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Bachelor Thesis

**THE IMPACT OF ESG FACTORS ON
SUPPLY CHAIN INFORMATION SYSTEMS**

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ABSTRACT

This thesis explores the integration of environmental, social and governance (ESG) criteria into the management of supply chains, focusing on the role of information systems and emerging technologies such as blockchain, while also examining the shift in corporate decision-making towards sustainability and ethical governance, driven by factors such as investor interest, legislative changes and public awareness. The research examines the importance of data management along supply chains and the potential benefits of adopting cutting-edge technologies such as blockchain to improve traceability and transparency.

Through the analysis of recent European regulations, the thesis highlights the challenges and opportunities in ESG management and sustainable supply chain practices in the businesses, focusing on the role blockchain can play in improving transparency, traceability and efficiency in supply chain management, with a particular focus on the integration of sustainability standards. The study emphasises the importance of technology in ESG compliance and presents a case study illustrating the practical implementation of a pioneering software for monitoring sustainable supply chain practices. Ultimately, the thesis emphasises the dynamic nature of ESG goals, focusing on the importance and opportunities that technology provides in promoting continuous improvement towards sustainability and social responsibility.

Questa tesi approfondisce l'integrazione dei criteri ambientali, sociali e di governance (ESG) nella gestione delle filiere, concentrandosi sul ruolo dei sistemi informativi e delle tecnologie emergenti come la blockchain, esaminando al contempo lo spostamento del processo decisionale aziendale verso la sostenibilità e la governance etica, guidato da fattori quali l'interesse degli investitori, i cambiamenti legislativi e la consapevolezza pubblica. La ricerca esamina l'importanza della gestione dei dati lungo le catene di fornitura e i potenziali vantaggi dell'adozione di tecnologie all'avanguardia come la blockchain per migliorare la tracciabilità e la trasparenza. Attraverso l'analisi delle recenti regolamentazioni europee, la tesi mette in luce le sfide e le opportunità nella gestione ESG e nelle pratiche di supply chain sostenibile nelle imprese, concentrandosi sul ruolo che la blockchain può svolgere nel migliorare la trasparenza, la tracciabilità e l'efficienza nella gestione della supply chain, con particolare attenzione all'integrazione degli standard di sostenibilità. Lo studio sottolinea l'importanza della tecnologia nella conformità ESG e presenta un caso di studio che illustra l'implementazione pratica di un software all'avanguardia per il monitoraggio delle pratiche

sostenibili della catena di fornitura. Nel complesso, la tesi sottolinea la natura dinamica degli obiettivi ESG, concentrandosi sull'importanza e sulle opportunità che la tecnologia offre nel promuovere il miglioramento continuo verso la sostenibilità e la responsabilità sociale.

In dieser Bachelorarbeit wird die Integration von Umwelt-, Sozial- und Governance-Kriterien (ESG) in das Management von Lieferketten untersucht, wobei der Schwerpunkt auf der Rolle von Informationssystemen und aufkommenden Technologien wie Blockchain liegt. Gleichzeitig wird der Wandel in der Entscheidungsfindung von Unternehmen in Richtung Nachhaltigkeit und ethische Unternehmensführung untersucht, der durch Faktoren wie das Interesse von Investoren, Gesetzesänderungen und das öffentliche Bewusstsein vorangetrieben wird. Die Untersuchung befasst sich mit der Bedeutung des Datenmanagements entlang der Lieferketten und den potenziellen Vorteilen des Einsatzes von Spitzentechnologien wie Blockchain zur Verbesserung der Rückverfolgbarkeit und Transparenz. Durch die Analyse aktueller europäischer Verordnungen beleuchtet die Arbeit die Herausforderungen und Chancen des ESG-Managements und nachhaltiger Lieferkettenpraktiken in den Unternehmen, wobei der Schwerpunkt auf der Rolle liegt, die Blockchain bei der Verbesserung von Transparenz, Rückverfolgbarkeit und Effizienz im Lieferkettenmanagement spielen kann, mit besonderem Fokus auf der Integration von Nachhaltigkeitsstandards. Die Studie unterstreicht die Bedeutung von Technologie bei der Einhaltung von ESG-Vorgaben und stellt eine Fallstudie vor, die die praktische Umsetzung einer bahnbrechenden Software zur Überwachung nachhaltiger Lieferkettenpraktiken veranschaulicht. Schließlich unterstreicht die Arbeit den dynamischen Charakter von ESG-Zielen und konzentriert sich auf die Bedeutung und die Möglichkeiten, die Technologie bei der Förderung kontinuierlicher Verbesserungen im Hinblick auf Nachhaltigkeit und soziale Verantwortung bietet.

Keywords: ESG, supply chain management, blockchain technology, sustainability, transparency

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1. Introduction

Over the past few decades, there has been a significant increase in interest from investors, regulators and other stakeholders in environmental, social and governance (ESG) sustainability. This has been driven by growing concerns about climate change, social justice and corporate responsibility. As a result, companies are now faced with the challenge of effectively integrating ESG into their operations, including data management along the supply chain. The supply chain management industry is undergoing unprecedented change, driven by the urgent need to adopt more sustainable and ethical practices. In this context, the integration of environmental, social and governance (ESG) criteria is becoming increasingly important for companies wishing to operate responsibly and sustainably.

The adoption of ESG standards represents a dramatic change in the business environment for multinational companies. The paradigm of corporate decision-making has shifted from one where profit and shareholder interests were paramount to one where environmental impact, social responsibility and ethical governance are now key objectives. There are many reasons for this, including growing investor interest in companies that practice sustainability, legislative changes and public awareness of environmental issues.

Data management along supply chains is critical in today's business climate. In addition to informing internal operational decisions, a company's ability to collect, assess and track a wide range of ESG-related data is becoming increasingly important to investors, regulators and other stakeholders.

The adoption of cutting-edge technologies, such as blockchain, is emerging as a major opportunity to improve traceability and transparency along the supply chain, enabling companies to more accurately and consistently monitor and assess the ESG impact of their suppliers.

