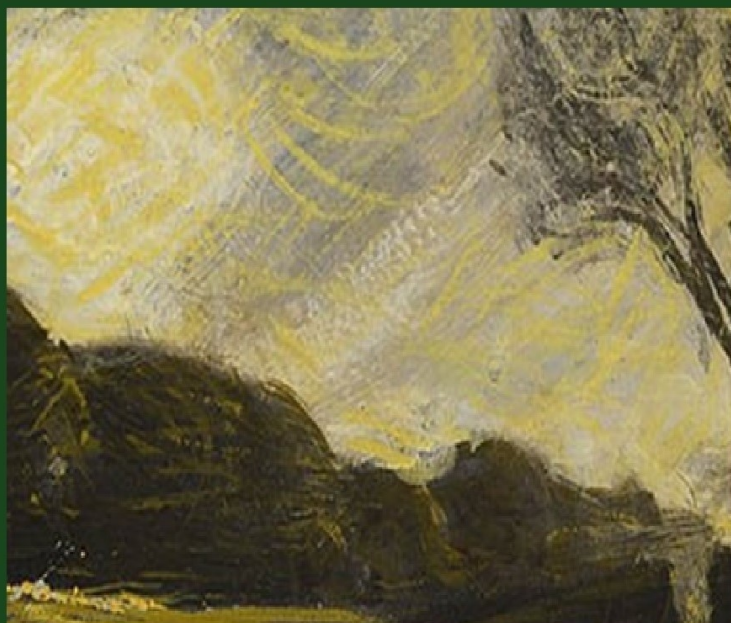


The Italian Law Journal



Vol. 08 No. 01 (2022)



EDIZIONI SCIENTIFICHE ITALIANE

www.theitalianlawjournal.it

THE ITALIAN LAW JOURNAL

An International Forum for the Critique of Italian Law

Vol. 08 – No. 01 (2022)

www.theitalianlawjournal.it

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Smart Contracts Operating on Blockchain: Advantages and Disadvantages

Ettore William Di Mauro*

Abstract

Moving on from the current national and transnational legal framework, the article will attempt to analyse the potential and critical issues arising from the application of blockchain and smart contracts to legal relations, especially for the protection of the so-called weak contracting party. The need to identify which rules to adopt implies a fundamental choice between the options of (a) considering smart contracts not only as an advanced technological tool but also as a means for carrying out the activity that must in any case be traced back to the person who benefits from and answers for it, and (b) the science fiction like scenario, but perhaps not that much, of enhancing the ability of smart contracts to make choices and therefore to be responsible for the activity performed.

I. Blockchain: Supporting Technology

The inspiration for smart contracts¹ is rooted in vending machines. Smart contracts are by no means a recent development² in that as far back as the late 1990s they began to spread rapidly in the United States with the advent of a supporting technology based on shared data ledgers: blockchain.³

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¹ The term 'smart contract' was coined by N. Szabo, 'Smart Contracts: Building Blocks for Digital Markets', available at <https://tinyurl.com/muwd5jpc> (last visited 30 June 2022), defining the new phenomenon as 'a set of promises, including protocols within which the parties perform on these promises' and recognising in the vending machine the precursor of the automatic contract; R. De Caria, 'The legal meaning of smart contracts' *European Review of Private Law*, 735 (2019).

² F. Di Ciommo, 'Smart contract e (non-)diritto: il caso dei mercati finanziari' *Nuovo diritto civile*, 257 (2019), recalls that, as Nick Szabo – who coined the expression 'smart contract' – made clear, he was inspired by vending machines for their invention. According to J.G. Landels, *Engineering in the ancient world* (Berkeley: Constable, 1978), 203, the idea thereof was conceived in even earlier times by a Greek mathematician.

³ A. Cinque, 'Gli "smart contract" nell'ambito del "FinTech" e dell'"InsurTech"' *Jus Civile*, 187 (2021); F. Bruschi, 'Le applicazioni delle nuove tecnologie: criptovalute, "blockchain" e "smart contract"' *Il Diritto industriale*, 162 (2020); I. Ferlito, "'Smart Contract". Automazione contrattuale ed etica dell'algoritmo' *Comparazione e diritto civile*, 661 (2020); P. Sanz Bayón, 'Key Legal Issues Surrounding Smart Contract Applications' *KLRI Journal of Law and Legislation*, 63 (2019); F. Scutiero, 'Smart contract e sistema di diritto, un connubio tutta da definire' *Il Foro napoletano*, 113 (2019); K. Kelly, *Out of control. La nuova tecnologia delle macchine, dei sistemi sociali e del mondo dell'economia* (Milan: Apogeo, 1996), 6; G. Rinaldi, 'Smart contract: meccanizzazione del contratto nel paradigma della blockchain', in G. Alpa ed, *Diritto ed intelligenza artificiale* (Pisa: Pacini giuridica, 2020), 343; J. Feliu Rey, 'Smart Contract Concepto,

The purpose of blockchain technology is to store and manage transactions by creating a database that is distributed to users of a network.⁴ In other words, the blockchain is a shared⁵ public ledger that can automatically update itself on each of the nodes in the chain, which are in fact computers. This ledger is made up of blocks, each of which represents a number of transactions and the source and time of execution of which are permanently recorded in an inalterable form using asymmetric key cryptography⁶ and timestamping.

ecosistema y principales cuestiones de Derecho privado' *La Ley mercantil*, 1 (2018); M. Knecht, 'Mandala: A Smart Contract Programming Language', available at academia.edu (2021); M. Giuliano, 'La blockchain e gli smart contracts nell'innovazione del diritto nel terzo millennio' *Diritto dell'informazione e dell'informatica*, 989 (2018); F. Faini, 'Blockchain e diritto: la "catena del valore" tra documenti informatici, smart contracts e data protection' *Responsabilità civile e previdenza*, 297 (2020); G. Pascuzzi, *Il diritto dell'era digitale* (Bologna: il Mulino, 2002), 61-66; A. Palladino, 'Dall'homo loquens all'homo smart: la contrattualistica del terzo millennio' *De Iustitia*, 90 (2020); K. Werbach and N. Cornell, 'Contracts ex machina' *Duke Law Journal*, 314 (2017); F. Delfini, 'Blockchain, Smart Contracts e innovazione tecnologica: l'informatica e il diritto dei contratti' *Rivista di diritto privato*, 167 (2019); C. Pernice, 'Smart contract e automazione contrattuale, potenzialità dei rischi della negoziazione algoritmica nell'era digitale' *Diritto del mercato assicurativo e finanziario*, 117 (2019); G. Lemme, 'Gli smart contracts e le tre leggi della robotica' *Analisi giuridica dell'economia*, 133 (2019); A.U. Janssen and F.P. Patti, 'Demistificare gli smart contracts' *Osservatorio del diritto civile e commerciale*, 32 (2020); E. Giorgini, 'Algorithms and Law' *The Italian Law Journal*, 131 (2019); A. Nuzzo, 'Algoritmi e potere' *Analisi giuridica dell'economia*, 39 (2019); L. Avitabile, 'Il diritto davanti all'algoritmo' *Rivista italiana per le scienze giuridiche*, 315 (2017); A. Cinque, 'Gli "smart contract"' n 3 above; F. Bruschi, 'Le applicazioni delle nuove tecnologie: criptovalute, "blockchain" e "smart contract"' *Il Diritto industriale*, 162 (2020).

⁴ L. Parola et al eds, 'Blockchain e smart contract: questioni giuridiche aperte' *Contratti*, 681 (2018); M.L. Perugini and P. Dal Checco, 'Introduzione agli smart contracts', available at papers.ssrn.com (2016); M. Giaccaglia, 'Considerazioni su blockchain e smart contracts (oltre le criptovalute)' *Contratto e impresa*, 941 (2019); G. Rinaldi, 'Smart contract' n 3 above, 347; R. De Caria, 'The legal meaning of Smart Contracts' n 1 above, 732-733, defines blockchain as 'a type of database that takes a number of records and puts them in a block (rather like collating them on to a single sheet of paper). Each block is then 'chained' to the next block, using a cryptographic signature. This allows block chains to be used like a ledger, which can be shared and corroborated by anyone with the appropriate permissions'; K. Werbach and N. Cornell, 'Contracts ex machina' n 3 above, 324; P. Cuccuru, 'Blockchain ed automazione contrattuale. Riflessioni sugli smart contract' *Nuova giurisprudenza civile commentata*, 107 (2017); F. Faini, 'Blockchain e diritto' n 3 above, 299; M. Manente, 'Blockchain: la pretesa di sostituire il notaio' *Notariato*, 211 (2016).

