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FEATURES OF LEGAL REGULATION OF THE USE OF SMART CONTRACTS: CLASSIFICATION AND MAIN CHARACTERISTICS

CARACTERÍSTICAS DA REGULAMENTAÇÃO LEGAL DO USO DE CONTRATOS INTELIGENTES: CLASSIFICAÇÃO E PRINCIPAIS CARACTERÍSTICAS

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ABSTRACT

Objective: The article is devoted to establishing the main characteristics and classification of smart contracts. The aim of the study is to present a more complete classification of smart contracts according to various criteria.

Methods: The utilized research methods rely on the analysis of a limited number of studies selected according to specific parameters and comprehensively reviewed.

Results: The study reveals that the existing approaches to defining the characteristics and classification of smart contracts fail to fully reflect the civil law essence of smart contracts. As a result of research, it is concluded that the key characteristics of smart contracts include decentralization, peer-to-peer nature, immutability, transparency, automation, fraud protection, security, and cost-effectiveness.

Conclusion: The authors propose a classification of smart contracts by spheres of application, including smart contracts in property relations, smart contracts in finance, smart contracts in credit obligations, smart contracts in social services, and smart contracts in media and reputation management. Additionally, smart contracts are classified by the environment of their execution, the degree of anonymity, the initiation mechanism, the level of automation, and the participation of the parties.

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ISSN: **2316-753X**

Keywords: smart contract; legal status; blockchain technology; Internet platform; civil turnover; contract law.

RESUMO

Objetivo: O artigo é dedicado a estabelecer as principais características e classificação dos contratos inteligentes. O objetivo do estudo é apresentar uma classificação mais completa dos contratos inteligentes de acordo com vários critérios.

Métodos: Os métodos de pesquisa utilizados dependem da análise de um número limitado de estudos selecionados de acordo com parâmetros específicos e exaustivamente revisados.

Resultados: O estudo revela que as abordagens existentes para definir as características e a classificação dos contratos inteligentes não refletem totalmente a essência do direito civil dos contratos inteligentes. Como resultado da pesquisa, conclui-se que as principais características dos contratos inteligentes incluem descentralização, natureza peer-to-peer, imutabilidade, transparência, automação, proteção contra fraudes, segurança e custo-benefício.

Conclusão: Os autores propõem uma classificação de contratos inteligentes por esferas de aplicação, incluindo contratos inteligentes em relações imobiliárias, contratos inteligentes em finanças, contratos inteligentes em obrigações de crédito, contratos inteligentes em serviços sociais e contratos inteligentes em mídia e gestão de reputação. Além disso, os contratos inteligentes são classificados pelo ambiente de sua execução, o grau de anonimato, o mecanismo de iniciação, o nível de automação e a participação das partes.

Palavras-chave: contrato inteligente; estatuto jurídico; tecnologia blockchain; Plataforma de internet; rotatividade civil; direito contratual.

1 INTRODUCTION

For a long time, contract law has been playing an important role in the legal system because most transactions, whether for business purposes or for life needs, involve the parties concluding contracts (Kaczorowska B., 2019). Along with the constant development of digital technologies, new concepts such as blockchain, bitcoin, and smart contracts have emerged on the Internet platform. Digitalization and the rapid development of the technological capabilities of society have contributed to the introduction of smart contracts into civil circulation (Gilcrest J., Carvalho A., 2018). Smart contracts were created in the early 2000s. They were developed with the aim of making contracts more secure and reliable (Szabo N., 2016). In essence, smart contracts are programs that can automatically perform certain tasks, such as exchanging money or transferring property rights (Giuffrida I., Lederer F., Vermeys N.,

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Aprovado em: 04/10/2023
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ISSN: **2316-753X**

2017). Smart contracts aid in the digitalization of the business environment. In the next decade, we can expect an increase in the automation of contractual legal relations. Smart contracts are a relatively new concept for modern law and are fully realized in the online environment. Therefore, the identification of the main characteristics and full classification of smart contracts by various criteria will be helpful in practice to solve the issues of legislative regulation of the use of smart contracts in civil turnover (Hulicki M., 2017). Understanding the legal nature, legal conceptual foundations, essence, and technical-legal principles of smart contracts is objectively needed to improve their civil legal support in the very near future.

