KU LEUVEN

FACULTY OF LAW

Academic year 2017 - 2018

Deregulatory potential of blockchain technology for peer-to-peer lending

Supervisor: prof. dr. V. COLAERT

Corrector: prof. dr. W. DEVROE

Master thesis, submitted by

Eline HOOGMARTENS

As part of the final examination for the degree of

MASTER OF LAW

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Summary

FinTech, technology-enabled innovation in financial services, has developed significantly over recent years and is impacting the way financial services are produced and delivered. Perhaps the most disruptive technology in the FinTech industry is blockchain technology. Blockchain technology enables the chronologically recording, sharing and synchronizing of data in a digital system decentralised across a network of multiple datastores. The main reason that blockchain technology is disruptive is that it allows transactions to take place without any intermediary.

One of the areas in which blockchain technology can play a significant role is peer-to-peer lending. P2P lending is a method of debt financing that enables individuals and businesses to lend or borrow directly from each other through an internet-based platform without the involvement of a bank. The removal of intermediaries not only leads to higher yields for the parties, it also brings significant risks. Examples include credit risk, liquidity risk, fraud, money laundering and conflict of interest. Blockchain technology is a natural ally for P2P lending as it allows transactions to take place directly between the parties in a secure and tamperproof way. Although the potential of blockchain technology for P2P lending has been suggested many times, the concrete possibilities of blockchain technology to address P2P lending risks are still waiting to be discovered. When it emerges that blockchain technology has the potential to adequately address P2P lending risks, (the impact of) regulatory measures might potentially be reduced for P2P lending platforms based on the blockchain. This interdisciplinary research paper wants to fill this gap by answering the research question: "*What is the deregulatory potential of blockchain technology for peer-to-peer lending?"*

On the basis of a thorough analysis of the risks of P2P lending and their regulatory framework (Chapter I) and the functioning of blockchain technology (Chapter II), the research paper studies the possibilities of blockchain technology to eliminate or reduce P2P lending risks (Chapter III) with a view to evaluating the deregulatory potential of blockchain technology for P2P lending (Chapter III and Conclusion).

The research paper shows that blockchain technology has an enormous potential to eliminate or reduce P2P lending risks and to support regulatory measures addressing these risks. This applies particularly to platform risk, fraud, money laundering, hacking and liquidity risk. However, (additional) regulatory measures remain necessary to adequately address several P2P lending risks. This applies particularly to credit risk, liquidity risk, conflict of interest and operational risk. Exceptions can be made for platform risk and, to a large extent, hacking.

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Table of contents

"*Technologies like blockchain can be game changers for financial services and beyond. We need to build an enabling framework to let innovation flourish, while managing risks and protecting consumers*."[1]

Mariya Gabriel**,** Commissioner for the Digital Economy and Society

INTRODUCTION

I. Introductory chapter

1. Blockchain technology

FinTech. FinTech, technology-enabled innovation in financial services, has developed significantly over recent years and is impacting the way financial services are produced and delivered.[2] FinTech does not only lead to an increasing automation of processes, but also to a fundamental reorganisation of financial services with new business models (for example, peer-to-peer lending and robo-advising) and new actors entering the market (for example, Apple).[3]

Blockchain technology. Perhaps the most disruptive technology in the FinTech industry is blockchain technology. Blockchain technology enables the chronologically recording, sharing and synchronizing of data in a digital system decentralised across a network of multiple datastores.[4] The main reason that blockchain technology is disruptive is that it makes it possible, for the first time, that transactions take place directly between the parties to the transaction, in a secure, tamperproof and unchangeable way, without the intervention of an intermediary.[5] In this regard, the European Commission's FinTech Action plan states that "Blockchain […] will likely lead to a major breakthrough that will transform the way information or assets are exchanged, validated, shared and accessed through digital networks."[6] Whilst mostly

[1] European Commission, 'COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN CENTRAL BANK, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS FinTech Action plan: For a more competitive and innovative European financial sector', Brussels, XXX COM(2018) 109/2, p. 2.
[2] Ibid. p. 2.
[3] T. Puschmann, 'Fintech', *Business & Information Systems Engineering*, 2017, p. 69.
[4] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 11; K. Werbach, 'Trust, But Verify: Why the Blockchain Needs the Law', *Berkeley Technology Law Journal*, 2018, p. 3; World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. IV.
[5] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 8-9.
[6] European Commission, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN CENTRAL BANK, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS FinTech Action plan: For a more competitive and innovative European financial sector, Brussels, XXX COM(2018) 109/2, p. 12. (Hereafter: 'FinTech Action plan: For a more competitive and innovative European financial sector')

understood in the context of cryptocurrencies such as Bitcoin, blockchain technology has a wide range of applications beyond cryptocurrency.

Potential of blockchain technology. EU institutions are fully exploring the potential of blockchain technology with proofs of concept and pilot projects in a wide range of areas such as payments, securities, deposits and lending, capital raising, investment management, market provisioning, trading and post-trade as well as trade finance and reporting.[7] Some EU initiatives aimed at discovering the potential of blockchain technology are worth mentioning. First, in November 2016, the European Commission set up an internal task force on financial technology, including blockchain technology, to assess whether existing rules and policies are adapted to the digital age and to identify ways to harness the potential opportunities fintech offers.[8] Second, in November 2017, the European Commission launched a € 250,000 study to assess the opportunity and feasibility of an EU Blockchain Infrastructure with as main objective to identify "the right conditions for an open, innovative, trustworthy, transparent, and EU law compliant data and transactional environment".[9] Third, in February 2018, the European Commission launched the EU Blockchain Observatory and Forum, which will bring together Europe's leading blockchain experts over the next two years. The Forum will report on technological and regulatory trends and propose recommendations where EU action may have a major impact. It will deliver reports on cross-cutting issues related to blockchain technology, such as interoperability, legal context and regulatory frameworks. So, whereas the potential of blockchain technology is undisputed at EU level, the concrete possibilities of blockchain technology are still waiting to be discovered.[10]

Risks of blockchain based applications. Whilst the potential of blockchain technology is not yet (fully) understood in most financial areas, a number of challenges and risks to blockchain-based applications, mainly cryptocurrency, were highlighted.[11] Examples include the high risk

[7] European Commission, 'FinTech Action plan: For a more competitive and innovative European financial sector', 2018, p. 12.

[8] European Commission, 'Task Force on Financial Technology', 2017, http://ec.europa.eu/newsroom/fisma/item-detail.cfm?item_id=56443&utm_source=fisma_newsroom&utm_medium=Website&utm_campaign=fisma&utm_content=Task%20Force%20on%20Financial%20Technology&lang=en.

[9] European Commission, 'Study on opportunity and feasibility of a EU blockchain infrastructure', 2017, https://ec.europa.eu/digital-single-market/en/news/study-opportunity-and-feasibility-eu-blockchain-infrastructure.

[10] European Commission, 'FinTech Action plan: For a more competitive and innovative European financial sector', p. 12.

[11] European Banking Authority, 'Warning to consumers on virtual currencies', EBA/WRG/2013/01, 2013, p. 2-3; European Banking Authority, 'Opinion of the European Banking Authority on the EU Commission's proposal to bring Virtual Currencies into the scope of Directive (EU) 2015/849 (4AMLD)', EBA-Op-2016-07, 2016, p.1.

of volatility, money laundering, terrorist and other illegal activity financing and lack of institutional backup.[12] Some risks have already led to regulatory intervention, even though the technology is still at an early stage. The key example in this regard is money laundering. In its Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing [...], the European Commission proposes to extend the scope of the (Fourth) Anti-Money Laundering Directive to cover virtual currency exchanges and wallet providers, being the foremost gatekeepers that control access to virtual currencies.[13] In December 2017, the European Parliament and the Council agreed upon this proposed amendment.[14]

Full potential of blockchain technology not yet discovered. Of course, the risks associated with blockchain based applications, such as cryptocurrency, are real and need to be effectively addressed. However, it is regrettable that the EU legislator has only seen the risks of blockchain based applications without considering the potential of its underlying blockchain technology to address financial risks. Peer-to-peer lending is one of those financial services in which blockchain technology can play a significant role (see *infra*).

2. Peer-to-peer lending

P2P lending: a new, much-needed form of technology-enabled financial services. Peer-to-peer lending (hereafter: P2P lending) is a method of debt financing that enables individuals and businesses to lend or borrow directly from each other through an internet-based platform without the involvement of a bank or other traditional financial institution.[15] As a new form of

[12] European Commission, 'FinTech Action plan: For a more competitive and innovative European financial sector', 2018, p. 3.

[13] European Commission, 'Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive (EU) 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing and amending Directive 2009/101/EC', Strasbourg, 5.7.2016, COM(2016) 450 final 2016/0208 (COD). The amendments only cover exchanges between virtual and fiat currencies; consequently, virtual-to-virtual currency exchanges fall outside the scope of the amended 4AMLD.

[14] European Commission, 'Report from the Commission to the European Parliament and the Council on the assessment of the risks of money laundering and terrorist financing affecting the internal market and relating to cross-border activities', COM(2017)340 final, 26.6.2017. The final compromise text of the so-called 5AMLD still needs to be formally approved and signed by the Council and the European Parliament. It will come into force 18 months after its publication in the Official Journal of the EU. The 5AMLD is therefore expected to come into force by the end of 2019.

[15] C. Luo, H. Xiong, W. Zhou, Y. Guo, and G. Deng, 'Enhancing investment decisions in P2P lending: An investor composition perspective', *Proceedings of the 17th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2011, San Diego, California, 2011, p. 292-300; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016,

technology-enabled financial service, P2P lending provides a much-needed alternative to bank lending (FinTech, see *supra*). The reason is that traditional bank loans currently available for groups such as start-ups, small enterprises, entrepreneurs and students are often expensive or difficult to access due to the lack of credit history or a lack of tangible collateral. P2P lending platforms facilitate the access to new sources of funding by acting as an intermediary between investors and those groups, while at the same time allowing investors to more easily identify and support projects and investment opportunities they are interested in. In addition, by removing the financial intermediary, borrowers usually obtain loans at lower interest rates than those offered by banks.[16] Lenders, which spread the amount they loan across many borrowers, receive steady, attractive returns while spreading risk across multiple borrowers.

P2P lending risks. However, P2P lending is "no free lunch". In return for higher yields, lenders and borrowers have to accept significant risks including some new risks that are specific to P2P lending.[17] Some P2P lenders might not be aware of these risks.[18] For example, P2P lenders themselves assume the credit and liquidity risk. Unlike commercial banks, which accumulate credit and liquidity risks on their balance sheets, platforms decentralise those risks by spreading them to their users.[19] Furthermore, P2P lending platforms largely attract investors that do not necessarily have the appropriate level of financial expertise and the lending experience to fully assess the credit risk of their (prospective) loans. In addition, the benefits of cyberspace-low entry barriers, user anonymity and spatial and temporal separation between loan parties make P2P lending platforms a fertile field for fraud, money laundering and hacking.[20]

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p. 2; S.C. Moenninghoff and A. Wieandt, 'The Future of Peer-to-Peer Finance', *Z betriebswirtsch Forsch* 65, 2013, p. 466.

[16] M. Klafft, 'Online peer-to-peer lending: A lenders' perspective', *Proceedings of the International Conference on E-Learning, EBusiness, Enterprise Information Systems, and E-Government, IEEE,* 2008, p. 371-375.

[17] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy, EJRR* 4, 2016, p. 688 and 692-607; A. Verstein, 'The Misregulation of Person-to-Person Lending', *U.C. Davis Law Review* 45(2), 2011, p. 447.

[18] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy, EJRR* 4, 2016, p. 695; A. Verstein, 'The Misregulation of Person-to-Person Lending', *U.C. Davis Law Review* 45(2), 2011, p. 465.

[19] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy, EJRR* 4, 2016, p. 688.

[20] C. Camp, 'Bitcoin may help criminals, but blockchain can help thwart fraud', *American Banker,* 2016, Vol. 181 Issue 91, http://www.americanbanker.com/bankthink/bitcoin-may-help-criminals-but-blockchain-can-help-thwart-fraud-1080937-1.html; B. Xiao and I. Benbasat, 'Product-related deception in e-commerce: A theoretical perspective', 2011, *MIS Q*, p. 35(1):169–196; J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation,* 2016, 2-25.

P2P lending: Proposal. The recent European Commission Proposal on European Crowdfunding Service Providers for Business (March 2018) establishes an (optional) legal framework for investment- and lending-based crowdfunding platforms that enables platforms to easily provide their services across the EU Single Market and seeks to address crowdfunding risks in a proportionate manner.[21] Investors will be protected by clear rules on information disclosures, rules on governance and risk management and a coherent approach to supervision. In particular, the initial assessment of appropriateness of a potential client and the possibility to simulate their ability to bear losses are worth mentioning (Article 15). In addition, the proposal is characterised by extensively elaborated safeguards regarding conflicts of interest (Article 7) and money laundering (Article 9, 10 and 13). Consumer lending falls outside the scope of the proposal as this service is already covered by other EU legislation such as the Consumer Credit Directive (CCD) and the Mortgage Credit Directive (MCD) (see, however, *infra*).[22]

European Commission's FinTech Action Plan: is its potential fully realised? The proposal is part of the European Commission's FinTech Action Plan, which is designed to better understand and enable technology to support the financial services sector. The Commission aims to opt for a "more innovation-oriented approach to FinTech by facilitating a regulatory environment where innovative financial services [can take place] in a safe, financially stable environment for investors".[23] Although the legal framework set out in the proposal is considerably innovation-oriented, the question arises whether the European Commission could not go (much) further in its innovation-oriented approach by relying on blockchain technology to address some or several risks of P2P lending, of course without undermining consumer protection. When it emerges that blockchain technology can indeed adequately address some or several P2P lending risks, (the impact of) legal measures addressing P2P lending risks might potentially be reduced for P2P lending platforms based on the blockchain. In this way, the European Commission would all the more respond to the calls by both the European Parliament and the European Council "for a more future-oriented regulatory framework embracing digitalisation and creating an environment where innovative FinTech products and solutions can be rapidly rolled out across the EU to benefit from the economies of scale of the single

[21] The proposal does not distinguish between P2P lending and lending-based crowdfunding. Both concepts can be considered as synonyms.
[22] European Commission, 'Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business and Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2014/65/EU on markets in financial instruments', Brussels, XXX SWD(2018) 56, p. 2.
[23] Ibid., p. 3.

market, without compromising financial stability or consumer and investor protection."[24] Although this suggestion may seem innovative at first sight, this can be put in perspective.

3. Potential of blockchain technology for P2P lending?

3.1 Blockchain technology and P2P lending: natural allies

Blockchain technology and P2P lending are natural allies. First, P2P lending and blockchain technology are natural allies. P2P lending enables individuals and businesses to lend or borrow directly from each other, which brings new and differently interpreted risks.[25] Blockchain technology is as it were a natural ally for P2P lending as it allows transactions to take place directly between the parties to the transaction in a secure and tamperproof way. It mainly does so by ensuring that funds are transferred and not merely copied. Previously, trusted intermediaries were needed to record transfers of funds and to reduce the amount paid from the payer's account (see *infra*).[26]

Principal characteristics of blockchain technology are promising for P2P lending. Without going into the concrete functioning of blockchain technology, blockchain technology's principal characteristics alone suggest that the technology can play a significant role in reducing P2P lending risks.

(i) Decentralisation. In blockchain technology, transaction data as well as control over these data are decentralised across a network of multiple datastores.[27] This means that everyone in the blockchain network can access the entire list of transactions and jointly supervise the full

[24] C. van Nieuwenhuizen, 'Report on FinTech: the influence of technology on the future of the financial sector', Committee on Economic and Monetary Affairs, 2016/2243(INI), 2017, http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+REPORT+A8-2017-0176+0+DOC+XML+V0//EN.

[25] C. Luo, H. Xiong, W. Zhou, Y. Guo, and G. Deng, 'Enhancing investment decisions in P2P lending: An investor composition perspective', *Proceedings of the 17th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2011, San Diego, California, 2011, p. 292-300; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 2; S.C. Moenninghoff and A. Wieandt, 'The Future of Peer-to-Peer Finance', *Z betriebswirtsch Forsch* 65, 2013, p. 466.

[26] U.W. Chohan, 'The Double-Spending Problem and Cryptocurrencies', 2017, Discussion Paper, Notes on the 21st Century, p. 1.

[27] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement', 2017, https://www.bis.org/cpmi/publ/d157.pdf, p. 14.

blockchain. Decentralisation also means that there is neither an obvious place for fraudsters to instigate a fraud scheme[28] nor a single point of failure for malicious attackers.[29]

(ii) Authentication. Accounts on blockchains are identifiable on pseudo-anonymous basis. Everyone can see which address sent how much to another public address.[30] Therefore, although participants in the blockchain network release no private information, the identity of each participant can be verified and transactions are traceable and visible network-wide.[31]

(iii) Immutability. Once transactions are recorded on the blockchain, cryptographic mechanisms make transactions records immutable, irreversible and tamperproof. These features not only prevent backdating data,[32] but also the creation of fictitious transactions as the origin of transaction funds can be traced.[33]

Potential of blockchain technology to reduce P2P lending risks. The main characteristics of blockchain technology suggest that blockchain technology has a certain potential to address at least some P2P lending risks, namely fraud, cyber-attacks and money laundering. Because blockchain technology allows transactions to take place directly between the parties to the transaction without the intervention of an intermediary, possibilities to address platform risk are conceivable as well.

3.2 RegTech

RegTech. Second, it is not first time that technology is deployed in the legal context. Financial institutions and the financial industry are increasingly applying technology to build automated systems to meet the ever-increasing demands of regulators.[34] The adoption of technologies to facilitate compliance with regulatory requirements is called 'RegTech' as a contraction of

[28] P. Tasca, 'Managing Risk under the Blockchain Paradigm', *Harvard Business Review*, 2017, p. 2.
[29] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement', 2017, https://www.bis.org/cpmi/publ/d157.pdf, p. 14.
[30] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 52. It is important to see that the public address of users cannot be linked back to personal information of those users.
[31] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Why Blockchain has the Potential to Serve as a Secure Accounting Information System', *The CPA Journal*, 2017, p. 2.
[32] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Blockchain: An Emerging Solution for Fraud Prevention', *The CPA Journal*, 2017, p.2.
[33] Y. Cai and D. Zhu, 'Fraud detections for online businesses: a perspective from blockchain technology', *Financial Innovation*, 2016, p. 2; J. Dai, Y. Wang and M.A. Vasarhelyi, 'Blockchain: An Emerging Solution for Fraud Prevention', *The CPA Journal*, 2017, p.2.
[34] D.W. Arner, J.N. Barberis and R. P. Buckley, 'FinTech, RegTech and the Reconceptualization of Financial Regulation', *Northwestern Journal of International Law and Business*, 2017, p. 16.

'regulatory technology'.[35] RegTech is also relevant regarding P2P lending risks, such as, for example, money laundering. Anti-money laundering (AML) legislation requires financial institutions to identify, monitor and report suspicious transactions. Computer software facilitates such detection of suspicious transactions through automated transaction monitoring.[36] For example, systems can generate an automatic alert when large cash transactions or unusual transactions occur in the account of a client.[37]

4. Gap in the literature

Gap in the literature. At the moment of writing, there is no research carried out on the possibilities of blockchain technology to address risks of P2P lending. Whereas the potential of blockchain technology for P2P lending has been suggested in several academic journals, blog posts, expert interviews and the financial press with titles such as 'What blockchain can do for P2P lending platforms', 'Can blockchain technology revive peer-to-peer lending' and 'The future of lending on the blockchain', contributions remain superficial and are usually limited to general overviews of the principal characteristics of blockchain technology relevant for P2P lending.[38] Therefore, an important gap in the literature concerns the concrete possibilities of blockchain technology to eliminate or reduce risks of P2P lending. On the other hand, there is a fairly extensive (academic) literature on the potential of blockchain technology for financial and cyber risks outside the context of P2P lending which is also relevant in the context of P2P lending. For example, there is literature on fraud, cyber-attack and money laundering, which are all important risks of P2P lending.[39] However, given that the business models and regulatory framework for P2P lending significantly differ from those of more traditional (lending) models (credit risk and liquidity risk, see *infra*), using this literature must be done with the utmost care.

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[35] Financial Conduct Authority, 'Call for Input: Supporting the development and adoption of RegTech', 2015, p. 3, https://www.fca.org.uk/publication/call-for-input/regtech-call-for-input.pdf.

[36] V. Colaert, 'RegTech as a Response to Regulatory Expansion in the Financial Sector', 2017, p. 7, https://ssrn.com/abstract=2677116 or http://dx.doi.org/10.2139/ssrn.2677116.

[37] V. Colaert, 'RegTech as a Response to Regulatory Expansion in the Financial Sector', 2017, p. 7, https://ssrn.com/abstract=2677116 or http://dx.doi.org/10.2139/ssrn.2677116.

[38] G. Halford-Thompson, 'What blockchain can do for P2P lending platforms', AltFi, 2017, http://www.altfi.com/article/2768_; P. Crosman, 'Can blockchain technology revive peer-to-peer lending?', American Banker, 2018, Vol. 183, p. 1; V. Deshpande, 'The future of lending on the blockchain', 2018, https://medium.com/nuo-news/the-future-of-lending-on-the-blockchain-778ca37d05df.

[39] For example: Y. Cai and D. Zhu, 'Fraud detections for online businesses: a perspective from blockchain technology', *Financial Innovation*, 2016, 2:20; F. Garitt, 'Blockchain and beyond: The New Technology Revolutionizing Traditional Banking', *The RMA Journal*, Vol. 99, Iss. 2, 2016, p. 32-33; J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25.

II. Research objectives, relevance and research question

1. Research objectives and relevance

Research objectives and relevance. First, the research paper aims to discover the possibilities of blockchain technology to reduce or eliminate the risks of P2P lending. With this objective, the research paper wants to fill the identified gap in the literature (see *supra*). Second, the research paper wants to obtain insight in the deregulatory potential of blockchain technology. In other words, it wants to provide insight into whether (the impact of) some or several regulatory measures addressing P2P lending risks may be reduced for blockchain based P2P lending platforms. This objective is relevant for legislators and blockchain based P2P lending platforms, as it provides insight into whether those platforms still need to be subject to all (proposed or existing) P2P lending regulatory measures. Finally, given that most, if not all, risks of P2P lending also occur outside the context of P2P lending, albeit in a different form, the research paper provides important insights into whether blockchain technology can play a (deregulatory, supporting or supplementing) role in other (financial) areas as well. Examples include credit risk, fraud, money laundering, liquidity risk and conflict of interest.

2. Research question

Research question. In order to achieve the above research objectives, the research question is:

"What is the deregulatory potential of blockchain technology for peer-to-peer lending?"

Sub-questions. The research question is divided in the following four sub-questions:

- *"What are the risks of P2P lending?"*
- *"What is the regulatory framework for P2P lending?"*
- *"How does blockchain technology function?"*
- *"What is the deregulatory potential of blockchain technology for P2P lending?"*

III. Methodology

Interdisciplinary approach and sources. Given the economic aspects of P2P lending, the technical aspects of blockchain technology and the research design in general, the research

paper takes a strong interdisciplinary approach. This means that, in addition to legal literature, literature stemming from economics and computer science is used. Whereas the academic literature on the risks of P2P lending and blockchain technology is fairly extensive, the (academic) literature on the regulatory framework for P2P lending risks and the potential of blockchain technology for P2P lending is very scarce (see *supra*). Therefore, the research paper also (inevitably) relies on (non-legal) sources, such as reports of (EU) research institutes, Big Four accounting firms and large law firms, whitepapers of P2P lending platforms and working papers. All sources are consulted with the utmost care and, where necessary, experts in the field were consulted to verify the sources used.

Sub-question 1: "What are the risks of P2P lending?"

Aim. The aim of the first sub-question is to get insight in the risks of P2P lending. By thoroughly discussing the P2P lending risks, the sub-question provides the basis for the answering of the main research question *"What is the deregulatory potential of blockchain technology for peer-to-peer lending?"*

Methodology. The research paper aims to uncover the risks of P2P lending at an abstract level, i.e. not limited to (a) certain legal system(s). The reason for this approach is twofold. First, blockchain technology itself is also not limited to a certain legal system. In particular because the legal literature on the potential of blockchain technology for P2P lending is very scarce, it would be unfortunate to not delve into all the (legal and technical) possibilities of blockchain technology for P2P lending by limiting the research paper to certain legal systems. Second, current P2P lending laws and regulations are subject to constant change as P2P lending is a relatively new development.[40] Temporary sandbox regimes in countries such as the UK and the Netherlands, which allow businesses to test out new, innovative financial services without incurring all the normal regulatory consequences of engaging in those activities, are a good example of the not (yet) established legislative framework of P2P lending.[41] At the EU level, there is also no definitive regulatory answer on the several P2P lending challenges. The European Commission adopted its Legislative proposal for an EU framework on crowd and peer to peer finance for businesses in March 2018, which will now be discussed by the European

[40] G. Ferrarini and E. Macchiavello, 'FinTech and Alternative Finance in the CMU: The Regulation of Marketplace Investing' in D. Busch and G. Ferrarini (eds.), *Capital Markets Union in Europe*, 2018, Oxford, OUP, forthcoming.
[41] Clifford Chance, 'European Fintech Regulation. An overview', 2017, p. 7-8. "A sandbox regime allows P2P lending platforms to test their services in the market under a more relaxed regulatory environment but within a well-defined space and duration agreed with the regulators until an appropriate legal framework is established."

Parliament and the Council (see *supra*).[42] For these reasons, studying the P2P lending risks at a more abstract level is the most relevant. It is important to note that 'at an abstract level' does not imply that the research paper will not take into account the present major business models in the P2P lending market, as these models form the object of study. More specially, the business models of the UK, Germany and, to a lesser extent, the US will be studied, as P2P lending is considerably developed in these countries and occupies a significant market share in the global lending industry in these countries.[43]

Roadmap. The answering on the first sub-question is set out in Chapter I: Peer-to-peer lending. To achieve a thorough insight in the P2P lending risks, the next steps will be taken. First, the concept of P2P lending is set out, considering its different interpretations and connection with crowdfunding. Second, the process of P2P lending is discussed and, where relevant, similarities and differences with traditional lending and/or between the different P2P lending national business models are indicated. Third, the risks of P2P lending are thoroughly discussed. More specifically, we discuss the following risks: (i) credit risk, (ii) fraud, (iii) money laundering, (iv) hacking, (v) liquidity risk, (vi) conflict of interest and (vii) operational risk.

Sub-question 2: "What is the regulatory framework for P2P lending?"

Aim. The aim of the second sub-question is to provide an overview of the regulatory framework for P2P lending with a view to evaluating which types of regulatory measures can be eliminated or reduced by blockchain technology. In other words, in order to evaluate the deregulatory potential of blockchain technology for P2P lending, it is necessary to have an overview of the (types of) regulatory measures addressing the risks of P2P lending.

Methodology. Because national regulatory frameworks for P2P lending are not yet (definitively) established and are very different from each other and to maintain an abstract level (see *supra*), the research paper focuses on EU regulatory measures addressing P2P lending risks. Most EU regulatory measures provide a framework for either P2P business lending or

[42] European Commission, 'Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113.
[43] M. Fenwick, J. McCahery and E. Vermeulen, 'Fintech and the Financing of Entrepreneurs: From Crowdfunding to Marketplace Lending', ECGI Working Paper Series in Law, 2017, Working Paper N° 369/2017, p. 25; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 6-17. In Belgium, there are currently no P2P lending platforms. Legal obstacles prevent the lawful establishment of P2P platforms. See: V. Colaert, 'On the absence of peer-to-peer lending in Belgium', *ECML* 4, 2016, p. 182-184 and D. Raes, 'Le *peer to peer lending* en droit belge – Espoir ou désespoir' in H. Daems, I. De Meuleneere, C. Houssa and N. Ragheno, *Digital finance / La finance numérique*, 2016, Anthemis, p. 98.

P2P consumer lending. Regarding P2P business lending, we focus on the European Commission's Proposal on European Crowdfunding Service Providers for Business (March 2018) (see *supra*).[44] Regarding P2P consumer lending, we discuss the relevant regulatory measures laid down in EU consumer protection law with a focus on the Consumer Credit Directive (CCD) and the Markets in Financial Instruments Directive (MiFID II).[45] This approach, namely the distinction between P2P business lending and P2P consumer lending, will be a common thread throughout the discussion of the regulatory framework for the several risks of P2P lending to the extent that such a distinction is necessary and/or relevant given the regulatory measures to be discussed. In addition, we distinguish between regulatory measures that protect lenders and regulatory measures that protect borrowers.

Roadmap. The answering on the second sub-question is set out in Chapter I: Peer-to-peer lending. The regulatory measures are set out for each P2P lending risk right after the discussion of the risk (see sub-question 1).

Sub-question 3: "How does blockchain technology function?"

Aim and methodology. The aim of the third sub-question is to get insight in the blockchain technology on which blockchain based P2P lending platforms rely. A substantial insight in blockchain technology is crucial to understand the possibilities and shortcomings of blockchain technology to eliminate or reduce P2P lending risks. Being aware that blockchain technology is a broad, overarching technology covering many variations, the research paper takes the significant common denominator of blockchain technology as main object of study. In addition, the research paper studies the particularities of the most widely used blockchains in blockchain based P2P lending specific blockchains, namely Bitcoin and Ethereum, to the extent that they are relevant to eliminate or reduce P2P lending risks.

[44] European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business, Brussels, 8.3.2018 COM(2018) 113 final 2018/0048 (COD). Article 3(1)(a): 'crowdfunding service' means the matching of business funding interest of *investors* and project owners through the use of a crowdfunding platform and which consist of any of the following: the facilitation of granting of loans […]. Article 3(1)(g): 'investor' means *any person* that, through a crowdfunding platform, grants loans or acquires transferable securities.

[45] Directive 2014/65/EU of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending Directive 2002/92/EC and Directive 2011/61/EU; Directive 2008/48/EC of the European Parliament and of the Council of 23 April 2008 on credit agreements for consumers. The Mortgage Credit Directive is discussed to a lesser extent as very few P2P lending platforms provide P2P lending solutions for real estate investment. See European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 25-26.

Roadmap. The answering on the third sub-question is set out in Chapter II: Blockchain technology. First, before delving into blockchain technology, the term 'blockchain technology' and closely related terms are set out. This is necessary, as these terms are often mixed up in the literature. Second, blockchain technology is discussed on the basis of a two-steps analysis. In a first step, the common basis of blockchain technology recurring in all specific blockchain technologies is discussed on the basis of the increasingly used interpretation of blockchain technology as a synthesis of three distinct key technologies: (i) peer-to-peer technology, (ii) cryptographic mechanisms and (iii) consensus mechanisms.[46] In a second step, the particularities of Bitcoin and Ethereum are discussed. The focus is on smart contracts and decentralised autonomous organisations (DAOs) made possible by Ethereum technology, as these applications are crucial to eliminate or reduce P2P lending risks.

Sub-question 4: "What is the deregulatory potential of blockchain technology for P2P lending?"

Aim and methodology. After discussing the risks of P2P lending (Chapter I) and the technicalities of blockchain (Chapter II), the gained insights are put together to study the possibilities (and limitations) of blockchain technology to eliminate or reduce the risks of P2P lending (Chapter III). This study, taken together with the regulatory framework for P2P lending (Chapter II), allows to provide an answering on the research question "*What is the deregulatory potential of blockchain technology for P2P lending*?" (Chapter III). The research paper gives an overview of the deregulatory potential of blockchain technology for each individual P2P lending risk set out in the first chapter.

Roadmap. The answering on the fourth sub-question is set out in Chapter III: Deregulatory potential of blockchain technology for P2P lending. This chapter is structured in parallel with the first chapter 'Chapter I: Peer-to-peer lending'. This means that the deregulatory potential of blockchain technology for each individual P2P lending risk is discussed in the same order as the P2P lending risks were set out in the first chapter. In short, we follow the following order: (i) credit risk, (ii) fraud, (iii) money laundering, (iv) hacking, (v) liquidity risk, (vi) conflict of interest and (vii) operational risk.

[46] T. Maas, 'What is blockchain technology?', Law & Blockchain, 2018, http://www.lawandblockchain.eu/post-template/; World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 9.

CHAPTER I: PEER-TO-PEER LENDING

I. Peer-to-peer lending: concept

Peer-to-peer lending. Peer-to-peer lending is a method of debt financing that enables individuals and businesses to lend or borrow directly from each other through an internet-based platform without the involvement of a bank or other traditional financial institution.[47] Several definitions of P2P lending exist with slightly different emphases. For example, the European Banking Authority (EBA) defines P2P lending as "raising funds for a project or for personal purposes, by concluding loan agreements usually with interest via an online platform", stressing fundraising,[48] whereas the British Peer-to-Peer Finance Association (P2PFA) defines P2P lending as "platforms that facilitate financial services via direct, one-to-one contracts between a single recipient and one or multiple providers" stressing the contracting of P2P lending.[49]

Broader and more narrow interpretation of P2P lending. Originally, the term 'peer-to-peer lending' referred to individuals granting unsecured loans to other individuals through online platforms. Later on, the model has expanded and it now also includes loans from individuals to businesses ('peer-to-business'), from businesses to businesses ('business-to-business') and from businesses to individuals ('business-to-peer').[50] As a result, there is a broader and more narrow interpretation of P2P lending.[51] In a narrow sense of P2P lending, platforms facilitate loans from individuals to other individuals (peer-to-peer lending), while in a broader sense of P2P lending, they facilitate loans from individuals to businesses, from businesses to businesses

[47] C. Luo, H. Xiong, W. Zhou, Y. Guo, and G. Deng, 'Enhancing investment decisions in P2P lending: An investor composition perspective', Proceedings of the 17th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, 2011, San Diego, California, 2011, p. 292-300; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 2; S.C. Moenninghoff and A. Wieandt, 'The Future of Peer-to-Peer Finance', *Z betriebswirtsch Forsch* 65, 2013, p. 466.

[48] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 8.

[49] Peer2Peer Finance Association, 'Launch of Peer-to-Peer Finance Association', 2016, http://p2pfa.info/p2pfa-launch. "The P2PFA was established in 2011 as a representative and self-regulatory body for peer-to-peer lending in the United Kingdom. The P2PFA seeks to inform and educate, promote high standards of business conduct and work with policy-makers and regulators to ensure an effective regulatory regime."

[50] Y. Pierrakis and L. Collins, 'Banking on Each Other, Peer-to-Peer Lending to Business: Evidence from Funding Circle', Nesta, 2013, p.11, https://www.nesta.org.uk/sites/default/files/banking_on_each_other.pdf.

[51] V. Colaert, 'On the absence of peer-to-peer lending in Belgium', *ECML* 4, 2016, p. 182.

and/or from businesses to individuals.[52] In its broader interpretation, P2P lending is sometimes considered as a synonym of loan-based crowdfunding.[53] For example, the British Peer-to-Peer Finance Association uses the term loan-based crowdfunding as an umbrella term to describe lending to both individuals and businesses: "Loan-based crowdfunding: people lend money to individuals or businesses in the hope of a financial return in the form of interest payments and a repayment of capital over time".[54]

P2P lending as a synonym of loan-based crowdfunding. 'Loan-based crowdfunding' is sometimes used as a synonym for P2P lending (see *supra*). In this typology, P2P lending is one of the three commercial types of crowdfunding, amongst reward-based[55] and equity-based crowdfunding.[56] Crowdfunding itself can be defined as an "open call for 'the collecting of resources (funds, money, tangible goods, time) from the population at large through an Internet platform" for both commercial or non-commercial purposes.[57] In this vein, P2P lending is a type of crowdfunding, whereby an internet platform collects small amounts of funds from individuals and businesses in the crowd to finance collectively a loan of a higher amount to individuals or businesses.[58] Legally speaking, the instrument is a loan agreement, which contains the lender's credit claim to receive redemption and interest payments in the future.[59] This interpretation of P2P lending is in the line with Klafft's comparison between P2P lending

[52] V. Colaert, 'On the absence of peer-to-peer lending in Belgium', *ECML* 4, 2016, p. 182; Financial Conduct Authority, 'Policy Statement: The FCA's regulatory approach to crowdfunding over the internet, and the promotion of non-readily realisable securities by other media', *PS14* 4, 2014, p. 11.

[53] G. Ferrarini, 'Regulating FinTech: Crowdfunding and Beyond', 2017, *European Economy* 2017.2, p. 124; Financial Conduct Authority, 'Policy Statement: The FCA's regulatory approach to crowdfunding over the internet, and the promotion of non-readily realisable securities by other media', *PS14* 4, 2014, p. 11.

[54] Financial Conduct Authority, 'A review of the regulatory regime for crowdfunding and the promotion of non-readily realisable securities by other media', 2015, London, p. 1; https://www.fca.org.uk/static/documents/crowdfunding-review.pdf; Financial Conduct Authority, 'Policy Statement: The FCA's regulatory approach to crowdfunding over the internet, and the promotion of non-readily realisable securities by other media', *PS14* 4, 2014, p. 11.

[55] Reward-based crowdfunding is a commercial type of crowdfunding, where people receive goods or services in exchange for their contributions. See: European Parliament, 'Crowdfunding in Europe Introduction and state of play', 2017, *European Parliamentary Research Service*, p. 2.

[56] Equity-based crowdfunding is a commercial type of crowdfunding, where people receive shares in the venture, in exchange for their contributions. See: European Parliament, 'Crowdfunding in Europe Introduction and state of play', 2017, *European Parliamentary Research Service*, p. 2.

[57] European Parliament, 'Crowdfunding in Europe Introduction and state of play', 2017, *European Parliamentary Research Service*, p. 2.