The purpose of this thesis is to investigate the importance of supply chain information systems for ESG management. The financial and operational benefits of integrating ESG into corporate decision-making will be explored through analysis. It will also examine the impact of recent European regulations on supply chain data management and ESG reporting standards. Through our research, we hope to shed light on the opportunities and challenges that companies face when it comes to ESG and to identify the best ways to manage data effectively throughout the supply chain in an increasingly sustainability-conscious society.

This thesis will examine the critical role that blockchain plays in supply chain information management, as well as its potential benefits for integrating ESG criteria. In particular, it will

look at different methods of monitoring and rating suppliers according to ESG standards, as well as cutting-edge approaches to sustainable supplier selection and the critical function of auditing in the context of sustainable supply chain management focusing on exploring the targeted application of blockchain technology to improve transparency and traceability throughout the supply chain. The discussion will conclude with a case study demonstrating one of the first real-world implementations of a software that can assist in monitoring sustainable supply chain management, highlighting the results and their implications for companies seeking to implement more ethical and environmentally friendly procurement practices. This research will provide a thorough overview of the difficulties and opportunities facing sustainable supply chain management, with a focus on the critical role of technology - specifically blockchain technology - in accelerating the shift to more moral, open and responsible procurement practices.

Chapter 2: ESGs and their influence on supply chain data management systems

2.1 The advent of ESG

Investors, regulators, and in general, stakeholders are increasingly demanding that companies report on their performance according to various ESG standards. These metrics are seen as a major shift in the sustainable revolution for companies worldwide.

The primary goal of companies has always been to maximize their profit and that of their shareholders, without focusing on the surrounding social environment. With the looming issue of climate change and sustainable transition, the attention is shifting to social aspects, also giving companies the important goal of ensuring benefits to the whole society and not just their own payoffs and their investors (Tsang et al., 2023).

These standards aim to focus on three main sides: Environmental Social and Governance.

The environmental dimension is the one receiving the most attention, as the climate issue has become increasingly discussed, mainly as a consequence of the Paris Agreement concluded among the member states of the United Nations Framework Convention (UNFCCC). This factor affects the whole side of the environmental impact that a company has through its corporate policies. Ranging from the use that is made of natural resources to greenhouse gas emissions to waste disposal, these standards are used to measure and evaluate the impact that businesses have on the environment and incentivize them to improve their green performance. The other significant factor is the social one. This includes all the relationships the company has within its business, ethical corporate values, and employee welfare. It seeks a fair and safe

working environment that leaves no room for discrimination. Furthermore, the governance factor, which includes the organizational and structural parts of the company, focuses more on corporate management and business supervision (Stecconi A., 2023).

These factors are found to improve profit for companies, with a big impact particularly on larger firms (Kim & Li, 2021), that implement them in their business choices, while also showing evident positive and some negative effects on export (Yang & Han, 2023). This certainly leaves room for great improvement; however, ESG factors are known already to have proven a highly competitive advantage in the business world and a fruitful choice for entrepreneurs who adopt these factors by implementing them in their businesses (Koroleva et al., 2020).

The world of ESG is constantly evolving and incorporating regulations and requirements at the European and global levels, which must be considered by managers when making strategic decisions (Pham et al., 2022). Investors are more aware of these parameters, to the point that banks themselves are more interested in financing companies that consider ESG parameters in their business and are advantaged in obtaining credit (Janicka & Sajnóg, 2022). ESG factors find both academic and professional fields, many supporters but they cannot be considered the best in terms of choice for all sectors and firm types. In the first place, ESG factors cannot be considered the only thing a company is interested in, this turns out to be impossible and utopic as there are many other aspects such as productivity, strategy, and capital allocation that in any case are indicative of a healthy and prosperous company (Edmans, 2022).

The risk for many entrepreneurs is that in a few years, their efforts will be much more considered in the context of ESG factors, and they will have to overcome these requirements in order to continue to receive funding and interest in their business.

ESG is very important if considered by many when taking a long-term view, the externalities it imposes on society should be considered and incorporated into company policy (Edmans, 2022) but this does not mean that all companies will be able to prosper or keep the current pace of business. The risk is that some companies, especially very old ones that have never been concerned with sustainable standards, will be thrown into a situation where the transition costs, the training required or in some cases their own business will be unsustainable to maintain in adopting these standards.

From the very beginning ESG supporters have always argued that companies should be obliged to disclose externalities so that they can be held accountable for reducing them; furthermore, linking the compensation of CEOs to externalities will further encourage this reduction (Edmans, 2022).

On the other hand, there can be downsides to the implementation of ESG primarily related to cost and resource allocation as implementing these factors within already consolidated businesses can generate high costs, in some cases too significant to be sustained. Companies might need to allocate resources to new technologies, processes and talented people, impacting financial performance in the short term.

Fulfilling ESG reporting standards can be very complex and time-consuming. The risk is that companies having to accommodate and disclose a lot of data on environmental impact, social practices and governance structures may divert attention from their core business activities negatively impacting the company's operations.

Furthermore, in industries where competitors do not adopt ESG practices, sometimes for reasons unrelated to corporate values but because they face pressure from investors and shareholders who focus on short-term financial returns, a company that prioritises sustainability may experience a competitive disadvantage.

It is essential that companies carefully consider these challenges and develop strategies to address them effectively while balancing the long-term benefits of incorporating ESG principles into their business operations.

2.2 Financial Benefits and performance of firms

ESG has an impact on all sectors of private and public enterprises, and today more than ever companies, which are larger than governments in terms of influence and capital, are called upon to focus on their sustainable impact and the use of sustainable standards in their organisations.

However, ESG should not only be seen by companies as an unnecessary investment that they are legally obliged to make but it has also been stated in several research studies that companies that actually follow and demonstrate a high performance of environmental, social and governance factors are more likely to have a much higher value in the market.(Aydoğmuş et al., 2022).

