Application Of Smart Contracts Under the Framework of Contract Law Introduction

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Abstract. This academic paper delves into the intricate legal dimensions of smart contracts within the context of traditional contract law, tracing the evolution of smart contracts, their intricate linkages with blockchain technology and ethereum, and their thriving applications in diverse fields such as finance and supply chain management. Using a combination of literature review and comparative analysis, this study not only highlights the multifaceted advantages offered by smart contracts, such as automated execution capabilities and greater security, but also provides insights into the legal challenges they pose. These challenges contrast with the principles of traditional contract law, including the dilemmas of the legal nature of smart contracts, contracting, performance, and modification and remedies. To reconcile these differences, this paper argues for a set of innovative solutions. These include the adoption of the integration of multi-signature protocols to enhance mutual agreement, the strategic involvement of governmental oversight to ensure regulatory compliance, and the implementation of hybrid models that synergize on-chain functionality with off-chain operations. Through this comprehensive analysis, the paper aims at forging a path towards coordinating the dynamic capabilities of smart contracts with the established tenets of contract law, thereby unlocking their full potential in a legally compliant.

Keywords: Smart Contract; contract Law; blockchain.

1. Introduction

1.1. Historical Context

Smart contracts were first proposed by Nick Szabo in 1996. He sees a smart contract as a series of digitally specified promises, including an agreementamong the parties to execute within those promises. Compared with traditional paper contracts, smart contracts are more efficient and convenient, and can automatically enforce the terms of the contract, thus reducing human intervention and enforcement costs. Szabo uses the example of a vending machine to illustrate the basic idea of smart contracts: a vending machine is able to automatically dispense with goods and make change after receiving coins by relying on a simple built-in mechanism, a process that in a way reflects the automatic execution of smart contracts. Nevertheless, with the development of Internet technologies the application of smart contracts is far beyond this, it can be applied to a variety of digital means of control of valuable goods, to achieve the automated management and transfer of property rights. And the main advantage of smart contracts is their ability to automate the enforcement of contract terms, which not only reduces fraud and enforcement costs, but also increases the efficiency and security of transactions. The creation of smart contracts opens up a new era of trust and contract enforcement in the digital economy [1].

1.2. Blockchain and Ethereum

Blockchain developments provide the necessary decentralised underlying technology for smart contracts. The origins of blockchain technology can be traced back to 2008, when Satoshi Nakamoto published his seminal paper, Bitcoin: A Peer-to-Peer Electronic Cash System [2]. Block chain is essentially a decentralised database technology that provides an innovative technological solution for storing, verifying, transmitting and exchanging data on the network without the need for third-party involvement [3]. The application of blockchain technology in smart contracts allows for the

maintenance of a secure, decentralised ledger of transactions that determines who has rights to what in the network [4].

Ethereum, introduced by Vitalik Buterin, further extends the use of smart contracts by providing a platform for executing complex contracts [5]. With the aid of a Turing-complete virtual machine known as the Ethereum Virtual Machine (EVM), it enables the execution of complex and tailored smart contracts [6]. The Ethereum Virtual Machine (EVM) provides an isolated running environment for Ethereum smart contracts. This sandbox environment ensures that the execution of smart contracts will not affect other parts of the network, thereby enhancing system security. Therefore, Ethereum significantly broadens the application scope of blockchain technology by providing a powerful and flexible smart contract platform. Not only does it increase the security of the network, it also provides automated solutions for finance and other industries, promoting the development and innovation of the entire blockchain ecosystem.