[58] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy, EJRR* 4, 2016, p. 688.

[59] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy, EJRR* 4, 2016, p. 688.

and an auction process, where borrowers place a request for loan and lenders bid to fund the loan through an online platform.[60]

Marketplace lending. The increasing participation of institutional lenders in P2P lending markets has led many platforms, especially in the US, to use the term 'marketplace lending' instead.[61] However, the term 'peer-to-peer lending' is still being used in the UK, irrespective of whether loans are funded by retail or institutional investors, as retail investors still fund a much larger share of loans than institutional investors in the UK.[62]

Role of P2P lending platform. Regardless all the different terms that are used for describing P2P lending, the activities performed by all these types of platforms are similar.[63] First of all, P2P lending platforms lay down the terms and conditions for obtaining and granting a loan. Second, platforms connect lenders and borrowers through an online platform.[64] After matching, platforms handle the loan requests, conduct borrowers' creditworthiness assessments, collect, bundle and transfer the redemption and interest payments of the loan. Note, however, the different role of P2P lending platforms in the loan origination in the client segregated account model and the notary model (P2P lending process, see *infra*).

Absence of financial intermediaries leads to higher yields, but also significant risks. P2P lending has been growing as an alternative to traditional lending[65] in which the mediation of financial institutions is not required.[66] By removing the financial intermediary, borrowers are able to gain access to funds more quickly (see introduction, *supra*) and typically at lower

[60] M. Klafft, 'Online peer-to-peer lending: A lenders' perspective', Proceedings of the International Conference on E-Learning, EBusiness, Enterprise Information Systems, and E-Government, *IEEE*, 2008, p. 371-375.
[61] B. Vallee and Y. Zeng, 'Marketplace Lending: A New Banking Paradigm?', *Working Paper 18-067*, Harvard Business School, p. 1.
[62] R. Wardrop, R. Rosenberg, B. Zhang, T. Ziegler, R. Squire, J. Burton, E. Hernadez and K. Garvey, 'Breaking New Ground: The Americas Alternative Finance Benchmarking Report', 2016, Cambridge Center for Alternative Finance, University of Cambridge Judge Business School, p. 31.
[63] C. Naidji, 'Regulation of European peer-to-peer lending Fintechs Regulatory framework to improve SME's access to capital', *Working Papers*, KU Leuven, 2017, p. 28.
[64] C. Naidji, 'Regulation of European peer-to-peer lending Fintechs Regulatory framework to improve SME's access to capital', *Working Papers*, KU Leuven, 2017, p. 28.
[65] A. Byanjankar , M. Heikkilä and J. Mezei, 'Predicting Credit Risk in Peer-to-Peer Lending: A Neural Network Approach', 2015 IEEE Symposium Series on Computational Intelligence, 2015, p. 1.
[66] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending. A Literature Review', *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7; C.R. Everett, 'Group membership , relationship banking and loan default risk: the case of online social lending', *Banking and Finance Review* 7(2), 2008, p. 5; M. Herzenstein, U.M. Dholakia and R.L. Andrews, 'Strategic Herding Behavior in Peer-to-Peer Loan Auctions', *Journal of Interactive Marketing*, 2011, Vol.25(1), p. 27-36; S. Herrero-Lopez, 'Social Interactions in P2P Lending', Proceedings of the 3rd Workshop on Social Network Mining and Analysis, 2009, Paris, ACM, 2009, p. 1-3.

interest rates than those offered by banks, making it an attractive alternative to bank loans. [67] In addition, since lenders typically fund only a portion of a loan and spread the amount they loan across many borrowers, lenders can potentially receive steady, attractive returns while spreading risk across multiple borrowers. Interest rates are, in absolute figures, usually higher in comparison with traditional lending.[68] However, P2P lending does not only yield higher returns, it also involves significant risks. For example, P2P lenders themselves assume the credit and liquidity risk. Unlike commercial banks, which "accumulate credit and liquidity risks on their balance sheets by creating loan assets on one side, funded with deposits and other liabilities on the other side, platforms decentralise these risks […] to their users" (see *infra*).[69]

II. Peer-to-peer lending: process

P2P lending process. The peer-to-peer lending process is aimed at matching the interests of borrowers and lenders through an online platform in order to provide a(n) (unsecured) loan.[70] To fully understand the risks of P2P lending, a substantial insight in the P2P lending process is indispensable. In this section, the P2P lending process is set out. Particular attention goes to the credit risk assessment, the determination of the interest rate and the loan origination. The reason is twofold. First, these parts of the lending process are the most deviating from the traditional lending process and consequently lead to (sometimes slightly) different risks. Second, the credit risk assessment, the determination of the interest rate and the loan origination are the ones in which (national) P2P lending business models differ the most from each other. The business models of the UK, Germany and the US are the main focus, as P2P lending is already considerably developed in these countries and occupies a significant market share in the global lending industry.[71]

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[67] M. Klafft, 'Online peer-to-peer lending: A lenders' perspective', Proceedings of the International Conference on E-Learning, EBusiness, Enterprise Information Systems, and E-Government, *IEEE*, 2008, p. 371-375.

[68] M. Klafft, 'Online peer-to-peer lending: A lenders' perspective', Proceedings of the International Conference on E-Learning, EBusiness, Enterprise Information Systems, and E-Government, *IEEE*, 2008, p. 371-375.

[69] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 688.

[70] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 37-44; E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 9.

[71] European Commission, 'Crowdfunding in the EU Capital Markets', Brussels, 3.5.2016 SWD(2016) 154 final, p. 18; U.M. Fenwick, J. McCahery and E. Vermeulen, 'Fintech and the Financing of Entrepreneurs: From Crowdfunding to Marketplace Lending', ECGI Working Paper Series in Law, 2017, Working Paper N° 369/2017, p. 25; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 6-17.

1. Loan application

Loan application. The P2P lending process begins with the loan application by borrowers.[72] When placing a loan request, borrowers need to provide information on the purpose of the loan, the amount requested and the interest willing to be paid. In addition, borrowers need to provide a significant amount of their financial and personal information, which varies between P2P lending platforms (see *infra*).

2. Credit risk assessment

Credit risk assessment in traditional lending. After the borrower has applied for the loan, the P2P lending platform conducts a credit risk assessment on the loan.[73] Such credit risk assessment is fairly different from credit risk assessments in traditional lending. In traditional lending, credit risk assessments are partly based on codified information such as income statements, tax reports and balance sheets and partly on non-codified information obtained from client interviews or by knowing the client as a long-time customer.[74] This second type of information is linked to interpersonal trust.[75] In P2P lending, such credit risk assessments are not possible as platforms have neither the individual customer contact nor the time needed to generate this kind of personal information.[76] Instead, P2P lending platforms use the tools of big data analytics to examine large data sets of financial and personal data.[77] Often, it is a software program that does the credit risk assessment, sets the pricing and decides whether to accept or reject the borrower's request for a P2P loan, autonomously and without interference from the platform's management. P2P lending platforms combine financial characteristics about borrowers with personal information given directly by the borrower or generated about the borrower from internet sources, such as social media. It is legitimate to ask whether P2P lending platforms conduct sufficient checks on the validity of this information. Little information is

[72] A. Byanjankar , M. Heikkilä and J. Mezei, 'Predicting Credit Risk in Peer-to-Peer Lending: A Neural Network Approach', 2015 IEEE Symposium Series on Computational Intelligence, 2015, p. 1; R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 691.

[73] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43.

[74] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, EJRR 4, 2016, p. 693.

[75] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 693.

[76] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7.

[77] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 693.

known on this. In addition, platforms release very little information about how they conduct credit risks assessments.[78] Given the absence of disclosure standards, they are also not obliged to do so. Although understandable from a business point of view, this makes it difficult for investors to assess and compare the quality of platforms and to make a careful selection of the "right" platform.

Financial characteristics and personal information. Regarding financial data, P2P lending platforms typically take into account detailed information on income and monthly expenses, house-ownership and debt to income ratio.[79] Some platforms include additional financial information on current credit lines and bankcard utilization.[80] Personal information typically includes borrowers' age, education, place of residence and social media activities. In a certain sense, borrowers' digital social footprint substitutes the interpersonal trust component of traditional relationship banking.

3. Determination of the interest rate

Determination of the interest rate. If the credit risk of the loan is acceptable and fits the platform's risk categories, the interest rate of the loan is determined. The determination of the interest rate is a particular part of the lending process which deviates from the traditional lending process and varies significantly between P2P lending platforms. In general, there are three methods to set the interest rate.[81]

(i) Interest rate determined in auction process. The first interest rate setting method is to allow borrowers to set the maximum rate at which they are willing to borrow (mostly, above some risk related, operator determined, minimum rate) and for investors to then bid for the loan(s) in an auction process.[82] If there are sufficient bids to fund the P2P loan by the auction closing date, the interest rate is set. If the loan is not fully funded by the auction closing date,

[78] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 699.
[79] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7.
[80] M. Klafft, 'Online peer-to-peer lending: A lenders' perspective', Proceedings of the International Conference on E-Learning, EBusiness, Enterprise Information Systems, and E-Government, 2008, *IEEE*, p. 371-375.
[81] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 37-44.
[82] I. Galloway, 'Peer-to-peer lending and community development finance', *Community Investments* 21(3), 2009, p. 19-23; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 5. The peer-to-peer lending platform Prosper is an example of a platform which uses an auction process to set the interest rate.

the loan is withdrawn from the platform and investors can invest their funds in other loans.[83] A further distinction can be made between non-uniform auctions and uniform auctions.[84] With non-uniform auctions, bidders receive what they bid, even if others bid differently.[85] With a uniform auction, all bidders receive the best price accepted, i.e. with the highest interest rate.

(ii) Interest rate determined by platform. The second interest rate setting method concerns the platform's determination of the interest rate by assigning a proprietary risk grade and related interest rate to the loan based on the P2P lending platform's credit risk assessment.[86] It is important to see that the interest rate set by the platform depends on the risk profile of the loan.[87] Under this method as well there can be a bidding process. The difference with the first method is that the interest rate is determined by the P2P lending platform's credit risk assessment and not by the maximum interest rate the borrower is willing to pay.[88] The bidding process ends after the loan has been funded.[89]

(iii) Interest rate determined by the market. The third interest setting method used by P2P lending platforms is to operate a market similarly to a stock market.[90] Based on the credit risk assessment and the maturity of the requested loan, borrowers receive an indicative estimate of the interest rate they could receive in the market. Subsequently, borrowers set a maximum rate at which they are willing to borrow.[91] Lenders see the indicative interest rate(s) and set the minimum rate at which they are prepared to lend. The P2P lending platform then matches

[83] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce,* vol. 16, no.2, 2011, p. 7.
[84] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 5.
[85] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 5; Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 5.
[86] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7; K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 37-44. Peer-to-peer lending platforms, such as the German platform smava.de, calculate the interest rates for a loan request, based on the borrowers' characteristics (financial and demographic).
[87] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 5.
[88] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 5.
[89] B. Collier and R. Hampshire, 'Sending Mixed Signals: Multilevel Reputation Effects in Peer-to-Peer Lending Markets', ACM Conference on Computer Supported Cooperative Work, 2010, Savannah, Georgia, p. 1-10.
[90] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 37-44
[91] I. Galloway, 'Peer-to-peer lending and community development finance', *Community Investments* 21(3), 2009, p. 19-23.

lenders and borrowers whose bid and offer interest rates are compatible (and which generate the required level of funding) to originate the loan.

4. Publication of loan requests

Loan requests are anonymously published. If the borrower agrees on the determined interest rate, the platform publishes the offer to its users for a predefined period, typically two or four weeks.[92] Requests for consumer loans are usually published anonymously, while business loans requests are usually published with the name of the potential borrower.[93]

5. Placement of lenders' loan offers

Lenders' access to the platform. After online publication of the loan request, lenders have a fixed period to place their offers to provide (small portions of) the required loan amount. In order to gain access to the platform, lenders must first sign a service contract with the platform and complete a due diligence process. Platforms (usually) conduct anti-fraud checks and verify whether lenders' offers comply with anti-money laundering legislation.[94] Just like borrowers, lenders' names are usually not published and are referred to on the platform by coded usernames.[95]

6. Matching parties to the loan transaction

Two matching models. Broadly speaking, there are two ways in which borrowers and lenders are matched with a view to the subsequent loan origination. Murphy defines two different types of P2P lending operating models in use around the world, namely the active and passive P2P lending model.[96]

[92] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 691.
[93] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43.
[94] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 5.
[95] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 692.
[96] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 37-44 referring to J.P. Murphy, 'P2P lending: Assessing sources of potential competitive advantage', adapted honours thesis used as a reference for paper presented at the 21st Melbourne Money and Finance Conference, 2016.

6.1 The active P2P lending model

The active P2P lending model. The active P2P lending model enables investors to directly select loans in which to invest from the pool of potential borrowers published by the platform.[97] Investors often do not know the identity of borrowers, but they have information about the purpose of the loan, the amount requested, the interest willing to be paid and financial and personal information related to borrowers' creditworthiness (see *supra*).

6.2 The passive P2P lending model

The passive P2P lending model. In the passive P2P lending model, lenders have less say in the selection of loans.[98] After lenders have selected the risk category and/or the maturity of loans in which they would like to invest, P2P lending platforms match them to a set of borrowers whose loan applications meet these criteria.[99] The lender can thus not directly choose which loans to invest in. As such, lenders are only aware of the average characteristics of categories of borrowers on the platform rather than the specific characteristics of the borrowers they have invested in. Note that in the passive model as well, contrary to what the name indicates, platforms take an active role in matching the P2P lenders and borrowers.

7. Loan origination

Two models of loan origination. Once the lenders have selected the loans in the active P2P lending model, and the lenders are selected by the P2P lending platform in the passive P2P lending model, the loan can be originated. Depending on the national regulatory system and the principles by which the platforms found themselves on, the loan origination happens directly between the parties to the loan transaction or indirectly, i.e. with the assistance of a third instance, usually a bank.[100] The direct and indirect loan origination is respectively reflected in 'the client segregated account model' and 'the notary model'.

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[97] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43 referring to J.P. Murphy, 'P2P lending: Assessing sources of potential competitive advantage', adapted honours thesis used as a reference for paper presented at the 21st Melbourne Money and Finance Conference, 2016.

[98] J.P. Murphy, 'P2P lending: Assessing sources of potential competitive advantage', adapted honours thesis used as a reference for paper presented at the 21st Melbourne Money and Finance Conference, 2016.

[99] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43.

[100] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7.

(i) Client segregated account model. The client segregated account model is the model in which the P2P lending platform acts most similarly to an intermediary.[101] The platform serves to connect the borrower to the lender but the true creditor is the lender. Because the platform operates the platform on which the loan is contractually created, the loan is said to be originated by the P2P lending platform.[102] In the client segregated account model, all funds from borrowers and investors are separated from the balance sheet of the platform and go through legally segregated client accounts.[103] In the event of a collapse of the platform, creditors nor the platform have any claim on the platform's client funds and loan claims remain valid.[104] The client segregated account model is mainly used in the UK. The main reason is that the UK Financial Conduct Authority (FCA), in a bid to mitigate platform fraud, has determined that that UK P2P lending platforms must hold client funds in a segregated client account, separated from their own operating cash.[105]

(ii) Notary model. In contrast to the client segregated account model in which loans are originated by the P2P lending platform, in the notary model, loans are originated by banks.[106] P2P lending platforms still play an important role by matching lenders and borrowers and by collecting and transferring redemption and interest payments,[107] but a bank is the actually entity that issues the loan.[108] After the bank originated the loan to the borrower, it sells a loan promissory note to the platform, and the platform sells this note to the lender. This note gives the lender entitlement to the redemption and interest payments represented by the note. [109] In

[101] A. Fong, 'Regulation of peer-to-peer lending in Hong Kong: state of play', *Law and Financial Markets Review* 9:4, 2015, p. 251-259; E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO Working Paper, 2014, p. 17.

[102] A. Fong, 'Regulation of peer-to-peer lending in Hong Kong: state of play', *Law and Financial Markets Review* 9:4, 2015, p. 251-259.

[103] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO Working Paper, 2014, p. 17.

[104] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO Working Paper, 2014, p. 17.

[105] I. Niblock, 'Professional analysis of the safety of peer-to-peer Lending, 2017, https://www.orcamoney.com/blog/p2p-lending-risks.

[106] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 18.

[107] G. Claesson and M. Tengvall, 'Peer-to-peer lending. The effects of institutional involvement in social lending', Working Paper, Jönköping International Business School, p. 11; G. Ferrarini, 'Regulating FinTech: Crowdfunding and Beyond', 2017, *European Economy* 2017.2, p. 127; E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 18.

[108] G. Claesson and M. Tengvall, 'Peer-to-peer lending. The effects of institutional involvement in social lending', *Working Paper*, Jönköping International Business School, p. 11; European Commission, 'Crowdfunding in the EU Capital Markets Union', *Commission Staff Working Document* SWD 154 final, 2016.

[109] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 18.

this regard, we should ask whether the promissory note, which is an instrument whose value is contingent upon the loan to the lender, is a security, which, as a result, need to be regulated as a security. For example, in the US, these notes are classified as securities under federal securities law and therefore regulated by the Securities Act of 1933 and the Securities Exchange Act of 1934.[110] The notary model is prevalent in the US and in Germany.[111] The reason is that in these countries only licensed banks are entitled to originate loans.[112] The involvement of a bank makes P2P lending more expensive for the parties to the loan transaction, as banks typically request a fee of 0.5 % to 1.5 % of the loan amount.[113]

8. Collection and transfer of loan payments

Collection of the payments. After the loan origination, the P2P lending platform collects and bundles the redemption and interest payments made by the borrower and transfers it to the lender(s).[114]

Platform does not assume credit risk. In both the active and passive P2P lending model of loan origination, the P2P lending platform's role is only to collect, bundle and transfer the redemption and interest payments. The platform does not assume credit risk by its own contractual positions as is the case with commercial banks.[115] Whereas commercial banks accumulate credit risks on their balance sheets by creating loan assets on one side, funded with deposits and other liabilities on the other side, platforms decentralise credit risk to their users.

Loan default. If the borrower defaults, the platform is (usually) obliged to arrange the collection of payments on behalf of the lenders, despite the fact that the platform itself does not assume credit risk.[116] P2P lending platforms have different policies in place. Some platforms arrange a sale of non-performing loans on behalf of lenders to a debt collection agent for a fixed

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[110] E. Chaffee and G. Rapp, 'Regulating Online Peer-to-Peer Lending in the Aftermath of Dodd-Frank: In Search of an Evolving Regulatory Regime for an Evolving Industry', *69 Washington and Lee Law Review* 495, 2012, p. 510; B. Käfer, 'Peer to Peer Lending – A (Financial Stability) Risk Perspective', *Joint Discussion Paper Series in Economics Marburg*, 2016, p. 4; Securities Exchange Commission, 'Order Instituting Cease-And-Desist Proceedings against Prosper Marketplace', Securities Act Release No 8984, 94 SEC Docket 1913, 2008; Securities Exchange Commission, Order Instituting Cease-And-Desist Proceedings against Prosper Marketplace, Inc, Securities Act Release No 8984, 94 SEC Docket 1913 (24 November 2008).

[111] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 692.

[112] Ibid.

[113] Ibid.

[114] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 688

[115] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43.

[116] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 692.

price to recover a minimum amount (for example, 15 % to 30 %) of the credit claim.[117] Other platforms have developed automated litigation and recovery processes.[118] In addition, P2P lending platforms increasingly have compensation funds in place from which lenders are recompensed.

III. Peer-to-peer lending: risks

P2P lending risks. Peer-to-peer lending is "no free lunch". In return for higher investment rates and cheaper financing rates, P2P lenders and borrowers have to accept significant risks including some new risks that are specific to P2P lending.[119] However, users of P2P lending platforms are not always aware of these risks.[120] In this section, we discuss the principal risks of P2P lending, namely (i) credit risk, (ii) fraud, (iii) money laundering, (iv) hacking, (v) liquidity risk, (vi) conflict of interest and (vii) operational risk.

1. Credit risk

1.1 Credit risk

Credit risk. The largest risk for P2P lenders is perhaps credit risk. Credit risk refers to the potential that the counterparty will fail to meet its obligations in accordance with agreed terms.[121] In the context of P2P lending, credit risk is the risk that the borrower fails to make the loan payments (redemption and interest payments) to the lender as agreed.[122]

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[117] Ibid.
[118] Ibid.
[119] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 688 and 692-607; A. Verstein, 'The Misregulation of Person-to-Person Lending', *U.C. Davis Law Review* 45(2), 2011, p. 447.
[120] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 695; A. Verstein, 'The Misregulation of Person-to-Person Lending', *U.C. Davis Law Review* 45(2), 2011, p. 465.
[121] Risk Management Group of the Basel Committee on Banking Supervision, 'Principles for the Management of Credit Risk', Basel, 2000, p. 1, https://www.bis.org/publ/bcbs75.pdf. See also: M. Crouhy, D. Galai and R. Mark, *The essentials of risk management Vol. 1*, 2006, New York, McGraw-Hill, 2006, p. 14; For a thorough explanation of credit risk, see A.D. Servigny and O. Renault, *Measuring and Managing Credit Risk*, 2004, New York, McGraw-Hill, 388 p. and S. Bouteille and D. Coogan, *The Handbook of Credit Risk Management: Originating, Assessing, and Managing Credit Exposures*, 2013, Wiley Finance, 352 p.
[122] Corporate Finance Institute (CFI) , 'What is credit risk?', https://corporatefinanceinstitute.com/resources/knowledge/finance/credit-risk/; C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.

Reasons credit risk. There are different reasons as to why credit risk may arise. For example, the borrower may become insolvent, may behave negligently or may have insufficient funds to make the lending payments as agreed.[123] This credit risk is inherent in any investment or loan. However, failure to appropriately assess the creditworthiness of borrowers can create a higher risk.[124] According to the European Banking Authority (EBA), credit risk may also arise because of the wrongdoing or omission due to the platform. The EBA takes as example that a lender may not receive the funds collected from borrowers, when a P2P lending platform is "not required to apply for a license or permission to provide payment services/money remittance and furthermore does not have adequate arrangements in place to safeguard participant's money".[125] Another example provided by EBA is that the P2P lending platform has insufficient financial safeguards in place, such as loan follow-up requirements.[126]

Credit risk limited to counterparty (?) At first sight, it seems strange to impute credit risk to the platform, which only matches the parties without assuming any credit risk. However, when remembering that platforms play a major role by collecting, bundling and transferring redemption and interest payments and that transfers of loan payments and credit claims are done contemporaneously as counterclaims, it becomes more understandable why the EBA puts forward the wrongdoing or omission of the platform as a reason for credit risk. Although credit risk is legally speaking not assumed by the platform, the hindrance of redemption and interest payments being made because of the wrongdoing or omission due to the platform is at the basis of credit risk, i.e. the risk that the borrower fails to make the loan payments to the lender as agreed. However, in my opinion, from a legal point of view, credit risk should be better limited to the counterparty risk in line with more traditional definitions of credit risk.[127] The examples provided by EBA such as inadequate arrangements to safeguard the lender's money and insufficient loan follow-up requirements should rather be categorised as operational risk

[123] European Banking Authority, 'Opinion of the European Banking Authority on lending -based crowdfunding', 2015, London, European Banking Authority, p. 12.
[124] Ibid., p. 12.
[125] Ibid., p. 12.
[126] Ibid., p. 14.
[127] The definition of credit risk put forward by the Basel Committee on Banking Supervision is in line with this approach: "the potential that a bank borrower or counterparty will fail to meet its obligations in accordance with agreed terms." See Basel Committee on Banking Supervision, 'Principles for the Management of Credit Risk', 2000, p. 4, https://www.bis.org/publ/bcbs75.pdf. See also: M. Crouhy, D. Galai and R. Mark, *The essentials of risk management Vol. 1*, 2006, New York, McGraw-Hill, 2006, p. 14.

defined as "the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events" (operational risks, see infra).[128]

1.1.1 Credit risk borne by P2P lenders

Credit risk borne by lenders in P2P lending. No investment is without risk, nor the investment to P2P loan is. Although credit risk borne by lenders in P2P lending is similar to that of traditional lenders in the sense that they both risk to lose their capital invested (and potential interests), credit risk has a particular interpretation in P2P lending, mainly because loans are directly granted by lenders.[129] First, P2P lenders themselves assume credit risk. Second, the traditional role of credit risk assessment is ultimately left to the lenders, notwithstanding some risk-mitigating tools provided by the platform. Third, P2P loans are usually unsecured.[130]

(i) Lenders assume credit risk. In P2P lending, loans are granted by the lenders and not by the platform.[131] The platform does not act as a counterparty of the borrowers. The platform's role is limited to matching borrowers and lenders on the one hand and to collecting, bundling and transferring loan payments to the lenders on the other hand. Unlike commercial banks, the platform does not take credit risk by its own contractual positions.[132] "Whereas banks accumulate credit […] risks on their balance sheets by creating loan assets on one side, funded with deposits and other liabilities on the other side, platforms decentralise the risks by spreading them to their users." Therefore, in P2P lending, lenders assume credit risk.

(ii) Credit risk assessment is ultimately left to lenders. P2P lending platforms offer tools to lenders to (better) assess credit risk, such as borrowers' creditworthiness assessments.[133] While these tools significantly improve the lender's risk exposure, credit risk for lenders with a limited

[128] Basel Committee on Banking Supervision, 'Principles for the Sound Management of Operational Risk', 2011, Bank for International Settlements 2011, p. 3, https://www.bis.org/publ/bcbs195.pdf.
[129] C. Serrano-Cinca, B. Gutiérrez-Nieto, and L. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.
[130] J. Magee, 'Peer-to-Peer Lending in the United States: Surviving After Dodd-Frank', *15 North Carolina Banking Institute* 139, 2011, p. 152.
[131] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 12; C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.
[132] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43.
[133] Z. Eiger and J. Mandell, 'Practice Pointers on P2P Lending: How It Works, Current Regulations and Considerations', 2018, p. 2, https://media2.mofo.com/documents/150129p2plendingbasics.pdf.

level of financial literacy remains significant.[134] Lenders may encounter credit risk by considering inappropriate factors in selecting borrowers (see *infra*).[135] Herzenstein et al. denounce that there are no explicit rules that guide lenders to make a decision on how to lend their money.[136] As most P2P loans are not secured by collateral, the creditworthiness assessment of borrowers is nonetheless crucial.[137]

(iii) Unsecured lending. Third, most P2P loans are not secured by collateral or any kind of guarantee fund.[138] This mean that lenders have no or little recourse to the borrower's assets in the event of default as is usually the case with traditional lending. Although platforms are (usually) in charge of debt collection in case of default, the likelihood of regaining a considerable return is usually low.[139]

1.1.2 Information asymmetry as underlying problem of credit risk

Information asymmetry as underlying problem of credit risk. Information asymmetry between lenders and borrowers arises because borrowers are better informed than lenders of their ability and willingness to repay.[140] While lenders want to get as much valid information about the borrower as possible, the borrower might be interested in hiding some of his characteristics in order to get an interest rate as low as possible. The existence of information asymmetries in the financial market is well known, but the information asymmetry between a borrower and potential lenders in the P2P lending market is even more acute.[141] So far, those

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[134] C. Serrano-Cinca, B. Gutiérrez-Nieto, and L. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.

[135] A. Verstein, 'The Misregulation of person-to-person lending', *UCDL Rev*. 45, 2011, p. 445-530.

[136] M. Herzenstein, R. L. Andrews, U. Dholakia and E. Lyandres, 'The democratization of personal consumer loans? Determinants of success in online peer-to-peer lending communities', Boston University School of Management Research Paper, 2009, p. 14.

[137] A. Mild, M. Waitz and J. Wöckl, 'How low can you go? - Overcoming the inability of lenders to set proper interest rates on unsecured peer-to-peer lending markets', *Journal of Business Review* 68, 2015, p. 1291-1305.

[138] J. Magee, 'Peer-to-Peer Lending in the United States: Surviving After Dodd-Frank', *15 North Carolina Banking Institute* 139, 2011, p. 152; C. Naidji, 'Regulation of European peer-to-peer lending Fintechs Regulatory framework to improve SME's access to capital', Working Papers, KU Leuven, 2017, p. 28; C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3; H. Wang, and M. E. Greiner, 'Prosper—The eBay for money in lending 2.0.', *Com. Ass. Inf. Sys*. 29(1), 2011, p. 243-258.

[139] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 9.

[140] R. Emekter, Y. Tu, B. Jirasakuldech and M. Lu, 'Evaluating credit risk and loan performance in online Peer-to-Peer (P2P) lending', *Applied Economics* 47:1, 2015, p. 55; C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 1-4.

[141] T.S. Campbell and W.A. Kracaw, 'Information production, market signalling, and the theory of financial intermediation', *J. Financ.* 35(4), *1980,* p. 863–882; S.C. Myers and N.S. Majluf, 'Corporate financing and investment decisions when firms have information that investors do not have', *J. Financ Econ.* 13(2), 1984, p.

interested in knowing the factors explaining loan default were risk analysts in financial institutions.[142] However, P2P lending platforms largely attract retail investors who do not necessarily have the appropriate level of financial expertise and the lending experience to make a fully educated decision about a specific investment opportunity.[143] P2P lenders also do not usually possess the resources and expertise to undertake a costly due diligence procedure.[144] Klafft states that most lenders face difficulty in judging the quality of a loan application and to distinguish borrowers with a high probability of default from solvent ones.[145] The pseudonymous online environment makes borrowers' creditworthiness assessment arguably more difficult.[146]

Borrowers' creditworthiness analysis. In order to reduce the information asymmetry between lenders and borrowers, and therefore credit risk, P2P lending platforms offer borrowers' creditworthiness assessments to lenders.[147] Creditworthiness assessments provide extensive financial and personal information on borrowers (see *supra*). However, Yum et al. state that P2P lenders may also misinterpret borrowers' creditworthiness assessments precisely because of the significant information asymmetry between lenders and borrowers in P2P lending (see

187–221; M. Pokornáa and M. Sponera, 'Social lending and its risks', *Procedia - Social and Behavioral Sciences* 220, 2016, p.330-337; A. Sufi, 'Information asymmetry and financing arragement: evidence from syndicated loans', *Journal of Finance* 62, 2007, p. 393–410. Leland and Pyle, Campbell and Kracaw and Myers and Majluf suggest that informational asymmetries may be a primary reason to explain financial institutions' existence. See: H.E. Leland and D.H. Pyle, 'Informational asymmetries, financial structure, and financial intermediation', *J. Financ.* 32(2), 1977, p. 371–387.

[142] C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.

[143] M. Pokornáa and M. Sponera, 'Social lending and its risks', *Procedia - Social and Behavioral Sciences* 220, 2016, p.330-337; C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.

[144] Y. Haewon, L. Byungtae and C. Myungsin, 'From the wisdom of crowds to my own judgment in microfinance through online peer-to-peer lending platforms' *Electronic Commerce Research and Applications* 11,2012, p. 469–483.

[145] A. Byanjankar , M. Heikkilä and J. Mezei, 'Predicting Credit Risk in Peer-to-Peer Lending: A Neural Network Approach', 2015 IEEE Symposium Series on Computational Intelligence, 2015, p. 1; M. Klafft, 'Online peer-to-peer lending: A lenders' perspective', Proceedings of the International Conference on E-Learning, EBusiness, Enterprise Information Systems, and E-Government, 2008, IEEE, p. 371-375.

[146] M. Klafft, 'Online peer-to-peer lending: A lenders' perspective', Proceedings of the International Conference on E-Learning, EBusiness, Enterprise Information Systems, and E-Government, 2008, *IEEE*, p. 371-375; M. Pokornáa and M. Sponera, 'Social lending and its risks', *Procedia - Social and Behavioral Sciences* 220, 2016, p.330-337.

[147] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 22.

infra).[148] For example, appraising the risk-reward ratio of a business investment requires detailed information about the project or business plan that P2P lenders usually do not have.[149] Several platforms allow lenders to download the historical financial and personal information with regard to all loans funded through the platform.[150] Creditworthiness assessments also allow platforms to rate loans with a grade that tries to capture the risk of default. The subsequent placement of loans in different risk categories helps to reduce the information asymmetry between the P2P lenders and borrowers as well. It is obvious that credit risk increases when P2P lending platforms fail to appropriately assess the creditworthiness of borrowers or when platforms fail to provide understandable and reliable explanations about a loan investment.[151]

Determinants of Default in P2P Lending. An important research project in this regard is 'Determinants of Default in P2P Lending' of the Spanish researchers C. Serrano-Cinca, B. Gutiérrez-Nieto and L. López-Palacios.[152] This empirical research investigates the relevance of the information provided by P2P lending platforms for lenders' decision-making and for lowering information asymmetry. More specifically, it deals with the question whether lenders should only focus on interest rates provided by the platform or whether they should analyse additional factors. The research uses data from Lending Club, the biggest US P2P lending company. Until recently, such research was not possible due to data availability on the loan status.

Grade assigned by the P2P lending company is the best default predictor. The research shows that the grade capturing the risk default assigned by the P2P lending platform is the best default predictor. The Spanish researchers demonstrate a clear relationship between the grade assigned by Lending Club and the probability of default: 94.4% of A-grade loans[153] were reimbursed in contrast to only 61.8% of the G-grade loans. As the interest rate assigned (mainly)

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[148] H. Yum, B. Lee and M. Chae, 'From the wisdom of crowds to my own judgment in microfinance through online peer-to-peer lending platforms', 2012, *Electron. Commer. R. A.* 11(5), p. 469-483.

[149] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 9.

[150] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 22.
For example, see Lendingclub.com: https://www.lendingclub.com/info/ download-data.action; Prosper.com: https://www.prosper.com/tools/DataExport.aspx and Kiva.org: http://build.kiva.org/docs/data/). This contrasts with common traditional bank practices.

[151] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 12.

[152] C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.

[153] A-grade loans are the loans with the lowest degree of risk and G-grade loans are the loans with the highest degree of risk.

depends on the grade assigned, the higher the interest rate, the higher the default risk is.[154] Therefore, the research question "whether lenders should only focus on interest rates provided by the platform" can be answered rather positively. To further decrease credit risk, lenders should take into account the loan purpose as a factor explaining default, with wedding the least risky and small business the riskiest loan purpose.[155] Borrower characteristics, such as annual income, current housing situation, credit history and borrower indebtedness are also relevant factors to predict loan default.[156] By contrast, no statistically significant differences are found with regard to the loan amount or the length of employment.

Trustworthiness borrowers' creditworthiness assessments (?) Creditworthiness assessments conducted by the P2P lending platform serve as the main tool for lenders to assess the credit risk of their (prospective) loans.[157] Therefore, lenders need to rely on the integrity and accuracy of these assessments.[158] This assumes that lenders must be confident that the incentives of the platform when conducting the creditworthiness assessments align with their investor interests.[159] This is not so obvious, as platforms may have a short run incentive to maximise loan volume with a view to increase their revenue, which may influence the stringency of creditworthiness assessments.[160] For example, platforms may develop borrowers profiles in a more appealing light in order to attract more investors. Competition between P2P lending platforms for borrower listings may have similar effects. The problem is that lenders are usually not in the position to assess the platform's reputation and probity, as there is little independent information available about the reputation of platforms (conflict of interest, see *infra*).

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[154] C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 1. See also: R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 694.

[155] C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 8.

[156] C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 6.

[157] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 2

[158] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 37-44.

[159] Finance Watch, 'Finance Watch response to the consultation Capital Markets Union mid-term review 2017 Brussels', 2017, http://www.finance-watch.org/, p. 5-6.

[160] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 37-44; Finance Watch, 'Finance Watch response to the consultation Capital Markets Union mid-term review 2017 Brussels', 2017, http://www.finance-watch.org/, p. 5-6.

1.1.3 Measures mitigating credit risk

Measures to reduce or mitigate credit risk. In order to have a full understanding of credit risk in P2P lending, worthwhile measures undertaken by P2P lending platforms to mitigate credit risk are discussed in this section.

Diversification. Diversification of loan portfolios is an increasingly used measure of P2P lending platforms to help lenders in mitigating credit risk.[161] The idea is that by diversifying the total investment through smaller loan parts across multiple loans, the costs of a loan default can be absorbed by the other holdings within the portfolio.[162] Examples of platforms which have diversification as a compulsory requirement for investing are Zopa, Alfluenta and Sinolending. Zopa requires borrowers to split each loan into £ 10 parts, to be spread out across multiple loans. In the passive P2P lending model, lenders have no control over the level of diversification as platforms select the number of loans funded by them. P2P lending platforms typically counteract this with compensation funds.

Compensation funds. P2P lending platforms also increasingly put forward compensation funds to mitigate credit risk.[163] The idea is that each borrower contributes a percentage of their overall loan in the compensation funds from which lenders are recompensed if a borrower is unable to pay back the loan.[164] Compensation funds can cover both redemption and interest payments. By means of a compensation fund, the loan default risk to a single investor is, in part, transformed into the risk that the fund will run out. If that happens, then in some models, the investor faces the loan default risk of their portfolio, while in other models the loan default risk for individual loans is shared across all investors (after buffer fund depletion).[165] Compensation funds can be expected to reduce uncertainty created by default during 'normal' times. However, in more severe economic scenarios funds are likely to run out quickly and no longer cover default losses.[166]

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[161] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 25.
[162] Ibid, p. 25.
[163] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 25; R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 695.
[164] S. Dunn, 'Fears grow over safety of 'peer-to-peer' savings after lender Quakle goes bust', *Daily Mail*, 2012; E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 25-26; R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 695.
[165] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 32.
[166] Ibid.

