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The Role of the CFO of an Industrial Company: An Analysis of the Impact of Blockchain Technology

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Abstract: This qualitative multiple case study explores the influence of blockchain technology on the chief financial officer (CFO) of an industrial company. Due to the advancing digitalization of business sectors and increasing competitive pressures, industrial companies are forced to promote their own digital transformation to sustain on the market. Here, the literature regards the CFO as a key corporate function to induce digitization initiatives within organizations. The blockchain technology, due to its features of transparency, immutability and cryptography combined with its ability to coordinate data flows of e.g., the Internet of Things (IoT) or Artificial Intelligence (AI), constitutes a suitable instrument for the CFO to meet the requirements of Industry 4.0. This paper provides a contribution to address existing research gaps regarding the application side of blockchain technology. Thus, the objective of this work is to provide corporate financial functions, such as the CFO of an industrial company, with an understanding of the extent to which blockchain technology can be used for the role-specific responsibilities. Therefore, the underlying qualitative study explores the influence of blockchain technology on the CFO-function of an industrial company. Thus, intending to address a research gap on the application side, it asks (1) What is the impact of blockchain technology on the financial as well strategic role of the CFO? (2) What is the impact of blockchain technology in convergence with the Machine Economy on the key performance indicators (KPIs) of the CFO? (3) What is the impact of blockchain-enabled integrated business ecosystems on the role of the CFO? Based on a review of literature, semi-structured expert interviews were conducted with 23 participants. Analysis of the responses demonstrated a considerable impact of blockchain technology on the CFO-function. The results indicate improvements of business processes in regard to efficiency and automation, a relocation of the CFO's strategic role, improvements of CFO-relevant KPIs through integrating machines into payment networks as well as the emergence of integrated business ecosystems facilitating new forms of inter-organizational collaboration. Necessary prerequisites for adoption include digital competences of the CFO, appropriate organizational structures, digital currencies and identities on the blockchain, a change of the competitive mindset as well as standardized platforms with a neutral governance.

Keywords: blockchain technology; CFO; smart contracts; business process optimization; KPI; business ecosystems; internet of things; machine economy

1. Introduction

The role of the CFO is not considered to be particularly innovative. For many, his daily work is associated with balance sheets, cash flow analyses and Excel spreadsheets. With the advent of the blockchain technology, however, this perception could change and shift this financial corporate function towards a strategically operating innovation manager.

This applies, in particular, to CFOs who operate in an industrial environment and are influenced by the Machine Economy. The arrival of Big Data and the advent of emerging technologies, such as the Internet of Things (IoT) or Artificial Intelligence (AI) introduced the fourth industrial revolution, also referred to as Industry 4.0. Within Industry 4.0, fully networked value chains result in future-oriented production logics, leading to novel business models and growth opportunities. Through machine-to-machine (M2M) communication, intelligent and interconnected industrial components, such as machinery or sensor-equipped warehousing, are fully automated and exchange data without human intervention. Here, the blockchain technology serves as a key technology to facilitate the complete integration of data flow of all functions involved in the economic process of the future industrial period. The integration of blockchain improves an organization's cost efficiency and data availability, it integrates and automates business processes across company borders, and ensures robust and analytical business operations. Importantly, the blockchain also allows the automation of a firm's accounting and payment processes through an integration of machines into payment networks, prospectively, by using digital representations of conventional currencies.

In particular, the convergence of different technologies promises the emergence of integrated business ecosystems facilitated by the blockchain-enabled data integrity. Such ecosystems receive data recorded by the IoT, which are then administered and verified by the blockchain to be consequently automated by AI [1].

As a result of the aforementioned opportunities, it appears that the CFO and his finance department, unlike any other corporate function, can leverage blockchain technology for meaningful applications to accelerate the digital transformation of his organization. The appliance of blockchain technology thus potentially has a considerable influence on the role of the CFO of an industrial company.

For German industrial companies in particular, the digital transformation should be of the highest priority in order to remain competitive in an increasingly globalized and transnational economy. Predominantly, Asian economic areas exert considerable competitive pressure on the German industry [2]. Moreover, in 2018, the overall manufacturing industry accounted for about one third of the German gross domestic product [3]. Moreover, around 15 million German jobs currently directly and indirectly depend on the manufacturing industry [4]. This indicates just how important a robust and well utilized industry is for the national economy. In this context, the digital transformation will be an important building block for a sustainable and future-oriented economic development. Prospectively, the use of digital technologies will significantly contribute to the digital transformation of key German industries, such as the mechanical engineering, automotive or chemical industry. In this context, the blockchain technology plays a decisive role in achieving a high degree of digitization.

However, in the scientific field of blockchain technology, there is still a considerable divergence between the scientific implications and the practical implementation.

Therefore, the presented study aims to determine the impact of blockchain technology on the CFO of an industrial company in respect to his financial and strategic role, on his role-specific performance indicators as well as in regard to integrated business ecosystems.

As such, the paper is organized as follows. Section 2 describes the basic characteristics of blockchain technology, gives an insight into the blockchain-based Internet of Things as well as into the machine-to-machine economy. Section 3 introduces the research method and the underlying research questions. Thereafter, Section 4 provides the study's discussion of the experimental results. Section 5 then provides a conclusion and an outlook on further work on this topic.