1.3. Applications and Challenges

Today, digital contracts are extensively utilized across various sectors, encompassing finance, supply chain management, and beyond. For instance, regarding payments and remittances, smart contracts facilitate the automation of international transactions, minimizing both the expenses and duration of these operations. Through the employment of cryptocurrencies or stablecoins, they guarantee a swift and secure transfer of funds [7]. In addition, smart contracts improve the transparency and traceability of supply chain management, especially in the food safety and pharmaceutical industries, by recording tamper-proof data on the blockchain. They automate the execution of contract terms, such as delivery of goods, payment and quality control, not only reducing manual intervention, increasing efficiency and reducing error rates, but also preventing fraud and malicious behavior, thus improving the overall security of the supply chain.As smart contracts are used more and more frequently in various fields of social life, the conflict between them and traditional contract law has become increasingly prominent. Given that smart contracts are based on blockchain technology, their automated execution and non-temperable data characteristics makes them different from traditional contract law in some respects, which brings a series of challenges to the legal validity and application practice of smart contracts. Therefore, this article compares the differences between smart contracts and traditional contracts in the process of signing, performing, rescinding and providing remedy, and deeply explores the legal nature of smart contracts, whether they can be incorporated into the current contract law system, and whether their related legal issues can be solved within the framework of contract law, and finally gives suggestions for the development of the legal field of smart contracts.

2. Smart Contract Overview

2.1. Smart Contract Definition

As mentioned above, as the proposer of the concept of smart contracts, Nick Szabo describes smart contracts as “a computer agreement set in digital form that embeds contract terms into software code so that these terms can be automatically executed or enforced. Execution.” He believes that smart contracts can greatly improve the efficiency of contract execution and reduce the need for intermediaries [1]. Since then, with the continuous development and application of blockchain and Ethereum technologies, scholars’ definitions of smart contracts have undergone some changes. Wang Zhou et al. believe that “the term smart contract is widely used to refer to low-level code scripts that run on blockchain platforms [8].”

In addition, Jeremy M. Sklaroff also discussed the concept of smart contracts in his paper. He believes that “these contracts are decentralized agreements encoded in the form of computer code and stored on the blockchain [9].”

However, those who hold the most unique views are Wang Shuai et al. They not only provide a definition of smart contracts in a broad sense, but also provide a unique definition of smart contracts

from the field of contract law that "Smart contracts are computer protocols designed to digitally facilitate, verify, or enforce the negotiation or performance of a contract [10]." This paper favours this definition because it argues that smart contracts are also contracts in their legal nature and should be defined in the framework of contracts.

2.2. Characteristics of smart contracts compared to traditional contracts.

Smart contracts not only integrate the decentralization and security features of the blockchain, but also combine the programmability of the smart contract programming language, making the execution of the contract more efficient, transparent and secure. Compared with traditional contracts, smart contracts have a series of unique characteristics that bring new possibilities for contract execution. By comparing to traditional contracts, several salient features of smart contracts are demonstrated below.

Firstly, automated execution: One of the core features of smart contracts is their ability to automatically execute the terms of the contract without human intervention. This is achieved by encoding the terms of the contract into computer programs that run on cryptocurrency platforms such as Ethereum. When the conditions defined in the contract are met, the smart contract automatically triggers the corresponding contract behavior, such as fund transfer, service delivery, or rights transfer. This automatic execution capability significantly improves the efficiency and reliability of contract execution and reduces delays and errors during execution [11].

Secondly, disintermediation: Traditional contract execution relies on intermediaries such as banks, lawyers and arbitration institutions to verify the legality of transactions and urge the execution of contract terms. Smart contracts eliminate the need for these intermediaries by writing and executing contract code directly on the blockchain. This disintermediation not only reduces transaction costs, it also speeds up transactions and reduces the risk of fraud and intermediary failure [12].

Thirdly,immutability: In traditional contract law, contracts can be in written form or oral agreements. Although these forms can be used as valid evidence in court, they are at risk of being tampered with and forged. In contrast, smart contracts rely entirely on digital form, written and executed through computer code on a blockchain technology platform. Blockchain verifies and records transactions through a consensus mechanism among multiple nodes in the network. It records every transaction and the deployment of smart contracts. Once recorded, it cannot be deleted or modified [13].