The majority of scholars indicate that there is a positive relationship between ESG performance and company value. Investors are becoming increasingly interested in having companies with high ESG ratings in their portfolios as they are considered as those that will have better long-term development (Egorova et al., 2022). The return of an investment portfolio formed considering ESG factors will outweigh that of a portfolio that does not take these factors into account (Garnov et al., 2022), leading those who do not take environmental and social criteria sufficiently into consideration to decrease their value in the long run.

Businesses with better ESG performance are able to raise internal and external financial intermediation starting from liquidity to short- and long-term debt, thereby easing the company's financial constraints (Zhang et al., 2023).

ESG factors will be considered increasingly relevant for banks and private investors when determining whether to invest in a particular business, which will result in huge financial benefits for those who have implemented them within their organisation, also leading to an increase in their corporate reputation.

Higher ESG-rated companies have better operational performance and financial results and are more attractive to investors. The majority of research shows that companies that develop and implement ESG criteria are strengthening their market position while the company's value is also rising (Egorova et al., 2022).

Furthermore, organisations that focus on ESG factors are more likely to be ethical while not sacrificing returns, and such companies may have a better chance to counter the crises and demands presented by the sustainability revolution (Pedersen et al., 2021).

It is surely a wise thing to consider that the financial benefits of ESG integration depend on various factors, including sector, geographic location and specific initiatives undertaken (Wuet al., 2022), however, it must be taken into consideration that on some fundamental points such as corporate reputation, access to capital, corporate attractiveness and risk management all organisations will be impacted.

The ESG revolution is putting organisations in situations of change and transition. Such a change is crucial for everyone as losing this transition could lead to losing many jobs along with shareholders.

2.3 Last updates on the European regulation

Starting from 2015 with the adoption of the Paris Agreement, the European Union has always shared an interest in finding new solutions to fight climate change and become a more

sustainable continent, this first agreement has been the first one of many that are changing the way Europe behaves towards the environment and social aspects.

Furthermore, another important accord that occurred to regulate the finance world is the sustainable action plan (SFAP) which is a major policy objective of the European Union which aims to promote sustainable investment across the 27-nation bloc. This is further divided into the Sustainable Finance Disclosure Regulation (SFDR), the EU Green Taxonomy Regulation and finally Corporate Sustainability Reporting Directive (CSRD).

The SFDR is a set of rules that aims to make the sustainability profile of funds more comparable and more easily comprehensible for end investors. It has been implemented to help them feel more secure in investing in sustainable assets, having the confidence that such information is truthful, as different European financial institutions have to disclose their level of social and environmental footprint. (Birindelli et al., 2023).

The EU Green Taxonomy Regulation like the SFDR is implemented to ensure fair competition and the protection of legal rights for all businesses operating in the European territory and it is a system which determines which investments are environmentally sustainable aiming to restrain greenwashing activities. This Taxonomy focuses on six different objectives which are climate change mitigation and adaptation, sustainable use and protection of water and marine resources, circular economy, pollution prevention and control and protection and restoration of biodiversity and ecosystems. To be considered sustainable, a business must follow at least one of these objectives and strictly does 'no significant harm' (DNSH) to any of the others (Bassen et al., 2022).

The CSRD is a more recent directive whose purpose is to give a physical tool to the public by regularly publishing reports on the risks they encounter, considering the impact of the environment and the people on whom their business activities have an influence (Commission et al., 2023). This has been disruptive in the European context as everyone is subject to the same framework and it is more complicated to greenwash as companies are subject to several controls.

In order to improve reporting and ensure the comparability of data in between European companies, the sustainability reporting required by the CSRD is to be prepared according to a common European standard drawn up by the European Financial Reporting Advisory Group (EFRAG), which has merged in 2023 with the ESRS- European Sustainability Reporting

Standard. In this way, it is expected to be easier to compare the ESG performance of different organisations (Agostinelli, 2023)

The European Commission has adopted 12 ESRS standards by a delegated act on 31 July 2023, the so-called first set of ESRS contains two cross-cutting standards which are General requirement (ESRS 1) and General disclosures (ESRS 2) and 10 topical standards that are further divided into environmental, social and governance (EFRAG, 2022)

Cross-cutting standards and topical standards are sector-agnostic, meaning that they apply to all undertakings regardless of which sector or sectors the undertaking operates in. The transposition of the ESRS will be implemented gradually, depending on the characteristics of the companies. From 2024, it will only be mandatory to conduct this data collection for public interest entities (PIEs) already subject to the Non-Financial Reporting Directive that at the closing date of the financial statements have an average number of more than 500 employees and a balance sheet of more than EUR 20Mln or net revenues of more than EUR 40Mln.

Furthermore, starting in 2025, this will apply to large companies that close with at least two of the following criteria: i) 250 is the average number of employees, ii) the balance sheet exceeds 25 million, iii) net revenues are greater than 50 million, with the requirement to publish the report in 2026.

As of 2026, listed SMEs, except for micro-enterprises, which have at least one of these characteristics: i) 10 to 250 employees, ii) 900.000-50 million net revenue, iii) 450.000-25 million balance sheet, will have to start collecting this data facilitating reporting by the year 2027, however, they have the possibility to opt-out for two years, with a mandatory reporting obligation by 2029. As for SMEs, the EFRAG will develop specific ESRS to take into account their specificities.

Finally, as of 2028, this will also apply to all non-EU companies with at least one branch or subsidiary in the EU.

The goal is to bring ESG standards to a global level, encouraging international companies to comply with reporting requirements as well.

The ESRS contains topical standards which are divided into three big categories: environment, social and governance. The ESRS E1-E5 includes climate change, pollution, water and marine resources, biodiversity and ecosystems, resource use and circular economy. The ESRS S1-S4 are own force, workers in the value chain, affected communities, consumers and end-users. Finally, considering the governance side in the ESRS G1 is business conduct.

2.4 Role of supply chain information systems in managing ESG factors

The supply chain has a huge impact on an organization's sustainability, and its information system is critical for calculating and tracking ESGs. The ESRS require that reporting also extend to the upstream and downstream realities of the company's value chain, incorporating relevant social, environmental and governance data.

