# INTRODUCING BLOCKCHAIN TO COMMERCIAL REAL ESTATE

Exploring the applicability of blockchain technology in lowering transaction costs of the commercial real estate due diligence process

Master thesis report

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CUSHMAN & WAKEFIELD

# INTRODUCING BLOCKCHAIN TO COMMERCIAL REAL ESTATE

EXPLORING THE APPLICABILITY OF BLOCKCHAIN TECHNOLOGY IN LOWERING TRANSACTION COSTS OF THE COMMERCIAL REAL ESTATE DUE DILIGENCE PROCESS

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Inspired by a friend of mine, I started reading about blockchain and cryptocurrencies in the summer of 2017. Although a new world opened for me and as I became more convinced of its potential, I did not expect to be writing my Master's thesis on the potential of blockchain in the commercial real estate sector one year later at Cushman & Wakefield. It has been a wild ride for me and I am convinced that the result of my graduation thesis would have never been the same without a number of exceptional people. Therefore, I would like to express my sincere gratitude towards those who have supported me during the last period of my time as a student.

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Enjoy reading,

Floor Seuren
*July 2018, Amsterdam*

# EXECUTIVE SUMMARY

In 2008, just after the global financial industry crashed, perhaps propitiously, a pseudonymous person under the alias Satoshi Nakamoto released blockchain as the technology underpinning Bitcoin, a peer-to-peer electronic cash system (Nakamoto, 2008). Launched into the limelight as the platform sustaining Bitcoin, blockchain is the little-understood yet much-discussed technology of the modern investment world (Palmer, 2017, pp. 14-15). Compared to a classic intermediary role, a unique feature of blockchain is that it maintains reliability in a decentralized, distributed management system without requiring a trusted third party, even with the presence of malicious actors in the network (Swan, 2015).

Based on a literature review on (combinations of) key terms '*blockchain', 'commercial real estate', 'due diligence',* and *'transaction costs'*, we established that the current body of academic knowledge lacks publications combining the concepts of blockchain and real estate. Despite this untapped combination, the commercial real estate (CRE) market could be subject to improvement in terms of transparency, efficiency, and automation (Dijkstra, 2017). The process of transacting CRE properties tends to be lengthy, cumbersome and entails relatively high transaction costs. Today, significant time is spent on due diligence (DD) activities in commercial real estate transactions, predominantly due to using physical documents for proof of identity and electronic documents that are hosted on disparate databases. This inefficient manual verification process causes an administrative burden accompanied with high transaction costs and is moreover prone to loss of information and errors. Additionally, the involvement of a vast amount of trusted third parties, such as bankers, notaries, and brokers, tends to elongate the due diligence process as well as to increase the transaction costs of a due diligence process (Deloitte, 2017, p. 9).

This thesis aims at assessing the applicability of blockchain-based applications in lowering the transaction costs within the DD process of CRE transactions by impacting the sources of those transaction costs. This objective is addressed by designing a *decision path* that assesses the applicability (and most suitable type) of a blockchain-based solution. It also provides insight into the expected impact on the eventual transaction costs. An explorative case study research approach as defined by Stake (1995) is used as a guideline to combine insights from both empirical and established academic literature in the design of the *decision path*. The objective of this study is achieved by answering the main research question, which is formulated as follows:

> "To what extent could a blockchain-based solution be applicable in a commercial real estate due diligence process and how could it impact the transaction costs?"

The research is executed in three steps, each of which is represented by a distinct sub research question answered in separate chapters. In short, these steps revolve around first determining the functioning and applicability of blockchain, then delineating the phases and allocation of transaction costs in a CRE DD process, and finally presenting a *decision path* that assesses the applicability (and most suitable type) of blockchain-based solution. This decision path is the main deliverable of this research and is used to answer the main research question.

First, based on a literature review and expert validation, we defined 5 core components of blockchain: 1) ledger, 2) P2P network, 3) cryptography, 4) consensus mechanism, and 5) validity rules. A blockchain is a distributed *ledger* that is updated synchronously among all participants of the network. This network requires no trusted third party to validate transactions, enabling participants to make direct, peer-to-peer transactions in a so-called *P2P network*. Transactions in this P2P network are validated according to the standards of a specific *consensus mechanism*, a means of achieving consensus as to the validity of a transaction. Consensus is reached if the transaction complies with a predetermined set of *validity rules*. To achieve consensus, participants must be able to trust each other, even if they are mutually unknown. Trust is therefore based on *cryptographic* proof rather than on relational agreements. Once consensus is reached about the validity of a transaction, a new block containing (among others) that transaction is added to the chain of blocks and cannot be altered or deleted anymore because of the applied cryptography.

We established that blockchain-based applications require certain case-specific contexts in order to be an adequate solution that outperforms conventional solutions. To determine whether (and in what form) blockchain is applicable, we designed a decision path (depicted in Figure 3 and delineated with a blue dotted line), inspired by a combination of the models of Meunier (2018) and Wüst and Gervais (2017). If all questions in this decision path can be answered positively, i.e. with 'yes' or 'true', a blockchain-based solution is likely to be suitable in that case.

Second, we concretized the findings with respect to the due diligence process that were outlined in the theoretical background during expert brainstorm sessions, literature study, and expert interviews with institutional investors. We defined the due diligence process as the period between signing the Letter of Intent (LOI) and signing the Sales- and Purchase Agreement (SPA), during which the potential purchaser is granted exclusivity. Seven separate phases of the entire DD process in CRE transactions are defined, including the preparatory as well as the concluding phases. These phases are: 1) sale preparation, 2) pre-DD (market analysis), 3) commercial negotiations + sign LOI, 4) data check, 5) red flag assessment, 6) SPA negotiations, and 7) signing SPA.

The DD process, together with all relevant ancillary actors, activities and transaction cost drivers, is captured in Figure 1. The figure contains five rows: the upper row indicates the general phases of the entire process and indicates where exactly the DD process takes place. The second row assigns the phases, which are depicted in the third row, to the transaction cost components according to the transaction cost theory. In addition to distinguishing the phases, the third row also lists the activities that are undertaken during each phase along with the result of that phase, i.e. the output of that phase. In the fourth row, the transaction cost drivers are indicated. These activities impact the eventual transaction costs. Lastly, the bottom row demonstrates by whom the transaction costs are incurred. The sum of these transaction costs is usually passed on to the purchaser and, as a rule of thumb, amounts to approximately 1% of the total transaction sum.

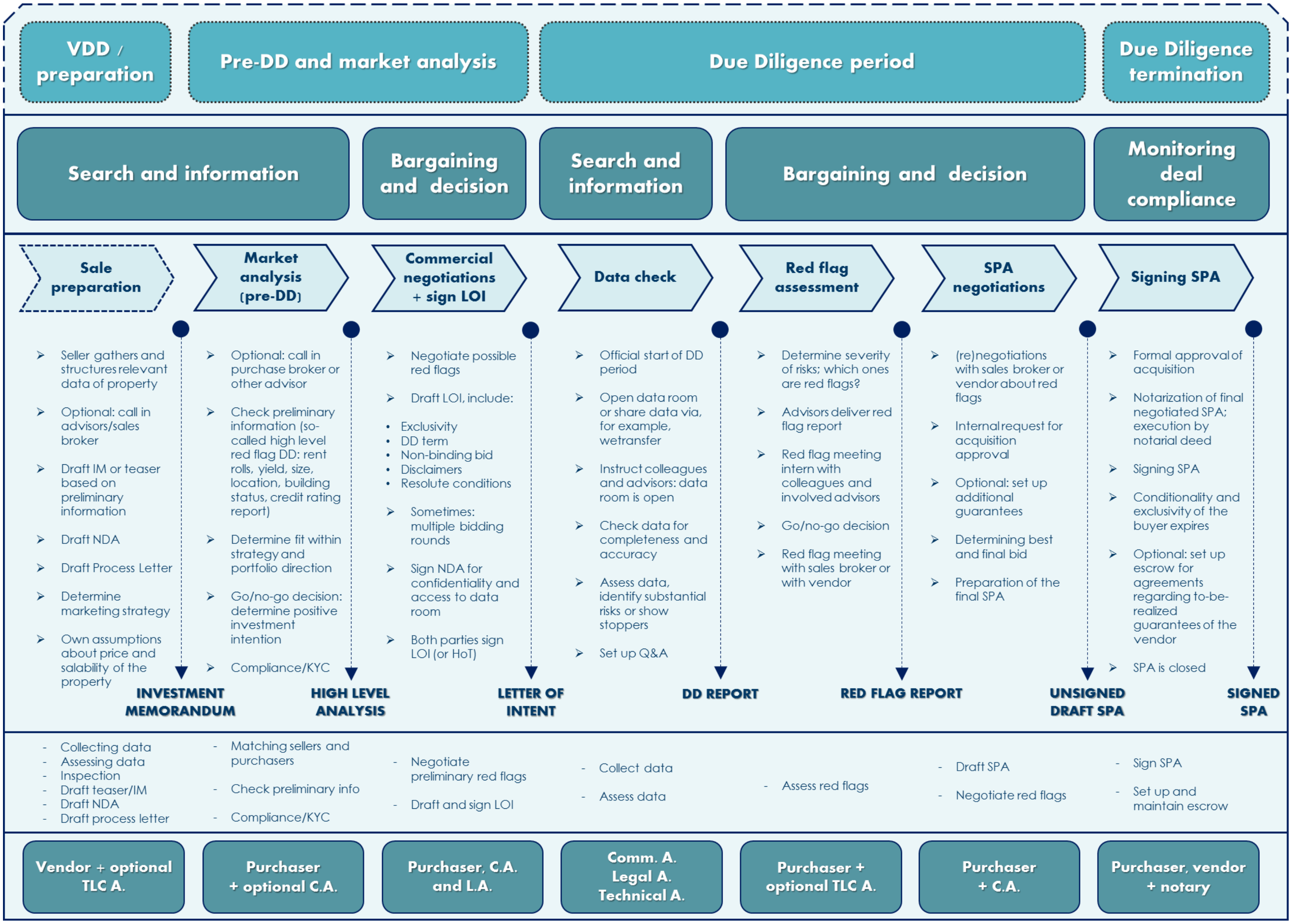


*Figure 1 | Phases and relevant aspects of the Commercial Real Estate Due Diligence process*

The complexity and size of the due diligence process in CRE transactions are directly linked to the characteristics of real estate, which fundamentally differ from the characteristics of shares and stocks. Contrary to shares, real estate assets are found to be heterogeneous and immobile, resulting in segmented and localized markets, in turn leading to price illiquidity and privately negotiated prices. Based on the transaction cost theory framework of Williamson (1979), supplemented with the dimensions of transaction costs as mentioned by Coase (1937), we showed that the characteristics of real estate impact the sources of transaction costs in such a way that the eventual transaction costs are relatively high in comparison to stock exchange markets, as depicted in Figure 2.