2 METHODS

At the basis of the study lies the analysis of studies on the features, characteristics, and classification of smart contracts. For this purpose, a database of 100 studies conducted between 2015 and 2022, posted in the public domain, and indexed in the Scopus and Web of Science (WoS) international citation databases was compiled and analyzed.

Scopus and WoS have a set of intelligent tools that make it possible to analyze the considered scientific works.

Papers for the study were selected automatically according to the following criteria:

1. The author has at least two publications on the topics of legal status, features, characteristics, and classification of smart contracts in the last 3-7 years;
2. Numerical preponderance of more than 60% of studies on legal topics in the total number of the author's publications;
3. The author's profile indicates that their publications are thematically related to legal sciences;
4. The paper was published between 2015 and 2022.

With this approach, initially, more than 100 publications were selected. The majority (34%) were published by Russian researchers, and the rest were distributed

Submetido em: 27/08/2023
Aprovado em: 04/10/2023
Avaliação: Double Blind Reviewe-
ISSN: **2316-753X**

as follows: 20% – Western Europe, 16% – India, 8% – the USA, 5% – Indonesia, 7% – Canada, 3% – Singapore, and about 1.9% – Malaysia, Iran, Africa, China, and Nigeria each. A total of 55 papers were selected and analyzed as part of the present study.

Through analyzing the research papers, we identified the main characteristics of smart contracts as highlighted by scholars in their works:

- decentralization, which is not characteristic of classical contracts (22%);
- peer-to-peer nature (20%);
- immutability, a characteristic inherent in blockchain technology, through which smart contracts operate, and not inherent in classical contracts (11%);
- transparency, a property of blockchain (10%);
- automation, a feature of blockchain (9%);
- fraud protection (9%);
- security (8.5%);
- economic efficiency (8.5%).

Based on the extracted criteria, a classification of smart contracts according to different criteria was described and the characteristic features of smart contracts were defined.

3 RESULTS

The institution of smart contracts was developed further in 2008 due to the introduction of blockchain technologies into civil turnover (Giancaspro M., 2017). Smart contracts and blockchain are two closely interconnected technologies. A smart contract is a program that is executed on the blockchain and automates the implementation of certain conditions and rules. Blockchain, on the other hand, is a distributed database that stores information about transactions and their confirmation (Rohr J. G., 2019).

Smart contracts can automate a variety of processes, such as the conclusion of transactions, payment for services, etc. They can also be used to create decentralized applications (dApps) that work without third parties and ensure security and reliability (Kirillova E. A. et al., 2019).

Submetido em: 27/08/2023
Aprovado em: 04/10/2023
Avaliação: Double Blind Reviewe-
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Blockchain provides the basis for the operation of smart contracts. It offers security and immutability of data and ensures that transactions are confirmed only after they meet certain conditions (Cannarsa M., 2018).

Smart contracts and blockchain are complementary technologies that enable more secure and efficient systems to accomplish a wide range of tasks (Mik E., 2019). Smart contracts can be created based on various programming languages such as Ethereum, Solidity, Hyperledger Fabric, and others. Automating different processes, they reduce the risks associated with the human factor, such as fraud, calculation errors, etc. Smart contracts can also be utilized to develop decentralized applications that operate without the involvement of a third party (Savelyev A., 2017).

Having examined various studies by experts in the use of smart contracts (Chetrit N. et al., 2020), we can distinguish the following specific features:

- any smart contract consists of "if..., then..." conditions, for example, participants bet on a sports team winning, and the smart contract will distribute the revenues of the participants in the deal according to pre-established conditions (Kaulartz M., 2016);

- the rules of smart contracts cannot be changed once the terms have been agreed upon (Chub D. V., 2019);

- a smart contract is created with the help of a programming language; therefore, ambiguities are eliminated and the rules of a smart contract are limited to the logic of the program code (Möslein F., 2019);

- the verification mechanism of smart contract execution ensures the transparency of transactions in terms of validation of correctness, keeping the data closed to third parties (Drummer D., Neumann D., 2020).