1.2 Regulatory framework

Credit risk in P2P lending: particular regulatory framework. Whereas the meaning of credit risk is the same in traditional lending and P2P lending, namely the risk that the borrower will fail to make the loan payments to the lender as agreed,[167] credit risk in P2P lending requires a fairly different approach than that of traditional lending. The reason is that P2P lending platforms do not grant loans nor assume credit risk by their own contractual positions, unlike banks, but decentralise the risk to the lenders.[168] This difference is reflected in different kind of regulations. Whereas the core element of traditional lending regulation is "to prevent banks from taking too much risk, so that their continued existence and functionality are not endangered", "the core element of platform regulation is not the platform itself, but rather the process in which capital is mediated between lenders and borrowers".[169] Therefore, P2P lending requires a regulatory framework that safeguards a fair and transparent lending process, whereby both parties to the loan transaction are well-informed and able to assess and carry credit risks taken, rather than regulatory measures such as equity loss-absorption buffers.[170] The deregulatory potential of blockchain technology for credit risk needs to be studied in the light of this particular framework (see *infra*).

Roadmap. In this section, we discuss several existing and proposed regulatory measures at EU level aimed at reducing credit risk. More specifically, we discuss (i) disclosure standards, (ii) suitability and appropriateness tests and (iii) creditworthiness assessments.

Preliminary note: distinction between P2P business lending and P2P consumer lending. Before discussing the regulatory measures addressing credit risk, it is important to see that regulatory measures provide a framework for either P2P business lending or P2P consumer lending. Regarding P2P business lending, including B2B and C2B lending, we focus on the European Commission's Proposal on European Crowdfunding Service Providers for Business

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[167] Corporate Finance Institute (CFI) , 'What is credit risk?', 2018, https://corporatefinanceinstitute.com/resources/knowledge/finance/credit-risk/; C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', 2015, p. 3, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4591266/?otool=ibekuleulib.

[168] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', Prepared for the 21st Melbourne Money and Finance Conference, Brighton, Victoria, July 2016, p. 6.

[169] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 698.

[170] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 698. See also: H. Yum, B. Lee and M. Chae, 'From the wisdom of crowds to my own judgment in microfinance through online peer-to-peer lending platforms', 2012, *Electron. Commer. R. A.* 11(5), p. 469.

(March 2018).[171] P2P loan services provided to consumers as defined in Article 3(a) of Directive 2008/48/EC (Consumer Credit Directive (CCD)) fall outside the scope of the proposal. In this regard, the proposal refers to the (partial) application of existing EU consumer protection legislations. More specifically, (i) when a consumer is receiving a loan for personal consumption and operating outside his professional capacity, P2P lending falls within the remit of the Consumer Credit Directive and (ii) when a consumer is receiving a loan to purchase an immovable property, P2P lending falls within the remit of the Mortgage Credit Directive. Therefore, regarding P2P consumer lending, we discuss the relevant regulatory measures laid down in EU consumer protection legislations with a focus on the CCD. Note that when P2P lending platforms offer both business lending services and consumer lending services, it is very likely that they need to comply with the most strict regulatory measures applicable.

1.2.1 Disclosure standards (protection for P2P lenders)

Disclosure standards. Given the significant asymmetric information problem in P2P lending, disclosure standards regarding the creditworthiness of borrowers and P2P lending risks are crucial to reduce credit risk for P2P lenders.

Disclosure standards for P2P business lending. With regard to P2P business lending, disclosure standards are laid down in Article 14 ('Information to clients') and Article 16 ('Key investment information sheet') of the Proposal on European Crowdfunding Service Providers for Business (hereafter: proposal). These disclosure standards mainly aim at protecting P2P lenders when they make investment decisions on the P2P lending platform.

Article 14: Information to clients. Pursuant to Article 14 of the proposal, P2P lending platforms must provide information about (i) the costs and charges related to crowdfunding services or investments, (ii) the crowdfunding conditions, including crowdfunding project selection criteria and (iii) the nature of and risks associated with their crowdfunding services to (potential) clients before they enter into a P2P lending transaction. This information must be available to all (prospective) clients on a clearly identified section of the website of the crowdfunding platform and in a non-discriminatory manner. Article 14 underlines that all

[171] European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business, Brussels, 8.3.2018 COM(2018) 113 final 2018/0048 (COD). Article 3(1)(a): 'crowdfunding service' means the matching of business funding interest of *investors* and project owners through the use of a crowdfunding platform and which consist of any of the following: the facilitation of granting of loans […]. Article 3(1)(g): 'investor' means *any person* that, through a crowdfunding platform, grants loans or acquires transferable securities.

information, including marketing communications, from crowdfunding service providers to (prospective) clients about themselves must be clear, comprehensible, complete and correct. The disclosure standards laid down in Article 14 aim to protect both P2P lenders and borrowers.

Article 16: Key investment information sheet. In addition and perhaps more importantly, Article 16 of the proposal requires P2P lending platforms to provide (prospective) investors (i.e. (prospective) lenders) with a clear, comprehensible and correct key investment information sheet. The main aim of this key investment information sheet is to warn prospective P2P lenders that the investing environment they have entered into entails risks and is covered neither by the deposit compensation scheme nor by investor compensation guarantees.[172] The key investment information sheet focuses on material information about the project owners, the investors' rights and fees and the type of securities.[173] An overview of the information to be provided in the key investment information sheet is presented in the Annex to the proposal.[174] Because the project owner concerned is in the best position to provide information about himself, the proposal provides that the key investment information sheet is drawn up by the project owner.[175] However, since the P2P lending platform is responsible for informing (prospective) investors, P2P lending platforms must have adequate procedures in place to verify the completeness, timeliness and the clarity of information contained in the key investment information sheet. It is clear that Article 16 of the proposal is (only) aimed at protecting P2P lenders.

Article 16: Explanatory statement and risk warning. It is noteworthy that the key investment information sheet also contains the following explanatory statement and risk warning, aimed at the protection of P2P lenders. First, the key investment information sheet contains the following explanatory statement, appearing directly underneath the title of the key investment information sheet: *"This crowdfunding offer has been neither verified nor approved by ESMA or national competent authorities. The appropriateness of your education and knowledge have not been assessed before you were granted access to this investment. By making this investment, you assume full risk of taking this investment, including the risk of partial or entire loss of the money*

[172] Recital 31 of the Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113.
[173] Recital 32 of the Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113.
[174] For an overview of the information to be provided in the key investment information sheet, see ANNEX to the Proposal for a Regulation of the European Parliament and of the Council on European Crowdfunding Service Providers (ECSP) for Business {SWD(2018) 56 final} - {SWD(2018) 57 final}, Brussels, 8.3.2018 COM(2018) 113 final, ANNEX.
[175] Recital 32 of the Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113.

invested." Second, the key investment information sheet contains the following risk warning: "*Investment in this crowdfunding offer entails risks, including the risk of partial or entire loss of the money invested. Your investment is not covered by the deposit guarantee and investor compensation schemes established in accordance with Directive 2014/49/EU of the European Parliament and of the Council* and Directive 97/9/EC of the European Parliament and of the Council.** You may not receive any return on your investment. This is not a saving product and you should not invest more than 10% of your net wealth in crowdfunding projects. You may not be able to sell the investment instruments when you wish."*

Disclosure standards for P2P lending platforms sufficiently far-reaching to reduce credit risk? Although the disclosure standards laid down in Article 14 of proposal are fairly extensive, they do not empower lenders to conduct a risk-return analysis by comparing the performance statistics of competing P2P lending platforms.[176] In addition, although understandable from a business point of view, there are also no disclosure standards regarding platforms' credit risk assessment methods.[177] Both elements make it impossible for lenders to assess and compare the quality of platforms and so make a careful selection of the "right" platform.[178]

Disclosure standards for P2P consumer lending. P2P consumer lending falls outside the scope of the Proposal on European Crowdfunding Service Providers for Business (see *supra*).[179] Although the proposal refers for P2P consumer lending to the application of the Consumer Credit Directive (CCD), this cannot be taken for granted.[180] The reason is that P2P lending platforms do not easily fall into the scope of the CCD.[181] In particular, the concept of 'creditor'

[176] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 695. "Although platforms usually publish investment statistics including gross interest rates, bad debt rates and default rates on its website and clients normally receive monthly performance statistics for their individual portfolio, comparing performance statistics of competing P2P lending platforms is difficult as the methods used for calculating the risk-adjusted net returns differ considerably from platform to platform because there is not yet a common standard for measuring the performance of P2P-loan investments."
[177] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 698-99.
[178] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 699.
[179] European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business, Brussels, 8.3.2018 COM(2018) 113 final 2018/0048 (COD), p. 2.
[180] Directive 2008/48/EC of the European Parliament and of the Council of 23 April 2008 on credit agreements for consumers (herafter: CCD); Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113.
[181] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31. See also with regard to the Belgian transposition law: D. Raes, 'Le *peer to peer lending* en droit belge – Espoir ou désespoir' in H. Daems, I. De Meuleneere, C. Houssa and N. Ragheno, *Digital finance / La finance numérique*, 2016, Anthemis, p. 98.

is difficult. The CCD applies to credit agreements between a creditor and a consumer. In this regard, 'credit agreement' means "an agreement whereby a creditor grants or promises to grant to a consumer credit in the form of a deferred payment, loan or other similar financial accommodation […]" (Article 3(c)).[182] 'Creditor' means a natural or legal person who grants or promises to grant credit in the course of his trade, business or profession (Article 3(b)).[183] The definition of 'creditor' leads to three considerations. First, the CCD is only applicable to B2C lending (and is, therefore, not applicable to C2C lending).[184] Consumers cannot be considered as 'creditor' in the meaning of the CCD as they do not grant or promise to grant credit *in the course of [their] trade, business or profession*. The exclusion of C2C lending from the scope of CCD is problematic as there is currently no (similar) legal protection for consumer lenders and borrowers in C2C lending. Second, P2P lending platforms are no 'creditor' as they do not grant nor promise to grant credit.[185] In P2P lending, lenders grant or promise to grant the credit themselves. As a result, P2P lending platforms do not fall within the principal scope of application of the CCD. However, this does not mean that P2P lending platforms completely fall outside the scope of the CCD as the CCD also regulates certain obligations of credit intermediaries in relation to consumers (see *infra*).[186] '[C]redit intermediary' is defined as "a natural or legal person who is not acting as a creditor and who, in the course of his trade, business or profession, for a fee […]: (i) presents or offers credit agreements to consumers; (ii) assists consumers by undertaking preparatory work in respect of credit agreements other than as referred to in (i); or (iii) concludes credit agreements with consumers on behalf of the creditor" (Article 3(f)). It is highly probable that P2P lending platforms qualify as 'credit intermediary' in the meaning of the CCD (see *infra*).[187] Here too, the limitation applies that the CCD is only applicable to B2C lending with the same problem that there is currently no (similar) legal protection for consumer lenders and borrowers in C2C lending.[188] A special note

[182] D. Raes, 'Le *peer to peer lending* en droit belge – Espoir ou désespoir' in H. Daems, I. De Meuleneere, C. Houssa and N. Ragheno, *Digital finance / La finance numérique*, 2016, Anthemis, p. 98.
[183] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31.
[184] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31; D. Raes, 'Le *peer to peer lending* en droit belge – Espoir ou désespoir' in H. Daems, I. De Meuleneere, C. Houssa and N. Ragheno, *Digital finance / La finance numérique*, 2016, Anthemis, p. 99.
[185] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31.
[186] Recital 17 of the CCD. See also: European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31, fn. 27.
[187] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31, fn. 27.
[188] D. Raes, 'Le *peer to peer lending* en droit belge – Espoir ou désespoir' in H. Daems, I. De Meuleneere, C. Houssa and N. Ragheno, *Digital finance / La finance numérique*, 2016, Anthemis, p. 100. See also: C. Lewalle et

should be made for the notary model in which a commercial bank grants credit to borrowers. It is highly probable that the commercial bank can be considered as 'creditor' in the meaning of the CCD, with the result that the bank needs to comply with the disclosure standards set out in the CCD. The discussion of the disclosure standards applicable on those banks is beyond the scope of the research paper. Third, it is highly probable that lenders in B2C lending are 'creditor' under the CCD. Further research is needed to ascertain the implications of this, in particular regarding the disclosure standards imposed on creditors (see *supra*).

Disclosure standards for P2P lending platforms: CCD. The CCD provides "only certain obligations of credit intermediaries in relation to consumers".[189] These obligations aim at protecting borrowers. Note that the CCD does not contain disclosure standards for lenders, which is problematic in the particular (regulatory) framework of P2P lending in which P2P lenders assume credit risk and asymmetric information is a significant problem. First and foremost, the qualification of P2P lending platforms as 'credit intermediary' means that the pre-contractual information duties (Article 5) are applicable on P2P lending platforms.[190] Recital (24) provides: "The consumer needs to be given comprehensive information before he concludes the credit agreement, regardless of whether or not a credit intermediary is involved in the marketing of the credit. Therefore, in general, the pre-contractual information requirements should also apply to credit intermediaries." Pre-contractual information relevant for addressing credit risk includes: (a) the type of credit; (c) the total amount of credit and the conditions governing the drawdown; (d) the duration of the credit agreement; (f) the borrowing rate, the conditions governing the application of the borrowing rate; (g) the annual percentage rate of charge and the total amount payable by the consume; (h) the amount, number and frequency of payments to be made by the consumer (l) the interest rate applicable in the case of late payments and the arrangements for its adjustment, (m) a warning regarding the consequences of missing payments; (n) where applicable, the sureties required; (o) the existence or absence of a right of withdrawal; (p) the right of early repayment, and, where applicable, information concerning the creditor's right to compensation and the way in which that compensation will be determined. Second, the qualification of P2P lending platforms as 'credit intermediary' means that P2P lending platforms have a duty to assist the consumer in deciding

S. Decoster, 'Le crowdfunding : règlementation applicable, enjeux et perspectives', *Rev. Banc. et Fin*., 2014/6, p. 455.

[189] Recital 16 of the CCD. See also: European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31

[190] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31, fn. 27.

which credit agreement, within the range of products proposed, is the most appropriate for his needs and financial situation (recital (27)).[191] Although this duty seems to suggest an appropriateness test for lenders, it remains limited to disclosure standards (suitability and appropriateness tests, see *infra*). Pursuant to Article 5, paragraph 6, member states shall ensure that credit intermediaries provide adequate explanations to the consumer, in order to place the consumer in a position enabling him to assess whether the proposed credit agreement is adapted to his needs and to his financial situation, where appropriate by explaining the pre-contractual information to be provided (see *supra*), the essential characteristics of the products proposed and the specific effects they may have on the consumer, including the consequences of default in payment by the consumer.

1.2.2 Suitability and appropriateness tests (protection for P2P lenders)

Entry knowledge test of investors for P2P business lending. To ensure that P2P loan investments are appropriate to P2P lenders, Article 15 of the Proposal on European Crowdfunding Service Providers for Business requires P2P lending platforms to assess whether and which crowdfunding services offered are appropriate for (prospective) investors. In this regard, platforms must request information about the prospective investor's basic knowledge and understanding of risk in investing in general and in the types of investments offered on the crowdfunding platform.[192] This includes information about (i) the prospective investor's past investments in transferable securities or loan agreements and (ii) any relevant knowledge or professional experience in relation to crowdfunding investments. If prospective investors do not provide the information required, or when platforms consider that the prospective investors have insufficient knowledge, platforms must explicitly warn prospective investors that the services offered on their platforms may be inappropriate for them. However, this risk warning does not prevent (prospective) investors from investing in crowdfunding projects.

Simulation of the ability to bear loss. In addition, the proposal provides that P2P lending platforms shall at all times offer (prospective) investors the possibility to simulate their ability to bear loss, calculated as 10% of their net worth, based on the following information: (i) regular income and total income, and whether the income is earned on a permanent or temporary basis; (ii) assets, including financial investments, personal and investment property, pension funds

[191] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', EBA/Op/2015/03, p. 31, fn. 27.
[192] European Commission, 'Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113.

and any cash deposits; and (iii) financial commitments, including regular, existing or future. Here also, irrespective of the results of the simulation, investors are not prevented from investing in crowdfunding projects. This measure mainly protects P2P lenders.

Suitability and appropriateness test of prospective investors for P2P consumer lending. In P2P consumer lending, there is currently no suitability or appropriateness test of (prospective) investors. Consideration needs to be given to the introduction of suitability and appropriateness tests in P2P consumer lending as well, i.e. C2C lending and B2C lending. In particular, when we remember that P2P lenders does not usually have the financial literacy and investment experience to properly assess credit risk of P2P lending (see Chapter I), such tests are crucial.[193] Inspiration can be taken from the entry knowledge test of investors of the Proposal on European Crowdfunding Service Providers for Business (see *supra*) or from the suitability and appropriateness test provided in Article 25, paragraph 2, of MiFID II.[194] In the vein of this latter test, P2P lending platforms should obtain the following information from an investor prior to concluding the loan agreement: (i) that person's knowledge and experience of the investment field relevant to the specific type of loan, (ii) that person's financial situation including his ability to bear losses; and (iii) that person's investment objectives including his risk tolerance. The important discussion about which P2P lending platforms (and for which services) fall under MiFID II is beyond the scope of this research paper.

1.2.3 Creditworthiness assessments (protection for P2P lenders and borrowers)

Creditworthiness assessments of P2P lending borrowers. Creditworthiness assessments aim at protecting lenders when making an investment decision on the P2P lending platform and borrower when entering into a P2P loan agreement. Article 8 of the Consumer Credit Directive lays down the obligation to assess the creditworthiness of consumers on the basis of sufficient information, where appropriate obtained from the consumer and, where necessary, on the basis of a consultation of the relevant database.[195] However, Article 8 imposes this obligation on the

[193] M. Herzenstein, R. L. Andrews, U. Dholakia and E. Lyandres, 'The democratization of personal consumer loans? Determinants of success in online peer-to-peer lending communities', Boston University School of Management Research Paper, 2009, p. 14; C. Serrano-Cinca, B. Gutiérrez-Nieto, and L. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.
[194] Directive 2014/65/EU of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending Directive 2002/92/EC and Directive 2011/61/EU (hereafter: MiFID II)
[195] See also Article 18 of the Directive 2014/17/EU of the European Parliament and of the Council of 4 February 2014 on credit agreements for consumers relating to residential immovable property and amending Directives 2008/48/EC and 2013/36/EU and Regulation (EU) No 1093/2010 (Mortgage Credit Directive): *"Member States shall ensure that, before concluding a credit agreement, the creditor makes a thorough assessment of the*

creditor, i.e. the P2P lender, without extending this obligation to credit intermediaries. The Proposal on European Crowdfunding Service Providers for Business does not contain any provision regarding creditworthiness assessments of borrowers at all. Given the significant asymmetric information problem in P2P lending and insufficient pre-contractual information standards (see *supra*), it is problematic that there are no regulatory measures that require P2P lending platforms to conduct qualitative creditworthiness assessments of borrowers. A legitimate question in the context of P2P consumer lending is whether the objectives set out in Recital (26) of the CCD regarding responsible lending can still be achieved: "Member States should take appropriate measures to promote responsible practices during all phases of the credit relationship, taking into account the specific features of their credit market. Those measures may include, for instance, the provision of information to, and the education of, consumers, including warnings about the risks attaching to default on payment and to over-indebtedness. In the expanding credit market, *in particular, it is important that creditors should not engage in irresponsible lending or give out credit without prior assessment of creditworthiness* […]*"*.[196] More in general, there is a need to ascertain what kind of creditworthiness assessments are needed to ensure responsible lending in P2P lending and therefore, to combat over-indebtedness of borrowers. In addition, we have to remember that creditworthiness assessments provide (the most) crucial tool for lenders to assess credit risk in P2P lending (information asymmetry in P2P lending, see *supra*).[197]

1.2.4 Other regulatory measures addressing credit risk (protection for lenders)

Other regulatory measures which address credit risk. Finally, we want to provide a brief overview of regulatory measures proposed by EBA to address credit risk in P2P lending. All regulatory measures aim at protecting the lender when making a loan investment decision.

(i) Obligatory due diligence procedure. First, EBA proposes obligatory due diligence procedures on any investment advertised on the P2P lending platform, possibly above a certain threshold, before advertising the investment on the platform's website.[198] In this way, EBA aims to meet the risk that lenders underestimate the risks of an investment assuming that every

consumer's creditworthiness. That assessment shall take appropriate account of factors relevant to verifying the prospect of the consumer to meet his obligations under the credit agreement."

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[197] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature Review, *Journal of Internet Banking and Commerce*, vol. 16, no.2, 2011, p. 7; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 22.

[198] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 20.

project advertised on a platform is subject to due diligence. Such due diligence procedure would at least include the risk assessment of the investment project.[199] The results of the due diligence procedure would be disclosed to enable P2P lenders to make an informed investment decision.[200] According to EBA, one should consider to oblige platforms to reject projects which do not pass the due diligence procedure. It is noteworthy that EBA discusses this regulatory measure outside the context of creditworthiness assessments, whilst such due diligence procedures are usually part of creditworthiness assessments.

(ii) Categorization of lenders in risk categories. Second, EBA suggests that P2P lending platforms could be required to check and evaluate the financial literacy and investment experience of lenders and to categorise them accordingly in risk categories.[201] A lender would only be permitted to invest in opportunities that are intended for lenders of his risk category. This (highly) controversial regulatory measure is reminiscent of the product governance rules laid down in Article 24, paragraph 2.[202]

(iii) Investment limits. Third, EBA suggests that investment limits for lenders or per category of lenders could be established.[203] For example, lenders could only be permitted to invest a maximum amount per project, within a certain period of time or depending on his income. To ensure adherence to investment limits, platforms would be obliged to ask lenders to confirm that they comply with the statutory limit and will not exceed the limit due to the intended investment in a particular offering.[204] This regulatory measure is also controversial and may be received by some as too paternalistic.

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[199] Ibid.
[200] Ibid.
[201] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 19.
[202] Article 24, paragraph 2 of MiFID II stipulates: "Investment firms which manufacture financial instruments for sale to clients shall ensure that those financial instruments are designed to meet the needs of an identified target market of end clients within the relevant category of clients, the strategy for distribution of the financial instruments is compatible with the identified target market, and the investment firm takes reasonable steps to ensure that the financial instrument is distributed to the identified target market. An investment firm shall understand the financial instruments they offer or recommend, assess the compatibility of the financial instruments with the needs of the clients to whom it provides investment services, also taking account of the identified target market of end clients as referred to in Article 16(3), and ensure that financial instruments are offered or recommended only when this is in the interest of the client."
[203] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 19.
[204] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 19.

2. Fraud

2.1 Fraud

Fraud. Another significant risk for P2P lenders is fraud. Fraud is the "misrepresentation or concealment with reference to some fact material to a transaction that is made with knowledge of its falsity or in reckless disregard of its truth or falsity and with the intent to deceive another and that is reasonably relied on by the other who is injured thereby."[205] Loan fraud refers to the providing of false information or the concealing of relevant information when applying for or receiving a loan.[206] If a lender lends money to a borrower whose sole intent is obtain funds fraudulently, this can be damaging in several ways. First and foremost, lenders will obviously lose money when the fraudulent borrower defaults on the loan. Second, lenders will lose confidence in the ability of the platform to accurately secure legitimate borrowers. The risk of fraud for lenders can be situated at both the borrower level (the borrower acts fraudulently) and the platform level (the platform is not secure or able to cope with fraud).

P2P lending is particularly sensitive to fraud. The benefits of cyberspace-low entry barriers, user anonymity and spatial and temporal separation between loan parties make P2P lending platforms a fertile field for fraud.[207] The anonymity of P2P lending provides opportunities for borrowers to act under false pretences and to offer fake investment opportunities.[208] The geographical separation between borrowers and lenders may prohibit lenders from physically overseeing the (business) project in which they invest. For these reasons, it is highly important for P2P lending platforms to ensure that they obtain sufficient identification and contact information about borrowers, including evidence, especially because retail investors may not

[205] J.J. Xu, Y. Lu and M. Chau, 'P2P Lending Fraud Detection': A Big Data Approach' in H. Chen and C.C. *Intelligence and Security Informatics*, 2008, Springer, p. 71-81, referring to the Merriam-Webster's Dictionary of Law.

[206] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 14.

[207] C. Camp, 'Bitcoin may help criminals, but blockchain can help thwart fraud', *American Banker*, 2016, Vol. 181 Issue 91, http://www.americanbanker.com/bankthink/bitcoin-may-help-criminals-but-blockchain-can-help-thwart-fraud-1080937-1.html; B. Xiao and I. Benbasat, 'Product-related deception in e-commerce: A theoretical perspective', 2011, *MIS Q*, p. 35(1):169–196; J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2-25.

[208] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 14; E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 26.

know what information to ask for that would lessen the risk of fraud.[209] It is obvious that the risk of fraud increases if platforms fail to conduct thorough anti-fraud checks on borrowers.

Different forms of fraud in P2P lending. Fraud appears in different forms in P2P lending. Perhaps the most important form of fraud is identity fraud, where borrowers are using fake IDs and are registering with a fake IP address.[210] The risk of identity fraud increased due to the quick loan acceptance process and the absence of face-to-face meetings between the platform's staff and the borrowers. Related to this, the risk of personal data being stolen or misused (also relevant for borrowers) need to be mentioned.[211] The risk arises if the platform has no sufficiently robust document handling policy or when such a policy is not properly implemented, leading to the loss of data.[212] Another important form of fraud in P2P lending is herding effect fraud, where borrowers intend to attract investors by conveying an image of creditworthiness by investing money in their own project.[213]

Preventing fraud. In some countries, the industry itself has taken the initiative for self-regulation to mitigate fraud.[214] Some platforms report that they manually check each borrower for fraudulent motivations before allowing them to advertise for lenders on their sites; other platforms use third party information as well as checking the identity of the borrowers before originating the loans.[215] Social media is increasingly used as a tool in fraud prevention as it allows investors to perform research on the borrowers before deciding if they want to invest. Of course, this is only possible when borrowers are not kept anonymous. In most P2P lending platforms, names of businesses are made public, while private individuals are kept anonymous. Platforms also experiment with fraud detection mechanisms.

[209] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 26.
[210] C. Naidji, 'Regulation of European peer-to-peer lending Fintechs Regulatory framework to improve SME's access to capital', Working Papers, KU Leuven, 2017, p. 37.
[211] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 14.
[212] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 14.
[213] C. Naidji, 'Regulation of European peer-to-peer lending Fintechs Regulatory framework to improve SME's access to capital', Working Papers, KU Leuven, 2017, p. 37.
[214] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 26.
[215] Ibid.

2.2 Regulatory framework

Regulatory framework. At EU level, there is no harmonised regulation of fraud. Fraud is mainly addressed by national civil and criminal law. However, it is worthwhile to consider the proposal of EBA to require P2P lending platforms to conduct background checks on borrowers.[216] According to EBA, platforms should be obliged to request identification information, addresses, information about financial status/creditworthiness and potential criminal records from borrowers and lenders, including evidence.[217] Furthermore, EBA considers that platforms should be required to deny access to their website if they have reason to believe that a (prospective) P2P lending party might potentially act fraudulently.[218]

3. Money laundering

3.1 Money laundering

Money laundering. P2P lending platforms may also be misused for or shut down due to money laundering activities.[219] The Fourth Anti-Money Laundering Directive defines money laundering as the following conduct, when committed intentionally:[220]

(a) the conversion or transfer of property, knowing that such property is derived from criminal activity or from an act of participation in such activity, for the purpose of concealing or disguising the illicit origin of the property or of assisting any person who is involved in the commission of such an activity to evade the legal consequences of that person's action;

(b) the concealment or disguise of the true nature, source, location, disposition, movement, rights with respect to, or ownership of, property, knowing that such property is derived from criminal activity or from an act of participation in such an activity;

[216] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 20.
[217] Ibid.
[218] Ibid.
[219] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 18.
[220] Article 1, paragraph 3 of the Directive (EU) 2015/849 of the European Parliament and of the Council of 20 May 2015 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing, amending Regulation (EU) No 648/2012 of the European Parliament and of the Council, and repealing Directive 2005/60/EC of the European Parliament and of the Council and Commission Directive 2006/70/EC (AMLD).

(c) the concealment or disguise of the true nature, source, location, disposition, movement, rights with respect to, or ownership of, property, knowing that such property is derived from criminal activity or from an act of participation in such an activity;

(d) participation in, association to commit, attempts to commit and aiding, abetting, facilitating and counselling the commission of any of the actions referred to in points (a), (b) and (c).

The International Monetary Fund (IMF) defines money laundering as "the process of conducting financial transactions in a manner that obscures the link between funds and their origin".[221] Money laundering poses a real threat to the financial sector, including the P2P lending sector.[222] The risk of money laundering arises due to a lack of, or insufficient customer due diligence with regard to addresses, creditworthiness, criminal records, etc.[223]

3.2 Regulatory framework

Proposal on European Crowdfunding Service Providers for Business. The European Commission's Proposal on European Crowdfunding Service Providers for Business recognises that P2P lending as any other financial service may be exposed to money laundering.[224] Therefore, it provides several safeguards to minimise the risk that such practices are carried out. First and foremost, Article 9 requires that all payments for P2P lending transactions must take place via entities that are authorised under the Payment Services Directive (PSD II) and, therefore, subject to the 4th Anti-Money Laundering Directive (AMLD) (see *infra*). Second, Article 10 introduces requirements for the 'good repute' of managers, which include not having any criminal record under anti-money laundering legislations. Third, Article 13 requires National Competent Authorities (NCAs), including national competent authorities designated under the provisions of Directive (EU) 2015/849, to notify ESMA of any issue that is relevant

[221] International Monetary Fund, 'IMF and the Fight Against Money Laundering and the Financing of Terrorism', 2018, http://www.imf.org/en/About/Factsheets/Sheets/2016/08/01/16/31/Fight-Against-Money-Laundering-the-Financing-of-Terrorism. See also: D. DCosta, 'Blockchain for AML – Harnessing Blockchain Technology to Detect and Prevent Money Laundering', *International Banker*, 2017, https://internationalbanker.com/technology/blockchain-aml-harnessing-blockchain-technology-detect-prevent-money-laundering/.

[222] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 20.

[223] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 18.

[224] European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business, Brussels, 8.3.2018 COM(2018) 113 final 2018/0048 (COD), p. 10.

under the Anti-Money Laundering Directive (AMLD) and involving a P2P lending platform. ESMA may subsequently withdraw the license based on this information.

Important obligations laid down in the AMLD to reduce money laundering. The following two obligations imposed on obliged entities under the Fourth AMLD are important in the context of money laundering in P2P lending.[225] First, the obligation to identify and assess the risks of money laundering, taking into account risk factors including those relating to their customers, countries or geographic areas, products, services, transactions or delivery channels (Article 7). In this regard, the AMLD requires obliged entities under the Directive to have policies, controls and procedures in place to mitigate and manage effectively the risks of money laundering. Second, the obligation to perform due diligence measures to reduce money laundering (Article 13). Such due diligence measures include (i) identifying the customer and verifying the customer's identity, (ii) assessing and, as appropriate, obtaining information on the purpose and intended nature of the business relationship and (iii) conducting ongoing monitoring of the business relationship including scrutiny of transactions undertaken throughout the course of that relationship to ensure that the transactions being conducted are consistent with the obliged entity's knowledge of the customer, the business and risk profile.

P2P consumer lending within the scope of the AMLD? The European Commission's Proposal on European Crowdfunding Service Providers for Business does not apply to P2P consumer lending (see credit risk, *supra*). However, the risk of money laundering is also significant in P2P consumer lending. Therefore, in the light of the recent European Commission's proposal to amend the Fourth Anti-Money Laundering Directive (AMLD) (2016), which aims to address the issue of insufficient monitoring of suspicious transactions made through virtual currencies by the authorities, it is worth investigating whether P2P lending platforms fall within the scope provided in this proposal.[226]

5th AMLD: **P2P lending platforms do not fall within the extended scope of the Fifth AMLD**. From the impact assessment prior to the proposal to amend the Fourth AMLD, it appears that suspicious transactions made through virtual currencies are not sufficiently

[225] Directive (EU) 2015/849 of the European Parliament and of the Council of 20 May 2015 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing, amending Regulation (EU) No 648/2012 of the European Parliament and of the Council, and repealing Directive 2005/60/EC of the European Parliament and of the Council and Commission Directive 2006/70/EC.

[226] European Commission, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive (EU) 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing and amending Directive 2009/101/EC, Strasbourg, 5.7.2016, COM(2016) 450 final 2016/0208 (COD).

monitored by the authorities, which are unable to link the transactions to identified persons.[227] Therefore, the proposed amendments to the Fourth AMLD extend the list of obliged entities under the AMLD to 'virtual currency exchange platforms'[228] as well as 'custodian wallet providers',[229] being the foremost gatekeepers that control access to virtual currencies.[230] P2P lending platforms do not fall within the scope of the Fifth AMLD as they are neither 'virtual currency exchange platforms' nor 'custodian wallet providers'. Recital (7) of the proposal to amend the Fourth AMLD recognises this: "The inclusion of virtual exchange platforms and custodian wallet providers will not entirely address the issue of anonymity attached to virtual currency transactions, as a large part of the virtual currency environment will remain anonymous because users can also transact without exchange platforms or custodian wallet providers."

Approaches to bring P2P lending platforms within the scope of the AMLD. There are at least three approaches conceivable to bring P2P lending platforms within the scope of the AMLD. First, the scope of the AMLD could be extended to include P2P lending platforms. Second, in the case that P2P lending platforms fall within the scope of MiFID II, they are automatically subject to the AMLD through a cross-reference in Article 3(2)(c) of the AMLD (see credit risk, *supra*).[231] Third, to the extent that P2P lending platforms provide certain payment services within the meaning of the Payment Services Directive (PSD II), they are also

[227] European Commission, COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Accompanying the document Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business and Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2014/65/EU on markets in financial instruments {COM(2018) 113} - {COM(2018) 99} - {SWD(2018) 57}, Brussels, XXX SWD(2018) 56, p. 27.

[228] Article 2(1)(g): 'virtual exchange platforms' are "providers engaged primarily and professionally in exchange services between virtual currencies and fiat currencies".

[229] Article 2(1)(h): 'custodian wallet providers' are "wallet providers offering custodial services of credentials necessary to access virtual currencies". To put it more simply, 'custodian wallet providers' are entities that provide services to safeguard private cryptographic keys on behalf of their customers, to hold, store and transfer virtual currencies.

[230] European Commission, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive (EU) 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing and amending Directive 2009/101/EC, Strasbourg, 5.7.2016, COM(2016) 450 final 2016/0208 (COD); Article 3(18): 'virtual currency' is defined as "a digital representation of value that is neither issued by a central bank or a public authority, nor necessarily attached to a fiat currency, but is accepted by natural or legal persons as a means of payment and can be transferred, stored or traded electronically".

[231] See the cross-reference in Article 3(2)(c) Directive 2005/60/EC of the European Parliament and of the Council of 26 October 2005 on the prevention of the use of the financial system for the purpose of money laundering and terrorist financing.

subject to the AMLD (see *supra*).[232] In this regard, a similar legal provision to Article 9 of the European Commission's Proposal on European Crowdfunding Service Providers for Business that requires that all payments for P2P lending transactions must take place via entities that are authorised under the Payment Services Directive (PSD II) and therefore subject to the AMLD could be considered (see *supra*). The important discussion about which P2P lending platforms and for which services fall under MiFID II and the PSD II is beyond the scope of this research paper.

4. Hacking

4.1 Hacking

Online malicious activities and hacking. The benefits of cyberspace-low entry barriers, user anonymity, and spatial and temporal separation between users make P2P lending platforms also a fertile field for other online malicious activities.[233] In particular, the risk of cyber-attacks is significant in P2P lending.[234] Cyber-attacks come in many forms, from overloading the platform's infrastructure to damaging or destroying a computer network or system and confusing accounts and identity theft. Perhaps the most important form of cyber-attacks in P2P lending is hacking. Hacking is the unauthorised intrusion into a computer or mobile device connected to the P2P lending network, usually with the intention to modify or insert data on the platform.[235] The centralised data-storage and management systems make P2P lending platforms significantly susceptible to hacking and other kind of intrusions.[236]

4.2 Regulatory framework

At EU level, there is no harmonised regulation of hacking. Hacking is mainly addressed by national civil and criminal law. In addition, hacking is no specific risk of P2P lending.

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[232] Directive 2007/64/EC of the European Parliament and of the Council of 13 November 2007 on payment services in the internal market amending Directives 97/7/EC, 2002/65/EC, 2005/60/EC and 2006/48/EC and repealing Directive 97/5/EC.
[233] X. B. Benbasat, 'Product-related deception in e-commerce: A theoretical perspective', *MIS Q* 35(1), 2011, p. 169–196.
[234] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 18; E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 5 and 26; R. Tendulkar, 'Cyber-crime, securities markets and systemic risk', IOSCO Research Department Staff Working Paper, 2013, p. 2.
[235] D. Efanov and P. Roschin, 'The All-Pervasiveness of the Blockchain Technology', *Procedia Computer* Science 123, 2018, p. 119.
[236] Ibid.

Therefore, the discussion of the regulatory framework is beyond the scope of the research paper.