⁵ Distribution of a database to users of a network is the distinctive feature of distributed ledger technology (DLT), of which the blockchain is the best-known example. Distribution of operation of a database contrasts, as a concept, with the traditional logic of centralised data management (eg at banks and financial institutions for financial data and public bodies for personal data, etc) involving data that is controlled by one (single and superior) central authority. There is no hierarchy in DLT because all of the network users are on the same level and can only act with the consent of the majority.

⁶ With asymmetric cryptography, each user has two keys (a public one and a private one) that are uniquely related. The private key is kept secret by its owner, while the public one, which is generated by the private key, is made available to the other party. The private key is required in order to decrypt the message that has been encrypted with the public key. This technical encrypting mechanism underpins the digital signature. The public key can be shared openly, eg as a result of it being sent along the network to someone else. But whilst it can encrypt a message, it cannot decodify it. Only the corresponding private key can decodify or release the hold on messages codified with the public key, hence the requirement for secrecy.

Each block is irreversibly linked to the previous one using a particular logarithmic operation called a hash function, which forms the chain of blocks – ie the blockchain – that all of the nodes on the network have access to and can inspect. Before being added to the chain, each block is checked, validated and encrypted by a certain number of nodes, which are called miners, using a complex mathematical process.⁷

The blockchain means that the data relating to the transactions that have been recorded on a network can be verified, approved and archived on all of the nodes of that network, without a third party or central authority having to be involved.

The absence of a centralised control system could give rise to the risk of double spending, ie the same virtual resources being used for a number of transactions. The solution adopted is to have not one single platform but blocks of shared recording. Once executed, the transaction becomes permanent and cannot be altered unless there is a new and opposite transaction and agreement by all of the enabled nodes or the majority of them, which is difficult to achieve.

Smart contracts are widely used on this technological platform.

However, it should be clarified that the relationship between smart contracts and blockchain is not inseparable, ie smart contracts can work regardless of blockchain.

It was noted that *'what gets bundled up as blockchain technologies, smart contracts, encryption and distributed ledger, are separate concepts'*.⁸ The three may be implemented together, but they do not need to be.

An automated recurring payment that someone sets up with a bank is an example of a smart contract. Blockchain is not needed to gain the benefits from smart contracts, because the latter can be set up on a centralised system, a bank's system or a platform dedicated to smart contracts used by individuals.⁹

Despite their independence, smart contracts find fertile ground in blockchain

Cf M. Giuliano, 'La blockchain' n 3 above, 999-1000.

⁷ The hash is the 'chain' that links the individual blocks by means of a digital mechanism that is used in order to compress data in a specific format of certain length. The hash is a sequence of letters and numbers obtained by using a particular calculation algorithm to the sequence of bits that form the file or message. All the algorithm does is sequentially scan, one after another, all of the bytes that make up the file and, step by step, extract a series of 'intermediate hashes', each of which depends on the previous one, producing the definitive hash once the scanning is complete. Each step in the processing is influenced by the previous steps and establishes the status of the subsequent ones. This means that simply by modifying just one bit of the whole file alone, a different hash is obtained. To establish whether a message has been modified, all that is required is to see if the hashes of the two messages are the same. Another important feature of the hash is that it is impossible to trace back to the original message. The algorithm is designed to ensure that no one can work out what generated a certain hash. In the blockchain, the hash is used to create a link between each specific block. This is done by writing the hash of every previous block in the next block along the chain. When a block is created, a hash of data is created within it, and the hash that is created includes the hash of the previous block.

⁸ H. Halaburda, 'Blockchain revolution without the blockchain', available at <https://tinyurl.com/2eycn233> (last visited 30 June 2022).

⁹ *ibid* 5.

not only for simple operations, such as the transfer of virtual currency from one person to another, but also for structurally more complex operations, such as the transfer of a virtual good (which nothing prohibits being the digital representation of a tangible good) introduced into the system against the transfer of a price.

In these cases, the transactions executed by the smart contracts form the blocks of the blockchain structure.

But first things first.

II. The Smart Contract Protocol

In spite of how fluid the subject is, the idea of this present work is to seek to reconstruct the advantages and disadvantages of this new technology within the Italian legal system in order to establish whether it is possible to consider the notion of contract in the legal sense as still very much alive or whether by contrast that notion is to be treated as outdated in view of the application of such technologies in everyday life.

Starting from the provisions of the so-called Simplification Decree of 2018, Italian law has sought to give a legal definition of smart contract. However, the legislation in question has chosen to regulate only smart contracts operating on blockchain, thus recognising only some of their potential.

It is common ground that smart contracts mean computer protocols whereby, once a pre-established condition that can be checked by computer has been satisfied, the system automatically executes a certain task.¹⁰

An example is a sale with reservation of title. Where payment of the price is not recorded, title is automatically transferred back to the seller in execution of the setting of the algorithm, thereby avoiding the time and cost of court proceedings.

The contractual terms are converted into computer code and put on a logical ledger based on the 'if-then' dual concept, pursuant to which where a certain event takes place ('if') it has the digitally related effect ('then'), which might be

¹⁰ C.D. Clack et al, 'Smart contract templates: foundations, design landscape and research directions', (2021), available at *researchgate.net*, define smart contracts as 'an automatable and enforceable agreement. Automatable by computer, although some parts may require human input and control. Enforceable either by legal enforcement of rights and obligations or via tamper-proof execution of computer'; K. Werbach and N. Cornell, *Contracts ex machina* n 4 above, 338. There are many definitions given by American authors. Just to name a few: R. O'Shields, 'Smart contracts: legal agreements for the blockchain' *North Carolina Banking Institute*, 179 (2017), defines it as 'self-executing electronic instructions drafted in computer code'; T. Hingley, 'A smart new world: blockchain and smart contracts', (2021), available at <https://tinyurl.com/ym9rsjvp> (last visited 30 June 2022), as 'a piece of computer code that is capable of monitoring, executing and enforcing an agreement' (last visited 30 June 2022); G. Jaccard, 'Smart contracts and the role of law', available at *papers.ssrn.com*, (2021) as 'a software, with which computer code binds two, or multitude, of parties in view of the execution of predefined effects, and that is stored on a distributed ledger'; L.W. Cong and Z. He, 'Blockchain disruption and smart contracts', available at *papers.ssrn.com*, (2021) as 'digital contracts allowing terms contingent on decentralized consensus that are self-enforcing and tamperproof through automated execution'.

performance of the clauses agreed upon or adjustment of the payment or service in line with events that have occurred in the meantime.¹¹

Automation can be total or partial,¹² and the power to choose the algorithm, the content and the system used to establish that the pre-established conditions have been met is also liable to change.

In the case of a smart contract operating on blockchain, the input (the ‘if’) can be based on internal elements of the contract (eg a deadline) or elements outside the contract (eg the price of the goods), and can concern data from public or institutional sources or data which call for an extended system of confirmation: in the former case, the code will result in this check being carried out; in the latter case, checks to establish that the event has taken place will require help from an ‘oracle’,¹³ a platform that ‘interrogates’ the network on the condition to be checked and provides confirmation when a certain number of positive responses has been reached.¹⁴ In other words, it is a program outside the blockchain that links the network to reality.

An example can better clarify how smart contracts work on the blockchain platform. Let’s take the sale of a licence. Suppose A creates a smart contract to which he annexes information x (the licence), programming so that the licence is transferred once €y has been paid.¹⁵ The smart contract is launched by A into the blockchain. If B wants to purchase the licence, he simply has to interact with the protocol created by A and transfer €y. Once the conditions of the exchange have been satisfied, the algorithm releases the licence to B and transfers the money to A.¹⁶ These movements will be recorded and shared on all nodes of the chain, which will be able to preserve their history and the origin of the licence.

¹¹ C. Pernice, ‘Smart contract’ n 3 above, 119, states that, once inserted in the blockchain, the smart contract works autonomously and becomes unstoppable. The implementation of the agreement is beyond the control of man who cannot interrupt performance.

¹² The parties can decide whether to entrust all or part of the execution to the algorithm.

¹³ P. Cuccuru, ‘Blockchain’ n 4 above, 111, describes oracles such as blockchain-independent programs that monitor external data the decentralised system, such as share prices indices or the seller database, and communicate to the linked smart contracts the fulfilment of relevant conditions; L. Piatti, ‘Dal Codice civile al codice binario: blockchain e smart contracts’ *Cyberspazio e diritto*, 334 (2016); F. Scutiero, ‘Smart contract’ n 3 above, 122.

¹⁴ C. Pernice, ‘Smart contract e automazione contrattuale’ n 3 above, 119.