In summary, a smart contract can be defined as any digital agreement that satisfies the following conditions:

- is written in computer code (hence part of the software);

- runs on a blockchain or similar decentralized registry technology (blockchains);

- is automatically executed without the involvement of a human.

The algorithm of a smart contract is described in the following steps (Table 1).

Table 1. Algorithm of operation of a smart contract

Submetido em: 27/08/2023
Aprovado em: 04/10/2023
Avaliação: Double Blind Reviewe-
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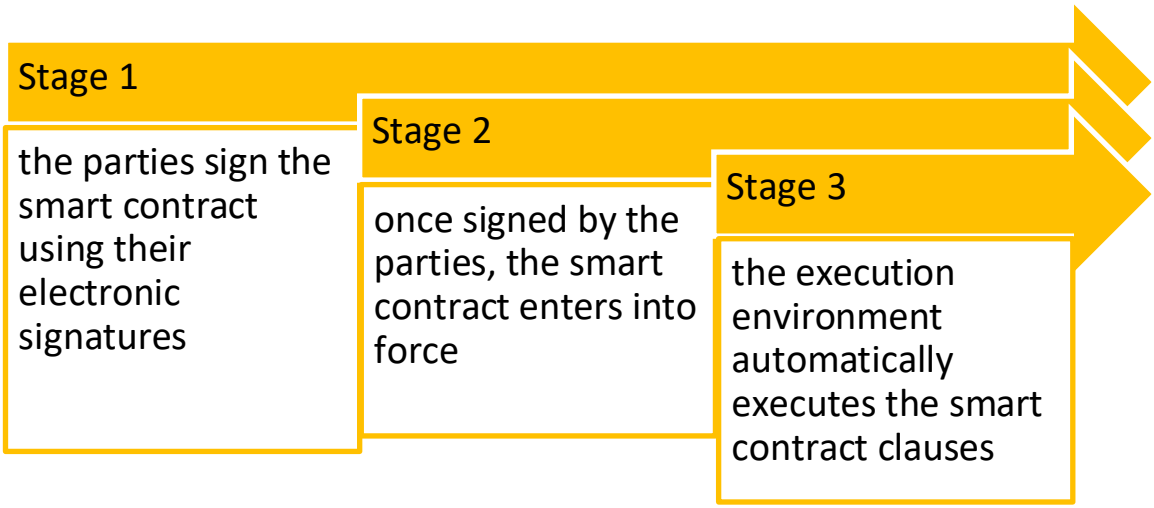

The use of smart contracts has greatly grown in popularity in recent years due to the development of blockchain and cryptocurrency technologies. Smart contracts have become popular in various fields such as finance, real estate, healthcare, and more (Kaulartz M., Heckmann J., 2016).

To distinguish the types of smart contracts by spheres of application, we need to refer to studies in narrow areas, such as finance, banking, and tax law, and identify the spheres where smart contracts are most promisingly used. Based on the conducted systematization the following types of smart contracts can be distinguished (Table 2).

Table 2. Types of smart contracts by application spheres

Sphere of application	Researchers who distinguished the sphere of application
Control over property relations – possession and conduct of transactions with digital assets, including cryptocurrencies and tokens (Bitcoin, ETN, XRP, and others)	Lauslahti K., Mattila J., Seppala T. (2017); Rohr J. G. (2019); Cannarsa M. (2018); Waltl B., Sillaber C., Gallersdörfer U., Matthes F. (2019); Lauslahti K., Mattila J., Hukkinen T., Seppälä T. (2018); Cornelius K. B. (2018); Chetrit N., Danor M., Shavit A., Yona B., Greenbaum D. (2020); Djurovic M., Janssen A. (2018); Drummer D., Neumann D. (2020)
Financial services – trade finance, stock trading, participation in auctions, etc.	Jaccard G. (2018); Borselli A. (2020); Vigliotti M. G. (2021); Ryan P. A. (2017); Kraus D., Obrist T., Hari O. (2019); Sava N. A., Dragoș D. (2022); Gilcrest J., Carvalho A. (2018); Ferreira A. (2021)