2. Blockchain Technology

Blockchain technology was firstly introduced in 2008 in the form of a white paper called "Bitcoin: A Peer-to-Peer Electronic Cash System" published by an anonymous individual or group known as Satoshi Nakamoto [5]. Thus, the cryptocurrency Bitcoin constitutes the first application of blockchain technology. A blockchain is described as a digital data structure; that is, a shared and distributed database containing a continuously expanding log of transactions [6]. The data are stored in decentralized and uniform ledgers that are distributed among all participants, also referred to as nodes, of a computer network. A blockchain is composed of a series of blocks linking every new block cryptographically to the previous one. These blocks contain a certain quantity of records of transactions. Once a new block is verified, the ledger is updated and offers all participants a shared truth of records [7,8]. This results in a number of distinctive characteristics in regard to decentralization, persistency, anonymity and auditability [9]. Blockchains, other than highly centralized systems, avoid a single point of failure due to the redundant storage of data in a distributed ledger across all participants of the network. In case a single network participant should drop out or be compromised, the identical data records remain available at the other network participants, causing a high degree of persistency and transparency [10,11]. Thereby, it is nearly impossible for a single network participant to falsify or tamper data, as the comparison of the consistent data records being held by the other network participants would reveal a corruption of data [12]. As a result, a blockchain incorporates a high resilience to node compromise. The block-chain also eliminates the need for intervention of central authorities, which normally build participants' trust in centralized systems [9]. Each transaction performed on the blockchain is validated with the consensus of the network nodes. Therefore, a trust-free operation is possible without the necessity of a mediating party checking for compliance and accuracy of the operation. The requirement for consensus validation of the transactions and the provision of a time stamp on each transaction render the individual transactions highly auditable [13]. Even though the cryptocurrency Bitcoin remains the most popular application of this technology, the scope of application goes far beyond cryptographic currencies. Accordingly, Wang et al. see fields of applications in various financial services such as digital assets, remittance and online payment [9]. Thus, the latter authors see blockchain technology as an enabler for the next generation of internet interaction systems, such as smart contracts, public services and IoT. Outlier Ventures consider the blockchain as a key technology to enable intelligent M2M networks that could potentially exert a considerable influence on traditional industries such as design and manufacturing, distribution and logistics, as well as retail and commerce [14]. However, today's blockchain protocols still need to cope with a multitude of disadvantages compared to traditional centralized databases. Challenges include the scalability, security, anonymity and data privacy [11]. In particular, public blockchains such as Bitcoin or Ethereum suffer from a comparably low transaction throughput and high latencies for transaction settlements, leading to limited scalability. The transaction throughput of Bitcoin is currently maximized to seven transactions per second. To put this into perspective, VISA's centralized transaction processing network can process an average of 2000 transactions within the same timeframe [15]. Moreover, the purposefully designed energy-intensive consensus mechanisms of e.g., Bitcoin also limit the scalability, while further neglecting ecological sustainability [16]. However, the scalability is a critical element as it is decisive for a wide-scale adaptation of a technology in the practical context [17]. In addition, the rise of quantum computing represents a considerable vulnerability to the security of current crypto-graphic architecture as it could undermine the security measures of digital signatures [11]. Moreover, in the context of anonymity and data privacy, the identification mechanism in public blockchains via the public/private key, which can be traced publicly on the blockchain, facilitates the traceability of a user's identity [18]. The challenges outlined above continue to prevent the blockchain technology from a widespread adoption, which is why further technological advancements of this new technology are required. With respect to participating to consensus, there are two modes of operation: permissionless and permissioned. If participation is permissionless, anybody is allowed to participate in the network. This mode is true for Ethereum as a public blockchain. On the other hand, if participation is permissioned, participants are selected in advance and access to the network is restricted to these only. This is true for Fabric and Corda. The mode of participation, permissionless or permissioned, has a profound impact on how consensus is reached.

2.1. Blockchain-Enabled Internet of Things

Although the literature provides no universal definition of the internet of things (IoT), Rose et al. define IoT as "scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention" [19] (p. 5). Internet-connected machines, sensors and other everyday items such as cars, kitchen appliances, televisions, drones or even intra-body sensors can thereby interact with each other to form an independent ecosystem, to exchange data and to make intelligent decisions [7,20]. Specifically, IHS forecasts a total and worldwide installed base of IoT connected devices of around 75 billion in 2025, a fivefold increase since 2015 [21].

The advent of the distributed ledger technology is expected to act as an enabling technology for the Machine Economy. With its properties of decentralized trust, validation, security as well as privacy, it facilitates the interaction of various non-trusting members through a peer-to-peer network without the necessity for intermediaries [14,18].

The blockchain technology provides the exponentially growing number of IoT connected devices with addressability by a theoretically possible availability of e.g., 2160 unique Ethereum addresses. This opens up the possibility of a direct connection between IoT devices, effectively facilitating the Machine Economy instead of utilizing a cost-intensive and efficiency-hampering centralized database, which enables the data exchange. It will also provide compliance and governance for autonomous systems, originating in the immutability of the distributed ledger in connection with the application of smart contracts [10]. For a summary of different IoT blockchain protocols see Table 1.

Table 1. Overview of different Internet of Things (IoT) blockchain protocols; supplemented from [10].

