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Smart Pledges: creation, perfection and performance of information duties

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1. Introduction

Business processes are increasingly digital and automated. For example, several companies are working on 'business ecosystems' on blockchains, linking multiple actors in a value chain [(2)]. Another example is the use of loan management systems by banks (and contract life cycle management systems more generally), to monitor debtor compliance and manage collateral [(3)]. A third example is the rise of virtual assistants and other software agents in the retail space, from financial services to personal management [(4)].

This trend has found its way to the global secured finance markets. Some illustrations of this trend include:

* Ethereum, the largest blockchain after Bitcoin,[(5)] has introduced *ETHLend*, a "marketplace allowing lenders and borrowers from all over the world to create peer-to-peer lending agreements" secured by pledges on Ethereum-based ERC-20 compatible digital tokens using "smart contracts" [(6)].

* the International Swaps and Derivatives Association (ISDA) has introduced a consistent event and product model for financial products (ISDA CDM), which incorporates features for the pledging of financial securities using blockchain technology [(7)].

* more and more companies are starting to develop smart contracts for a variety of purposes in the financial markets [(8)].

The Grand Duchy of Luxembourg ("**Luxembourg**") is often involved as a jurisdiction in global secured finance market transactions. Typically, the security arrangements in respect of certain assets held by Luxembourg companies are governed by Luxembourg law and the financing agreement is governed by foreign law, such as English law. The trend towards digitization and automation raises the question as to whether or not Luxembourg law is sufficiently flexible to allow for the valid creation and perfection of financial collateral arrangements in the form of smart contracts. After a discussion of smart contracts (section 2), this article will assess whether it is possible (1) to create and perfect pledge agreements in the form of smart contracts, in conformity with the **law of 5 August 2005** – as amended - on financial collateral arrangements, and (2) to automate the performance of information duties (section 3).

2. Smart Contracts

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2.1 Neither smart nor contract per se

Today, the adjective “smart” is used rather loosely to label software applications or objects which use the following technologies: data collection (e.g. through a camera and microphone), internet-based data processing, artificial intelligence (mostly machine learning) and robotic process automation [(9)]. The term “smart contracts” predates this trend and stems from a series of papers written by computer scientist Nick Szabo [(10)].

Szabo defined smart contracts as “*a set of promises, including protocols within which the parties perform on the other promises […] usually implemented with programs on a computer network, or in other forms of digital electronics*”. Due to their implementation using digital electronics, they are "smarter" than their paper-based ancestors, according to Szabo. At the same time, “no use of artificial intelligence is implied”. [(11)] The phrase “smart contract” refers to a set of promises *to perform an action*, implemented with computer protocols which automate the performance of those promises. This is made clear in Szabo’s explanation of the basic principles of contract design, which include the observability and verifiability of actions [(12)]. However, the choice of the words “smart” and “contract” for these protocols is not ideal [(13)]. First, “smart” does not bear a relation to artificial intelligence or machine learning; an archetypical smart contract merely executes code and does not evaluate the input in any meaningful way [(14)]. Second, it is evident that using the noun “contract” does not magically transform text and computer code into a legally enforceable contract. The rules of the relevant governing law determine the existence and enforceability of a contract [(15)]. Third, a contract usually does not solely contain ‘operational clauses’, *i.e.* promises which give rise to obligations and which can be implemented using conditional logic premised on observable and verifiable conditions [(16)]. In addition to these operational clauses which self-execute if the conditions are met [(17)], a contract contains non-operational clauses, such as jurisdiction clauses or ‘entire agreement’ clauses [(18)]. Therefore, a contract cannot be fully implemented by computer protocols which automate observable and verifiable conditions [(19)].