¹⁵ According to M.L. Perugini and P. Dal Checco, ‘Introduzione agli smart contract’ n 4 above, 10, the use of blockchain functions imposes some technical limits: indirect electronic commerce services cannot be performed by computer. All clauses relating to goods or services which, although purchased online, have a tangible consistency or must be performed in the material world are excluded from the application such as, for example, the delivery of a book or the cleaning service of an office or a restaurant; P. Cuccuru, ‘Blockchain’ n 4 above, 108, is of a different opinion. He believes that any type of information can be represented digitally, inserted and stored in a blockchain: intangible assets, rights, personal data, licences, wills and company financial statements.

¹⁶ C. Pernice, ‘Smart contract e automazione contrattuale’ n 3 above, 120, describes another example. Let’s imagine that a web marketing agency asks some sponsors to finance their video by guaranteeing a certain number of views in a given time. In this case, a smart contract will be created with an oracle that will have the task of communicating the number of views on YouTube.

This mechanism can also be used in the supply and payment for electricity and in the use of musical content. In the first scenario, the reading on the electricity meter, which, in this case, is the oracle that links the code to external reality, results in an accurate bill being issued and payment being made promptly. In the second scenario, the users of a musical platform (eg UjoMusic) can listen to music and pay the artists directly, without having to go through an intermediary.¹⁷

The fact that a series of conditions is established, with the steps that each party is required to take being set out in detail once those conditions are met, means that in performing the contract, an immediate and automatic response is obtained from the system, without any kind of assessment¹⁸ or intermediation.

This description seems to limit smart contracts to mere computer programs that execute performance already agreed in a pre-existing contract and that have little to do with the creation of the contract itself. However, it is necessary to verify whether it is possible to consider smart contracts as something more than that and give them legal relevance for the purposes of the formation of contracts.¹⁹

III. Attempts at Classification

Before embarking on an analysis of the regulatory framework, Italian legal scholars have long debated the legal nature of smart contracts, regardless of whether or not they are used on blockchain platforms.

The impact of information technology on the world of trade has led some in the academic legal world to the conclusion that what we are in fact witnessing here is the decline of the notion of agreement, in the sense that reciprocal dialogue between the parties is gradually disappearing and being replaced by substitutes for linguistic and verbal communication or by a simple exchange of payments and services, to the extent that the contract itself can be broken down into a combination of two unilateral steps, producing an '*exchange without agreement*'.²⁰

¹⁷ L. Parola et al, 'Blockchain e smart contract: questioni giuridiche aperte' n 4 above, 685.

¹⁸ F. Scutiero, 'Smart contract e sistema di diritto' n 3 above, 123.

¹⁹ S. Orlando, 'Profili definitivi degli "smart contracts"', in R. Clarizia ed, *Internet. Contratto e persona, Quale futuro?* (Pisa: Pacini editore, 2021), 48.

²⁰ N. Irti, *Norma e luoghi. Problemi di geo-diritto* (Roma-Bari: Editori Laterza, 2006), 182, specifies that 'the decline of the agreement, resulting from the crisis of word and dialogue, reduces the contract to a combination of two unilateral acts: lawful acts, of expounding and preferring, requiring only the referability to an author and the natural capacity of understanding and volition. The parties to the exchange take decisions, which arise and remain separate'; G. Lemme, 'Gli smart contracts' n 3 above, 140 confirms Irti's thought, believing that the latter 'predicts the passage from *homo loquens* to *homo videns*: from the one who, through dialogue, contributes to the formation of the contract, to the one who passively suffers, without expressing himself with the spoken language, a hetero-formation of the contractual content'; A. Palladino, 'Dall'homo loquens all'homo smart' n 3 above, 2 (2020), believes that the needs of homo digitalis have been oriented towards the more complete objectification of the exchange, preferring dynamics aimed at reducing the element of the will and power of the parties to affect the negotiating structure, in order to mitigate the risks associated with information asymmetry and negotiation

Other legal scholars deny that smart contracts are contractual at all, maintaining that they are merely as a tool for the conclusion and management of agreements, but nothing more.²¹

In essence, smart contracts are viewed as a translation into computer language of a contract, the performance of which is self-executing, which has been concluded in the traditional way for forming an agreement.²² From this perspective, the functional advantage of using a smart contract lies solely in the fact that it could provide for an indefinite number of clauses that establish, at a given moment and taking into account the actual circumstances, what they parties' respective performance consists of. In other words, simple but highly digitalised vending machines.

Following in the footsteps of the academic legal world in America,²³ other

costs; U. Breccia, *Sub art. 1321*, in E. Gabrielli ed, *Commentario del codice civile* (Torino: UTET giuridica, 2011), 7; V. Roppo, *Il contratto del duemila* (Torino: Giappichelli editore, 2011), 25. *Contra* G. Oppo, 'Disumanizzazione del contratto?' *Rivista di diritto civile*, 525 (1998). On this point see also P. Perlingieri, 'Metodo, categorie, sistema nel diritto del commercio elettronico', in Id ed, *Il diritto dei contratti fra persona e mercato* (Napoli: Edizioni Scientifiche Italiane, 2003), 652; C.M. Bianca, 'Acontrattualità dei contratti di massa?' *Vita notarile*, 1120 (2001).

²¹ F. Di Ciommo, 'Blockchain, smart contract, intelligenza artificiale (IA) e "trading" algoritmo: ovvero, del regno del non diritto' *Rivista degli infortuni e delle malattie professionali* (2019), states that 'when the contract is concluded exclusively through the activity of one or more software programs, the automated ascertainment of the factual prerequisites for its conclusion will have to take place in accordance with rules predetermined by the parties in a framework contract or, in any case, in some form of contractual arrangement'; L. Parola et al, 'Blockchain' n 4 above, 685. Consider, for example, the purchase of a licence to use a work of intellectual property, or the transfer of any other data, such as the preferences of a certain category of people, inferred from their online activities, for advertising purposes. Suppose that A creates a smart contract, to which he attaches information x (the licence or the preferences), scheduling it to be transferred upon the fulfilment of certain conditions (eg a counter-performance in virtual currency y), and launches the protocol on a blockchain. At the moment when B intends to obtain x, it interacts with the protocol created by A, transferring, if the terms of the exchange are accepted, the sum y. As the terms of the exchange are fulfilled, the smart contract algorithm releases x to B and transfers y to A, eliminating the time gap between the linked performances, as well as any room for wilful default by the parties. The mechanism mimics escrow. See C. Pernice, 'Smart contract e automazione contrattuale' n 3 above, 133-134.

²² D. Di Sabato, 'Gli smart contracts: robot che gestiscono il rischio contrattuale' *Contratto e impresa*, 378 (2017).

²³ For American jurists, smart contracts entail real contracts every time they contain an exchange of promises from which a *do ut des* and a contractual intention can be deduced. Cf S. Aceto di Capriglia, 'Contrattazione algoritmica. Problemi di proliferazione e prospettive operazionali. L'esperienza "pilota" statunitense' *federalismi.it*, 6-7 (2019); I. Ferlito, ' "Smart contract" ' n 3 above, 12. Other authors believe that smart contracts are independent of law: A. Savelyev, 'Contract law 2.0: 'smart' contracts as the beginning of the end of classic contract law', available at reaserchgate.net, 17 (2021); V. Zeno Zencovich, 'Smart contracts', 'granular norms' and non-discrimination', H. Busch and A. De Franceschi eds, *Data Economy and Algorithmic Regulation: A Handbook on Personalized Law*, available at papers.ssrn.com, 1 (2020); R. Pardolesi and A. Davola, 'Smart contract': lusinghe ed equivoci dell'innovazione purchessia' *Il Foro Italiano*, 297 (2019); F. Di Ciommo, 'Smart contract e (non-)diritto. Il caso dei mercati finanziari' *Nuovo diritto civile*, 257 (2019); Id, 'Blockchain, smart contract, intelligenza artificiale (AI) e "trading" algoritmico: ovvero, del regno del non diritto' *Rivista degli infortuni*

legal scholars²⁴ instead argue that smart contracts are capable of completely replacing contracts that are formed in accordance with traditional methods and that the computer code comprises the entire contract. Smart codes are legally binding upon the parties in accordance with Art 1372 of the Italian Civil Code and are, it is argued, thus self-sufficient, self-executing and self-imposed, with the result that they are conceivably beyond reach in terms of control by States and relevant legal jurisdiction.