	Consensus	Blocktime	TPS	Scalability	Security	Privacy	Smart Contract	Public/Private	Permission State
Ethereum	PoW	~15s	~15	**	***	**	****	Public	Both
Hyperledger Fabric	PBFT	~1s	~3500	****	***	***	***	Public	Permissioned
Multichain	PBFT	Adjustable	~500	****	****	****	*	Private	Permissioned
Lisk	DPoS	~10s	~2.5	***	***	***	**	Public	Both
NEO	DBFT	~15s	~1000	***	***	***	***	Public	Both
EOS	DPoS	~0.5s	~1000	***	**	****	***	Private	Permissioned
IOTA	FBC		~50	*****	***	***	***	Public	Both

1 - * Low ** Medium *** High **** Very High ***** Better High
2- Both = permissioned + permissionless
DPoS = Delegated Proof-of-Stake Consensus
PBFT = Practical Byzantine Fault Tolerance
DBFT = Delegated Byzantine Fault Tolerance
PoW = Proof of Work
FBC = Fast Probabilistic Consensus

2.2. Blockchain-Based Machine-to-Machine (M2M) Economy

The advent of blockchain technology with its decentralized ledger technology, is considered to be a suitable backbone enabling a machine-to-machine (M2M) economy in the future [10]. M2M economy and M2M communication will thus be outlined further below.

In recent years, economy has experienced a shift from human economy, characterized by an interaction and interoperability between people and machines, towards a machine economy. On a global scale, the per capita average number of devices and connections will rise from two in 2015 to more than three by 2020. Inter alia M2M connections will represent approximately 46 percent of total connected devices. Therefore, M2M is considered to grow faster than any other category [22]. By 2020, more than 75 billion IoT-capable devices will be in place, stating the immense impact of M2M devices on society and the economy [21]. Eichmann even considers "everything will be smart, autonomous and connected, economically independent and most likely managed by a new technical backbone—and not by old mainframes anymore" [23] (p. 1). Machine-to-machine economy or M2M economy is defined as a communication network whereby machines, objects and sensors are connected with each other [24,25]. The concept of machine economy, however, originally emerged from basic fleet management solutions with the aim to improve specific processes, for instance the monitoring of valuable shipments and data is most likely not shared beyond its silo. At this moment in time, the integration of stand-alone solutions into a broader business context was not taken into consideration [24]. Two markets exist for M2M economy: on the one hand, the B2B market which includes the industrial internet and is considered the main market of M2M, and on the other hand, machine economy targets a B2C market which entails the Internet of Things (IoT) [24]. M2M economy has so far been driven by device-centric solutions, but due to recent developments in technology, these solutions have now been replaced by sophisticated process-centric solutions whereby data streams are combined.

Furthermore, emerging technologies including the Internet of Things, which will be explained in further detail below, enables connected solutions. According to Anton-Haro and Dohler, "M2M will ultimately pervade all aspects of [...] lives including environments with which we interact, every aspect of economic [...] activities that underpins our daily lives." [24] (p. 350).

3. Research Method

3.1. Research Context

In the scientific field of blockchain technology, there is still a considerable divergence between the scientific implications and the practical implementation. Although industry leaders generally consider blockchain technology to be potentially disruptive, they often miss the comprehension of where and how blockchain technology can be used effectively and where it has considerable practical benefits [26].

Consequently, it is indispensable for science to consider not only the technological aspects of blockchain technology but also the field of practical application. In this context, research should primarily focus on corporate functions, such as the CFO, that can advance and facilitate a meaningful application of the blockchain technology. By identifying relevant benefits for the respective corporate function, this can contribute considerably to the practical adoption. As a result, presumably more than in any other research area, research can currently contribute to the sustainable development of the manufacturing industry.

3.2. Participants

Previous to the selection process, the target group for the expert panel and the sample size have to be determined [27]. Thus, only interview partners with an appropriate expertise gained by profession either in blockchain technology, consulting and/or from industries were consulted. Of special interest were CFOs and financial experts from different industries, including chemical pharmaceutical supply chains, fast moving consumer goods as well as legal services and asset management. Experts are people who, due to their long-standing experience, possess specific knowledge or skills. This sector-specific knowledge was the fundamental criterion used when selecting experts [28]. Specifically, in the case of this study, these were persons who, by exercising their professional role, were able to judge and evaluate the effects of blockchain technology on the finance function of an industrial company. The primary target groups were individuals from the fields of industry, consulting and academia. The sample size of this study was 23 (n = 23), as shown in Table 2. Due to the narrow study aim, a sample size of 23 participants provides sufficient information power. Firstly, this is due to a combination of participants that is highly specific for the study aim. Secondly, the results of the interviews are supportable by established theory [29]. Firstly, derived from the audio-recording, the collected data were subject to transcription. Due to the non-standardized nature, the transcribed data were then compressed, and a set of categories created following the logic of the previously defined research questions [30–32].

Table 2. Overview of expert panel.

Expert	Job Title	Industry
1	Board Member	FinTech
2	Partner	Consulting
3	Senior Consultant	IT Services
4	Senior Consultant	Consulting
5	Strategy Consultant	Consulting
6	Senior Manager	FinTech
7	Managing Director	Consulting
8	Senior Consultant	Consulting
9	Managing Partner	FinTech
10	CFO	Consumer Goods
11	Co-Founder	Chemical
12	Partner	Legal
13	Senior Consultant for Digital Technology	Insurance
14	Head of Business Development	Consulting
15	Head of Business Development	Chemical
16	Head of Supply Chain Business	Consulting
17	Professor for Finance and Entrepreneurship	Academia
18	Business Development Manager	Finance
19	Portfolio Manager	IT-Services
20	Senior Digital Strategist	Chemical
21	Consultant	Consulting
22	CFO	Finance
23	Attorney	Legal

3.3. Instruments

For purposes of primary research, new information can either be gathered via observation, surveys or based on interviews [33]; however, telephone interviews were chosen. For credibility purposes of the interviewer, three criteria have to be fulfilled when conducting an expert panel [32]. First of all, the interviewer has to be knowledgeable concerning the research topic, furthermore, he should consider the organizational context of the interview and an adequate location for conducting the expert panel chosen [32]. Considered a necessary prerequisite, the expert panel received a briefing beforehand. During the telephone interview, the semi-structured nature of the questionnaire allowed for slight amendments and/or further enquiries in accordance with an interviewee's expertise. In addition, each expert has been informed that the interview has to be recorded and in the case of interest, results would be shared afterwards.