2.2 Mechanics

In order to provide a suitable definition of a smart contract, it is useful to consider its economic function. A smart contract automates the performance of certain obligations of the parties under an agreement. The benefit of such automation is to minimize performance-related transaction costs [(20)]. For example, a purchaser and a vendor can agree that the purchaser will automatically make a payment to the bank account of the vendor upon certain conditions, such as the receipt by the purchaser of a payment from third party before a certain date. In this example:

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1. the contracting parties must have a digital representation to execute the smart contract (*digital identity*);

2. the smart contract must have the ability to receive information about payments received by the purchaser, and the current date and time (*data*);

3. the smart contract must contain a mechanism that verifies receipt of payments, the current date, the details of the payment to be made and determine whether or not the payment should be made (*logic*); and

4. the smart contract must be able to initiate the payment order by connecting to the purchaser's bank account, in order for the purchaser's bank to execute the order (*output, connectivity*).

In theory, smart contracts can vary in terms of the use of natural language and the degree of automation. They range from 100% computer code[(21)] to a contract entirely set out in natural language with a software protocol that automates the performance of one specific action [(22)]. Intermediate versions are smart contracts fully set out in natural language and duplicated in computer code ('duplicate model'), and smart contracts set out in natural language supplemented with computer code automating a broader set of actions ('split model') [(23)]. In the remainder of this paper, we will focus on the split model [(24)].

A split-model smart contract has a component which sets out the agreement in natural language (*.txt*) (the 'text component'), and several components written in code to implement certain provisions of the agreement: model parameters (*.cto*) and logic (*.js*) [(25)]. The key component is the logic. Essentially, the logic of a smart contract is a software protocol consisting of a sequence of 'if-then' expressions which must be evaluated and instructions which must be executed [(26)]. If the protocol is written in an *object oriented programming language*, the logic will define objects, such as an asset, a business entity or an action (e.g. a payment) and use those objects as inputs. The protocol will also define the results of running the script (i.e. the output). This output could be a change in the status of the smart contract, data which will be used as input for the next smart contract to be invoked or a message broadcasted to a network.

To create a smart contract on a blockchain, a party must sign it using his or her private key, after which the smart contract is stored on the blockchain [(27)]. The smart contract will evaluate data transmitted to its location.[(28)] If the data conforms to the specified conditions of the contract's logic, the smart contract will self-execute and perform the actions specified in its code.

2.3 Technology

Smart contracts are mostly discussed in connection with blockchain or distributed ledger technology. Given that smart contracts are essentially software protocols, they can be stored in a variety of other data structures, such as cloud computing or peer-to-peer networks [(29)]. It is beneficial to adopt a technology-neutral definition of smart contracts, in order to generalize the conclusions to smart contracts irrespective of the underlying technology.

2.4 A working definition

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Clack, Bakshi and Braine propose a high-level definition of a smart contract: "[a] *smart contract is 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 code*" [(30)]. This definition refines Szabo's definition, acknowledging that a smart contract need not be fully automated and may be legally enforceable. In light of the considerations in section 2.3 above and on the basis of the split-model smart contract, the following working definition is proposed:

"smart contract" means "*an agreement, set out in natural language and supplemented with self-executing computer code components with which the parties automate the performance of certain obligations under that agreement.*"

2.5 Benefits of smart contracts

The main economic incentives for contracting parties to use smart contracts to automate the performance of obligations are the reduction of transaction costs and the minimization of human error [(31)]. The performance of contractual obligations is less costly, because the marginal cost of computerized labor is lower than the marginal cost of human capital in the long run [(32)]. The automated performance of contractual obligations also reduces human error in the execution of the obligations [(33)]. At the same time, the upfront costs of development and deployment may be higher [(34)]. In addition, the use of smart contracts may expose the parties to novel cybersecurity risks [(35)].

Ultimately, the cost efficiency of smart contracts relies on the interoperability of the data architectures used by the parties. In most use cases, a smart contract receives data from one application, processes the data, and sends its output to a third application. To maximize cost savings, the transmission between, and processing by, the smart contract and parties' data architectures must be seamless. This requires, *inter alia*, defining the data specifications, tailoring of application processing interfaces (APIs) to these specifications and ideally, the design of a single platform or ecosystem.

