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APPLICATION OF BLOCKCHAIN TECHNOLOGY IN WASTE REGULATION IN FOREIGN TRADE

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ABSTRACT

Teknologi blockchain menghadirkan pendekatan yang transformatif dalam regulasi limbah dalam perdagangan internasional. Sifatnya yang terdesentralisasi dan transparan dapat meningkatkan pelacakan dan pengelolaan sumber daya limbah, sehingga meningkatkan kepatuhan terhadap standar lingkungan. Dengan memanfaatkan blockchain, para pemangku kepentingan dapat memastikan keterlacakan limbah dari asalnya hingga tujuan akhirnya, mengurangi risiko pembuangan limbah ilegal, dan meningkatkan akuntabilitas di antara para peserta dalam perdagangan limbah.

Selain itu, kontrak pintar yang dibangun di atas blockchain dapat mengotomatisasi proses dan menegakkan peraturan secara real-time, meminimalkan kesalahan manusia, dan meningkatkan efisiensi. Aplikasi ini dapat menyederhanakan dokumentasi dan pemeriksaan kepatuhan, memudahkan otoritas bea cukai dalam memantau pergerakan lintas batas limbah.

Integrasi blockchain dalam regulasi limbah juga dapat mendorong kolaborasi yang lebih besar diantara entitas internasional, menciptakan kerangka kerja yang terintegrasi untuk pelaporan dan pengelolaan kegiatan perdagangan limbah. Hal ini dapat menghasilkan pengambilan keputusan yang lebih terinformasi dan pengembangan kebijakan yang lebih baik di seluruh dunia, yang pada akhirnya mendukung tujuan ekonomi sirkular dan pembangunan berkelanjutan.

Blockchain technology presents a transformative approach to the regulation of waste in foreign trade. Its decentralized and transparent nature can enhance the tracking and management of waste resources, thereby improving compliance with environmental standards. By utilizing blockchain, stakeholders can ensure the traceability of waste from its origin to its final destination, reducing the risk of illegal dumping and enhancing accountability among participants in the waste trade.

Moreover, smart contracts built on blockchain can automate processes and enforce regulations in real-time, minimizing human error and increasing efficiency. This application could streamline documentation and compliance checks, making it easier for customs authorities to monitor transboundary movements of waste.

The integration of blockchain in waste regulation can also foster greater collaboration among international entities, creating a unified framework for reporting and managing waste trade activities. This could lead to more informed decision-making and improved policy development across borders, ultimately supporting the goals of a circular economy and sustainable development.

1. INTRODUCTION

1.1. Background of Study

Every year, the world generates 2.01 billion tons of solid waste, with numerous countries producing significant volumes that necessitate a serious approach to their disposal.

Global waste trade represents an exchange between nations aimed at recycling or waste management. This practice is driven by low costs, which facilitate the achievement of recycling goals and the reduction of waste volumes at national landfills. Non-recyclable materials are often incinerated, sent to landfills, or discharged into water bodies, creating risks for the environment and public health.

The transportation of waste is a necessity, as it not only helps maintain the natural balance of the Earth but also strengthens international ties. The importation of waste is also in high demand due to the potential for profit generation. Typically, countries exporting waste are poor or developing nations lacking the capacity to process such large volumes of garbage. They may also sell their waste, which assists in sustaining their economies. Importing countries, on the other hand, benefit significantly from recycling and reuse. Thus, both importers and exporters support each other, promoting sustainable economic development.

The significance of waste trade is profound for the concept of circular economy (or closed-loop economy). In this context, waste is used for recycling and the creation of new products. This practice upholds principles of sustainability and fosters production based on modern technologies.

However, the increasing transboundary movements of waste may pose challenges for customs control of recycled products at borders, as it is practically impossible to verify how the goods were produced. Furthermore, documentary verification carries the risk of false declarations and the movement of new products disguised as restored goods with understated customs values. This study proposes a solution for customs regulation of waste trade by utilizing blockchain technology.

