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IMPLEMENTING DLTS IN LISTED COMPANIES: SHAREHOLDERS' IDENTIFICATION

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Abstract

Technological innovation has often meant disruption of the status quo. In this regard, Distributed Ledger Technologies (DLTs) have broadened new horizons. Blockchain has come to be known as the backbone behind the Bitcoin cryptocurrency, but now it is recognized as the engine that may revolutionize multiple sectors of our everyday life.
So many uses imply it becomes difficult to keep track of constant changes.

This research will analyse the impact the DLTs may have on public listed companies and securities markets. More specifically, it will focus on studying the effects of its application on the process of identifying the company's shareholders.

Securities markets are structured around long chains of intermediaries, which almost always operate through cross-border transactions. DLTs have the potential to favour disintermediation, simplifying the process of shareholder's identification and reducing the transaction costs associated to it. However, implementation of the DLTs come at a price.

Scope of this research is analysing whether it is possible to adopt DLTs in order to make shareholder's identification easier, in a way which is desirable both for the shareholders and for the securities' issuers.

As it will be shown, it is possible to achieve a positive outcome by implementing DLTs in the post-trading scenario. Nevertheless, the result is highly subjective to the specific model of shared ledger that is chosen to be applied.

INTRODUCTION

Openness in capital markets has allowed companies listed on the main stock exchanges to offer their equity securities to a wide variety of investors. Especially in Western countries, ownership is often said to be dispersed, with many investors participating to a very small amount of the legal capital. However, in practice the majority of the ownership is almost always represented by institutional investors and other large blockholders. Only the minority of the shareholders can be properly defined as dispersed.

Investors often buy securities through brokers which in turn deal with other financial agents, in a long intermediation chain that ultimately ends with listed companies. As a consequence, there is a loss of contact between the securities' issuer and the final investor, leading to an intrinsic difficulty in identifying the companies' shareholders at a specific time and place.

However, correct identification is required for proper corporate governance and for shareholders to exercise their equity rights, especially when general and special meetings are scheduled.

This research will begin by studying the intermediation chain at the heart of securities markets, and defining what are the many impediments to an easy identification of shareholders.
It will then introduce the concept of DLTs (the fundamentals behind the Blockchain), and analyse some of the models currently being developed for the securities markets. Further, the advantages and disadvantages stemming from the application of this ledger protocols are discussed.
The last chapter will try to answer the question as to whether it would be possible applying DLTs in the securities' clearance and settlement systems, in order to make shareholders' identification easier in a way that is both beneficial to the investor and the company.

Although there is much literature regarding the concept of shareholders' identification, only a few offer some insights into the practical possibilities offered by the DLT. This research will deepen the context further, by introducing real applications and studying their limits and promises.

Lastly, only a qualitative analysis will be conducted. In case the results will be insightful, I hope further studies will try to deepen the topic by a quantitative point of view too.

The analysis starts with a brief depiction of public listed companies in Western countries, focusing on the concept of separation between ownership and control. Most of the investors buy securities from financial intermediaries, which operate over a chain that has CSDs (Central Securities Depositories) at its core. The main characteristics and the functioning of CSDs are then illustrated, emphasising the procedures that make shareholder identification often a burdensome task. The research continues with the introduction of some legal limits to proper shareholder identification, before delving into the procedures through which securities' issuers can request shareholders' identification. At the end of the chapter, lack of transparency

and excessive financial intermediation are summarised as the main problems for shareholders' identification, and the concept of DLTs as a possible solution is introduced.

CHAPTER I

IDENTIFYING SHAREHOLDERS

1.1 Public listed companies and dispersed ownership

In the modern era, there are multiple types of companies with completely different characteristics. The first distinction usually revolves around companies being either private or public, where the former is entitled to offer their securities to the public while the latter cannot.

Another point of disjunction regards limitation of liabilities: in limited companies, the legal capital is separated from the shareholders' individual properties through a veil, which prevents third parties from seeking compensation against the company in the form of economic reimbursement by shareholders. On the reverse, unlimited companies do not enjoy limited liability, but they are subject to less demanding disclosure requirements[1].

The focus of the study is centred around public listed companies in Western countries, which are identified by five main characteristics of public limited companies: legal personality; limited liability; shares being freely transferable; separation between ownership and control; and delegated management under a board structure[2].

Public listed companies are also characterised by their shares being tradeable on secondary markets like organized exchanges, such as the LSE (London Stock Exchange) or the NYSE (New York Stock Exchange). Nonetheless, listing on the major exchanges requires companies to publish additional reports regarding their economic and financial position, and disclosing compliance with corporate governance rules[3].

This research starts considering the division between management of the company by directors, and ownership by shareholders. Such structure is at the heart of modern corporate governance, which assumes it is more efficient delegating the routine management of the company to a board of directors. These act as agents of the shareholders, and their functions include, but are not limited to, producing the annual accounts, as well as supervising the company's administration[4].

At the other side of the spectrum, shareholders are left with a minimum number of functions, some of which include amending the company's articles of association or bylaws, and deciding upon issuance of newer

[1] Paul L. Davies & Sarah Worthington, *Gower's Principles of Modern Company Law* 12-13; 16-17 (10th ed. 2016)
[2] Reinier Kraakman et al., *The Anatomy of Corporate Law* 5-15 (3rd ed. 2017)
[3] Paul L. Davies & Sarah Worthington, *Gower's Principles of Modern Company Law* 14-15 (10th ed. 2016)
[4] *Id.*, 365-366

shares[5]. They can attend general and special meetings, and their voting power (given by their voice right) is extremely important for correct corporate governance, especially when removal of directors is one of the few available solutions to an underperforming company[6].

Nonetheless, shareholders are typically identified with their position as investors, being primarily interested in dividends and in returns from buying equity securities. If they want to exercise their voice right, investors first need to be recognized as shareholders by the company.

1.2 The intermediation chain: investors and CSDs

Investors may buy securities through a financial intermediary such as a broker. Nowadays, online platforms have made transactions easy to perform: the investor deposits money on an account, and then he can buy securities on any organized exchange or OTC market served by the broker. This structure has become important in cross-border transactions, so that it is now common to refer to global financial markets[7].

However, the above-mentioned structure is too much of a simplification; it is the façade experienced by the average investor, and it just represents the execution process of an order.
In practice, securities transactions involve more financial intermediaries interwoven with the processes of clearance and settlement. The former operation refers to the act of establishing the obligations of buyer and seller in securities trading. On the reverse, the latter implies the transfer of the financial instrument from seller to buyer[8].