To gain insight into the actual sources of transaction costs for this case study, we defined three transaction cost categories to which the transaction costs within DD processes are attributable: sometimes the client lacks the required knowledge (*expertise* needed), sometimes the client is not authorized to do something (*authority/right* needed) and sometimes the client fails in what he tries to achieve (due to *technological inefficiencies*). The transaction cost drivers as defined in the DD process are set off against these categories. By doing so, we concluded that the majority of transaction cost drivers within the DD process are attributable to a lack of expert knowledge, in this case mostly *tacit* knowledge: non-transferable internal knowledge such as know-how, experience, skills, network, or intuition.

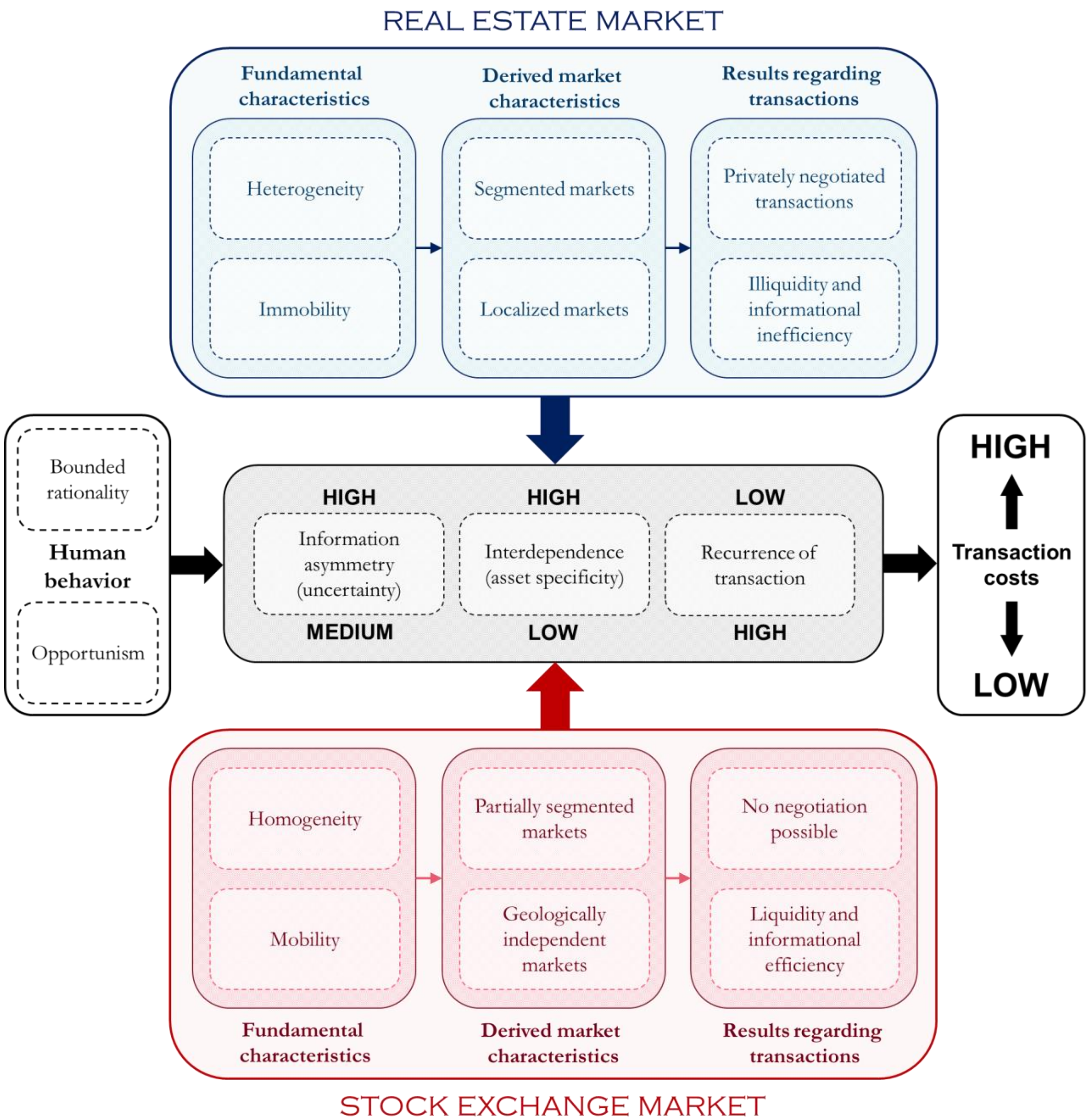


*Figure 2 | Real estate and shares characteristics and their respective impact on the sources of market frictions, resulting in transaction costs*

The third part of this thesis combines the results and insights from the first two steps, departing from the DD process as *currently* performed. We assessed the applicability of blockchain as a tamperproof database, where all relevant documents are up-to-date and available with one click, following the decision path as depicted in Figure 3. By doing so, we found that blockchain appears not to be the most suitable IT-solution to perform the role as described above. First, blockchain does not allow for modifications of data once entered (it at most allows for adding new blocks with updated information), while data modifications required for property-related databases. Second, blockchain adds value by creating trust in trustless environments with mutually unknown network participants, while interviews pointed out that there is in general no lack of trust between buyer and seller. The advantages blockchain has compared to conventional (distributed) databases do not hold for the current DD process and therefore a conventional database should suffice in at least expediting the process through more efficient way of storing, structuring and sharing relevant documents. Although blockchain is demonstrated to be unfit for improving the quality of data provision, applying expertise in information assessment, or providing a one-click fully up-to-date property-specific database containing all relevant documents, we found that a number of cost drivers are suitable for improvement (or automation) with the implementation of smart contracts, which are a smart LOI, smart SPA and smart escrow.

To effectively assess the impact of the identified smart contract applications on the eventual transaction costs of the DD process, the third part of this research resulted in an extended decision path (see Figure 3). The decision path comprises two components; a general component (delineated with a blue dotted line) and a case-specific component. The first component is general in the sense that this decision path can be followed for decision making processes entailing multiple actors and a type of database in order to determine whether blockchain is a suitable solution at all. If so, the decision path proceeds to a case-specific component that works towards a statement regarding the impact on transaction costs. This way, we showed that only a smart escrow has the potential to lower transaction costs of the current DD process, although the impact is seemingly insignificant.

In earlier work, Veuger (2018) and Dijkstra (2017) explored how blockchain could theoretically be applicable in the CRE management and transaction process as a whole, based on the proclaimed characteristics of blockchain technology (efficiency, transparency, reliability, automation). From a scientific perspective, this study has however contributed by presenting a novel decision path to determine the suitability of a blockchain-based application and its associated impact on transaction costs. Contrastingly, from a practical point of view, the conclusions drawn from this study may be surprising, unexpected or even disappointing, because currently, blockchain as a state-of-the-art technology seems to be too nascent (and unfit) to function as an efficacious solution to today's DD processes. However, the discussion of this thesis provides several thoughts that fall outside the scope of this research, and are approached from an entirely different perspective than this study's approach. Instead of focusing on the current DD process and investigating whether blockchain fits as a solution to this process in its current form (*brownfield thinking)*, another perspective is chosen in the discussion, where the property is the central element and where the DD process (based on a blockchain application) is designed given its current potential (*greenfield thinking)*. When looking at blockchain from this perspective, it seems that there still may be a bright and prosperous future ahead for blockchain in (commercial) real estate. Taking this into consideration, we suggest that especially the concepts of tokenization and digital building passports deserve further research.

