МРНТИ 10.87.79, 10.87.17
DOI: 10.32523/3079-7888-2025-13-1-75-84

Prospects for implementing decentralized ledgers to record and verify international legal obligations

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Abstract. The article discusses the prospects of implementing decentralized ledgers based on blockchain technology for the establishment and verification of international obligations in various fields. A comparative analysis of traditional liability accounting systems and new solutions based on distributed technologies has been carried out. Specific successful cases of the implementation of blockchain platforms, such as the TradeLens platform for the digitalization of international trade and the Climate Action Data Trust for environmental agreements under the 2015 Paris Agreement, have also been examined. The article discusses the legal aspects of blockchain in international law, including the provisions of the UNCITRAL model laws, OECD recommendations and the challenges of legal recognition of digitally recorded data. It finds that decentralized technologies can significantly increase transparency, trust and the speed of implementation of international obligations, but those legal and political challenges need to be overcome. Conclusions are drawn on the need for further harmonization of international legal norms and standards for the widespread adoption of blockchain technologies. The paper identifies opportunities for international organizations and states to develop legal and technical infrastructure for the effective use of distributed ledgers in various areas of international relations.

Keywords: distributed ledger technologies, blockchain, international obligations, international law, smart contracts, digital diplomacy, Paris Agreement, UNCITRAL Model Laws, OECD.

Халықаралық-құқықтық міндеттемелерді бекіту және верификациялау үшін орталықтандырылмаған тізілімдерді енгізу перспективалары

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Аңдатпа. Мақалада әртүрлі салалардағы халықаралық міндеттемелерді бекіту және тексеру үшін блокчейн технологиясына негізделген орталықтандырылмаған тізілімдерді енгізу перспективалары қарастырылады. Орталықтырылмаған технологиялар негізінде міндеттемелер мен жаңа шешімдерді есепке алудың дәстүрлі жүйелеріне салыстырмалы талдау жүргізілді. Сондай-ақ, халықаралық сауданы цифрландыруға арналған TradeLens платформасы және 2015 жылғы Париж келісімі шеңберіндегі экологиялық келісімдерге арналған Climate Action Data Trust сияқты блокчейн-платформаларды енгізудің сәтті жағдайлары зерттелді. Мақалада блокчейнді халықаралық құқықта қолданудың құқықтық аспектілері, соның ішінде ЮНСИТРАЛ үлгілік заңдарының ережелері, ЭЫДҰ ұсынымдары және цифрлық нысанда тіркелген деректерді заңды тану мәселелері егжей-тегжейлі қарастырылған. Орталықтандырылмаған технологиялар халықаралық міндеттемелерді орындаудың ашықтығын, сенімін және жеделдігін едәуір арттыра алатыны, алайда құқықтық және саяси сын-қатерлерді еңсеруді талап ететіні атап өтілді. Блокчейн-технологияларды кеңінен енгізу үшін халықаралық-құқықтық нормалар мен стандарттарды одан әрі үйлестіру қажеттілігі туралы қорытындылар жасалды. Халықаралық қатынастардың әртүрлі салаларында үлестірілген тізілімдерді тиімді қолдану үшін нормативтік-құқықтық қамтамасыз ету мен техникалық инфрақұрылымды дамыту бойынша халықаралық ұйымдар мен мемлекеттердің даму мүмкіндіктері айқындалды.

Түйін сөздер: үлестірілген тізілім технологиялары, блокчейн, халықаралық міндеттемелер, халықаралық құқық, ақылды келісімшарттар, цифрлық дипломатия, Париж келісімі, ЮНСИТРАЛ үлгілік заңдары, ЭЫДҰ.