2. LITERATURE REVIEW AND HYPOTHESIS

The challenges and pathways for the development of a circular economy have attracted the attention of both Russian and international researchers for several years. Some academic works focus on waste management and environmental pollution (Kellenberg D., Tesfaye F., Lindberg D., Hamuyuni J., Taskinen P., Hupa L., Dave Shailesh R., Shah Monal B., and Devayani R. Tipre). The most prominent scholarly work on resource trading within the framework of the circular economy is the publication "Circular Economy: From Waste to Resources through International Trade" by Albaladejo M., Mulder N., Mirazo P., and Mugica Jauregi I. Russian economists are also examining the phenomenon of the circular economy, with particular emphasis on the article by V.Yu. Salamatov, I.Z. Aronov, and A.M. Rybakov titled "International Trade in Secondary Goods: A Review." However, there currently exists a lack of research and scholarly articles specifically dedicated to customs control of waste and goods derived from their recycling.

3. RESEARCH METHODOLOGY

This article analyzes the key indicators of waste trade related to transactions within the framework of the circular economy. The research identifies the problem of insufficient regulation regarding the principles of customs control for the movement of circular goods, as well as a lack of resources to effectively implement such control. Based on methods of analysis, induction, and synthesis, this study articulates the potential applicability of blockchain technology for waste regulation and other types of goods in the context of a circular economy.

4. RESULTS AND FINDINGS

4.1. Findings

The trade in secondary raw materials (hereinafter referred to as SRM) serves as a circular indicator that aids in tracking progress towards achieving the standards of a circular economy. Within the framework of the circular economy, the objective of utilizing residual materials is their recycling and reintegration into the economy as new raw material resources. This approach can yield several advantages, such as reducing waste volumes and enhancing the security of raw material supply. Furthermore, it is essential to consider the movement of raw materials derived from waste, namely secondary raw materials. SRM contributes to positive economic and environmental effects by lowering material costs.

According to a report by BDO LLP (2022), the societal drive towards consuming more sustainable products has led to significant investments in brands that utilize circular and sustainable materials. This is reflected in a 35% contribution to material recycling within the manufacturing and processing sectors. This trend is also evident in retail, the consumer sector, and the entertainment industry, where 40% of investments are directed towards more circular raw materials.

Analysts from the German company Statista have projected the growth of turnover in the trade of circular goods by 2026 compared to 2022 (see Fig. 1) (StartUs, 2023). According to their estimates, the volume of trade in circular goods is expected to more than double across various product categories that can be identified as "used goods." This indicates that international trade, at least in used goods, is also anticipated to increase approximately twofold.

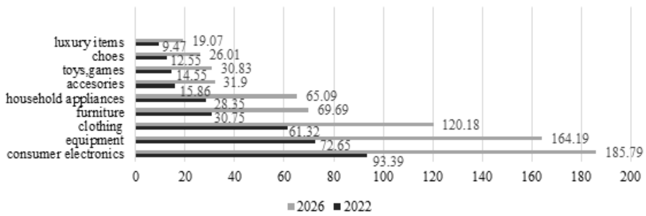

Figure 1. Growth of trade volumes of circular goods by 2026 [StartUs, 2023]

In the context of the circular economy, several business model options can be employed either individually or in combination (Zink, Geyer, 2017).

1) Circular Value Chains – This model involves replacing limited resources with entirely renewable sources. For instance, bioethanol and biodiesel derived from plant biomass can be

utilized as fuel for internal combustion engines instead of petroleum-based products.

2) Extended Product Lifecycle – This model enables the preservation of economic value for as long as possible through restoration, repair, upgrading, or remarketing of products. It also entails a shift from selling goods to offering services related to their use.
3) Sharing Economy – This model is based on the exchange of goods or assets with low utilization rates. Examples of sharing platforms include transportation services like "Blablacar" and accommodation services such as "Airbnb."
4) Product as a Service (Servitization) – In this model, customers utilize products through "leasing" arrangements with payment based on actual usage. Several companies abroad offer lighting as a service, retaining ownership of the equipment so that customers are not responsible for installation or equipment failure—these aspects are included in the service agreement.
5) Recovery and Recycling – This model leverages technological innovations and capabilities for the recovery and reuse of resources. Examples include closed-loop recycling systems that convert waste into new resources.
6) Extended Product Lifecycle – This model again emphasizes the preservation of economic value through restoration, repair, upgrading, or remarketing of products, while also promoting a transition from selling goods to providing services related to their use.