Submetido em: 27/08/2023
Aprovado em: 04/10/2023
Avaliação: Double Blind Reviewe-
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Credit obligations – fulfillment of obligations under various forms of bank credit products at the time of occurrence of events	Eschenbruch K. (2018); Savelyev A. (2017); Herian R. (2021); Patel D., Shah K., Shanbhag S., Mistry V. (2018); Fries M. (2018); Goldenfein J., Leiter A. (2018); Heckelmann M. (2018); Kaczorowska B. (2019)
Social services – voting procedures, elections, insurance processes	Giuffrida I., Lederer F., Vermeys N. (2017); Cutts T. (2019); Chub D. V. (2019); Hoffmann T. (2019); Kaulartz M. (2016); Shah A., Alsadiey J. (2022); Hulicki M. (2017); Lamb K. (2018); Kasprzyk K. (2018); Liu Y., Huang J. (2019)
Organization of management of product delivery and storage	Rühl G. (2021); Woebbeking M. K. (2019); Filatova N. (2020); Turitsyn A. V., Melikhov V. M., Uskova M. S., Turitsyn D. A. (2019); Temte M. N. (2019); Zavyalova E. B., Shumskaia E. I., Kuzmin M. D. (2020); Dell'Erba M. (2018); Bocek T., Stiller B. (2017)
Media With the advent of NFT art, many authors have begun to use digital reality to share and sell their works (music, videos, photos, graphics, etc.)	Liu Y., Huang J. (2019); Hohn-Hein N., Barth G. (2018); Kaulartz M. (2019); Kaulartz M., Heckmann J. (2016); Möslein F. (2019); Möslein F. (2019); Szabo N. (2016); Tapscott D., Tapscott A. (2016)
Business reputation management – ratings and reviews Smart contracts provide reliable and independent ratings of companies (movies, products, people, etc.)	Gilcrest J., Carvalho A. (2018); Kirillova E. A., Bogdan V. V., Lagutin I. B., Gorevoy E. D. (2019); De Caria R. (2018); Giancaspro M. (2017); Schmitz A., Rule C. (2019)

Smart contracts are already widely used in civil turnover, and many transactions are now performed with the help of smart contracts. However, legal regulation in this area is still under development (Ryan P. A., 2017). Relevant laws regulating the use of smart contracts are now being developed at the international level.

Such legislation, for example, may impose requirements for verification of the smart contract code, establish rules for dispute resolution, etc. Legal acts are not the only means of regulating smart contracts. There are various approaches in the sphere of regulation of legal relations involving smart contracts, such as:

Standardization. The development of standards and protocols for smart contracts helps to ensure their compatibility and uniformity. For example, Ethereum uses the ERC-20 standard to create tokens, and Solidity is the programming language used to write smart contracts on Ethereum (Vigliotti M. G., 2021; Rühl G., 2021).

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Self-regulation. Some organizations, such as R3, develop standards and guidelines for smart contracts that can be adopted by the community of developers (Tapscott D., Tapscott A., 2016; Cutts T., 2019).

Case law. Court decisions related to the use of smart contracts can serve as guidelines for other market participants. For example, the U.S. Supreme Court's decision in the case of eBay v. MercExchange determined that smart contracts are not ordinary contracts and should be subject to the rules of good faith (Dell'Erba M., 2018; Hoffmann T, 2019).

Cryptocurrency exchanges. Some cryptocurrency exchanges, such as Coinbase, provide storage and trading services for cryptocurrencies but also offer the opportunity to use smart contracts for transactions (Temte M. N., 2019; Shah A., Alsadiey J., 2022).

Security standards. Ensuring the security of smart contracts is an important aspect of their regulation. The existing security standards, such as ERC-677, provide protection against buffer overflow attacks (Hohn-Hein N., Barth G., 2018; Lamb K., 2018).

Outsourcing. Some companies provide services to create and maintain smart contracts. This helps to reduce the risks associated with the development and use of smart contracts (Woebbeking M. K., 2019; Kasprzyk K., 2018).