Due to the explorative nature of the paper, theoretical knowledge from secondary literature as well as an analysis of a multiple case study were drawn as an accession process for creating a profound understanding of the research topic. It also fostered the creation of the questionnaire for the expert panel. However, the aim of the expert interview was to answer the previously defined research questions and therefore, primary research methods had to be included. This thesis interrogated the expert panel on the impact of blockchain technology on the future role of a CFO, including the probability and extent. Moreover, it discussed benefits and possible obstacles of blockchain technology on the financial sector and CFOs. In the following, the interview strategy, selection of interview partners including sampling as well as the preparation and execution of interviews and the evaluation method will be described.

The overall aim of an exploratory study is to gain further qualitative insights and valuable statements on the research questions from the expert panel [30,32]. Due to the explorative nature of the paper, a semi-structured telephone interview was the chosen tool [34]; thus, all participants received a questionnaire including identical guideline questions in advance. The guideline is designed to capture the respondent's opinions and attitudes on a specific topic, instead of aiming for quantifiable statements of a quantitative survey. The guideline enables the interviewer to respond to the interviewee depending on the situation and to lead the conversation [35].

3.3.1. Multiple Case Study Analysis

By exploring various bounded systems over a certain period of time, a multiple case study analysis serves to understand the value of findings, enable a broader theoretical evolution as well as derive research questions [36]. Due to its novelty, the underlying study has partly been built upon a multiple case study analysis and allows for more interesting research [28].

3.3.2. Expert Interviews

The theoretical foundation of this study comprises a synthesis of existing research of secondary literature to provide a profound understanding of the research topic. Due to the explorative nature of this research, a primary research method is to be used by a systematic and theoretical procedure of data collection in the form of interviews with people in possession of exclusive knowledge [29]. The scientific results are generated from the statements of the interview partners and analyzed on the basis of theoretical concepts [37].

3.4. Research Questions

- RQ1: What is the impact of blockchain technology on the financial as well strategic role of the CFO?
- RQ2: How will blockchain technology and the possibility of machine-to-machine payments leverage the CFO role and improve its company's key financial metrics?
- RQ3: What is the impact of blockchain-enabled Integrated Business Ecosystems on the role of the CFO?

4. Analysis of the Results

Alongside the results, the previously defined research questions will be discussed in chronological order. It will combine the experts' statements with this paper's theoretical foundation to examine the impact of blockchain technology on the CFO of an industrial company. Firstly, the impact of blockchain technology on the financial as well as strategic role of the CFO will be discussed. Thereafter, the impact of blockchain technology in convergence with the Machine Economy on the KPIs of the CFO will be examined to ultimately determine the influence of blockchain-enabled integrated business ecosystems on the role of the CFO.

4.1. RQ1: What is the Impact of Blockchain Technology on the Financial as Well Strategic Role of the CFO?

The CFO is involved in the formulation of the strategic financial strategy as well as in the corporate strategy of his organization. This is where blockchain technology provides the CFO with a useful toolset. The integration of blockchain improves an organization's cost efficiency and data availability, it integrates and automates business processes and ensures robust and analytical business operations. As such, the following sections will discuss the impact of blockchain technology on the CFO's strategic financial management, including accounting, reporting and auditing as well as the impact on the corporate strategic management.

The CFO oversees the organization's financial reporting and exercises influence on existing accounting functions. In this context, blockchain technology serves as an additional layer to enterprise-resource-planning (ERP) systems, facilitating operational efficiency and accuracy of data. By utilizing a blockchain, occurring financial transactions are immutably and automatically recorded in real-time and stored in a joint and company-distributed ledger. Hereby, existing data silos within a company are broken down and the financial data are aggregated, standardized and cryptographically verified. This process allows the CFO to meet the challenges of digitization in terms of controlling and data management. Firstly, the blockchain offers an effective data quality management as the data are consistently processed, maintained and represented. Secondly, the blockchain harmonizes and aligns a firm's IT infrastructure and enhances inter-departmental interoperability. Likewise, the blockchain simplifies the CFO's IT security, risk management and data governance. Unlike centralized databases, a blockchain does not leave room for a single point of failure. Consequently, it is considerably more difficult for attackers to deactivate a system or to manipulate data. Moreover, all data on the blockchain are cryptographically secured which prevents unauthorized access to confidential information. Given the high adaptability of consortium blockchains, authorized and granular access to financial data to external parties is facilitated, e.g., to tax authorities, auditors, banks or investors, consistently compliant with the general data protection regulations (GDPR).