Перспективы внедрения децентрализованных реестров для фиксации и верификации международно-правовых обязательств

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Аннотация. В статье рассматриваются перспективы внедрения децентрализованных реестров, основанных на технологии блокчейн, для фиксации и верификации международных обязательств в различных сферах. Проведён сравнительный анализ традиционных систем учёта обязательств и новых решений на базе распределённых технологий. Также были изучены конкретные успешные кейсы внедрения блокчейн-платформ, такие как платформа TradeLens для цифровизации международной торговли и Climate Action Data Trust для экологических соглашений в рамках Парижского

соглашения 2015 года. В статье подробно рассмотрены правовые аспекты использования блокчейна в международном праве, включая положения типовых законов ЮНСИТРАЛ, рекомендации ОЭСР и проблемы юридического признания данных, зафиксированных в цифровой форме. Отмечено, что децентрализованные технологии способны существенно повысить прозрачность, доверие и оперативность исполнения международных обязательств, однако требуют преодоления правовых и политических вызовов. Сделаны выводы о необходимости дальнейшей гармонизации международно-правовых норм и стандартов для широкого внедрения блокчейн-технологий. Определены возможности развития нормативно-правового обеспечения и технической инфраструктуры для международных организаций и государств, с целью эффективного применения распределённых реестров в различных областях международных отношений.

Ключевые слова: технологии распределенного реестра, блокчейн, международные обязательства, международное право, умные контракты, цифровая дипломатия, Парижское соглашение, типовые законы ЮНСИТРАЛ, ОЭСР.

Introduction

The contemporary system of international agreements necessitates the establishment of effective mechanisms for the recording and verification of states' fulfilment of their international legal obligations in various fields. Conventional approaches to data collection and oversight, such as centralized registers, state reports, and inspections, frequently encounter challenges related to data fragmentation and a paucity of transparency [1]. This has the potential to result in a diminution of trust between the parties to the treaty, thereby complicating the monitoring of compliance with the concluded agreements.

It is the contention of the present study that the issue can be effectively resolved through the utilization of Distributed Ledger Technology (hereinafter referred to as DLT), including blockchain, which offers an innovative approach to addressing these challenges. A decentralized ledger can be defined as an immutable and transparently updated database, copies of which are held by multiple parties to an international treaty. This approach ensures a high degree of reliability in information exchange and safeguards the integrity of treaty documents from unauthorized alterations.

In view of the existence of three primary categories of technology – namely, public, private and hybrid – the application of blockchain covers a wide range of intrastate areas. In the context of international obligations, DLT has the potential to increase transparency and accountability through open access to records by stakeholders, as well as automate processes for verifying compliance with terms and conditions through smart contracts [2]. Many international organizations and experts consider blockchain to be a promising tool for building trust in areas such as trade, ecology, human rights protection and arms control [3, 4].

The present article aims to analyze the prospects of implementing decentralized ledgers for fixing and verifying international obligations. In order to achieve this objective, a comparative analysis of extant solutions in the world practice is conducted, specific examples of the application of DLT in the framework of international agreements are studied, and a legal analysis of international norms and regulatory acts related to the implementation of blockchain technologies is performed. The article adopts an interdisciplinary approach, integrating technical and legal perspectives, thereby facilitating a comprehensive evaluation of the prospects and constraints of decentralized registries in the context of interstate relations.

Methodology

The methodological framework of the study incorporates three complementary approaches: comparative analysis, case analysis (case-study) and legal analysis. The application of the former approach enabled the determination of the significance of blockchain technology based on extant examples of both centralized and decentralized systems. The study also utilized a case study method, which is a detailed examination of individual cases of successful use of distributed ledger technologies in international legal agreements. Two illustrative examples from different fields were selected for the purposes of this study: TradeLens in the field of global trade and Climate Action Data Trust in the field of environmental agreements. In addition, the study included a legal analysis of international legal norms and regulations applicable to the use of decentralized registries, such as the Paris Agreement, the UN Convention on Contracts for the International Sale of Goods, the OECD Council Recommendation on Blockchain, and others. The analysis was conducted in several areas: (1) international treaties enshrining obligations in the relevant areas and the potential of blockchain application in their enforcement; (2) model laws and recommendations of international organizations that create a legal framework for the recognition of electronic records and smart contracts; (3) existing policies and principles of digital economy regulation relevant to the DLT. The results of the legal analysis are integrated into the subsequent section on international legal aspects of DLT implementation.