Fourthly, transparency and anonymity: Smart contracts allow data sharing and synchronisation across multiple computers, which can be referred to as nodes. And each node keeps a full copy of the blockchain, so any operation performed and recorded on the blockchain - including the deployment and execution of smart contracts - is visible to all nodes. The transparency of smart contracts comes from this sharing and accessibility of data. At the same time, blockchain technology allows users to maintain a certain degree of anonymity while conducting transactions. Other network participants can only view the relevant terms and framework, but cannot view any personal privacy information, which reduces the possibility of information leakage and protects personal privacy.

Smart contracts provide a new contract execution mechanism by encoding contract terms into automatically executable computer programs. They utilize the distributed, non-temperable nature of blockchain technology to ensure the transparency and security of contract execution. Compared with traditional contracts, these characteristics of smart contracts give them significant advantages in improving contract execution efficiency, reducing costs, enhancing security, and protecting privacy. However, this also brings challenges to the existing contract law framework, including the legal effect of contracts, the interpretation and enforcement of contract terms, and the resolution of legal disputes.

3. The Contract Law Regulatory Path for Smart Contracts

3.1. Legal Nature of Smart Contracts

There are three main schools of thought on the legal nature of smart contracts: the computer programme doctrine, the self-help act doctrine and the contract doctrine.

3.1.1 Computer Program Doctrine

This doctrine holds that smart contract is a kind of computer program and the technical characteristics of smart contract under blockchain technology such as decentralisation, de-willfulness, non-tampering, automatic execution, etc., in fact, aim at pursuing higher efficiency and mechanical automatic execution[14] rather than the participation of the law's execution, which excludes itself from the contractual breach of contract remedies and other legal rules, making it impossible for the judicial mechanism to intervene[15]. In addition, many scholars have encountered many difficulties when trying to explain smart contract using the traditional contract law. At this time, the negation of its contractual attributes become the simplest and most direct way to solve the problem. Therefore, some scholars believe that smart contracts should be regarded as computer programmes rather than legal contracts. However, the viewpoint of "computer programme" ignores the protection of the interests of the parties in the smart contract under the blockchain technology and the fact that it contains the expression of the parties' declaration of intention, which is not conducive to the development of the judicial reform and financial innovation under the good laws and regulations.

3.1.2 The Self-help Act Doctrine

The self-help act doctrine, while recognising the legal status of smart contracts, considers them to be de facto acts rather than traditional contractual acts. Scholars in favour of this view believe that "smart contracts are only a new form of pre-emptive self-help that should not be discouraged by the legislature or the courts [16]." Based on the self-executing nature of smart contracts, scholars have defined them as a form of "self-help behaviour", which does solve the problem of obligation performance to a certain extent, but not only does it not involve the signing of smart contract, ignoring the most important declaration of the parties' intention in it, but also does not work in terms of jurisprudence because self-help behaviour is generally an emergency relief after the fact, whereas the relevant provisions of the smart contract is in favour of ex ante and there is no emergency situation.

3.1.3 Contract Doctrine

Scholars in favour of the contract theory believe that changes in digital assets resulting from smart contracts based on blockchain technology can be regarded as contracts with legal effect and can be regulated under the framework of the current contract law. They believe that the essential purpose of the two parties is to reach a transaction, while smart contracts based on blockchain technology provide a platform to adjust the economic relationship between the two parties, exchange meanings and realise the transfer of assets. In contrast to the first two doctrines, the contract doctrine recognises the legal status of smart contracts and their ability to be included in the regulation of contract law. In this paper, the contract theory is considered to be more reasonable and preferable.

When it comes to talking about contracting, the first step is to examine whether the smart contract meets the attributes of a contract in terms of both form and content. From the aspect of form, the current contract law upholds the principle of "freedom of form", and the code form of smart contracts is not prohibited by law. Although the code language is difficult to be understood by natural persons, it does not mean that the law does not recognize the formal validity of the contract carried in the code language, to take a very simple example, the form validity of a contract signed by two British people in Chinese will not be denied because the parties cannot read Chinese. Thus, it can be assumed that the smart contract meets the requirements of the law in terms of form [17].