Smart contracts are a new phenomenon with special characteristics, so it is not feasible to regulate legal relations in the sphere of smart contracts use with existing legal acts. This raises the need to develop legal norms that account for the fundamental features of smart contracts.

4 DISCUSSION

Of scientific interest is the classification of smart contracts by initiation mechanism, which is supported by some experts (Patel D., Shah K., Shanbhag S., & Mistry V., 2018). By the initiation mechanism, smart contracts are categorized into restricted and preset smart contracts. As an example, we can mention the preset smart contracts on Waves and Bitshares platforms. Waves is a blockchain platform that uses Waves technology to create smart contracts. It enables developers to create smart contracts using the Wavescript programming language. The platform also supports

Submetido em: 27/08/2023
Aprovado em: 04/10/2023
Avaliação: Double Blind Reviewe-
ISSN: **2316-753X**

Waves cryptocurrency, which is used to pay fees for smart contracts and other transactions (Fries M., 2018).

Bitshares is another blockchain platform that also allows the creation of smart contracts. This platform employs the Bitcore programming language to develop smart contracts and supports the BTS token, which is used to pay for transactions and commissions. Bitshares also provides the opportunity to create decentralized applications and work with cryptocurrency assets (Liu Y., Huang J., 2019).

In limited smart contracts, transactions are performed with no possibility to add new features and modifications (Goldenfein J., Leiter A., 2018).

Some researchers emphasize the importance of classifying smart contracts according to their execution environment, distinguishing between centralized and decentralized contracts (Djurovic M., Janssen A., 2018). Centralized and decentralized smart contracts refer to different models of contract management and execution in blockchain networks. Centralized smart contracts are executed on a node or server managed by a third party (Ferreira A., 2021). These contracts can only be created and modified through that node or server, and contract execution typically occurs by interacting with that node or server.

In contrast, decentralized smart contracts do not require a centralized server for their execution. Instead, a decentralized smart contract is executed through communication between network participants who use their private keys to sign transactions (Schmitz A., Rule C., 2019).

Some smart contracts can be called both centralized and decentralized depending on their features (De Caria R., 2018). For example, a contract that runs on a node managed by a company can be decentralized if network participants can sign transactions without having to interact with the node (Lauslahti K., Mattila J., Seppala T., 2017).

According to the criterion of anonymity, smart contracts are categorized into confidential, partially open, and fully open (Cornelius K. B., 2018).

Confidential smart contracts are designed for closed networks where access to information is limited. Such contracts are typically used to store sensitive data such as passwords or access keys.

Partially open and fully open smart contracts, on the contrary, are designed to be used in open networks where information is available to all participants

Submetido em: 27/08/2023
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ISSN: **2316-753X**

(Eschenbruch K., Gerstberger R., 2018). Such contracts can be used for financial transactions, cryptocurrency exchange, and other tasks.

Another classification of smart contracts presented by researchers is the differentiation of contracts by the degree of automation into fully automated and partially automated smart contracts (Lauslahti K. et al., 2018).

Fully automated smart contracts are executed automatically without human presence. They can be used to perform complex tasks such as investment management, business process automation, and more (Herian R. 2021).