An argument that is easier to accept, and closer to standard practice, is that they are part of the traditional legal system, highlighting a lack of conformity between the agreement reached by the parties and the codified protocol and, therefore, the need for the addition of further elements, of necessity, which express the parties' intention.²⁵ This position is based on the split contracting model or hybrid agreement, which involves a contract being drawn up at the same time in natural language together with a copy in code, or inclusion, in the wording of the contract, of certain codified and self-executable parts.²⁶

Standard practice usually involves the contract being drawn up by means of a web interface, ie a form that contains (i) the wording in natural language and (ii) the parameters that can be put in computer code that relate to information to be obtained from external sources for any conditions that performance and/or amendment of the contract are subject to.²⁷

IV. The Advantages

The possibility of encrypting information and making it permanent, traceable and self-executing, through the combined use of smart contracts with blockchain, has aroused the interest of the general public in these technologies enticed by the prospect of obtaining greater independence, savings and certainty as to

e delle malattie professionali, 1 (2019); P. Cuccuru, 'Blockchain ed automazione contrattuale' n 4 above, 110.; A.J. Kolber, 'Not-so-Smart Blockchain contracts and artificial responsibility' *Stanford Technology Law Review*, 198 (2018).

²⁴ M. Giuliano, 'La blockchain' n 3 above, 989; M. Durovic and F. Lech, 'The Enforceability of Smart Contracts' *The Italian Law Journal*, 493 (2019).

²⁵ L. Parola et al, 'Blockchain' n 4 above, 681; F. Di Ciommo, 'Blockchain' n 21 above, 4; F. Faini, 'Blockchain e diritto' n 3 above, 297; A. Stazi, *Automazione contrattuale e "contratti intelligenti"* (Torino: Giappichelli editore, 2019), 161; A. Palladino, 'Dall'homo loquens' n 3 above, 90. On the relevance of fulfilment in smart contracts, I. Ferlito, "'Smart contract'" n 3 above, 17.

²⁶ A. Stazi, *Automazione contrattuale* n 25 above, 161; V. Pasquino, 'Smart contracts: caratteristiche, vantaggi e problematiche' *Diritto e processo*, 245 (2017); P. De Filippi and A. Wright, *Blockchain and the Law: The Rule of Code* (Cambridge: Harvard University Press, 2018), 76-78; M. Giaccaglia, 'Il contratto del futuro? Brevi riflessioni sullo smart contract e sulla perdurante vitalità delle categorie giuridiche attuali e delle norme vigenti del Codice civile italiano' *Tecnologie e diritto*, 113 (2021).

²⁷ Often referred to as a smart contract but which, from a legal point of view, constitutes only the part relating to automatic performance.

transactions compared to traditional systems.²⁸

In these terms smart contracts bestow definite advantages.

It does in fact seem that smart contracts based on blockchain technology can keep the risk of default to a minimum.²⁹ Trust in the voluntary performance of the counterparty becomes irrelevant when performance of the agreement is entrusted to a computer network that is very difficult to influence. Once launched in the blockchain, the smart contract is independent of a change of heart of a party because it only follows the instructions given to it automatically.³⁰

A ‘traditional’ contract is guaranteed and protected by its legally binding character determined by an external normative source. In other words, as long as one of the parties is willing to suffer the legal consequences of its behaviour, it is basically free not to fulfil the signed contract.³¹

By contrast, in smart contracts, the effectiveness and guarantee of performance of the relationships derive directly from the code layer in which they are executed and the platform that hosts them, in our case, blockchain.³²

The fact that a computer program can foresee innumerable variables, thereby ‘neutralising’ the risk of contingencies and ensuring definite fulfilment in the timeframe and manner envisaged by the algorithm, is an undoubted advantage. Upon the occurrence of a condition envisaged by the algorithm, the effect is inevitable because it is automatic.³³

There could be various benefits to a mechanism along these lines. For example, firstly, the risk of fraud is drastically reduced: given that proper performance by A is dependent upon and inseparable from proper performance by B, the terms of the agreement are performed at the same time, which is ideal. So it would be impossible, for example, for one of them to withhold the payment of €y without delivering the goods x as promised, or for the payment of €y to be annulled once in receipt of x.

Secondly, performance of the agreement makes it possible to dispense with the intermediation of third parties, with a consequent reduction in costs and the possibility of error, with a drop in expensive litigation, the outcome of which

²⁸ C. Pernice, ‘Smart contract e automazione contrattuale’ n 3 above, 121.

²⁹ L. Parola et al, ‘Blockchain e smart contract’ n 4 above, 687; F. Scutiero, ‘Smart contract e sistema di diritto’ n 3 above, 127-129; E. Mik, ‘Smart contract: Terminology, Technical Limitations and real-world complexity’ *Law, Innovation and Technology*, 14-15 (2017).

³⁰ P. Cuccuru, ‘Blockchain ed automazione contrattuale’ n 4 above, 112.

³¹ *ibid* 112; C.J. Goetz and R.E. Scott, ‘Liquidated damages, penalties and the just compensation principle: some notes on an enforcement model and a theory of efficient breach’ *Columbia Law Review*, 554-558 (1977).

³² The implicit normative character in digital ecosystems has been conceptualised by L. Lessig, *Code and other Laws of Cyberspace* (New York: Basic Books, 1999), 1; *Id*, *The future of ideas: the fate of the Commons in a connected world* (New York: Vintage, 2001), 246, specifies that a ‘code layer’ or a ‘logical layer’ is ‘the space where code decide show content and applications flow, and where code could control how innovation develops’.

³³ D. Di Sabato, ‘Gli smart contracts’ n 22 above, 398.

always remains uncertain.³⁴

Thirdly, the high degree of certainty and security of transactions that smart contracts potentially offer when operating on blockchain³⁵ allows the parties to dispense with the need for penalty clauses or mechanisms to monitor the agreement, with obvious simplification of negotiations and savings in the overall economy of the deal.

Fourthly, computer language, characterised by being unequivocal and highly predictable, tends to eliminate those aspects of uncertainty deriving from the intrinsic ambiguity of natural language because it leaves no space for interpretation. The rigour and rigidity of the code prevents discordant interpretations of the contractual clauses, avoiding the emergence of disputes based on the different understandings of the wording used, especially in international trade.³⁶

Finally, the use of the blockchain on smart contracts imbues them with formal certainty timewise in view of the stamp (timestamping), containing exact time and date, digitally affixed every time an instruction is inserted in the blocks shared by the network.³⁷

In practice, all of the main advantages identified by fans of the blockchain technology applied to smart contracts tend to focus on improved efficiency in contractual relations, which translates into fewer resources being required in the negotiations phase and when the contract is performed, services and payments being provided and processed more swiftly and with more immediacy, and a significant reduction in the risk of disputes arising between the parties.

V. Disadvantages

However, like the advantages, the drawbacks of smart contracts operating

³⁴ Cf R. De Caria, 'The legal meaning of smart contracts' n 1 above, 740-741; A. Savelyev, 'Contract law 2.0: "Smart" contracts as the beginning of the end of classic contract law' *Information and Communication Technology Law*, 18 (2017).

³⁵ According to H. Halaburda, 'Blockchain revolution' n 8 above, 7, distributed ledgers are a special type of distributed databases, which have been known and used for three decades. But 'while previous distributed databases were permissioned and required a third party to manage the permissions and help maintain the database', blockchain (and its most widespread application Bitcoin) was the first that allowed for a permissionless distributed ledger.

³⁶ D. Di Sabato, 'Gli smart contracts' n 22 above, 398, specifies that the program can contain infinite variables, but only the programmed ones are relevant. There is no margin for an evaluation in terms of reasonableness; H. Surden, 'Computable Contracts' *UC Davies Law Review*, 634 (2012); P. De Filippi and A. Wright, 'Decentralized blockchain technology and the rise of lex cryptographia' *Social Science Research Network*, 24-25 (2015).

³⁷ In this way, hypothetical difficulties deriving from the uncertain temporal context of the agreement could be prevented. This feature is useful in the registration of goods (including material goods) of which to certify the origin or verify property. In this regard, a study by the UK Government Office for Science, *Distributed Ledger Technology: beyond blockchain*, available at assets.publishing.service.gov.uk/government, 56 (2021), is interesting, for the use of blockchain to trace the origin of diamonds and follow the chain of their sales.

on blockchain stem from the very characteristics of the decentralised architecture in which they operate.

Preliminarily, the problem of the comprehensibility and natural rigidity of the instrument arises. The immutability of the decentralised registers contained in a blockchain would appear to hinder any external intervention (eg a court injunction) raising important issues of controllability and governability of the smart contracts,³⁸ which operate in it.