In turn, the materials used in the circular economy can be categorized into several groups (Tesfaye et al., 2017):

1) Used goods: These items can be directly reused, repaired, refurbished, or upgraded, or utilized as secondary raw materials.
2) Restored (refurbished) goods: According to estimates by the Organisation for Economic Co-operation and Development (OECD), restoration processes can lead to energy savings of more than 50% and a reduction in waste generation of over 80% (OECD, 2018).
3) Secondary raw materials: These typically include materials used in the production process that replace or supplement the use of new materials. Metal and textile trading are among the most common forms of this type of trade, both in terms of value and volume.
4) Waste and scrap: Trade in waste is highly heterogeneous, complicating its regulation.

The popularity of trading such goods is driven by high demand in developing countries, as it allows the acquisition of quality used goods at lower prices compared to similarly low-quality new products (Albaladejo et al., 2001). Thus, waste recycling and reuse constitute essential elements of the circular economy.

Russia has announced a transition to a new environmental policy focused on maximizing waste reduction through recycling and integrating waste into the economic cycle. In recent years, the country has established a state registry of waste disposal sites, with all types of waste included in the federal classification catalog. The licensing system for waste management activities has expanded to include processing and disposal. A phased ban on the landfill disposal of unprocessed waste, as well as waste that can be utilized as secondary raw materials, is being implemented. Thus, through gradual steps and learning from mistakes, we are moving towards creating a modern and efficient waste management system (Girich et al., 2019). Statistical data is presented in Table 1 (APPENDIX I).

The volumes of waste generation from production and consumption increased by 1.7 times from 2012 to 2021; however, a growth trend was observed in all years of the analyzed period, except for 2020, when a decrease of 10.3% in waste generation volumes was recorded compared to 2019 (see Fig. 3 APPENDIX II).

Regarding the recycling, treatment, and disposal of production and consumption waste in the Russian Federation from 2012 to 2021, the dynamics presented in Figure 4 were not unequivocal. The volumes of recycling and treatment of production and consumption waste increased on average by 176.6 million tons annually, reflecting a growth of 67.7% over the decade. The volumes of waste disposal at enterprise-owned facilities also rose annually by an average of 175.6 million tons.

See Figure 4 in Appendix III

The motivation for businesses to engage with industrial waste stems not only from ecological risks and economic prospects but also from government initiatives (Salamatov et al., 2023). For instance, the federal program "Circular Economy" aims to more than double the rate of secondary use of industrial waste over six years – from 20% in 2024 to 42% by 2030. The Energy Strategy of Russia outlines an equally ambitious goal: the recycling of 50% of industrial waste containing ash by 2035.

One of the most promising directions for the development of a circular economy is the utilization of industrial waste within a company's own production processes. This initiative is actively pursued by the company "Severstal". Thus, the conducted analysis allows us to conclude that the level of circularity in the Russian economy, i.e., the reintegration of waste into the production system of material goods, is continuously increasing. It is noteworthy that this trend is characteristic of many countries around the world.

4.2. Discussion

Based on the previously presented statistics, it follows that the products obtained through recycling can also participate in foreign trade. However, to date, neither in Russia nor globally has a customs control technology been developed that would effectively track and monitor the flows of such goods. In this regard, it is essential to formulate proposals for regulating this issue, taking into account modern technologies.

The most suitable technology in this context is blockchain—a decentralized, digitally distributed ledger that facilitates the tracking and verification of transactions. Although blockchain is best known as the technology underpinning cryptocurrencies such as Ethereum and Bitcoin, experts are finding other applications for it across various sectors of the economy. It is noteworthy that blockchain is currently being actively utilized in customs operations within product traceability systems (Timchuk, 2022).

