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UNDERSTANDING BLOCKCHAIN FOR A FUTURE CIRCULAR ECONOMY

Umi Khulzum [1] and Djuminah [2]

[1,2] Universitas Sebelas Maret Surakarta.
Email: [1]umikhulzum97@gmail.com

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Abstrak

Circular economy, as a sustainable development approach, seeks to maximize the use of resources through recycling practices and waste reduction. On the other hand, blockchain, a decentralized technology, is becoming a key force to increase transparency in the circular economy. This research will further detail how blockchain, as a technological tool, is capable of redefining the way we view and manage the circular economy. Researchers will adopt an unstructured literature review approach. The literature selection process is carried out carefully, considering inclusion and exclusion criteria to ensure that the selected literature is relevant and valid. The selected case studies are then analyzed with an unstructured literature review approach. Blockchain implementation allows the creation of systems capable of tracking and managing product lifecycle details without neglecting security. Companies like IBM Food Trust, Plastic Bank, and Provenance have successfully used blockchain to ensure supply chain transparency and encourage sustainable practices. With the added benefit of supporting the development of smart cities and automation of resource management, blockchain adoption lays the foundation for developers and enterprises to design solutions towards a more sustainable circular economy.

Keywords: Blockchain, Circular Economy, Future Sustainability.

INTRODUCTION

In the last decade, the world has been witnessed by the emergence of a technological innovation that has profound potential to change the paradigm of the global economy. Blockchain technology, which was first introduced through the concept of cryptocurrencies such as Bitcoin, does not only serve as a means of digital exchange of value. Moreover, blockchain leads us to a fundamental change in the economic order, especially in the context of a circular economy (Böckel et al., 2021).

Researchers have carefully observed how this technology is not just a "buzzword" in the realm of information technology, but an important instrument that forms a new basis for viewing and designing a circular economy (Böhmecke-Schwafert et al., 2022). Blockchain, as a form of decentralized technology, can offer unprecedented transparency in the supply chain (Kouhizadeh et al., 2020).

From a circular economy perspective, where the concepts of reuse and recycling are crucial, blockchain provides a solution to address the complex challenges of ensuring resource sustainability by recording every transaction and transfer of ownership in a way that cannot be manipulated, blockchain provides clarity regarding the history of a product, from the manufacturing stage to finally reaching the consumer (Basile et al., 2023). In-depth knowledge of blockchain technology gives researchers insight into how value can be exchanged in a more efficient way, especially in an economic context that puts forward the principle of sustainability (Böhmecke-Schwafert et al., 2022; Nandi et al., 2021). Through the token mechanism and the concept of a decentralized digital economy, blockchain can be implemented to encourage sustainable behavior in every stage of the circular economy (Kouhizadeh et al., 2020).

This research will further detail how blockchain, as a technological tool, is capable of redefining the way we view and manage the circular economy. Researchers will dig deeper into the role of blockchain in the circular economy and we can assess the extent of the positive impact that blockchain integration can have in realizing a more sustainable circular economy.

LITERATURE REVIEW

Pengantar Circular Economy

Circular economy is an economic paradigm that responds to the challenges of resource waste and negative environmental impacts by designing a sustainable economic model (Ruiz et al., 2020). This model is different from linear economics that relies on extraction, production, use, and disposal, which often produce waste and harm ecosystems (Rossi et al., 2020).

In the circular economy, the main focus is on optimizing the use of resources through practices of reuse, recycling, and designing durable products. The system is designed to reduce waste and maximize the value of each product cycle (Shojaei et al., 2021). This concept encourages the adoption of a closed cycle in which products, upon reaching the end of their useful life, can be renewed, recycled, or reused in production systems without creating unused waste (Ferasso et al., 2020). This creates an environment where products become an integral part of the supply chain, providing value over time.

The implementation of circular economy also involves changes in consumer culture and government policies that support sustainable practices (Cantú et al., 2021). Thus, circular economy aims to create a business environment that is not only resource-efficient but also contributes positively to global environmental sustainability.

Transparency in Circular Supply Chains

Transparency in the supply chain is a critical foundation in realizing the vision of a sustainable circular economy. As a concept that encompasses the extent to which information and data can be accessed, understood, and audited at every stage of the product journey, this transparency is at the core of efforts to steer the economy towards a more sustainable model (Nandi et al., 2021).