In terms of content, there is an expression of intent in smart contracts. Generally speaking, in a smart contract, the offer is fixed in the form of code on the distributed ledger and the relevant terms and conditions are given as a reminder, while the acceptance is completed after the accepter has read

the preset terms and agreed to the content of the contract, so that both parties have made an expression of intent. Therefore, a smart contract actually satisfies the content and form elements of contract law, and it falls within the contractual [18].

3.2. Analysis of Contract Law Applicable to the Fulfilment of Smart Contracts

3.2.1 Smart Contract Formulation and Consultation

Although smart contracts can be analysed under the framework of contract law, there are some major differences in contract signing. For example, the self-executing nature of smart contracts increases the importance of the drafting phase of the contract as opposed to the execution phase. Smart contracts are more difficult to modify than traditional contracts, the coding of contracts requires a higher degree of formalisation of contractual terms and smart contracts lack the most important step of traditional contract formation - consultation. This requires that the terms of the contract be very clear and unambiguous in order to avoid surprises or disputes during execution. Contract drafters need to have some programming knowledge to ensure that the contract code accurately reflects the intent of the contract. At the same time, its lack of a traditional contract negotiation process results in a lack of personalization and flexibility in contract terms. This may make the contract not fully meets the actual needs of both parties, especially in complex business transactions, and the lack of a negotiation process may result in a contract that is not sufficiently precise or does not fully meet the interests of both parties and subsequent disputes [19].

3.2.2 Smart Contract Execution

There are some issues with smart contracts in enforcing contracts. Smart contracts can effectively automate transaction terms that can be clearly quantified, such as payment amounts and transaction quantities. However, for terms such as quality assurance or rights integrity, which requires subjective judgement, the application of smart contracts is limited. In addition, the operation of smart contracts can be affected by technical issues, such as errors in programming or external hacking, which may cause the contract not to be executed as intended. Even if the parties agree on the content of the contract, such technical obstacles may prevent the contract from being performed correctly, thus affecting the achievement of the contract's objectives. Smart contracts rely entirely on the code behind them, and if the code is not written correctly or has vulnerability, it could lead to incorrect contract execution or loss of funds [20]. This kind of problem was particularly prominent in The DAO incident in 2016, when a vulnerability in a smart contract led to the theft of millions of dollars' worth of Ethereum.In response to these problems, many scholars will consider proposing solutions from a legislative perspective or technical level, but in fact, the lack of specific criteria for testing the performance of smart contracts belongs to the problem of unclear contractual agreement in traditional contract law, and the problem of code loopholes in fact belongs to the failure to perform in traditional contract law, which should be pursued to hold the Ministry of the development of the contract or the procedure responsible. At first glance, the problems in the performance of smart contracts appear to be entirely new and require new laws or other measures to solve them, but in reality, they are merely variations of traditional problems.

3.3. Smart Contract Challenges in Termination and Modification

The central feature of smart contracts is that they cannot be altered once deployed, which contrasts with the flexibility allowed by traditional contract law. Contract law recognises the limited rationality of human beings, the incompleteness of information and the uncertainty of the matter in question and allows the parties to negotiate adjustments to the content of the contract, or even termination of the contract, in the light of changes in the matter in the course of its performance. For example, if a change in policy causes the continued performance of a contract to significantly affect the interests of one or both parties, the parties may negotiate a change in the contract. However, smart contracts seem to be inconsistent with this legal logic, as they are designed in such a way that they cannot foresee all future scenarios and are difficult to modify once deployed. The author tries to solve this

problem with the existing provisions of contract law but based on the non-modifiability and self-executing nature, it is difficult to discuss this issue in the same way as ordinary contracts. However, we can still address this challenge in the following three ways.