Most people undoubtedly lack the IT and computer programming skills required in order to write an agreement in bits. Translating an agreement into code is a complex task, and this is even more so the case when we consider the variety of interests that the parties wish to protect and the very many shades of meaning that contractual clauses can have.³⁹

The negotiation and drafting of smart contracts thus necessarily require not only the collaboration and participation of persons able to write and read algorithms but, in the case of operations on blockchain, also of those able to manage the functioning of such a network and to bear the relative costs. From this perspective, the technical-digital inexperience of most contracting parties will have the opposite effect, reintroducing the very intermediation that it was intended to eliminate in the first place.⁴⁰

Professional practitioners will no longer be called in to deal with performance of the agreement but to handle the design of the agreement itself. This will also result in an increase in that costs that will be transferred from the performance phase to the creation phase, leading to, in addition, the inevitable risk of the certainty and predictability that should be a feature of smart contracts and blockchain being undermined. Whilst transposing the contract into code, there is the potential for programmers and computer scientists to fail to express the parties' intentions properly and accurately, with the smart contract therefore having unexpected effects or ones that are different to what the parties actually decided. This is because they have a tendency to simplify the instructions that they are given in order to help the IT system understand and assist it in the execution phase.⁴¹

³⁸ P. Cuccuru, 'Blockchain ed automazione contrattuale' n 4 above, 113-114; On the limits see R. De Caria, 'The legal meaning of smart contracts' n 1 above, 743; K. Werbach and N. Cornell, 'Contracts ex machina' n 3 above, 352.

³⁹ I. Ferlito, "'Smart contract'" n 3 above, 20; G. Rinaldi, 'Smart contract' n 3 above, 352-357; L. Piatti, 'Dal codice civile al codice binario' n 3 above, 337-338; G. Finocchiaro, 'Il contratto nell'era dell'intelligenza artificiale' *Rivista trimestrale di diritto e procedura civile*, 455-456; I. Morea, 'Il consenso', in A. Fusaro ed, *I vizi del consenso* (Torino: Giappichelli, 2013), 59.

⁴⁰ I. Ferlito, "'Smart contract'" n 3 above 20; M. Manente, 'Blockchain: la pretesa di sostituire il notaio' *Notariato*, 217-218 (2018); P. Cuccuru, 'Blockchain' n 4 above, 114.

⁴¹ P. Cuccuru, 'Blockchain' n 4 above, 115, believes that the linguistic obstacle could become temporary over time. According to the author, one cannot rule out that the progressive spread of programming and computer skills, in legal and non-legal environments, can eliminate the problem of the comprehensibility of the code. Furthermore, the development of technology could allow computers to understand and process instructions expressed in natural language, a

The aim on the part of those who devised smart contracts to significantly reduce human involvement to a minimum or even dispense with it altogether does not appear to have been achieved.

Moreover, eliminating any form of input whatsoever in human relations in terms of interpretation cannot be put on a pedestal as an achievement of the third millennium. We cannot return to the elementary legal principle *in claris non fit interpretatio* – meaning that where something is clear, interpretation is not permitted – since the actual case in question hinges on interests that are always different and human dynamics are difficult to boil down into binary format.⁴² Efficiency, automation and simplification are values that need to be balanced with other values that characterise the human person and can be found in the principles enshrined in the Italian Constitution and characterise our society, with dignity being first in line.

To claim to be able to translate all of the circumstances that might affect a contract in its ‘real and actual life’ into code seems ambitious and somewhat unrealistic, given the extent to which these circumstances cannot be foreseen and the fact that translating what are certain essential interpretative criteria into contractual arrangements, such as good faith and reasonableness, is, objectively speaking, an impossible task.⁴³

Besides, if code is the computer translation of natural language, the incompleteness or the ambiguity of the latter will produce consequences also in the computer code. If the information is ambiguous, the input that represents it will be ambiguous too.⁴⁴

With programmers and computer scientists involved in writing the algorithm, there is in point of fact an increased risk of intent and declaration not being fully in line with one another, as well as an increased danger of the party to the contract, especially the weak contracting party, finding that they have signed an

task they are currently unable to perform; D.K. Citron, ‘Technological Due Process’ *Washington University Law Review*, 1249 (2008).

⁴² C. Pernice, ‘Smart contract’ n 3 above, 123; P. Perlingieri, ‘L’interpretazione della legge come sistematica ed assiologica. Il broccardo in claris non fit interpretatio, il ruolo dell’art. 12 disp. prel. c.c. e la nuova scuola dell’esegesi’ *Rassegna di diritto civile*, 990 (1985); A. Gentili, *Il diritto come discorso* (Milano: Giuffrè editore, 2013), 3.

⁴³ I. Ferlito, ‘“Smart contract”’ n 3 above, 21-22 specifies that foreseeing every eventuality in a complete way, without leaving room for interpretation, would require the drafting of very long contracts, with a consequent increase in the risk of incurring programming errors; J.I.H. Hsiao, ‘Smart contract on the blockchain. Paradigm shift for contract law’ *US-China Law Review*, 694 (2017), stresses that ‘smart contract is based on a binary zero-sum logic that does not appear in all real-life contract case’; G. Perlingieri, *Profili applicativi della ragionevolezza nel diritto civile* (Napoli: Edizioni Scientifiche Italiane, 2015), 35, highlights that legal certainty is not a given in the system but an objective that the jurist must strive to achieve; Id, ‘Sul criterio di ragionevolezza’, in C. Perlingieri and L. Ruggeri eds, *L’incidenza della dottrina sulla giurisprudenza nel diritto dei contratti* (Napoli: Edizioni Scientifiche Italiane, 2016), 29; F. Faini, ‘Blockchain e diritto’ n 43 above, 307-308; D. Di Sabato, ‘Gli smart contract’ n 22 above, 399.

⁴⁴ C. Pernice, ‘Smart contract e automazione contrattuale’ n 3 above, 125; S. Capaccioli, ‘Smart contracts: traiettorie di un’utopia divenuta attuabile’ *Cyberspazio e diritto*, 37, 25-45 (2016).

agreement without being fully informed.

The additional costs, the difficulties in translation and the risks relating to the programmers' intervention might operate to discourage the use of smart contracts.⁴⁵

In addition, the rigidity of the code and decentralisation, which should be strengths where smart contracts and the blockchain are concerned, by contrast present additional limitations.

There is a risk of a '*self-regulating online ecosystem*' emerging that is not subject to any form of external control whatsoever, even where this involves legitimate steps in order to correct malfunctions and safeguard the peremptory norms of a legal system.

Moreover, the irreversibility of automated relationships would seem to preclude the parties from resorting to self-defence tools in the face of unlawful, flawed or in any case unfair agreements,⁴⁶ especially when operating on blockchain because it is characterised by the immutability of the transactions recorded in it.

The inevitability of the effect upon the occurrence of the input implies, for example, a waiver of any defence of non-performance. This is inconsistent with Art 1341 of the Italian Civil Code which provides that conditions establishing limitations to the right to raise defences are invalid unless specifically approved in writing.

As performance is simultaneous, there is no requirement for enhanced measures to ensure compliance. As a breach is not considered possible, there can be no objection that one has been committed,⁴⁷ with the parties therefore 'forced' to waive that objection.

Another problem, for example, is liability, meaning the obligee's liability or liability for an unlawful act.

In light of developments in technology and the increasingly more sophisticated software being used in everyday life, working on the basis of a simple apportionment of liability between the various parties somehow involved in the use of a smart contract does not appear possible. There is a fundamental choice to be made here between (i) seeing the software as an advanced technological tool, with its work remaining the responsibility of human beings, or (ii) seeing the software as a 'person', who is credited with the work carried out, to the extent that we have algorithms with cognitive and learning skills.⁴⁸

⁴⁵ However, it would seem that a large margin for the development of smart contracts exists in highly standardised and relatively simple agreements, prepared by professionals and companies who can cover the coding costs with large-scale application of the 'smart' codified clauses.

⁴⁶ P. Cuccuru, 'Blockchain' n 4 above, 116 adds that not only could the parties not, for example, refuse the service if the agreement is fraudulent or flawed but also, at the same time, the public authorities would have difficulty in ensuring compliance with political-legislative choices. Think of a smart contract that automatically releases, for a fee, the access key to child pornography material stored on the paid web.

⁴⁷ C. Pernice, 'Smart contract e automazione contrattuale' n 3 above, 134.

⁴⁸ On 26 October 2017 Saudi Arabia granted honorary citizenship to Sophia, a humanoid

This problem brings to light a further issue regarding identification of the data controller⁴⁹ and coordination with data protection law.⁵⁰

Presumed anonymity, one of the defining elements of blockchain technology, is not absolute but relative.

Anyone can take part in the activities recorded on the database without needing to establish the identity of those carrying out the transactions, on condition that they have the access keys. Whoever is in dialogue with the database states that they are a certain person, but this statement is not validated in any way, with the result that no link is created between the computer profile and the 'real' one.