In the context of circular economy, transparency is not just an administrative obligation, but a unifier of all stakeholders, from producers, material providers, to consumers (Sudusinghe &; Seuring, 2022). Clear and measurable information about the origin, journey, and impact of a product is expected to create an environment where every stage of the product life cycle can be effectively supervised and managed (Nandi et al., 2021).

Transparency provides an open window for consumers and other stakeholders to verify the authenticity of products and understand their origins. Through easily accessible information, consumers can ensure that products are manufactured with integrity and in accordance with sustainability principles (Burke et al., 2023; Nandi et al., 2020).

In the context of circular economy, transparency plays a key role in supporting recycling and reuse efforts by enabling the identification of reprocessable materials, supply chains can be designed to be more efficient and products can be re-routed into the production cycle (Amir et al., 2023; Burke et al., 2023; Nandi et al., 2020).

Through a deep understanding of each stage in the supply chain, businesses can identify and manage risks associated with resources, production and distribution (Burke et al., 2023). This not only improves operational efficiency but also reduces unintended environmental impacts.

Transparency creates a stage for collaboration and information sharing between various stakeholders. This stimulates continuous innovation by enabling the adoption of best practices to improve the sustainability of products and production processes (Nandi et al., 2020). In the context of regulations and policies, transparency ensures that all parties involved adhere to established sustainability standards. It creates a regulatory compliant business environment and supports the global agenda to achieve sustainable development goals (Sudusinghe &; Seuring, 2022). Transparency in the supply chain is not only a prerequisite for achieving sustainability, but rather it is a foundation that builds trust, encourages innovation, and forms a more environmentally responsible business ecosystem (Centobelli et al., 2021).

Blockchain for Circular Economy

In an era of global sustainability challenges, circular economy theory (Piscitelli et al., 2020) stands out as the foundation for a paradigmatic shift. This model, which focuses on reducing waste and increasing reuse, is a call to action to save our planet. This concept is not just rhetoric, because it is a commitment to restructure the global economy. In this ecosystem, transparency is emerging as key to ensuring the integrity of the product lifecycle. How can we achieve this transparency? The answer comes in the form of blockchain innovation (Kouhizadeh et al., 2020).

Blockchain, as the backbone of technology in this era, brings a revolution in understanding and implementing the circular economy. The principle of decentralization, a foothold in blockchain theory, provides a secure and distributed foundation for storing digital traces of transactions and product movements (Alves et al., 2022). The advantage of data immutability makes every step in the supply chain that creates gapless transparency (Chidepatil et al., 2020).

However, this transformation does not stand alone. In technology intersection, the Internet of Things (IoT) and Artificial Intelligence (AI) form a strong alliance (Cacciagrano et al., 2021; Fraga-Lamas et al., 2021). IoT sensors power real-time tracking, while AI artificial intelligence processes complex data, enabling intelligent, automated decision-making. The application of blockchain for transparency in the circular economy is witnessing real changes. Open supply chains, accurate product origin records, and automation through smart contracts provide a solid foundation for sustainable practices (Fraga-Lamas et al., 2021).

METHOD

In this study, to understand the impact of blockchain technology on transparency in the context of circular economy, researchers will adopt an unstructured literature review approach. The main focus of the research is to explore case studies from

various media sources, including reputable international journals, to provide deep and thorough insights.

The initial step is to determine the scope of the research by identifying key parameters, such as focusing on the influence of blockchain technology on transparency in the circular economy. Source searches are conducted using related keywords, such as "blockchain," "transparency," and "circular economy." Priority is given to international journals recognized for the accuracy and quality of information obtained.

The literature selection process is carried out carefully, considering inclusion and exclusion criteria to ensure that the selected literature is relevant and valid. The selected case studies are then analyzed with an unstructured literature review approach, exploring emerging findings from various perspectives and contexts.

The results of the literature analysis led to the identification of trends, patterns, and differences in the use of blockchain technology to increase transparency in the circular economy. These findings are then harmonized, enabling the establishment of an analytical framework that can provide a holistic understanding of the influence of blockchain technology on circular economy transparency.