Having said that, the use of a blockchain provides the CFO not only with advantages with regards to internal accounting, but also benefits the inter-organizational exchange through the integration and automation of payment versus delivery. According to experts, blockchain-enabled automated accounting serves as a tool for business process optimization. Hence, previously labor-intensive and time-consuming accounting processes created by the non-harmonized transition from one company to another can be automated and streamlined by deploying smart contracts autonomously executing business logics. The resulting inter-organizational standardization and alignment allows for a concurrent settlement without the need for time- and capital-intensive reconciliations. In this way, new financial strategies can be designed such as ensuring a more efficient working capital or cash flow management. Such improvements can have a considerable influence on the accounts payable process. Currently, the hand-operated procedure of coordinating and authorizing payments is labor- and cost-intensive. In contrast, blockchain allows payments to be instantaneously approved not only in an autonomous and immediate manner, but also in accordance with the underlying smart contract. Such efficiency gains will considerably improve an organization's cash flow, as well as the Days Sales Outstanding (DSO). Moreover, the account receivable process could also be automated by utilizing a blockchain. Here, too, a smart contract could pre-authorize payments, resulting in the organization's improved cash flow and transaction speed. Ultimately, the use of the blockchain improves a firm's liquidity ratio and working capital.

In terms of the CFO's reporting function, the blockchain-enabled real-time operational insight into financial data and all occurring transactions likewise exerts considerable efficiency improvements. Firstly, the CFO obtains real-time, time-stamped, verified and tamperproof metrics. Secondly, the data are standardized and fully aggregated into a single data pool. Such transparency not only supports a company's decision making and material utilization, but also facilitates a comprehensive status report on the firm's financial condition. Thus, the arising benefits from incorporating blockchain technology into an organization's daily operations ultimately support the CFO's goal of maximizing the shareholder value.

The standardization of business processes, the increase in data transparency and integrity across separate corporate departments and the enhancement in operational insight enable the CFO to automate existing auditing processes. Thus, the blockchain serves as a single source of truth on which all closed contracts and executed transactions are digitally stated and automatically verified by all the parties involved. Thereby, the auditor can generate a thorough and time-efficient transaction review without the necessity of random transaction sampling. According to experts, the resulting transparency significantly reduces error rates, as well as the CFO's liability risks. In addition, according to Expert 8, the digital representation of physical assets on the blockchain allows for a complete and immutable audit trail, which becomes particularly valuable for industrial firms trading with highly regulated goods.

According to expert opinion and the literature [38], emerging technologies, such as robotic process automation (RPA) and artificial intelligence (AI), enable the broad automation of an organization's accounting, reporting and auditing activities. Here, the blockchain serves as the necessary backbone by providing all relevant and consolidated data. In line with the experts, the convergence of blockchain with emerging technologies creates an increase in business process optimization (BPO), reduces human capital costs, increases the transaction speed and, in turn, results in a reduction in error rates. Thus, blockchain technology may be understood as the basis for data processing of accounting, auditing and reporting activities with a considerable and long-term impact on the net profit of a company.

As confirmed by the surveyed experts, digitization, along with its continuing growth in data volumes, is shifting the CFO function to a supportive role that assists the chief executive officer (CEO) in formulating the company's corporate strategy. The exponential growth in data volumes offers companies new possibilities for analyses, but also poses the challenge of structuring and analyzing the data [39]. Although the era of Big Data is a cornerstone to analyzing valuable and company-relevant data, raw data often remain unstructured and unconsolidated within company structures. This can prevent a meaningful analysis, potentially leading to false implications. Moreover, data from external and unknown sources are oftentimes not authenticatable, which increases the risk of handling incorrect or unlawful data sets and, again, can cause misinterpretations or legal infringements.

In this context, blockchain technology is of central relevance in supporting the CFO's responsibility of creating an effective information system management. Thus, incoming data can be verified and authenticated by checking the associated hash function of the data set. Therefore, unintentional modifications or other forms of manipulation can be detected before the consolidation of data takes place. As further within the last chapter, through blockchain technology, the data then can be bundled into a sophisticated data pool in a standardized, immutable and complete manner. The generated data optimization offers the CFO the ability to perform advanced data analytics. Internal financial data can thus be combined with other data sources, enabling the CFO to play a leading role in the formulation of the corporate strategy. In this way, it is possible to more proficiently run descriptive, diagnostic, predictive or prescriptive analyses. In combination with AI, this provides, for example, a more precise presentation of company data, a clearer understanding of the root causes for poor company performance as well as earlier recognition of market trends or competitive behavior.

As a result of the blockchain, the CFO will be able to analyze larger amounts of data more economically, faster and with greater accuracy. Thereby, the CFO can support other members of the C-Suite more efficiently in formulating the strategic direction of the company. Hereby, the CFO's task is to ensure that the appropriate systems, instruments and trainings are in place to support his/her workforce in performing such analyses. If successfully implemented, a CFO can influence the corporate strategy of a company more than any other board function. With the blockchain as a basis for decision making, the CFO can make a company more steadfast, while reducing the firm's vulnerability to risks.

4.2. How Will Blockchain Technology and the Possibility of Machine-to-Machine Payments Leverage the CFO Role and Improve its Company's Key Financial Metrics?

By 2025, the total installed base of IoT devices is estimated to equal 75 billion [21]. While a large proportion of this quantity will certainly represent household devices, this will also refer to industrial components within Industry 4.0 such as interconnected machinery or sensor-equipped warehousing as silos. In this respect, according to the expert interviews, the blockchain serves as a key technology to facilitate the complete integration of the data flow of all functions involved in the economic process of the future industrial period. The conducted expert interviews have shown a significant influence of blockchain in convergence with the Machine Economy on the KPIs of the CFO of an industrial company. These include a reduction in operational expenditures, an improvement of the CFO's working capital management, an enhancement in treasury and cash management as well as an improvement of capital provision.