5. Liquidity risk

5.1 Liquidity risk

Liquidity risk. Another important risk assumed by P2P lenders is liquidity risk.[237] Liquidity risk is the risk stemming from the lack of marketability of an investment that cannot be bought or sold quickly enough to prevent or minimise a loss.[238] Lenders may face liquidity problems if, after the loan is given out, the repayments do not follow the agreed terms or if its position cannot be unwounded before the term of the contract.[239] This risk arises due to a lack of, or an insufficient timeline of fund availability, and when the lender does not have the possibility to access the provided funds before the term of the loan. This risk plays an important role for institutional lenders, which generally require some asset liquidity and therefore need an opportunity to exist their investments.[240]

P2P lending without secondary markets. In particular for lenders who cannot rely on secondary markets, liquidity risk is important to consider. [241] The reason is that such lenders cannot liquidate their investments by selling loans held to other investors. As long as borrowers are abiding by the terms of the loan agreement, lenders have no legal right to access their capital early. This is problematic given that most P2P lending platforms are facilitating loans with a fixed maturity from one to seven years, with an average of three years.[242] On the other hand, P2P lending platforms without secondary markets often offer liquidity services. For example, Funding Circle in the UK allows its business customers to repay loans early, with their automated bidding re-investing funds in new loan applications.[243] Another example is Zopa

[237] S.C. Moenninghoff and A. Wieandt, 'The Future of Peer-to-Peer Finance', *Z betriebswirtsch Forsch* 65, 2013, p. 466.
[238] A.J. McNeil, R. Frey and P. Embrechts, *Quantitative Risk Management: Concepts, Techniques and Tools - Revised Edition*, Princeton, Princeton University Press, 2015, p. 5.
[239] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 16.
[240] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy, EJRR* 4, 2016, p. 688.
[241] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 5.
[242] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43; E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 6 and 10.
[243] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 21-22.

Classic allowing investors to sell loans they hold for a fee.[244] Although these liquidity services address liquidity risk to a certain extent, they involve a significant discount to the face value. P2P lending platforms are also at a competitive disadvantage relative to banks in providing such liquidity services, as they do not have access to money market funding or to central bank liquidity.

P2P lending with secondary markets. There is the potential for P2P lending platforms to develop secondary markets enabling investors to liquidate investments by selling loans held to other investors (or to the P2P lending platform acting as a market maker) and platforms increasingly do provide such facility.[245] Secondary markets allow lenders to access their funds before maturity to sell their remaining loans to other investors. Note that the purpose of these secondary markets is not to provide liquidity transformation. The underlying asset remains the key determinant to the liquidity of the investment, and the ability to sell the remaining loans is not guaranteed. Most platforms charge for the use of secondary markets, and investors may also face additional costs or losses when they sell their remaining loans if interest rates have moved against them. While the tradability of loans can reduce liquidity risk, the downside is an additional market risk in the form of fluctuating market prices of the loans.

Presence secondary markets does not mean excessive use of them. The presence of secondary markets does not mean that P2P lenders have recourse on them. From the Oxera analysis it appears that annual secondary market transactions in the UK comprise less than one-quarter of the size of the loan book in all cases and much lower than one-quarter on some of the platforms.[246] Generally, the larger the P2P lending platform in terms of loan volumes the more active the secondary market is. This does not mean that investors do not value the option of using secondary markets, but it does suggest that lenders consider the investment in line with the characteristics of the underlying asset. Another suggestion is that investors understand the fees involved in exiting investments early.[247]

5.2 Regulatory framework

Proposal on European Crowdfunding Service Providers for Business. In order to address liquidity risk, which is borne by P2P lenders, the Proposal on European Crowdfunding Service

[244] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 21-22.
[245] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43.
[246] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 45.
[247] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 45.

Providers for Business establishes that the key investment information sheet to each prospective investor includes the risk warning **"***You may not be able to sell the investment instruments when you wish."* (Article 14) (see credit risk, *supra*). In addition, the proposal requires platforms that allow their investors to interact directly with each other to buy and sell loan agreements to inform their clients that they do not operate a trading system and that such buying and selling activity on their platforms is at the client's own discretion and responsibility (Article 17). Platforms that suggest a reference price for the buying and selling of loan agreements must inform their clients that the suggested reference price is non-binding and substantiate the suggested reference price (Article 17). The regulatory measures above rely on disclosure standards to address liquidity risk without really touching upon the liquidity problem itself. A possible reason for this is that P2P lenders themselves bear liquidity risk (see *supra*). Further research is needed to decide upon whether these disclosure standards are sufficient to address liquidity risk. The relatively low usage of secondary markets in P2P lending suggests that investors treat P2P lending (rather) as a long-term investment, which puts the seriousness of liquidity risk into perspective.[248] The regulatory framework for P2P consumer lending does not currently have similar provisions to address liquidity risk. Inspiration can certainly be drawn from the Proposal on European Crowdfunding Service Providers for Business.

EBA Opinion on lending-based crowdfunding. Regulatory measures to address liquidity risk must go beyond provisions on secondary markets as several P2P lending platforms (also) offer liquidity services (see Chapter I, *supra*). In this regard, the European Banking Authority (EBA) proposes in its 'Opinion on lending-based crowdfunding' to require P2P lending platforms to inform lenders of their rights to cancel a contract prior to maturity, if any. According to EBA, platforms should offer a true, clear and complete explanation of their legal and contractual termination rights.[249] This includes the explicit disclosure on their website of the exact point in time at which it would no longer be possible to terminate the investment prior to maturity.[250] In addition, the EBA proposes to require P2P lending platforms to take reasonable care to establish and maintain systems and controls that are appropriate to their business, including in relation to the timely transfer of agreed funds.[251] Finally, according to EBA, P2P lending platforms

[248] Oxera, 'The economics of peer-to-peer lending', prepared for the Peer-to-Peer Finance Association, 2016, p. 19.
[249] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 22.
[250] Ibid, p. 22.
[251] Ibid., p. 23.

should disclose all risks, including the risk that pledged money may not be paid when it is due, in a way that is fair, clear and not misleading.[252]

6. Conflict of interest

6.1 Conflict of interest

Lenders need to trust tools offered by P2P lending platforms. In P2P lending, the information asymmetry between the P2P lenders and borrowers is acute (credit risk, see *supra*).[253] An enhancing factor is that platforms largely attract lenders that do not necessarily have the level of financial literacy to make a rational investment decision.[254] Therefore, lenders have to rely on tools offered by P2P lending platforms such as borrowers' creditworthiness assessments and risk-adequate rates set by the platform.[255] Given the little information about the methods P2P lending platforms use to assess the borrowers' creditworthiness, lenders need to have an almost blind trust in the P2P lending platform.[256] Nevertheless, this trust may not always be justified, as both the platform and borrowers have the incentive of making a less critical review of the risks entailed.[257] First, platforms have an incentive to encourage lending through origination fees.[258] Second, borrowers have an incentive to overestimate their creditworthiness to get funding faster and against lower interests. These conflicts of interest may result in inadequate credit risk assessments with loan defaults and corresponding losses as a result.

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[252] Ibid.

[253] A. Sufi, 'Information asymmetry and financing arragement: evidence from syndicated loans', *Journal of Finance* 62, 2007, p. 393–410. See also: T.S. Campbell and W.A. Kracaw, 'Information production, market signalling, and the theory of financial intermediation', *J. Financ.* 35(4), *1980*, p. 863–882; H.E. Leland and D.H. Pyle, 'Informational asymmetries, financial structure, and financial intermediation', *J. Financ.* 32(2), 1977, p. 371–387; S.C. Myers and N.S. Majluf, 'Corporate financing and investment decisions when firms have information that investors do not have', *J. Financ Econ.* 13(2), 1984, p. 187–221.

[254] M. Pokornáa and M. Sponera, 'Social lending and its risks', *Procedia - Social and Behavioral Sciences* 220, 2016, p.330-337.

[255] Z. Eiger and J. Mandell, 'Practice Pointers on P2P Lending: How It Works, Current Regulations and Considerations', 2018, https://media2.mofo.com/documents/150129p2plendingbasics.pdf; R. Emekter, Y. Tu, B. Jirasakuldech and M. Lu, 'Evaluating credit risk and loan performance in online Peer-to-Peer (P2P) lending', *Applied Economics* 47:1, 2015, p. 55.

[256] Finance Watch, 'Finance Watch response to the consultation Capital Markets Union mid-term review 2017 Brussels', 2017, http://www.finance-watch.org/, p. 5-6.

[257] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 9. Finance Watch response to the consultation Capital Markets Union mid-term review 2017 Brussels, 17 March 2017

[258] A. Verstein, 'The Misregulation of Person-to-Person Lending', *U.C. Davis Law Review* 45(2), 2011, p. 468.

Fee structure basis of principal-agent problem. The conflict of interest at the level of the platform primarily relates to the common fee structure of P2P lending platforms that is based on a percentage of the loan transaction volume and the profits.[259] This fee structure provides a steady incentive for platforms to stimulate the loan transaction volume by "exaggerating investment opportunities and profit chances, while plating down or concealing risks of investment projects and overstating liquidity".[260] Therefore, it is conceivable that this incentive has an influence on the stringency of the borrowers' creditworthiness analyses. Furthermore, P2P lending platforms do not typically invest any of their own capital into loans on their platform and thus are not exposed to credit risk.[261]

Preference of institutional investors. The conflict of interest is somehow also reflected in the recent move to gain more institutional investors as clients, as they bring a much higher investment volume than retail investors.[262] This could lead to institutional investors being allowed to cherry-pick loan offers or buy up an entire issue before retail investors have an opportunity to invest.[263]

Transparency and code of conduct to establish trust. Given that platforms' incentives may not always align with investor protection, it is important for lenders to get insight in the underlying interests of the platform and the related risks they face. However, in practice it appears difficult for lenders to find independent information about platforms' reputation and probity. P2P lending platforms are not required to comply with legal disclosure requirements. National associations of P2P lending platforms have understand this and try to establish this trust by committing members to sign a code of conduct of operating rules with disclosure standards.[264] However, experience in other industry sectors reveals that such associations often lack both appropriate measures and intrinsic motivation to enforce compliance with such codes of conduct.[265] In this regard, ratings and comments of platform users in internet forums have a much stronger disciplinary impact on platforms' business operations.

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[259] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 32.
[260] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 32.
[261] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43.
[262] Finance Watch, 'Finance Watch response to the consultation Capital Markets Union mid-term review 2017 Brussels', 2017, http://www.finance-watch.org/, p. 5-6.
[263] Finance Watch, 'Finance Watch response to the consultation Capital Markets Union mid-term review 2017 Brussels', 2017, http://www.finance-watch.org/, p. 5-6.
[264] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 696.
[265] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 696.

6.2 Regulatory framework

Proposal on European Crowdfunding Service Providers for Business (art. 7). Regarding P2P business lending, the conflict of interest provisions in the European Commission's proposal on European Crowdfunding Service Providers for Business are relevant.[266] The proposal requires P2P lending platforms to maintain and operate effective organisational and administrative arrangements with a view to taking all reasonable steps designed to prevent conflicts of interest from adversely affecting the interests of its clients.[267] More specifically, the proposal imposes the following requirements on P2P lending platforms. First, Article 7, paragraph 4, requires platforms to take all appropriate steps to identify and to prevent or manage conflicts of interest between themselves, including their managers and employees, or any person directly or indirectly linked to them by control, as defined in Article 4(1)(35)(b) of Directive 2014/65/EU (MiFID II), and their clients or between one client and another that arise in the course of providing any services. Second, in the event that the conflict of interest still occurs, the proposal establishes that P2P lending platforms must disclose to their (potential) clients the general nature and sources of conflicts of interest and the steps taken to mitigate those risks when they consider that this is necessary for the measures taken in accordance with their internal rules to prevent conflicts of interest (Article 7, paragraph 5). Such disclosure must be made in a durable medium, include sufficient detail, taking into account the nature of each client, to enable each client to take an informed decision about the service in the context of which the conflict of interest arises (Article 7, paragraph 6). Third, with regard to the specific conflict of interest that P2P lending platforms, its managers or key employees have financial interests in the business of a borrower, the proposal establishes that P2P lending platforms may not have any financial participation in any crowdfunding offer on their platforms (Article 7, paragraph 1) and that P2P lending platforms may not accept as their clients any of their shareholders holding 20% or more of share capital or voting rights, any of their managers or employees, or any person directly or indirectly linked to those shareholders, managers and employees by control as defined in Article 4(1)(35)(b) of MiFID II. Platforms are also

[266] European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113.
[267] European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113, p. 9.

prohibited from accepting fees to induce clients towards certain projects (Article 7, paragraph 2).[268]

Resemblance to conflict of interest provisions in MiFID (II). Although it is regrettable that the European Commission's proposal does not provide substantial guidelines to address the potential conflicts of interest in P2P lending, which are nonetheless fairly similar to all P2P lending platforms, the proposal lays down a robust legal framework consisting of subsequent measures that P2P lending platforms must take to address the conflict of interest. From the wording of Article 7 of the proposal, it is clear that the conflict of interest provisions of the proposal are highly inspired by the conflict of interest provisions laid down in Article 23 of MiFID II. This means that, even in the (unlikely?) case that the proposal will not be adopted, P2P lending platforms can or have to address conflicts of interest according to Article 23 MiFID.[269] The discussion whether (all) P2P lending platforms with (all) their services fall into the scope of MiFID is beyond the scope of this research paper. In any case, the answering on this question does not prevent P2P lending platforms from relying on the framework set out in Article 23 of MIFID II to appropriately address potential conflicts of interest in P2P lending.

MiFID II. Regarding P2P consumer lending, the conflict of interest provisions of MiFID II are the most notable regulatory measures to address potential conflicts of interest (see, however, *supra*). As already mentioned, the wording of the conflict of interest provisions of MiFID II is almost identical to that of the conflict of interest provisions set out in the Proposal on European Crowdfunding Service Providers for Business. Pursuant to Article 16 of MiFID II, "[a]n investment firm shall maintain and operate effective organisational and administrative arrangements with a view to taking all reasonable steps designed to prevent conflicts of interest as defined in Article 23 from adversely affecting the interests of its clients." Highly similar to Article 7 of the proposal, Article 23 of MiFID II provides that "Member States shall require investment firms to take all appropriate steps to identify and to prevent or manage conflicts of interest between themselves […] and their clients or between one client and another that arise in the course of providing any investment […], including those caused by the receipt of inducements from third parties or by the investment firm's own remuneration and other incentive structures." Whereas the organisational or administrative arrangements made by the

[268] European Commission, 'Fact Sheet. Frequently asked questions: Proposal for a Regulation on European Crowdfunding Services for Business', 2018, Brussels, http://europa.eu/rapid/press-release_MEMO-18-1423_en.htm.

[269] For a discussion of the conflict of interest rules, see D. Busch, 'MiFID II: Stricter conduct of business rules for investment firms', *Capital Markets Law Journal*, 2017, p. 374-375.

investment firm are not sufficient to ensure that risks of damage to client interests will be prevented, "the investment firm shall clearly disclose to the client the general nature and/or sources of conflicts of interest and the steps taken to mitigate those risks before undertaking business on its behalf." This disclosure shall (also) be made in a durable medium and include sufficient detail, taking into account the nature of the client, to enable that client to take an informed decision with respect to the service in the context of which the conflict of interest arises.

Preference of institutional lenders. We have seen that the conflict of interest is also reflected in the recent move to gain more institutional lenders as clients, as they bring a much higher investment volume than retail investors.[270] A possible regulatory answer to this particular conflict of interest is the provision that every lender is given the same rights and opportunities regardless of their investment volume in order to avoid that no favourable treatment is given to institutional investors.[271] LENZ underlines the importance that (existing) caps for the maximum investable amount per single loan apply to both retail and institutional lenders and not only to retail investors.[272] In a similar vein, the Proposal on Crowdfunding Service Providers for Business provides that P2P lending platforms that are promoting their services through marketing communications may not give preferential treatment to particular projects by singling them out from other projects offered on the platform (Article 14 and recital 37).[273] Note that LENZ's note concerns protection for lenders, whereas the regulatory measure laid down in the proposal concerns protection for borrowers.

7. Operational risk

7.1 Operational risk

Operational risk. In Basel II and Article 4, paragraph 1, of Regulation (EU) No 575/2013, 'operational risk' is defined as "the risk of loss resulting from inadequate or failed internal

[270] Finance Watch, 'Finance Watch response to the consultation Capital Markets Union mid-term review 2017 Brussels', 2017, http://www.finance-watch.org/, p. 5-6.
[271] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 700.
[272] R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 699.
[273] European Commission, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European Crowdfunding Service Providers (ECSP) for Business', COM(2018)113, p. 9.

processes, people and systems or from external events".[274] Examples of inadequate processes or systems are inadequate arrangements to safeguard the lender's money, insufficient loan follow-up requirements (credit risk, see *supra*) and inadequate processes that ensure that lenders commit money to projects in a timely fashion.[275] Another causal driver is technical failures.[276] For example, algorithms may make connections they should not, resulting in an incorrect credit risk assessment. Although operational risk is at the level of the P2P lending platform, this risk is also relevant for P2P lenders and borrowers, as they bear the direct financial consequences upon the occurrence of operational risk. Furthermore, given the relatively short period P2P lending platforms exist, operational risk is conceivable and real.

Platform risk. A crucial part of operational risk is platform risk, i.e. the risk that a P2P lending platform ceases operations due to operational events, such as failure of the platform software.[277] Platform risk (or sometimes called agency risk) includes the temporary and permanent shut-down of the P2P lending platform.[278] The shut-down of the platform may lead to disastrous consequences for lenders as it can put portfolios of loans at risk of not being repaid as the platform, responsible for the collection and transfer of loan payments, is unable to play its intermediary role.[279] Adequate answers on the question of what happens to the loans from a discontinued platform are not only necessary for the users of the discontinued platform, but also for the P2P lending platforms that remain to estimate the potentially damaging consequences.[280]

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[274] Basel Committee on Banking Supervision, 'Principles for the Sound Management of Operational Risk', 2011, Bank for International Settlements 2011, p. 3, https://www.bis.org/publ/bcbs195.pdf; Article 4(1) of Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012. Another definition of operational risk is: "Operational risk refers to financial loss resulting from a host of potential operational breakdowns that we can think of in terms of people risks, process risks, and technology risks (e.g., […], inadequate computer systems, a failure in controls, a mistake in operations, a guideline that has been circumvented, or a natural disaster)." See: M. Crouhy, D. Galai and R. Mark, *The essentials of risk management Vol. 1*, 2006, New York, McGraw-Hill, 2006, p. 14

[275] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 17.

[276] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, London, European Banking Authority, p. 18.

[277] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43; A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 12.

[278] K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 43; M. Pokornáa and M. Sponera, 'Social lending and its risks', *Procedia - Social and Behavioral Sciences* 220, 2016, p.330-337.

[279] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO, Staff Working Paper, p. 25.

[280] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 23-25.

P2P lending platforms put forward own measures. Several P2P lending platforms have put measures in place to manage platform risk to lenders in the event of platform failure. These measures are aimed at ensuring that existing loan contracts will continue to be managed and administered in accordance with the contract terms ('the living will').[281] Measures undertaken by (associations of) P2P lending platforms are crucial because P2P lending platforms have to rely on themselves, in contrast to banks, which are generally backed by central and national banks.[282]

Segregated client accounts. Many P2P lending platforms have chosen for business models with segregated client accounts so that client money goes through separate accounts.[283] In the event of platform closure, creditors nor the platform have any claim on the client funds and the contractual agreements of loans remain valid (see P2P lending process, *supra*).[284] Segregated client accounts allow that client accounts can easily be taken over by other entities, allowing the existing loans to be runoff.

Resolution plans. Several P2P lending platforms have also set out resolution plans. Resolution plans describe how loan repayments will continue to be collected. Such plans may include fully funded run-off plans, contracts with back-up services providers and the setting-up of bankruptcy-remote vehicles that these providers can administer in order to wind down portfolios of loans.[285]

7.2 Regulatory framework

Proposal on European Crowdfunding Service Providers for Business. The European Commission's Proposal on European Crowdfunding Service Providers for Business contains several regulatory measures to address operational risk. First, Article 10 of the proposal provides that the application to ESMA for authorization as a crowd funding service provider

[281] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 35. See also: Financial Conduct Authority, 'CP16/5: Handbook changes to reflect the introduction of the Innovative Finance ISA and the regulated activity of advising on peer-to-peer agreements', Consultation Paper CP16/5, 2016, p. 21, https://www.fca.org.uk/static/fca/article-type/consultation%20paper/cp16-05.pdf.
[282] A. Milne and P. Parboteeah, 'The Business Models and Economics of Peer-to-Peer Lending', European Credit Research Institute, 2016, nr. 17/2016, p. 23-25.
[283] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO Working Paper, 2014, p. 17.
[284] E. Kirby and S. Worner, 'Crowd-funding: An Infant Industry Growing Fast', IOSCO Working Paper, 2014, p. 17.
[285] Oxera, 'The economics of P2P lending', Prepared for the Peer-to-Peer Finance Association, 2016, p. 35-36.

requires the submission of several operational risk-related documents. More specifically, the following documents are required:

- (d) a programme of operations setting out the types of crowdfunding services that the prospective crowd funding service provider wishes to provide;
- (e) a description of the prospective crowdfunding service provider's governance arrangements and internal control mechanisms to ensure compliance with this Regulation, including risk management and accounting procedures;
- (f) a description of the prospective crowdfunding service provider's systems, resources and procedures for the control and safeguarding of the data processing systems;
- (g) a description of the prospective crowdfunding service provider's business continuity arrangements;
- (i) proof that the persons referred to in point (h) are of good repute and possess appropriate knowledge and experience to manage the prospective crowdfunding service provider.

Second, the proposal provides that the management of P2P lending platforms shall establish and oversee the implementation of adequate policies and procedures to ensure effective and prudent management, including the segregation of duties and business continuity, in a manner that promotes the integrity of the market and the interest of their clients (Article 5). Third, the proposal obliges P2P lending platforms to take all reasonable steps to avoid additional operational risk, when they rely on a third party for the performance of operational functions (Article 8).

P2P consumer lending. There are no specific regulatory measures which address operational risk in P2P consumer lending. Inspiration can be drawn from the European Commission's Proposal on European Crowdfunding Service Providers for Business (see *supra*) and the Capital Requirements Directive (CRD IV).[286] Although the CRD IV is not applicable to P2P lending platforms, as platforms are no credit institutions under Article 4(1)(1) of the Regulation (EU) No 575/2013 on prudential requirements for credit institutions and investment firms,[287] Article

[286] DIRECTIVE 2013/36/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC

[287] P2P lending platforms are no credit institutions under Article 4(1)(1) of the Regulation (EU) No 575/2013 on prudential requirements for credit institutions and investment firms […] (Article 3(1)(1) CRD IV) as they cannot be considered as "an undertaking the business of which is to take deposits or other repayable funds from the public and to grant credits for its own account". See also: R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 692. See also: Recital 14

85 of the CRD IV can serve as source of inspiration for regulatory measures addressing operational risk in P2P (consumer) lending.[288] Article 85 stipulates:

"1. Competent authorities shall ensure that institutions implement policies and processes to evaluate and manage the exposure to operational risk, including model risk, and to cover low-frequency high-severity events. Institutions shall articulate what constitutes operational risk for the purposes of those policies and procedures.

2. Competent authorities shall ensure that contingency and business continuity plans are in place to ensure an institution's ability to operate on an ongoing basis and limit losses in the event of severe business disruption."

Continuity and contingency plans: PSD II. In addition, the Payment Services Directive (PSD II) can provide inspiration for continuity and contingency plans.[289] Article 5(h) of the PSD II provides that entities that wish to be authorised as a payment institution shall submit a description of business continuity arrangements including a clear identification of the critical operations, effective contingency plans and a procedure to regularly test and review the adequacy and efficiency of such plans. Article 95 of the PDS2 further provides that "payment service providers [shall] establish a framework with appropriate mitigation measures and control mechanisms to manage the operational and security risks, relating to the payment services they provide. As part of that framework, payment service providers shall establish and maintain effective incident management procedures, including for the detection and classification of major operational and security incidents." The discussion on whether and to which the PSD II is applicable on P2P lending is beyond the scope of the research paper.

Minimum capital requirements: CRD IV. Finally, consideration should be given to minimum capital requirements for P2P lending platforms in order to reduce operational risk. Although the CRD IV is not applicable on P2P lending platforms,[290] inspiration can be drawn from the

CRD IV: "The scope of measures should therefore be as broad as possible, covering all institutions whose business is to receive repayable funds from the public, whether in the form of deposits or in other forms such as the continuing issue of bonds and other comparable securities and to grant credits for their own account."

[288] In this context, 'competent authorities' means competent authorities designated by the Member States.

[289] Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015 on payment services in the internal market, amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No 1093/2010, and repealing Directive 2007/64/EC. See also for the importance of continuity and contingency plans: K. Davis and J. Murphy, 'Peer-to-Peer Lending: Structures, Risks and Regulation', *The Finsia Journal of Applied Finance* 3, 2016, p. 13; R. Lenz, 'Peer-to-peer lending: Opportunities and Risks', *Special Issue on The Risks and Opportunities of the Sharing Economy*, *EJRR* 4, 2016, p. 698.

[290] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 25.

minimum capital requirements for operational risk for credit institutions and investment firms introduced by Basel II (Article 85 CRD IV and Article 20, Article 95, Title III (Articles 312-324), Article 446, Article 454, Article 500, Recital (52) CRR (Regulation 575/2013)).[291] Given that P2P lending platforms do not assume credit risk, possible minimum capital requirements should be lower for P2P lending platforms. Further research is needed to decide upon which (combinations of) regulatory measures are adequate to address operational risk in P2P lending. In any case, it is crucial that P2P lending platforms provide transparent information to (prospective) users about the (legal) consequences for the loan payments in the case operational risk materialises.

[291] DIRECTIVE 2013/36/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC; Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012. See: B. Penn, E. Katz and D. Carolan, 'Capital Requirements Directive IV Framework *Operational Risk*', 2014, p. 3, http://www.allenovery.com/SiteCollectionDocuments/Capital%20Requirements%20Directive%20IV%20Framework/Operational%20Risk.pdf.

Blockchain is a way to go back in history, because when you think about the way we were lending, the way we were paying, the way we were trusting each other, it was peer-to-peer. Over time we added intermediaries and third parties because we stopped trusting each other.[292]

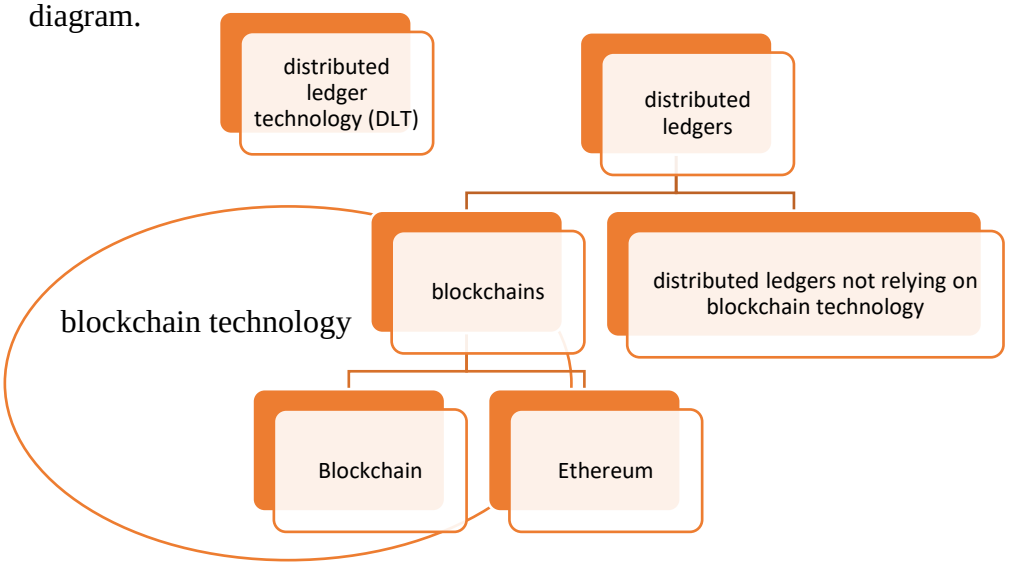
(Eric Piscini)[293]

CHAPTER II: BLOCKCHAIN TECHNOLOGY

I. Blockchain technology: terminology

Importance of terminology. Before delving into the technicalities of blockchain technology, it is important to have a clear understanding of the term 'blockchain technology'. This is necessary because several terms closely related to 'blockchain technology' are mixed up in the literature.[294] For example, the term 'blockchain technology' is sometimes interchanged with 'blockchain' and 'distributed ledger technology' (DLT).[295] Therefore, this section defines the following terms related to blockchain technology in a logical order: 'distributed ledger technology', 'distributed ledger', 'blockchain', 'Blockchain' and 'blockchain technology'. In doing so, the research paper avoids that readers are confused when they read the technical terms for blockchain concepts of which they actually already have some understanding under a different term.

The relation between the terms 'distributed ledger technology', 'distributed ledger', 'blockchain', 'Blockchain' and 'blockchain technology' can best be presented in a Venn diagram.



[292] P. Crosman, 'See blockchain put peers back in P2P', *American Banker Magazine*, 2018, New York, Vol. 128, Iss. 1, p. 24-25.
[293] E. Pisicini is a principal in banking and technology at Deloitte Consulting.
[294] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 11.
[295] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 1.

Distributed Ledger Technology (DLT) and distributed ledgers. Distributed Ledger Technology (DLT) refers to the technology which enables the chronologically recording, sharing and synchronizing of data in a digital system decentralised across a network of multiple datastores (ledgers).[296] A distributed ledger is an enhanced database in which a copy of the data is stored and updated through validation and consensus (see *infra*).[297] Unlike traditional databases, distributed ledgers have no central datastore or central controlling authority. Instead, all computers or mobile devices connected to the distributed ledger network (the so-called nodes) have the collective responsibility to validate, record and update the data in the decentralised network (see *infra*).[298]

Blockchains. The term 'blockchain', with a lowercase b, is often used for any kind of distributed ledger.[299] Technically, however, blockchains only connote the variants of distributed ledgers that record data in packages ('blocks') which are hashed ('chained') to another and where trust is *enforced by the rules* governing the blockchain (see *infra*).[300] A major determinant of blockchains are the cryptographic algorithms, which verify the creation and transfer of data in the decentralised network.[301] A 'blockchain' has also been defined as a "decentralized, shared, encrypted database that serves as an irreversible and incorruptible public repository of information".[302] For a thorough explanation of all these components, see section II.A Blockchain technology: Common basis.

Blockchain, with capital B, is the name of one specific distributed ledger: Bitcoin's distributed ledger.[303] Because of Bitcoin' ingenuity and success, the term blockchain has become so

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[296] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. IV; A. Wright and P. De Filippi, 'Decentralized Blockchain Technology and the Rise of Lex Cryptographia', 2017, p. 6, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2580664.

[297] K. Werbach, 'Trust, But Verify: Why the Blockchain Needs the Law', *Berkeley Technology Law Journal*, (forthcoming 2018), p. 3, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2844409.

[298] L. Howard, 'Whitepaper On Distributed Ledger Technology', Hong Kong Monetary Authority, 2016 p. 30.

[299] Deloitte, 'Bitcoin, Blockchain & distributed ledgers: Caught between promise and reality', Centre for the Edge, 2016, p. 9, https://www2.deloitte.com/content/dam/Deloitte/au/Images/infographics/au-deloitte-technology-bitcoin-blockchain-distributed-ledgers-180416.pdf.

[300] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 11.

[301] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 3.

[302] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 3; A. Wright and P. De Filippi, 'Decentralized Blockchain Technology and the Rise of Lex Cryptographia', 2017, p. 2, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2580664. Although a blockchain is frequently described as immutable, it is important to bear in mind that this is merely the case to the extent that its human creators decide not to intervene. See: A. Walch, 'The Path of the Blockchain Lexicon (and the Law)', *36 Rev. of Banking and Finance Law 713*, 2017, p. 16, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2940335.

[303] Deloitte, 'Bitcoin, Blockchain & distributed ledgers: Caught between promise and reality', Centre for the Edge, 2016, p. 9, https://www2.deloitte.com/content/dam/Deloitte/au/Images/infographics/au-deloitte-technology-

popular that other distributed ledgers, which are often inspired by the Blockchain, are referred to as 'blockchains'.[304]

Blockchain technology. When distributed ledgers follow the same principles as blockchains, such as data storage in blocks and cryptographic algorithms to verify the creation of blocks, we can say that they apply the 'blockchain technology'.[305] For a thorough discussion of the common basis of blockchain technology, see II.A Blockchain technology: common basis. In addition to Blockchain, Ethereum is the key example of another distributed ledger relying on blockchain technology. Both Blockchain and Ethereum are essential objects of study when setting up a comprehensive framework of the potential of blockchain technology to reduce or eliminate the risks of P2P lending. For a discussion of the relevant elements of Blockchain and Ethereum for P2P lending, see II.B. Particularities of Blockchain and Ethereum.

II. Blockchain technology

Roadmap. In this section, blockchain technology will be thoroughly studied. As described in the introduction, the approach is a two-step one. In a first step, the common basis of blockchain technology recurring in all specific blockchain technologies is discussed. In a second step, we study the particularities of Blockchain and Ethereum in so far as relevant to address the risks of P2P lending.

A. Blockchain technology: Common basis

1. Public/private and permissioned/permissionless blockchains

Distinctions in blockchain technology. Before proceeding to the technicalities of blockchain technology, it is crucial to see that certain aspects of blockchain technology may differ depending on whether everyone or only network participants (nodes) can access the blockchain and whether everyone or only network participants can contribute to the blockchain.[306]

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bitcoin-blockchain-distributed-ledgers-180416.pdf; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 12.

[304] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 12.

[305] Deloitte, 'Bitcoin, Blockchain & distributed ledgers: Caught between promise and reality', Centre for the Edge, 2016, p. 9, https://www2.deloitte.com/content/dam/Deloitte/au/Images/infographics/au-deloitte-technology-bitcoin-blockchain-distributed-ledgers-180416.pdf; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 12.

[306] A. Lewis, 'A Gentle Introduction To Blockchain Technology', BraveNewCoin, p. 6, https://bravenewcoin.com/assets/Reference-Papers/A-Gentle-Introduction/A-Gentle-Introduction-To-Blockchain-Technology-WEB.pdf.

Permissioned or permissionless blockchains. First, blockchains are categorised as permissioned or permissionless, depending on whether network participants (nodes) need permission to access the blockchain.[307] This distinction underlines that while blockchains are frequently presented as decentralised ledgers with no central controlling authority, they can in fact be designed as closed systems (see *infra*).[308]

Public or private blockchains. Second, blockchains are categorised as public or private depending on whether anyone is allowed to contribute to the blockchain or only known, vetted participants.[309] Blockchains can be 'public' in two senses. First, they can be public in the sense that anyone, without permission granted by an authority, can *write* data.[310] Second, they can be public in the sense that anyone, without permission granted by an authority, can *read* data.[311] Usually, when people refer to public blockchains, they mean anyone-can-write.

Combined types of blockchains. In practice, blockchains are usually permissionless and public or permissioned and private. However, this is not a set rule. For example, it is conceivable that a company wants to set up a platform on the blockchain that is only useful within the company. In that case, the company chooses for a permissioned blockchain with access limited to, for example, business managers and employees of the company. At the same time, the company can decide that all these business managers and employees of the company can contribute to the blockchain, thereby making the blockchain public. P2P lending platforms are usually set up on permissionless, public blockchains. Examples include Bitcoin and Ethereum (See B. Particularities of Blockchain and Ethereum).

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[307] Deloitte, 'Bitcoin, Blockchain & distributed ledgers: Caught between promise and reality', Centre for the Edge, 2016, p. 22, https://www2.deloitte.com/content/dam/Deloitte/au/Images/infographics/au-deloitte-technology-bitcoin-blockchain-distributed-ledgers-180416.pdf; Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser', 2015, p. 17; B.G. Williams, D. Gunn, E. Roma, and B. Bansal, 'Distributed Ledgers in Payments : Beyond the Bitcoin Hype', 2016, http://www.bain.com/publications/articles/distributed-ledgers-in-payments-beyond-bitcoin-hype.aspx; N. Williamson, 'Permissionless vs Permissioned Consensus and Tradeoffs', 2016, http://credits.vision/posts/permissionless-vs-permissionedconsensus-tradeoffs.

[308] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 3; A. Lewis, 'A Gentle Introduction To Blockchain Technology', BraveNewCoin, p. 6, https://bravenewcoin.com/assets/Reference-Papers/A-Gentle-Introduction/A-Gentle-Introduction-To-Blockchain-Technology-WEB.pdf.

[309] Nodes are all computer or (mobil) devices that connected to the blockchain network.

[310] A. Lewis, 'A Gentle Introduction To Blockchain Technology', BraveNewCoin, p. 6, https://bravenewcoin.com/assets/Reference-Papers/A-Gentle-Introduction/A-Gentle-Introduction-To-Blockchain-Technology-WEB.pdf.

[311] A. Lewis, 'A Gentle Introduction To Blockchain Technology', BraveNewCoin, p. 6, https://bravenewcoin.com/assets/Reference-Papers/A-Gentle-Introduction/A-Gentle-Introduction-To-Blockchain-Technology-WEB.pdf.

Security in permissionless blockchains. The choice for a permissioned/permissionless blockchain is often motivated by business reasons. However, this choice can have an impact on the security of the blockchain. In permissionless blockchains, there is no central owner or administrator.[312] Security is provided through the wide distribution of data in a large, open and transparent network in combination with complex consensus mechanisms (see *infra*). For a cyber-attack to be successful all existing copies of the ledger need to be simultaneously attacked, which has never happened to date.[313] Furthermore, network participants would quickly spot such attacks (see *infra*).

Security in permissioned blockchains. In permissioned blockchains, a central party controls the network access and sets the rules of the ledger.[314] This given solves several concerns governments and regulators have, such as identity verification of network members, whom to license and regulate, and legal ownership of the ledger.[315] However, it also requires the network participants to trust the central party.[316] The foregoing should be put in perspective, as the role of the central party is minimal and of administrative nature; there is no need for a central party to execute transactions, as transactions happen directly between the parties (see *infra*). In permissioned blockchains, security is provided through smaller networks (in which the nodes are at least known by the central party and often by each other) and more legal clarity over ownership of assets.