In the preparation of research reports, findings are presented narratively and analytically, following a clear structure, including introduction, methodology, findings, and conclusions. The resulting conclusions are then verified with strong and relevant references. This research aims to provide in-depth insights into the contribution of blockchain technology to transparency in the circular economy. Through an unstructured literature review approach and the use of diverse case studies, it is hoped that this research can provide a comprehensive and sustainable understanding of these developments that are crucial for a sustainable future.

RESULTS AND DISCUSSION

The Emergence of Blockchain that Changed the Economic System

Economists have studied human behavior for hundreds of years, including the way we make decisions, act individually and in groups, and the exchange of values. However, there is a new technological institution that will fundamentally change the way we exchange value, and it is called blockchain (Akhtaruzzaman et al., 2019; Cacciagrano et al., 2021; Hassija et al., 2020). Although this technology is relatively new, it is a continuation of a very long humanitarian story.

Blockchain is a decentralized database that maintains a list of assets and transactions across peer-to-peer networks (Al-Sakran &; Al-shamaileh, 2021). It is a public record of who owns what and who makes what transactions. These transactions are secured through cryptography, and over time, the transaction history is locked in cryptographically connected and secure blocks of data (Akhtaruzzaman et al., 2019). This creates an immutable and unfalsifiable record of all transactions across the network. Blockchain enables the creation of movable identities, transparency in complex supply chains, and the use of smart contracts that can guarantee contract fulfillment without the need for a third party.

The application of blockchain in various fields (Aggarwal &; Floridi, 2018), such as user identity, transparent supply chains, and smart contracts for breaking contracts. The advantage of using blockchain is that it can offer more transparency to consumers and enable automation and collateralization in human economic activities.

Although blockchain has great potential, researchers acknowledge that the technology is still in the early stages of development. It takes a lot of experimentation and research before we truly understand the entire potential use of blockchain in the economy. However, many parties, ranging from financial institutions to technology companies, startups, and universities, are actively working on the development and application of this technology. Although the technology is not yet fully mature, we can see that blockchain has great potential to change paradigms in the economy and how we exchange value in the future.

Paradigm Shift in Economic Dynamics

Blockchain technology has attracted great attention in recent years, evolving beyond its origins in the cryptocurrency world. As expressed by Marc Andreessen (Nagarajan, 2023), blockchain technology represents a paradigm shift similar to the emergence of the internet itself, promising a transformative change in the way we exchange value globally.

Provenance introduced the vision of creating a comprehensive and open network on the blockchain (Foundation, 2023). This approach is driven by the belief that transparency in the production process, from material creation to final product, can open up new possibilities for sustainable material management. Blockchain utilization ensures decentralized control, eliminating the risks associated with centralized data authority (Foundation, 2023; Umer et al., 2023).

Provenance's methodology involves using blockchain to create digital passports for materials, documenting their journey from inception to final product. These digital passports enable a secure and transparent exchange of information along the supply chain. By focusing on sectors such as food, beverage, fashion, and furniture, Provenance seeks to increase brand value by making production processes visible to consumers.

Through collaboration with companies like DSM, Provenance envisions a future where material values can be programmed in blockchain. This innovative approach aims to go beyond traditional supply chain tracking and revolutionize the way we view and exchange materials in global markets. The author emphasizes the transformative potential of tokens, not just as financial instruments but as key components that align the goals of a network. By distributing ownership through tokens, the blockchain network can ensure that all participants benefit from the system's success, building a more fair and sustainable economic model.

Provenance's innovative approach, along with the potential of blockchain tokens, displays a convincing vision for the future. As we explore this transformative era, the combination of blockchain and sustainable economic models may be the trigger for a new age in material management.

The Role of Blockchain Technology in Circular Economy Transparency

Blockchain technology, with its decentralized nature and cryptographic security, is emerging as an important catalyst in realizing transparency in the context of the circular economy (Basile et al., 2023). One of blockchain's major contributions to circular economy transparency is through accurate supply chain tracking. By using blockchain, every stage from production, distribution, to recycling can be recorded transparently and verifiably. This opens a new window for consumers to get clear

information regarding the origin of the product, the raw materials used, and how the product is manufactured (N. M. Kumar &; Chopra, 2022; Upadhyay et al., 2021).