4.2.1. Reduction in Operational Expenditures

As previously discussed, the blockchain offers a variety of cost-efficiencies regarding internal and inter-organizational accounting, reporting, auditing as well as the high potential of business process automation through smart contracts and emerging technologies. These advantages also materialize in the context of Industry 4.0, with the incorporation of both machine and sensor data recorded on the blockchain. Following the executed expert interviews, this enables the subsequent cost-cutting measures regarding operational expenditures.

With reference to Expert 15, the installation of sensors into e.g., chemical silos enables real-time insight into the associated filling level. Here, for instance, the silo operator as well as the customer run a separate blockchain node to sign and verify the metered telemetry data. On the one hand, this allows for a highly accurate and ongoing stocktaking of the silo content. This simplifies the otherwise regular, cost- and time-intensive inventory process and provides insight into consumption data, which offer blockchain-enabled full integrity and transparency with fully automated replenishment of raw materials. On the other hand, this enables highly accurate forecasts of expected consumption which prevents excess production. Resulting from the high degree of transparency and trust among the operator and customer, a silo can be embedded into the payment transaction processing by additionally using the blockchain as a payment layer. Consequently, if a customer consumes chemicals out of the operator's silo, the silo itself automatically and directly executes the invoicing and audits the incoming payments. Thus, instead of the silo operator's accounting department, the silo itself sends the invoice and checks incoming payments based on the underlying smart contract predefining the order lifecycle. This also eliminates the need for invoice verification and payment instruction on the part of the customer. According to Expert 15, machines therefore have the potential to become independent economic actors referred to as "profit centers". In this scenario, machines are equipped with their own digital wallets, which make it possible for the machines to send and receive funds. This happens without requiring an additional intermediary for the transaction processing, such as a human-operated accounting department. This process considerably reduces administrative expenditures per transaction by the facilitated machine-to-machine payments and prospectively enables a decentral governance of organizations.

4.2.2. Improvement of Working Capital Management

Blockchain technology facilitates full transparency and integrity of the sensors' telemetry data measuring a company's assets. According to the surveyed experts, this considerably improves the working capital management of a CFO. Firstly, blockchain-enabled predictive advanced data analytics support the CFO in minimizing the warehouse stock. Consequently, the tied-up capital declines and therefore working capital is reduced, which in turn increases the company's liquidity.

Secondly, in addition to minimizing the warehouse stock, the blockchain enables the CFO to capitalize a company's assets on the balance sheet. If, for instance, the silo is situated at the customer's plant, it is currently rather complex to gain real-time and verified insight into the filling level of the silo. However, if these measurement data are now transmitted in a fully transparent and verified manner, the CFO can capitalize the available assets on the balance sheet at any time. Consequently, previously hidden reserves are disclosed which positively impacts the asset side and therefore the working capital.

The integration of machines into payment transactions also exerts a positive influence on a CFO's working capital ratio. The utilization of blockchain-enabled autonomous M2M payments shortens the supplier's DSOs, as payments are instantly settled. This, in turn, positively impacts the cash-to-cash cycle time and liquidity, while ultimately lowering the working capital associated with the increase in transaction speed.

4.2.3. Improvement of Treasury and Cash Management

The strategic financial management of a CFO comprises the overall cash management, while heading the treasury department of a company [40,41]. Again, the interviews conducted revealed a substantial influence on the CFO's key performance indicators in the realms of cash management and treasury.

The blockchain-enabled automated M2M payments provide the ability to integrate machines into payment networks. Notably, the blockchain technology also facilitates the representation of traditional currencies as units of account. According to the experts, the representation of e.g., the Euro on the blockchain permits the association of the currency with functions by then being programmable. Hence, not only the programming of simple payment logics is conceivable, but also the depiction of predefined and already existing entire business logics. In the industrial environment, leasing contracts, factoring processes or interest payments would be plausible.

Accordingly, a possible application would be a revolutionary form of leasing of machinery and production equipment. As previously discussed, the blockchain technology creates a high degree of transparency and integrity associated with machine sensor data. As a result, these data could be used by the lessor to provide the lessee with a usage-based and flexible leasing rate. In accordance with the profit center logic, the lessee does not represent a specific company, but the machine itself, which also fully automatically pays the lease payments and keeps accounts.

Similarly, a machine could conclude factoring contracts and decide for itself when an inflow of money should occur. In order to make this possible, a blockchain-based capital market that runs in the background would ensure the sufficient provision and funding of the factoring. Up until now, economically feasible asset-backed security transactions can only be carried out if the securitization is based on a sufficient volume of receivables. In contrast, due to its high degree of automation and transparency, the blockchain could prospectively securitize even relatively small receivables without the need for an intermediary. Additionally, the CFO can also use machine data to more accurately determine financing needs to prevent the over- or under-funding of dept capital.

4.2.4. Improvement of Capital Provision and Reduction in Capital Costs

The CFO, in his role of managing the financing portfolio of a company, is provided with a new instrument for corporate financing by the possibility of blockchain-based tokenization of assets to be traded on capital markets. By capturing telemetric data and the simultaneous verification by the parties involved, potential investors gain the data security they demand to invest in previously illiquid assets—in a highly granular manner. This allows not only the securitization of accounts receivable, as in the case of factoring, but also the securitization of entire production facilities and their individual components. Consequently, by displaying and tokenizing individual machines or silos as digital twins on the blockchain, an unchangeable and complete audit trail is generated that records the utilization of an industrial component and allows the subsequent investor's rate of return to be calculated. This complements the aforementioned profit center logic. Therefore, in the environment of Industry 4.0, the securitized machine or silo do not only autonomously perform management in regard to accounting, reporting and auditing but also independently control the own capital provision by facilitating availability on the capital markets.