The current financial system, and capital markets in particular, heavily rely on centralised organizations for clearance and settlement such as the CSDs (Central Securities Depositories)[9]. They first appeared in their modern form in the 60s and 70s, due to practical constraints in handling paper certificates of securities. The process involved immobilizing the paper certificates, by physically storing them in the CSD itself, and then accounting for transfers through a book-entry system. This approach was necessary for the development of faster trading venues, and nowadays CSDs are fundamental for the correct functioning of the securities markets[10].

CSDs are financial intermediaries, and their operations do not influence neither liquidity nor credit risk borne by investors[11]. On the contrary, their expertise and economies of scale make it possible for clearance

[5] *Id.*, 364-365
[6] *Id.*, 378-379
[7] Zvi Bodie et al., *Investments* 68-69; 74-75 (10th ed. 2013)
[8] Heiko Schmiedel et al., *Economies of Scale and Technological Development in Securities Depository and Settlement Systems*, 6 Journal of Banking and Finance 1783, 1784-85 (2006)
[9] *Id.*
[10] Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276, 281 (2018)
[11] *Id.*, p.7

and settlement costs to be as low as possible in securities transactions, at least in the current state-of-the-world[12].

Their core functions include: a notary service, which is performed by recording newly issued securities in a book-entry system; and maintenance of top-tier securities accounts with the companies issuing securities on the market. In this regard, CSDs are the financial agents which allow end investors to get into contact with listed companies.
Sometimes, they also provide settlement services, as being the cash leg of securities transactions[13]. Another main role played by CSDs is their depository function, in quality of safekeepers of assets and securities' administrators on behalf of investors and other agents located down the intermediation chain[14].

In order to enjoy the last-mentioned service, investors (or their brokers) need to open an account with the CSD. The ECSDA (European Central Securities Depositories Association) represents most of the CSDs in the EU, and it has identified three types of accounts.
The first one is omnibus client segregation, commonly referred to as omnibus account, which involves one account for the CSD participant's own securities and a separate one for all of its clients' securities. It is the least transparent model, but the most cost-efficient as well.
Another type involves individual client segregation, where separate accounts for any individual client of the participant are kept. It should be noted that these accounts are often registered under the participant's name and not its clients', limiting the possibilities for immediate investor identification.
The last model is defined as end investor segregation, which involves segregated accounts for any individual end investor, who often coincides with the client of the participant's client. Though the CSD has no direct relation with such investors, it still is the most transparent model[15].

When it comes to the territory in which CSDs operate, these institutions can be divided in two categories: national and international CSDs. The former handle securities that are issued in a framework where domestic securities laws mainly determine contractual relationships between the agents. As for the latter, they deal with securities which are being issued in a mainframe that accounts for cross-border corporate and contractual structuring[16] The biggest international CSDs are Euroclear, Clearstream International, and DTC.

[12] Heiko Schmiedel et al., *Economies of Scale and Technological Development in Securities Depository and Settlement Systems*, 6 Journal of Banking and Finance 1783, 1785 (2006)
[13] Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276, 282-283 (2018)
[14] Heiko Schmiedel et al., *Economies of Scale and Technological Development in Securities Depository and Settlement Systems*, 6 Journal of Banking and Finance 1783, 1789 (2006)
[15] Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276, 285-287 (2018)
[16] *Id.*, 282

At this point it should be clearer what functions the CSDs perform, how they operate and the kind of securities they handle. It is now time to identify their positioning within the chain of financial intermediation.

At the beginning of the chain, listed companies issue securities which are registered by CSDs in a book-entry system (in the EU, all securities traded on an exchange must be registered in a CSD[17]; this is usually done either by Euroclear or Clearstream, while in the US this task is performed by the DTC)[18]. Sub-custodians open accounts with CSDs and become their participants; this category may involve domestic and foreign financial institutions as well as other CSDs. Global custodians (often investment banks) are the final linking ring in the chain, connecting sub-custodians to end investors[19].

The chain of intermediation has a direct impact on the process of shareholders' identification, as its length and the types of registered accounts affect the speed required by investors' information to reach listed companies.

1.3 The problem of identifying shareholders

Shareholders' identification requires flows of information: it follows that a long chain of intermediaries makes the collection of information burdensome and expensive. A similar outcome can happen when clients' accounts are not entirely segregated and require additional steps in order to circumvent the lack of transparency. Investing time and effort in long operative procedures results in excessive transaction costs, which often act as a disincentive for both investors and companies.

Identification begins at the initial depository bank and it is centralised at the CSD. The process involves identifying the next intermediary in the chain, and transmitting the information of the investor regarding his identity and its shares. When shareholders are called upon voting in a general meeting, confirmation of the direction of the votes cast is also an additional element that needs to be transmitted along the chain[20].

If the identification has been requested by a company, costs and benefits should be carefully weighed: it may turn out to be expensive, and not necessarily lead to additional participation of shareholders to the corporate decisions. Nonetheless, even a small fraction of votes might be important when the Board of Directors is being contested in a meeting or in a takeover[21].

[17] Regulation (EU) No 909/2014 art. 3 (2)
[18] [18] Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276, 284 (2018)
[19] *Id.*, 285-286
[20] Peter Böckli et al., *Shareholder Engagement and Identification* 7 (2015), *available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2568741*
[21] *Id.*

As for the process of collecting information, what are the elements that make such gathering so complex? Four main reasons are highlighted: extensive use of omnibus accounts; mandatory disclosure only above a minimum threshold of owned shares; the legal procedure for updating the company's ledgers on a national level; and different legislation on a cross-border level.

1.4 Commingled accounts and mandatory disclosure

To start with, omnibus accounts have become established as the industry's preferred account model, since it is both cost and operation efficient. The number of entries and data to be registered is relatively small, and that saves time and the amount of information that needs to be transferred along the chain. In a state-of-the-world where investors are primarily interested in short-term gains from holding equity securities, the complete information disclosure required for exercising voting rights doesn't seem to be the main goal[22].
In addition, commingled accounts are commonly used for settlement internalisation: when two clients of a CSD's participant trade securities, the settlement transactions are recorded only in the participant's ledger, lowering operational costs for the CSD[23].
Another appreciated feature of omnibus accounts is data uniqueness: investor's information is precious, and storing multiple copies of personal identity throughout the intermediation chain sometimes can lead to data loss or theft[24].
Furthermore, omnibus client segregation eases the role of CSDs as controllers of the issued securities' integrity: they periodically check that the number of securities hold in all the accounts is equal to the total issued amount[25].