In the context of product use, blockchain technology enables more efficient monitoring of the product life cycle. The data recorded in the blockchain can include information regarding product usage and usage, enabling consumers to make more sustainable decisions (Böckel et al., 2021; Upadhyay et al., 2021). For example, consumers can see the extent to which a product can be recycled or how best to dispose of it with minimal environmental impact.

Blockchain can also optimize the recycling process by facilitating better collaboration between industry players (Qian et al., 2023). The information recorded in the blockchain can provide overall visibility into the needs of recycled raw materials, aiding in more efficient planning. In addition, blockchain can reward sustainable practices. By creating blockchain-based tokens or incentive systems, participants in the circular economy can be given recognition and incentives for practices that support sustainability (Böhmecke-Schwafert et al., 2022; Chidepatil et al., 2020).

Resilience to information falsification is another significant aspect of blockchain's role in circular economy transparency (A. Kumar et al., 2023). With immutable and verified records, the risk of data manipulation or falsification is significantly reduced. This creates an environment where information can be exchanged with trust, which is critical in efforts to improve supply chain integrity and reduce negative impacts on the environment (Bhubalan et al., 2022).

Finally, blockchain enables real-time monitoring of sustainability performance. With constantly updated data in blockchain, interested parties can quickly evaluate the sustainability impact of a product or business practice (Böhmecke-Schwafert et al., 2022). This allows the adoption of policies and actions that are more responsive to changing environmental or market conditions.

One prominent case study in the application of blockchain technology to increase transparency in the circular economy is the IBM Food Trust project (High, 2020). The project focuses on the food sector and leverages the power of blockchain to track the food supply chain from producer to consumer. By using IBM Food Trust, information related to the origin, production process, and distribution of food products can be accessed in real-time by all parties involved (Murphy, 2021).

In the context of circular economy, IBM Food Trust (High, 2020, 2020; Plüss, 2022) enables transparent tracking of ingredients used in food production. Consumers can easily check whether a product contains recycled materials or whether the materials come from sustainable sources. This contributes significantly in empowering consumers to make sustainable decisions and supporting producers who adopt environmentally friendly practices.

In addition, IBM Food Trust also provides an additional layer of security against food safety risks. With irreversible and verified transaction records, early identification of potential contamination or food safety can be done more efficiently. This has a positive impact on consumer health and safety, which is a critical aspect in a circular economy focused on sustainability and responsibility.

This case study shows how the application of blockchain technology can change the way we view and interact with the food supply chain. By providing full visibility and transparency into every stage of production and distribution, IBM Food Trust opens

the door to a circular economy in the food sector. The success of the project can also serve as an inspiration for other sectors to adopt similar technologies in an effort to achieve greater transparency and sustainability.

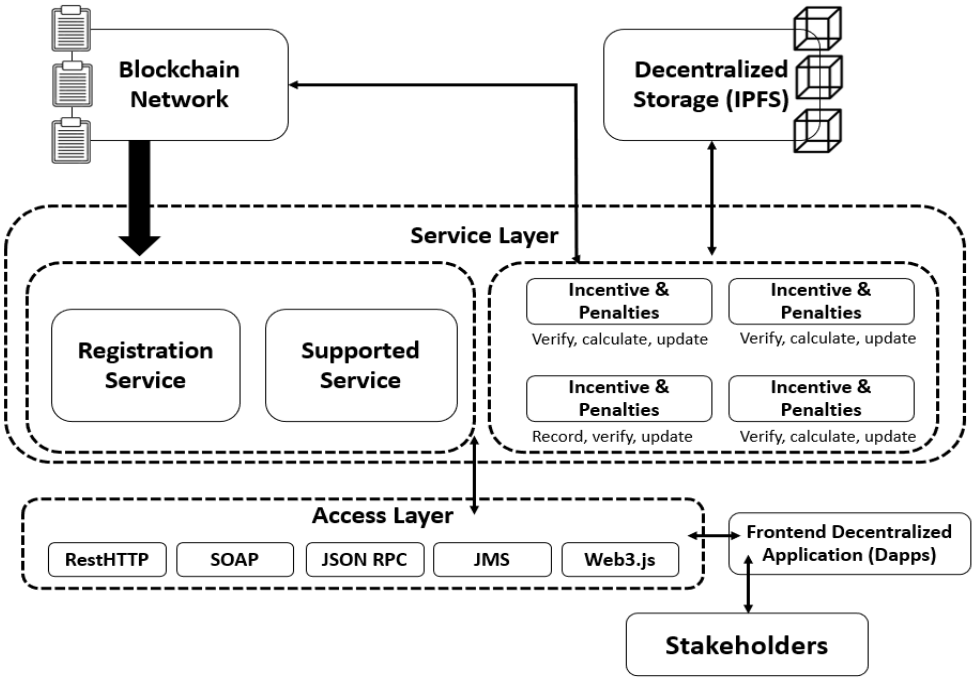
In addition to IBM Food Trust, there are other case studies that show how blockchain technology can be used to increase transparency in the circular economy. One prominent example is the Plastic Bank project. Plastic Bank (Priyana et al., 2023; Reports, 2018) uses blockchain to engage communities in the collection and recycling of plastic waste. Through the blockchain platform, everyone who collects plastic waste can be given incentives or rewards in the form of digital currency. This digital currency can be used for the purchase of goods or services, creating an effective incentive system to motivate participation in waste management.