3. Luxembourg law

Following the definition of a smart contract, a "**smart pledge**" could be defined as "*a pledge agreement (contrat de gage ou de nantissement portant sur des avoirs), set out in natural language and supplemented with self-executing computer code components with which the parties automate the performance of certain obligations under that pledge agreement.*"

If the pledged assets are financial instruments or claims, the creation (1) and perfection (2) of the smart pledge must comply with the provisions of:

* the amended law of 5 August 2005 on financial collateral arrangements ("**FCL**")[(36)] which transposes Directive **2002/47/EC** of the European Parliament and of the Council of 6 June 2002 on financial collateral arrangements (the "**Directive**"); and

* with the Luxembourg Civil code ("**LCC**").

3.1 Creation

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The valid creation of a smart pledge in compliance with **article 1108 LCC** requires compliance with any applicable formalities (*conditions de forme*). Therefore, the key question is whether the set of computer files which comprises the smart pledge, qualifies as a valid *instrumentum* for the *negotium* (the parties' agreement).

Based on the principle of consensus (*consensualisme*), there are no mandatory formalities to ensure the validity of a contract, unless specifically imposed by law [(37)]. The FCL does not provide such formalities to the pledge. The Directive clearly provides that "*in order to limit the administrative burdens for parties […], the creation, validity, perfection […] of a financial collateral arrangement, or the provision of financial collateral under a financial collateral arrangement, should not be made dependent on the performance of any formal act* […]"[(38)] , a rule which has been transposed by the Luxembourg legislator [(39)]. As a financial collateral agreement, the pledge is assumed to be a commercial transaction (*acte de commerce*) conforming with **article 2**(1) FCL, and therefore merely subject to the probative regime of **article 109** of the *Code de commerce*[(40)].

By contrast, the FCL clearly imposes that the provision of collateral (*constitution de garantie*) must be capable of being evidenced in writing [(41)]. The evidence may be in electronic format or any other durable medium and must allow for the identification of the collateral to which it applies [(42)]. The objective of the rule is to provide a minimal probative regime. In fact, the rule only serves to ensure traceability of the collateral [(43)].

The smart pledge meets these durable medium and collateral identification requirements. Commonly used files such as portable document format (*.pdf*) files, images saved in a compressed graphic format standardized by the Joint Photographic Experts Group (*.jpeg*), plain text (*.txt*) files and text files that contain protocols which can be run by a computer program [(44)], are all in electronic format and can contain information allowing for the identification of the parties and the collateral in natural language. Moreover, these files can be stored in a way that prevents subsequent modifications to them ('read-only' format).

In practice, pledges also contain other contractual obligations of the pledgor to which the formality applies that they should be in writing and signed by the pledgor, such as payment obligations [(45)]. A smart pledge should be considered a writing, provided that it contains the entire negotium in "language expressed by a series of signs with intelligible meaning" and is "recorded on a durable medium capable of being consulted after its creation, whatever it may be and whatever the methods of transmission" [(46)]. As the smart pledge is ultimately a collection of text files stored on a blockchain or on a server, the parties can sign it validly using an electronic signature [(47)].

In conclusion, an electronically signed smart pledge constitutes a financial collateral arrangement validly created in accordance with the FCL.

3.2 Perfection

The perfection of a pledge requires the transfer of possession (*dépossession*) in accordance with the FCL. **Article 5 FCL** stipulates the formalities applicable to the transfer of possession, which depend on the type and form of the pledged assets. The most common pledged assets are claims, financial instruments in registered form and bank accounts.

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If the collateral is a claim, the possession of the claim is transferred by the mere execution of the smart pledge (48). Since the debtor may validly discharge his or her obligation by payment to the pledger, the debtor should be notified. One benefit of a smart pledge is that the notification can be automated, for example by automatically sending an email using the simple mail transfer protocol (SMTP) upon execution of the smart pledge.

If the collateral is a registered financial instrument, the possession of the instrument is transferred by entering the pledge over the instrument in the register (49). Generally, it is sufficient to notify the company issuing the instrument, which subsequently updates the register(50) .