So far, the securitization of such granular commodities has not been economically viable due to the high costs associated with legal structuring or auditing. The legal reorientation of legislation that can now be observed, for example in Liechtenstein, renders it possible to set up and issue singular capital goods in an economically sensible manner. Additionally, high administration costs will be largely omitted, which will make high audit costs obsolete. Thus, companies can automate the issuance, sale and administration of granular capital assets.

In line with the conducted interviews, the CFOs of industrial companies and small and medium-sized companies (SMEs) are able to significantly reduce debt capital costs, ensure faster and cheaper on-demand refinancing and significantly increase the underlying investor base. In the long run, the dependence of industrial companies on a small number of banks will thus be reduced. In the future, it will be private or institutional investors who ensure sufficient financing, together with other industrial companies that finance each other. In this way, capital goods can be off-balanced in order to contract the company's balance sheet.

4.3. RQ3: What Is the Impact of Blockchain-Enabled Integrated Business Ecosystems on the Role of the CFO?

The blockchain-enabled data integrity facilitates new forms of inter-organizational and inter-industry collaboration, serving as a backbone for applications in the fields of e.g., Industry 4.0, Mobility and Energy. Previously costly and incompatible intermediate stages of the business process, caused by incompatible ERP systems, data silos, different company policies and a lack of trust, are thus merged and harmonized over the entire business process lifecycle and are monitored by the conditions of a smart contract. Hence, the blockchain's characteristics of transparency, immutability and cryptography are the cornerstones for the emergence of inter-company and inter-industry collaboration. This creates a high level of trust among participants of integrated ecosystems, permitting a high degree of automation with auditable parameters and simultaneously reducing the need for human intervention to a minimum. For a CFO of an industrial company operating under the influence of the Machine Economy, these benefits are of great importance in order to enable all the different actors such as humans, companies and machines to network and transact with each other on an inter-company basis. The resulting interoperability leads to an outward reorientation of the CFO's company, enabling organizations to be part of a globally networked economy, potentially leading to an economic paradigm shift. The outward-looking orientation of the company allows for a reciprocal exchange of data, which will result in a highly collaborative and diverse ecosystem.

However, in such ecosystems, the blockchain can only develop its potential and create added value in convergence with other emerging technologies. Such ecosystems receive data recorded by the Internet of Things, these data are then administered and verified by the blockchain to be consequently automated by artificial intelligence [1]. In particular, the experts surveyed see the potential of integrated ecosystems particularly for companies with a large machine base permitting connectivity to the internet, for businesses with high-volume and industry-relevant data production and for corporations maintaining recurring and intensive supply relationships amongst each other. In the first case, using such a blockchain-based integrated ecosystem, companies can integrate their machines into a payment network, achieve a high degree of automation and at the same time make the machines accessible to the external market, for instance, to increase the machine utilization and to consequently reduce idle time. Additionally, the CFO can leverage the blockchain and emerging ecosystems to exchange valuable and industry-relevant data with other ecosystem participants to subsequently monetize it. For example, vehicle data on the blockchain are already being exchanged between several car manufacturers in an ecosystem with the aim of improving the performance of vehicles. Moreover, applying blockchain technology eliminates barriers that previously hindered the secure and transparent exchange of this data. All participants, including the drivers, retain full control over their data and can decide which data they want to pass on and which to not. Additionally, companies with large and multi-dimensional supply relationships can use such ecosystems to automate and streamline the entire order lifecycle. Thus, participating in an integrated ecosystem potentially results in cost reductions with regard to cost-efficiencies through the automation of business processes, a decrease in administrative expenditures as well as a reduction in labor costs. In addition, integrated business ecosystems provide an opportunity for new business models and therefore new profit pools for the CFO and his organization.

However, as with the KPIs of the CFO, certain preconditions must be met in order to capitalize on the aforementioned business opportunities. Firstly, due to the still relatively nascent development stage of the blockchain technology, a variety of different platforms and non-interoperable systems have emerged. Due to insufficient interoperability of different blockchains, an efficient and productive cooperation of various actors is frequently hampered. The top management of firms should therefore involve industry stakeholders in order to agree upon common standards and requirements to foster collaboration. Consequently, and secondly, a change in mindset at the top management level is required. In the highly collaborative environment of integrated ecosystems, companies are required to be willing to engage with external parties, including even their competitors. This is of central importance as it is the only way to realize the benefits in terms of cost efficiencies and new business models. Unlike in the classical business environment, this inevitably implies an increased obligation to exchange data with the other participants of the ecosystem. In order to master the technological challenges and to determine new fields of business, industrial companies are advised to establish innovation hubs, acquire startups or to collaborate with external partners. A further essential element is the governance and design of such ecosystems. Especially for competitors operating in the same ecosystem, it is of utmost importance to establish a neutral platform design. Both rights and obligations in these ecosystems must be equally distributed to avoid an imbalance of benefits. Only then will the participants be willing to engage in the ecosystem and collaborate and exchange data with other actors.