**Keywords:** *Blockchain, Case Study, Commercial Real Estate, Due Diligence, Transaction Cost Economics*

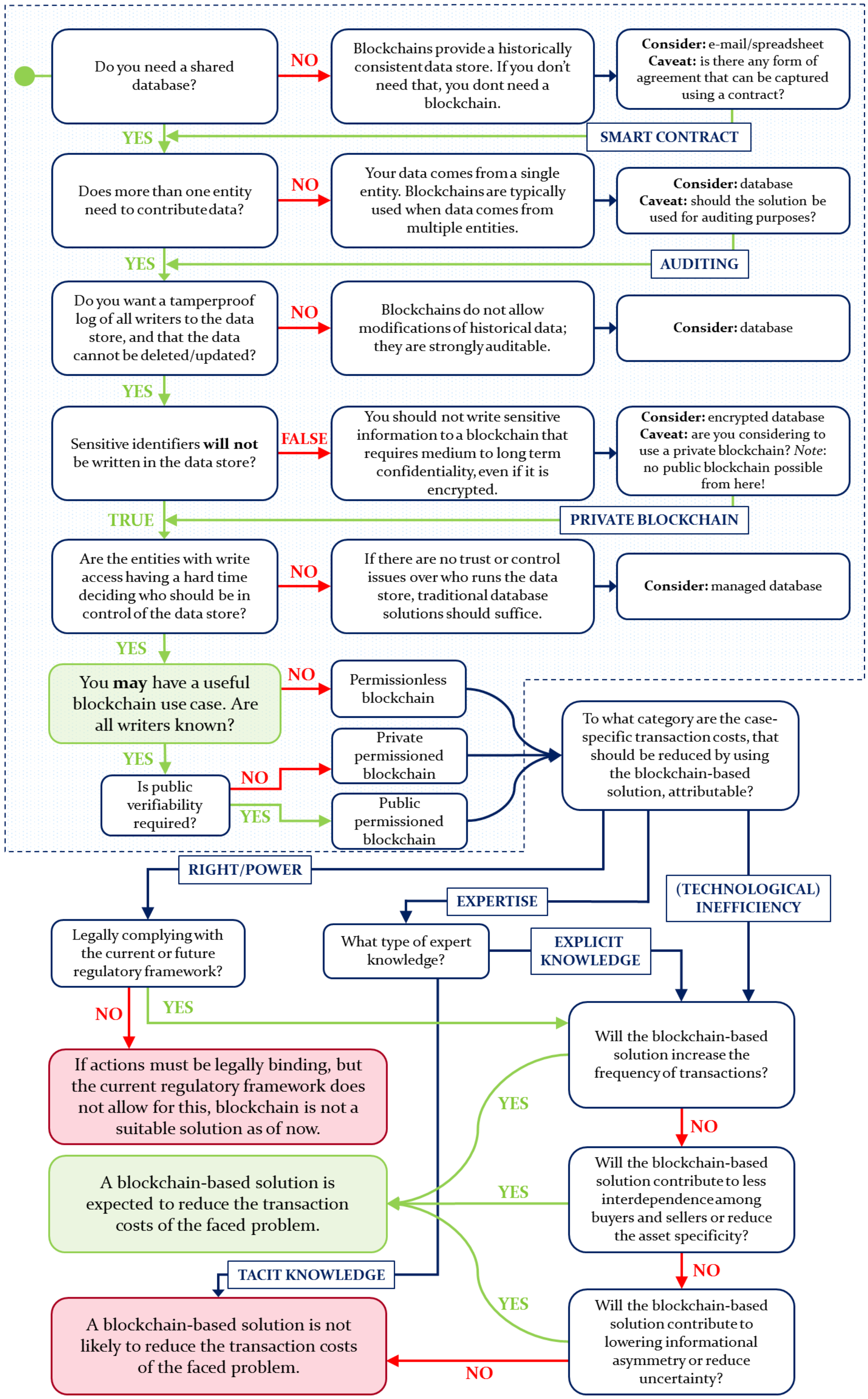


*Figure 3 | Final decision path to assess blockchain's applicability in lowering transaction costs*

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| | |
|---|---|
| CAPEX | Capital Expenditures |
| CoC | Chamber of Commerce |
| COSEM | Complex Systems Engineering and Management |
| CRE | Commercial Real Estate |
| CSR | Case Study Research |
| DD | Due Diligence |
| DLT | Decentralized Ledger Technology |
| EC | European Commission |
| ECB | European Central Bank |
| EPC | Energy Performance Certificate |
| EU | European Union |
| FTE | Fulltime-equivalent |
| GDPR | General Data Protection Regulation |
| GIGO | Garbage In, Garbage Out |
| GIY | Gross Initial Yield |
| HoT | Head of Terms |
| IC | Investment Committee |
| IM | Investment Memorandum |
| IS | Information System |
| KPI | Key Performance Indicator |
| KYC | Know Your Customer |
| LFA | Lettable Floor Area |
| LOI | Letter of Intent |
| NDA | Non-Disclosure Agreement |
| NIY | Net Initial Yield |
| P2P | Peer-to-Peer |
| PKI | Public Key Infrastructure |
| POA | Proof-of-Authority |
| POS | Proof-of-Stake |
| POW | Proof-of-Work |
| QE | Quantitative Easing |
| SHA-256 | Secure Hash Algorithm 256 |
| SPA | Sales and Purchase Agreement |
| TCE | Transaction Cost Economics |

# 1 INTRODUCTION

The first section of this chapter elucidates the starting point of this research and introduces the reader to the concept of blockchain the principal characteristics of real estate. Next, the current state of research is determined in section 1.2. Subsequently, section 1.3 revolves around defining the problem, which is done by defining the knowledge gaps and deriving the problem statement, research objective and main research question, respectively. Section 1.4 discusses the main deliverable of this research and section 1.5 finally provides the reader with a reading guide for the remainder of the report.

## 1.1 Background reading

### 1.1.1 The rapid rise of blockchain

Over the past five decades, the Internet has revolutionized the computer and communications technology like nothing before. The invention of the telegraph, telephone, radio and computer have set the stage for an unprecedented integration of capabilities. The advent of the Internet as a mechanism for information dissemination has been great for reducing the costs of searching, collaborating and exchanging information without regard for geographical location (Tapscott & Tapscott, 2016, p. 3; Rabah, 2017, p. 125).

Yet once again, it appears that we may be at the dawn of a new revolution. In 2008, just after the global financial industry crashed, perhaps propitiously, a pseudonymous person under the alias Satoshi Nakamoto released blockchain as the technology underpinning Bitcoin, a peer-to-peer electronic cash system (Nakamoto, 2008). Launched into the limelight as the platform sustaining Bitcoin, blockchain is the little-understood and much-discussed technology of the modern investment world (Palmer, 2017, pp. 14-15). It is often compared with the rise of the internet; just as the TCP/IP-based internet led to a revolution in the way businesses functioned, the blockchain technology seems to repeat this process all over again. Bitcoin is for the blockchain what e-mail was for the internet in 1992 (Rabah, 2017, p. 127). Where internet is used to transfer words and images, blockchain platforms can be used to transfer money and assets (Dijkstra, 2017, p. 20).

In essence, a blockchain is a type of shared database of which the contents are verified and agreed upon by a network of independent nodes. In order to add a new piece of data (such as the last transaction price of a property) to the blockchain, the independent verifiers must come to consensus as to its validity (Zheng et al., 2016; Carlozo, 2017). A distinctive characteristic of blockchain is that this peer-to-peer platform solves the so-called 'double spend'-problem, and by doing so allows for transactions without the need for intervention of a trusted third party, like a bank or a notary. Because each new set of transactions (called a *block*) is cryptographically linked to the previous block, it is extraordinarily difficult to change data in a blockchain as any such change would be directly detectable by the independent verifiers. With this in mind, data entered into the blockchain can be considered as immutable and therefore a blockchain serves as a fraud-resistant record of a proof of ownership (Fanning & Centers, 2016; Ngo, 2016).

Cryptocurrencies are the first instantiation of blockchain technology, which have attracted the attention of investors and economists (Böhme et al., 2015). At the time of writing, the valuation of the total cryptocurrency market amounts to more than $350 billion, of which approx. 42% is represented by Bitcoin (Coinmarketcap, 2018). Together with the blockchain technology, cryptocurrencies have notably entered the hype-cycle of media, business and government attention (Tapscott & Tapscott, 2016). In 95% of the cases when people talk about blockchain, they refer to cryptocurrencies like Bitcoin or Ethereum (Lifthrasir, 2016). However, while digital money (in the form of Bitcoins) was the application domain in which blockchain first emerged, the potential benefits of blockchain reach further than just financial markets – they extend into political, humanitarian, social, financial and scientific domains (Swan, 2015, p. viii). Based on blockchain technology, new business models have been unraveling in a widely-varying range of market segments over the past years, as can be seen in the typology depicted in Figure 4. One of these markets, depicted in the top left corner, is the real estate market, which is introduced in the next sub-section.

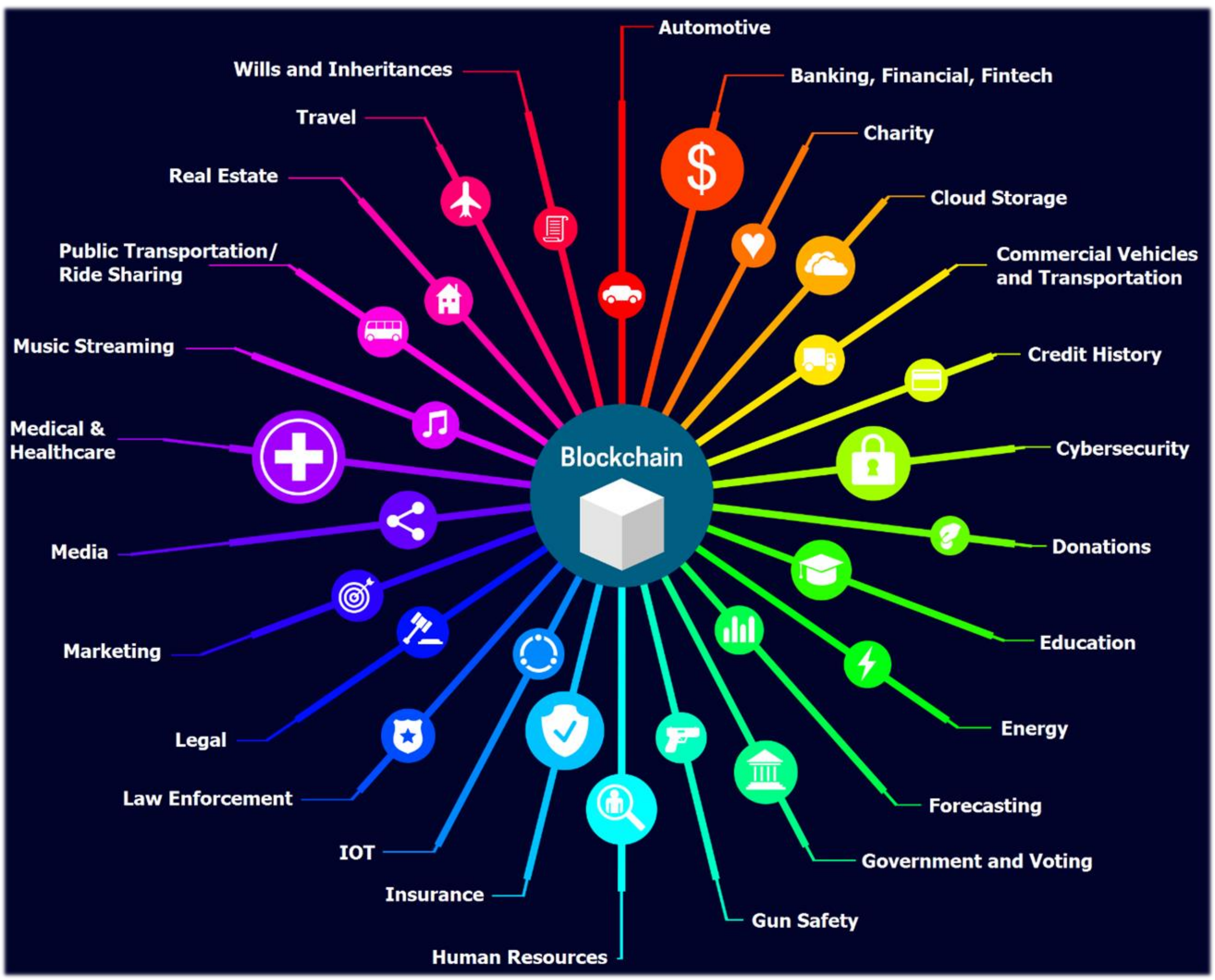


*Figure 4 | Use cases for blockchain technology, retrieved and adapted from Filipowski (2018)*