A hybridisation of the decentralised platforms would allow private or 'permissioned' blockchains to be created, and would provide a solution to the problem of identification, as access by potential users could be restricted to certain people, as is the case with digital signatures. The ability to identify the computers that carry out the smart contract processing activity, within the blockchain network, would ensure that regulatory measures, judicial decisions and parties' claims would have a concrete addressee. Identifiable nodes are essentially the meeting point between the blockchain, smart contracts and the legal system, providing an 'emergency entrance' platform whenever intervention is required or instructions need to be changed.⁵¹

robot created by Hong Kong Hanson Robotics. Fitted with artificial intelligence and able to converse, Sophia recognises human emotions and responds in real time, smiling and changing her own facial expressions. Cf I. Ferlito, ' "Smart contract" ' n 3 above, 26; On the difference between natural and artificial see G. Zagrebelsky, *Intorno alla legge. Il diritto come dimensione del vivere comune* (Torino: Einaudi, 2009), 40. The European Parliament has also commented on the matter in its Resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics. Aware of the existence of at least three levels of robotics, with distinct and growing levels of autonomy, ranging from robots that are operated completely remotely to those that learn from their experience, and of the various types of interaction with human beings and the environment that the machine is capable of with, and alarmed by the new scenarios emerging, the Parliament prompted the Commission to introduce regulatory measures in order to resolve the issues regarding who it is that actually does what the robots do and who is liable for the resulting loss and damage, placing heavy emphasis on the need for clarification on the possibility of the androids having legal personality in their own right.

⁴⁹ F. Scutiero, 'Smart contract e sistema di diritto' n 3 above, 133; F. Faini, 'Blockchain e diritto' n 3 above, 310; M. Giuliano, 'La blockchain' n 3 above, 1012.

⁵⁰ On this point, see M. Giuliano, n 3 above, 1010. He argues that the main characters of blockchain technology (transparency, sharing, decentralisation, disintermediation, irreversibility) should be reconciled with the principles contained in the GDPR (EU Regulation 2016/679) on the processing of personal data.

⁵¹ P. Cuccuru, 'Blockchain' n 4 above, 116-117, believes that permissioned blockchain seems to be the structure that is best suited to the commercial exploitation of technology. An example of permissioned blockchain can be found in the Corda platform developed in the banking world. Participation within the platform is regulated and the central element is the so-called 'state object', a digital document that contains all the relevant information of a specific agreement between the parties, including its existence, content and current status. Consensus between the parties is reached only on the specific 'state object' and not on the entire ledger distributed as, instead, happens on a blockchain of permissionless type, for example Ethereum and Bitcoin. It is shared only by those who are allowed to see it, because they have a specific cryptographic

But with any solution designed to transform the system into a permissioned system there is the risk of denying the fundamental essence of the blockchain architecture, which is in fact based on a permissionless system.

VI. Brief Outline of International and European Law

At international level, the very complexity of these new technologies has greatly discouraged States from regulating technologies and only a small number have adopted specific legislation on smart contracts, at least for the time being. One important example here is the State of Arizona, in the United States, which, in March 2017, amended its regulations on electronic transactions to in order to provide that smart contracts and blockchains have full legal effect.⁵² Nevada,⁵³ Ohio⁵⁴ and Tennessee⁵⁵ then followed suit.

On a European level,⁵⁶ with its Resolution of 3 October 2018, the European

hash that identifies the data of the operation and the persons involved. On this subject see R. Gendal Brown, 'The Corda Platform: an introduction', available at www.r3.com (2018,) which specifies that 'in contrast to other "permissioned" blockchain platforms, the Corda Platform is intended to allow multiple groups of participants (and associated applications) to co-exist and interoperate across the same open network'; J. Polge, J. Robert and Y. Le Traon, 'Permissioned blockchain frameworks in the industry: A comparison', available at sciencedirect.com (2021).

⁵² Arizona House Bill No. 2417, An Act Amending Section 44-7003, Arizona Revised Statutes; amending title 44, chapter 26, Arizona Revised Statutes, by adding Art 5; relating to electronic transactions. In particular, it provides that (a) 'a signature that is secured through blockchain technology is considered to be in an electronic form and to be an electronic signature', (b) 'a record or contract that is secured through blockchain technology is considered to be in an electronic form and to be an electronic record' and that (c) 'smart contracts may exist in commerce. A contract relating to a transaction may not be denied legal effect, validity or enforceability solely because that contract contains a smart contract term'. Cf R. De Caria, 'The legal meaning of smart contracts' n 1 above, 738.

⁵³ Nevada Senate Bill no 398, An act relating to electronic transactions; recognizing and authorizing the use of blockchain technology; prohibiting a local government from taxing or imposing restrictions upon the use of a blockchain; and providing other matters properly relating thereto.

⁵⁴ Ohio Senate Bill no 220, An act to amend sections 1306.01 and 3772.01 and to enact sections 1354.01, 1354.02, 1354.03, 1354.04 and 1354.05 of the Revised Code to provide a legal safe harbor to covered entities that implement a specified cybersecurity program, to allow transactions recorded by blockchain technology under the Uniform Electronic Transactions Act, and to alter the definition of 'key employee' under the Casino Gaming Law.

⁵⁵ Tennessee Senate Bill no 1662, An act to amend Tennessee Code Annotated, Title 12; Title 47; Title 48; Title 61 and Title 66, relative to electronic transactions. Cf M. Durovic and F. Lech, *The enforceability of smart contracts* n 24 above, p. 499.

⁵⁶ Beyond the first analyses of the phenomenon carried out by its own institutions aimed at encouraging a harmonised set of rules between the various Member States on the subject of blockchain and smart contracts, the work drawn up by the *European Parliamentary Research Service*, entitled *How Blockchain Technology Could Change Our Lives*, highlights the need for legislators to work to harmonise and connect the rules of contract law with smart contracts. The establishment of an Observatory and Forum on blockchains, the *Blockchain4EU* project and the creation of the *European Blockchain Partnership* (EBP), pursue the aim of creating a shared infrastructure to improve access and use of cross-border digital public services within

Parliament highlighted the potential of blockchain technologies and, where smart contracts are concerned, reported that the Commission should carry out an in-depth assessment of the legal implications, suggesting that actual cases be examined in order to foster their use by means of legal coordination or mutual recognition between Member States regarding smart contracts.⁵⁷

Subsequently, on 4 December 2018, the Southern European countries in EuroMed 7 (Italy, Cyprus, France, Greece, Malta, Portugal and Spain) signed a declaration setting out a commitment to establish a close technological partnership in order to promote the understanding of blockchain technologies and work jointly on their development, in accordance with fundamental European principles. This declaration identifies smart contracts as a potential turning point, capable of transforming the provision and enjoyment of services in areas such as ‘*certification of the origin of products, education, transport, mobility, maritime navigation, land registries, customs, business registers and health*’.⁵⁸

Despite the approval on a group basis, however, Malta stands alone as the country with the most advanced and organised set of regulations in this field.⁵⁹

Maltese legislation makes a distinction between smart contracts in the IT sense, defined as protocols for computers, and smart contracts that can amount to a legal commitment, being treated as outright contractual agreements that are drawn up and formed, in whole or in part, digitally. They are protected by means of the mechanisms within their computer code that prompt automatic execution of the agreed terms, or by going down the traditional route of the courts. In addition, the Maltese Government has established an important cornerstone on which to construct the legislative framework required by the blockchain operators, setting up an independent authority responsible for promoting and developing the full range of solutions and services that use innovative technologies.⁶⁰

the European Union. Cf *European Commission launches the EU Blockchain Observatory and Forum*, in europa.eu; P. Boucher, S. Nascimento and M. Kritikos, *How Blockchain Technology Could Change Our Lives* (Brussels: European Parliamentary Research Service, 2017), 4; S. Nascimento, A. Polvora and J.S. Lourenco, *#Blockchain4EU: Blockchain for Industrial Transformations* (Luxembourg: Publications Office of the European Union, 2018), 7.

⁵⁷ EU Parliament, Resolution P8_TA-PROV(2018)0373 of 3 October 2018, Distributed ledger technologies and blockchains: building trust with disintermediation.

⁵⁸ Ministerial Declaration of Southern European Countries on Technologies Based on Distributed Registers, Brussels, 2018, 2, available at sviluppoeconomico.gov.it.

⁵⁹ The Maltese legal framework consists of three acts: Virtual Financial Assets Act, Malta Digital Innovation Authority Act and Innovative Technology Arrangements and Services Act.

⁶⁰ Art 8 of the *Malta Digital Innovation Authority Act*. Even France, although in a different way, has recognised the value of the new digital mechanism, applying it in deposit contracts, in the film and music sector to generate a more equitable distribution of the remuneration inherent in copyright among all stakeholders, who participate to the supply chain. Cf C. Wagnier, ‘Blockchains et smart contracts: premiers retours d’expérience dans l’industrie musicale’ *Annales des Mines-Réalités industrielle*, 46-49 (2017). Furthermore, France has allowed the use of blockchain technology for minibons and for the registration and transfer of unlisted financial products as an alternative system to the traditional registration in accounting and corporate books, and with equal legal effects. In December 2018 the French Parliament announced its intention to

VII. Italian Legislation

The position adopted by Italian law⁶¹ in the wake of international developments has been welcomed with enthusiasm even if in practice the legislation has posed more questions than answers.