Discussion

The international legal aspects of the implementation of decentralized ledgers.

One of the most advanced areas is the application of blockchain in multilateral environmental agreements. The 2015 Paris Agreement, a follow-up to the UN Framework Convention on Climate Change, establishes commitments by parties to reduce emissions and provides for mechanisms for international transfer of emission reduction results (Clause 2, Article 6), subject to transparency and absence of double counting [5]. However, in practice, ensuring full confidence in emissions data provided by different countries remains a difficult task due to the fragmentation of national accounting systems [6]. The application of distributed registry technologies is regarded as a means of strengthening the monitoring system of the Paris

Agreement. To illustrate this point, consider the function of the Climate Action Data Trust platform, which, as a meta-registry, serves to unify disparate carbon registries and transparently track the movement of carbon credits between nations. The immutability of blockchain records guarantees that the same reduced carbon dioxide (CO2) tonnage will not be declared by two different parties (which meets the requirement to avoid double counting, explicitly enshrined in Article 6 of the Paris Agreement) [6]. The integration of DLT tools within the architecture of the Paris Agreement implementation has garnered support from the expert community. For instance, a study published in the journal Sustainability in 2020 demonstrated that a blockchain solution can enhance transparency and automate the accounting of emission reductions, thereby complementing the existing mechanism of the agreement [2]. From a legal perspective, it is important that the use of blockchain does not contradict the objectives of the Paris Agreement, but rather contributes to its transparency goals. Nevertheless, formal implementation of such systems may require the approval of the Conference of the Parties, or the body authorized to develop accounting rules for Article 6. There are already steps being taken to integrate new technologies, as evidenced by the discussion of digital solutions for tracking nationally determined contributions at Framework Convention meetings. In 2022, the UN Development Program and partners launched initiatives for digital monitoring of climate action based on the SDGs. Consequently, within the environmental domain, decentralized ledgers are largely consistent with the spirit and letter of international agreements (ensuring transparency as stipulated in the Paris Agreement) and are progressively gaining acceptance as an ancillary instrument that does not necessitate a radical alteration of the legal framework, but merely its technological augmentation.

International trade

In the context of international trade, the legal recognition of electronically recorded data and transactions constitutes a critical factor for the application of blockchain. The foundational multilateral treaty that governs cross-border commercial transactions is the 1980 UN Vienna Convention on Contracts for the International Sale of Goods (CISG) [7]. This convention does not explicitly prohibit the use of electronic communications in the conclusion of contracts; however, as of 1980, it did not provide for modern technology. Subsequent decades have seen significant efforts within the framework of the UN Commission on International Trade Law (UNCITRAL) to adapt the legal framework to electronic transactions. The UNCITRAL Model Laws on Electronic Commerce (1996) [8] and on Electronic Transferable Records (2017) [9], as well as the UN Convention on Electronic Communications in International Contracts (2005), have established principles that legalize digital records and contracts [10]. The key principles enshrined in these instruments include technological neutrality (non-discrimination of a document just because it is in electronic form) and functional equivalence of electronic and paper documents [10]. This signifies that, for instance, an electronic bill of lading or smart contract that fulfils the established reliability criteria can be regarded as equivalent to

traditional paper documents. The 2017 Model Law on Electronic Transferable Records is particularly illustrative in this regard, as it explicitly provides for the possibility of using distributed registries in the circulation of digital equivalents of documents such as warehouse certificates or bills of lading [10]. Many states have already implemented these models in their national legislation, creating legal conditions for platforms such as TradeLens. For instance, the legislation of Singapore and Bahrain has been amended in accordance with the 2017 model, thereby enabling the legal recognition of blockchain-transmitted documents pertaining to goods turnover. While the 1980 United Nations Convention on the Law of the Sea (UNCLOS) does not explicitly mention blockchain, the body of international acts adopted as a follow-up to its provisions de facto provides legal recognition of decentralized digital transactions. This signifies that participants in international trade can record their obligations and transfer title to goods via blockchain without compromising the legal effect of such actions.