2. Blockchain technology as a synthesis of three distinct technologies

Blockchain technology: three distinct technologies. In this section, blockchain technology is discussed as a synthesis of three distinct key technologies: (i) peer-to-peer technology (decentralisation), (ii) cryptographic mechanisms and (iii) consensus mechanisms.[317] Before studying each of these technologies separately, a very concise overview of the working of

[312] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 5.
[313] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 35.
[314] At first sight, the presence of a central party seems in contrast with blockchain's original idea of decentralization and disintermediation (see, however, *infra*).
[315] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 11.
[316] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 11.
[317] T. Maas, 'What is blockchain technology?', Law & Blockchain, 2018, http://www.lawandblockchain.eu/post-template/; World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 9.

blockchain technology is provided. This overview allows to get a first idea about the interplay between the distinct technologies and their role in ensuring the integrity of the blockchain.

Concise overview of the functioning of blockchain technology. A blockchain is essentially a decentralised ledger of data chronologically recorded in linearly-connected blocks.[318] New additions to this enhanced database are initiated by one of the members (nodes), who creates a new 'block' of data, for example, containing several transaction records.[319] Information about this new data block is then shared across the entire peer-to-peer network (peer-to-peer technology), containing encrypted data so transaction details are not made public (cryptographic mechanisms).[320] All network participants collectively determine the block's validity according to a pre-defined algorithmic validation method (consensus mechanisms). Instead of relying on a third party, nodes use a consensus protocol to agree on the blockchain content. Only after validation, all participants add the new block to their respective ledgers. Through this mechanism each change to the ledger is replicated across the entire network and each network member has a full, identical copy of the entire ledger at any point in time (peer-to-peer technology). The new block is chained to the other blocks of the ledger using a cryptographic hash function, which ensures the immutability of the data within the blocks (cryptographic mechanisms). In sum, blockchain technology uses cryptographic and algorithmic methods to create and verify a continuously growing data structure that takes the form of a chain of blocks, the blockchain.[321]

2.1 Peer-to-peer technology

P2P technology: decentralisation. In order to understand blockchain technology, one needs to understand its underlying peer-to-peer technology and more specifically, the role of a decentralised peer-to-peer network.[322] The basic idea of decentralisation is to decentralise control to the peripheries instead of one central entity being in full control.[323] In blockchain technology, there is no single entity that has control over the data contained within the blockchain, instead the whole peer-to-peer network of nodes is responsible for maintaining the

[318] T. Maas, 'What is blockchain technology?', Law & Blockchain, 2018, http://www.lawandblockchain.eu/post-template/; J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2.
[319] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 1.
[320] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 11.
[321] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 1.
[322] D. Drescher, *Blockchain Basics*, 2017, Frankfurt am Main, Apress, p. 19.
[323] I. Bashir, *Mastering blockchain*, Birmingham, Packt Publishing, 2017, p. 34.

validity of the blockchain.[324] Nodes are able to exercise this responsibility as a copy of the blockchain is stored and synchronised on each full node of the blockchain at all times.[325] Indeed, each time after data is validated by the nodes according to a pre-defined algorithmic validation method (consensus mechanisms, see *infra*), the new data blocks are added to all respective ledgers to ensure data consistency across the peer-to-peer network. At any point in time, only one version of the blockchain exists.[326]

Decentralisations leads to a new form of trust. Decentralisation of control is one of the most important innovations of blockchain technology.[327] The reason is that the collective validation of data by miners according to rules laid down in consensus protocols provides confidence among the participants in the network, even between parties that do not know each other,[328] or perhaps better said, blockchain technology makes it possible to 'trust the outputs of a system without trusting any actor within it'.[329] Third trusted parties can be eliminated as there is no central 'trusted' authority in which trust must be established.[330]

Decentralisation leads to authenticity and security. The fact that transaction data as well as control over these data are decentralised across a peer-to-peer network means that no single nodes can approve new additions to the ledger or amend past data entries in the ledger.[331] Although the authenticity of blockchains is mainly guaranteed by cryptographic mechanisms (cryptographic mechanisms, see *infra*), the decentralised nature of blockchains facilitates joint supervision of wrongful data additions and data changes by nodes in the network.[332]

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[324] Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser', 2015, p. 47; K. Werbach, 'Trust, But Verify: Why the Blockchain Needs the Law', *Berkeley Technology Law Journal*, (forthcoming 2018), p. 3, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2844409

[325] K. Werbach, 'Trust, But Verify: Why the Blockchain Needs the Law', *Berkeley Technology Law Journal*, (forthcoming 2018), p. 3, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2844409. Nodes of the network are computers and (mobile) devices connected to the blockchain network.

[326] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 3.

[327] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 1.

[328] N. Bauerle, 'What is the difference between a Blockchain and a Database?', Coin desk, https://www.coindesk.com/information/what-is-the-difference-blockchain-and-database/; M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 3; K. Werbach, 'Trust, But Verify: Why the Blockchain Needs the Law', *Berkeley Technology Law Journal*, (forthcoming 2018), p. 3, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2844409;

[329] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2844409.

[330] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 5; K. Werbach, 'Trustless Trust', 2016, p. 5; R. Hoffman, 'The Future of the Bitcoin Ecosystem and "Trustless Trust" – Why I Invested in Blockstream', 2014, https://www.linkedin.com/pulse/20141117154558-1213- the-future-of-the-bitcoin-ecosystem-and-trustless-trust-why-i-invested-inblockstream; Recognizing the Potential How peer-to-peer systems may change the world.

[331] Recognizing the Potential How peer-to-peer systems may change the world

[332] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Blockchain: An Emerging Solution for Fraud Prevention', *The CPA Journal*, 2017, p. 12-14.

Decentralisation of data and control over these data also means that there is no single point of failure for malicious attackers nor an obvious place for someone to instigate a fraud scheme.[333] In order for a cyber-attack to be successful, all copies of the blockchain need to be attacked simultaneously.[334] This means that a hacker would not only have to attack the specific block of the data targeted, but also every block ever created before it and he would have to do so on every node in the network simultaneously.

2.2 Cryptographic mechanisms

Cryptography in blockchain. Cryptography is at the core of blockchain technology. The importance of cryptography is well-expressed in hashes and digital signatures.[335] Cryptographic hashes ensure that any alteration to transaction input in the blockchain, even the most minuscule change, results in a different hash value being computed, indicating potentially compromised transaction input. Digital signatures, at their turn, ensure that transactions are originated from senders (signed with private keys) and not imposters. In sum, cryptography is crucial to preserve the integrity of the blockchain.[336]

Roadmap section. This section provides a step-by-step explanation of cryptography, hashes and digital signatures. In addition to providing insight into the technicalities of these cryptographic mechanisms, this section aims to highlight their role in preserving the integrity of the blockchain.

2.2.1 Asymmetric cryptography in blockchain technology

Cryptography. Generally speaking, cryptography is the method of encrypting (disguising) and decrypting (revealing) information through complex mathematics.[337] The method involves

[333] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement', 2017, p. 14, https://www.bis.org/cpmi/publ/d157.pdf; C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 4; World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 1.
A single point of failure is defined as any point in a system that, if it failed to work correctly, would lead to a failure of the entire system.
[334] Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser', 2015, p. 6.
[335] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 4.
[336] M. Finck, 'Blockchain Regulation', Max Planck Institute for Innovation and Competition Research Paper No. 17-13, 2017, p. 4.
[337] Link Academy, 'Blockchain cryptography explained', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/blockchain-cryptography-explained; T.K. Sharma, 'How does blockchain use public key cryptography', 2018, https://www.blockchain-council.org/blockchain/how-does-blockchain-use-public-key-cryptography/.

taking unencrypted data, such as a piece of text, and encrypting it using a mathematical algorithm known as a cipher.[338] This produces a ciphertext, a piece of information that is completely useless and nonsensical until it is decrypted. In doing so, cryptography wants to ensure that certain information can only be viewed by the intended recipients and nobody else. The common method of encryption is symmetric-key cryptography where the same key is used to encrypt and decrypt the message.

Asymmetric or public-key cryptography. Despite being founded upon a similar framework, the type of cryptography used in blockchain technology differs from the common method of encryption.[339] Blockchain technology makes use of asymmetric or public-key cryptography.[340] In this type of cryptography, the key that is used to encrypt the data is different from the key that is used to decrypt the data.[341] More specially, a public key is used to encrypt data and a private key is used to decrypt data.[342] Asymmetric cryptography represents an improvement on standard symmetric-key cryptography as it allows computers to send a message encrypted for specific recipients such that anyone can verify the sender's authenticity, but only intended recipients can read the message contents (digital signatures, see *infra*).[343]

2.2.2 Hashing

Hashing. Hashing is the process of taking an input of arbitrary length and turning it into a cryptographic fixed output through a mathematical algorithm.[344] In blockchain, each new data entry is 'hashed', which means that a cryptographic hash function is applied to the original message.[345] The hash output is a so-called 'digest' of a defined length, which is based on, and

[338] In cryptography, a cipher is an algorithm for performing encryption or decryption. See: Lisk Academy, 'Blockchain Cryptography Explained', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/blockchain-cryptography-explained.
[339] Link Academy, 'Blockchain cryptography explained', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/blockchain-cryptography-explained; World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. IV.
[340] C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 4; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 31; World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. IV; Symmetric cryptography was developed in the late 1970s, see D. Whitefield Diffie and M.E. Hellman, 'New Directions in Cryptography', *22 IEEE transactions on information theory*, 1976 p. 644.
[341] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. IV.
[342] M. Finck, 'Blockchains and Data Protection in the EU', Max Planck Institute for Innovation and Competition Research Paper No. 18-01, p. 5.
[343] Link Academy, 'Blockchain cryptography explained', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/blockchain-cryptography-explained; C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 4.
[344] For example, Bitcoin uses SHA-256.
[345] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 8.

therefore shaped by, all previous transactions that have occurred on the blockchain.[346] The hash output is as a digital fingerprint similar to a human fingerprint, which cannot be changed unless the data itself is changed.[347]

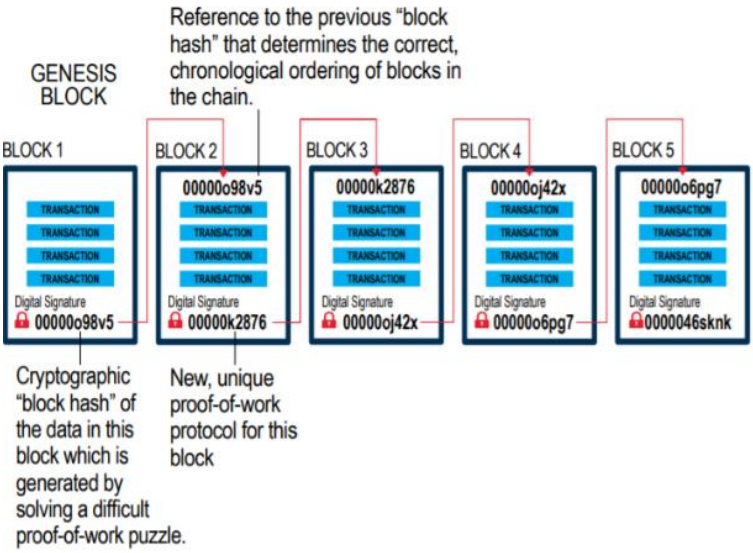
Example hash function. Consider the example below that makes use of SHA-256 (Secure Hashing Algorithm 256), which is the hashing algorithm of Bitcoin.[348] It appears from the example that no matter how big or small the input is, the output will always have a fixed 256-bits length.

INPUT	HASH
Hi	639EFCD08ABB273B1619E82E78C29A7DF02C1051B1820E99FC395DCAA3326B8
Welcome	53A53FC9E2A03F9B6E66D84BA701574CD9CF5F01FB498C41731881BCDC68A7C8

Blockgeeks, 'What is hashing?', 2018, https://blockgeeks.com/guides/what-is-hashing/.

Hashing blocks together. Blocks are cryptographically chained together because each block contains the hash of the previous block, which in turn contains the hash of the previous, and so on back to the first block.[349] The hash of the first block of the blockchain, 'the genesis block', is calculated by only using the transactions inside that block.[350] For every new block that is generated afterwards, the previous block's hash is used together with the data of the new block, as input to determine its block hash**.** This is how a chain of blocks is formed: each block links back to its previous block through its hash, forming a chain back to the genesis block, hence the name blockchain.

[346] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 8.
[347] C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 4.
[348] Blockgeeks, 'What is hashing?', 2018, https://blockgeeks.com/guides/what-is-hashing/.
[349] Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser', 2015, p. 17; O. Wyman and Euroclear, 'Blockchain in Capital Markets: The Prize and the Journey', 2016, p. 5, http://www.oliverwyman.com/content/dam/oliver-wyman/global/en/2016/feb/BlockChain-In-Capital-Markets.pdf.
[350] A. Lewis, 'A Gentle Introduction To Blockchain Technology', BraveNewCoin, p. 7, https://bravenewcoin.com/assets/Reference-Papers/A-Gentle-Introduction/A-Gentle-Introduction-To-Blockchain-Technology-WEB.pdf; World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 9.



World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', FinTech Note, No. 1, 2017, p. 9.

Crucial properties of hashing functions. To better understand how hashing contributes to the integrity of blockchain (see *infra*), it is relevant to discuss its crucial properties.[351]

(i) Preimage resistance. First, a hash has preimage resistance, i.e. it operates in one direction: from input data to hash value, but not vice versa.[352] As a result, it is almost impossible to determine input data based on the hash value. This is one of the foremost properties of hashes.

(ii) Collision resistance. Second, a hash is collision resistant, i.e. it is highly unlikely to generate the same hash twice.[353] First, this means that it is almost impossible to produce the same hash value for differing inputs. Second, this means that no matter how many times you enter a particular input through a hash function you will always get the same result.[354]

(iii) Avalanche effect. Third, a hash has an avalanche effect, i.e. a (very) slight change in the input data will completely change the hash value.[355] This is a matter of a security as if a slight

[351] See also: E.W. Weisstein, 'Hash function', MathWorld: http://mathworld.wolfram.com/ HashFunction.html.
[352] M. Finck, 'Blockchains and Data Protection in the EU', Max Planck Institute for Innovation and Competition Research Paper No. 18-01, p. 5; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 16; P. Rogaway and T. Shrimpton, 'Cryptographic hash-function basics: definitions, implications, and separations for preimage resistance, second-preimage resistance, and collision resistance' in B. Roy and W. Meier (eds.), *Fast software encryption*, 2004, Berlin, Springer, 2004, p. 371.
[353] P. Rogaway, and T. Shrimpton, 'Cryptographic hash-function basics: definitions, implications, and separations for preimage resistance, second-preimage resistance, and collision resistance' in B. Roy and W. Meier (eds.), *Fast software encryption*, 2004, Berlin, Springer, p. 371; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 16.
[354] A. Rosic, 'What is hashing under the hood of blockchain?', 2017, https://blockgeeks.com/guides/what-is-hashing/.
[355] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 16.

change only made a slight difference it would be considerably easier to work out what the input was.

Importance of hashing in blockchain technology. Hashing in blockchain technology in crucial for two reasons. First, hashing largely guarantees the integrity of blockchains in the sense of there being no chance of any fraudulent data.[356] The reason is that if any single part of a transaction changes, so does the hash of the block to which it belongs, and any following blocks' hashes as a result. In other words, modifying any part of a past block would invalidate all the subsequent hashes. Second, hashing enables detection of double spending as when the same funds are used again, the hash computed will be different than the originally generated hash.[357] Hashes make it fairly easy to catch both instances as the small, unique 'fingerprints' allow quick comparison of large datasets.[358]

2.2.3 Digital signatures

Digital signatures. In blockchain technology, data messages are signed with a digital signature, which binds the sender to the content of the data, akin to a signature on a contract.[359] In order to sign a digital message, senders use their private key, which is just like a password only known by the individual user. It is very important that users never share their private key with anyone. If the private key is lost, everything that is controlled by the key is lost too (see Chapter III: identity theft, *infra*).

Asymmetric cryptography. Digital signatures use asymmetric cryptography.[360] Asymmetric cryptography allows users to send a message encrypted for specific recipients such that anyone can verify the sender's authenticity with the public key but only intended recipients can read the message on the basis of the public key and the message received.[361] Asymmetric

[356] Lisk Academy, How does Blockchain work?, 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work; P. Rogaway, and T. Shrimpton, 'Cryptographic hash-function basics: definitions, implications, and separations for preimage resistance, second-preimage resistance, and collision resistance' in B. Roy and W. Meier (eds.), *Fast software encryption*, 2004, Berlin, Springer, p. 371.
[357] Double-spend occurs when the same single cryptocurrency or token is spent more than once.
[358] C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 4. Double-spend
[359] Z. Ramzan, 'Bitcoin: Digital Signatures', 2013, https://www.khanacademy.org/economicsfinance-domain/core-finance/money-andbanking/bitcoin/v/bitcoin-digital-signatures.
[360] T.K. Sharma, 'How does blockchain use public key cryptography', 2018, https://www.blockchain-council.org/blockchain/how-does-blockchain-use-public-key-cryptography/.
[361] T.K. Sharma, 'How does blockchain use public key cryptography', 2018, https://www.blockchain-council.org/blockchain/how-does-blockchain-use-public-key-cryptography/.

cryptography makes it impossible to work out the private key based on the public key or data that it has encrypted.

Three algorithms. Digital signatures are created by utilizing three algorithms: (i) a key generation algorithm, providing a private and public key (ii) a signing algorithm that combines the data content and the private key to make a digital signature and (iii) an algorithm that verifies signatures and determines whether the message is authentic.[362] These algorithms together ensure the authenticity of a signature based on the message and the private key, and verified through the public key.[363]

Integrity, authentication and non-repudiation. Digital signatures are crucial in blockchain technology as they ensure (i) integrity of data, (ii) authentication and (iii) non-repudiation.[364]

(i) Integrity of data. First, digital signatures ensure integrity of blockchain data. The reason is that, since data are part of the digital signature, changing even a tiny aspect of the data reshapes the whole signature, making it false and obsolete. In this way, asymmetric cryptography ensures that any data being transferred is true, accurate and untampered with and that the peer-to-peer network will not recognise digital signatures as valid if any part of it is tampered with.[365]

(ii) Authentication of sender. Second, digital signatures ensure authentication of the sender. When a message is digitally signed, the sender can be verified by all nodes in the network on the basis of the digital signature. Nodes use the public key to decrypt the digital signature to reveal the message digest. Successful decryption proves authenticity of the document, meaning that the digital signature really belongs to the person who is claiming ownership. Asymmetric cryptography guarantees that even the most proficient hacker cannot fake another's digital signature.

(iii) Non-repudiation. Third, digital signatures ensure non-repudiation. If a data message is signed by a user, that data is undeniably associated with that user.[366] In this regard, it is

[362] Lisk Academy, 'Digital Signatures', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/digital-signatures.
[363] Lisk Academy, 'Digital Signatures', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/digital-signatures.
[364] A. Baliga, 'The Blockchain Landscape', Persistent, 2016, p. 5, https://www.persistent.com/wp-content/uploads/2016/03/The-Blockchain-Landscape-.pdf; Z. Ramzan, 'Bitcoin: Digital Signatures', 2013, https://www.khanacademy.org/economicsfinance-domain/core-finance/money-andbanking/bitcoin/v/bitcoin-digital-signatures.
[365] M. Finck, 'Blockchains and Data Protection in the EU', Max Planck Institute for Innovation and Competition Research Paper No. 18-01, p. 5.
[366] Link Academy, 'Digital signatures', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/digital-signatures.

important to see that the quality of non-repudiation is heavily dependent on there being no doubt that the private key that signed the data was not compromised, used or seen by anyone other than its owner (see *infra*).

2.3 Consensus mechanisms

2.3.1 Need of consensus in blockchain technology

Centralised versus decentralised systems. In centralised systems, an administrator manages the database and decides what data to store and how to update them.[367] By contrast, in the decentralised blockchain network, all nodes together manage the blockchain and decide what data to store and to update.[368] The decentralised nature of blockchain technology requires the nodes to reach a consensus regarding the validity of new data entries.[369] Consensus is reached through a consensus mechanism that is specified in the algorithmic design of the blockchain.[370] In most blockchains, every node can propose an addition to the blockchain. See, however, the proof-of-stake consensus mechanism where only some nodes can propose an addition to the blockchain (see *infra*).

Consensus required in peer-to-peer network. In general, consensus is necessary to establish whether a transaction is valid or not.[371] There are two cases in which consensus in particularly required. First, consensus is necessary to meet the inherent problem of peer-to-peer networks that, even if all peers are trusted, peers may be updating at different speeds, which may result in different states of the blockchain. Second, consensus is crucial to handle conflicts between multiple simultaneous competing entries and to prevent malicious peers from modifying past blocks.[372] For example, an attacker may attempt to spend some money and then reverse the transaction by broadcasting their own version of that blockchain, not including the transaction.[373] This is known as double spending (see *infra*).[374]

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[367] C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 4.
[368] A.M. Tulpule, 'Enforcement and compliance in a blockchain(ed) world', 2017, p. 1, https://www.competitionpolicyinternational.com/wp-content/uploads/2017/01/CPI-Tulpule.pdf.
[369] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 7; G. Wood, 'Ethereum Yellow Paper', 2016, https://github.com/ethereum/yellowpaper.
[370] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 7.
[371] A.M. Tulpule, 'Enforcement and compliance in a blockchain(ed) world', 2017, p. 1, https://www.competitionpolicyinternational.com/wp-content/uploads/2017/01/CPI-Tulpule.pdf.
[372] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 7.
[373] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 7.
[374] Double-spend occurs when the same single digital is spent more than once.

Mining to find out the 'true state' of the blockchain. The question Satoshi Nakamoto grappled with when designing Bitcoin, the first blockchain, was how a peer-to-peer network could agree on the status of the blockchain continually and in real-time. He found the answer in 'mining.' Mining is the process of computers validating data in the blockchain network, hereby adding blocks onto the blockchain.[375] Mining makes it impossible that malicious actors rewrite past blocks, as they need to re-generate all following blocks and overtake the honest nodes in the network. This is computationally infeasible, as long as honest peers control a large share of the total hashing power (see *infra*).

2.3.2 Consensus mechanisms

Roadmap. In this section, the mining process is explained on the basis of the most well-known consensus mechanism, namely proof-of-work (PoW). Although mining slightly differs throughout the different consensus mechanisms, there is a significant common basis in all consensus mechanisms, which is certainly present in PoW. In addition, the proof-of-stake (PoS) consensus mechanism is discussed. PoW and PoS are the most important consensus mechanisms for blockchain based P2P lending.

2.3.3 Proof-of-work (PoW)

Proof-of-work. Proof-of-work (PoW) is the most well-known consensus mechanism, used by many blockchains, such as Bitcoin, Ethereum (see, however, *infra*), Ethereum Classic and Litecoin. As the name suggests, proof-of-work requires nodes to prove they have done a significant amount of work to validate new transactions and to add new set of data entries to the blockchain, thereby generating a new block in the blockchain.[376] In this regard, 'work' refers to the large amount of computing power and processing time required to solve a difficult cryptographic puzzle. This cryptographic puzzle is aimed at finding a valid hash that includes every single information that the block has to include (see *infra*).[377] PoW is generated by repeatedly running one-way cryptographic hashing algorithms until a string of numbers is produced that satisfies a predefined but arbitrary condition. The computational challenge is hard

[375] C. Dannen, 'Mining Ether' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 112.
[376] G. Pîrlea, A review of the Blockchain literature, 2016, p. 5, http://students.cs.ucl.ac.uk/2016/group15/reports/research.pdf.
[377] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 17-18.

to solve in terms of computing power, but easy to verify. This overall process of generating PoW is called 'mining'.[378]

Cryptographic puzzle and finding a valid hash. The cryptographic puzzle is aimed at finding a valid hash that includes every single information that the block has to include.[379] The structure of such a valid hash varies from one consensus mechanism to another. In the case of Bitcoin, first of all, the hash has to start with a certain number of zeros. To find the appropriate number of zeros, a miner must make multiple, random guesses using different input data.[380] However, if a hash only requires a certain number of zeros to be valid, a miner could easily reuse the same input, generate the same hash, and create another valid block over and over again.[381] Hence, there is a second requirement for the hash to be valid: it must also incorporate the hash of the previous block.[382] Since no two blocks have the same hash, Bitcoin miners are forced to change their input data every time a new competition begins. Once the miner has found the valid hash, the mathematical puzzle is solved. Finding the valid hash proofs that work went into the generation of the hash, and by extension, into the validation of the block.

Verification by the other nodes. The cryptographic puzzle can only be solved by brute forcing solutions and miners spend considerable money on the electricity needed to run the graphics processing units (GPUs) to do this.[383] Therefore, if a block is mined by someone, the block is spread to the other nodes in the network, which will verify that the hash of the previous block is correct and that the hash function generates a valid hash.[384] If more than 50 % of the nodes start working on the next block, it can be assumed that the block is valid, and therefore, part of the 'true state' of the blockchain. After the validation of the block, all nodes add the new block to their respective ledgers.

Miners. In theory, every miner has the ability to generate the PoW for a specific block. However, as more and more miners have dedicated more and more computer power, which enable them to arrive at correct guesses much faster, and thus mine many more coins, the

[378] C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 12.
[379] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 17-18.
[380] T.K. Sharma, 'How does blockchain use public key cryptography', 2018, https://www.blockchain-council.org/blockchain/how-does-blockchain-use-public-key-cryptography/.
[381] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 17.
[382] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 17.
[383] T. Maas, 'What is blockchain technology?', Law & Blockchain, 2018, http://www.lawandblockchain.eu/post-template/.
[384] T. Maas, 'What is blockchain technology?', Law & Blockchain, 2018, http://www.lawandblockchain.eu/post-template/.

demands to effectively participate in mining increase.[385] In particular, the high costs of electricity and the initial capital required to acquire the appropriate mining hardware make blockchain networks that use PoW increasingly difficult to join.[386] Furthermore, miners have started to group into communities, better known as 'mining pools', to have better chances of finding valid hashes.[387] One the hand, this evolution must be welcomed as the security of blockchains that uses PoW as consensus mechanism is backed by the amount of computing power required to prove the work.[388] On the other hand, when fewer and fewer people can afford mining technology, the potential for centralization increases, which jeopardises the decentralised control and data validation by independent nodes in the blockchain network.

Cryptocurrencies for mining. Each miner that produces a valid PoW receives cryptocurrencies as a reward, which serves as an economic incentive to preserve the integrity of the blockchain.[389] In the case of Blockchain, miners receive bitcoins. This reward system is crucial, as network security is directly related to having a large number of nodes in the system that are incentivised to accurately validate new changes to the ledger and establish a consensus across the network to ensure data consistency.

2.3.4 Proof-of-stake (PoS)

Proof-of-stake. Proof-of-stake (PoS) is a consensus mechanism in which miners are selected to mine the next block.[390] The system was initially suggested in 2011 and the first cryptocurrency to implement it was Peercoin in 2012.[391] Other cryptocurrencies include NXT, ShadowCash, Nem and Dash.[392] It is important to note that Ethereum is planning to move its protocol from PoW to PoS.[393]

Selection of miners. In contrast to PoW, where all nodes have the ability to generate the proof-of-work for the next block, miners are selected in PoS. The basic principle of the selection

[385] I. Simpson, 'To Understand Blockchains, You Should Understand Cryptographic Hashes First', 2017, https://medium.com/vandal-press/to-understand-blockchains-you-should-understand-cryptographic-hashes-first-for-normies-93bc7645e816.
[386] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 21.
[387] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 22.
[388] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 21-22.
[389] A. Baliga, 'The Blockchain Landscape', Persistent, 2016, p. 5, https://www.persistent.com/wp-content/uploads/2016/03/The-Blockchain-Landscape-.pdf; G. Pîrlea, A review of the Blockchain literature, 2016, p. 5, http://students.cs.ucl.ac.uk/2016/group15/reports/research.pdf.
[390] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 203.
[391] Ibid.
[392] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 205.
[393] See: A. Hertig, 'Ethereum's Big Switch: the New Roadmap to Proof-of-Stake', 2017, https://www.coindesk.com/ethereums-big-switch-the-new-roadmap-to-proof-of-stake/.

process is that miners need to own coins to own mining power. The underlying idea is that the more coins a miner owns, the more stake he has in the market and the more chances that person should have to be chosen to update the blockchain.[394] A pure proof-of-stake mechanism assigns odds to every miner depending on his stake in the coin.[395] For example, if someone owns 3% of all coins and is willing to mine a block, that person will have at least a 3% chance of mining the next block. Note that we mentioned "at least" since some nodes might not be interested in mining.

Less energy-consuming algorithm. PoS is the result of the search to a less energy-consuming alternative for PoW. Unlike PoW, which is backed by computing power, PoS does not require specialised mining hardware or high amounts of energy being burned to generate a block.[396] As a result, miners also do not have to pay high costs of electricity and sophisticated mining hardware.

B. Particularities of Blockchain and Ethereum

Use of Blockchain and Ethereum in blockchain based P2P lending platforms. After studying the (significant) common basis of blockchain technology recurring in all specific blockchain technologies, we proceed to the discussion of Blockchain (or Bitcoin) and Ethereum, the two most widely used blockchains in blockchain based P2P lending specific blockchains. Examples of P2P lending platforms which are based on Blockchain are BTCJam, BTCPOP and Bitbond. Examples of P2P lending platforms which rely on Ethereum are ETHLend, Celsius and Getline. The research paper is limited to a discussion of the features and applications of these blockchains with the potential to eliminate or reduce risks of P2P lending. Therefore, the focus is on the data structure of Blockchain and the smart contracts and DAOs (decentralised autonomous organisations) made possible by Ethereum.

[394] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 203.
[395] A. Baliga, 'The Blockchain Landscape', Persistent, 2016, p. 7, https://www.persistent.com/wp-content/uploads/2016/03/The-Blockchain-Landscape-.pdf.
[396] C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 12; R. Patterson, 'Alternatives for Proof of Work, Part 1: Proof Of Stake', 2015, https://bytecoin.org/blog/proof-of-stake-proofof-work-comparison/.

1. Blockchain (or Bitcoin)

Blockchain or Bitcoin. Blockchain (or Bitcoin), the first and largest public blockchain, was introduced in 2008 by someone (or some group) using the pseudonym Satoshi Nakamoto.[397] Blockchain and its underlying (blockchain) technology were for the first time described in Nakamoto's paper titled 'Bitcoin: A Peer-To-Peer Electronic Cash System as a digital asset and payment system for the cryptocurrency bitcoin.'[398] In essence, Bitcoin allows recording the creation and transfer of bitcoins without the need of a third trusted party or central server. Bitcoin was the first digital currency to solve the double-spending problem through cryptographic hashes and a consensus mechanism (see *infra*).

Blockchain: a chain of blocks. As the name 'blockchain' indicates, the importance of blockchain technology lies in the blocks being cryptographically chained together. Blocks are cryptographically chained together, because each block contains the hash of the previous block, which in turn contains the hash of the previous, and so on back to the first block (see *supra*).[399] Whereas the technique of cryptographically chaining blocks was for the first time introduced in Blockchain, it is now a common feature of all blockchains, including Ethereum (see *infra*). For the importance of all blocks being cryptographically chained together, see hashing, *supra*.

Blockchain: a chain of blocks. Whereas the cryptographically chaining of blocks is similar in all types of blockchains, the data structure of the blocks varies from blockchain to blockchain. In Blockchain, Bitcoin's blockchain, each block consists of a block header and a transaction list. The block header is located at the head of the transaction list and consists of three parts: (i) the hash of the previous block header, (ii) the hash of the block and (iii) a merkle root.[400] The transaction list is implemented as a merkle tree with at the top the merkle root being part of the block header (see *infra*). In this way, the block header and the transaction list are attached to each other.

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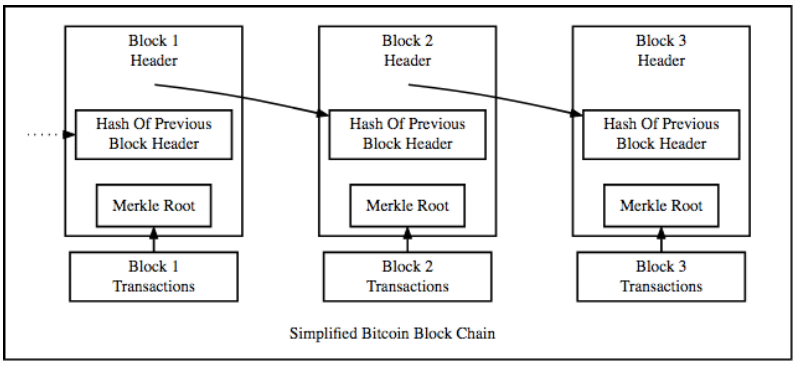
[397] K. Werbach, 'Trust, But Verify: Why the Blockchain Needs the Law', *Berkeley Technology Law Journal*, (forthcoming 2018), p. 2, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2844409.

[398] S. Nakamoto, 'Bitcoin: A Peer-To-Peer Electronic Cash System', 2008, https://bitcoin.org/bitcoin.pdf. Nakamoto's identity has never been conclusively identified.

[399] Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser', 2015, p. 17; O. Wyman and Euroclear, 'Blockchain in Capital Markets: The Prize and the Journey', 2016, p. 5, http://www.oliverwyman.com/content/dam/oliver-wyman/global/en/2016/feb/BlockChain-In-Capital-Markets.pdf.

[400] A. Lewis, 'A Gentle Introduction To Blockchain Technology', BraveNewCoin, p. 7, https://bravenewcoin.com/assets/Reference-Papers/A-Gentle-Introduction/A-Gentle-Introduction-To-Blockchain-Technology-WEB.pdf; G. Pîrlea, A review of the Blockchain literature, 2016, p. 5, http://students.cs.ucl.ac.uk/2016/group15/reports/research.pdf.



Blockchain queries, 'What is the blockchain?', 2017, http://web-impress.com/2017/12/26/what-is-the-blockchain-2/.

(i) The previous block hash. Remember that in a blockchain, every block is cryptographically chained to the previous block because the previous block's hash is used to create the new block's hash.[401]

(ii) Hash of the block. For a block to be part of the blockchain, it needs to be given a valid hash (consensus mechanisms, see *supra*). The valid hash is the solution of a difficult cryptographic puzzle (see consensus mechanisms, *supra*).

(iii) Merkle root. The third part of the block is the merkle root. By hashing all the transactions together into a merkle tree, the transaction list of the block can be represented by one single hash on the top of the merkle tree, called the merkle root (hash). This hash root is mainly used for verifying the stored data and preventing any modification of data in the network. Indeed, the slightest modification of data will change the hash of the data and consequently the merkle root, which is visible to other nodes verifying the blocks.

Transaction list implemented as a merkle tree. The list of transactions is implemented as a merkle tree.[402] A merkle tree is a data structure of hashes used to record data onto the blockchain in a secure and efficient manner. The system works by running a block of data through an algorithm to generate a hash for that block of data. Hashes of data blocks (the 'leaves' or 'child hashes') are paired and hashed together with hashes of other data blocks to 'branches' or 'parent hashes', which, at their turn, are paired and hashed together until a single hash remains, the

[401] D. Cosset, 'Blockchain: what is in a block?', 2017, https://dev.to/damcosset/blockchain-what-is-in-a-block-48jo.
[402] The concept was patented by Ralph Merkle in 1979.

'merkle root'.[403] Depending on the data size of the blocks, the number of levels until the merkle root may differ.

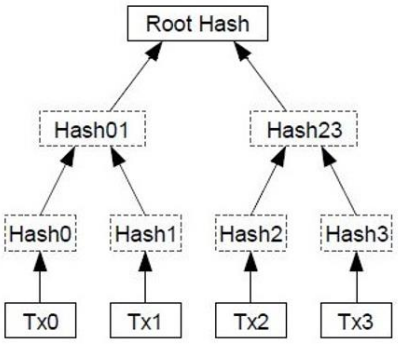


Figure 2: Visual example of a Merkle Tree

'Merkle tree', http://operationblockchain.org/merkle-tree.html.

Merkle trees and efficiency. Merkle trees are efficient as they allow nodes to confirm the validity of an individual transaction without having to download the entire blockchain consisting of thousands and thousands of transactions. As long as nodes have the root hash, they can easily confirm the validity of the relevant transaction by taking together the hashes of the relevant 'leaves' and 'branches' of that transaction.[404]

Merkle trees and security. The most important is that merkle trees provide security, integrity and irrefutability. The reason is that any modification in a transaction of the merkle tree will change the hash of the node and consequently the hash root of the tree which is visible to the other nodes.[405]

2. Ethereum

Ethereum. Ethereum is the second largest public and permissionless blockchain. Whereas Bitcoin is limited to recording the creation and transfer of bitcoins, Ethereum is a programmable blockchain with many more possibilities than recording the creation and transfer of Ether. Two crucial applications enabled by Ethereum are 'smart contracts' and 'decentralised autonomous

[403] M.H. Tabatabaei, 'Data Structure', http://www.uio.no/studier/emner/matnat/ifi/IN5420/v18/timeplan/resources/summary-third-topic/datastructure-mohamtabatabaei.pdf.
[404] Lisk Academy, 'What is hashing?', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/what-is-hashing.
[405] M.H. Tabatabaei, 'Data Structure', http://www.uio.no/studier/emner/matnat/ifi/IN5420/v18/timeplan/resources/summary-third-topic/datastructure-mohamtabatabaei.pdf.

organisations' ('DAOs').[406] Both applications play a crucial role in eliminating or reducing risks of P2P lending (see Chapter III, *infra*).