### 1.1.2 Commercial real estate and the due diligence process

Approximately 10 years after the notorious financial crisis in which the housing bubble burst, the global real estate market now seems to grow stronger again. Currently, it has a total value of more than $200 trillion and comprises nearly 60% of the value of all global assets, including equities, bonds and gold (Cushman & Wakefield, 2018a). Concerning the Dutch real estate investment market, a Dutch branch organization of real estate agents and appraisers called 'the Dutch Association of Real Estate Brokers' concluded that approx. €11bn has been directly invested in 2016 (NVM, 2017). The largest part of these investments, amounting to approx. €8bn, was related to commercial real estate (i.e. offices, commercial buildings, shops, and hotels). The increased demand from private and institutional investors was not only driven by the wide availability of capital and low interest rates. The fact that the economy recovered well and that more real estate was rented by companies and institutions than in previous years, had an impact on the buying spirit. For foreign investors, attractive initial yields on real estate were also an important stimulus (NVM, 2017).

The state of the real estate market might seem prosperous, yet it should not be ignored that there are still significant hurdles to overcome. For example, the commercial real estate (CRE) industry tries to maintain competitive advantage by not revealing certain strategic information (Levitt & Syverson, 2008), such as comparable transaction prices or lease rates, information about (potential) buyers, valuations and other relevant knowledge (Maurer, 2016; Deloitte, 2017). Moreover, compared to exchange-traded securities such as stocks, real estate markets are ill-organized with high transaction costs, lack of information transparency, time consuming due diligence (DD) processes and less efficient price discovery mechanisms, which have implications for the overall informational efficiency of the market (Geltner et al., 2001, pp. 11-12; Ambrose & Lusht, 2008, p. 3).

Real estate is a unique and complex asset class with two key characteristics: heterogeneity and immobility. Because both the supply and demand are location and type specific, real estate markets are highly segmented, implying that space markets tend to be rather local than national and specialized around categories of building types (Geltner et al., 2001, pp. 11-12). A commercial real estate transaction comprises an acquisition for the buyer and a disposition for the seller. Based on different studies, Dijkstra (2017) found that this process is characterized by four distinct phases, respectively: preparation, marketing, due diligence and exchange to completion. An important conclusion of Dijkstra's master's thesis is that the due diligence process in commercial real estate transactions and management could be subject to improvement by implementing blockchain technology (Dijkstra, 2017, p. 81).

For an investor, conducting a due diligence is of decisive importance as it serves the purpose of 'knowing what you are buying' and 'mitigating the risk of a bad bargain'. But what is due diligence? The term *due diligence* describes a process and indicates a detailed examination, analysis and assessment of the circumstances of the transaction object in fact and in law (Stapenhorst & Just, 2018). The starting point of this process is the information asymmetry between the parties to the transaction contract. It is the period during which the buyer, accompanied with a whole host of environmental, technical, legal and engineering experts, thoroughly inspects a property. During this period, the owners, the creditworthiness of the tenants, and the physical state of the building are examined in detail in order to find any condition that might be problematic for the new owner of the property (DeMay, 1998).

Today, usually significant time is spent on CRE due diligence activities, predominantly due to using physical documents for proof of identity and electronic documents that are hosted on disparate databases. This inefficient manual verification process causes an administrative burden accompanied with high transaction costs and is moreover prone to loss of information and errors. Additionally, the involvement of a vast amount of trusted third parties, such as bankers, notaries and brokers, tends to elongate the due diligence process as well as to increase the transaction costs of a due diligence process (Deloitte, 2017, p. 9). Blockchain is introduced in the next sub-section as a potential solution to the currently encountered problems.

### 1.1.3 The promise of blockchain in commercial real estate

Technological advancements, such as the online Dutch cadaster, are increasingly automating brokerage and leasing tasks and activities, gradually bringing down the barriers between potential investors and real estate owners (Sheth, 2015). As a result, property-related information is increasingly available in both digital and paper form. However, a significant portion of the digitized information is hosted on disparate systems, still lacking in transparency and efficiency, and causing a higher incidence of inaccuracies that makes involved parties particularly susceptible to fraud or tampering.

According to Maurer (2016), the promises of blockchain are reducing errors, improving efficiency, and eliminating transactional risks. Property records that are validated by consensus in a distributed ledger will help to eliminate paper-based errors as we see them today. It could even make paper-based records obsolete, since all the real estate transactions would be meticulously stored on an immutable and decentralized ledger (Goldman Sachs, 2016). Automation of the due diligence process would imply that blockchain could drastically change the role which brokers, notaries and other middlemen play in these processes and eventually lead to decreasing transaction costs (Ngo, 2016; Lawrence, 2018).

Will the real estate industry retain its current value, or will it change due to surprising technologies, renewed business models, and strategies or innovative ways of managing and transacting real estate? Taking the promises of upcoming technologies such as blockchain into account, the real estate world finds itself at a turning point of transition. Assuming that blockchain will emerge as a widely-adopted technology, this research aims at delineating the specific impacts on the transaction costs of CRE transactions, particularly those in the due diligence process. Additionally, this research delineates the phases of the CRE DD process, explains what aspects of the DD process can be impacted by blockchain, and explains for what aspects blockchain is not applicable given its current potential.

## 1.2 Status Quaestionis

Given the fact that blockchain was invented a mere a decade ago, it is assumed that both the technology and its regulations are still nascent. To obtain an accurate picture of these developments, the current state of academic research is examined by consulting Scopus. The publication years, ranging from 2013 to 2018 Q1, are set off against different combinations of keywords. The results represent the number of publications and are depicted in Table 1.

*Table 1 | Publications on Scopus given certain keywords (Scopus, 2018)*

| | "Blockchain" | "Real Estate" | "Blockchain" AND "Real Estate" | "Blockchain" AND "Due Diligence" | "Blockchain" AND "transaction costs" | "Blockchain" AND "real property" | "Blockchain" AND "commercial real estate" |
|---|---|---|---|---|---|---|---|
| **2013** | 6 | 4,799 | 0 | 0 | 0 | 0 | 0 |
| **2014** | 27 | 5,125 | 0 | 0 | 2 | 0 | 0 |
| **2015** | 74 | 5,063 | 0 | 0 | 1 | 0 | 0 |
| **2016** | 250 | 5,436 | 2 | 0 | 8 | 2 | 1 |
| **2017** | 964 | 6,026 | 13 | 8 | 17 | 2 | 1 |
| **2018** | 172 | 1,112 | 3 | 0 | 2 | 0 | 2 |
| **Total** | **1493** | **27,561** | **18** | **8** | **30** | **4** | **4** |

At a first glance, it appears evident that blockchain is rising in popularity. From 2013 to 2017, the number of publications containing blockchain has approximately tripled every year, demonstrating the increasing popularity. However, even though publications about real estate can be found in extensive amounts, the combination of blockchain and real estate is used in a mere 1.2% of all publications containing 'blockchain'. This is an important finding as it stresses the fact that the current body of academic knowledge lacks publications about blockchain and real estate. The combination 'blockchain + real estate + due diligence' returned no search results. Among the 18 results that mention blockchain and real estate, only one paper (Veuger, 2018) specifically describes the essence of blockchain for real estate in the Netherlands and includes expectations of future applications. With regards to the keywords 'blockchain' and 'due diligence', only one (out of eight) article addresses the potential added value of blockchain in know your customer (KYC) due diligence processes, primarily focusing on the customer verification process of financial institutions. An interesting finding is that the implementation of decentralized ledger technology (DLT) in the case-specific DD process "allows for efficiency gains, cost reduction, improved customer experience and increased transparency throughout the process of onboarding a customer" (Moyano & Ross, 2017). Lastly, a relevant study that is not covered by the results of Scopus, is the master thesis of Dijkstra (2017) concerning the implementation of blockchain in real estate management processes. In this thesis, the fundamental concepts of blockchain and its connection with real estate are explained and used as a starting point for further elaboration.

To conclude, a minor number of useful articles has been found among the publications, mostly because most publications focus on specific technical or organizational issues. Therefore, a rather unexplored knowledge field remains with much room for exploration. A vast amount of literature about the topics 'blockchain' and 'real estate' is at hand, but combinations of these separate scientific fields appear to be lacking, apart from the articles mentioned above.

## 1.3 Problem definition

### 1.3.1 Ultimate problem owner

Cushman & Wakefield, Stibbe, ABN Amro Bank, Deloitte, FRIS, and Sweco have started a joint project to explore the possibilities and added value of combining forces to perform a complete DD process from different disciplines. In addition to the joint project between abovementioned parties, this report is written for Cushman & Wakefield at the behest of the Delft University of Technology. Cushman & Wakefield is a commercial real estate advisor and strategically advises investors with, among other things, the acquisition or disposition of commercial real estate. For Cushman & Wakefield, the problem is twofold. On the one hand, a new technology is disrupting many markets and might form a threat for their business model (as an intermediary). On the other hand, as an advisor, Cushman & Wakefield currently encounters lots of time-consuming tasks during the DD process. Since the payment structure of commercial advisors is based on a 'no cure, no pay' principle, the process is inefficient in the sense that doing more work is not necessarily rewarded with a higher fee. Although this thesis is written for Cushman & Wakefield, the ultimate problem owner is the investor (i.e., from an advisor's perspective, the client). As will be described in chapter 4, the problem they cope with are mainly the high transaction costs of the DD process due to procedural inefficiencies. This implies that when this study mentions 'efficiency', the efficiency from an investor's perspective is meant, unless stated otherwise. In most cases, the efficiency of a DD directly impacts the transaction costs borne by the investor, which in turn are caused by the intermediaries. The problems and pain points are initially formulated by a co-operation of technical, legal, fiscal and commercial advisors, and a bank. Subsequently, these pain points are validated by the problem owners to gain proper understanding of the problems they experience.