However, jurisdictional and dispute resolution issues persist. With a decentralized ledger, it may be more challenging to ascertain the applicable law and responsible parties in the event of a system failure. In order to address these issues, harmonized approaches are required, for example in the form of harmonized rules for digital trade transactions under UNCITRAL or the World Trade Organization. Nevertheless, the trend is that the legal infrastructure is gradually adapting to the requirements of the digital trade era, and dApp platforms like TradeLens fit into this infrastructure, provided that common standards for electronic document management are met.

Human rights and humanitarian sphere

The utilization of distributed ledgers for the purpose of monitoring compliance with international human rights obligations and humanitarian agreements is a concept that is currently under consideration. Despite the absence of explicit references to blockchain in UN human rights documents, the technology has the potential to enhance oversight and transparency. For instance, the principles of responsible business conduct and international labor rights standards require multinational corporations to monitor their supply chains to ensure that there is no child labor or forced labor. In this context, blockchain platforms have the capacity to record supply chains and labor contracts in a way that data cannot be falsified, thereby assisting companies and auditors in verifying that workers' rights are being upheld. Research undertaken under the auspices of the Council of Europe suggests that the capacity of blockchain to furnish transparent, accurate, and accessible records can be directly employed to protect human rights [11]. To illustrate this point, decentralized ledgers have the capacity to store evidence of human rights violations (e.g. videos, testimonies) in a time-bound and immutable manner, facilitating international investigations and courts. Such initiatives are already being implemented by non-governmental organizations, with blockchain ledgers being utilized to document data on violations in conflict zones, ensuring their preservation and verification. Furthermore, the DLT is regarded as a mechanism for the management of identities

for refugees and stateless individuals. The utilisation of a distributed registry ensures the integrity of data pertaining to an individual's status, documents, and the assistance provided, a matter of particular significance in the context of interstate refugee protection programmes. The legal implications of this are twofold, relating to privacy and data protection. In this regard, international law stipulates that the implementation of blockchain systems must not infringe upon privacy rights. Consequently, the application of blockchain in the human rights sphere is currently restricted, but it demonstrates potential as a technology that can enhance the transparency and accountability of states and organizations in fulfilling their humanitarian obligations. International institutions, including the United Nations Office of the High Commissioner for Human Rights (OHCHR) and the Council of Europe, are actively exploring these issues, issuing reports and recommendations to steer technology development in a human rights-compatible direction [12].

A further area in which reliable data recording and trust between actors are critical is that of arms control and disarmament. International treaties, including the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and arms limitation agreements, mandate states to provide detailed information (e.g., declarations of armaments, notifications of missile launch) and establish inspection mechanisms. In this area, proposals have been made to utilize blockchain technology to enhance the reliability of the data provided. Experts have posited that a distributed ledger has the potential to function as a "trust machine," thereby recording all arms reduction activities and inspections by inspectors, thus creating an additional level of confidence between the parties [13]. For instance, the utilization of blockchain technology for the recording of unique identifiers for weapons or warheads, along with the subsequent documentation of their destruction, has been proposed. In this scenario, the integrity of the records maintained by inspectors from the IAEA or other organizations would be ensured, as they would be able to verify the authenticity of the records, with the knowledge that they have not been tampered with. Experiments are already underway: between 2019-2021 Research centers such as King's College London, in conjunction with the UN, have been examining the potential of DLT to track nuclear materials and adhere to the terms of the NPT [13]. A report by the Center for Security Science Studies (CSSS) indicates that blockchain has the potential to facilitate verification of compliance with agreements by acting as a single trusted log for all parties [13]. The legal challenges in this regard pertain to secrecy and verification regimes, given that not all weapons data may be publicly available, and even for authorized distributed networks, strict control of access is required. Notwithstanding, from a legal perspective, there are no fundamental obstacles to the use of DLT in this area, provided that the countries parties to the relevant treaty agree on a protocol for the maintenance of such a ledger and recognize it as part of verification mechanisms. The potential for the incorporation of digital verification mechanisms within the framework of international arms control law is a prospect that may be explored in future, contingent upon the success and efficacy of pilot projects in this domain.