On the reverse of the spectrum, segregated accounts (either at a client's or end investor's level) allows faster and more direct communication between shareholders and the company's management[26]. In particular, minority shareholders may favour the use of such accounts and disintermediation in general, for exercising their voice rights in an easier way[27].
Other consequences of account segregation include anti money laundering and tax compliance being easier to assess, and production of disaggregated data on global securities for regulators. This last characteristic is extremely important when it comes to forecasting business cycles and economic regressions[28].

Most of the CSDs mainly register omnibus accounts with their participants. As an example, consider DTC, which primarily covers the US securities markets. It operates its business on an omnibus-accounts model,

[22] Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276, 278 (2018)
[23] *Id.*, 291-292
[24] *Id.*, 291-292
[25] *Id.*, 285
[26] *Id.*, 308
[27] *Id.*, 295; 298-299
[28] *Id.*, 308

with only a couple of exceptions: the DRS (Direct Registration System, which is available for end investors) and the Seg-100 Accounts (related to equity ownership of foreign investors in specific industries, such as telecommunications)[29].

The only modern CSDs based on a segregated accounts model are the national ones, which operate in countries that developed a favourable legislative environment. As an example, in Norway some procedures of tax compliances are directly dealt with by CSDs on behalf of their participants[30]. Moreover in the EU, CSDs must segregate their own accounts and their clients' ones. If a participant decides to keep its own client accounts segregated, the CSD must comply with it[31].

When it comes to shareholders' identification, it should be noted how it is mandatory only above minimum thresholds of ownership. In all the other cases, securities' issuers should manually request disclosure of information to CSDs, and the procedure changes upon the different legal systems.

In the UK, issuers send a cascading notice down the intermediation chain. CSDs must report to the issuers the available information regarding their participants' accounts. When the accounts are commingled, participants forward the notice to their own clients, until the end investors are identified[32].

Speaking of Italy, the financial intermediary allowed to emit certifications for the rights held by shareholders, is the last one in the chain[33]. The issuer (listed in Italy) may request the intermediaries at its own expenses to recover the data of all the shareholders, except for the ones who expressly denied such possibility[34].

Issuers in the US can request investors' information following the SEC Rule 14a[35]. However, investors may request their brokers not to have their identities disclosed [36].

As it can be derived, some investors may desire to keep their position secret. This may be due to different reasons, being them either acquiring a majority percentage in a company, or avoiding economic sanctions. Omnibus accounts can be used to protect the identity of the securities' final owners[37]. In alternative, investors may prefer specific derivatives to equity, that allow the shareholders to exercise their rights without the need for disclosure of all information[38].

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[29] *Id.*, 285-286
[30] *Id.*, 290
[31] Regulation (EU) No 909/2014 art.38
[32] UK Companies Act 2006 s. 793
[33] Consob, *Disciplina delle Controparti Centrali, dei Depositari Centrali e dell'Attività di Gestione Accentrata* artt. 2; 41 (2018)
[34] Consob, *Testo Unico della Finanza* art. 83-duodecies (2020)
[35] US Securities and Exchange Commission, *17 Code of Federal Regulations* § 240 14a
[36] Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276, 300-301 (2018)
[37] *Id.*, 277-278
[38] Peter Böckli et al., *Shareholder Engagement and Identification* 8 (2015), *available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2568741*

1.5 National shareholder entitlement and cross-border identification

An important point regarding shareholders' identification revolves around the different legal procedures for transmitting information up to the company. Every country has its own way of setting the environment for the flow of information, although it is possible to group them according to the model applied: some countries rely on a centralised model (with CSDs as intermediaries in the middle, as Italy does), on a decentralised one (where issuers forward their requests at every level of the intermediation chain, like in Germany or in the UK) or on an automatic structure (as France does with the BRN)[39].

In Germany, investors owning registered shares must have their names added to the company's register of members, in order to be considered as shareholders and having the right to express their votes at general meetings[40]. The legislation requires that custodians of the investors' securities have an obligation to send relevant information of their clients to the companies, so that the issuers may regularly update the register[41]. Nevertheless, investors must additionally send an autonomous request where they specify their willingness to be added to the register[42].
The practise may be burdensome for some investors. Therefore, custodians often enter their names in the register as nominees, having the right to vote on behalf of investors upon authorisation.[43]

Transfer of information is done in an electronic fashion in France. The BRNs (*Bordereau de Référence Nominative*) are electronic messages generated by the French settlement system and sent to national CSDs, so that these institutions can forward the information to the issuers of securities. The messages contain information regarding the custodians' clients, including the investors' names that will be inserted in the members' register, recognizing them as shareholders and entitling them to vote[44].

As for Italy, shareholders do not need to have their names inserted into the register, in order for them to cast votes at meetings: investors are required to ask to their custodians a confirmation of entitlement as of the meeting's record date[45]. The request is then sent up along the financial chain of intermediation until it reaches the CSDs participants, which are the only bodies that can emit confirmations of entitlement having legal value[46]. This system heavily relies on a timely delivery of information, and it can become quite burdensome for the final investors[47].

[39] Matteo Gargantini, *Barriers to shareholder identification and entitlement*, in *Enforcing Shareholders' duties*, 6-7 (2019)
[40] Aktiengesetz par. 67 (2)
[41] *Id.*, par. 67 (4)
[42] Matteo Gargantini, *Barriers to shareholder identification and entitlement*, in *Enforcing Shareholders' duties*, 6-7 (2019)
[43] Aktiengesetz par. 135 (6)
[44] Matteo Gargantini, *Barriers to shareholder identification and entitlement*, in *Enforcing Shareholders' duties*, 6-7 (2019)
[45] IT Legislative Decree 58/1998 art. 83-quinquies (3)
[46] Matteo Gargantini, *Barriers to shareholder identification and entitlement*, in *Enforcing Shareholders' duties*, 6-7 (2019)
[47] *Id.*, 10-11

To conclude the comparison, the UK is considered as an indirect-ownership system, meaning that securities' custodians can have proprietary interests[48]. This leads to the separation between investors' equitable ownership and custodians' legal ownership, where the former is entitled to receive the economic benefits stemming from the securities, while the latter is considered the agent formally entitled to exercise legal rights. In the UK, only the agents reported in the register are considered to be members[49]: these often coincide with the intermediaries belonging to the CREST system[50]. The investors interested in the company's matters should expressly instruct the custodians inserted in the register, in order to be allowed to vote or participate in meetings as proxy holders[51].

All of the above-mentioned models present additional limitations when they take into account investors being located outside the relevant country. Such restraints may not seem noticeable at first glance, but they need to be solved in creative ways by investors who want to buy equity securities in the global capital markets, and who desire to exercise the related voice rights.