1.1 Smart contracts

Smart contracts. Perhaps the most important application of blockchain technology for P2P lending is smart contracts.[407] Smart contracts were theorised by cryptographer Nick Szabo in the late 1990s, but it took almost twenty years before their potential was truly appreciated.[408] Smart contracts are described by Szabo as follows:

> "A smart contract is a computerized transaction protocol that executes the terms of a contract. The general objectives are to satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions both malicious and accidental, and minimize the need for trusted intermediaries. Related economic goals include lowering fraud loss, arbitrations and enforcement costs, and other transaction costs."

No universal definition. There exists no universally accepted definition of smart contracts.[409] This appears, for example, from the divergences between the definitions from those with a computer science background, thinking of smart contracts in terms of code designed to execute certain tasks, and those with a legal background, connoting a very particular relationship of obligations.[410] In the same vein, Stark presents two distinct 'schools of smart contracts':[411]

- **Smart legal contracts**: This first school defines smart contracts as "legal contracts, or elements of legal contracts, being represented and executed by software". This conception corresponds the most with those with a legal background.

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[406] L. Caisley, D. Lucking, M. Zdrowski and C O'Hanlon, 'Decentralized Autonomous Organizations', 2016, Allen and Overy, http://www.allenovery.com/SiteCollectionDocuments/Article%20Decentralized%20Autonomous%20Organizations.pdf.

[407] M. Crosby, P. Nachiappan, S. Verma and V. Kalyanaraman, 'Blockchain technology: Beyond bitcoin', 2016, *Appl Innov Rev*, 2016, p. 6–19; A. Kosba, S.E. Miller, Z. Wen and C. Papmanthou, 'Hawk: The blockchain model of cryptography and privacy-perserving smart contracts', 2016, Proceedings of IEEE 2016 Symposium on Security and Privacy, p 839–858.

[408] I. Bashir, *Mastering Blockchain*, Birmingham, Packt Publishing, 2017, p. 198.

[409] T. Swanson, 'Consensus-as-a-service: a brief report on the emergence of permissioned, distributed ledger systems', 2015, http://www.ofnumbers.com/wp-content/uploads/2015/ 04/Permissioned-distributed-ledgers.pdf.

[410] ISDA and Linklaters, 'Whitepaper Smart Contracts and Distributed Ledger – A Legal Perspective', 2017, p.5; N. Szabo, 'Formalizing and securing relationships on public networks', *First mind*, 2(9), 1997, p. 2.

[411] J. Stark, 'Making sense of blockchain smart contracts', 2016, http://www.coindesk/com/making-sense-smart-contracts/. Also cited in C. Clack, V. Bakshi, and L. Braine, 'Smart Contract Templates: foundations, design landscape and research directions', 2017, https://arxiv.org/abs/1608.00771.

- **Smart contract code**: The other school refers less to contracts and defines smart contracts as a "piece of code that is designed to execute certain tasks if pre-defined conditions are met. Such tasks are often embedded within, and performed on, a distributed ledger."

Smart legal contracts and smart contract code: closely related to each other? Rather than considering smart legal contracts and smart contract code separately, one should look to the relationship between both.[412] In order to implement smart legal contracts, pieces of code designed to execute certain tasks if pre-defined conditions are met need to be embedded.[413] Smart legal contracts are thus functionally made up of smart contract code, but, crucially, "under the umbrella of an overall relationship that creates legally enforceable rights".[414] In order for smart legal contracts to be valid, a legal contract satisfying the requirements of the relevant governing law remains necessary. Perhaps the law will evolve to recognise the legal enforceability of certain types of code without more, but at present more traditional legal contracts remain necessary.[415]

Functioning of smart contracts. In the 1997 white paper of smart contracts, Nick Szabo used a vending machine to illustrate the idea of a smart contract.[416] "The vending machine, a mechanical device, controls ownership of an asset, the candy bar, and executes the transfer of ownership when triggered by a defined input, the event of entering a coin into the machine. The vending machine therefore enforces the terms of the pre-agreed 'contract' that defines the underlying assets, inputs, and consequential actions".[417] Twenty years later, the comparison with a vending machine is still valid. Smart contracts are capable of verifying, executing and enforcing a set of predefined instructions.[418] Smart contracts allow transactions to be executed only if all necessary conditions are met. In the context of P2P lending, smart contracts mainly

[412] ISDA and Linklaters, 'Whitepaper Smart Contracts and Distributed Ledger – A Legal Perspective', 2017, p.5.
[413] ISDA and Linklaters, 'Whitepaper Smart Contracts and Distributed Ledger – A Legal Perspective', 2017, p.5.
[414] Ibid, p. 5.
[415] Clifford Chance, 'Are smart contracts contracts? Talking Tech looks at the concepts and realities of smart contracts', 2017, https://talkingtech.cliffordchance.com/en/tech/are-smart-contracts-contracts.html.
[416] N. Szabo, 'The Idea of Smart Contracts', 1997, http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/idea.html.
[417] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 29.
[418] A.M. Tulpule, 'Enforcement and compliance in a blockchain(ed) world', 2017, https://www.competitionpolicyinternational.com/wp-content/uploads/2017/01/CPI-Tulpule.pdf.

play a role in the payment of redemption and interest payments and in the execution of collateral on the blockchain (see Chapter III, *infra*).[419]

Automatized and self-enforcing smart contracts: something new? The automation of legal obligations upon satisfaction of pre-defined conditions has been feasible for some time.[420] So far, though, the automatization of legal obligations has required the contracting parties to have programmed their own computers and to have been running separate instances of the program on their own systems.[421] This implied the risk that two different implementations of the program existed. Blockchain technology addresses this risk as, by embedding the code in the blockchain, only one single version of the smart contract exists. Furthermore, once the code is switched on, the smart contract ensures that no party can tamper with the code (see *supra*).[422]

Challenges smart contracts: flexibility, addressing external information and linking smart contracts to real assets. Although the automatization, self-execution and enforcement possibilities of smart contracts have potential to address P2P lending risks (Chapter III: see *infra*), several challenges need to be overcome. Although the challenges set out below are mainly problems within the area of software, they have (major) legal consequences as well.

(i) Flexibility. First, flexibility is a major concern as it is not possible to stop or modify a smart contract once included in the blockchain: it continues to operate irrespective of external events until its pre-set expiration date.[423] The only possibility is to add a new contract and disrupt the previous one. Coders must foresee this and they need to be able to translate legal contracts with very specific legal terms into a digital smart contract that enforces these legal terms.[424]

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[419] Bank of England, 'Banking on the blockchain: World's first crypto bond', *International Financial Law Review*, 2018, p 1-2-3.
[420] ISDA and Linklaters, 'Whitepaper Smart Contracts and Distributed Ledger – A Legal Perspective', 2017, p. 8-9.
[421] Ibid., p. 8-9.
[422] Smart contracts are "self-enforcing" because they automatically transfer tokens upon the occurrence of pre-defined events or automatically block access to cars or flats, in the event of non-payment of a loan or rent. See: K.D. Atta-Krah, 'Preventing A Boom from Turning Bust: Regulators Should Turn Their Attention to Starter Interrupt Devices Before the Subprime Auto Lending Bubble Bursts', 101 *Iowa Law Review*, 2016, p. 1187.
[423] C.D. Clack, et al., 'Smart Contract Templates: foundations, design landscape and research directions', 2016, ArXiv e-prints, p. 4; E. Mik, 'Smart contracts: Terminology, technical limitations and real world complexity', *Law, Innovation and Technology*, 2017, p. 293; J. Ream, D. Schatsky and Y. Chu, 'Upgrading blockchains', 2016, Deloitte University Press, p. 6, https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/innovatie/deloitte-nl-innovatie-upgrading-blockchains-smart-contract-use-cases-in-industry.pdf.
[424] M. von Haller Gronbæk, 'Blockchain 2.0, smart contracts and challenges', 2016, http://www.twobirds.com/en/news/articles/2016/ uk/blockchain-2-0--smart-contracts-andchallenges.

(ii) Addressing external information. Second, bringing external information into smart contracts proves to be difficult.[425] The main solution is perhaps the use of oracles, i.e. 'real-work' agents that find and verify real-world occurrences and submit this information to the blockchain.[426] Oracles do not feed such information into the blockchain directly, but sign the script unlocking the tokens with their private key when an off-chain event is established as true.[427]

(iii) Linking smart contracts to real assets. Third, linking smart contract to real assets will be challenging as well.[428] A participant can claim ownership but there is no way to verify these claims. Smart contracts need reliable data as input in order to come to the right execution. Therefore, either a third party or an oracle is needed. Whereas a third party brings back concerns of centralization, oracles are not well-developed enough for the foreseeable future.[429] Internet-of-Things (IoT) starts to play a growing role in this respect. Internet-of-Things (IoT) is defined as "a way for sensors and machines to communicate with each other by combining the capabilities of big data, analytics and artificial intelligence to anticipate needs, solve problems, and increase efficiency".[430] For a thorough discussion of the possibilities of IoT in P2P lending, see Chapter III, *infra*.

Acceptability and wide implementation. Other challenges concern acceptability and wide implementation. When governments fail to adapt legislation to make smart contracts legally binding, such contracts will lose strength.[431]

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[425] 'External information' is information which is not written in the blockchain. J. Ream, D. Schatsky, and Y. Chu, 'Upgrading blockchains', 2016, Deloitte University Press, p. 6, https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/innovatie/deloitte-nl-innovatie-upgrading-blockchains-smart-contract-use-cases-in-industry.pdf.

[426] M. Grey, 'Introducing Project "Bletchley"', 2016, https://github.com/Azure/azure-blockchainprojects/blob/master/bletchley/bletchleywhitepaper.md. Oracles are entities that furnish the technical infrastructure to communicate information about off-chain events to smart contracts.

[427] E. Mik, 'Smart Contracts: Terminology, Technical Limitations and Real World Complexity', *Law, Innovation and Technology*, 2017, p. 292.

[428] J. Ream, D. Schatsky and Y. Chu, 'Upgrading blockchains', 2016, Deloitte University Press, p. 6, https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/innovatie/deloitte-nl-innovatie-upgrading-blockchains-smart-contract-use-cases-in-industry.pdf; M. von Haller Gronbæk, 'Blockchain 2.0, smart contracts and challenges', 2016, http://www.twobirds.com/en/news/articles/2016/ uk/blockchain-2-0--smart-contracts-andchallenges.

[429] T. Maas, 'Ethereum – The New Internet or a New Bubble?', 2017, https://www.linkedin.com/pulse/ethereum-new-internet-bubble-complete-guide-thijs-maas/.

[430] A. K. Agarwal, 'Banking on The Internet of Things IoT', 2015, https://www.finextra.com/blogs/fullblog.aspx?blogid=11676.

[431] P. Satyavolu and A. Sangamnerkar, 'Blockchain's Smart Contracts', 2016, p. 9, https://www.cognizant.com/whitepapers/blockchains-smart-contracts-driving-the-next-wave-of-innovation-across-manufacturing-value-chains-codex2113.pdf.

1.2 Decentralised Autonomous Organisations (DAOs)

DAOs. A Decentralised Autonomous Organisation (DAO) is a "computer program, running on a peer-to-peer network, incorporating governance and decision-making rules".[432] DAOs can be programmed to operate autonomously or the code can provide for direct, real-time control of the DAO and the funds controlled by it through member consultation and voting.[433] A combination of both is also conceivable.

DAO as a community with 'contractors' and 'curators'. A DAO can be considered as a community, in which 'contractors', actors in the physical world who can perform tasks, can make (and veto) proposals to the community on how to devote the resources of the DAO.[434] The members of the DAO then debate and vote on the proposal during a set period of time. In addition, a 'curator', a participant who is tasked with maintaining the code of the DAO, can propose changes to the DAO. A curator is also a safeguard against a 'tyranny of the majority', i.e. "an individual or group gaining control of 51% of the DAO tokens, abusing their voting power and sending all funds to themselves".[435]

Formation of a DAO. A DAO starts with a group of people writing the smart contracts that will run the DAO. Thereafter, an initial funding period takes place in which people add funds to the DAO to give it the resources it needs by purchasing tokens that represent ownership. This is called an initial coin offering (ICO). When the initial funding period is over, the DAO begins to operate.

Legal status of DAOs. The legal status of DAOs is a point of discussion. Some authors argue that DAOs are autonomous code and can operate independently of legal systems; others have said that they must be owned or operated by humans or human-created entities.[436] Ultimately, the legal status of a DAO will depend on many factors, including "how DAO code is used, where it is used, and who uses it".[437] As long as the legal status of DAOs is not established, the full potential of DAOs will not be realised. The reason is that uncertainty about legal rights attributable to DAOs and the responsible party in DAOs is not conducive to their development.

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[432] L. Caisley, D. Lucking, M. Zdrowski and C O'Hanlon, 'Decentralized Autonomous Organizations', 2016, Allen and Overy, p. 5, http://www.allenovery.com/SiteCollectionDocuments/Article%20Decentralized%20Autonomous%20Organizations.pdf.
[433] Ibid.
[434] Ibid.
[435] Ibid.
[436] Ibid.
[437] Ibid.

According to CAISLEY et al., it is conceivable that DAOs fall within the categories of a general partnership or joint venture agreement between the participants.[438]

Jurisdiction of DAOs. The determination of the jurisdiction of a DAO (and its members) can also be problematic.[439] The reason is that DAOs can be developed by many contributors, some known, some not known, based in multiple jurisdictions, using servers based in yet more jurisdictions.

Legal status of DAO tokens. DAOs are funded by members using Ether. In exchange, DAOs provide its members with tokens, proportional to their investment, representing voting and ownership rights. The combination of voting and ownership rights makes the legal status of DAO tokens difficult. CAISLEY et al. recognise this: "DAO tokens represent the initial contribution by each investor [and have similar attributes to shares or equity], but if there is no legal entity they cannot be considered to be shares or ownership rights or stakes".[440] However, the risk remains that regulators qualify DAO tokens as securities.[441]

Potential liability of a DAO and its participants. Given that the legal status of DAOs and DAO tokens and the jurisdiction of DAOs are not yet established, it is not surprising that also the liability issue is significant. When DAOs are considered as general partnerships or as joint ventures, it is likely that DAO members would be held liable.[442] However, given that members are not always known and/or based in multiple jurisdictions, this can be legally challenging. Therefore, it is not unconceivable that courts might, depending on the facts, be prepared to find liability against developers, promoters or creators of DAOs.[443]

[438] Ibid.
[439] Ibid.
[440] Ibid.
[441] Ibid.
[442] Ibid, p. 6-7.
[443] Ibid.

CHAPTER III: DEREGULATORY POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR P2P LENDING

Aim chapter. After discussing the risks of P2P lending and their regulatory framework in the first chapter and discussing the functioning of blockchain technology in the second chapter, we put together the gained insights to study the possibilities (and limitations) of blockchain technology to eliminate or reduce the risks of P2P lending. This study allows to provide an answer on the research question "*What is the deregulatory potential of blockchain technology for P2P lending*?" The research paper aims to give a thorough overview of the deregulatory potential of blockchain technology for each individual P2P lending risk in the same order as they were set out in the first chapter. In short, we discuss the deregulatory potential of blockchain technology for (i) credit risk, (ii) fraud (iii) money laundering, (iv) hacking, (v) liquidity risk, (vi) conflict of interest and (vii) operational risk.

I. Credit risk

Blockchain technology and credit risk. In the context of P2P lending, credit risk is the risk that the borrower fails to make the loan payments to the lender as agreed.[444] A distinction can be made between credit risk in the strict sense (the risk that the borrower is not creditworthy) and credit risk in the broad sense (the risk that lenders do not receive their loan payments as agreed). The potential of blockchain technology to reduce credit risk in the strict sense is limited, as no technology in itself can change the creditworthiness of borrowers. However, blockchain technology is able to reduce credit risk in the broad sense, i.e. the risk that P2P lenders do not receive their redemption and interest payments as agreed. It does so by (i) improving transaction settlement, (ii) improving credit risk assessments so that it becomes less likely for lenders to be matched with an uncreditworthy borrower and (iii) allowing fast and effective execution of collateral, in the case that credit risk materialises.

[444] Corporate Finance Institute (CFI) , 'What is credit risk?', https://corporatefinanceinstitute.com/resources/knowledge/finance/credit-risk/; C. Serrano-Cinca, B. Gutiérrez-Nieto, and l. López-Palacios, 'Determinants of Default in P2P Lending', *PLoS*, 2015, p. 3.

1.1 Improved transaction settlement

Improved transaction settlement. Blockchain technology reduces credit risk in broad terms by improving transaction settlement. More precisely, smart contracts allow (near) real-time transaction settlement and certainty of transaction settlement.[445]

(i) (Near) real-time transaction settlement. First, smart contracts allow (near) real-time or near-instant transaction settlement. The reason is that loan payments are transferred automatically and directly between the parties to the loan contract without the intervention of any intermediary.[446] (Near) real-time transaction settlement reduces credit risk in the broad sense as it increases certainty of transaction settlement (see *infra*) and strongly decreases reconciliation work.[447] Indeed, as both sides of the lending transaction are executed simultaneously, there is only one (valid) version of the loan transaction. Rare differences between transaction records, for example as a consequence of the blockchain being updated at different speeds, are immediately reduced to one valid transaction record by consensus mechanisms so that the true state of the blockchain remains.[448] This possibility of blockchain technology may also have an impact outside the context of blockchain based P2P lending. For example, it may potentially obviate liability regimes such as the payer's liability regime for unauthorised payment transactions laid down in the Payment Services Directive (Article 74).[449]

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[445] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement An analytical framework', 2017, Bank for International Settlements, p. 12, https://www.bis.org/cpmi/publ/d157.pdf; G.W. Peters and E. Panayi, 'Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money, 2015, p. 28, https://arxiv.org/pdf/1511.05740.pdf.

[446] Deloitte, 'Continuous interconnected supply chain. Using Blockchain & Internet-of-Things in supply chain traceability', 2017, p. 5, https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/technology/lu-blockchain-internet-things-supply-chain-traceability.pdf.

[447] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement An analytical framework', 2017, Bank for International Settlements, p. 13, https://www.bis.org/cpmi/publ/d157.pdf; F. Garitt, 'Blockchain and beyond: The New Technology Revolutionizing Traditional Banking', *The RMA Journal*, Vol. 99, Iss. 2, 2016, p. 32-33; Y. Chu, J. Ream, and D. Schatsky, 'Upgrading blockchains: smart contract use cases in industry', 2016, Deloitte University Press, p. 5, https://www2.deloitte.com/insights/us/en/focus/signals-for-strategists/using-blockchain-for-smart-contracts.html?top=4.

[448] H. Byström, 'Blockchains, real-time accounting and the future of credit risk modeling', Working Papers, 2016, Lund University, Department of Economics, p. 2; Deloitte, 'Continuous interconnected supply chain. Using Blockchain & Internet-of-Things in supply chain traceability', 2017, p. 5, https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/technology/lu-blockchain-internet-things-supply-chain-traceability.pdf.

[449] Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015 on payment services in the internal market, amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No 1093/2010, and repealing Directive 2007/64/EC.

(ii) Certainty of transaction settlement. Second, certainty of transaction settlement reduces credit risk in the broad sense. Relying on consensus mechanisms, blockchain technology ensures that borrowers can only spend what they own (or have previously borrowed) and that loan transactions are immediately and immutably recorded on the blockchain.[450] This is done as follows. First, mining nodes check whether borrowers have enough funds for the relevant loan transaction. Because every transaction is recorded in the blockchain, it is easy to find out the number of cryptocurrencies borrowers own.[451] Second, if it turns out that borrowers have enough funds, the blockchain will automatically and immutably record the transfer of loan funds to the lender and mark them as spent by the borrower.[452] The borrower will no longer be able to spend the same funds as they will be marked as transferred to someone else.

1.2 Improved credit risk assessment

Credit risk assessments in P2P lending. Given the significant information asymmetry between P2P lenders and borrowers, credit risk assessments are crucial for P2P lenders to assess credit risk of the prospective P2P loan(s).[453] Although many P2P lending platforms already rely on sophisticated techniques in their credit risk assessments, such as Artificial Intelligence (AI) and Machine Learning, blockchain technology takes credit risk assessments, including creditworthiness assessments, to the next level so that it becomes less likely for P2P lenders to be matched with an uncreditworthy borrower.[454] In this section, we discuss how blockchain technology succeeds in doing this. We will discuss (i) historical data keeping, (ii) blockchain and real-time accounting and (iii) blockchain based creditworthiness assessments.

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[450] F. Garitt, 'Blockchain and beyond: The New Technology Revolutionizing Traditional Banking', *The RMA Journal*, Vol. 99, Iss. 2, 2016, p. 32-33; G.W. Peters and E. Panayi, 'Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money, 2015, p. 17, https://arxiv.org/pdf/1511.05740.pdf.

[451] To find the number of cryptocurrencies a borrower has/had, nodes need to subtract the number of cryptocurrencies the borrower has spent from the number of cryptocurrencies he received.

[452] Automated transactions are not only faster, but also less prone to manual error. See: Y. Chu, J. Ream, and D. Schatsky, 'Upgrading blockchains: smart contract use cases in industry', 2016, Deloitte University Press, p. 5, https://www2.deloitte.com/insights/us/en/focus/signals-for-strategists/using-blockchain-for-smart-contracts.html?top=4.

[453] A. Bachmann, B. Funk et al., 'Online Peer-to-Peer Lending- A Literature', *Journal of Internet Banking and* Commerce, 2011, vol. 16, no.2, p. 7; A. Sufi, 'Information asymmetry and financing arrangement: evidence from syndicated loans', *Journal of Finance* 62, 2007, p. 393–410.

[454] Ripio Credit Network, 'A global credit network based on cosigned smart contracts' by Ripio International Limited, p. 1-2.

1.2.1 Historical data keeping

Historical data keeping. Whereas non-blockchain based P2P lending platforms must keep up with complex transaction histories and interactions between parties to the loan transaction, applications built on the blockchain do this automatically.[455] Blockchains create an immutable, permanent record of every single transaction performed and do so autonomously and immediately after validation.[456] In this way, blockchain based P2P lending platforms can be sure that creditworthiness assessments are based on all data available for their users. Of course, this only applies to the extent that (all) relevant data of borrowers are recorded on the blockchain. To the extent that data relevant for creditworthiness assessments are not on the blockchain, P2P lending platforms should be obliged to consult the relevant credit database in order to fully assess the creditworthiness of their users (see, for example, Article 9 Consumer Credit Directive and Article 18 Mortgage Credit Directive).[457] Furthermore, blockchain technology guarantees that the data on the blockchain to be analysed are accurate and reliable (see Chapter II, *supra* and *infra*).

1.2.2 Blockchain and real-time accounting

Blockchain technology as an improvement for imperfect accounting information. Credit risk assessments rely to a large extent on accounting data, such as balance sheet data and income statements. However, it is well-known that these data are often imperfect.[458] Accounting data suffer from problems such as "ambiguous and non-uniform accounting practices, managers engaging in creative accounting and reports lagging real events".[459] Blockchain technology improves the quality of accounting data by making them (at least much more) accurate and timely.[460] When credit risk assessments are based on highly accurate and consistently updated data, it becomes less likely for P2P lenders to be matched with an uncreditworthy borrower. It

[455] S. Rogers, 'Celsius aims to disrupt the consumer credit industry by using blockchain', 2017, https://venturebeat.com/2017/10/10/celsius-is-using-blockchain-technology-to-disrupt-the-1-1-trillion-consumer-credit-industry/; R. Tkatchuk, 'P2P lending reaps blockchain's rewards', 2017, https://www.cio.com/article/3243927/financial-it/p2p-lending-reaps-blockchain-s-rewards.html.

[456] R. Tkatchuk, 'P2P lending reaps blockchain's rewards', 2017, p. 2, https://www.cio.com/article/3243927/financial-it/p2p-lending-reaps-blockchain-s-rewards.html.

[457] When all data of credit databases would be on the blockchain, credit risk may significantly be reduced.

[458] H. Byström, 'Blockchains, real-time accounting and the future of credit risk modeling', Working Papers, 2016, Lund University, Department of Economics, p. 2; D. Duffie and D. Lando, 'Term Structures of Credit Spreads with Incomplete Accounting Information', *Econometrica* 69 (3), 2001, p. 633-664.

[459] H. Byström, 'Blockchains, real-time accounting and the future of credit risk modeling', Working Papers, 2016, Lund University, Department of Economics, p. 2.

[460] R. Lazanis, 'How Technology Behind Bitcoin Could Transform Accounting as We Know It', 2015, www.techvibes.com.

is obvious that the potential of blockchain technology can only be fully realised when borrowers put all (or most of) their accounting data on the blockchain.[461] By doing so, borrowers take part in building a reusable identity that builds up trust over time.

(i) Accuracy of data. Blockchain technology ensures accuracy of accounting data. First, asymmetric cryptography ensures that all data being transferred are true, accurate and untampered with.[462] The reason is that changing even a tiny aspect of the data reshapes the digital signature related to the data, making it false and obsolete. On a larger scale, the cryptographically chaining of blocks guarantees that no transaction on the blockchain can be tampered with. If any single part of a transaction changes, so does the hash of the block to which it belongs, and any following blocks' hashes as a result. This is an obvious (but great) outcome when we remember that each block in the blockchain contains the hash of the previous block. Because blockchain transactions are tamperproof, the issue of mistrust of financial statements in accounts is to a large extent solved.[463] Second, consensus mechanisms contribute to the accuracy of data on the blockchain.[464] By verifying the authenticity of the digital signature related to the data and verifying how many funds P2P borrowers have, consensus mechanisms are capable to decide on the accuracy of data and to handle conflicts between (possible) multiple simultaneous competing entries.[465]

(ii) Timeliness of data. Blockchain technology ensures timeliness of accounting data.[466] It does so by relying on (near) real-time transaction settlement of transactions and the automatic, real-time update of the blockchain immediately after transactions are validated through consensus mechanisms (see, inherent features that reduce credit risk in broad terms, *supra*).[467] As such,

[461] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Why Blockchain has the Potential to Serve as a Secure Accounting Information System, *The CPA Journal*, 2017, p. 2; D. Yermack, 'Corporate Governance and Blockchains', *Review of Finance*, 2017, p. 7-31.
[462] M. Finck, 'Blockchains and Data Protection in the EU', Max Planck Institute for Innovation and Competition Research Paper No. 18-01, p. 5.
[463] H. Byström, 'Blockchains, real-time accounting and the future of credit risk modeling', Working Papers, 2016, Lund University, Department of Economics, p. 4.
[464] A.M. Tulpule, 'Enforcement and compliance in a blockchain(ed) world', 2017, p. 2, https://www.competitionpolicyinternational.com/wp-content/uploads/2017/01/CPI-Tulpule.pdf.
[465] World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 7.
[466] H. Byström, 'Blockchains, real-time accounting and the future of credit risk modeling', Working Papers, 2016, Lund University, Department of Economics, p. 5; D. Yermack, 'Corporate Governance and Blockchains', *Review of Finance*, 2017, p. 7-31.
[467] H. Byström, 'Blockchains, real-time accounting and the future of credit risk modeling', Working Papers, 2016, Lund University, Department of Economics, p. 2; R. Lazanis, 'How Technology Behind Bitcoin Could Transform Accounting as We Know It', 2015, www.techvibes.com.

the blockchain could be useful as a trustworthy and continuously updated ledger for accounting records.[468]

Uniformity of transaction data. Finally, it is important to see that blockchain technology guarantees uniformity of transaction data. Because transactions are automatically and immediately recorded on the blockchain after validation, without any human intervention, all transaction data are uniformly recorded on the blockchain. This possibility of blockchain technology may eliminate or, in any case, significantly reduce regulatory measures that aim at ensuring that a "true and fair view" is given. Examples include IFRS (International Financial Reporting Standards) and GAAP (Generally Accepted Accounting Principles).

1.2.3 Blockchain based creditworthiness assessments

Blockchain based creditworthiness assessments. Many P2P lending platforms rely on Artificial Intelligence (AI) and Machine Learning to optimise creditworthiness assessments. When these sophisticated techniques are combined with blockchain technology, the quality of creditworthiness assessments significantly increases.[469] It goes without saying that this reduces credit risk.

Blockchain based creditworthiness assessments: multitude of data. Blockchain based creditworthiness assessments rely on risk algorithms, which automatically assess the creditworthiness of borrowers based on their historical financial and transactional data on the blockchain.[470] Because blockchain technology automatically records data on the blockchain, P2P lending platforms can be sure that creditworthiness assessments of borrowers are based on all data available for borrowers (see historical data keeping, *supra*). Here too, blockchain technology's potential can only be fully realised when all relevant data of borrowers are on the blockchain (for the (possible) obligation to consult the credit database, see *supra*). Automatization of complex data keeping allows P2P lending platforms to take into account thousands of data points. Relying on artificial intelligence and blockchain technology, platforms can choose for each type of borrower which data points they take into account and

[468] R. Lazanis, 'How Technology Behind Bitcoin Could Transform Accounting as We Know It', 2015, www.techvibes.com.
[469] Ripio Credit Network, 'A global credit network based on cosigned smart contracts' by Ripio International Limited, p. 1.
[470] N. De, 'Royal Bank of Canada Explores Blockchain to Automate Credit Scores', 2018, https://www.coindesk.com/royal-bank-of-canada-credit-scores-blockchain-patent-application/; A, Manivannan, Holy Grail of Credit Scoring: The Blockchain, 2017, https://medium.com/@AadhiMNV/holy-grail-of-credit-scoring-the-blockchain-d72667319ba8.

how much importance they attach to them. P2P lending platforms still predominantly rely on traditional financial data, such as payment history and credit line amounts. However, non-financial data, such as employment history, educational merits and certifications, and trivial information, such as which websites a borrower browses to and daily location patterns, increasingly make their appearance.[471] Finally, it is interesting to mention that recent software applications have introduced a dynamic indicator of a borrower's likelihood to pay his debt that adapts to the maturity of the borrower's credit history (or lack thereof).[472] By relying on artificial intelligence and blockchain technology, creditworthiness assessments can be split into three phases that each take into account different data points with varying weights. In this way, P2P lending platforms can establish creditworthiness assessments that are kept up-to-date during the lending transaction.[473] Finally, blockchain accounting guarantees that the data taken into account for credit risk assessments are accurate, timely and tamperproof (see *supra*).

1.3 Fast and effective execution of collateral

2.3.1 Collateral on the blockchain

Collateral on the blockchain. In the case that credit risk occurs, blockchain technology automatically makes fast and effective execution of collateral possible.[474] In this section, we will see that blockchain technology is highly suitable to enforce loan contract terms, which has a beneficial influence on credit risk in broad terms.[475]

(i) Cryptocurrency as collateral. In blockchain based P2P lending, secured loans are on this rise.[476] So far, cryptocurrency is typically used as collateral, but tokens representing real-world assets increasingly provide an alternative (see *infra*). Cryptocurrency as collateral is particularly suitable for people who hold cryptocurrencies for the long term and need cash. These so-called

[471] B. Dickson, 'How big data and artificial intelligence are changing online lending', 2017, https://cointelegraph.com/news/how-big-data-and-artificial-intelligence-are-changing-online-lending.
[472] J. Leimgruber, A. Meier and J. Backus, 'Bloom Protocol Decentralized credit scoring powered by Ethereum and IPFS', 2018, p. 3.
[473] J. Leimgruber, A. Meier and J. Backus, 'Bloom Protocol Decentralized credit scoring powered by Ethereum and IPFS', 2018, p. 3.
[474] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement An analytical framework', 2017, Bank for International Settlements, p. 1, 11 and 13, https://www.bis.org/cpmi/publ/d157.pdf.
[475] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement An analytical framework', 2017, Bank for International Settlements, p. 1, 11 and 13, https://www.bis.org/cpmi/publ/d157.pdf.
[476] P. Keenan and A. Taylor, '6 Blockchain-Based Crypto Lenders Changing P2P Lending', *Lending* Times, 2018. Examples include SALT, EthLend, Celsius and LendingBlock.

'hodlers'[477] do not usually want to sell their cryptocurrencies, although they are willing to lend them out. Several blockchain based P2P lending platforms meet their need by giving them loans in exchange for cryptocurrency collateral, plus interest, so 'hodlers' can access their crypto wealth without cashing out (and paying taxes and forfeiting potential future gains).[478] In sum, cryptocurrency investors can leverage their cryptocurrency to borrow the cash they need today, while still maintaining their crypto portfolio for future value.

(ii) Non-cryptocurrency as collateral. In addition to cryptocurrency, almost any other (fraction of an) asset can be used as collateral on the blockchain through tokenization. In the process of tokenization, each real-world asset is assigned a digital token as a unit of value for the specific asset it represents.[479] For example, tokens can represent company shares, bonds, intellectual property, art and commodities.[480] When borrowers want to use gold as collateral, they use the 'ERC-20 token' that represents the value of gold. For each token representing 1 gram of gold, the token holder factually owns 1 gram of gold.[481] Different techniques are used to ensure the authenticity of the assets underlying the token. Examples include audit, oracles or any sort of outsourced trust (see Chapter II, *supra*).[482]

Tokenization of assets as collateral. Tokens can be used as collateral to secure loan payments on the blockchain. Instead of selling and closing a token position, a borrower can pledge digital tokens to receive the relevant cryptocurrency.[483] Pledging tokens means that the borrower promises to give up the pledged token(s) for the lender, if the borrower does not make the required loan payments.[484] In that case, smart contracts automatically transfer the tokens to the lender, who can sell the tokens. Several platforms have their own token exchange.[485]

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[477] Apparently, this term was started by a Reddit post that went viral; it was titled "I am Hodling," with a misspelling of "holding" that the writer acknowledged.

[478] Celsius, 'Deposit coins. Borrow cash against your cryptocurrency. Earn interest.', white paper, p. 4.

[479] A. Cameron-Huff, 'Op Ed: How Tokenization Is Putting Real-World Assets on Blockchains', 2017, https://bitcoinmagazine.com/articles/op-ed-how-tokenization-putting-real-world-assets-blockchains/; J. English, 'Is Tokenization Is Its Infancy?', 2017, Nasdaq, https://www.nasdaq.com/article/is-tokenization-in-its-infancy-cm832819.

[480] A. Cameron-Huff, 'Op Ed: How Tokenization Is Putting Real-World Assets on Blockchains', 2017, https://bitcoinmagazine.com/articles/op-ed-how-tokenization-putting-real-world-assets-blockchains/.

[481] ETHLend, 'ETHLend.io White Paper - Democratizing Lending', 2018, https://github.com/ETHLend/Documentation/blob/master/ETHLendWhitePaper.md.

[482] Y. Fu, 'Off-Chain Computation Solutions for Ethereum Developers', 2017, https://medium.com/@YondonFu/off-chain-computation-solutions-for-ethereum-developers-507b23355b17.

[483] ETHLend, 'ETHLend.io White Paper - Democratizing Lending', 2018, https://github.com/ETHLend/Documentation/blob/master/ETHLendWhitePaper.md.

[484] Ibid.

[485] Well-known blockchain based P2P lending platforms with their own exchange are LoanBit and BTCPOP.

Advantages of tokens as collateral. Tokens are highly suitable for fast and effective execution of collateral on the blockchain. First, smart contracts automatically trigger the tokens attached to them, if redemption and interest payments are not made (on time).[486] Because smart contracts automatize the transfer of tokens to lenders in case of loan default, tokens significantly reduce loan execution time. Second, accepting tokens as collateral rids the lender of issues of monetizing the collateral in case of default. Because tokens are highly liquid and divisible, lenders can easily sell tokens on an exchange, possibly that of the platform (see *supra*).[487] Therefore, tokens simplify transfer of ownership and lower execution costs.[488] By enabling short selling, lenders can eventually profit from a down market.[489]

Regulatory framework for tokens? It is clear that the technical possibilities of collateral tokens are far-reaching. However, it is important to see that tokens representing (fractions of) assets are worthless without a legal contract that gives the lender rights over the underlying assets.[490] In addition, the legal qualification of (loan) tokens has not yet been clarified.[491] This qualification is needed to, inter alia, assess whether loan tokenization requires new legal entities designed around cross-jurisdictional property, insolvency and tax law.[492] This applies in particular for jurisdictions that have legal rules in place that require certain transfers to take place using a certain form or be registered in a certain way with the government authority.[493] If tokens are qualified as financial instruments, they may potentially fall within the legal framework of MiFID II.[494] However, further research is needed in this regard.

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[486] This applies as far as sensors or machines can be connected to collateral which in turn can be connected to the internet.

[487] C. McLain, 'Tokenization of Everything: How Tokens Will Create a More Liquid World', https://masterthecrypto.com/tokenization-tokens-create-liquid-world/.

[488] Ibid.

[489] J. English, 'Is Tokenization In Its Infancy?', https://www.nasdaq.com/article/is-tokenization-in-its-infancy-cm832819.

[490] M. G. Casil, 'Asset Tokenization: Soft Tokens vs Hard tokens', 2017, *Maecenas*, https://medium.com/maecenas/asset-tokenisation-soft-tokens-vs-hard-tokens-1ad3a8e39340.

[491] C. McLain, 'Tokenization of Everything: How Tokens Will Create a More Liquid World', https://masterthecrypto.com/tokenization-tokens-create-liquid-world/; S. Revell, 'Editors' Note', *Capital Markets Law Journal*, 2017, p. 414.

[492] C. McLain, 'Tokenization of Everything: How Tokens Will Create a More Liquid World', https://masterthecrypto.com/tokenization-tokens-create-liquid-world/.