Blockchain technology possesses characteristics such as decentralization, protection against unauthorized access, encryption of records, and so forth, which can address issues related to product traceability, thereby enhancing consumer trust (Korovyakovsky, 2018). With the ongoing development of blockchain technology, an increasing number of applications in the customs field will emerge (Somov, 2018). Blockchain can help mitigate risks associated with illegal movement, use, or disposal of waste, as well as distortions in customs valuation when products are misrepresented as recycled goods, among other issues (Karpinskaya, Kudryavtsev, 2022).

A waste and circular goods traceability system must meet several requirements, namely:

- the system must eliminate the possibility of unauthorized information entry;
- the system must have mechanisms for real-time tracking of changes by all partners;
- the system must prevent post-facto data alteration;
- the system must ensure independent access to necessary data for each partner, meaning that required data should be stored by each participant in the economic relations;
- the system must utilize a real-time data synchronization algorithm among partners;
- the system must guarantee compliance with access rights to information.

Such a traceability system for waste and circular goods, accommodating these requirements, can be implemented through the application of blockchain technology.

Figure 5 illustrates an example of how blockchain technology can be applied for customs control of goods that may be reused after restoration and are misrepresented by unscrupulous foreign trade participants as newly created products to reduce customs value.

Through blockchain, a product passport is generated that will track its entire life cycle trajectory: from manufacturing to recycling and sale, as depicted in Figure 5 (APPENDIX IV)

The passport will contain information that can be divided into two main blocks:

- information about counterparties: 1. Manufacturer (location, charter). 2. Seller (location, charter). 3. Buyer (location, charter). 4. Transaction counterparties (declarant, carrier, freight forwarder, etc.);
- information about the product: 1. Commercial documents (contract with appendices, invoice, supply agreements, etc.). 2. Permitting documents (certificates of origin, quality, etc.). 3. Transport documents (waybills, transport invoices, etc.). 4. Other documents.

The information included in the product passport (blockchain container) regarding the recycling of goods will be impossible to delete, thereby enabling the detection of this fact during customs control. Consequently, it will not be feasible to misrepresent recycled goods as newly created products. Furthermore, the information obtained about counterparties and the specifics of contracts can also be utilized for categorizing participants in foreign economic activity within the risk management system.

Thus, blockchain can create optimal conditions for monitoring the disposal, placement, burial, and reuse of waste.

5. CONCLUSIONS

5.1. Conclusion

One of the most pressing issues in waste management and recycling is ensuring proper tracking and tracing of waste. Blockchain technology can provide a transparent and unauthorized access-resistant registry that records each stage of the waste management process, from collection to disposal or recycling. This enhanced visibility can help prevent illegal dumping, ensure proper waste disposal, and support recycling efforts.

As the waste management and recycling industry continues to evolve, it becomes increasingly evident that blockchain technology will play a crucial role in fostering innovation and sustainable development. By leveraging blockchain capabilities, businesses and governments can collaborate to create a more environmentally friendly, efficient, and transparent waste management system that benefits both the environment and society as a whole.

In conclusion, it is important to emphasize that blockchain technology holds tremendous potential for transforming the waste management and recycling industry. By providing increased transparency, traceability, and efficiency, blockchain can help address the growing challenges of waste generation and disposal, paving the way for a more sustainable future.

5.2. Recommendation

The application of blockchain technology in the operations of customs authorities for the customs control of restored (repaired) goods, processed products, and waste for subsequent use in production will enable:

1) The management of waste and restored goods security issues, thereby creating a reliable supply chain and sales process with enhanced transparency.
2) The assurance of information security for data entered into the blockchain.
3) The identification of perpetrators of violations within the blockchain framework.
4) The facilitation of circular economy development by reducing transaction costs and minimizing the number of intermediaries.
5) More effective identification of restored goods at the customs border during customs control.
6) The promotion of transparent trade, which minimizes the risk of false declarations regarding the materials used in the production of goods (preventing new products from being misrepresented as restored to evade customs valuation).