Foreign investors are not checked on a regular basis by the German identification systems, so that their custodians often act as their nominees when it comes to casting votes in company's meetings. Additionally, investors may encounter non-familiar technicalities as for participating to meetings, including the necessity of sending both a notice of participation, and a request issued by the custodian to have the shareholders' names inserted in the company's register. On the positive side, depositary banks may send such information directly to the securities' issuers without the need of forwarding it through the chain of intermediaries[52].

Speaking of France, the use of BRNs is rooted in the national clearing and settlement system, so that foreign custodians are under no obligation of issuing these messages to the French CSDs. As a remedy, foreign investors rely on nominee accounts that allow them to indirectly express their voting directions[53]. On another side, the Italian centralised model may prove to be too cumbersome for foreign investors to obtain certificates of entitlement on time, with the consequence of them being excluded from attending meetings and voting[54].

The UK system may be even more problematic for investors retaining ownership from abroad, due to the division of equitable and legal ownership. Investors should instruct their custodians on how to vote; nonetheless they might be not knowledgeable about the identity of the custodians at the beginning of the

[48] Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276, 283 (2018)
[49] UK Companies Act 2006, sec. 112 (2)
[50] Antonio Capizzi, *Catene di Intermediazione Transfrontaliere nella Gestione Accentrata di Strumenti Finanziari e Legittimazione all'Esercizio dei Diritti Sociali: quale Ruolo per la Tecnologia DLT/Blockchain?*, Orizzonti del Diritto Commerciale (2018), pp. 10-11
[51] Matteo Gargantini, *Barriers to shareholder identification and entitlement*, in *Enforcing Shareholders' duties*, 10-11 (2019)
[52] *Id.*, 6-7
[53] Code de commerce L 228-1 (7)
[54] Matteo Gargantini, *Barriers to shareholder identification and entitlement*, in *Enforcing Shareholders' duties*, 8 (2019)

intermediation chain. As a consequence, instructions may require to be delivered through the whole chain, and related delays could lead to an exclusion from casting votes[55].

Harmonising the various clearance and settlement systems may reduce some of the disincentives for investors in buying foreign securities. First of all, this would reduce the amount of time spent by investors in understanding the laws regulating different markets, and lower the fees charged by intermediaries for dealing with other legal systems. Secondly, it would reduce the disparity in information and resources between domestic and foreign investors, with the result of making foreign markets more attractive.
The EU has already made some steps in this direction. The Directive 2007/36/EC introduced some harmonisation rules on the voting process and exercising shareholders' rights in EU listed companies[56]. Ten years later, the Directive 2017/828/EU amended the former one in a way that encourages long-term shareholder engagement: it strengthened harmonisation on shareholder identification's processes, and it established obligations that should reduce agency problems in the intermediation chain[57].

Summing up, shareholder entitlement is necessary for efficient corporate governance, and it requires knowledge of the shareholders' identity. Some problems that impede or make identification a difficult process are based on lack of transparency, long chains of financial intermediaries, and disharmonised cross-border legal procedures. The next chapter of this research will deal with the concept of DLTs (Distributed Ledger Technologies) and how their applications could propose solutions to the above-mentioned problems.

[55] *Id.*, 9
[56] Directive 2007/36/EC
[57] Directive 2017/828/EU

CHAPTER II

DEFINING DISTRIBUTED LEDGER TECHNOLOGIES AND THEIR APPLICATIONS

2.1 Definition and characteristics of the DLTs

Most of the everyday and commercial transactions rely on the concept of trust between parties. When buyer and seller settle an agreement, there is always a certain percentage of risk that the former will not pay for the goods and services he receives. This problem led to the conceptualization of the idea about a credit risk, which is based on the reputation of the parties and it should serve as a proxy to assess the probability a party will not satisfy its obligations. Financial intermediaries such as credit rating agencies and commercial banks use their expertise to compute credit risks for transactions with companies and individual agents. However, the procedures required are costly, leading to an overall increase in transaction costs (either an increase in lending interest rates or in operational fees) and a decrease in efficiency[58].

If there would be no information asymmetry, then the system itself would be more efficient, and transactions would become both faster and cheaper. Economic agents have personal incentives not to disclose all the information they possess, and financial intermediaries own proprietary registers with restricted access. The solution seems to theoretically be a bridge linking the multiple parties, where reliable information of every agent could flow smoothly to every party requesting it.

A solution that may rely on the current technological progress: Distributed Ledger Technologies, which allow the users to store and retrieve information in a shared database. As of the financial systems, DLTs can be used to archive information related either to transactions, accounts or users, that may be employed to settle operations without the need of an intermediary for certifying the reliability of such information[59].

This is the reason for many economic agents considering the DLTs as cheaper alternatives to central validation systems, and as potential tools for maintaining their reciprocal records up-to-date[60].

There exists no single model of DLT: its technical specification and design allows users to perform different tasks, which may lead to different preferences depending on the underlying economic environment. In particular, three reference points are used in classifying the type of DLT: access to the ledger (restricted or

[58] Frederic S. Mishkin & Stanley G. Eakins, *Financial Markets and Institutions* 130-133 (9th ed. 2018)
[59] Andrea Pinna & Wiebe Ruttenberg, Distributed Ledger Technologies in Securities Post-Trading, 172 European Central Bank Occasional Paper Series 7 (2016)
[60] *Id.*

unrestricted participation); process of validation by the users (allocation of voting power); structure of the shared database (unspent transactions output or consensus ledgers)[61].

When it comes to the users that should access the ledger (also referred to as the "nodes" of the network), the designer of a DLT will face the choice of creating either a restricted or an unrestricted register. In the former case, only the agents which have been authorised by the body controlling it, will have the ability of requesting or updating the data available in the ledger. The behaviour of participants is also recorded in the protocol and observable by all the agents who have access to the register. A consensus protocol does not seem to be necessary, since any unauthorised change in the database may be punished as a breach of contractual obligations, by retrieving the user's known identity. Nonetheless, consensus could still be important as a way of improving security of the database, against system malfunctioning or malevolent attacks. This structure could fit the needs of many financial intermediaries, which need to keep quickly track of any change in the registers of collaborating partners, without having the information disclosed to the public[62].

On the other hand, in the latter structure no authority can restrict any access to the ledger, whose data can be modified by any participating agent. This feature explains why choice of the right validation method becomes fundamental for assuring data reliability. The behaviour of participants is also exposed to everyone having access to the register, although their identities often remain anonymous, leading to the impossibility of applying fines to the wrongdoers. A well-chosen consensus protocol is required for giving users the right incentives in keeping an agreed-upon behaviour, often through use of mathematical properties and computational power. This overall structure can be preferred in cases where anonymity or broad diffusion of data are needed[63].