[493] A. Cameron-Huff, 'Op Ed: How Tokenization Is Putting Real-World Assets on Blockchains', 2017, https://bitcoinmagazine.com/articles/op-ed-how-tokenization-putting-real-world-assets-blockchains/.

[494] P. Hacker and C. Thomale, 'Crypto-Securities Regulation: ICOs, Token Sales and Cryptocurrencies under EU Financial Law', 2017, p.14-15;

https://ssrn.com/abstract=3075820 or http://dx.doi.org/10.2139/ssrn.3075820; S. Revell, 'Editors' Note', *Capital Markets Law Journal*, 2017, p. 414.

2.3.2 Valuation of collateral: Internet-of-Things (IoT)

Valuation of collateral on the blockchain. Whereas the value of cryptocurrencies is easy to establish,[495] although volatile, the valuation of tokens (and the underlying assets) is more difficult. In this regard, blockchain technology relies, inter alia, upon two techniques. First, smart contracts amalgamate real-time global market price metrics from multiple data channels to establish the mark-to-market valuation of the collateral, while simultaneously tracking the borrower's loan balance.[496] Second, smart contracts rely on Internet-of-Things (IoT) to receive information on any change in value of the collateral.

Internet-of-Things in blockchain based P2P lending Internet-of-Things (IoT) is defined as a way for sensors and machines to communicate with each other by combining the capabilities of big data, analytics and artificial intelligence to anticipate needs, solve problems, and increase efficiency.[497] IoT can include everything that is both connected to the internet and able to communicate and share information with other smart devices.[498] In blockchain based P2P lending, IoT allows lenders and the platform to receive (near) real-time information about changes in value of collateral. It is obvious that the potential of IoT increases in parallel with the number of goods attachable to smart contracts.

Examples IoT. We clarify the use of IoT by means of two examples. First, in the case of car collateral, P2P lending platforms can leverage IoT via installed location and impact sensors in vehicles which cannot be tampered with.[499] The sensors will inform lenders and/or the P2P lending platform as soon as someone tries to remove those sensors from the vehicle or whenever the vehicle has an impact above a certain level. Second, in the case of housing mortgage, P2P lending platforms can leverage IoT via installed sensors in homes, which will inform them when there is a dampness in the wall above a certain percentage or when there is significant internal damage to the walls.[500]

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[495] Prices of cryptocurrencies can be consulted at https://coinmarketcap.com/.

[496] C. Russo, 'SALT: Leverage Your Blockchain Assets to Secure Cash Loans', 2018, https://sludgefeed.com/salt-leveraging-blockchain-assets-to-secure-cash-loans/; SALT, 'Blockchain-Backed Loans', SALT whitepaper, p. 5, https://membership.saltlending.com/files/abstract.pdf.

[497] A. K. Agarwal, 'Banking on The Internet of Things IoT', 2015, https://www.finextra.com/blogs/fullblog.aspx?blogid=11676.

[498] Ibid.

[499] Infosys, 'IoT-enabled Banking Services', Whitepaper, p. 5, https://www.infosys.com/industries/financial-services/white-papers/Documents/IoT-enabled-banking.pdf.

[500] A. K. Agarwal, 'Banking on The Internet of Things IoT', 2015, https://www.finextra.com/blogs/fullblog.aspx?blogid=11676.

2.3.3 Value changes of collateral on the blockchain

Decrease of value of collateral does not affect loan. If the value of the collateral depreciates below a dynamically determined threshold on the smart contract, the borrower can (i) add more collateral by making an extra payment, or (ii) do nothing and the smart contract will automatically initiate the liquidation of (a portion of) the collateral.[501] After (partial) liquidation, the smart contract automatically sends the sale proceeds to the lender as a payment on the borrower's behalf. It is obvious that such automatic liquidation may have drastic consequences for borrowers. Further research is needed on what legal protection is needed in this regard.

Increase of value of underlying asset does not affect loan. If, by contrast, the value of the collateral rises above a dynamically determined threshold, then, depending on the terms of the smart contract, the borrower has the option to (i) add the increased value to the principal of the loan for an additional extension of credit from the lender or (ii) withdraw excess collateral.[502]

1.4 Conclusion

Conclusion. Blockchain technology has the potential to reduce credit risk in the broad sense, i.e. the risk that P2P lenders do not receive their redemption and interest payments as agreed.[503] It does so by guaranteeing (near) real-time transaction settlement and certainty of transaction settlement on the one hand and enabling an improved credit risk assessment on the other hand. In addition, blockchain technology allows fast and effective execution of collateral, in the case that credit risk materialises. The effective potential of blockchain technology in this regard will depend on whether there is an existing and adequate regulatory framework. However, the fact remains that blockchain technology, like any other technology, has almost no impact on the creditworthiness of borrowers, which, after all, remains the major tool to reduce credit risk. Therefore, regulatory measures addressing credit risk in the strict sense, namely the risk that borrowers are not creditworthy, are still needed in blockchain based P2P lending. Key examples are disclosure standards for lenders and borrowers, suitability and appropriateness tests of lenders and creditworthiness assessments of borrowers (see Chapter I, *supra*).

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[501] ChronoLogic, 'Trustless Peer-to-Peer Crypto Lending', 2017, https://blog.chronologic.network/the-future-of-debt-374bdc31c93d.

[502] Remember that tokens are worthless without a legal contract that gives those tokens bearer rights over the underlying assets (see *supra*).

[503] Risk Management Group of the Basel Committee on Banking Supervision, 'Principles for the Management of Credit Risk', Basel, 2000, p. 1, https://www.bis.org/publ/bcbs75.pdf.

II. Fraud

Fraud. Fraud is a type of malicious activity that intends to obtain advantage or benefit by deceiving others.[504] In the context of P2P lending, fraud mainly refers to the provision of false (financial or personal) information when applying for a loan. For example, P2P borrowers may falsify their repayment history to obtain a higher credit score and lower interest rates.[505]

Blockchain technology and fraud: road map. Blockchain technology cannot eliminate fraud in P2P lending, because it is not able to identify fraud. For example, it cannot find out whether borrowers provide false information when that information does not build further on data already on the blockchain. For a discussion of fraud identification, see *infra*. However, blockchain technology largely prevents fraud regarding both financial and personal information on the parties to the loan transaction recorded on the blockchain and loan transactions (including loan funds) on the blockchain.[506] In this regard, blockchain technology relies on (i) its inherent features, (ii) permissioned blockchains and (iii) smart contracts.

2.1 Blockchain technology

2.1.1 Inherent features of blockchain technology that reduce fraud

Roadmap. Blockchain technology has several inherent features that can be deployed to reduce fraud.[507] In this section, we discuss the following features of blockchain technology: decentralisation, immutability, transparency and auditability and asymmetric cryptography.

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[504] J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25, p. 4.

[505] Y. Cai and D. Zhu, 'Fraud detections for online businesses: a perspective from blockchain technology', *Financial Innovation*, 2016, 2:20, p. 6, DOI 10.1186/s40854-016-0039-4; J. Kim, K. Choi, G. Kim G and Y. Suh, 'Classification cost: An empirical comparison among traditional classifier, cost-sensitive classifier, and metacost', *Expert Syst with Appl*, 2012, p. 39(4):4013–4019.

[506] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Blockchain: An Emerging Solution for Fraud Prevention', *The CPA Journal*, 2017, p. 2; D. Efanov and P. Roschin, 'The All-Pervasiveness of the Blockchain Technology', *Procedia Computer* Science 123, 2018, p. 119. See also: A. Baxter, 'Blockchain-Unchaining the world from fraud?, 2016, http://www.thepaypers.com/expert-opinion/blockchain-unchaining-the-world-from-fraud-/763845; C. Camp, 'Bitcoin may help criminals, but blockchain can help thwart fraud', *American Banker*, 2016, Vol. 181 Issue 91, http://www.americanbanker.com/bankthink/bitcoin-may-help-criminals-but-blockchain-can-help-thwart-fraud-1080937-1.html; J.J. Xu, "Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25, p. 3.

[507] N. Joshi, 'Mitigating attacks on blockchain', 2017, Allerin, https://www.allerin.com/blog/mitigating-attacks-blockchain; J.J. Xu, "Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25, p. 3. Baxter and Camp also mention blockchain technology's possibility to make blockchains "permissioned". See: C. Camp, 'Bitcoin may help criminals, but blockchain can help thwart fraud', *American Banker*, 2016, Vol. 181 Issue 91, http://www.americanbanker.com/bankthink/bitcoin-may-help-criminals-but-blockchain-can-help-thwart-fraud-1080937-1.html.

Decentralisation. In blockchain technology, transaction data as well as control over these data are decentralised across a peer-to-peer network (see Chapter II, *supra*). This means that there is no obvious place for a fraudster to instigate a fraud scheme.[508] The lack of a centralised point of vulnerability makes it extremely difficult for fraudsters to conceal their criminal activities as nodes jointly supervise transactions on the blockchain.[509] Furthermore, fraudulent transactions are fairly easy to identify as the history and transfer of all loan payments on the blockchain are publicly accessible. Fraudsters (in collusion) need to have to control a majority of the system to tamper with transaction records (51% attack, see *infra*).[510]

Immutability. After transactions are validated through consensus mechanisms, transactions are immutably recorded on the blockchain.[511] New transactions can still change the original state of transactions, but the original (or previous) records will remain accessible and the new state will simply be added to the blockchain.[512] Because loan transactions and loan payments on the blockchain will have provenance due to their immutable transaction history, it becomes difficult to pass off fake loan transactions of loan payments as real.[513] The immutability of blockchain technology prevents not only backdating data,[514] but also the creation of fictitious transactions as the origin of transaction funds can be traced.[515] Finally, is interesting to note that the immutability of records enables supervisors that know the actual identities behind pseudonyms to make fraudsters accountable for what they have done and when, at the maximum precision level.[516]

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[508] R. Mauri, 'Three features of blockchain that help prevent fraud', 2017, https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/; P. Tasca, 'Managing Risk under the Blockchain Paradigm, *Harvard Business Review*, 2017, p. 2. A single point-of-failure is defined as any point in a system, whether a service, activity, or process, that, if it failed to work correctly, would lead to a failure of the entire system.

[509] R. Mauri, 'Three features of blockchain that help prevent fraud', 2017, https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/; J. Dai, Y. Wang and M.A. Vasarhelyi, 'Blockchain: An Emerging Solution for Fraud Prevention', *The CPA Journal*, 2017, p.2.

[510] J. McKinlay, D. Pithouse, J. McGonagle and J. Sanders, 'Blockchain, Background and Legal Challenges', 2018, https://www.dlapiper.com/en/uk/insights/publications/2017/06/blockchain-background-challenges-legal-issues/.

[511] R. Mauri, 'Three features of blockchain that help prevent fraud', 2017, https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/.

[512] R. Mauri, 'Three features of blockchain that help prevent fraud', 2017, https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/.

[513] R. Mauri, 'Three features of blockchain that help prevent fraud', 2017, https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/

[514] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Blockchain: An Emerging Solution for Fraud Prevention', *The CPA Journal*, 2017, p.2; https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/.

[515] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Blockchain: An Emerging Solution for Fraud Prevention', *The CPA Journal*, 2017, p. 2; https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/.

[516] P. Tasca, 'Managing Risk under the Blockchain Paradigm, *Harvard Business Review*, 2017, p. 2.

Transparency and auditability. Because accounts on blockchains are identifiable on pseudo-anonymous basis, everyone can see which address sent how much to another public address.[517] So, although parties in the network release no private information, transactions are traceable and visible network-wide.[518] Transparent transactions in combination with historical data keeping make it easier to detect suspicious patterns and therefore to identify fraud (fraud detection, see *infra*).[519]

Asymmetric cryptography. Finally, blockchain technology's cryptographic mechanisms are worth mentioning. In blockchain technology, transactions are encrypted using the sender's private key and broadcasted to the entire peer-to-peer network. Miners use then the public key published by the sender to recover the content of the message, compare the amount with the sender's most recent balance recorded in the blockchain and examine the validity of the transfer.[520] If the message is valid, the transaction is executed, and the block containing it is appended to the end of the blockchain. Fraudulent transactions are deemed invalid according to the rules set out in the consensus protocols and will therefore be rejected. Once a transaction is added to the blockchain, the transaction is virtually fraud-proof (see immutability and transparency, *supra*).[521] The reason is that if any single part of a transaction changes, so does the hash of the block to which it belongs, and any following blocks' hashes as a result (see Chapter II, *supra*). Changes in cryptographic hashes are easily to detect and, as a result, (attempts to) fraud with transactions as well.[522]

2.1.2 Permissioned blockchains

Permissioned blockchains. Another or additional way to reduce fraud in P2P lending is to build P2P lending platforms on permissioned blockchains.[523] In permissioned blockchains, only

[517] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 52. It is important to see that the public address cannot be linked back to 'real-world' personal information of the parties.
[518] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Why Blockchain has the Potential to Serve as a Secure Accounting Information System, *The CPA Journal*, 2017, p. 2.
[519] R. Tkatchuk, 'P2P lending reaps blockchain's rewards', 2017, https://www.cio.com/article/3243927/financial-it/p2p-lending-reaps-blockchain-s-rewards.html; Y. Wang and A. Kogan, 'Designing Privacy-Preserving Blockchain-Based Accounting Information Systems', Working paper, 2017, http://bit.ly/2qJDEJc.
[520] Lisk Academy, 'Digital Signatures', 2018, https://lisk.io/academy/blockchain-basics/how-does-blockchain-work/digital-signatures.
[521] C. Camp, 'Bitcoin may help criminals, but blockchain can help thwart fraud', *American Banker*, 2016, Vol. 181 Issue 91, http://www.americanbanker.com/bankthink/bitcoin-may-help-criminals-but-blockchain-can-help-thwart-fraud-1080937-1.html.
[522] J. McKinlay, D. Pithouse, J. McGonagle and J. Sanders, 'Blockchain, Background and Legal Challenges', 2018, https://www.dlapiper.com/en/uk/insights/publications/2017/06/blockchain-background-challenges-legal-issues/.
[523] R. Mauri, 'Three features of blockchain that help prevent fraud', 2017, https://www.ibm.com/blogs/blockchain/2017/09/three-features-of-blockchain-that-help-prevent-fraud/.

pre-selected participants can join the blockchain and make contributions to it.[524] A central party restricts who is allowed to participate and in what capacity (Chapter II, see *supra*). Permissioned blockchains are particularly useful in the context of P2P lending as they allow P2P lending platforms to restrict access to the P2P lending platform to parties that underwent fraud checks conducted by the platform. Furthermore, having a good picture about who can access the blockchain and in what capacity may help to prevent and address fraud. However, this supposes that the permissioned blockchain has a sufficient number of independent verifiers which can uncover fraudulent transactions.[525]

2.1.3 Smart contracts

Smart contracts. Finally, smart contracts can be deployed to combat fraud in P2P lending. Smart contracts can achieve similar results as permissioned blockchains (see *supra*).[526] More specifically, smart contracts can be embedded with advanced access control criteria that allow only authorised users to access the blockchain and create loan transactions.[527] For example, smart contracts can prohibit loan transactions by P2P parties to the loan transaction that did not undergo fraud checks laid down in the smart contract.

2.2 Limitation: fraud identification

Fraud identification. Blockchain technology largely prevents fraud regarding both financial and personal information on the parties to the loan transaction recorded on the blockchain and loan transactions (including loan funds) on the blockchain. However, the technology has a major limitation: it cannot find out whether P2P borrowers provide false information when that information does not build further on data already on the blockchain. The problem therefore

[524] Deloitte, 'Bitcoin, Blockchain & distributed ledgers: Caught between promise and reality', Centre for the Edge, 2016, https://www2.deloitte.com/content/dam/Deloitte/au/Images/infographics/au-deloitte-technology-bitcoin-blockchain-distributed-ledgers-180416.pdf, p. 22; Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser', 2015, p. 17; B.G. Williams, D. Gunn, E. Roma, and B. Bansal, 'Distributed Ledgers in Payments : Beyond the Bitcoin Hype', 2016, http://www.bain.com/publications/articles/distributed-ledgers-in-payments-beyond-bitcoin-hype.aspx; N. Williamson, 'Permissionless vs Permissioned Consensus and Tradeoffs', 2016, http://credits.vision/posts/permissionless-vs-permissionedconsensus-tradeoffs.

[525] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Why Blockchain has the Potential to Serve as a Secure Accounting Information System, *The CPA Journal*, 2017, p. 2.

[526] M. Gulker, 'Are Smart Contracts the Future of Fraud Prevention?', 2017, https://www.aier.org/article/are-smart-contracts-future-fraud-prevention.

[527] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Why Blockchain has the Potential to Serve as a Secure Accounting Information System, *The CPA Journal*, 2017, p. 2.

arises mainly at the beginning of the P2P lending process and in particular, during the loan application and the credit risk assessment.

2.3 Conclusion

Conclusion. The potential of blockchain technology to reduce fraud is significant. Blockchain technology can certainly be deployed to address fraud in P2P lending. However, in addition, regulatory measures are needed to address the challenge of fraud identification. The proposal of EBA to require P2P lending platforms to conduct background checks on the parties to the loan transaction is an adequate regulatory measure in this regard.[528] According to EBA, platforms should be obliged to request identification information, addresses, information about financial status/creditworthiness and potential criminal records from borrowers and lenders, including evidence.[529] Furthermore, EBA considers that platforms should be required to deny access to their website if they have reason to believe that a (prospective) P2P lending party might potentially act fraudulently.[530]

III. Money laundering

Definition money laundering. Money laundering as "the process of conducting financial transactions in a manner that obscures the link between funds and their origin".[531] Money laundering poses a real threat to the financial sector, including the P2P lending sector.[532]

Increased risk of money laundering with cryptocurrencies? Whereas the risk of money laundering is already considered significant in non-blockchain based P2P lending, some scholars argue that this risk is even more present in blockchain based P2P lending.[533] In this regard, they refer to the fact that cryptocurrencies are decentralised, anonymous (see, however,

[528] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 20.
[529] Ibid.
[530] Ibid.
[531] D. DCosta, 'Blockchain for AML – Harnessing Blockchain Technology to Detect and Prevent Money Laundering', *International Banker*, 2017, https://internationalbanker.com/technology/blockchain-aml-harnessing-blockchain-technology-detect-prevent-money-laundering/.
[532] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 20.
[533] C. Brenig Et Al, 'Economic Analysis Of Cryptocurrency Backed Money Laundering', 2015, https://aisel.aisnet.org/ecis2015_cr/20/; 'Can Blockchain Be Key to Overcoming AML Challenge in Cryptocurrency?, 2017, https://cointelegraph.com/news/can-blockchain-be-key-to-overcoming-aml-challenge-in-cryptocurrency.

infra), transferable between borders and reasonably safe from confiscation.[534] In addition, the lack of identifying information related to transactions would be a substantial obstacle to anti-money laundering (AML) surveillance and enforcement capabilities.

Decreased risk of money laundering with blockchain technology? On the other hand, an increasing number of blockchain experts consider that blockchain technology has the potential to improve AML efforts, even surpassing mechanisms already in place today.[535] In this vein, they argue that the essential regulatory and enforcement elements, namely (i) identification of parties and information and (ii) the supervision and validation of transactions, can all exist in a blockchain based PP2 lending system.

Roadmap. First, we discuss how blockchain technology can reduce money laundering and improve AML efforts on the basis of a two-step approach. In a first step, we discuss how blockchain technology contributes to the identification of parties and information. In a second step, we discuss how blockchain technology contributes to the supervision and validation of transactions. Second, we discuss the proposal of Floyd DCosta, Co-Founder at Blockchain Worx, to build up an anti-money laundering system on the blockchain of which each financial institution would be part.

3.1 Identification of parties and information

Pseudo-anonymous nature of blockchain based P2P makes risk of money laundering real. The creation of a digital wallet does not require the parties to the loan transaction to enter any identifying information. Releasing private information is also not necessary to send and accept cryptocurrencies and tokens from one wallet to another; the public key suffices.[536] Therefore, parties to the loan transaction can perform loan transactions on the blockchain without disclosing any identifying information.[537] This may create the impression that blockchain

[534] European Commission, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive (EU) 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing and amending Directive 2009/101/EC, p. 12; C. Brenig Et Al, 'Economic Analysis Of Cryptocurrency Backed Money Laundering', 2015, https://aisel.aisnet.org/ecis2015_cr/20/; M. Garellek, U.M. Sheikh and J. Suri, 'KYL and AML Compliance – Can Blockchains Help?', https://cointelegraph.com/news/can-blockchain-be-key-to-overcoming-aml-challenge-in-cryptocurrency.

[535] Kpeluso, 'Blockchain and Money Laundering', Fordham Journal of Corporate and Financial Law, blog, 2017, https://news.law.fordham.edu/jcfl/2017/12/15/blockchain-and-money-laundering/#_edn3.

[536] Private information in included in the private key, which is (recommended to be) secret. Gtg advocates, 'Could Blockchain be the new dawn for AML?', 2018, https://www.gtgadvocates.com/could-blockchain-be-the-new-dawn-for-aml/.

[537] 'Can Blockchain Be Key to Overcoming AML Challenge in Cryptocurrency?', 2017, https://cointelegraph.com/news/can-blockchain-be-key-to-overcoming-aml-challenge-in-cryptocurrency.

technology makes P2P lending completely anonymous. However, the possibility to track and monitor every loan transaction on the blockchain removes the "truly" anonymous nature of blockchain based P2P lending.[538] Therefore, it is better to speak of pseudo-anonymity in blockchain based P2P lending.[539] However, because public keys do not contain any identifying information, the risk of money laundering remains real (see *infra*).

KYC checks as a worldwide prerequisite to issuing e-wallets. In order to reduce money laundering, blockchain based P2P lending platforms can require parties to the loan transaction to create a crypto-currency account or to undergo a KYC check in order to open a new digital wallet.[540] So, by virtue of owning a digital wallet, anonymity is compromised. KYC checks aim to verify the identity of the parties to the loan transaction. For example, they aim to find out where a borrower or lender is from, whether their names are on known lists, what kind of credit history they have etc. In most countries today, P2P lenders already need to undergo KYC checks to open a new digital wallet. However, as long as there are countries in which parties to the loan transaction can open digital wallets without a proper identification process, the risk remains that "dirty money" comes into the system. This is particularly true after the arrival of new privacy focused coins such as Zcash and Monero, all of which aim to obscure transaction data.[541] Therefore, consideration should be given to the expansion of KYC checks as a worldwide prerequisite to issuing e-wallets.

Blockchain technology facilitates and improves KYC checks. The requirement to undergo KYC checks in order to open a new digital wallet is not that spectacular as also non-blockchain based P2P lending platforms can impose KYC checks on their users. However, blockchain technology can facilitate and improve KYC checks in P2P lending. First, blockchain technology avoids duplication of KYC checks by sharing checks and registering them on the blockchain. Second, blockchain technology allows KYC information to be updated in (near) real-time so that blockchain based P2P lending platforms always have access to the latest information on

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[538] 'Can Blockchain Be Key to Overcoming AML Challenge in Cryptocurrency?', 2017, https://cointelegraph.com/news/can-blockchain-be-key-to-overcoming-aml-challenge-in-cryptocurrency.

[539] D. Adler, 'Blockchain and Money Laundering', *Fordham Journal of Corporate and Financial Law*, blog, https://news.law.fordham.edu/jcfl/2017/12/15/blockchain-and-money-laundering/#_edn20;
S. Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System', 2008 https://bitcoin.org/bitcoin.pdf.

[540] D. Adler, 'Blockchain and Money Laundering', *Fordham Journal of Corporate and Financial Law*, blog, https://news.law.fordham.edu/jcfl/2017/12/15/blockchain-and-money-laundering/#_edn20.

[541] D. Adler, 'Blockchain and Money Laundering', *Fordham Journal of Corporate and Financial Law*, blog, https://news.law.fordham.edu/jcfl/2017/12/15/blockchain-and-money-laundering/#_edn20; N. Reiff, The Rise of 'Private' Cryptocurrencies, 2017, *Investopedia*, https://www.investopedia.com/news/rise-private-cryptocurrencies/.

the identity of each client.[542] Third, historical and immutable records provide adequate proof of whether the P2P lending platform has done the KYC check properly.[543] Finally, once recorded on the blockchain, no single entity can tamper with the historical record of all documents shared and compliance activities undertaken for each client.

Blockchain technology ensures additional guarantees to reduce money laundering. In addition, the potential of blockchain technology to reduce money laundering is expressed in the following guarantees. First, smart contracts make actual enforcement of the KYC prerequisite to issuing e-wallets possible. They can do so by prohibiting loan transactions and token transfers from and to a wallet that do not meet the KYC requirements laid down in the smart contract. Second, blockchain technology creates an immutable, permanent record of every single transaction performed, which allows that all loan transactions can be traced back to an identified e-wallet.[544] Third and finally, blockchain technology enables AML risk analysis mechanisms to take into account entire loan transaction processes, surpassing monitoring systems that only take into account entry and exit points of transactions.[545]

3.2 Supervision and validation of transactions

Supervision and validation of transactions. Blockchain technology also reduces money laundering by ensuring adequate supervision and validation of loan transactions. In Chapter II, we thoroughly discussed how blockchain technology accomplishes this (Chapter II, consensus mechanisms, see *supra*). The key to reduce money laundering lies in the fact that blockchain technology enables instantaneous blockage of transactions which were not verified in all transaction phases, including the departure wallet, the destination wallet, the currency type and amount, without any human supervision.[546] As a result, it will be difficult to carry out money laundering.

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[542] E. Hofmann, U. M. Strewe and N. Bosia, *Supply Chain Finance and Blockchain Technology. The Case of Reverse Securitisation*, 2018, Berlin, Springer, p. 18; S. Paris, 'Blockchain applications in banking. Opportunities for services and compliance activities', 2016, https://www2.deloitte.com/mt/en/pages/financial-services/articles/mt-blockchain-applications-in-banking.html.

[543] E. Hofmann, U. M. Strewe and N. Bosia, *Supply Chain Finance and Blockchain Technology. The Case of Reverse Securitisation*, 2018, Berlin, Springer, p. 18.

[544] 'Can Blockchain Be Key to Overcoming AML Challenge in Cryptocurrency?, 2017, https://cointelegraph.com/news/can-blockchain-be-key-to-overcoming-aml-challenge-in-cryptocurrency.

[545] 'Can Blockchain Be Key to Overcoming AML Challenge in Cryptocurrency?, 2017, https://cointelegraph.com/news/can-blockchain-be-key-to-overcoming-aml-challenge-in-cryptocurrency.

[546] R. Keidar, Y. Arnon, 'How blockchain could end, instead of enable, money laundering', 2017, https://venturebeat.com/2017/10/08/how-blockchain-could-end-instead-of-enable-money-laundering/.

3.3 Anti-money laundering system of financial institutions

Anti-money laundering system. Some blockchain experts go further than implementing blockchain technology in existing AML systems to combat money laundering. Most noteworthy, Floyd DCosta, co-founder at Blockchain Worx, proposes an anti-money laundering system built on a private permissioned blockchain of which each financial institution would be part (see Chapter II, *supra*). Although DCosta does not include P2P lending platforms in his proposed AML system, his system has (only) a large potential to reduce money laundering (in P2P lending) when P2P lending platforms are included in his global system as well.

Blockchain technology helps to detect AML activities. DCosta's proposed AML system aims to leverage the cryptographically secure, decentralised and immutable nature of blockchain technology to identify and stop suspicious transactions effectively.[547] Each financial institution being part of the system would use smart contracts with inbuilt algorithms to securely parse transactions, payments, customer profile data, patterns and other details through an AML engine on the blockchain.[548] In doing so, the AML system integrates the monitoring efforts of all the financial institutions being part of the system. Since all relevant information would be stored in the blockchain and made available to each financial institution in an automated, quick and effective way, suspicious activity can be detected and highlighted to all related participants. Participating financial institutions would be able to instantly alert each other about any potentially money laundering activity and flag them for further investigation.

Blockchain technology and compliance with AML regulations. DCosta's blockchain based AML system would also be useful for responsible authorities to monitor complex transactions in an automated and effective manner and to immutably record audit trails of suspicious transactions across the system.[549]

3.4 Conclusion

Conclusion. The potential of blockchain technology to address money laundering is enormous. Smart contracts' ability to prohibit loan transactions and token transfers from and to a wallet

[547] Gtg advocates, 'Could Blockchain be the new dawn for AML?', 2018, https://www.gtgadvocates.com/could-blockchain-be-the-new-dawn-for-aml/.
[548] Gtg advocates, 'Could Blockchain be the new dawn for AML?', 2018, https://www.gtgadvocates.com/could-blockchain-be-the-new-dawn-for-aml/.
[549] Gtg advocates, 'Could Blockchain be the new dawn for AML?', 2018, https://www.gtgadvocates.com/could-blockchain-be-the-new-dawn-for-aml/.

that do not meet the KYC requirements laid down in the smart contract, immutable, permanent records of every single loan transaction performed that allow that all loan transactions can be traced back to an identified e-wallet and risk analysis mechanisms that take into account entire loan transaction processes are some key examples.[550] However, this enormous potential can only be fully realised when a significant number of P2P lending platforms are based on the blockchain of which the users are moreover subject to adequate KYC checks. Indeed, as long as P2P lending users in some countries can open digital wallets without a proper identification process, the risk remains that "dirty money" comes into the system. Given the early stage of blockchain technology in P2P lending, in our view, blockchain based P2P lending platforms should be subject to the Anti-Money Laundering Directive. However, in the (future?) case that all P2P lending platforms would be based on the blockchain, blockchain technology can almost completely eliminate money laundering. The key lies in preventing that "dirty money" comes into the system by relying on smart contracts that prohibit loan transactions and token transfers from and to a wallet that do not meet the KYC requirements laid down in the smart contract and the several other possibilities of the technology (see *supra*).

IV. Hacking

4.1 Blockchain technology

Hacking. In P2P lending, hacking is the unauthorised intrusion into a computer or mobile device connected to the P2P lending network, usually with the intention to modify or insert data on the platform.[551] Centralised data-storage and management systems make non-blockchain based P2P lending platforms significantly susceptible to hacking and other kind of intrusions.[552]

Blockchain technology and hacking: peer-to-peer technology. Blockchain technology makes P2P lending quasi-immune to hacking.[553] It does by relying on its three underlying technologies, namely peer-to-peer technology, cryptographic mechanisms and consensus mechanisms (see Chapter II, *supra*). First and foremost, peer-to-peer technology plays a crucial role in preventing hacking. Because loan transaction data as well as control over these data are

[550] 'Can Blockchain Be Key to Overcoming AML Challenge in Cryptocurrency?, 2017, https://cointelegraph.com/news/can-blockchain-be-key-to-overcoming-aml-challenge-in-cryptocurrency.
[551] D. Efanov and P. Roschin, 'The All-Pervasiveness of the Blockchain Technology', *Procedia Computer* Science 123, 2018, p. 119.
[552] Ibid.
[553] Ibid.

decentralised across a peer-to-peer network, there is no single point of failure for malicious attackers.[554] In order for hacking to be successful, all copies of the blockchain need to be attacked simultaneously.[555] In addition, a hacker would not only have to attack the specific block of the transaction targeted, but also every block ever created before it and he would have to do so on every node in the network simultaneously (see Chapter II, *supra*). Furthermore, even when some blockchains are hacked, the large number of other network copies provide reliable backup and allow nodes to overwrite the hacked version.[556]

Cryptographic mechanisms prevent hackers from inserting data. Second, cryptographic mechanisms play a role in preventing hacking. They do so by preventing hackers from inserting data on the blockchain. In order to insert data on the blockchain, a hacker needs to have the digital signature of the node(s) that is (are) the target of the hacking.[557] However, cryptographic mechanisms make it impossible for hackers to fake another's digital signature. The reason is that cryptographic hashes underlying digital signatures have preimage resistance, i.e. they operate in only one direction: from input data to hash value, but not vice versa.[558] As a result, it is almost impossible to determine the input based on hash value, and thus to fake another's digital signature.[559] Furthermore, by means of the public key, nodes can verify the authenticity of the sender and thus whether the digital signature really belongs to the person who is claiming ownership (see Chapter II, *supra*).[560]

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[554] Committee on Payments and Market Infrastructures, 'Distributed ledger technology in payment, clearing and settlement', 2017, https://www.bis.org/cpmi/publ/d157.pdf, p. 14. A single point-of-failure is any point in a system that, if it failed to work correctly, would lead to a failure of the entire system. World Bank Group, 'Distributed Ledger Technology (DLT) and Blockchain', *FinTech Note, No. 1*, 2017, p. 1; C. Dannen, 'Bridging the Blockchain Knowledge Gap' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 4.

[555] Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser', 2015, p. 6.

[556] D. Efanov and P. Roschin, 'The All-Pervasiveness of the Blockchain Technology', *Procedia Computer* Science 123, 2018, p. 119.

[557] A. Baliga, 'The Blockchain Landscape', Persistent, 2016, p. 5, https://www.persistent.com/wp-content/uploads/2016/03/The-Blockchain-Landscape-.pdf.

[558] M. Finck, 'Blockchains and Data Protection in the EU', Max Planck Institute for Innovation and Competition Research Paper No. 18-01, p. 5; P. Rogaway, and T. Shrimpton, 'Cryptographic hash-function basics: definitions, implications, and separations for preimage resistance, second-preimage resistance, and collision resistance' in B. Roy and W. Meier (eds.), *Fast software encryption*, 2004, Berlin, Springer, p. 371; J.-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 16.

[559] Notice the use of the wording "almost impossible". We already know that it is not strictly impossible to determine the original input from its hash value, more specifically, by means of the "brute-force" method. The brute-force method basically means that you have to pick up a random input, hash it and then compare the output with the target hash and repeat until you find a match.

[560] T.K. Sharma, 'How does blockchain use public key cryptography', 2018, https://www.blockchain-council.org/blockchain/how-does-blockchain-use-public-key-cryptography/.

Consensus mechanisms prevent hackers from modifying data. Third, consensus mechanisms are important to prevent hacking in P2P lending as they prevent hackers from modifying data on the blockchain.[561] In blockchain technology, each loan transaction is validated by the community of miners.[562] After validation, the transaction is automatically recorded on the blockchain.[563] In order to modify data recorded on the blockchain, hackers need to rewrite all previous blocks and overtake the honest nodes in the network.[564] This is computationally infeasible as long as honest peers control the majority of the hashing power.[565] Only when hackers have exceptionally 51% of the computational energy, they can break the consensus algorithm (see *infra*). At the moment of writing, a 51% attack is highly unlikely given the huge amount of computational energy required, however, not impossible in the future with the use of quantum computers.[566] Even in that case, hackers will be immediately noticed as the blockchain is constantly supervised by the entire peer-to-peer network of nodes.[567]

4.2 Limitations

Limitations blockchain technology. Despite its enormous potential to reduce hacking, blockchain technology has its limitations. In particular, the 51% attack and identity theft are worthwhile to discuss in the context of hacking. Note that identity theft is a general limitation of blockchain technology.

4.2.1 The 51% attack

51% attack. A 51% attack may occur when a single miner node, which happens to have exceptionally more computational resources than the rest of the network nodes, dominates the

[561] K. Bui, 'Nasdaq uses blockchain-based technology to reduce risk and prevent fraud', 2016, http://feedzai.com/blog/nasdaq-uses-blockchain-based-technology-to-reduce-risk-and-prevent-fraud/.
[562] C. Dannen, 'Mining Ether' in *Introducing Ethereum and Solidity*, 2017, Apress, DOI 10.1007/978-1-4842-2535-6_1, p. 112; C. Thompson, 'Blockchain Security for Enterprise: How safe is it?', 2016, https://medium.com/blockchain-review/blockchain-security-for-enterprise-how-safe-is-it-aaad560f6b1e.
[563] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 26.
[564] R. Tripathy, 'Fixing smart contracts - Here comes Blockchain Contracts', 2018, https://medium.com/ranchimall/fixing-smart-contracts-here-comes-blockchain-contracts-ca0243ef506f; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 55.
[565] J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25, p. 5, https://doi.org/10.1186/s40854-016-0046-5.
[566] S. Malik, 'Can The Blockchain Be Hacked?', 2017, https://thehedgecoingroup.com/can-blockchain-hacked/; Blockchain Council, 'Where is blockchain hosted and why it is difficult to hack it?', 2018; https://www.blockchain-council.org/blockchain/where-is-blockchain-hosted-why-it-is-difficult-to-hack-it/.
[567] D. Efanov and P. Roschin, 'The All-Pervasiveness of the Blockchain Technology', *Procedia Computer* Science 123, 2018, p. 119.

verification and approval of transactions and controls the content of a blockchain.[568] During the period in which the attacker has control, he/she can control which transactions are included in the blockchain, prevent other people from creating blocks that will remain in the blockchain, create empty blocks by selecting none of the transactions in the pool of pending transactions and mislead others about the transactions that are recorded in the blockchain.[569] In addition, the attacker can insert fraudulent transactions (see hacking, *supra*).[570] The reason is that the 51% attacker is able to mine blocks faster than anyone else and use those blocks to build a longer blockchain branch than anyone else in the same duration of time. The consequences are limited to the duration of the attacker's control over the blockchain. No cryptocurrencies would be stolen since private keys are necessary to spend them, but recent transactions could be blocked.[571] In addition to practical damage to the relevant blockchain, a 51% attack would damage the blockchain's reputation.[572]

Unlikeliness of 51% attack. Controlling 51% of the network's hashing power would require massive investments in mining material.[573] Whereas it seems currently impossible for an individual to gain that much computing power, larger companies, governments and perhaps certain mining pools might have sufficient funds for this purpose (see Chapter II, *supra*).[574] Although theoretically possible, it is highly unlikely that such a 51% attack will happen. For example, so far, no 51% attacks have occurred in the Bitcoin network since January 2009, when the first genesis block was created and added to the Blockchain.[575] The reason is that incentive systems in blockchains are set up in such a way that it is more profitable for attackers to co-operate with the blockchain system than to attack the blockchain.[576] Those who have that amount of computing power would gain more by simply mining cryptocurrencies.