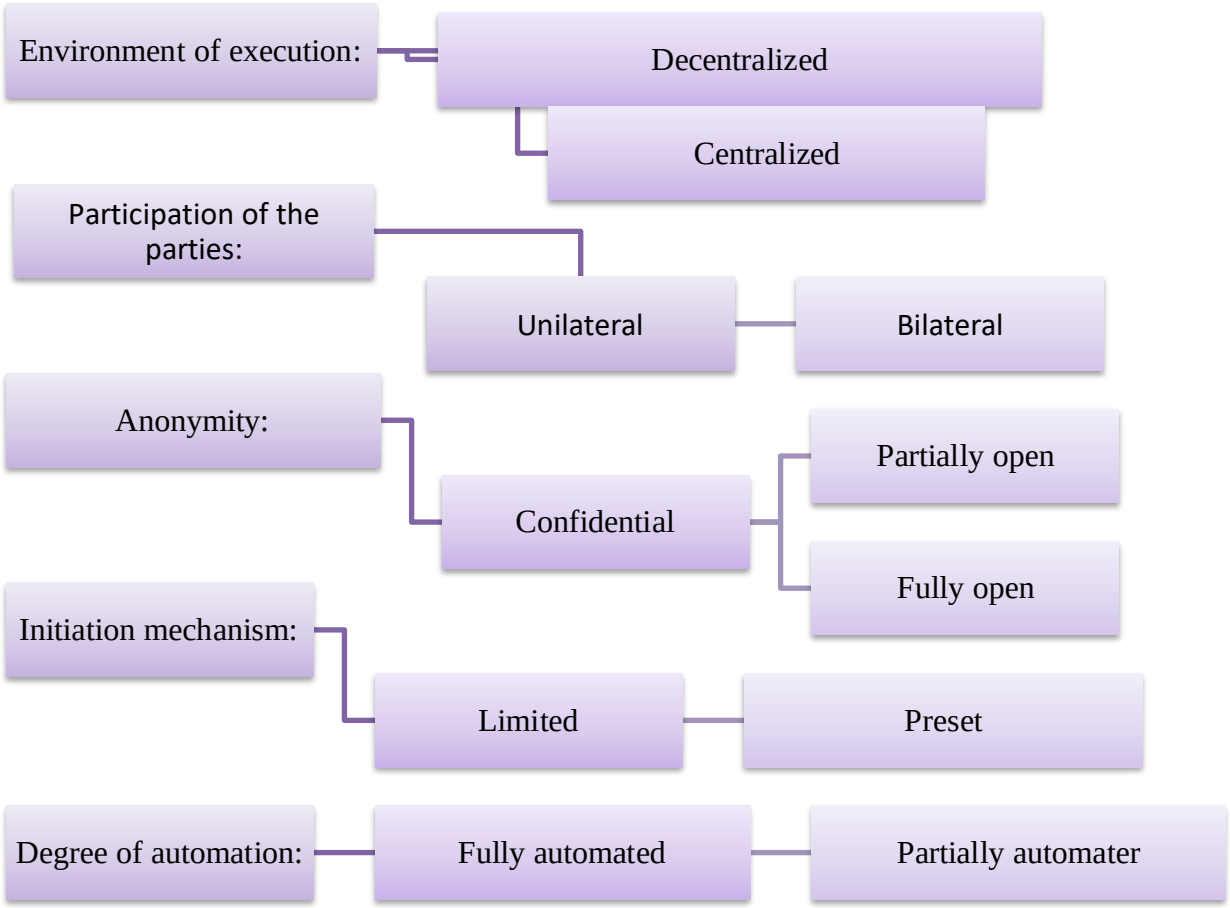
Partially automated smart contracts require a human to perform some of the tasks. These can be used to automate simple tasks such as calendar management or reminders (Heckelmann M., 2018).

It has also been noted in studies that smart contracts can be unilateral or bilateral (Waltl B. et al., 2019). Unilateral smart contracts are those where only one party can initiate the fulfillment of the contract, while in bilateral smart contracts, both parties are able to do so.

The conducted detailed analysis of studies on the differentiation of smart contracts by parameters suggests the following types of smart contracts (Table 3).

Table 3. Types of smart contracts by the identified parameters

Submetido em: 27/08/2023
Aprovado em: 04/10/2023
Avaliação: Double Blind Reviewe-
ISSN: **2316-753X**



There are plenty of studies examining the key characteristics of smart contracts. Through a comparative analysis of classical and smart contracts, researchers have identified an entire range of features exclusive to smart contracts (Kraus D. et al., 2019; Jaccard G., 2018; Borselli A., 2020). The main characteristics of smart contracts are their decentralized and peer-to-peer nature and immutability.

Describing the decentralized nature of smart contracts, experts note that once launched and executed, smart contracts and the original participants who launched them need no further interaction (Turitsyn A. V. et al., 2019; Sava N.A., Dragoș D., 2022). The distinctive feature of blockchain is that information is stored in a decentralized manner rather than controlled by some specific agent and is managed by all participants in the system for the sake of precision and transparency (Möslein F., 2019). Furthermore, smart contracts are decentralized by virtue of the fact that they are based on a decentralized network with blockchains, where publicly available data does not exist on a single server, but is shared, distributed, and executed

Submetido em: 27/08/2023
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independently, so smart contracts cannot be controlled by a single party (Kaulartz M., 2019).