International principles and regulation of digital technology

The Organization for Economic Cooperation and Development (OECD) was among the first to acknowledge the significance of blockchain for the global economy and to establish pertinent guidelines. In June 2022, the OECD Council at the ministerial level adopted the Recommendation on Blockchain and Other Distributed Ledger Technologies (DLT), which is noteworthy as the first international document to comprehensively describe the policy in this area [14]. The Recommendation calls upon governments to ensure responsible implementation of blockchain innovation at the national level, whilst also encouraging active cooperation in the international arena to develop compatible standards. The recommendation emphasizes the necessity of ensuring that blockchain applications comply with legal requirements, that network management mechanisms are transparent, that different blockchain systems are interoperable, and that personal data is protected. Special attention is paid to the ethical aspects (principles of fairness, inclusiveness) and environmental sustainability of the application of DLT [14]. While not mandatory, these principles serve as a guideline for OECD member countries and other states in the formation of national strategies in the field of digital economy. In addition to the OECD, other international organizations have issued their own recommendations. For instance, the United Nations Conference on Trade and Development (UNCTAD) has issued reports recommending that developing countries adopt digital technologies (including blockchain) to achieve the Sustainable Development Goals, whilst developing national legal frameworks for these technologies. The Group of Twenty (G20) has also recognized in recent summit declarations the need to work together to regulate new technologies in finance and trade, which include distributed ledgers. These initiatives illustrate the global community's recognition that the full realization of the potential of blockchain in interstate relations necessitates not only technical implementation, but also the harmonization of legal norms and standards. This has resulted in a gradual evolution of the international legal environment, wherein decentralized ledgers are no longer considered legal vacuums. Instead, specific principles are being formulated for them, and they are being integrated into existing normative fields, such as trade law, environmental law and human rights.

Conclusion

The advent of decentralized ledgers for the purpose of fixing and verifying international obligations appears to be a promising development at the intersection of technological innovation and contemporary international law. The study has demonstrated that distributed ledgers have the capacity to enhance the efficiency and transparency of control over the implementation of agreements. A comparative analysis has confirmed the superiority of DLT over traditional accounting systems in a number of parameters (data immutability, real-time synchronization, trust without intermediaries). Furthermore, the studied cases as TradeLens and CAD Trust, have clearly demonstrated the feasibility of these advantages in practice. However, it was

also revealed that the success of such initiatives is contingent on the existence of a favorable regulatory environment.

A legal analysis has demonstrated that international law is adapting to the challenges of digitalization, with new agreements and recommendations (e.g., UNCITRAL model laws and OECD principles) removing barriers to the legal recognition of blockchain records and transactions.

Nevertheless, challenges persist, ranging from unifying the jurisdictional status of decentralized ledgers to developing liability mechanisms for failures in their operation. Addressing these challenges necessitates sustained research and collaboration between technical experts, international lawyers, and government agencies.

In conclusion, if implemented effectively, decentralized ledgers have the potential to serve as a significant confidence-building instrument in international relations. They complement existing institutions of control, thereby rendering the fulfilment of international obligations more transparent and accountable to all stakeholders. Pilot projects in the domains of trade and environmental cooperation have already yielded tangible results, and the integration of blockchain technology into formal agreement mechanisms is gradually becoming a norm. The future direction of SDT in areas such as human rights and disarmament shows great potential for a paradigm shift in the approach to monitoring the implementation of global agreements, with the prospect of enhanced enforcement discipline. To this end, it is imperative for the global community to collaborate in establishing standards and to collectively share experiences in implementing novel technologies. This collaborative endeavor will ensure the maximization of the potential offered by decentralized registries, while at the same time ensuring that the fundamental principles of international law, as enshrined in the UN Charter and other international legal instruments, are not violated.

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