form of ownership, collaboration with other parties, scale of blockchain implementation, and its place in the supply chain. Based on these results, we propose the following research propositions:

Proposition 1. *(Company size): Blockchain projects are usually implemented by large, privately-owned companies.*

This fact is related with the blockchain technology high costs and lack of sufficient financial resources in small and medium-sized businesses. Moreover, these businesses usually lack technical, IT and blockchain skills (e.g., knowledgeable employees, relevant IT and blockchain experience, etc.). Therefore, they need collaboration support, as we saw in the case studies from both countries.

Proposition 2. *(Form of ownership): For sectors which are partially or entirely owned and controlled by the state (e.g., oil and gas), projects are implemented by state companies.*

This fact may be caused by the highly strategic importance of the energy sector for the national economy (especially in Russia), the state control of natural resources as well as the existent high volume of reserves and production (particularly Russian oil and gas energy sector). For Russia, this can also be related to the fact that it is easier for large corporations to receive government support for implementing innovative projects due to certain lobbying ties.

Table 1. The key characteristics of the blockchain implementation process.

Company	Key Characteristics				
	Company Size	**Form of Owner-Ship**	**Collaboration with Other Parties**	**Scale of Blockchain Implementation**	**Place in the Supply Chain**
Germany					
GS1	Large business	Private	More than 35 companies, business association, research institute	Global	Downstream
GFT Technologies SE & MYTIGATE	Large and small business	Private	State government, universities, research consortium, IT solution provider	Global	Upstream
Bayer AG	Large business	Private	IT solution provider	Global	Upstream
Bayer AG & Ant Financial	Large business	Private	No (Ant Financial provides the IT solution)	Global	Upstream
Innogy SE	Large business	Private	IT solution provider	Global	Upstream, production, downstream
Russia					
Magnit	Large business	Private	IT solution provider	Global	Downstream
Dixy	Large business	Private	IT solution provider	Global	Downstream
Vnesheconombank	Large business	State	Regional government, regional clinical hospital, IT solution provider	Local	Downstream
Surgutneftegaz	Large business	Private	Russian Railways, United Metallurgical Company, IT solution provider	Local	Upstream
Gazprom Neft	Large business	State/ Private	Gazprom Neft Shelf, Gazpromneft Neft Snabzhenie, Russian Railways, IT solution provider	Local	Upstream

Proposition 3. *(Collaboration with other parties): Unless one of the partners is the IT solution provider, all projects imply collaboration with at least one other party (i.e., the IT solution provider). Companies usually collaborate with other parties (e.g., other companies, universities, research institutes or consortia, business associations).*

Collaboration with other parties can be related to the high level of specialization of modern economies in both Germany and Russia. Extensive and specific technical and technological know-how required for a successful implementation of the blockchain is usually concentrated in research and academia and provided by research, scientific, and development institutions. Even for a very large company, it is difficult to dispose of everything needed for organizing and setting up new, blockchain-based supply chain solutions, or to possess all needed skills and resources.

Proposition 4. *(Scale of blockchain implementation): Blockchain is usually implemented on a global scale, except for projects involving state companies. In these cases, blockchain is implemented on a local* scale.

This can be explained by the high costs of implementing blockchain technologies, which pays off only with a global coverage of the supply chain. Therefore, private companies initially assume a wide coverage of their counterparties when introducing blockchain technologies. However, large businesses can, as a local experiment, introduce blockchain into logistics processes with the aim not to primarily increase business efficiency, but firstly to gain experience in using innovative technologies. This holds true especially in case of blockchain projects supported by the state.

Proposition 5. *(Place in the supply chain): Blockchain projects are implemented all across the supply chain (upstream, production and downstream).*

There is no preferred part of the supply chain for implementing blockchain projects. There is a high need for digitalization and implementing blockchain-based solutions across all parts of the supply chain. However, particular tendencies for certain specializations can be noticed. Thus, industries that are more focused on serving the end market (food retail and pharmaceuticals) tend to implement blockchain in the downstream part of their supply chain. In contrast, energy companies tend to control their supplier, and therefore implement blockchain projects more often in the upstream part of the energy supply chain.

4.2. Discussion: Blockchain in the Supply Chain Management and its Relation with Open Innovation

The efficiency of modern business is greatly determined by the efficiency of supply chains. Improving the efficiency of supply chain management processes can be realized through the use of open innovation. Open innovation can create the basis for the formation of a new type of open supply chains [49]. Yun and Yigitcanlar identify five areas of using open innovation in supply chains: user open innovation, customer open innovation, common profit community, together growth community, and inner open innovation [50]. Each of these five areas can definitely be improved using blockchain technologies. Based on several practical cases, Rosa et al. conclude that blockchain has already established itself as the main technology for creating open innovation ecosystems and that it has sufficient technical capabilities for widespread adoption of sustainable platform solutions based on open innovation [51]. It is the blockchain technology that seems to be the tool that will ensure reliable protection of intellectual property and allow the use of open innovation platform solutions not only for large, but also for small and medium-sized businesses [52].

The possibility of using open innovation to solve logistics tasks is discussed in many articles. For example, Diouf and Kwak prove that fuzzy analytical hierarchy process (fuzzy AHP) and data envelopment analysis (DEA) are sequentially performed to rank and select the best suppliers from the perspective of open innovation [53]. DEA applications in supply chain in different models is also discussed in [54–56]. Undoubtedly, well-known virtual enterprises (VE) use open innovations to achieve competitiveness, including innovation on product development. However, its limited resources, combined with the innovation resulted from the diversity of partners involved, rises certain challenges to management, especially with respect to risk management. To fulfill these requirements, fuzzy logic risk management models were conceived to assess the level of risk in the context of open innovation [57].

The implementation of blockchain in different parts of the supply chain has shown its effectiveness in various projects around the world. However, some studies show that blockchain integration in the supply chain is more intense in developed countries (e.g., USA, UK, and Germany), which is reflected in a large number of publications on this topic. At the same time, there is a lack of relevant publications in Latin America and Africa [58]. Nevertheless, our research demonstrates that emerging countries such as Russia are actively following the path of introducing blockchain into logistics processes at various stages of the value chain. Thus, we believe that blockchain can also be effective in supply chains in emerging countries.

5. Conclusions

Summing up the results of our analysis, we can conclude that the blockchain technology has a very high potential for supply chains. An increasing number of companies are turning to this technology both in Germany and Russia. The results of its application indicate its significant impact on the automation and efficiency of business, ensuring transparency of business processes, increasing trust between supply chains participants, and developing relations between government, manufacturers, intermediaries, and end customers. However, the implementation of blockchain-based solutions requires serious investment and the availability of corresponding technological and human resources.

As all presented cases show, blockchain implementation is typical in all three sectors that have been analyzed, for both German and Russian companies. In addition, the cases highlight the importance of blockchain implementation in all three key parts of the supply chain—upstream, production, and downstream—, which is also typical in both countries.

At the same time, the analysis also shows a number of differences in the implementation process of blockchain in the two economies. While in Germany this is mainly financed by the businesses themselves, in Russia the support of regional authorities is very important. This government support is particularly significant for industries in which Russia does not have large companies, as well as in those areas where blockchain is being implemented in social projects like medicine. Thus, the Russian oil and gas giants and representatives of the large Russian retail sector have the necessary resources for implementing blockchain technologies. However, in contrast to Germany, Russia does not have very large companies in the medicine and pharmaceuticals field. Therefore, blockchain implementation in these areas requires joint public and private funding.

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