Art 8-ter (para 2) of decreto legge no 135 of 14 December 2018, converted into Law no 12 of 11 February 2019, states that a ‘*smart contract*’ is ‘a computer program that operates on technologies based on distributed ledgers and its execution automatically binds two or more parties on the basis of the effects that they established in advance. Smart contracts meet the requirement of written form by means of the computerised identification of the parties concerned, via a process that meets the requirements established by the Agency for Digital Italy with the guidelines to be adopted within ninety days of the date of entry into force of the law that this decree is converted into’. By ‘*written form*’ in this respect is meant that, in line with Italian law, the contracts must be reduced to writing as a precondition to their validity.

As a preliminary step, in order to better understand the meaning of the rule, it seems appropriate to go back to Nick Szabo’s original idea. According to the American computer scientist, there are many contractual clauses (such as warranties, acceptance of obligations and restrictions on title, etc) that can be incorporated into hardware and software.⁶²

Szabo’s view is that as a result of the combination of hardware and software installed on the same car, for example, the smart contract activates in order to disable the ignition if a certain number of instalments have been missed (where the car was purchased on a deferred payment basis).⁶³

If this is the basic idea, we can see from a swift comparison with the Italian

finance the implementation of blockchain technology in public administration over the next three years, with the allocation of 500 million euros. Cf N. Richard and R. Bloch, ‘Des parlementaires préconisent d’investir 500 millions dans la blockchain en trois ans’, (2021), available at <https://tinyurl.com/2strep66> (last visited 30 June 2022); S. Aceto di Capriglia, ‘Contrattazione algoritmica. Problemi di profilazione e prospettive operazionali. L’esperienza “pilota” statunitense’ *federalismi.it*, 32 (2019), notes that, in Spain, smart contracts are not considered real contracts but as an innovative method of conclusion or, alternatively, as an additional form to the traditional ones (public deed, private contract or implied contract).

⁶¹ I. Ferlito, ‘“Smart contract”’ n 3 above, 693. In October 2017 the National Council of Notaries presented the ‘*Notarchain*’, a new method of archiving digital data in a dual mode: distributed registers (blockchain) and voluntary digital registers. There are other projects such as, for example, the ‘*Torrefazione Caffè San Domenico*’ and the ‘*Wine Blockchain EY*’, which use blockchain technology to trace the supply chain path of the finished product. See S. Morabito, ‘L’applicabilità della Blockchain nel diritto dell’arte’ *businessjus.com*, 2 (2018); G. Magri, ‘La Blockchain può rendere più sicuro il mercato dell’arte?’ *Aedon.mulino.it*, 2019; M. Giaccaglia, ‘Considerazioni su blockchain e smart contracts (oltre le criptovalute)’ *Contratti e impresa*, 941 (2019).

⁶² N. Szabo, ‘Formalising and Securing Relationships on Public Networks’ *firstmonday.org*, 1997.

⁶³ N. Szabo, ‘Secure Property Title with Owner Authority’ *fon.hum.uva.nl*, 2021.

provision referred to above that the hardware component is not referred to. Art 8-ter simply defines a smart contract as a '*computer program*' (so just software), while the original idea was supposed to involve integration between software and hardware.

A vending machine in fact has a software component (which contains the instructions) and a hardware component that actually dispenses the product. And this is what should happen in the case of the car, where hardware is required that actually stops the engine from physically being started 'executing' the inputs received.⁶⁴

As a result, in order to make a smart contract 'run', it seems that a simple 'computer program' on its own is not enough: an additional device is needed that it will be programmed to act upon.⁶⁵

Another problem that comes to light as a result of examining the provision in question is in the expression '*the effects established by the parties in advance*': while it seems to suggest the moment at which the agreement that preceded the smart contract was formed, it means the smart contract as the source of the legal constraint between the parties, and therefore conflicts with the pre-existence of a contractual arrangement. If the smart contract is already the source in law of a constraint, there is no need to establish an additional constraint.⁶⁶

Finally, Article 8-ter recognises smart contracts as documents in writing, the result of which is to bring them closer to a genuine contract, but introduces the problem of the form that they must take.

Despite the fact that on the basis of its actual wording, Art 1325 of the Italian Civil Code seems to provide that a prescribed form is only essential where specified by law, with the contract otherwise being null and void, a 'generic' form of contract is 'always essential',⁶⁷ because the decision always needs to be externalised or declared.⁶⁸

The general rule of the legal system remains liberty of form but not absence

⁶⁴ M. Manente, 'Smart contract e tecnologie basate su registri distribuiti' *Studio n.1 2019 DI del Consiglio Nazionale del Notariato*, 2 (2019).

⁶⁵ Indeed, the additional device may be a hardware device but also another software device, but the algorithm alone seems not to be enough. G. Rinaldi, 'Smart contract' n 3 above, 367-368, specifies that the same provision does not distinguish, for example, unlike the Maltese legislation, between smart contracts in the IT sense and smart contracts in the legal sense.

⁶⁶ M. Manente, n 64 above, 3.

⁶⁷ M. Giuliano, 'La blockchain' n 3 above, 1030.

⁶⁸ P. Perlingieri, *Manuale di diritto civile* (Napoli: Edizioni Scientifiche Italiane, 9th ed, 2018), 512, specifies that, on the one hand, form is considered as the vehicle (declaration or conduct implying acceptance) that allows one to objectively recognise the structure of interests composed of the parties. On the other hand, form, as an autonomous requirement, is identified in the document (public deed, private deed or IT document) from which the manifestation of will results. Of the two notions, only the latter fulfils the requirement as to form for contracts, while the former addresses only the different issue of the necessary externalisation of the manifestations of the will of the contracting parties; N. Irti, *Studi sul formalismo negoziale* (Padova: CEDAM, 1997), 137.

of form. This point takes on particular relevance when it comes to contracts for which a prescribed form is specified by law in order to be valid.

The function here is twofold: (i) it is an expression of the ‘function of proof’, ie its purpose is to have certainty about the exact content of the parties’ declarations; (ii) it is an expression of the ‘function of awareness’, ie it calls the parties’ attention to the importance of the step that they are about to take.⁶⁹

In these terms, considerable difficulties arise in incorporating the agreement that the parties have reached: as is in fact the case with smart contracts, the document containing the contract cannot always be physically drawn up by the parties concerned, hence the need to identify a tool that is capable of properly representing the parties’ decision to be bound in the contract, including where the document is prepared by third parties.

This tool normally takes the form of a signature, but smart contracts bring with them the problem of whom the document is attributable to and identification of the parties.⁷⁰

The provision in question does not in fact specifically specify any form of signature, authorising the Agency for Digital Italy to establish the requirements to be met in order for the parties to be identified.⁷¹

The similarity, in terms of wording, between the formula used by Parliament for smart contracts and that already to be found in Italy’s Digital Administration Code for digital signatures gives rise to additional questions.

Firstly, it is apparent from the wording used by Parliament that this

⁶⁹ M. Manente, ‘Smart contract e tecnologie basate su registri distribuiti’ n 64 above, 4.

⁷⁰ A signature expresses three functions: indicative, because it allows to identify the author of the document; declarative, because it allows the assumption of authorship of the document; probative, because it demonstrates the authenticity of the document. Cf G. Petrelli, ‘Documento informatico, contratto in forma elettronica e atto notarile’ *Notariato*, 567 (1997); G. Casu, *L’atto notarile tra forma e sostanza* (Milano: Giuffrè, 1996), 148.

⁷¹ This new 2018 provision appears to be in line with Art 20 (para 1-bis) and Art 21 (para 2-bis) of decreto legislativo 5 March 2005 n 82 - Italy’s ‘Digital Administration Code’ - which states: ‘A computer document meets the requirement of written form and is effective as specified by Art 2702 of the Italian Civil Code where a digital signature, another type of qualified electronic signature or an advanced electronic signature has been affixed or where, following computer identification of its author, it is formed by means of a process that meets the requirements established by the Agency for Digital Italy in accordance with Art 71, in such a way that guarantees the security and integrity of the document and guarantees that it cannot be modified and that it can clearly and unequivocally be attributed to the author. In all other cases, whether the computer document meets the requirement of written form and its evidential weight can be assessed freely in court proceedings, in relation to the characteristics of security and integrity and its inability to be modified’ and ‘Save in the case of an authenticated signature, the private agreements referred to in Art 1350 (first para, points 1 to 12) of the Italian Civil Code are, where done with a computer document, to be signed with a qualified electronic signature or with a digital signature and shall otherwise be null and void. The documents referred to in Art 1350 (point 13) of the Italian Civil Code drawn up as a computer document or formed via computer processes are to be signed with an advanced electronic signature, a qualified electronic signature or a digital signature or are to be formed in accordance with the additional procedures referred to in Art 20 (para 1-bis, first sentence) and shall otherwise be null and void’.