If the collateral is a current account held with a credit institution, the transfer of possession is effected by the mere execution of the smart pledge (51). However, because it is common practice that the general terms and conditions applicable to current accounts contain a pledge in favor of the credit institution, a waiver should be obtained from the credit institution if the parties to the smart pledge seek to create a first-ranking pledge.

At present, it is unclear which perfection requirements apply to a blockchain token, an issue which is outside of the scope of this essay. There is no consensus as to which features of a blockchain token would support the position that it is a financial instrument in the sense of **article 1**(8) of the FCL.

3.3 Performance of information duties

Most pledge agreements stipulate information duties of the pledgor to the pledgee. The pledgor (*solvens*) agrees to perform the information duties (*objet de l'obligation*) for the benefit of the pledgee (*accipiens*) (52). In general, two types of information duties can be distinguished, *specific* duties and *general* duties. For example:

1. *immediately upon receipt of any report, accounts, circular, offer or notice received by it in respect of* the pledged assets, the pledger shall deliver a copy to the pledgee with notice that it relates to a given pledge agreement. (specific duty)

2. the pledgor must promptly inform the pledgee, by notice in writing, of events which are *reasonably likely to have a material adverse effect* on a given pledge. (general duty)

It is common practice to provide for specific duties of the pledger to provide information which is foreseeably of interest to the pledgee and a general duty of the pledgor as a 'catch-all' obligation in respect of information which is harder to specify in advance.

On the one hand, smart pledges are well-suited to automate the performance of specific information duties. Practically, the smart pledge can receive such information from an application processing interface (API) which makes certain company information available, and can transmit that information to the pledgee. Unless prescribed by law, parties are free to agree on the modality of performance of information duties. (53) To clarify their intentions, the parties can expressly stipulate in the text component of the smart pledge that the pledgor will comply with the specific information duties upon transmission by the smart pledge of the relevant information to the pledgee.

On the other hand, it is unlikely that parties will agree on the use of smart contracts to implement general information duties. Specific information duties normally involve objectively verifiable conditions, such as 'in respect of the pledged assets' in the example above, which do not require further judgment. In

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comparison, general information duties require evaluation of information against a subjective standard (c. q. 'reasonably likely'), hence, lack an objectively verifiable condition. Therefore, there is no satisfying formal representation of the general information duty (54). Moreover, the legal interpretation of contractual duties is partially driven by facts and circumstances surrounding the contractual relationship, adding another layer of complexity to the representation problem and the costs of negotiation. The corollary to this is that a pledgor using software protocols to automate the performance of general information duties, is exposed to contractual liability for the non-performance of such duties.

4. Conclusion

The response to the main question of this essay – whether it is possible to create and perfect pledge agreements in the form of smart contracts in conformity with the amended law of 5 August 2005 on financial collateral arrangements – is affirmative. The main economic benefit of using smart pledges is the automation of the performance of certain contractual obligations. In the case of information duties, the duties must be specific in order to be automatable.

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(2) Examples are FundsDLT (https://fundsdlt.net/) and the commodity trade finance solution built by IBM, Natixis and Trafigura using Linux Hyperledger (**https://www-03.ibm.com/press/us/en/pressrelease/51951.wss**).

(3) See for example SAP (Systems, Applications and Products for data processing) Loans Management (FS CML), **https://help.sap.com/**. Regulators stimulate the use of these systems, e.g. European Central Bank, 'Guidance to banks on non-performing loans', March 2017, p. 26 (**https://www.bankingsupervision.europa.eu/ecb/pub/pdf/guidance_on_npl.en.pdf**).

(4) Examples of digital personal assistants include Amazon's Alexa, Microsoft's Cortana, Apple's Siri and Google's Assistant. Another example of a popular software agent is a digital financial adviser or 'robo-advisor'. See as well: 'Robo-Advisors: investor protection to code or not to code? ', Melvin Tjon Akon, Legimag nr 19, October 2017, Legitech.

(5) Source: **https://coinmarketcap.com**.

(6) ETHLend Whitepaper (25 February 2018), source: https://github.com/ETHLend/Documentation/blob/master/ETHLendWhitePaper.md, accessed on 17 March 2018.