### 1.3.2 Knowledge gaps

Blockchain's rapid rise in popularity has triggered scientists from diverse market sectors to investigate the possibilities in their field of interest, resulting in an influx of scientific articles exploring new use cases for blockchain. Today, a lot of information about the general concept of due diligence, the appliance in real estate and the concept of blockchain is at hand, but, apart from a couple of mentioned articles, the application of blockchain in the real estate sector - let alone due diligence processes and transaction costs - is barely covered in the academic literature. Moreover, it remains unexplored what the impacts of blockchain can be on the role and the daily practices of real estate services, banks, notaries, and other middlemen. Taking these concerns into account, the following knowledge gaps are defined:

- It is unclear how blockchain technology challenges the role of intermediaries in transactions of commercial real estate properties. The transparent and efficient way of storing and exchanging data on a blockchain fundamentally differs from currently used document-management systems. Where intermediaries benefit from a lack of transparency and efficiency within the CRE industry, blockchain could potentially disintermediate these middlemen and shift control towards purchaser and seller of the property.
- It is unexplored how blockchain technology can be approached through the lens of transaction cost economics, and especially how the drivers of transaction costs can be impacted with the implementation of a blockchain-based application. Following the framework as presented by Williamson (1979), blockchains can be viewed as an institutional technology to economize on the costs of opportunism, bounded rationality and uncertainty in a decentralized way. In addition, the combination of transaction cost economics (and the drivers of transaction costs) with blockchain, applied to CRE transactions and especially the due diligence process is yet unexplored and lacks in current academic literature.

- It is unclear based on what market- and process characteristics a CRE DD process can be compared with other transaction processes, and how it can be determined where the relatively high transaction costs in CRE transactions originate from. Current academic literature lacks in concretizing the main drivers of transaction costs within the CRE DD process.
- Except from a few overly simplistic decision paths, current literature investigating blockchain use cases lacks a comprehensive generic decision path concerning the applicability of a blockchain-based solution. To assess the applicability of a blockchain-based application in a structured way and to subsequently determine the impact on transaction costs, factors are required to determine the fit of blockchain in certain business processes. These factors are not explicitly mentioned in academic literature and therefore need to be explored.

### 1.3.3 Problem statement

Taking the lack of scientific focus on the relationship between blockchain, transaction cost economics, and CRE DD processes into consideration together with the lacking knowledge about the challenges and implications of integrating blockchain into this process, the problem statement for this research has been defined as follows:

> "Currently, there is a lack of insight and guidance regarding the applicability of a blockchain-based application that aims at lowering the total transaction costs as incurred in the CRE DD process, by impacting the sources of those transaction costs."

### 1.3.4 Research objective

Considering that there is a lack of proper insight and guidance regarding the applicability of blockchain in lowering transaction costs as incurred during CRE DD processes, together with the need to identify specific use cases in which a blockchain-based solution would be more suitable for lowering transaction costs compared to other IT-solutions, the research objective of this research is defined as follows:

> "To assess the applicability of blockchain-based applications in lowering transaction costs within the DD process of CRE transactions, and specific use cases, by impacting the sources of those transaction costs."

### 1.3.5 Main research question

Following from the knowledge gaps, the problem statement and research objective of this thesis project as delineated in sections 1.3.2, 1.3.3, and 1.3.4, the main research question of this research is defined as follows:

> "To what extent could a blockchain-based solution be applicable in a CRE DD process and how could it impact the transaction costs?"

## 1.4 Research deliverables

Suitability and applicability of blockchain-based applications are heavily determined by the extent of added value such solution can provide relative to currently applied IT-solutions. It is still unclear if, and on what aspects within the DD process, blockchain can deployed in such a way that it contributes to lowering the transactions costs that are associated with the DD process in commercial real estate transactions. This research works towards one main deliverable by answering various sub-questions and delivering various interim-deliverables accordingly.

The research starts with unraveling the core components, functioning, implications and benefits of blockchain to finally construct a decision path that supports with assessing the applicability of blockchain technology for situations where a type of database is needed. Subsequently, the next chapter is mainly dedicated to delineating the phases and allocation of transaction costs within the CRE DD process. The interim-deliverables resulting from this chapter are firstly an extensive overview of the abovementioned DD phases with an identification and allocation of transaction costs in the DD process, and second an explanation why CRE transactions entail higher transaction costs than stock market transactions based on a comparison between their fundamental characteristics and the influence on the source of market frictions according to the transaction costs theory. Finally, the last chapter combines the findings from previous chapters and presents a new decision path for firstly assessing the suitability of a blockchain-based application and secondly the impact of a blockchain-based application on lowering transaction costs according to self-defined transaction cost categories in CRE DD processes. This extended decision path is the main deliverable of this research and is used to answer the main research question.

## 1.5 Reading guide

This thesis is written in such a fashion that any reader, without prior knowledge about real estate or blockchain technology, can follow the line of reasoning, which means that the main concepts are extensively elaborated. Chapter 2 justifies the choice for a Case Study Research combined with the application of Transaction Cost Economics (TCE) and subsequently defines the research questions and methods. Also, this chapter presents the research flow diagram and determines the scope. Chapter 3 elaborates on the fundamental principles of blockchain by describing the core components, the main benefits and implications and the techniques used in blockchain technology. Also, this chapter illustrates how transactions on the blockchain work, provides a preliminary exploration of the legal aspects regarding blockchain applications and presents a decision path for assessing the suitability of a blockchain-based solution following a specific series of questions. The DD process and its fit within CRE transactions is extensively outlined in chapter 4, followed by a substantiated assignment of the transaction costs and its allocation within the identified phases of the DD process. Chapter 5 combines the previous chapters and assesses the potential of blockchain technology in lowering the transaction costs of CRE DD processes. Subsequently, this chapter suggests a number of use cases within the DD process where blockchain might play a role and in order to verify this, an extended version of the decision path from chapter 3 is proposed and used. Then, chapter 6 concludes the research by explicitly answering the research questions, reflecting on the research, and providing recommendations for further research, followed by an inspiring out-of-the-box discussion in chapter 7.

# 2 RESEARCH APPROACH

The first section of this chapter introduces case study research (CSR) and justifies the adequacy of the approach for this study. Next, section 2.2 justifies why transaction cost economics is a suitable methodology to express the extent of efficiency gains of potential market interventions, such as a blockchain application. Thereafter, the research questions and methods are formulated in section 2.3, followed by a schematic overview of the research in section 2.4 with the presentation of a research flow diagram that provides a step-by-step structure of the research. Lastly, section 2.5 delineates the scope of the research with respect to the three principal concepts of 'blockchain', 'real estate', and 'due diligence'.

## 2.1 Research strategy: an explorative case study research

Due to the rather untapped combination of blockchain and DD, this research predominantly has an exploratory character with a research strategy of qualitative nature. As outlined in section 1.2, blockchain technology is nascent and so is the amount of academic literature about blockchain. The technology is developing in a high pace, causing the environment to be dynamic and complex. The main research question as formulated in section 1.3.5 revolves around lowering the transaction costs of particularly DD processes in commercial real estate transactions, and therefore this research follows the CSR approach. This section elaborates on the goal and types of CSR, followed by an explanation of the suitability of CSR for this study.

### 2.1.1 Goal and types of case study research

A CSR is a research strategy in which the researcher tries to gain a profound insight into one or several processes that are confined in time and space (Verschuren & Doorewaard, 2010, p. 178). Put differently, a specific case is researched in a CSR with the aim of understanding the boundaries of the case and to complexity of the behavioral patterns of the bounded systems. According to Miles and Huberman (1994, p. 25), the *case* of the study can be defined as "a phenomenon of some sort occurring in a bounded context, which is, in effect, your unit of analysis". For this research, the due diligence process is the case to be studied within the context of commercial real estate transactions.

Once determined that the main research question can best be answered using a qualitative case study, it is considered what type of case study will be conducted (Baxter & Jack, 2008). The selection of a specific type of case study is usually guided by the overall purpose of the research. Stake (1995) used different terms to distinguish a various types of case studies, such as explanatory, exploratory, descriptive, multiple-case studies, intrinsic and instrumental. For this research, the most applicable type of case study is an *explorative* case study, which is used to explore those situations in which the intervention being evaluated has no clear, single set of outcomes. This corresponds with the explorative nature of this study, which aims at constructing a decision path with a series of questions that can be followed to assess the applicability of blockchain and its subsequent impact on incurred transaction costs.

### 2.1.2 Justifying the adequacy of the CSR approach

Contrary to problem-centered researches, this study considers blockchain as an objective-centered solution and aims at developing a decision path to assess its potential with respect to DD as a specific use case. This is especially useful in situations where a research need is identified that can be addressed by exploring the potential for developing an artifact. Blockchain as an information system could be such artifact; several untapped markets are being explored amongst which is the CRE industry, where blockchain could potentially influence the role of the middlemen that benefit from the current amount of transaction costs. It may be clear that the explorative component of this study prevails, yet the choice for a CSR approach rather than, for example, a design science research approach can be more substantiated. Therefore, this sub-section zooms in on the characteristics of a typical case study and elucidates how these apply for the case of this research.

According to Verschuren and Doorewaard (2010, p. 178), case studies are characterized by:

- a small domain, consisting of a *small number* of research units;
- *intensive* data generation;
- more *depth* than breadth;
- a *selective*, i.e. a strategic sample;
- an assertion concerning the object as a whole;
- an *open* observation of the case in its natural context;
- *qualitative* data and research methods.