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[568] J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25, p. 5, https://doi.org/10.1186/s40854-016-0046-5.
[569] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 59.
[570] J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25, p. 5, https://doi.org/10.1186/s40854-016-0046-5.
[571] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 59.
[572] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 60.
[573] R. Tripathy, 'Fixing smart contracts - Here comes Blockchain Contracts', 2018, https://medium.com/ranchimall/fixing-smart-contracts-here-comes-blockchain-contracts-ca0243ef506f; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 59.
[574] M. Swan, *Blockchain: Blueprint for a New Economy*, 2015, Beijing, O'Reilly Media; J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 59.
[575] M. Crosby, P.P. Nachiappan, S. Verma and V. Kalyanaraman, 'Blockchain technology: Beyond bitcoin', 2016, *Appl Innov Rev*, 2016, 2:6–19; A. Sundararajan, *The Sharing Economy*, 2016, Cambridge, The MIT Press, p. 99.
[576] R. Tripathy, 'Fixing smart contracts - Here comes Blockchain Contracts', 2018, https://medium.com/ranchimall/fixing-smart-contracts-here-comes-blockchain-contracts-ca0243ef506f.

Blockchain measures against 51% attack. Most blockchain mechanisms are designed to avoid the 51% attack.[577] The basic assumption of these mechanisms is that a large number of nodes participate in the system, making it almost impossible for one to have the capability to control more than half of the nodes in the system.[578]

4.2.2 Identity theft

Identity theft. Identity theft is the deliberate use of someone else's identity, usually to gain a financial advantage (such as obtaining credit).[579] Whilst cryptographic keys preserve the integrity of data on the blockchain and the authenticity of senders, cryptographic keys also make blockchains vulnerable to digital identity theft.[580] The reason is that loss of the private key means loss of identity on the blockchain network and, very likely, loss of cryptocurrencies and tokens.[581] Furthermore, blockchains' (pseudo-)anonymous nature makes it almost impossible to identify the thief. Because only the private key is needed to divert assets and no central authority is able to block access upon notice of loss, it is obvious that the private key itself becomes the target.[582]

Blockchain measures against identity theft. A possible measure against identity theft is to build an identity and reputation system that records 'fingerprint events' on the blockchain.[583] Instead of recording personal identifiers, such as social security numbers, birth certificates and passports, the blockchain would track life events, such as births, schooling, acquiring student loans, opening bank accounts, buying cars or purchasing homes. When recorded on the

[577] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Why Blockchain has the Potential to Serve as a Secure Accounting Information System, *The CPA Journal*, 2017, p. 2.
[578] J. Dai, Y. Wang and M.A. Vasarhelyi, 'Why Blockchain has the Potential to Serve as a Secure Accounting Information System, *The CPA Journal*, 2017, p. 2.
[579] D. Efanov and P. Roschin, 'The All-Pervasiveness of the Blockchain Technology', *Procedia Computer* Science 123, 2018, p. 119; C.J. Hoofnagle, 'Identity Theft: Making the Known Unknowns Known', *21 Harv. J. L. & Tech. 97*, 2007, p. 11.
[580] D. NGO, 'How blockchain technology can enhance fraud detection', 2016, http://coinjournal.net/how-blockchain-technology-can-enhance-fraud-detection-interview-with-feedzais-cto/; J.J. Xu, 'Are Blockchains Immune to All Malicious Attacks?', *Fin. Innov.I 6*, 2016, 2:25, p. 7.
[581] D. Efanov and P. Roschin, 'The All-Pervasiveness of the Blockchain Technology', *Procedia Computer* Science 123, 2018, p. 119; J.J. Xu, 'Are Blockchains Immune to All Malicious Attacks?', *Fin. Innov.I 6*, 2016, 2:25, p. 6; S. Zafar, 'Can blockchain prevent cybercrime?', 2016, https://www.finextra.com/blogposting/13032/can-blockchain-prevent-cybercrime.
[582] D. Zetzsche, R.P. Buckley and W. Douglas, 'The Distributed Liability of Distributed Ledgers: Legal Risks of Blockchain', EBI Working Paper Series, 2017, nr. 14, p. 15.
[583] A. Baxter, 'Blockchain-Unchaining the world from fraud?', 2016, http://www.thepaypers.com/expert-opinion/blockchain-unchaining-the-world-from-fraud-/763845; G. Nordseth, 'Blockchain: Identity revolution or evolution?', 2016, https://www.signicat.com/eid/blockchain/.

immutable blockchain, these life events become a digital identity that is much more difficult to steal because it is unforgeable, time-stamped and publicly monitored.[584]

Regulatory measures. Given the significant consequences of identity theft, consideration should be given to adequate regulatory measures. Because identity theft is part of criminal law and no specific risk of P2P lending, the discussion of such regulatory measures is beyond the scope of this research paper. However, at this place, we want to underline that regulatory measures need to take into account the decentralised nature of blockchain based P2P lending. This means that liability regimes such as the 'Payer's liability for unauthorised payment transactions' laid down in the Payment Services Directive II cannot be taken over that easily (Article 69, 74 and recital 71 of PSD II).[585]

4.3 Conclusion

Blockchain technology makes hacking in P2P lending almost impossible by relying on its underlying peer-to-peer technology. The reason is that, in order for hacking to be successful, all copies of the blockchain need to be attacked simultaneously. Furthermore, a hacker would not only have to attack the specific block of the transaction targeted, but also every block ever created before it and he/she would have to do so on every node in the network simultaneously. Given the significant consequences of identity theft, consideration should be given to adequate regulatory measures addressing identity theft in P2P lending, taking into account blockchain technology's decentralised nature. Because identity theft is part of criminal law and no specific risk of P2P lending, the discussion of such regulatory measures is beyond the scope of this research paper.

V. Liquidity risk

5.1 Blockchain technology

Liquidity risk in non-blockchain based P2P lending. In P2P lending, lenders are subject to liquidity risk.[586] Liquidity risk is the risk stemming from the lack of marketability of an

[584] J.J. Xu, 'Are Blockchains Immune to All Malicious Attacks?', *Fin. Innov.I 6*, 2016, 2:25, p. 7.
[585] Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015 on payment services in the internal market, amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No 1093/2010, and repealing Directive 2007/64/EC.
[586] S.C. Moenninghoff and Axel Wieandt, 'The Future of Peer-to-peer Fiance', *Zfbf*, 2013, p. 469.

investment that cannot be bought or sold quickly enough to prevent or minimise loss (see Chapter I, *supra*).[587] This risk is particularly important for P2P lenders who cannot rely on (liquid) secondary markets.[588] Although there is the potential for P2P lending platforms to develop secondary markets and P2P lending platforms increasingly do so, this is not (yet) the general rule in non-blockchain based P2P lending.[589]

Blockchain technology can reduce liquidity risk through loan tokenization. Blockchain technology is able to reduce liquidity risk through tokenization. Tokenization is the process of converting assets into a digital token that is backed by the assets themselves.[590] In the context of P2P lending, tokenization concerns the conversion of the right to receive loan payments into (a) digital cryptographic token(s) similar to a bitcoin.[591] For each token a lender holds, the lender will receive the loan payments that the token represents.

Trade of loan tokens. Loan tokenization reduces liquidity risk by enabling investors to sell their loans more easily to other investors. By removing middlemen and embedding execution within smart contract code, tokens lower the cost global transfers of ownership.[592] Loan tokens also augment the ease of divisibility. It is precisely because tokens are highly divisible and global that the potential number of market participants is substantially higher than in markets for illiquid assets. It is important to see that the mere act of tokenization has no impact on liquidity.[593] If a token is thinly traded, it is still relatively illiquid. The key to reduce liquidity risk lies in enabling deeper loan markets.

Legal challenges with regard to tokenization. Although loan tokenization is promising from a technical point of view, some legal challenges have to be overcome. Most notably is the legal qualification of loan tokens.[594] When tokens qualify as financial instruments, they potentially

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[587] A.J. McNeil, R. Frey and P. Embrechts, *Quantitative Risk Management: Concepts, Techniques and Tools - Revised Edition*, Princeton, Princeton University Press, 2015, p. 5.

[588] E. Kirby and S. Worner, "Crowd-funding: An Infant Industry Growing Fast", IOSCO, Staff Working Paper, p. 9, http://www .iosco.org/research/pdf/swp/Crowd-funding-An-Infant-Industry -Growing-Fast.pdf.

[589] K. Davis and J. Murphy, Peer-to-Peer Lending: Structures, Risks and Regulation, Prepared for the 21st Melbourne Money and Finance Conference, Brighton, Victoria, July 2016, p. 6.

[590] P. Kravchenko, 'Assets Will Be Tokens (And It Will Change Finance)', 2017, https://www.coindesk.com/tokenization-will-make-assets-more-valuable/.

[591] H. Green, 'When blockchain meets online lending: The business using one to improve the other', 2017, http://www.cityam.com/262882/blockchain-meets-online-lending-business-using-one-improve.

[592] C. McLain, 'Tokenization of Everything: How Tokens Will Create a More Liquid World', https://masterthecrypto.com/tokenization-tokens-create-liquid-world/.

[593] S. McKeon, 'Traditional Asset Tokenization', 2017, https://hackernoon.com/traditional-asset-tokenization-b8a59585a7e0.

[594] P. Hacker and C. Thomale, 'Crypto-Securities Regulation: ICOs, Token Sales and Cryptocurrencies under EU Financial Law', 2017, p.14-15;

fall within the scope of MiFID II.[595] However, when they do not, loan tokenization may require new legal entities designed around cross-jurisdictional property and tax law.[596] This would apply in particular to jurisdictions which have legal rules in place that require certain transfers to take place using a certain form or be registered in a certain way with the government authority.[597] Further research is needed on the legal classification of tokens.[598]

5.2 Conclusion

Conclusion. In sum, blockchain technology has the potential to significantly reduce liquidity risk in P2P lending through loan tokenization. The deregulatory potential of blockchain technology for liquidity risk will depend on whether there is an existing and adequate regulatory framework for tokens (see *supra*). In addition, given the current absence of (liquid) secondary markets in the P2P lending market, regulatory measures that require P2P lending platforms to inform lenders of their rights to cancel a contract prior to maturity, if any, remain needed.

VI. Conflict of interest

6.1 Blockchain technology

Conflict of interest. In chapter I, we have studied the problem of the conflict of interest between the P2P lending platform and P2P lenders. This conflict of interest can be summarised as follows. P2P lending platforms generate their revenue on the basis of fees that correspond to a certain percentage of the transaction volume and profits.[599] This fee structure provides an incentive for platforms to stimulate the platform's transaction volume by exaggerating investment opportunities and profit chances, while the risks of investment projects are rather

https://ssrn.com/abstract=3075820 or http://dx.doi.org/10.2139/ssrn.3075820; S. Revell, 'Editors' Note', *Capital Markets Law Journal*, 2017, p. 414.

[595] P. Hacker and C. Thomale, 'Crypto-Securities Regulation: ICOs, Token Sales and Cryptocurrencies under EU Financial Law', 2017, p.14-15; https://ssrn.com/abstract=3075820 or http://dx.doi.org/10.2139/ssrn.3075820.

[596] C. McLain, 'Tokenization of Everything: How Tokens Will Create a More Liquid World', https://masterthecrypto.com/tokenization-tokens-create-liquid-world/.

[597] A. Cameron-Huff, 'Op Ed: How Tokenization Is Putting Real-World Assets on Blockchains', 2017, https://bitcoinmagazine.com/articles/op-ed-how-tokenization-putting-real-world-assets-blockchains/.

[598] In this regard, the research paper of P. Hacker and C. Thomale is a strong starting point: P. Hacker and C. Thomale, 'Crypto-Securities Regulation: ICOs, Token Sales and Cryptocurrencies under EU Financial Law', 2017, 45 p., https://ssrn.com/abstract=3075820 or http://dx.doi.org/10.2139/ssrn.3075820.

[599] Ibid, p. 51.

played down or concealed and liquidity is overstated.[600] We have seen that it is not unlikely that this incentive might have an influence on the stringency of credit risk assessments conducted by the platform.[601] However, this is worrying when we remember the significant information asymmetry between parties to the loan transaction, which obliges lenders to rely on the credit risk assessments conducted by the platform.[602] This conflict of interest may result in (significant) losses for lenders as a consequence of a not fully informed investment decision.

DAOs and the conflict of interest. At the moment of writing this research paper, it is unclear whether blockchain technology can reduce conflicts of interest in P2P lending. A possible approach to address conflicts of interest might be to establish P2P lending platforms as *decentralised autonomous organisations* (DAOs).[603] DAOs are computer programs that incorporate governance and decision-making rules, which can be programmed to operate autonomously or the code can provide for direct control of the DAO and the funds controlled by it through member consultation and/or vote (see Chapter II, *supra*).[604] DAOs allow members of the DAO to defend their own interests, proportionally to their investment in the DAO. In blockchain based P2P lending, DAOs could be set up so that no rule or action can be changed without the obligatory consultation of all members of the DAO or; perhaps better, by majority vote of the members of the DAO. In order to reduce the conflict of interest, the community of such DAOs could, inter alia, consist of users of the platform, namely lenders and borrowers. By involving lenders in the DAO, DAOs could create a platform in which the interests of lenders (such as, for example, more stringent credit risk assessments) provide a counterbalance

[600] Oxera, 'The economics of peer-to-peer lending', prepared for the Peer-to-Peer Finance Association, 2016, p. 51; N. Rovnick, 'City grandee Lord Turner warns on peer-to-peer lending risks', Financial Times, 10 February 2016. "In February 2016, Lord Adair Turner, former Chairman of the FCA, voiced concerns with regard to credit risk assessment, stating: 'You cannot lend money to small and medium enterprises in particular without somebody going and doing good credit underwriting.'"

[601] K. Davis, 'Peer-to-Peer Lending: Structures, Risks and Regulation', 2016, Prepared for the 21st Melbourne Money and Finance Conference, Brighton, Victoria, July 2016, p. 6.

[602] T.S. Campbell and W.A. Kracaw WA, 'Information production, market signalling, and the theory of financial intermediation', *J. Financ*., 35(4), 1980, p. 863–882; H.E. Leland and D.H. Pyle, 'Informational asymmetries, financial structure, and financial intermediation', *J. Financ*, 32(2), 1977, p. 371–387; Oxera, 'The economics of peer-to-peer lending', prepared for the Peer-to-Peer Finance Association, 2016, p. 52; C. Serrano-Cinca, B. Guttierez-Nieto and L. Lopez-Palacios, 'Determinants of Default in P2P lending', PLOS, 2015, p. 3-4; A. Sufi, 'Information asymmetry and financing arrangement: evidence from syndicated loans' *Journal of Finance*, 62, 2007, p. 393–410.

[603] ETHLend, 'Decentralized Applications and Lending on the Blockchain', 2017, https://blog.ethlend.io/decentralized-applications-and-lending-on-the-blockchain-10523a309a67.

[604] L. Caisley, D. Lucking, M. Zdrowski and C O'Hanlon, 'Decentralized Autonomous Organizations', 2016, Allen and Overy, p.3-4, http://www.allenovery.com/SiteCollectionDocuments/Article%20Decentralized%20Autonomous%20Organizations.pdf.

to the interests of the platform (see *supra*). In this way, the decision-making power over the platform would no longer exclusively lie with the P2P lending platform.

Critical considerations. Although DAOs seem promising to reduce conflicts of interest, there are several flies in the ointment. First and foremost, DAOs are at a very early stage of development. There is currently little information (available) on (i) how such a DAO would precisely function in practice (see, however, Chapter II, *supra*), (ii) the legal status of such a DAO (see Chapter II, *supra*) and (iii) the regulatory framework it requires to function adequately. Second, even assuming that such a DAO would adequately function, technically and legally speaking, some difficulties remain. For example, in order for P2P lending platforms to be (or remain) economically sound, DAO members, including users, must have some basic financial literacy, which may be not so obvious (see Chapter I, *supra*). In addition, P2P lending platforms themselves may not, directly or indirectly, be represented to any significant extent in the DAO community. Otherwise, the original conflict of interest would arise again as platforms might advocate decisions which stimulate their transaction volume and profits. Finally, we should question whether lenders and borrowers have sufficient incentives to put effort and time in the well-functioning of the P2P lending platform. If this is not the case, we must ask who is responsible for keeping the P2P lending platform profitable, given the fact that lenders and borrowers have a great deal of say and that the interests of lenders, borrowers and the platform do not necessarily coincide.

6.2 Conclusion

Conclusion. Although DAOs seem promising for the future, they are at a too early stage of development to be deployed to eliminate conflicts of interest in P2P lending (critical considerations, see *supra*). Therefore, conflict of interest provisions that address conflict of interest in P2P lending are still needed (see Chapter I, *supra*).

VII. Operational risk

7.1 Blockchain technology

Blockchain possibilities to reduce operational risk in P2P lending. In Basel II and Article 4(1) of Regulation (EU) No 575/2013, 'operational risk' is defined as "the risk of loss resulting

from inadequate or failed internal processes, people and systems or from external events".[605] Blockchain technology has several inherent features that reduce operational risk. First and foremost, the automation of loan payments and the execution of collateral through smart contracts reduce operational risk.[606] The reason is that automation of these processes allows for faster settlement time, reduced operational complexity and the reduction of the number of intermediaries.[607] Second, blockchain technology's decentralised consensus across the peer-to-peer network reduces operational risk.[608] Finally, blockchain technology's ability to eliminate or, at least, strongly reduce reconciliation work reduces operational risk.[609] As both sides of the lending transaction are executed simultaneously, there is only one valid version of the loan transaction. Rare differences between transaction records, for example as a consequence of the blockchain being updated at different speeds, are immediately and automatically resolved by consensus mechanisms so that the true state of the blockchain remains.[610]

Platform risk. In addition, blockchain technology has the potential to eliminate platform risk being part of operational risk. Platform risk is the risk that a P2P lending platform ceases operations due to operational events, such as failure of the platform software.[611] In this section, we discuss how blockchain technology eliminates platform risk. They key lies in the so-called disintermediation.

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[605] Basel Committee on Banking Supervision, 'Principles for the Sound Management of Operational Risk', 2011, Bank for International Settlements 2011, p. 3, https://www.bis.org/publ/bcbs195.pdf; Article 4(1) of Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012.

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Disintermediation. In non-blockchain based P2P lending, P2P lending platforms play an important intermediating role by collecting, bundling and transferring redemption and interest payments from the borrower to the lender. It is obvious that, when such a P2P lending platform ceases to collect, bundle and/or transfer loan payments, lenders bear the risk of significant losses. In blockchain based P2P lending, this intermediating role has disappeared as blockchain technology makes it possible that loan payments are made directly between the parties to the loan transaction without the intervention of the platform (see *infra*). This means that lenders are not dependent anymore on the P2P lending platform to receive their loan payments. As a result, lenders are not subject to platform risk anymore. The elimination of platform risk also means the elimination of the risk that lenders do not receive their loan funds, because a P2P lending platform is not required to apply for a license or permission to provide payment services (such as money remittance) and furthermore does not have adequate arrangements in place to safeguard participant's money (see Chapter I, credit risk, *supra*).[612] In the event of the (permanent) shut-down of the platform, loan claims are captured on the blockchain so that there is no ambiguity in loan claims. In this regard, however, it is advisable that P2P lending platforms make appropriate arrangements in advance to adequately deal with loan claims.

Disintermediation in P2P lending eliminates prior transfer problem. Blockchain technology makes it possible to remove the intermediating role of P2P lending platforms in collecting, bundling and transferring loan payments. The key lies in blockchain technology's ability to transfer data instead of copying data.[613] Prior to the advent of blockchain technology, digital transfer of loan payments was already possible, but a trusted third party was required to record the transfer of loan payments and to reduce the amount paid from the lender's account.[614] Blockchain technology guarantees the transfer of loan funds between the parties to the loan transaction without the need to rely on P2P lending platforms.[615] It does this as follows. First of all, mining nodes check whether the borrower has enough funds for the loan (consensus mechanisms, see Chapter II, *supra*). Because every transaction is publicly recorded on the

[612] European Banking Authority, 'Opinion of the European Banking Authority on lending-based crowdfunding', 2015, EBA/Op/2015/03, p. 12.
[613] P. Crosman, 'See blockchain put peers back in P2P', *American Banker Magazine*, 2018, New York, Vol. 128, Iss. 1, 24-25.
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blockchain, it is easy to find out the number of cryptocurrencies the borrower owns.[616] If it turns out that the borrower has enough funds, the blockchain will automatically record the transfer of loan payments to the lender and mark them as spent by the borrower.[617] As a result, the borrower will no longer be able to spend the same loan funds because they will be marked in the blockchain as transferred to someone else. Because loan transactions are chronologically recorded, cryptographically chained together and updated through consensus on the blockchain, parties to the loan transaction can trust that loan payments are not only directly, but also safely made between them (see Chapter II, *supra*).

Operational risk has far-reaching consequences in blockchain based P2P lending. Blockchain technology is able to significantly reduce operational risk and to eliminate platform risk being part of operational risk. However, when operational risk occurs, it has vast consequences as an error once implemented in the code may easily spread over the whole system affecting a bigger number of nodes than a centralised ledger.[618] The risk is ongoing as software is ever-changing through new releases.[619] Poorly maintained, outdated or deficient code is not only problematic in the light of operational risk but could also open the door for system hacks (see *supra*).[620]

7.2 Conclusion

Conclusion. Blockchain technology has a significant potential to reduce operational risk. First, it eliminates platform risk. The key lies in disintermediation. Second, (i) the automation of loan payments through smart contracts which allows for faster settlement time, reduced operational complexity and a reduced number of intermediaries and (ii) blockchain technology's ability to eliminate or, at least, strongly reduce reconciliation work reduce operational risk. However, given the possible vast consequences when operational risk materialises, regulatory measures

[616] In order to find the number of cryptocurrencies a borrower owns, mining nodes subtract the number of cryptocurrencies the borrower has spent from the number of cryptocurrencies he received.
[617] J-L. Verhelst, *Bitcoin, the Blockchain and beyond*, self-published, 2017, p. 47.
[618] ESMA, 'Report - The distributed ledger technology applied to securities markets', 2017, p. 11 https://www.esma.europa.eu/system/files_force/library/dlt_report_-_esma50-1121423017-285.pdf; A. Walch, 'The Bitcoin Blockchain as Financial Market Infrastructure: A Consideration of Operational Risk', *18 N.Y.U. J. LEGIS. & PUB. POL'Y* 837, 2015, p. 865-867; A. Zetzsche, R.P. Buckley and W. Douglas, 'The Distributed Liability of Distributed Ledgers: Legal Risks of Blockchain', EBI Working Paper Series, 2017, nr. 14, p. 19.
[619] H. Kakavand and N. Kost De Sevres and B. Chilton, 'The blockchain revolution: an analysis of regulation and technology related to distributed ledger technologies', 2017, p. 25; A. Walch, 'The Bitcoin Blockchain as Financial Market Infrastructure: A Consideration of Operational Risk', *Journal of Legislation and Public Policy*, Vol. 18:837, 2015, p. 56 (quoting Federal Reserve Policy on Payment System Risk, 79 Fed. Reg. 67326, 67333 (Nov. 12, 2014)).
[620] J.J. Xu, 'Are blockchains immune to all malicious attacks?', *Financial Innovation*, 2016, 2:25, p. 5.

including adequate safeguards remain needed. Consideration should be given to minimum capital requirements, business continuity plans and contingency plans that ensure that loan payments will continue to be collected (see Chapter I, *supra*).

CONCLUSION

Conclusion. The research paper provides an answer to the research question: *"What is the deregulatory potential of blockchain technology for P2P lending?"* In order to give a coherent and full answering, the research was carried out on the basis of four research sub-questions.

Sub-question 1: ***"What are the risks of P2P lending?"*** In the first chapter, we studied the risks of (non-blockchain based) P2P lending. The principal risks of P2P lending are credit risk, fraud, money laundering, hacking, liquidity risk, conflict of interest and operational risk. In particular, credit risk and liquidity risk are important to consider in P2P lending. Unlike commercial banks, P2P lending platforms do not take credit risk and liquidity risk by their own contractual positions, but they decentralise these risks to their users. Another reason to give particular attention to credit risk is its underlying asymmetric information problem. So far, those interested in knowing the factors explaining loan default were risk analysts in financial institutions. However, P2P lending platforms attract investors that do not necessarily have the appropriate level of financial expertise and the lending experience to make fully educated investment decisions. In addition, platform risk, i.e. risk that the platform ceases operations due to operational events, plays an important role in P2P lending. The reason is that platforms play a crucial intermediating role by collecting, bundling and transferring loan payments from borrowers to lenders. It is obvious that, when platforms cease to collect, bundle and/or transfer loan payments, lenders are subject to the risk of significant losses.

Sub-question 2: "What is the regulatory framework for P2P lending?" In the first chapter, we also studied EU regulatory measures addressing P2P lending risks in order to subsequently evaluate which types of regulatory measures can be eliminated or reduced by blockchain technology. We distinguished between regulatory measures for P2P business lending and P2P consumer lending. Regarding P2P business lending, we discussed the European Commission's Proposal on European Crowdfunding Service Providers for Business, which provides a fairly comprehensive framework for P2P risks. Most notably are the extensive disclosure standards and warnings related to credit risk for investors and the extensive regulatory measures for money laundering and conflict of interest. P2P consumer lending has a considerably less extensive regulatory framework. The application of the Consumer Credit Directive (CCD) on P2P lending platforms is highly limited and the application of MiFID II on P2P lending, which would be relevant for credit risk and conflict of interest, is not yet certain. Regulatory measures addressing money laundering are lacking as well.

Sub-question 3: ***"How does blockchain technology function?"*** In the second chapter, we studied the functioning of blockchain technology on the basis of the increasingly used interpretation of blockchain technology as a synthesis of three distinct key technologies: (i) peer-to-peer technology, (ii) cryptographic mechanisms and (iii) consensus mechanisms. Perhaps the two greatest achievements of blockchain technology, which also play a significant role in P2P lending, are the following. First, blockchain technology allows transactions to take place directly between parties to the transaction in a secure and tamperproof way without the intervention of the platform. The key lies in blockchain technology's ability to transfer data instead of merely copying data. Second, blockchain technology enables the chronologically recording, sharing and synchronizing of data in a digital system decentralised across a network of multiple datastores. By relying on cryptographic mechanisms and consensus mechanisms, blockchain technology guarantees that data on the blockchain are immutable, irreversible and tamperproof and that transactions are transparent, traceable and auditable. Particularities of Bitcoin and Ethereum, the two most widely used blockchains in blockchain based P2P lending were also discussed. Most notably are smart contracts and decentralised autonomous organisations (DAOs).

Sub-question 4: ***"What is the deregulatory potential of blockchain technology for P2P lending?"*** In the third chapter, we studied the possibilities (and limitations) of blockchain technology to eliminate or reduce P2P lending risks. This study, taken together with the regulatory framework for P2P lending set out in Chapter II, allows to provide an answering on the research question "*What is the deregulatory potential of blockchain technology for P2P lending*?" Below, the deregulatory potential of blockchain technology for the different P2P lending risks is presented in order of importance.

1. Potential of blockchain technology to eliminate risks of P2P lending

Platform risk. Blockchain technology eliminates one P2P lending risk, namely platform risk being part of operational risk. Blockchain technology eliminates platform risk by allowing loan transactions to take place directly between the parties to the loan transaction without the intervention of the platform. This means that P2P lenders are not dependent anymore on the platform to receive their loan payments.

2. Potential of blockchain technology to significantly reduce risks of P2P lending

Fraud. Blockchain technology has the potential to significantly reduce several P2P lending risks. First, blockchain technology prevents fraud regarding both financial and personal information on parties to the loan transaction recorded on the blockchain and loan transactions (including loan funds) on the blockchain. In this regard, blockchain technology relies on its decentralised, immutable, transparent and auditable nature. However, blockchain technology is not able to identify fraudulent information. Therefore, background checks on parties to the loan transaction are needed. In this regard, the European Banking Authority (EBA) proposes to require platforms to request identification information, addresses, information about financial status/creditworthiness and potential criminal records from borrowers and lenders, including evidence. On the other hand, permissioned blockchains and smart contracts are highly useful to restrict access to the platform to parties that underwent background checks conducted by the platform. Therefore, blockchain technology can play a supporting role in the enforcement of (potential) fraud regulation in P2P lending.

Money laundering. Second, blockchain technology has significant possibilities to reduce money laundering. Smart contracts' ability to prohibit loan transactions and token transfers from and to a wallet that do not meet the KYC requirements laid down in the smart contract, immutable, permanent records of every single loan transaction performed that allow that all loan transactions can be traced back to an identified e-wallet and risk analysis mechanisms that take into account entire loan transaction processes are some key examples. However, this enormous potential can only be fully realised when all P2P lending platforms are based on the blockchain of which the users are subject to adequate KYC checks. Otherwise, the risk remains that "dirty money" comes into the system. Given the early stage of blockchain technology in P2P lending and as long as P2P lenders and borrowers in some countries can open digital wallets without a proper identification process, blockchain based P2P lending platforms should be subject to the Anti-Money Laundering Directive. Nevertheless, blockchain technology can play a crucial supporting role in the enforcement of AML regulations by relying on its features above. Most noteworthy is the ability of smart contracts to prohibit loan transactions and token transfers from and to a wallet that do not meet the KYC requirements laid down in the smart contract. In the (future?) case that all P2P lending platforms would be based on the blockchain, it is likely that blockchain technology can almost completely eliminate money laundering. The key lies in preventing that "dirty money" comes into the system by relying on smart contracts

that prohibit loan transactions and token transfers from and to a wallet that do not meet the KYC requirements laid down in the smart contract and the several other possibilities of the technology set out in Chapter III.

Hacking. Third, blockchain technology makes hacking in P2P lending almost impossible by relying on its underlying peer-to-peer technology. The reason is that, in order for hacking to be successful, all copies of the blockchain need to be attacked simultaneously. Furthermore, a hacker would not only have to attack the specific block of the transaction targeted, but also every block ever created before it and he/she would have to do so on every node in the network simultaneously. Noteworthy limitations are the (theoretical) 51% attack and identity theft. Given the significant consequences of identity theft, consideration should be given to regulatory measures addressing identity theft in P2P lending. Because identity theft is part of criminal law and no specific risk of P2P lending, the discussion of such regulatory measures is beyond the scope of this research paper. Nevertheless, the research paper wants to emphasise that regulatory measures need to take into account the decentralised nature of blockchain technology.

3. Considerable potential of blockchain technology to reduce risks of P2P lending

Credit risk. Blockchain technology has considerable potential to reduce the following P2P lending risks. First, blockchain technology has the potential to reduce credit risk in the broad sense, i.e. the risk that P2P lenders do not receive their redemption and interest payments as agreed. It does so by guaranteeing (near) real-time transaction settlement and certainty of transaction settlement on the one hand and enabling an improved credit risk assessment on the other hand. In addition, blockchain technology allows fast and effective execution of collateral, in the case that credit risk materialises. The effective potential of blockchain technology in this regard will depend on whether there is an existing and adequate regulatory framework. However, the fact remains that blockchain technology, like any other technology, has almost no impact on the creditworthiness of borrowers, which, after all, remains the major tool to reduce credit risk. Therefore, regulatory measures addressing credit risk in the strict sense are still needed in blockchain based P2P lending. In this regard, it is important to understand that credit in P2P lending requires a fairly different regulatory approach than that of traditional lending. Whereas the core element of traditional lending regulation is to prevent banks from taking too much risk, the core element of platform regulation is not the platform itself, but rather

the lending process in which capital is mediated between borrowers and lenders. The reason is that P2P lending platforms do not assume credit risk by their own contractual positions, but decentralise this risk to their users. Therefore, LENZ rightly states that P2P lending requires a regulatory framework that safeguards a fair and transparent lending process, whereby every lending party is well-informed and is able to assess and carry credit risks taken, rather than regulatory measures such as equity loss-absorption buffers. The disclosure standards laid down in Article 14 of the Proposal on European Crowdfunding Service Providers for Business and, to a lesser extent, the pre-contractual information duties laid down in Article 5 of the Consumer Credit Directive provide a fairly adequate answer to this need but are not sufficient for lenders to assess and compare the quality of P2P lending platforms and so make a careful selection of the "right" platform. In addition, because P2P investors do not typically have the appropriate level of financial expertise and the lending experience to make fully educated investment decisions, suitability and appropriateness tests of investors should be considered. In this regard, we discussed the 'early knowledge test' laid down in Article 15 of the Proposal on European Crowdfunding Service Providers for Business and the suitability and appropriateness test provided in Article 25, paragraph 2, of MiFID II. Finally, creditworthiness assessments of borrowers are crucial to reduce credit risk and to mitigate the asymmetric information problem in P2P lending. They are also important in the light of 'responsible lending'. Both the Proposal on European Crowdfunding Service Providers for Business and the CCD are inadequate in this regard.

Liquidity risk. Second, blockchain technology has the potential to reduce liquidity risk in P2P lending and, more precisely, through loan tokenization. Whilst the mere act of tokenization has no impact on liquidity risk, loan tokens have an impact upon liquidity risk through the creation of deeper loan markets. More specifically, by removing middlemen, easing divisibility and embedding execution within smart contract code, tokens facilitate and lower the cost of global transfers of ownership. However, the effective deregulatory potential of blockchain technology for liquidity risk will depend on whether there is an existing and adequate regulatory framework for tokens, which in turn is depended on its not yet established legal qualification. In addition, regulatory measures that require P2P lending platforms to inform lenders of their rights to cancel a contract prior to maturity, if any, remain important to reduce liquidity risk. This particularly applies for P2P lending platforms without secondary markets. EBA also proposes to require P2P lending platforms to take reasonable care to establish and maintain systems and

controls that are appropriate to their business, including in relation to the timely transfer of agreed funds.

Operational risk. Third, blockchain technology considerably reduces operational risk. In particular, (i) the automation of loan payments through smart contracts which allows for faster settlement time, reduced operational complexity and a reduced number of intermediaries and (ii) blockchain technology's ability to eliminate or, at least, strongly reduce reconciliation work reduce operational risk. However, when operational risk materialises, its consequences are more far-reaching than in centralised ledgers. The reason is that an error once implemented in the code may easily spread over the whole system affecting a bigger number of nodes than in centralised ledgers. Therefore, consideration should be given to regulatory measures addressing operational risk, such as minimum capital requirements, business continuity plans and contingency plans that ensure that loan payments will continue to be collected. Regarding P2P business lending, we discussed Article 10 of the European Commission's Proposal on European Crowdfunding Service Providers for Business, which contains extensive measures to address operational risk. Regarding P2P consumer lending, inspiration for (possible) continuity and contingency plans can be found in the Payment Services Directive (PSD II) and inspiration for minimum capital requirements in the Capital Requirements Directive (CRD IV). Given that P2P lending platforms do not assume credit risk, minimum capital requirements should be lower for P2P lending platforms.

4. Uncertain potential of blockchain technology for P2P lending

Conflicts of interest. At the moment of writing, the potential of blockchain technology to reduce conflicts of interest between the P2P lending platform and P2P lenders remains uncertain. We have seen that platforms can be established as *decentralised autonomous organisations* (DAOs), consisting, inter alia, of lenders and borrowers of the platform. The idea is that, by involving lenders in the DAO, DAOs can create a platform in which the interests of lenders (such as, for example, more stringent credit risk assessments) provide a counterbalance to the interests of the platform (an increase in transaction volume). To achieve this, DAOs could be set up so that no rule or action can be changed without the obligatory consultation of all members of the DAO or, perhaps better, by majority vote of the members of the DAO. However, there is too little information available to provide a definitive answer on whether and to which extent blockchain technology can effectively address conflicts of interest in P2P

lending. For example, there is currently no information available on (i) how such DAOs would precisely function in practice, (ii) the legal status of such DAOs and (iii) the regulatory framework it requires to function adequately. Given that the possibilities of blockchain technology to address conflicts of interest are not (yet) discovered, consideration should be given to regulatory measures that address conflicts of interest in P2P lending. In this regard, we discussed the regulatory measures laid down in Article 7 of the Proposal on European Crowdfunding Service Providers for Business and Article 23 MiFID II. Both provisions set out a (highly similar) legal framework that aims at identifying and preventing or managing conflicts of interest between the platform and its user or between one user and another. Only when steps to identify and to prevent or manage conflicts of interest are insufficient to ensure that risks of damage to client interests will be prevented, the provisions provide for disclosure of the general nature and/or sources of conflicts of interest and the steps taken to mitigate these risks.

5. Final conclusion

Conclusion deregulatory potential of blockchain technology for P2P lending. Blockchain technology has an enormous potential to address risks of P2P lending and to support regulatory measures addressing risks of P2P lending. However, this does not mean that its deregulatory potential is just as great. Several (additional) regulatory measures are still needed to adequately address P2P lending risks. An exception can be made for platform risk and, to a large extent, hacking. Nevertheless, it is clear that blockchain based P2P lending platforms can significantly reduce P2P lending risks and support regulatory measures addressing these risks by relying on blockchain technology. We expect that the deregulatory potential of blockchain technology will increase in parallel with the number of P2P lending platforms based on the blockchain and the further development of regulatory frameworks for (loan) tokenisation and DAOs.

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