Validation of transactions implies identifying which users are allowed to apply changes in the register, and identifying whether those changes are correct or wrongful. This notion is strictly linked to the concept of consensus protocol, which determines how specific transactions can be validated by participants. The originator of a transaction must provide data for three aspects: the latest version of the distributed ledger; the number of assets being moved; and the parties involved. Validators check that the assets being moved are effectively available at the origination of the transactions, and that those assets are only sent to the receiving party (to avoid the risk of double-spending).

In restricted ledgers, validation rights can be assigned on a "one-head one-vote" basis, because it is nearly impossible to create a large number of network addresses to increase voting power without any authorisation (this malevolent exploit is also referred to as "Sybil attack")[64].

[61] *Id., 10*
[62] *Id., 11-12*
[63] *Id.*
[64] *Id.,* 13

The same is not true for unrestricted databases, which need to rely upon consensus protocols deterring the incentives for illicit transactions[65]. However, in order to understand the way such protocols work, it is first needed to introduce how a DLT updates data in the register. The Blockchain is a widespread example of DLTs, and it provides a starting point for understanding validation of transactions.

2.2 Blockchain fundamentals

The Blockchain is a particular type of unrestricted DLT which was originally introduced as the backbone for the Bitcoin, a cryptocurrency whose development began in 2009 and whose commercial value peaked in 2017[66]. Nevertheless, this technology can be employed for many different applications, from virtual currencies to shared databases[67].

It was first applied for completing transactions with a cryptocurrency, so description of the process will employ terminology and concepts familiar to economic markets. Nevertheless, applications of the Blockchain can be used to transfer different kinds of data, including virtual currencies, claims on real assets, and generic data.

As for its basic functioning, it can be thought of as a chain of digital signatures. Each user on the network is identified by a unique address, and he owns both a private and a public key. When initiating a transaction, the buyer side sends a message to the Blockchain networks asking to start a transfer of assets to the seller[68]. This is done by signing a hash (portion of blocks of the whole chain) with both the public key of the payee and the private key of the payor[69].

Checking the keys allows the network to verify the buyer has the funds asked to be transferred, and that he is entitled to move such funds[70]. This validation process is required to avoid the risk of the payee to be double-spending the same amount of funds, by applying a timestamp determining the uniqueness of the transaction. In a restricted network, a central authority can perform the process of verification; however, in an unrestricted ledger, the participants must agree on a common consensus protocol to determine whether the transaction can be validated or not[71].

Two consensus protocols have been studied and applied up to date: the most widespread one is defined as "Proof-of-Work" (POW), while the most recent one is called "Proof-of-Stake" (POS). The former involves exploiting computational power to mine a new hash from the historical record of

[65] *Id.*
[66] https://coinmarketcap.com/currencies/bitcoin/
[67] Vitalik Buterin, *A Next-Generation Smart Contract and Decentralized Application Platform* (2013), *available at* https://ethereum.org/whitepaper/
[68] Alex Tapscott et al., Financial Services Revolution, 266-268 (2019)
[69] Satoshi Nakamoto, *Bitcoin: a Peer-to-Peer Electronic Cash System*, 2 (2008), available at https://bitcoin.org/bitcoin.pdf
[70] Alex Tapscott et al., Financial Services Revolution, 266-268 (2019)
[71] Satoshi Nakamoto, *Bitcoin: a Peer-to-Peer Electronic Cash System*, 2-3 (2008), available at https://bitcoin.org/bitcoin.pdf

transactions, whose string of code must begin with a certain number of zero bits. This can be seen as solving complex mathematical problems, which exponentially increase in difficulty as the length of the Blockchain itself increases[72]. POW can solve the problem of assigning validation rights in unrestricted ledgers: instead of expressing votes on a "one-head-one-vote" basis, votes can be assigned on a "one-CPU-one-vote" model[73]. All the nodes constituting the users who wish for only honest transactions to be executed will grant all their computational power toward the same end, while malevolent users will be required to invest in computational resources which should overcome every other nodes' power[74]. Since the complexity in mining hashes increases as new transactions are validated, it soon becomes difficult to attack the security of the network.

On the reverse, in a POS system there is no necessity to apply computational power: new hashes are forged by validators, which are chosen by algorithms that give preference to the nodes which have the highest stakes in the virtual currency or token available in the network[75]. This implies malevolent nodes will have to economically invest in the network's accepted currency, in order to have their transactions validated. Such a condition should be sufficient to deter attacks to the network; nonetheless, some algorithms may provide for loss of the invested stakes in case the transaction is found to be fraudulent[76].

Once the transaction has been validated by the nodes, it is bundled into a block and added to the chain of previous transactions based on the Blockchain protocol. Implementing the block automatically settles the transaction and transfers the funds from the buyer to the seller side[77].

In a POW system, the nodes which validated the transaction are compensated with a certain percentage of virtual currency or tokens, plus a transaction fee. On the other hand, validators in a POS model only receive a validation fee, since no computational power has been dedicated[78].

One last feature that needs to be mentioned about the Blockchain, is its possibility of developing self-executing applications that run on the network ledgers. These programs are called smart contracts, and they have the potential of automatizing many processes that otherwise should be done manually by agents. Speaking of financial implications, smart contracts could access specific accounts and transfer assets as soon as certain conditions are met[79].

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[72] *Id.*

[73] although it should be more correct to say "one-ID address-one vote"

[74] Satoshi Nakamoto, *Bitcoin: a Peer-to-Peer Electronic Cash System*, 2-3 (2008), available at https://bitcoin.org/bitcoin.pdf

[75] ProofofStake.com, *"Proof-of-Stake" in Blockchain Technology*, *available at* https://proofofstake.com/

[76] Ameer Rosic, *What is Ethereum Casper Protocol? A Crash Course*, *available at* https://blockgeeks.com/guides/ethereum-casper/

[77] Alex Tapscott et al., Financial Services Revolution, 266-268 (2019)

[78] Ameer Rosic, *Proof of Work vs Proof of Stake: Basic Mining Guide*, *available at* https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/

[79] Andrea Pinna & Wiebe Ruttenberg, *Distributed Ledger Technologies in Securities Post-Trading*, 172 European Central Bank Occasional Paper Series 9 (2016)

This concludes a brief summary on how the DLTs, and the Blockchain in particular, work. Additional details go beyond the scope of this research, and notes are provided for the readers who wish to deepen their knowledge about the topic. It may be questioned why information about the Blockchain has been provided, since most of the needs of the financial services could be served primarily by restricted DLTs. The reason is, not only the Blockchain is a good example of how exchange of data and information might be registered in a decentralized ledger, but it also provides some example of consensus protocols that may be employed to strengthen the register's resilience to external or malevolent attacks.
The next question that need to be answered is how DLTs may be employed in the clearing and settlement services, in a way that makes shareholders' identification easier.