The acceleration of digitization is supporting change in supply chain management around companies, and it is an incredible resource that needs to be exploited. In fact, a lack of IT systems controlling the real-time efficiency of all activities may result in a lack of synergy effects, and companies intend to continue to invest in digital transformation to address the challenges that will occur in the coming years (Lichocik & Sadowski, 2013). Digital transformation offers the chance to streamline procedures, hire a guide to help you through the process and avoid making haphazard investments.

Optimization would effectively begin with the definition of supply chain information systems and their components; creating a clear and organized structure contributes to better performance and understanding of the issue.

It is critical to understand how these information systems manage to collect and analyse ESG factors by finding a way to best manage them within the supply chain. This is because the main purpose of implementing ESG factors in supply chain information systems is to have the ability to understand and explore the positive results due to implementation or a possible negative effect due to a failure or insufficient commitment to ESG factors.

As soon as the information system is working and optimized, risk management and operational efficiency also benefit because there is a more transparent and improved understanding of what is occurring and what are the strengths or weaknesses of the supply chain.

Risk management is a fundamental part of supply management that takes charge of framing the risk by trying to delineate the context in which it is, assessing it by interpreting the criticality of the risk and the potential impact it is likely to have. After evaluating and defining it, it is time to react to the risk in such a way that it is contained while continuing to monitor it in alternating periods (Boyens et al., 2015). Investment in risk management solutions is critical to keeping up with the needs of the business.

Operational efficiency is equally important as properly planned and completed logistics work has the potential to improve the performance of a company and the entire supply chain. It is critical to understand that a supply chain will undoubtedly become less effective if strategic planning and analysis procedures are neglected. Developing an appropriate new model or

optimizing the current supply chain can be very beneficial to a company in terms of market position and financial performance (Lichocik & Sadowski, 2013).

Another key point to consider is the management of the firm's inventory. The implementation of a digitized information system would help management to understand the movements in the supply chain better, reduce costs, and make inventory management more optimized and efficient. Since information technology is used to speed up processes and make them more successful and competitive, it can be stated that as of today it generally offers several benefits (Habsi et al., 2023). This certainly provides better control over ensuring that ESG factors are being monitored within the supply chain.

Furthermore, with the introduction of ESRS standards, companies will have to implement the principle of dual materiality in their evaluations and decisions, meaning that they will have to disclose information regarding the impact of their activities on stakeholders, focusing on people and the environment (inside-out approach), and how ESG matters affect the economic and financial performance of the company (outside-in approach). The concept of dual materiality describes how the information made public can affect a company's value in the marketplace and its influence on the world in general, with a particular focus on ESG factors. Assessing the impact of external variables on companies and how they influence ESG concerns is critical. Since a company's actions on environmental, social, and governance (ESG) matters can result in a financial impact, it is also fundamental to investigate the connections between financial materiality and environmental and social materiality (Appelbaum et al., 2023).

Because the ESRS takes a "dual materiality" approach, it mandates that businesses explain how they affect people and the environment as well as how these issues affect the firm in terms of financial risks and opportunities.

Chapter 3: The monitoring and evaluation of suppliers based on ESG criteria

3.1 Monitoring techniques that companies can implement

Managing and monitoring suppliers' practices, especially in global supply chains, can be complex and may require additional resources. Implementing an ESG-based supplier monitoring and evaluation system is critical to ensuring that the company operates in a sustainable and environmentally responsible manner.

Management with regard to this topic can implement several techniques starting with risk assessment of each supplier. By identifying and assessing each supplier's risk at the level of environmental, social, and governance impacts, the executive can have the ability to assess

whether it is appropriate to keep that one supplier or in the case of loss at the level of ESG values, to change it. This can be done by using tools such as questionnaires, interviews, and analysis to gather information about suppliers.

You can avoid unpleasant problems when ESG criteria integration is implemented already at source with supplier selection, by giving priority to those who demonstrate a strong commitment to sustainability and social responsibility while considering the background track record of these suppliers against ESG standards. By selecting potential suppliers according to eligibility criteria, evaluating, and ranking potential suppliers of products/services according to ESG evaluation criteria, the identification of potential suppliers becomes more facilitated. Also, by using sample testing, certifications already in place of their management systems, and audits at the supplier's site (Afteni et al., 2021).

By the time suppliers are chosen, it is not enough just to do a previous analysis but to establish a structured system for the regular collection of ESG data from suppliers. This can also be accomplished through the use of digital platforms that simplify the collection and analysis, and it is necessary to ensure that the data are accurate, complete and maintained up to date with the corresponding controls and security measures in place.

Once the data is collected, it is necessary to evaluate and analyze it in accordance with ESG key performance indicators (KPIs), comparing suppliers' performance with the company's standards and objectives, identifying potential areas for improvement and success.

Nonetheless, to be certain that these factors are being considered and pursued even after a contract with the supplier, some corrective actions must be established considering procedures to address supplier violations of ESG standards. Implementing corrective actions, which may include training, technical support, or even suspension of cooperation in case of serious violations helps monitor and verify the achievement of ESG factors and sustainable practices. Another significant consideration is open and transparent communication with suppliers about such factors and social responsibility in order to communicate how important they are to our company and collectively work to implement mutually appropriate sustainable solutions. In this way, best practices can be shared and suppliers can become even more involved in the company's ESG initiatives.

3.2 Identifying the most innovative methods for sustainable supplier selection

In the context of supply chain management, supplier selection has a fundamental role in defining an organization's long-term success. However, it is imperative to acknowledge that

traditional methods of supplier selection have significant limitations, especially when addressing the growing needs for environmental, social and economic sustainability, as they frequently focus exclusively on financial metrics and product quality, neglecting crucial sustainability issues.

Sustainable supplier selection necessitates the implementation of innovative approaches that go beyond traditional practices. In this regard, one can leverage technologies such as blockchain or AI to ensure the sustainable sourcing of materials and resources and to identify suppliers with sustainable performance.