The first and most important characteristic of a case study is the use of a relatively small number of cases, which for this study is just one case: the DD process in CRE transactions. Second, this research provides an in-depth study regarding the DD process rather than a broad exploration of blockchain use cases in the entire CRE market. The scope therefore, which is defined in section 2.5, plays an important role in determining the boundaries of the case. This depth is realized using various, intensive methods for generating data. For this study, face-to-face interviews with open questions, brainstorm sessions with experts and an extensive literature study were used to gain profound insight into the DD process. Third, a strategic sample is taken in this study in order to increase the external validity of the research. To illustrate, during the interviews, the respondents were specifically asked to describe the *commercial* DD process from the *buy-side* perspective of an *institutional* investor for properties in *the Netherlands*. Selecting this strategic sample enabled the interviewer to be consciously guided by the information that was intended to extract from the interviews and brainstorm sessions. Fourthly, a case study usually tries to obtain a general idea of the process in its entirety, which holds for this study as the DD process in its entirety is investigated and subject to assessment for blockchain intervention. Fifth, the case is studied in its natural context, which implies that that researcher should get as close as possible to the case and interview the actors that are directly in contact or working with the case. For this study, institutional investors were approached with experience in conducting DD processes and were explicitly asked to share a recent experience. Lastly, use cases are typically researched using qualitative methods, which corresponds to the interviews and literature study as used in this research.

Every research approach has its criticisms and drawbacks, and these should not be ignored. The search for particularity in a CSR competes with the search for generalizability, which in turn has attracted criticism based on methodological weaknesses and rigor inadequacies. Criticism of CSR as a research strategy is directed at many levels (ranging from abstract to practical), and the approach is often charged with causal determinism, subjective conclusions, absence of quantitative substantiation, lack of generalizable conclusions, biased case selection and lacking empirical clout. Usually, these types of criticism emanate from social scientists who value those ideals (Idowu, 2016, p. 184). To prevent this study from depending too strongly on qualitative information and to minimize biases in the case selection, the claims made in this research have been substantiated with quantitative data where needed. The case study has been selected and designed by a joint group of six professionals (legal, technical, commercial, and fiscal CRE advisors), and in total nine interviews are conducted during a period of three months. Quantitative substantiations can be retrieved in Appendix III (background figures regarding the Dutch CRE market), and Appendix VI (transaction costs of a fictitious CRE transaction).

## 2.2 Transaction cost economics

Because the effects of blockchain implementations in commercial real estate transaction processes cannot be determined empirically yet, this research requires a theoretical framework to be applied to determine the efficiency of potential market interventions. For this research, especially since the aim of the research is identifying the potential to decrease transaction costs in a DD process, the transaction costs theory turns out to provide the most suitable framework to express to what extent blockchain could increase the efficiency of the DD process – and thus decreasing the transaction costs. This section introduces the transaction costs economics and compares it to other organization economics theories to justify its applicability in this study. Additionally, the sources of transaction costs are discussed according to the framework of Williamson (1979), supplemented with the dimensions of transaction costs as mentioned by Coase (1937).

### 2.2.1 Explaining why companies exist: the origination of transaction costs economics

All kinds of privatization of government organizations have occurred in the Netherlands since the early 80s. Increasing the economic efficiency was regularly mentioned as an important argument for internal and external privatization. The economic efficiency is the relationship between the (monetized) means of production (inputs) and the products realized (outputs). The neo-institutional economics, which presumably had its starting point with the classical economist Adam Smith's *Wealth of Nations* (Smith & McCulloch, 1838; Buitelaar, 2009, p. 19), questions which organizational structures perform optimally in a given situation, or, more specifically, what organizational forms lead to maximum economic efficiency (Ter Bogt, 1998, p. 43).

In some respects, the neo-institutional economics differs from the neoclassical economics. For example, neo-institutional economics does not assume that individuals have free and full information at their disposal in all imaginable possibilities of action, and assumes that individuals strive to maximize their usefulness in good faith. Moreover, the neoclassical economics is mainly interested in markets and the manner of price formation on these markets (Ter Bogt, 1998, p. 44). Since the neoclassical economics does not consider transaction costs and because actors usually have diverging goals with conflicting interests, the neoclassical economic theory is unfit for this research.

The neo-institutional economics as introduced by Williamson in 1975, on the other hand, focuses on the internal organization of companies and to the consequences that institutions – like interest groups, regulations, organizational forms and social norms - can have on the actions of individuals and organizations, and thus on economic efficiency. It proposes a polycentric view as an addition to the neoclassical economics and includes non-materialistic matters and external costs into the theory (Hazeu, 2007, p. 71). These market inefficiencies, which are excluded from the neoclassical economics, are tackled by applying institutions. Hence, the theory is called 'neo-*institutional* economics'. Three important organization economics theories resulted from the neo-institutional economics, namely:

- **Property rights theory:** focuses on property rights as socially-enforced constructs in economics for determining how a resource of economic good is used and owned. Property rights can be considered as an attribute of an economic good and is composed of four elements: the right to *use* the good, the right to *earn income* from the good, the right to *transfer* the good, and the right to *enforce property rights*.
- **Agency theory:** a supposition that explains the relationship between principals and agents in businesses (principal-agent theory). This theory is concerned with resolving problems that arise in principal-agent relationships due to misalignment of goals (e.g. a situation in which the agent is not properly informed about his tasks or his discretionary power) or different aversion levels to risk. The relationship between shareholders (principal) and company executives (agent) is the most common principal-agent relationship in finance.
- **Transaction costs theory**: in addition to the neoclassical economics, this theory emphasizes that in a world without bounded rationality and opportunism (explained in sub-section 2.2.2), transactions come with certain costs in order to let it succeed. The transaction costs theory is widely applied in social sciences, economics, finance, organization theory, political science and strategic management (Kim & Mahoney, 2005) and seeks to explain why economic activities are organized in a certain way.

The latter of the abovementioned organizational theories of the neo-institutional economics applies to this research, because the added value of a blockchain-based application can be determined and measured based on decreasing transaction costs (see section 4.3). But what are transaction costs?

Put simply, a transaction is the transfer of good (or services) on a market, i.e. between two economic units. The transaction costs are the costs associated with this transfer: all costs needed to facilitate the transaction between two economic entities. Buitelaar (2009, p. 30) defines the transaction costs as *"the costs that are made to increase the information available to us and to reduce uncertainty"*, which may be the best suitable definition in this case. These costs comprise for example the collection of knowledge about diverse products and the market, the costs of consultation experts or drafting contracts, or the costs of coordinating activities within or between organizations. The starting point of the transaction costs theory is that in addition to production costs, the transaction costs prevail in determining the organizational structure that is chosen: it is about finding efficient organizational structures.

### 2.2.2 Elaboration on the cost components and sources of transaction costs

Within the transaction costs economics, several types of transaction costs are distinguished. First, all the costs that are made during a transaction and are considered transaction costs, can be categorized into three cost components: search and information costs, bargaining costs, and monitoring deal compliance. Second, Williamson has defined bounded rationality and opportunism as sources of transaction costs, which in this research is supplemented with Coase's three dimensions of transaction costs, namely the extent of recurrence, uncertainty and interdependence. These concepts are concisely explained in this sub-section.

*Cost components of transaction costs*

Transaction costs consist of three cost components (Hazeu, 2007), namely (applied to commercial real estate):

- **Search and information costs**: costs of marketing a property and searching potential investors (from a vendor's perspective) or finding the property that fits within the acquisition strategy (from a purchaser's perspective) fall under the searching costs. These costs are made during the search for suitable trading partners, which requires significant time and resources. Next, the information costs cover the costs of collecting, assessing and verifying information provided by the vendor, in the case of a due diligence process.
- **Bargaining and decision costs**: after a potential purchaser or a suited vendor has been found, preliminary investigation starts and when both parties are satisfied with the provisional results, the negotiations start in order to agree on a letter of intent (and in a later stadium agree on the sales and purchase agreement (SPA)). The efforts made during this phase and the respective costs fall under the negotiating and decision costs.
- **Monitoring deal compliance**: after the sales and purchase agreement has been signed, the deal is often monitored by both parties in order to ensure that all parties involved comply with the terms as agreed upon in the SPA.

*Sources of transaction costs*

Williamson (1979, pp. 245-246) appointed *bounded rationality* and *opportunistic behavior* as the main causes of transaction costs, which are based on the nature of human behavior.

- **Bounded rationality**: this essentially comes down to the fact that actors in principle aim at making rational decisions, but are only to a limited extent able to do so since they never have full information about the context of a deal. Actors cannot foresee every possible outcome and thus not behave optimally in every given situation. In the case of CRE transactions, this applies to all three components of transaction costs (i.e. searching and information costs, bargaining costs and monitoring deal compliance costs). Both purchaser and vendor do not know a priori which counterparty (and which advisor) eventually brings them the best deal, what negotiation-outcomes can be achieved during the negotiating process and how beneficial the contract can be drafted in their advantage. The lack of knowledge forces parties in the real estate market to accept a certain amount of uncertainty, which is subsequently priced in the eventual transaction price or mitigated with additional guarantees in the sales- and purchase agreement. Taking this into consideration, it can be stated that the impact of bounded rationality is dependent on the complexity of the deal: a higher complexity forces the purchaser to make more assumptions and thus increases uncertainty.

- **Opportunistic behavior**: if one party takes advantage of superior knowledge respective to its counterparty to pursue their own interests, it is called opportunistic behavior. A vendor could for example conceal that a property contains asbestos or that the soil is contaminated in the hope that it is not revealed by the purchaser or its advisor during the DD process. Creating trust among the involved parties is one way to decrease the need for opportunistic behavior. A vendor can only have superior knowledge in the case where the vendor possesses information that is not accessible to or known by the purchaser. This holds primarily for heterogeneous assets, thus where the assets mutually differ from each other based on asset-specific characteristics (like real estate).

Yet, even with bounded rationality and opportunistic behavior, the transaction costs could still be relatively low, if all transactions are similar and have the same characteristics (Buitelaar, 2009, p. 31). Therefore, the behavioral assumptions as described above should be extended with the dimensions that Coase gave to transactions back in 1937, namely interdependence (asset specificity), uncertainty and recurrence (Coase, 1937). These sources of market frictions are concisely elaborated below.