3.3.1 Scalable Smart Contract Design

By adopting an agent model to design scalable smart contracts, the contract logic can be updated to adapt to new laws and regulations or changes in the trading environment without changing the contract address. Although this increases the complexity of design and development, it gives the answer to balancing smart contract invariance and contract flexibility.

3.3.2 multi-signature agreement and negotiation mechanism

The flexibility of the contract can be increased by introducing multi-signature agreement, which requires both or more parties of the contract to participate in the process of confirming and executing the contract changes. This requires both parties to the contract to reserve an interface for negotiating changes in the smart contract, and when both parties reach an agreement on the changes, they will jointly confirm the changes through the multi-signature mechanism.

3.3.3 Combination of off-chain contract and on-chain execution

The smart contract is used as the on-chain execution mechanism, while the more flexible and changeable contract terms are kept off-chain. In this way, the smart contract is mainly responsible for those terms that can be automatically executed, such as payment, fund locking, etc., and the more complex and flexible parts are agreed through the off-chain contract. When there is a need to change the contract, both parties can reach a consensus through the off-chain agreement, and then update the terms of the off-chain contract referenced by the on-chain smart contract. Dual-track operation takes into account efficiency and flexibility.

3.4. Smart Contracts' Plight for Relief

In the academic community, some scholars have argued that there is no need for remedies for smart contracts based on their self-enforcing nature [21]. In practice, however, smart contracts are not omnipotent treaties, and it is impossible for them to provide for everything in advance. The automatic enforcement of smart contracts may also fail due to special circumstances, such as the accounts of the defaulters and the lack of enforceable property in their names, and the code loopholes mentioned above.Unlike traditional contracts that rely on third-party institutions such as courts and arbitration to ensure contract performance and remedies, smart contracts generally rely on the mandatory transfer of digital assets pledged by the defaulting party to achieve contract performance and remedies, and while this action protects the interests of the party in need of remedies in most cases, the fully mandatory and mechanical transfer of the assets creates other legal issues such as the emergency interruption of a car start if the the car was running at the time, that would have a high probability of causing a traffic accident. In addition, due to the anonymity of the services provided by smart contracts based on blockchain technology, the parties to the services often do not know the specific information of the other party, which is a difficulty for judicial prosecution as it is difficult to determine the identity of the parties.

This paper argues that on the platform of smart contracts, to set up an online dispute resolution mechanism, you can cooperate with the court, open a network court for mediation, and introduce an arbitration institution. The Open Baazar platform, for example, has established an arbitration mechanism that allows arbitrators to rule when disputes arise [22]. In addition to this, government agencies can be given higher authority to intervene in the blockchain, so that government agencies can not only obtain all the information and data related to the case, but also achieve the ability to force the defaulting party to fulfil its obligations and achieve relief.

4. Summary

The article supports the consideration of smart contracts as part of legally binding contracts and highlights their potential to enhance the transparency and security of transactions, while pointing out the need for the legal framework to adapt to the changes brought about by this new technology. In response to the impact of smart contracts on traditional contract law, the article offers solutions from both a legal and technical perspective, such as analysing the root causes of the problem, attempting to use existing contract law to resolve disputes under the new form, as well as scalable smart contract design and dual-tracking mechanisms that aim at maintaining the flexibility and automation advantages of smart contracts, while ensuring legal protection and freedom of contract. Although this paper presents a preliminary proposal for the integration of smart contracts and contract law, there are many unresolved issues, such as the standardisation of smart contract coding and cross-border conflict of laws. Future research could further explore these issues and consider the impact of technological advances on contract law practice. As an innovative technology, smart contracts show great potential for improving transaction efficiency and security. However, in order to give full play to its advantages, it is necessary to deepen the analysis and understanding of jurisprudence, coupled with the continuous improvement and refinement of technology, so that smart contracts can be operated in an orderly manner under the legal framework, thus ensuring the rights and interests of all transaction participants while promoting the development of the digital economy.

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