2.3 Applying DLTs to the post-trading landscape

In securities trading, post-trading processes are carried out by the multiplicity of financial agents composing a long intermediation chain, which is one of the limits to faster shareholder identification and entitlement. Due to legislative divergence and lack of transparency being consequences of the complex financial structure, I will start analysing how DLTs could theoretically be implemented in the post-trading services market in order to achieve simplification.

One of the DLT models that have been proposed, was defined as Utopia by its creators[80]. In this basic structure, companies issue their securities on a decentralised asset ledger, which is accessed by market participants through trading venues. A parallel cash ledger is established and linked to the asset's register, allowing for recording of payments in the system. CSDs act as custodians, oversighting securities' issuance, supervising the evolution of the ledger protocol, and managing the virtual currency to be used on the infrastructure. Buyer and seller for a specific security are still matched through intermediaries such as brokers; then the transaction is signed with both the private key of the payor and the public key of the payee, before being proposed to the network. If the nodes validate it, a new block constituting the transaction is added to the ledger; then the security is exchanged between the accounts and the payment is settled[81].

The above-mentioned model does not disrupt the current financial landscape, except for reliance on two shared registers rather than multiple private ledgers. Settlement and clearing should be expected to become faster, and transmission of investors' information would get quicker as well. Nonetheless, companies would still need to rely upon CSDs to get in contact with sub-custodians, which keep information regarding the

[80] Euroclear & Oliver Wyman, *Blockchain in the Capital Markets – The Prize and the Journey*, 9 (2016) *available at* https://www.euroclear.com/dam/Brochures/BlockchainInCapitalMarkets-ThePrizeAndTheJourney.pdf
[81] Euroclear & Slaughter and May, *Blockchain settlement: Regulation, Innovation and Application*, 8-10 (2016), *available at* https://www.euroclear.com/dam/PDFs/Blockchain/MA3880%20Blockchain%20S&M%209NOV2016.pdf

owners of the keys recorded in the asset ledger[82]. In addition, it is not clear how investors should instruct their securities' custodians to share information towards the companies.
Summing up, I can expect management and operational costs to be lower, since update of the registers is simultaneous and less human resources would be required. Nonetheless, it leaves too many questions open as for details about its application.

The European Fintech-Task Force (Fintech-TF) proposed an alternative infrastructure based on synchronised bilateral ledgers, where two counterparties update their own registers with information relative to their bilateral activities. This operation is repeated for every financial agent in the intermediation chain, in a fashion similar to the one currently implemented in global securities markets[83]. However, all these ledgers would belong to the same network, so that changes in the securities accounts might be registered simultaneously through the deployment of smart contracts, either in a top-down or in a bottom-up approach.
In the former case, the intermediary at the top-tier level would start the process of updating the registers, so that every agent in the chain will record the request for an update. When the last intermediaries (for the buying and selling side) sign with their keys their confirmation of exchanging of assets, the transaction is then validated and updated in the whole network.
In the latter case, it is the financial bodies last in the chain which start the request for validation, and the agent at the beginning of the intermediation chain to confirm that the transaction has been completed[84].

The infrastructure just discussed above does not look much similar to the widespread concept of DLT emphasised above: all the nodes do not participate to the same ledger, but rather to the same network. This implies that every market participant should abide to the same rules and protocols for managing and exchanging information, without the risk of entering erroneous data or accessing restricted information. The last model is based on a restricted DLT which grants both correctness and immutability of data, thanks to the shared validation process encrypted in the network. Furthermore, confidentiality is also confirmed, due to information being exchanged bilaterally[85].
Payments would likely be settled in tokens as a digital claim on a certain amount of fiat currency, although it is not excluded more than one real-world currency may be implemented. Tokens would also be used as claims on a specific type and amount of securities, carrying with them all the rights and responsibilities linked to the underlying assets[86].

[82] Euroclear & Oliver Wyman, *Blockchain in the Capital Markets – The Prize and the Journey*, 10-13 (2016) *available at* https://www.euroclear.com/dam/Brochures/BlockchainInCapitalMarkets-ThePrizeAndTheJourney.pdf
[83] Advisory Group on Market Infrastructures for Securities and Collateral, *Potential Use Cases for Innovative Technologies in Securities Post-Trading*, European Central Bank Publications 24 (January 2019)
[84] *Id.*, 27-28
[85] *Id.*, 25
[86] *Id.*, 29

Two methods have been specified for retrieving and transmitting information related to holders of equity securities: a pull and a push approach.

The first involves the securities' issuers to request information at every level of the custody chain, as it already happens in traditional post-trading services[87].

On the reverse, the second approach would require the above-mentioned tokens being distributed to the custodians of shareholders' securities. They could use such tokens as a proof that their clients are owners of the issuer's securities, so that shareholders may be added to the company's register of members[88]. However, while the pull approach implies retrieval of investors' information on a request basis by companies, the push scheme continuous update of the bilateral ledgers[89], leading to the risk of significantly increase operation costs.

Another DLT protocol based on a proprietary Blockchain is Corda, and it is being developed with the aim of applying it to global financial markets[90]. Differently from the previous two infrastructures, it implies the deployment of a single global decentralized ledger with no restrictions to entry. The model is based on the use of "state objects", which might be defined as digital documents containing all pertinent information regarding an agreement between two parties (identities of the parties, nature of the exchanged assets, amount, involved currency, etc.)[91]. Information about users and data is held secure through the use of cryptography. Any two parties can privately start a transaction, which will consume state objects to be initiated; after such transaction is confirmed, a new state object will be produced corresponding to an update in the ledger[92]. All processes and updates in the global register are carried out through legally enforceable smart contracts, leading to faster execution and lower risk of operative errors[93].

Nevertheless, the validation process has a key feature that suits it for regulatory compliance: consensus by the register requires assessing both validity and uniqueness of the transaction. The former element may be determined by the parties involved, through execution of the underlying code and checking for the use of the right signatures. However, uniqueness can be assessed only by a predetermined independent observer (such as a regulator), who controls that the input states are consumed only by that single transaction (in order to prevent both double-spending and fraud)[94].