- **Interdependence:** derived from the existence of asset specificity; interdependence arises when transactions are not recurring and take place between a limited number of buyers and sellers, imposing interdependence between these actors. Contrarily, the neo-classical economics assumes that resources are infinitely redeployable and substitutable. The level of asset specificity depends on how specialized the investment is in terms of its ability to be redeployed to alternative uses or by alternative users. For example, real estate assets are asset specific as they are heterogeneous and not suited for any purchaser; a retail investor attaches no value to an office property and vice versa.
- **Uncertainty:** Asymmetric or imperfect information leads to uncertainty and sometimes to adverse selection, where the purchaser ends up with a bad bargain. The adverse selection (and uncertainty) may be caused by non-observability of the counterparty's action or by pre-contract information. Uncertainty is as well caused by people with informational advantage who consciously try to distort the transaction by disguising information and also depends on the asset-complexity, which is attributable to the asset specificity (Buitelaar, 2009, p. 31).
- **Recurrence:** The duration and frequency of transactions impact the timing of the transaction, which is also a transaction dimension. Where the neoclassical economics assume instantaneous and recurring transactions of homogeneous goods, the real estate market turns out to be different (as described in section 4.1.2). Non-recurrently traded assets are often exclusive or complex and usually entail higher transaction costs.

Given the abovementioned three components of transaction costs, as well as the sources of market frictions according to the transaction costs theory, chapter 3 introduces the concept of blockchain and briefly mentions how this technology is expected to reduce transaction costs in general. Then, chapter 4 compares real estate with other asset classes and seeks to explain why a due diligence process in a real estate transaction entails relatively high transaction costs compared to the stock market.

## 2.3 Research questions and methods

Literature states that the DD process in CRE transactions is often found to be inefficient and time consuming. The use of multiple databases, untraceable information and a slow exchange of information have led to high transaction costs and strategic behavior of property sellers. The currently much-discussed blockchain technology is expected to be a solution for optimizing data-structuring and provision in the DD process. However, a deep dive into the CRE sector is required and a thorough research on what parts of the DD are potentially subject to change before being able to make useful assessments. Therefore, the main research question, formulated in section 1.3.5, reads as follows:

> "To what extent could a blockchain-based solution be applicable in a CRE DD process and how could it impact the transaction costs?"

The main research question has been further specified using sub-questions, which represent the structure of the report and therefore correspond with the build-up of the chapters in this report. Table 2 displays these sub questions, together with the methods or theories used to answer this question, and the subsequent results.

*Table 2 | Sub-questions, methods and output*

| Sub question | Method or applied theory | Result |
|---|---|---|
| 1. What are the core components of blockchain technology and how it can be determined whether a blockchain-based solution is applicable for a given use case? | • Literature study<br>• Expert consultation (blockchain) | • Concept definition of blockchain<br>• Decision path for assessment of blockchain applicability |
| 2. How is a due diligence process positioned within a CRE transaction and what are relevant characteristics, phases and transaction costs of a due diligence process? | • Transaction Cost Economics<br>• Literature study<br>• Expert interviews (CRE DD) | • Concept definition DD and CRE market characteristics<br>• Overview of transaction costs in DD process<br>• Involved actors overview |
| 3. How can the applicability of blockchain-based applications for lowering the transaction costs of the due diligence process in commercial real estate transactions be assessed?" | • Literature study<br>• Expert consultation (blockchain)<br>• Transaction Cost Economics | • Overview of blockchain-based applications suitable for the DD process<br>• Extended decision path for determining impact of blockchain application on transaction costs |

## 2.4 Research flow diagram

This section visualizes the outline of this research based on the defined research questions and methods, and the CSR approach supplemented with TCE. In the middle, the research steps are defined and form a logical step-wise structure of the report. Where applicable, the sub questions are presented left to the research steps. The interim deliverables are depicted on the right-hand side of the research flow diagram. The arrows indicate the interrelationships and links between the research steps and the deliverables. The most important interrelationships are indicated in Figure 5.

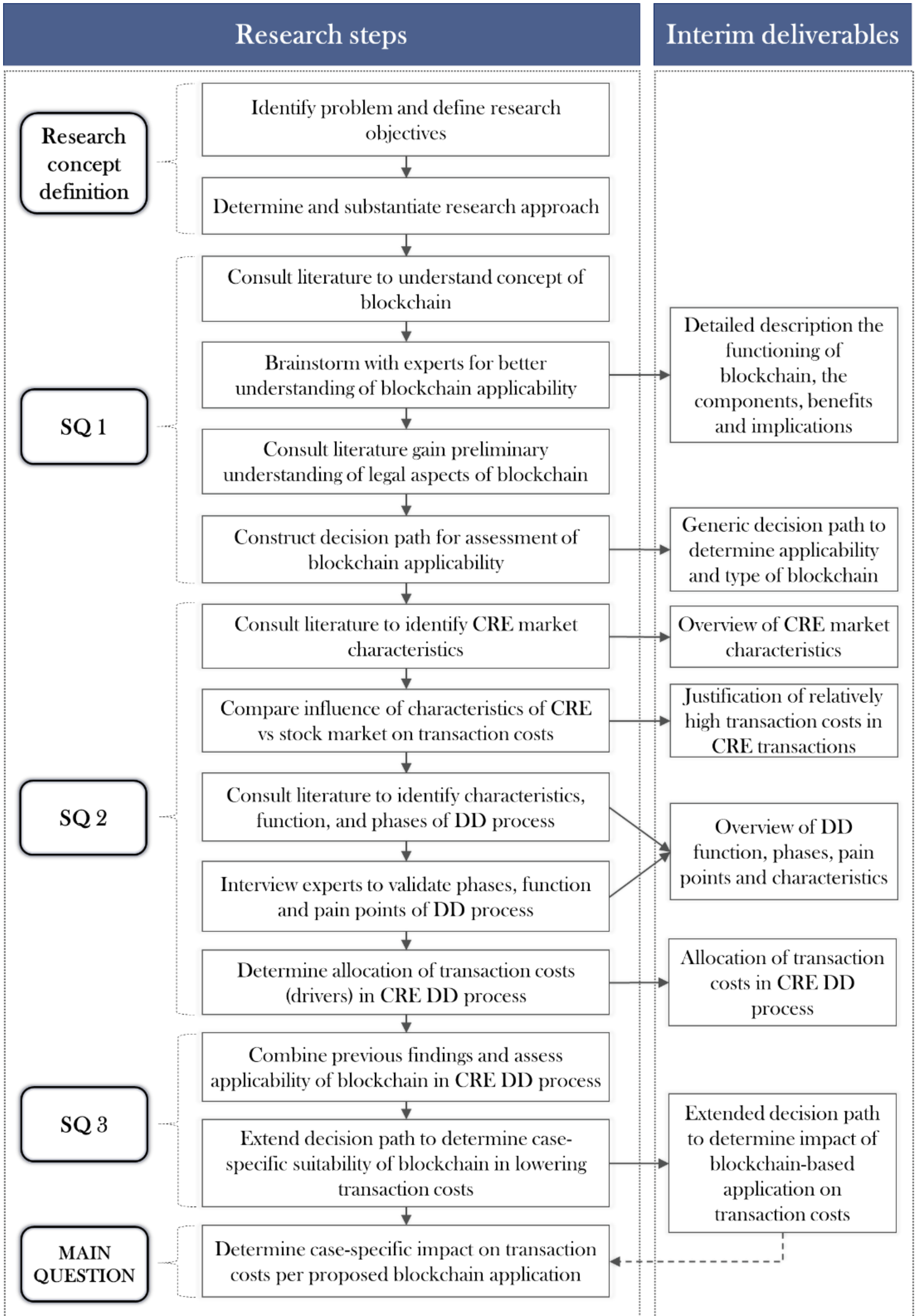


*Figure 5 | Research Flow Diagram*

## 2.5 Scope of the research

### 2.5.1 Real Estate

Within the world of real estate, property assets are usually assigned to either commercial, residential or industrial real estate. In general, commercial real estate revolves around generating income and is exploitation-driven. It is used solely for business purposes and the properties are used or leased out to function as a working space rather than a living space. By way of contrast, residential real estate has in principle no profit objective and is typically used for living purposes. Industrial real estate is used for the manufacture and production of goods (Premier Commission, 2015; Investopedia, n.d.). The case study in this research limits itself to the Dutch commercial real estate market. Therefore, a criterion for the respondents approached for the interviews is that they operate in the Dutch market, regardless of the origin of the company they serve, as long as it is an institutional investor.

### 2.5.2 Due Diligence

Literature differentiates several types of due diligence, ranging from tax, financial, legal, environmental, technical, fiscal, human resource and operational. In the CRE sector, a DD is usually performed from one of the following disciplines: technical (e.g. is the building not about to collapse?), juridical (e.g. are the rental agreements legally in order?) and commercial (e.g. are the tenants credit worthy and do they pay a market conform rental price?). The scope of this research is narrowed down to commercial DD and the respondents are therefore asked to share their experiences and knowledge solely related to commercial DD processes. The study explicitly addresses the DD process as defined in chapter 4, and comprises all the defined sub phases of the commercial DD process. For the sake of completeness, technical and legal DD are included where necessary. Chapter 4 explains that within DD processes a distinction can be made between new development and existing buildings. For both categories, the due diligence process is totally different and therefore difficult to compare. Therefore, this research is limited to due diligence of existing buildings, where the acquirer is rather looking for defects of the building than to inspect the technical drawings of the to-be-built object. Lastly, a distinction with respect to the DD initiator – i.e. the purchaser or the vendor – is made. In some cases, a vendor due diligence is performed to align the information that is available for the potential buyers of the object. During the interviews, because these types of DD are different on multiple aspects (see section 4.2.2.1), it is chosen to not incorporate the vendor DD in the questions and therefore the focus is on buy-side due diligences.