In light of the above, it is recommended to integrate this technology into the business processes of companies involved in both waste processing and disposal, as well as those engaged in production that generates waste. Blockchain will provide transparency in monitoring trade, disposal, and cross-border movement of goods, simplifying the work of customs authorities and ensuring a high level of customs control quality.

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APPENDIX I

Table 1: Volume of production and consumption waste in Russia from 2012 to 2021

Year	Generation of production and consumption waste, million tons	Utilization and disposal of production and consumption waste, million tons	Utilization and disposal of production and consumption waste, as a percentage of the total volume of generated waste	Placement of production and consumption waste at facilities owned by the enterprise, million tons	Ratio of production and consumption waste to GDP, %	Waste per capita in the country, tons per person
2012	5007,9	2348,1	47,0	2912,0	0,007	35,0
2013	5152,8	2043,6	39,7	4897,7	0,007	36,0
2014	5168,3	2357,2	45,6	2951,4	0,007	36,0
2015	5060,2	2685,1	53,1	2333,1	0,006	34,6
2016	5441,3	3243,7	59,6	2620,8	0,006	37,1
2017	6220,6	3264,6	52,5	3204,5	0,007	42,4
2018	7266,1	3818,4	52,6	3575,4	0,007	49,5
2019	7750,9	3881,9	50,1	3800,8	0,007	52,8
2020	6955,7	3429,0	49,3	3706,4	0,006	47,5
2021	8448,6	3937,2	46,6	4492,3	0,006	57,9

Source: Federal State Statistics Service. Environmental Protection in Russia. URL: https://rosstat.gov.ru/folder/210/document/13209

APPENDIX II

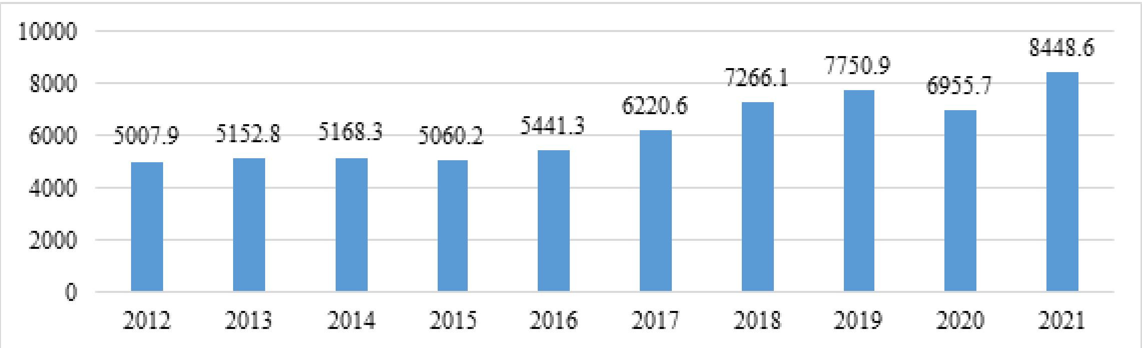

Figure 3. Waste Generation from production and consumption in the russian federation from 2012 to 2021, million tons

Source: Compiled by the authors based on data from Table 1.