Blockchain technology plays a key role in creating full transparency related to society's contribution to waste management. Every transaction, including the amount of garbage collected and the amount of digital currency received, is recorded and publicly accessible. This helps create an environment where communities can see the positive impact of their actions on environmental sustainability.

Moreover, Plastic Bank also creates an economic model that supports the circular economy concept by encouraging recycling and reuse of plastic materials. By assigning economic value to plastic waste, the project helps change people's perception of waste from something that should be thrown away to a valuable resource.

This case study reflects how blockchain not only increases transparency in the circular economy but also creates a sustainable incentive system to participate in sustainable practices. Plastic Bank provides an example that blockchain technology can be a key driver in building a more environmentally friendly and sustainable economy.

Blockchain Implementation in a Circular Economy



Source: (Ahmad et al., 2021) in modification

The researcher was inspired by the framework created by Ahmad et al. (2021) and the researcher made a slight modification as a framework for circular economy transparency. The main foundation of this framework is the Blockchain Network which uses ledger distribution technology to create high authenticity and transparency in permanently recording every transaction and related information. The Service Layer, consisting of Incentive and Penalties, Shipment Tracking and Route, Recycling, and Robotics-Based Segregation, provides integrated solutions to strengthen transparency throughout the circular economy supply chain.

The importance of Incentives and Penalties in providing incentives for stakeholders to actively participate in the circular economy process, accompanied by automated and decentralized mechanisms such as Get, Verify, Calculate, Transfer, and Update, opens up opportunities for a more fair and responsive system. Shipment Tracking and Route utilizes Store, Verify, Calculate, and Update to provide full visibility into shipments and route monitoring, strengthening responsibility and efficiency in goods distribution.

Recycling, as a critical component in the circular economy, uses Record, Verify, and Update to record and manage the recycling process, while Robotics-Based Segregation uses Share, Verify, Calculate, and Update to leverage artificial intelligence in waste separation. This framework not only provides solutions for transparency in waste management, but also accelerates the evolution towards an efficient and environmentally friendly circular economy

By incorporating Decentralized Storage (IPFS), the Service Layer can ensure the security and accessibility of decentralized data. The connected Access Layer with various communication protocols opens up integration opportunities with external systems and applications through RestHTTP, SOAP, JSON RPC, JMS, and Web3.js, creating the interoperability needed for diverse ecosystems. Frontend Decentralized Applications (DApps) as the end user interface help communities, enterprises, and institutions understand and take advantage of the transparency provided by blockchain.

By involving various stakeholders such as schools, factories, hospitals, households, regulatory agencies, and governments, this framework not only increases transparency but also creates wider collaboration opportunities. Overall, the framework creates the foundation for more efficient resource management and empowers the development of smart cities through the integration of blockchain technology in the circular economy.

Regulatory Opportunities and Challenge

One of the challenges in implementing blockchain and circular economy is the lack of regulation that supports or even hinders these practices. However, some countries, especially in Asia, have developed regulations regarding the implementation of circular economy several years ago, such as China, Japan, and Korea.