(7) ISDA, ISDA Common Domain Model Version 1.0 Design Definition Document, October 2017, p. 22.

(8) Some examples: R3 Corda, Cicero Accord (on Hyperledger Fabric) and EtherParty.

(9) Examples are 'smart plugs', 'smart fridges' and 'smart thermostats'.

(10) In particular, N. Szabo, *Smart Contracts Glossary*, Entropy #16, 1995, and N. Szabo, *Smart Contracts: Building Blocks for Digital Markets*, 1996.

(11) *Ibid.*

(12) Same. See also "Smart Contracts: 12 Use Cases for Business & Beyond. *A Technology, Legal and Regulatory Introduction - Foreword by N. Szabo*", Smart Contracts Alliance - In collaboration with Deloitte (Chamber of Digital Commerce initiative), December 2016.

(13) See e.g. LL2017, see footnote 14.

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(14) ISDA & Linklaters, *Whitepaper: smart contracts and distributed ledger - a legal perspective*, August 2017 ("LL2017"), p. 6.

(15) G. Cywie, *Le Smart Contract ou Contract Intelligent est-il un contrat?*, Legimag March 2017, nr. 17, p. 20-21, Legitech; LL2017, p. 6; Similarly, E. Roturier, J. Rix, '*Smart Contracts for finance parties – legal and regulatory risks for the financial sector*', A&O, source: **www.allenovery.com/publications/en-gb/lrrfs/cross-border/Pages/Smart-contracts-for-finance-parties.aspx**.

(16) See e.g. H. Surden, *Computable Contracts*, 46 U.C. DAVIS L. REV. 629 (2012) ("automated, prima-facie assessments about compliance or performance").

(17) See for a detailed explanation of self-executing contracts, e.g. A. Casey and A. Niblett, *Self-Driving Contracts*, The Journal of Corporation Law 2017, 43(1), p. 1-33.

(18) LL2017, p. 10-12.

(19) For this reason, some developers refer to the protocols as *chaincode*. To them, chaincode is "programmatic code deployed on the network, where it is executed and validated by chain validators together during the consensus process. Developers can use chaincodes to develop business contracts." See e.g. Hyperledger Fabric Master Documentation, http://hyperledgerdocs.readthedocs.io/en/latest /FAQ/chaincode_FAQ.html.

(20) See section 2.5.

(21) See for an example. https://www.ethereum.org/greeter.

(22) Norton Rose Fulbright, '*Smart Contracts: coding the fine print – a legal and regulatory guide*' ("**NRF** "), p. 13.

(23) *Ibid.* See also M. Finck, '*Blockchain Regulation*', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, p. 6.

(24) As the smart contract industry is still in its early stages, there is little standardization. The mechanics of smart contracts, as set out below, follow the Accord Project open source protocol. Disclaimer: the author has participated in Accord Working Groups.

(25) See for a similar view on translating natural language into code, E. Mik, '*Smart Contracts: Terminology, Technical Limitations and Real World Complexity*', Law, Innovation & Technology 2017; NRF, p. 13 (the 'split contracting model'). For example, the Cicero Accord project currently provides support for logic files written in JavaScript. Some authors consider the smart contract to consist solely of computer code. See e.g. K.D. Werbach & N. Cornell, 'Contracts Ex Machina', p. 29; NRF, p. 11. An alternative option is a 'minimal wrapper contract, see Clifford Chance, 'Are Smart contracts contracts?', source: https://www.cliffordchance.com/briefings/2017/08 /are_smart_contractscontracts.html.

(26) This is also known as the control flow.

(27) In Cicero, which is designed to interact with the Hyperledger Fabric blockchain, this is achieved by using two different files: a plain text file (.txt) which contains the contract in natural language and a domain model file (.cto) which contains the definitions and data types of the variables which are extracted from the text file.

(28) In Cicero, the data protocol is JavaScript Object Notation (JSON).