APPENDIX III

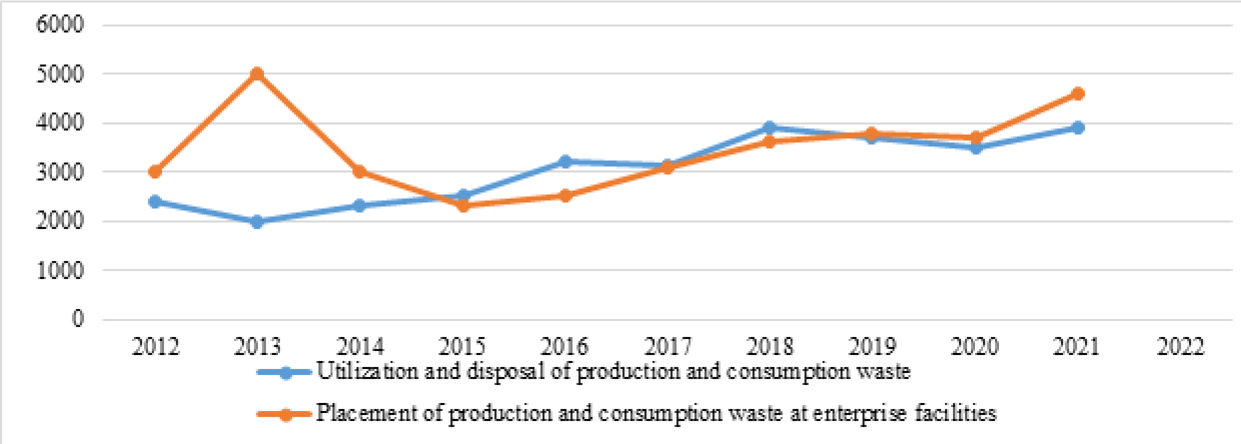

Figure 4. Volumes of recycling, treatment, and disposal of production and consumption waste in the russian federation from 2012 to 2021, million tons

Source: Compiled by the authors based on data from the table.

APPENDIX IV

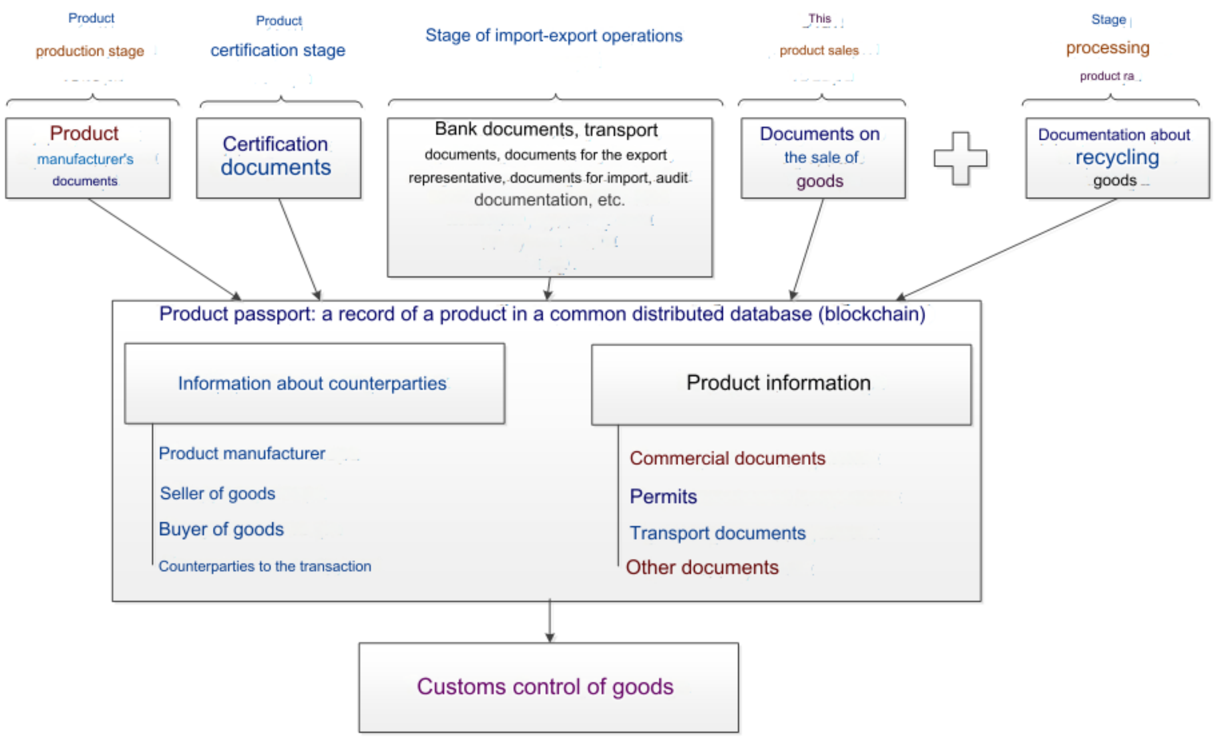

Figure 5. Diagram of the application of blockchain technology for customs control of goods that can be reused after restoration