To begin with, big data analytics enable the collection of broader and increasingly detailed information about suppliers' sustainable practices. These technologies can analyze huge amounts of data in real-time, providing a real-time, dynamic and up-to-date view of sustainable performance, thus helping to mitigate the risk of static and incomplete assessments. In general, leveraging so-called big data to identify trends and patterns related to supplier sustainability helps to forecast future supplier behaviour against ESG standards, enabling organizations to more accurately assess a supplier's contribution to sustainability goals.

In addition, by creating collaborative platforms where suppliers can share sustainability information and best practices, collaboration among suppliers is being facilitated to promote sustainable innovation in the supply chain.

One method, which despite everything still remains innovative and effective, is certifications, in this case digital, which when based on blockchain can guarantee the authenticity of suppliers' sustainable claims. Thanks to blockchain it is also possible to digitally track the complete path of a product throughout the supply chain and consequently its level of sustainability.

Furthermore, Artificial intelligence (AI) is revolutionising the evaluation of businesses' sustainable performance by allowing for in-depth comparisons of ESG KPIs across several industries, this has made it possible to evaluate big multinational corporations according to ESG criteria, showcasing those that adhere to ESG reporting guidelines. This technology gives businesses the chance to compare their own data to that of competitors or the industry, giving management insightful knowledge to enhance corporate reporting and sustainability plans aiming also to foster a more conscientious corporate culture that is focused on ongoing development toward more sustainable practices (Saxena et al., 2022).

Another solution can be the Life Cycle Assessment (LCA), which can be used for assessing the overall environmental impact of a product or service or having open feedback systems that

involve employees, customers and other stakeholders that help improve the supplier evaluation process (Jiang et al., 2022).

Through the integration of data collected from innovative approaches, the goal is to develop decision-making models, which can guide organizations in selecting suppliers responsibly and contribute to broader social and environmental responsibility goals.

3.3 The role and importance of auditing in this context

Regular audits verifying suppliers' compliance with ESG standards will be essential to verify the veracity of information and achievement of environmental and social goals.

The involvement of independent third parties increases evaluation objectivity and certainty and can help to improve continuously the supplier management process

By implementing these techniques, a company can promote sustainability and social responsibility throughout its supply chain and reduce the risks associated with unsustainable practices by suppliers (Afteni et al., 2021).

Frequent audits offer a thorough examination of suppliers' performance and approaches, guaranteeing that they adhere to set ESG requirements. Numerous topics are covered by these standards, such as social behaviours, environmental effects, and the efficiency of corporate governance. Any deviations from the predetermined objectives can be found and quickly corrected with diligent investigation.

Periodic modifications also encourage suppliers to offer accurate and comprehensive information on their ESG performance by enabling open and transparent communication. In order to resolve any concerns or areas for growth and to meet common sustainability goals, close cooperation between the company and its suppliers is essential.

Suppliers are also encouraged to take more sustainable actions over time and to continuously improve their practices by employing this ongoing audit process. These ought to be seen as a dynamic and cooperative component that encourages innovation and the constructive evolution of corporate operations, rather than just as a remedial measure.

In conclusion, regular company audits that evaluate suppliers' compliance with ESG standards are essential to establishing sustainable supply chains because they not only confirm the truthfulness of data but also foster a culture of shared accountability, which enables businesses to successfully pursue their social and environmental objectives over the long run (Appelbaum et al., 2023).

Chapter 4: Blockchain technology and how it can positively influence the management of supply chain information systems

4.1 What is blockchain technology and how can it be used within businesses to enhance management

Blockchain technology was first introduced in the year 1991 through the discovery of Stuart Haber and Scott Stornetta, gaining major significance from the year 2008 thanks to the introduction of Bitcoin by Satoshi Nakamoto (Tijan et al., 2019). Blockchain technology was created to give people an immutable, verified and decentralized digital tool. It uses with the help of cryptography the assignment of a private key, given to each user, and a public key, shared with everyone, which solves the problem of double spending, a problem that arises when a digital cryptocurrency transaction that involves the same currency being spent multiple times is made.

The main idea of the blockchain is that of a database that includes all transactions from the various parties, where each transaction is verified through the consent of other users making such information more trustworthy and unable to be deceptive (Zhao et al., 2016).

There are four main advantages of blockchain compared to other means. First of all, it is anonymous and has open access, which means that everyone has full rights to access, and no one can get denied. Furthermore, submitted data cannot be altered and, in particular, the guarantees of integrity are not provided by any centralized party, but by the consensus of the entire network thereby ensuring transparency and certainty.

Published data cannot be removed, which means that no authority can apply censorship to already published data. Since the blockchain is immutable, alteration of hidden messages is practically impossible (Partala, 2018).

Lastly, this technology increases efficiency and lowers the costs of managing the supply chain giving another reason for companies to implement this technology (Park & Li, 2021).

Blockchain technology is able to have these qualities especially because of the ability to create a digital token that protects the supply chain from potential counterfeiting or theft as at the beginning of production each item is associated with one, and throughout the supply chain to the end consumer the token assures the consumer and the management of the proper processing and achievement of different goals. This leads to greater consumer trust in the company and the product itself as they are aware that no one has the faculty to change anything that is inserted

into the flow (Tijan et al., 2019). Furthermore, this technology can efficiently and quickly share any data alterations, leading to a minimisation of human errors and transaction periods (Saber et al., 2019).

This can turn out to be very beneficial and of interest to companies as it gives the various players in the supply chain and subsequently to the final consumer, the opportunity to better control the quality of the product, its provenance and whether all given guidelines are followed during the process (Varriale et al., 2020).

In support of my research, blockchain technology has the potential to be used to assess and control that ESG factors within the supply chain are being followed and provide the management with secure and accurate data on which parts of the supply chain should be improved in order to improve the sustainable rating of the end product and consequently the business (Tijan et al., 2019).