1. China’s Circular Economy Promotion Law 2008

China's Circular Economy Promotion Law 2008 (Bleischwitz et al., 2022) is a law passed by China's National People's Congress in 2008 to promote circular economy development, improve resource utilization efficiency, protect and enhance the environment, and realize sustainable development. The law consists of seven

chapters, covering general principles, basic management rules, reduction, reuse and recycling, incentives, legal responsibilities, and additional provisions.

Blockchain technology is a system that enables the recording and management of data and transactions in a decentralized, transparent, and secure manner. By using blockchain, every party involved in the supply chain or waste management can share the same information and can be verified by all parties. This can increase trust, efficiency, and accountability in the circular economy system

China's 2008 Circular economy law and blockchain technology can support each other in creating a more sustainable and fair system. Some of the relationships between the two are:

China's 2008 Circular Economy Law encourages governments, the private sector, and the public to participate in circular economy development, and provides appropriate incentives and sanctions. Blockchain technology can be used to issue and manage certificates and tokens that demonstrate the environmental performance of products or services, as well as create smart contracts that automatically execute agreements and payments between parties involved in the circular economy.

China's Circular economy Law 2008 (Bleischwitz et al., 2022) encourages and supports research, development, and promotion of technologies related to circular economy, as well as international cooperation in the field1. Blockchain technology can be used to share information, experience, and best practices between various parties, as well as facilitate harmonization and interoperability between circular economy systems operating in different regions or countries.

China's 2008 Circular economy law encourages the reduction, reuse, and recycling of resources in production, circulation, and consumption processes, as well as effective and safe waste management. Blockchain technology can be used to store information about materials, components, and processes used in product manufacturing, as well as product usage, repair, and recycling history, thereby increasing transparency and traceability in supply chains and waste management.

2. Japan's Basic Act for Establishing a Sound Material-Cycle Society

Japan's Basic Act for Establishing a Sound Material-Cycle Society (FAO, 2000) is a legal framework introduced by the Japanese government to address the problem of unsustainability in resource management and promote sustainable material cycling. This law, which came into force in 2000, provided the foundation for the implementation of the circular economy concept in Japan. The main focus of these laws is to minimize waste, increase recycling, and create an environmentally conscious society.

In the context of blockchain technology, this legislation could play an important role in increasing transparency and accountability in the material cycle. Blockchain technology enables decentralized, secure, and immutable recording of transactions, which is in keeping with the Japanese government's goal of ensuring the integrity and authenticity of material management-related data.

The application of blockchain technology can provide innovative solutions for managing supply chains and recycling processes. For example, by using blockchain, every stage of the material cycle, from production to recycling, can be recorded transparently and accessible to all stakeholders. This creates a system where

manufacturers, distributors, consumers, and others can easily monitor and verify the origin, use, and processing of materials.

Smart contracts in blockchain can be used to automate incentive and penalty processes that conform to the principles of the law. For example, manufacturers or owners of goods can be incentivized to recycle their products by providing tokens or rewards through smart contracts after recycling has been successfully verified.

Blockchain can also support carbon monitoring initiatives and environmental footprints. Whenever a product or material moves through the material cycle, its carbon footprint and other environmental impacts can be recorded and accessed by the public. It provides transparency to consumers and other stakeholders on how their purchasing decisions can affect the environment.

By utilizing blockchain technology, Japan can optimize the implementation of Japan's Basic Act for Establishing a Sound Material-Cycle Society creating a more transparent, efficient, and sustainable environment in their efforts towards a circular economy.

3. South Korea's Framework Act on Resources Circulation

South Korea's Framework Act on Resources Circulation (Climate Change Laws, 2021), passed in 2018, is a law that aims to promote efficient utilization of resources and sustainable waste management. This law reflects the South Korean government's commitment to confronting environmental challenges and advancing circular economy principles within their policy framework.

In the context of blockchain technology, the Framework Act can be linked to efforts to increase transparency and accountability in material lifecycle management. The application of blockchain technology can contribute significantly to the goals of this legislation by providing a decentralized, secure, and documented system for recording and tracking the flow of resources and waste.