Most importantly about the Corda protocol, only specific nodes are granted the privileges to read certain portions of state objects. This implies that many participants will not be allowed to access private transactions between two parties, while higher-tier nodes such as observers will be able to watch over

[87] *Id.*, 30
[88] *Id.*
[89] *Id.*, 31
[90] Richard G. Brown et al., *Corda: An Introduction* (2016), *available at* https://docs.corda.net/en/pdf/corda-introductory-whitepaper.pdf
[91] *Id.*, 8
[92] *Id.*, 9
[93] *Id.*, 7
[94] *Id.*, 9-10

specific details of a transaction[95]. As a consequence, confidentiality is a main feature of the infrastructure, while transparency is also safeguarded through a hierarchy of privileges.
I assume that transmission of shareholders' information might become easier as a process, by granting companies the rights to access those portions of agreements that contain their securities as exchanged assets. On the other hand, it is still not clear how these privileges should be granted nor which authority should be entitled to do so, since Corda is based on a public ledger with no central authority.

So far I have performed this brief analysis regarding theoretical and practical applications of DLTs in the securities markets, by comparing three different infrastructures that could be thought of as the default models for further studies. The first is based on a global asset ledger monitored by CSDs, and accessible by financial agents through trading venues on behalf of their clients. The second model substitutes current private registers with synchronise bilateral ledgers operated through smart contracts, while keeping stable the functions of the agents in the intermediation chain. The last infrastructure relies upon a global unrestricted ledger where only the necessary information is reported to the nodes, but it still lacks criteria for determining which participant is allowed to read certain information. All the above models present their own way of favouring transmission of information and shareholders' identification. Nonetheless, such models have also their own strengths and challenges that indirectly affect collection of equity investors' information.

2.4 Advantages and disadvantages of applying DLTs

Implementation of DLTs in settlement and clearing services may bring certain advantages to the system as a whole.

First of all, enhanced transparency. Every node in a global unrestricted ledger may be advised of any transaction completed by a specific participant, at least when there are no hierarchical privileges involved. This would lead to a greater transparency in equity ownership, with a consequent simplification for companies in updating their members' register.
None of the previous DLT models was based on such infrastructure. However, companies can exploit increased transparency as a passive defence strategy against takeovers, by constantly monitoring changes in the percentage of acquired shares that may lead to hostile positions[96].
If enough securities' issuers come to believe this could be a good reason or favouring an open and unrestricted ledger, then new models may be based on this characteristic.

[95] *Id.*
[96] David Yermack, *Corporate Governance and Blockchains*, (2017) Review of Finance 7, 17-18

Another potential impact of DLTs on the financial markets might involve increased disintermediation in the custody chain. Only in the third model analysed above, participants of a network would engage in transactions without the need for an intermediary. Such an opportunity would reduce many operative costs that are currently reflected in commissions and higher bid-ask spreads[97]. Most importantly for the purpose of this research, investors would not need to send requests for certificates of entitlement through the whole intermediation chain anymore, reducing the time involved[98] and lowering the risk of not being able to attend meetings due to delays.

Gathering investors' information would seem to be an easier process under the application of shared registers rather than the current financial structure. Nevertheless, a protocol like the Blockchain may be employed in order to make voting more accessible to shareholders.
Suppose a company would utilise restricted DLT model where only its members may participate. Each eligible shareholder would get voting tokens in their accounts, in proportion to the percentage of equity being owned. These tokens would then be sent toward a central address, that would record the voting preferences[99]. In contrast to modern voting systems which heavily rely on proxies, automatized systems based on the Blockchain would prevent the insurgence of problems, such as inexact voters list and errors in vote tabulation. Simpler voting systems may lead to greater shareholders' activism, with increased efforts by the companies in assessing information about their members[100].

Lastly, an important consequence of applying DLTs in securities markets revolves around faster supervision processes. Due to having every transaction recorded in ledgers, exerting supervision on the transactions taking place would be a quicker and easier process[101], and I can assume much of the disclosure requirements would become embedded in the digital protocol. This could also lead to shorter procedures for shareholders who wish to obtain a certificate of entitlement.

At the other hand of the spectrum, DLTs carry many challenges with them. To start with, it must be noted that decentralised ledgers are more or less incompatible with the current post-trading landscape. This would imply that applying DLTs on a limited scale might take years, if not decades as long as drastic implementations are concerned[102].
Other limitations to fast applicability involve choice of the virtual currency to be operated on the network:

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[97] *Id.*, 19
[98] European Securities and Markets Authority, *The Distributed Ledger Technology Applied to Securities Markets*, 773 Discussion Paper, 10 (2016)
[99] David Yermack, *Corporate Governance and Blockchains*, (2017) Review of Finance 7, 23
[100] *Id.*
[101] [101] European Securities and Markets Authority, *The Distributed Ledger Technology Applied to Securities Markets*, 773 Discussion Paper, 11 (2016)
[102] European Central Securities Depositories Association, *Distributed Ledger Technology Applied to Securities Markets, 4* (2016), *available at* https://ecsda.eu/wp-content/uploads/2016_09_02_ECSDA_DLT.pdf

unless tokens representing fiat currencies are chosen, then completely digital tokens or currencies will be needed to settle transactions[103].

Furthermore, securities markets are likely to adopt shared ledgers which are restricted, in order to limit unauthorised access and malevolent attacks. Nonetheless, limits to access the registers require choosing the criteria that will be applied for selection of the participants. The risk is having ledgers become too restrictive when it comes to access of investors and companies to the networks[104]. Stringent allocation of powers may also imply that access to a specific type of information could be restricted, as it already happens with the Corda protocol. Although distributed ledgers allow simultaneous updates of data in multiple registers, when it comes to the securities markets certain information should be protected by anonymity and privacy[105].

[103] *Id.*, 14
[104] *Id.*, 15
[105] *Id.*, 16

CONCLUSION

The financial system is a complex environment, where aligning the incentives of its participant may often turn out being impractical. The need for intermediation has led to increasing complexity in identifying companies' shareholders, with procedures having the ultimate effect of reducing shareholders' activism.

The concept of shareholders' identification and entitlement was introduced at the beginning of this research. Investors need to have their information transmitted along multiple layers of a long intermediation chain. The procedure can be burdensome, especially when it involves cross-border securities trading, due to legislative divergence. Information delivery can become troublesome on a national level too, in case the presence of too many intermediaries would lead to delays.

Three problems in particular had been identified: excessive intermediation; lack of transparency; and different legislative procedures. At the core of this research, the concept of DLTs was explained, depicting different models that could be implemented to the current securities markets. Although this technology could potentially revolutionise the post-trading landscape, it has been applied only in a modest way as of the financial system.