Given the transparency and reliability of the data collected with this technology, consumers are more certain of the sources from which the products come and can, in certain cases, verify for themselves that they are also ethically correct. By reducing remanufacturing and product recalls, the consumption of greenhouse gases and resources can also be reduced, allowing a determination of the environmental impact and, consequently, the applicable carbon tax. Given that a product has a high ecological impact, the consumer, when presented with data-driven results, can decide to change and choose a more environmentally friendly product.

This technology can also help to check that the workplace environment and consequently the corporate sphere is as sustainable as possible, by helping to improve and maintain fair and safe working practices. These assessments can lead companies to make different management choices and change their supply chains to become more sustainable and less impactful due to consumer demand (Saber et al., 2019).

Research shows that its diffusion will lead to more sustainable and prosperous economies, thus encouraging governments, policymakers and all stakeholders to adopt blockchain technology in this respect, with the ultimate goal of improving the economic and social well-being of participants as well as preserving the environmental health of the planet (Sahoo et al., 2022).

4.2 Targeted application of blockchain in monitoring suppliers and environmental-social-governance factors in the value chain

Supply chains can be made more transparent and unchangeable with the use of blockchain, guaranteeing that all parties involved in the chain have easy access to supplier information. By examining consumers' level of concern for product quality and safety as well as their readiness to pay for a traceable product, supply chain businesses can determine how aware consumers are of traceability and implement that in the supply chain if consumers are highly aware of traceability (Fan et al., 2022).

However, so-called smart contracts can be used to control suppliers. In essence, these are made up of a digital code that offers a set of guarantees based on predefined guidelines that have been decided upon by the parties. To put it simply, the parties can choose to establish a condition that, if not fulfilled, may result in one or more actions. Smart contracts are blockchain-stored scripts that facilitate the automation of supply chain compliance checks. Smart contracts can be used to guarantee that providers abide by the suggested terms and conditions, leading to more moral and environmentally friendly behaviour (Christidis & Devetsikiotis, 2016). Through the use of blockchain technology, the advantage of real-time traceability will always be present and allow each stakeholder to control what is happening in real time reducing the risk of fraud and unsustainable practices.

Furthermore, the blockchain may potentially be utilized to monitor environmental, social, and governance aspects of the ESG. By adding ESG-related data to the blockchain, users can guarantee data integrity. Blockchain can boost data accuracy, promote regulatory compliance, and boost trust in ESG reporting by offering a decentralized, tamper-resistant mechanism (Salehi, 2023).

By focusing on the environmental side, because blockchain ensures data transparency and immutability, it may be used to monitor and reduce environmental impact across the value chain. This is because it can create a safe store for important environmental data, such as resource consumption and carbon emissions.

By enabling transparent verification of ESG elements throughout the whole value chain, the technology's decentralization raises awareness of environmental issues. Furthermore, the use of smart contracts streamlines procedures and minimizes waste by automating the tracking of environmentally friendly activities and complete product traceability (Salehi, 2023).

Blockchain technology can also manage social responsibility by providing transparent traceability, enabling ethical monitoring of working conditions along the supply chain. Encouraging sustainable behaviour and building a network of cooperation between suppliers, producers and consumers, enables the free exchange of knowledge. This thus acts as a catalyst for improving corporate social responsibility and increasing customer confidence in moral and sustainable business practices (W. Wu et al., 2022). Finally, it acts as a catalyst for the study of accountable and transparent governance in value chain organisations as, being decentralised, information can be shared freely and securely, fostering openness in all sectors. Blockchain's traceability makes it easier to monitor moral behaviour and business decisions, leading to more accountable governance. In the context of the value chain, technology thus becomes a crucial tool to create an organisational culture of openness and improve trust and integrity.

With the use of blockchain technology, it is also possible to design and apply digital tokens that are used as evidence of the product's ethical and sustainable practices. These tokens are then tracked down every step of the supply chain. Because each token has information on a specific product, it is possible to track the impact of a product and its suppliers in this way (W. Wu et al., 2022).

Dual materiality is also going to be considered more and more in a company's value chain as an essential component of sustainability and ESG (Environmental, Social, and Governance) considerations is the idea of dual materiality. Essentially, it comes down to realizing that businesses have an impact on their surroundings, but they are also impacted by other variables that may have an impact on their own sustainability. Stated differently, dual materiality pertains to the consideration of a company's external effects as well as the ways in which external circumstances might affect the company's performance and reputation (Appelbaum et al., 2023).

It becomes clear that blockchain is a useful instrument for incorporating dual materiality into corporate decision-making procedures. It is feasible to completely trace effects and influences because of its capacity to offer an unchangeable, transparent record of transactions and data. Blockchain may be used in this way. It also provides a dependable foundation for capturing and keeping important information regarding external and internal consequences because of the openness and immutability of data. This makes it possible to accurately track sustainability initiatives and ESG elements and to report on them transparently.

Smart contract deployment on the blockchain can automate double materiality processes. They can be configured, for example, to conduct audits automatically and to weigh the effects of both internal and external factors. Lastly, the blockchain's decentralized structure makes it easier to securely share information with stakeholders. Businesses may address external variables that impact their dual materiality and offer lucid evidence of their sustainable strategies. Through blockchain technology, it is possible to optimise evaluation and monitoring procedures and make it possible for the management to have a better understanding of how their suppliers are working and which part of their supply chain could need a change.

4.3 Limitations of this technology

Like all technologies, this too has limitations and considerations to be made before implementing it into business decisions. The constraints that can be faced can be divided into four categories: intra-organisational, inter-organisational, system-related, and external (Saber et al., 2019).

Intra-organisational barriers are all those related to the internal management of the company and how new technologies and innovations are perceived and implemented in the target company, as a lack of interest and awareness on the subject may result in such a change being difficult.

Concerning the inter-organisational aspect refers to all the challenges in the relationships between partners, mainly including the sharing of information due to different privacy policies. Therefore, in this case, collaboration, also for reasons that may be related to cultural differences within the supply chain, may pose difficulties for successful implementation.

Moving on to more relational barriers, external barriers involving government and stakeholders can also be a problem when considering this technology. (Saber et al., 2019)

Dwelling on more relational barriers, the external ones involving government and stakeholders can also be a challenge when considering this technology (Saber et al., 2019).