Blockchain enables immutable and verified recording of transactions, ensuring data integrity throughout the material lifecycle. It is important to ensure that the recycling process and resource use are carried out in accordance with standards set by governments, producers, and other stakeholders.

In practice, blockchain can be used to create distributed registers that record all transactions related to resource and waste management. From production, distribution, consumption, to recycling, every stage of the material cycle can be accessed and verified by interested parties. This provides a high level of transparency and enables efficient monitoring of practices that support the circular economy.

In addition, the concept of smart contracts in blockchain can be integrated into this Framework Act. Smart contracts can be used to automate incentive and penalty processes with respect to resource and waste management. For example, manufacturers adopting better recycling practices can be incentivized automatically through smart contract execution.

Blockchain can also be used to track and manage carbon footprint and other environmental impacts throughout the material lifecycle. This information can be used by governments, businesses, and consumers to make more sustainable decisions and understand the environmental impact of a product or service.

Overall, blockchain technology can be a key pillar in supporting the implementation of South Korea's Framework Act on Resources Circulation, bringing transparency, efficiency, and sustainability benefits to South Korea's circular economy.

1. Criticism of Future Regulation

Although several other countries have implemented regulations related to the circular economy, there are still some problems related to regulations in regulating blockchain procedures as circular economy transparency. Some examples of problems with lack of regulation are:

- Unclear legal and taxation status of blockchain-based or circular economy products or services. This can cause uncertainty and risk for businesses and consumers who want to participate in the system.
- Inconsistencies or conflicts between different regulations at the local, national, or international level. This can complicate harmonization and interoperability between blockchain systems or circular economies operating in different regions or countries.
- Regulatory lag or limitations to accommodate the latest technological developments and innovations. This could hinder the adoption and integration of blockchain or circular economy in potential sectors, such as energy, healthcare, or education.

To overcome this lack of regulation, we need to do several solutions, including:

- Encourage dialogue and cooperation between various stakeholders, such as governments, the private sector, academia, civil society, and international organizations, to align visions, goals, and policies related to blockchain and circular economy.
- Increase knowledge and awareness of the benefits and challenges of blockchain and circular economy, and provide a platform and tools for sharing information, experiences, and best practices between various parties.
- Develop and implement standards, guidelines, and indicators that can measure and evaluate the performance and impact of blockchain and circular economy, as well as provide appropriate incentives and sanctions.
- Encourage and support innovation and experimentation that can test and demonstrate the potential and reliability of blockchain and circular economy, as well as facilitate scalability and replication of successful solutions.

CONCLUSION

Circular economy is a sustainable development paradigm that aims to maximize the use of resources by retaining, recycling, and reducing waste. On the other hand, blockchain, a secure and transparent decentralized technology, has emerged as a driving force for increasing transparency in the circular economy.

Blockchain enables the creation of systems that can track and manage the entire product lifecycle in detail without compromising security. Several companies, such as IBM Food Trust, Plastic Bank, and Provenance, have proven blockchain's effectiveness in ensuring supply chain transparency and motivating sustainable practices.

IBM Food Trust leverages blockchain to monitor and verify food supply chains, maintain product authenticity and avoid waste. Plastic Bank uses blockchain to track and recycle plastic waste, incentivizing consumers to participate. Provenance focuses on transparency in the jewellery supply chain, ensuring that raw materials come from ethical sources.

Blockchain implementation frameworks can include a structure consisting of a blockchain network, a service layer with various functions such as incentives and penalties, shipment tracking and route, recycling, and robotics-based segregation. All of these can be connected with access layers, including technologies such as RestHTTP, SOAP, JSON RPC, JMS, and Web3.js, which then connect with frontend decentralized applications (DApps) for interaction with stakeholders.

The application of blockchain in the circular economy also has the potential to support the development of smart cities. By utilizing this technology, resource management can be automated and optimized, creating a more efficient and sustainable environment. Blockchain adoption can lay the groundwork for developers and enterprises to design solutions that accelerate the transition to a circular economy.

The benefits of utilizing blockchain within a country or globally involve increased transparency, accountability, and sustainability. By ensuring supply chain integrity, countries can build consumer trust, encourage sustainable practices, and reduce environmental impact. Overall, through the marriage between circular economy and blockchain technology, we are opening the door to a more sustainable and resource-efficient future.

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