5. Conclusions

As a result of the theoretical implications, this thesis provides a set of implications for practice. It is demonstrated that the blockchain has much more upside potential beyond the often-discussed application of cryptocurrencies. In addition to the considerable automation potential of business processes, the blockchain offers the CFO the opportunity to significantly enhance many of his role-specific key performance indicators. Particularly in the environment of the Machine Economy, these benefits of the blockchain technology are evident and will make a substantial contribution to the digitization of key German industries. Due to the increasing international competitive pressure, it would be negligent for companies to overlook the use of blockchain technology. Thus, particularly the finance departments of traditional industrial companies have the opportunity as well as the obligation to promote digital transformation in order to lead their organization into a sustainable and competitive-resistant future. Thus, the impulse for the implementation and adoption of the blockchain technology should originate from the CFO, as he is the one who can use the technology for meaningful applications within his field of responsibility. On the side of the CFO, this requires a basic interest and understanding of new technologies, appropriate corporate structures to facilitate an effective change management, a sufficient financial budget for research and development as well as an open dialogue with external parties. However, the adoption of blockchain technology in an industrial context is strongly dependent on external regulatory conditions as well as on further technological progress. Firstly, the Euro on the blockchain as well as digital identities will be a mandatory requirement to enable the CFO to adopt the blockchain technology. Only then proof of concepts can be implemented in live settings complying with the existing company structures and legal requirements. On the technological side, the Machine Economy and the associated Internet of Things require further advancements in transaction throughput and latency of blockchains as well as the establishment of standardized platforms to enable efficient inter-company business processes.

5.1. Scientific Implications

This explorative paper shows that blockchain technology will have a significant impact on the CFO-function of an industrial company. Specifically, this work not only supports but also extends existing research of e.g., Caglio et al. [42] and Datta and Iskandar–Datta [43] on the impact of emerging technologies on the financial corporate function by explicitly addressing blockchain technology. Firstly, it reaffirms the gradual reallocation of the CFO role from its traditional finance function towards an increasingly strategically operated corporate body. In this context, this thesis explores new insights into how blockchain technology can support the CFO in making informed strategic decisions by being able to effectively process and combine data. Furthermore, new possibilities of blockchain technology for business process optimization are outlined, which will redefine the accounting, reporting and auditing processes of enterprises in the coming years. Moreover, the conducted expert survey addresses a research gap regarding the effects of blockchain technology on the CFO-specific key performance indicators in the environment of the Machine Economy. It concludes that the blockchain technology considerably improves a number of performance indicators relevant to the CFO. In this context, this paper also addresses the so far overlooked prerequisites, which must be fulfilled in order to realize the detected potential performance increases. Furthermore, this work complements the existing literature on blockchain-enabled integrated business ecosystems and the resulting impact on the CFO and his organization potentially leading to an economic paradigm shift. In particular, it highlights the need to combine different technologies such as IoT and AI to achieve a high degree of automation in these ecosystems. In this context, new opportunities for inter-company cooperation are identified, the potential of new business models is examined and obligatory preconditions for establishing such ecosystems are investigated.

5.2. Limitations

The aim of this work is to provide an initial and wide-ranging overview of the impacts of blockchain technology on the CFO-function of an industrial company. As for the high explorative character of this paper, several limitations are present. Firstly, the results of this paper might be limited due to a potential geographical sample bias, as all the surveyed experts are German or are based in Germany. This circumstance potentially leads to a biased view on the effects and preconditions presented in this paper. Moreover, the sample size of n = 23 is insufficient to reliably identify significant relationships from the data and to be considered as representative. Additionally, due to the novelty of the investigated topic, experts might not be in possession of a comprehensive understanding to rightfully assess the impact of blockchain technology on the CFO. Another limitation results from the limited previous research on the investigated topic. In addition, due to the scope of this work, this paper outlines only a selection of possible factors influencing the role of the CFO and thus cannot guarantee completeness of results. Therefore, this study is to be understood as a multiple case study, whose hypothesis needs to be tested in a further and deeper research.

5.3. Implications for Further Research

Due to the novelty of blockchain technology and other emerging technologies such as IoT and AI, further research activities are essential to accelerate the adoption and commercial exploitation. Among others, opportunities for further research comprise the governance of blockchains, technological improvements, regulation and law as well as the blockchain's integration with the off-chain world. Referring to integrated business ecosystems, a central prerequisite for the success is the selection of an appropriate governance models. To the author's knowledge, no substantial research has been carried out on this subject to date. However, due to the blockchain's ability to incorporate numerous possibilities of configuring its governance, it will be of utmost importance to investigate suitable governance models to facilitate inter-company cooperation. The currently low scalability of blockchains remains an impediment to their adoption in the industrial sector. However, high scalability is an absolute imperative in industrial settings, as a high and cost-efficient data throughput must be ensured. Especially in interaction with IoT, it will become even more important in the future to be able to process larger amounts of data in a shorter period of time. In this area, research will need to develop solutions to increase scalability in order to position blockchain technology as a viable alternative to centralized systems. Although Germany is on the right track, many regulatory challenges still need to be overcome in order to realize the efficiency gains promised by a decentrally controlled Machine Economy. Particularly important will be the regulatory approval of the digital Euro as well as the authorization of digital identities. In this context, for a sound regulation, it will be vital that research assists legislators with the policy to ensure suitable solutions in order to create the necessary legal frameworks. Concerning the integration of sensor data on the blockchain, additional research gaps remain. Although the blockchain can verify received sensor data, it is unable to identify previously corrupted data that have been manipulated in the off-chain environment. To successfully converge blockchain technology with the Internet of Things research needs to identify techniques to detect corrupted data before they are processed and recorded on the ledger.

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