However, when speaking at a more technical level, the barriers encountered at the system level are certainly the most complex to discuss.

In the first place, scalability problems can be encountered, which is the problem that arises when, as the number of transactions rises, the time and resources required for consensus and validation also grow (Modani et al., 2021).

Moreover, a limited number of frameworks are available for blockchain implementation and for a company to change its database structure may result in a significant cost (Modani et al., 2021).

Furthermore, in the case of a lack of standardisation and interoperability between different blockchain platforms, obstacles arise for different blockchains to communicate and transfer assets seamlessly.

Besides, there may also be security and privacy issues, as while blockchain offers transparency and immutability, it may expose more information than intended. In order to solve these problems, various solutions are being explored and will certainly not be lacking in the coming years as the use of this technology increases (Modani et al., 2021)

A further significant problem, which is also related to sustainability, is energy consumption for which significant computing power and energy consumption are required, however, some blockchains are already exploring alternative and more energy-efficient mechanisms.

Chapter 5: YoY® Extended Supply Chain Planning System

5.1 Context of the Company

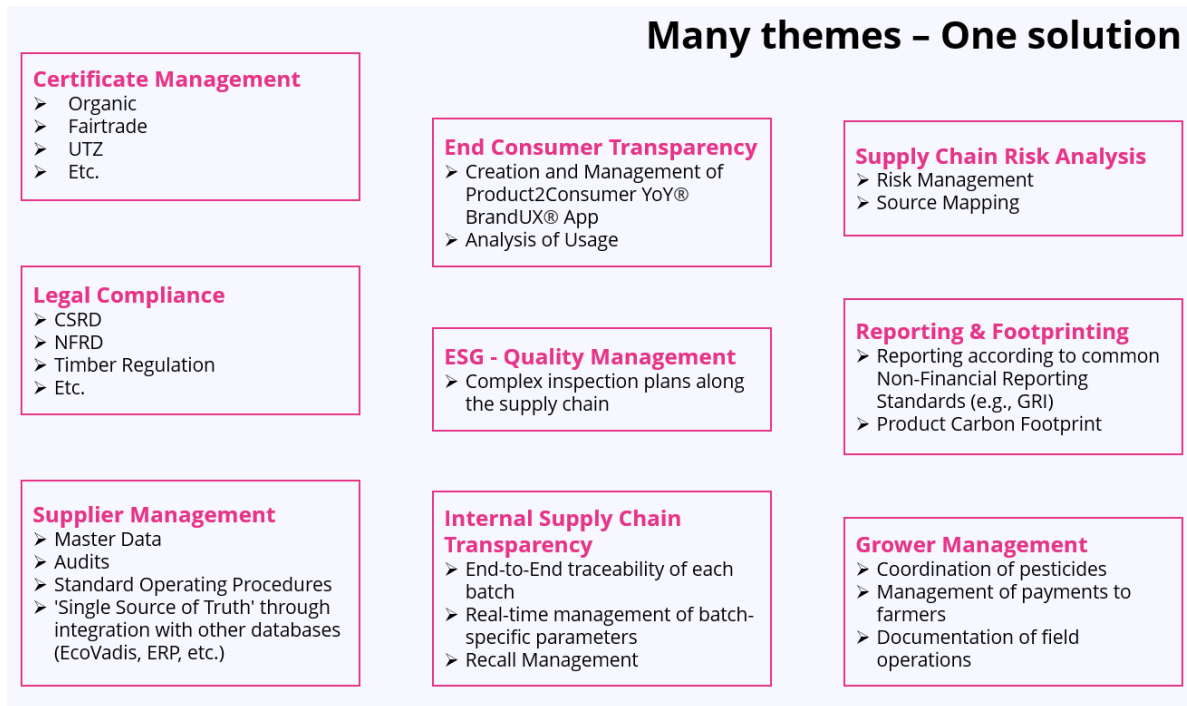
The YoY software is a fully integrated business solution that helps global companies in all sectors track their supply chain so that they can control better the production steps that take place from raw material to final product, helping both the entrepreneur and the final customer to understand how the company operates and where the products come from. This is one of the first multi-company ERP applications on the supply chain and blockchain that exist and it is thus an example of one of the first real experimentation of this kind of tool.

As people become more aware of sustainability, the demand for more information on how goods are produced will grow, and YoY offers all the functionality needed to manage and operate the value-creation process along the extended supply chain.

In the ESG field, The YoY software can be used to track the environmental, social and governance impact that a supply chain has on the world. This not only adds value to the product but also helps companies to more securely and transparently track their impact and empower management to implement changes and improvements in the supply chain in order to make positive changes inside the firm. The YoY software represents a great opportunity for both businesses and end customers who, thanks to this technology, can be sure of the provenance of

the product and the social fairness conditions of the workforce. Thanks to this technology it is possible to transition from a mere static, formal reporting typical of compliance to a more integrated governance system (Figure 1).

Figure 1: Many themes – One solutions



Source: case study YoY

5.2. Analysis of the Problem in the Light of the Case Study

As of today, one of the tasks performed by YOY software in the sustainability field is related to the company Coop Genossenschaft. With annual sales of more than CHF 33 billion and nearly 90,000 employees, this is Switzerland's largest grocery retailer, with an assortment of more than 40,000 unique items. Regardless of the company's size, Coop manages to maintain a strong commitment to sustainability in its operations.