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(29) For example, the Depository Trust & Clear Corporation has recently halted a distributed ledger technology project because the same results could be achieved with existing technology. A. Irrera, J. McCrank, '*Wall Street rethinks blockchain projects as euphoria meets reality*', Reuters Business News, 27 March 2018; M. Bodson, 'DLT Wave: From Hype to Progress', LinkedIn, 11 December 2017.

(30) C. Clack, V. Bakshi & L. Braine, '*Smart Contract Templates: foundations, design landscape and research directions*', March 15, 2017, accessed via https://arxiv.org/, p. 2.

(31) It should be mentioned that the use smart pledges could also contribute to the cost-efficiency of the financial market, one of the Directive's objectives (Recital 3 of the Directive; CJEU, *Private Equity Insurance Group v Swedbank AS*, 10 November 2016, C-156/15, nr. 22-26).

(32) McKinsey Global Institute, '*A Future That Works: Automation, Employment and Productivity*', January 2017 ("**McK2017**"), p. 65.

(33) McK2017, p. 24.

(34) See e.g. J. Sklaroff, 'Comment: Smart Contracts and the costs of inflexibility', University of Pennsylvania Law Review, Vol. 166, p. 296; McK2017, p. 66. The degree of smart contract standardization will play an important role in this respect.

(35) See e.g. M. Orcutt, '*Ethereum' smart contracts are full of holes*', MIT Technology Review, March 2018.

(36) *Loi du 5 août 2005 sur les contrats de garantie financière.*

(37) P. Ancel 2015, *Contrats et obligations conventionnelles en droit luxembourgeois*, nrs. 34,398; G. Cywie, Le Smart Contract ou Contract Intelligent est-il un contrat ?, op.cit., p. 20-21.

(38) Recitals (9)-(10) of the Directive; art. 3(1).

(39) Draft bill / projet de loi (« **PdL** ») **5251-00**, note to article 2: « *Il ressort, en effet, clairement du Considérant (10), de l'article 1.5 et l'article 3 de la Directive que celle-ci ne vise pas à régir le régime de preuve du contrat de garantie financière lui-même* ».

(40) See also PdL 5251-00, note to article 2.

(41) Art. 2(2) FCL.

(42) Idem. See A.-R. Cuny de la Verryère, *Sûretés et garanties au Grand-Duché de Luxembourg*, Promoculture-Larcier 2014 ("**AC2014**") , nr. 108. See also article 1(3) of the Directive, which refers to 'recording by electronic means'.

(43) PdL 5251-00, p. 15; recital 10 of the Directive. The instrument can be as simple as an account excerpt (*extrait de compte*). See PdL 5251-00, p. 15.

(44) Examples are Python files (*.py*) or Javascript files (*.js*).

(45) See **Art. 1326 LCC**.

(46) O. Poelmans, *Droit des obligations au Luxembourg*, Éditions Larcier, 2013, nr. 414. Note that this does not mean that the separate files must be compiled in a single file. It seems reasonable that analoguous to paper contracts, the files can be connected through cross-reference. In addition, even if the smart pledge would not be considered a writing, the negotium itself would not be invalidated. See Lux. 29 October 1913, Pas. 9 p. 539 (stating "*ce vice de forme n'affecte en rien la convention elle-même, qui peut être prouvée par tous les moyens rentrant dans le droit commun des preuves*").

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(47) See Art. 1322-1 LCC, the law of 14 August 2000 […], transposing Directive **1999/93** of 13 December 1999 on electronic signatures and Regulation (EU) No **910/2014** of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC. See also P. Ancel 2015, *op. cit.*, nr. 407.

(48) Art. 5(4) FCL.

(49) Art. 5(2)(c) FCL.

(50) *Ibid.* See also AC2014, nr. 114.

(51) Art. 5(4) FCL.

(52) The relevant provisions in the LCC are art. 1247 et seq., P. Ancel, *op. cit.*, nr 601, 602, 612.

(53) P. Ancel, *op. cit.*, nr 623; O; Poelmans, op. cit., p. 502.

(54) See e.g. LL2017, p. 12, on the limits of formal representation.

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