The next characteristic of smart contracts emphasized by researchers is their peer-to-peer nature. Peer-to-peer means that data in a smart contract is written to blockchains through a mechanism of consensus among all while minimizing the involvement of an intermediary (Liu Y., Huang J., 2019).

Another characteristic of smart contracts unanimously agreed upon by researchers is immutability, which means that once information is added to an existing data structure it cannot be changed or deleted (Zavyalova E. B. et al., 2020).

Drawing on the conducted analysis of studies, we can distinguish additional characteristics of smart contracts, which include:

- Transparency: smart contracts are stored in a distributed database that cannot be changed once the contract has been created. This guarantees transparency and reliability of contract execution. Smart contracts are easily auditable and can be verified by a third party, which reinforces the credibility of the contract (Gilcrest J., Carvalho A., 2018).

- Automation: smart contracts can automatically fulfill the contract terms without a third party. This reduces the time and cost of contract conclusion and execution.

- Fraud protection: smart contracts ensure that contract terms are automatically enforced and prevent fraud or deception.

- Security: smart contracts employ cryptographic techniques to ensure the security of data storage and transmission. In addition, they can be customized to protect against attacks and hacking.

- Cost-effectiveness: smart contracts reduce contracting costs and simplify the contract execution process, which can translate into higher economic efficiency.

Smart contracts possess the characteristics of blockchain technology, making them different from, and to some extent superior to, traditional contracts in the following key respects.

Firstly, smart contracts are executed without intermediaries, and removing the intermediary reduces the total cost of contract fulfillment (Bocek T., Stiller B., 2017). The process of confirming and executing a contract is also accelerated as users

Submetido em: 27/08/2023
Aprovado em: 04/10/2023
Avaliação: Double Blind Reviewe-
ISSN: **2316-753X**

interact with each other directly. In addition, smart contracts eliminate common reactions such as suspending transactions, requesting reimbursement, or contacting intermediaries (Filatova N., 2020).

Secondly, the terms of the contract, once programmed into the system, cannot be modified. Furthermore, intervention in the smart contract is minimal, except for the coding phase by programmers. Thus, users avoid the risk of changes to the content of the contract. The data on the blockchain is time-stamped and cannot be replaced, so even when new versions of the contract are updated, the old version is still saved to ensure the accuracy and transparency of the process.

Thirdly, smart contracts exist in the blockchain system, so the risk of a contract getting lost is ruled out. Every device connected to the network has a copy of the contract, and the data is forever stored on the blockchain.

6 CONCLUSION

A smart contract is a digital agreement that is written in software code, runs on blockchain or similar decentralized registry technologies (blockchains), and is automatically executed without human involvement.

Smart contracts and blockchain are complementary technologies that provide more secure and efficient systems to accomplish a variety of tasks. Smart contracts have the characteristics of blockchain technology, making smart contracts different from, and to some extent superior to, traditional contracts in the following key respects. Firstly, smart contracts are executed without intermediaries, and eliminating the intermediary reduces the total cost of executing the contract. Secondly, the terms of the contract, once encoded in the system, cannot be changed. Finally, smart contracts exist in the blockchain system, so there is no risk of a contract being lost.

The essential characteristics of smart contracts include decentralization, peer-to-peer nature, immutability, transparency, automation, fraud protection, security, and cost-effectiveness.

The following types of smart contracts are distinguished according to their spheres of application:

Submetido em: 27/08/2023
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ISSN: **2316-753X**

- smart contracts in property legal relations;
- smart contracts in finance;
- smart contracts in credit obligations;
- smart contracts in social services;
- smart contracts in media and reputation management.

Depending on their parameters, smart contracts can be classified into the following categories:

By the environment of execution: decentralized, centralized.

By anonymity: confidential, partially open, fully open.

By initiation mechanism: restricted, preset.

By degree of automation: fully automated, partially automated.

By participation of the parties: unilateral, bilateral.

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