Each DLT model has its own way of mutating the transfer of shareholders' information, from the end investor to the initial securities' issuer. The Utopia model relies on fast deployment of information on the ledger. Synchronised bilateral ledgers base shareholders' identification on the use of automatic smart contracts. Finally, Corda has the possibility of allowing only the interested companies in seeing nearly real-time data regarding their shareholders.

In case DLTs would be introduced to securities markets, it is likely that current problems for shareholders' entitlement regarding difference in legal procedures would cease to exist. After all, transfer of information would become dependent on the specific model being employed.
Nevertheless, if new models were designed to satisfy *a priori* requirements set by national legislators, divergence in legislative procedures would become a problem intrinsic to the choice of a specific DLT model.

However, shared ledgers guarantee by default greater transparency than most of the currently available settlement and clearing services. On the other hand, transparency should be balanced off with privacy, so that it could be better if only certain participants in the register may have access to specific information.

It is likely that most of DLTs implementations would make transaction settlement almost automatic through the implementation of smart contracts. Faster retrieval of information would only be a benefit for most minority shareholders.
In addition, global shared ledgers may favour disintermediation, with a positive impact on the direct

interaction between companies and their shareholders, though a negative impact when it comes to the current players in the securities markets.

Nonetheless, the legal landscape should be subject to intrinsic changes for the DLTs to be applied in securities trading. Although different legal systems may agree on the way a Blockchain based model operates, there could still be different laws when it comes to recognizing the data imprinted in a distributed ledger.

Summing up, it seems that DLTs have potential use cases in the financial system, often leading to faster communications and information exchanges that would likely benefit most of the shareholders and the companies willing to keep their members' register up-to-date. However, there are many more players in financial markets, and the desirability of a specific model of shared ledger should take into account the net effects on these other categories of economic agents.

Further researches would be required, in order to understand whether it is possible to build infrastructures that would be more suited for the needs of the financial system as a whole, and if it is possible to gather quantitative data on the effects stemming from the implementation of DLTs.

BIBLIOGRAPHY

- Paul L. Davies & Sarah Worthington, *Gower's Principles of Modern Company Law* 12-17 (10th ed. 2016).
- Reinier Kraakman et al., *The Anatomy of Corporate Law* 5-15 (3rd ed. 2017).
- Zvi Bodie et al., *Investments* 68-75 (10th ed. 2013).
- Heiko Schmiedel et al., *Economies of Scale and Technological Development in Securities Depository and Settlement Systems*, 6 Journal of Banking and Finance 1783 (2006).
- Delphine Nougayrède, *Towards a Global Financial Register? The Case for End Investor Transparency in Central Securities Depositories*, 4 Journal of Financial Regulation 276 (2018).
- Regulation (EU) No 909/2014 art. 3 (2), 38.
- Peter Böckli et al., *Shareholder Engagement and Identification* (2015), *available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2568741*.
- UK Companies Act 2006 s. 793, 112 (2).
- Consob, *Disciplina delle Controparti Centrali, dei Depositari Centrali e dell'Attività di Gestione Accentrata* artt. 2, 41 (2018).
- Consob, *Testo Unico della Finanza* Art. 83-duodecies (2020).
- US Securities and Exchange Commission, *17 Code of Federal Regulations* § 240 14a.
- Matteo Gargantini, *Barriers to shareholder identification and entitlement*, in *Enforcing Shareholders' duties*, 4 (2019).
- Aktiengesetz par. 67 (2); 135 (6).
- IT Legislative Decree no. 58/1998, Art. 83-quinquies (3).
- Code de commerce L 228-1 (7).
- Antonio Capizzi, *Catene di Intermediazione Transfrontaliere nella Gestione Accentrata di Strumenti Finanziari e Legittimazione all'Esercizio dei Diritti Sociali: quale Ruolo per la Tecnologia DLT/Blockchain*, Orizzonti del Diritto Commerciale (2018)
- Satoshi Nakamoto, *Bitcoin: a Peer-to-Peer Electronic Cash System*, 2-8 (2008), *available at* https://bitcoin.org/bitcoin.pdf.
- Frederic S. Mishkin & Stanley G. Eakins, *Financial Markets and Institutions* 130-133 (9th ed. 2018).
- Andrea Pinna & Wiebe Ruttenberg, *Distributed Ledger Technologies in Securities Post-Trading*, 172 European Central Bank Occasional Paper Series (2016).
- CoinMarketCap, *Bitcoin Charts*, *available at* https://coinmarketcap.com/currencies/bitcoin/
- Alex Tapscott et al., *Financial Services Revolution*, 266-268 (2019).

- ProofofStake.com, *"Proof-of-Stake" in Blockchain Technology*, *available at* https://proofofstake.com/.
- Ameer Rosic, *What is Ethereum Casper Protocol? A Crash Course*, *available at* https://blockgeeks.com/guides/ethereum-casper/.
- Ameer Rosic, *Proof of Work vs Proof of Stake: Basic Mining Guide*, *available at* https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/.
- Euroclear & Slaughter and May, *Blockchain settlement: Regulation, Innovation and Application* (2016), *available at* https://www.euroclear.com/dam/PDFs/Blockchain/MA3880%20Blockchain%20S&M%209NOV2016.pdf.
- Advisory Group on Market Infrastructures for Securities and Collateral, *Potential Use Cases for Innovative Technologies in Securities Post-Trading*, European Central Bank Publications (January 2019).
- Euroclear & Oliver Wyman, *Blockchain in the Capital Markets – The Prize and the Journey* (2016) *available at* https://www.euroclear.com/dam/Brochures/BlockchainInCapitalMarkets-ThePrizeAndTheJourney.pdf.
- Richard G. Brown et al., *Corda: An Introduction* (2016), *available at* https://docs.corda.net/en/pdf/corda-introductory-whitepaper.pdf.
- European Securities and Markets Authority, *The Distributed Ledger Technology Applied to Securities Markets*, 773 Discussion Paper (2016).
- European Central Securities Depositories Association, *Distributed Ledger Technology Applied to Securities Markets* (2016), *available at* https://ecsda.eu/wp-content/uploads/2016_09_02_ECSDA_DLT.pdf.
- David Yermack, *Corporate Governance and Blockchains*, (2017) Review of Finance 7
- Cristoph Van der Elst & Anne Lafarre, *Blockchain and Smart Contracting for the Shareholder Community*, 412 ECGI Working Paper Series in Law (2018).