'identification process' appears to be something different and alternative compared to what the Digital Administration Code specifies.

A methodical reading of the provisions arguably gives rise to the problem of whether, in carrying out its task, the Agency for Digital Italy can require the use of digital signatures in order for a smart contract to be properly attributable or, as specified for a computer document, different and additional processes must be involved over and above affixing a signature.⁷²

Secondly, the authority delegated to the Agency for Digital Italy appears to be too wide to be able to say that it has exclusive responsibility for adopting measures in order to avoid a person being substituted, without any minimum legislative cover here.

It follows that the provision in question would appear to lack a mechanism whereby the parties' unequivocal expression of their intention can be proved,⁷³ even though there is a glimpse of this in the wording '*its execution automatically binds two or more parties*'.

The word 'execution' refers to the phase of the contractual arrangement after the contract was formed, where the parties make the payments and/or provide the services as required.

The provision thereby appears to be legal nonsense because execution, meaning performance, cannot give rise to constraints; if anything, it results in an obligation being discharged, not in it arising.

But if we look for the meaning of the word 'execution', which is contained in the provision in question, in a linguistic register other than the legal register, perhaps it does not necessarily fail to make any sense.

In computer language, 'execution' means the 'launch' of a programme,⁷⁴ ie where the instructions loaded are read and stored within the system.⁷⁵ The physical step involved in 'launching' the program could produce proof of acceptance by a party of the instructions contained in the programme, and so the 'joint launch' of the program, by the parties involved, could produce proof that agreement was reached.

It remains the case, however, that in terms of how the legislation has been drafted, confusion arises in terms of the terminology chosen.

⁷² M. Manente, 'Smart contract e tecnologie basate su registri distribuiti' n 64 above, 6, fn 4, highlights that it would be necessary to verify the compatibility of this approach with Regulation (EU) no 910/2014 of the European Parliament and Council of 23 July 2014, in which the notion of 'electronic signature' is indicated as the set of data in electronic form, enclosed or connected by logical association to other electronic data and used by the signatory to sign.

⁷³ G. Rinaldi, 'Smart contract' n 3 above, 371; M. Nicotra, 'L'Italia prova a normare gli smart contract, ecco come: pro e contro' *agendadigitale.eu*, 2019; M. Giuliano, 'Blockchain, i rischi del tentativo italiano di regolamentazione' *agendadigitale.eu*, 2019; M. Giuliano, 'La blockchain' n 3 above, 1031.

⁷⁴ Literally 'the performance of an instruction or program'. See <https://tinyurl.com/2cfyn3kt> (last visited 30 June 2022).

⁷⁵ M. Manente, 'Smart contract' n 64 above, 75; G. Rinaldi, 'Smart contract' n 3 above, 373-374.

And on a functional level, it will be even more difficult to demonstrate the statutorily prescribed ‘cause’ of a smart contract (ie, underlying reason – one of the prerequisites that Italian law requires for a contract to be valid). A computer program can only contain execution-type instructions and not descriptive-type instructions, as they are not in fact instructions but the result of a process of interpretation that a computer’s binary logic will never be able to carry out.

Indeed, if it is possible to imagine the cause of a smart contract that oversees the operation of a drinks vending machine, this cannot be done for one that simply contains the instruction for payment of an amount by one party to another. The underlying reason for such a payment might in practice be found in numerous types of agreements (eg purchase and sale, secured loan or donation).

There is still room for an assessment of the extent to which the contract as a whole and the individual agreed terms translated into an equal number of ‘if-then’ formulas conform with the principles of good faith, propriety, reasonableness and proportionality.⁷⁶

Smart contracts make unforeseen events less likely. But they cannot rule them out altogether.

The rigid nature of the IT tool, which will be the special quality behind the possible success of smart contracts, might in fact be its main defect.

And adaptation of the legal content to the particular case is in fact one of the most difficult application problems that these IT tools have to deal with.

VIII. Conclusion

In light of the foregoing, as matters currently stand the benefits associated with these new technologies appear to be ‘overstated’⁷⁷ for several reasons.

Firstly, the fact that the parties are unlikely to be *au fait* with programming language casts doubt on whether the agreement between them would be intelligible, and also opens the door to bugs or errors in translation when

⁷⁶ D. Di Sabato, ‘Gli smart contracts’ n 22 above, 401; C. Pernice, ‘Smart contract’ n 3 above, 124-125; F. Scutiero, ‘Smart contract e sistema di diritto’ n 3 above, 131. On the interpretation see E. Betti, *Interpretazione della legge e degli atti giuridici* (Milano: Giuffrè, 1949), 168; E. Betti, ‘Interpretazione della legge e sua efficienza evolutiva’, in Id ed, *Diritto, metodo, ermeneutica* (Milano: Giuffrè, 1991), 536; E. Betti, *Teoria generale dell’interpretazione* (Milano: Giuffrè, 1990), passim; P. Perlingieri, *Il diritto civile nella legalità costituzionale* (Napoli: Edizioni Scientifiche Italiane, 2006), 563; P. Perlingieri, *Interpretazione e legalità costituzionale* (Napoli: Edizioni Scientifiche Italiane, 2012), 113; P. Perlingieri, ‘Applicazione e controllo nell’interpretazione giuridica’ *Rivista di diritto civile*, 317 (2010); P. Perlingieri, ‘Controllo e conformazione negli atti di autonomia negoziale’ *Rassegna di diritto civile*, 204 (2017); P. Perlingieri, ‘Interpretazione e controllo di conformità alla Costituzione’ *Rassegna di diritto civile*, 593 (2018); P. Perlingieri, ‘Interpretazione ed evoluzione dell’ordinamento’ *Rivista di diritto privato*, 159 (2011); N. Irti, ‘Principi e problemi di interpretazione contrattuale’ *Rivista trimestrale di diritto e procedura civile*, 1139 (1999); N. Irti, ‘Sulla positività ermeneutica’ *Rivista di diritto civile*, 923 (2016).

⁷⁷ C. Pernice, ‘Smart contract’ n 3 above, 136; G. Rinaldi, ‘Smart contract’ n 3 above, 360-365.

transforming the interests that the parties intend to pursue into an algorithm. So the need to consult third parties, computer scientists and computer programmers in order to create a smart contract would prevent any significant saving in costs.

Secondly, it is not entirely true to say that smart contracts ensure an 'objective' view, eliminating if not completely reducing to zero the interpretation done by legal practitioners, with a simultaneous decrease in the number of disputes. Algorithmic negotiation does not fundamentally rule out the possibility of challenging the effect produced technologically; recourse to the courts is simply postponed to a later stage. On the contrary, the fact that it is impossible for the parties to 'correct', in advance, the injustice of the programmed arrangement might paradoxically mean asking the courts to deal with matters that could have been remedied by agreement.⁷⁸

These reflections lead to the conclusion that although smart contracts are advanced technological tools, they do not yet have that informational and legal structure that enable them to be considered contracts in a strict legal sense.

A smart contract can be considered prevalently as a support 'tool' or as a 'part' of a broader contractual agreement, perhaps drawn up in accordance with more 'traditional' forms, which takes care of and simplifies the aspect relating to the fulfilment of the agreed obligations.⁷⁹ But it will certainly be difficult to rise to the technical-legal status of contract contained in Art 1321 of the Italian Civil Code, which is still very much alive today.

⁷⁸ C. Pernice, 'Smart contract e automazione contrattuale' n 3 above, 13.

⁷⁹ M. Manente, 'Smart contract e tecnologie basate su registri distribuiti' n 64 above, 7; F. Di Ciommo, "Blockchain, smart contract", *intelligenza artificiale (AI)* n 21 above, 4; C. Pernice, 'Smart contract' n 4 above, 137, considers that the most common areas of application seem to be in the insurance, banking and financial sector. A protocol, for example, could provide for the sale or acquisition of a certain number of shareholdings when a certain quotation is reached. In addition, smart contracts could be used to facilitate the collection of information in the banking and insurance markets in order to reduce the time and cost of mortgage disbursement and policy repayment procedures; S. Orlando, 'Profili definitivi degli "smart contracts"' n 19 above, 49; M. Giaccaglia, 'Il contratto del futuro? Brevi riflessioni sullo smart contract e sulla perdurante vitalità delle categorie giuridiche attuali e delle norme vigenti del Codice civile italiano' *Tecnologie e diritto*, 113 (2021).