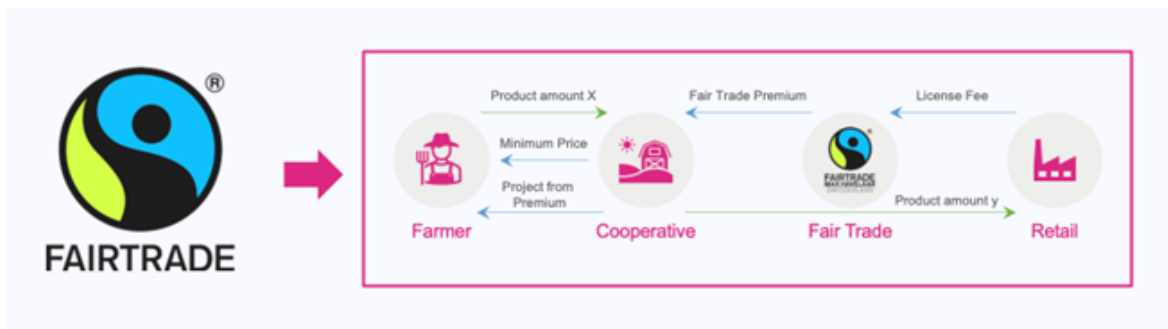
In recent decades, global supply chains have become increasingly opaque and traditional business practices have focused primarily on iteratively contributing to profit margins by reducing procurement costs, often neglecting social and ecological considerations. This has led to a systematic deferral of responsibility to upstream suppliers.

The implications are particularly evident in the food industry, where the concentration of European retailers has made the improvement of margins the only path to business growth, due to stagnating market growth rates and the inability to open up new market segments.

From the perspective of farmers in the global South, this squeezing of margins has reached a critical point. Smallholder farmers, who are responsible for 70 per cent of the world's food production, are facing diminishing returns on their harvests, risking having to close their activities. This, combined with climate change and loss of biodiversity, has accelerated the rural exodus, with farmers moving to urban areas in search of alternative livelihoods. A study of rural-urban population distribution in Mexico illustrates this trend, predicting a decline from nearly 50 per cent rural housing in 1950 to presumably just over 10 per cent by 2050, posing a significant risk to global food security (Juran, 2016). European companies now find themselves in a battle over dwindling raw material supplies, shifting the focus from profit margin increases to securing enough resources to sustain revenue.

To offer adequate compensation to farmers, thereby ensuring the continuation of their agricultural practices, initiatives such as social and sustainability labels and certifications have been employed (Figure 2).

Figure 2: Fairtrade labels



Source: case study YoY

For instance, Fairtrade certification involves retailers and brands selling certified goods, with Fairtrade distributing a portion of the collected licensing fees as premium payments along the supply chain, reaching cooperatives in producer countries.

However, a significant challenge persists in ensuring that these funds effectively reach the farmers, as cooperatives in the origin countries are tasked with the final distribution. Recent studies have highlighted that due to corruption issues in the Global South, premium payments

often fail to improve farmers' social standards. Instead, they may entrench corrupt structures and nepotism, resulting even in a negative social impact more often than in a positive impact.

5.3 Proposed Solution – Supply Chain Transparency & Traceability with YoY ESG Cloud

In response, Coop Genossenschaft aims to take on additional responsibility for its supply chains by paying the Living Income Reference Price to farmers. This price, calculated by Fairtrade International for various raw goods and origin countries, represents the gap needed to enable farmers to live decently from their labour.

To facilitate these payments, supply chain transparency and traceability are paramount to establishing direct contact with farmers. Coop has piloted this approach with a coffee project originating in Mexico, utilizing the YoY ESG Cloud.

YoY ESG Cloud enables batch traceability throughout the supply chain, documenting each significant process step, and allowing Coop to provide direct and proportionate additional payments to farmers, verified by the farmers themselves within the software solution.

5.4 Results – Waterproof reference between Farmer, Material & Payment

Coop Genossenschaft now has real-time visibility of every batch and a solid link between farmers, materials and payments. As a result of this choice, it is the first food retailer in the world able to directly transfer funds to farmers in addition to the actual quantities supplied. This direct payment system is confirmed by farmers within the software solution, avoiding middlemen and fostering a better connection within the supply chain.

This initiative not only generates a tangible social impact for farmers but also supports Coop in securing needed raw materials over the long term by allowing the company to influence production conditions along the supply chain. This influence translates into a substantial competitive advantage by aligning company operations with the growing global imperative for sustainable and ethical sourcing.

The YoY software relies on blockchain technology, however, its practical relevance in this field has been limited due to the so-called "Oracle problem." The value proposition of blockchain lies in tamper-proof data storage, which could foster trust and efficiency in sectors such as finance. However, the main challenge in such a supply chain is the accurate collection of quality data, a process to which blockchain finds it hard to contribute and given the significantly higher

costs of blockchain compared to traditional databases, its implementation in this context was not economically feasible.

Conclusion

Thanks to this research, it is possible to conclude that, although there are certain drawbacks to implementing ESG considerations overall, the advantages greatly exceed the disadvantages. The introduction of EU regulations will force businesses to reevaluate their internal strategic choices and most businesses looking to operate ethically and competitively in a world where people are becoming more and more concerned with the environment, society, and governance are starting to prioritise sustainable supply chain management. In this study, it was investigated how blockchain technology may significantly enhance supply chain management's traceability, transparency, and efficiency, with an emphasis on integrating ESG standards. Furthermore, it outlines the ways in which blockchain technology may be applied to enhance data collection and analysis, monitor and evaluate suppliers in relation to ESG standards, and promote cooperation and communication amongst stakeholders along the supply chain. Furthermore, it was discussed how important auditing is to make sure ESG standards are met as well as how blockchain technology can improve transparency, demonstrating how this technology can be used to enhance sustainable supply chain management. Thanks to the YoY Software case study, it is shown a solution on how businesses could precisely and independently monitor their supply chain's activities as well as any potential effects on the environment, society, or governance. What it has been cleared is that ESG is not only seen as static measures of current performance, but also as dynamic goals to be achieved in the short and medium term. ESG KPIs serve as guides for measuring progress towards sustainability and social responsibility goals, and must be integrated into a broader strategy of continuous improvement.

In conclusion, by promoting more accountability, transparency, and stakeholder confidence, blockchain technology offers a great deal of promise to enhance supply chain sustainability and ethics. It is crucial to acknowledge that some obstacles and constraints must be overcome, but technology can play a significant role in promoting more ethical and sustainable procurement practices that will benefit companies, communities, and the environment with sustained dedication and careful application.

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