### 2.5.3 Blockchain and the associated legal framework

Provided that neither the Dutch government, nor the EC, nor the G20 are regulating the use of blockchain technology for now, this research assumes that there is no legal framework to comply with. However, as it is relevant to at least consider the legal aspects of blockchain, section 3.5 briefly addresses these issues to provide a preliminary understanding of the current legal situation with respect to blockchain. For this research, it is assumed that transactions only take place between Dutch entities and thus the Dutch civil law is applicable.

This research deals with blockchain solely as a theoretical concept, based on literature study and expert brainstorms. It explains the underlying cryptography and the hashing of the blocks, but refrains from any in-depth conclusions or recommendations regarding technical aspects.

# 3 BLOCKCHAIN: FUNCTIONING AND APPLICABILITY

This chapter aims at efficaciously answering the first sub-question, which reads as follows: *'What are the core components of blockchain technology and how it can be determined whether a blockchain-based solution is applicable for a given use case?'*. First, the concept of blockchain technology is briefly introduced (section 3.1), followed by section 3.2 with a delineation of its core components associated with a comprehensive elaboration of the dominant consensus mechanisms, the concept of hashing and the applied cryptography techniques. Then, section 3.3 explains how transactions are executed on the blockchain and gives a basic understanding of the features and applicability of smart contracts. Section 3.4 discusses the main benefits and implications of blockchain technology and section 3.5 elaborates on the legal aspects of blockchain and smart contracts. Following from this, the findings combined in section 3.6 and a decision path is presented to determine the applicability of blockchain-based interventions. Additionally, this section rectifies a set of common misunderstandings with respect to the functioning of blockchain. Finally, this chapter is wrapped up in section 3.7 with an answer to the research question as posed above.

## 3.1 Introduction to blockchain technology

Blockchain is a disruptive technology underpinning Bitcoin, a digital currency that was introduced to the world by Nakamoto (2008). Compared to a classic intermediary role, one if the unique features of blockchain is that it maintains reliability with a decentralized and distributed management system without the need for a trusted third party, even with the presence of malicious actors in the network (Watanabe et al., 2016).

In order to understand the world of blockchain, it is important to distinguish Bitcoin from blockchain. Bitcoin is digital cash: a peer-to-peer (P2P) payment network that runs on a cryptographic *protocol*, whilst the underlying *technology* is called blockchain (Nakamoto, 2008). A blockchain is a distributed database that is replicated over a P2P network. It is a secure and decentralized (public) ledger that records transactions that have been recorded, which in turn are directly shared with all participants of the blockchain network (Swan, 2015; Düdder & Ross, 2017). The blockchain is constantly growing because the nodes of the network continuously add new blocks to the blockchain. These blocks are created by attempting to solve a cryptographic puzzle that requires a substantial amount of computing power. The first one to solve this puzzle can add a new block to the blockchain, which is subsequently validated by the other nodes in order to update the entire ledger. In the case of Bitcoin, the successful node is rewarded for its efforts by receiving a predetermined amount of (currently 12.5) Bitcoin. An important side note is that this study focuses on the applicability of blockchain technology, which has an impact that goes well beyond the specific use case of Bitcoin.

Blockchain as a technology has evolved rapidly over the past decade. Swan (2015, p. ix) distinguishes three generations of the blockchain since its invention; blockchain 1.0, blockchain 2.0 and blockchain 3.0. The first generation solely aims at digital currencies: the deployment of cryptocurrencies such as Bitcoin. Blockchain 2.0 is about contracts, which are economic-, market-, and financial applications that reach further than just cash transactions: stocks, bonds, shares, title, smart properties, and smart contracts. Finally, the third generation of blockchain indicates the applications beyond economic, financial and market applications: other market segments (such as health, automotive, supply chain, government, et cetera) are tapped into with this blockchain generation.

## 3.2 Blockchain's core components

The functioning of the blockchain can be best explained by highlighting its core components, and explaining how these interact in the technology of blockchain. However, a component is not the same as a beneficial characteristic, which in literature is interchangeably used when explaining the technology. To illustrate this, Table 3 shows a few publications in which the benefits and components are alternately used to describe blockchain.

*Table 3 | Various descriptions of blockchain's core components and characteristics*

| Author(s) | Description of blockchain |
|---|---|
| Tasca et al. (2017) | Decentralization of consensus, transparency, security, immutability, automation and smart contracts, storage |
| Rabah (2017) | Reliability, availability transparency, immutability, irrevocability, disintermediation |
| Veuger (2018) | Cryptography, P2P network, shared ledger |
| Düdder and Ross (2017) | Decentralization, consensus, immutability, validity, authentication |
| Swan (2015) | Decentralization, transparency, trustless, P2P network, public ledger, disintermediation |
| Tapscott and Tapscott (2016) | Distributed, public, encrypted |
| Wüst and Gervais (2017) | Public verifiability, transparency, privacy, integrity, redundancy, trust anchor |
| Zheng et al. (2016) | Decentralization, persistency, anonymity, auditability |
| Xu et al. (2017) | Immutable, non-repudiation, integrity, transparency, equal rights |

Reliability, security, immutability and transparency are not fundamental *components* of blockchain, but rather *benefits* that stem from the components. Hileman and Rauchs (2017) efficaciously describe a quintet of core components. This study therefore sticks with the components as mentioned by Hileman and Rauchs (2017), which are cryptography, P2P network, consensus mechanism, ledger and validity rules. Note that there exists a variety of blockchain types with different components. The components are elaborated below belong to the Bitcoin blockchain (Nakamoto, 2008; Swan, 2015; PWC, 2016; Spielman, 2016, p. 38; Tapscott & Tapscott, 2016; Watanabe et al., 2016; de Vos, 2017; Dijkstra, 2017; Hileman & Rauchs, 2017; Morgan Stanley, 2018; van den Hoven, 2018; Veuger, 2018):

**Ledger:** The blockchain is a ledger that is replicated to all nodes in the network. The ledger is composed of an overview of all *data* transactions that have ever been executed and is constantly growing when blocks are added in chronological order. Contrary to conventional databases, which are usually centrally controlled and adapted, this ledger is distributed among all participants of the network and continuously kept up to date. To illustrate: just like a heartbeat of the Bitcoin network, every ± 10 minutes the entire ledger is updated as one new block is added to the blockchain after being validated by at least 51% of the total computing power that is used to find the proof of work. Because the ledger is distributed, every participant has an exact copy that is downloaded automatically upon joining the network, which enhances transparency and trust in the network.

**P2P-network:** Power is distributed across the entire P2P network without any single point of control. There is no party that oversees the system, nor a party that is able to unilaterally shut down the network. Next to the fact that there exists no point of single power, the P2P network is also able to securely function without a necessary intervention of a trusted third party. As peers are directly connected in this network, blockchain technology can pave the way for disintermediation in multiple market segments: potentially a significant threat for companies such as Cushman & Wakefield.

**Consensus mechanism:** Formerly, it was difficult to rely on a group of independent, non-trusted actors to verify that a given scenario is valid (hard to effectuate if some of the actors were mischievous). However, the reason that blockchain allows a P2P system to function properly without the need for intermediaries, has to do with its unique mechanism of achieving consensus, which fundamentally differs from conventional databases. Three dominant consensus algorithms are called 'Proof-of-Work' (POW) and 'Proof-of-Stake' (POS), and 'Proof-of-Authority' (POA). Section 3.2.2 elaborates on these algorithms and outlines their mutual differences.


**Cryptography:** Traditionally, trust is provided by intermediaries known as trusted third parties, but within the blockchain technology it is provided through cryptographic proof. Cryptography is the study that revolves around protecting information using encryption codes and ciphers. Anyone who wishes to latch on and participate in the blockchain network must use cryptography - opting out is not an option. Cryptography is applied to several parts of the blockchain, among which the most important concepts are hash functions, digital signatures, verification of digital signatures (decryption) and private- and public encryption keys. These concepts are concisely explained in section 3.2.1.

**Validity rules:** Validity rules form the last core component of a blockchain, and are closely related to the operationalization of the consensus mechanism. To have a properly functioning P2P network, one must first agree with a principle set of rules that decides how and when transactions are considered valid, what consensus mechanisms are applied, how the ledger is updated, what incentives the network has (i.e. what the remuneration scheme looks like and how actors are incentivized to validate transactions), et cetera. The validation rules are the rules that nodes in a blockchain follows in order to stay in consensus with each other.

The abovementioned five components generically describe the functioning of a blockchain. However, two components, namely cryptography and consensus mechanisms, deserve a more in-depth explanation to gain a better understanding of the exact purpose of these components. Therefore, these are elaborated in the next two sub-sections.

### 3.2.1 Hashing and cryptography techniques

*Hashing*

Hashing is running a complicated algorithm over any file (PDF, Word, Excel, a text file, or in the case of Bitcoin: transactional data), of which the result is a compressed string of alphanumeric characters that is infeasible to compute back into the original document. Every same content gets the same hash, so if someone would hash the word 'blockchain' according to the Secure Hash Algorithm-256 (SHA-256), a unique 64-character hash string that exactly represents the word 'blockchain' is returned: *ef7797e13d3a75526946a3bcf00daec9fc9c9c4d51ddc7cc5df888f74dd434d1*. This means that if the file has not changed, the same hash value would be returned when the hash algorithm is run again over the file. Hence, this is a secure way to be able to reconfirm that the hash value is correct, without necessarily having insight into the file itself. The hash value is short enough to be saved in the blockchain, but mostly the documents are too large. Therefore, the hash value is entered into the blockchain instead of the original document, and via that hash value, the original document is encoded into the blockchain. Taking this into consideration, the blockchain can thus function as a tamperproof decentral document registry (Franco, 2014, pp. 95-99). The blocks in the blockchain are mutually connected via hashes: block X is hashed, and this hash is stored in the header of block X+1. If a (malevolent) actor attempts to change, adapt or remove a file or transaction in block X, then its hash would not correspond any longer with the stored hash in the next block (block X+1). This means the verifiers on the blockchain will not reach a consensus as to its validity, and thus is it not possible to alter the data that was initially entered in the block. How blocks are connected to each other using hashes, is - slightly simplified - visualized in Figure 6 (Swan, 2015, p. 39; Spielman, 2016).

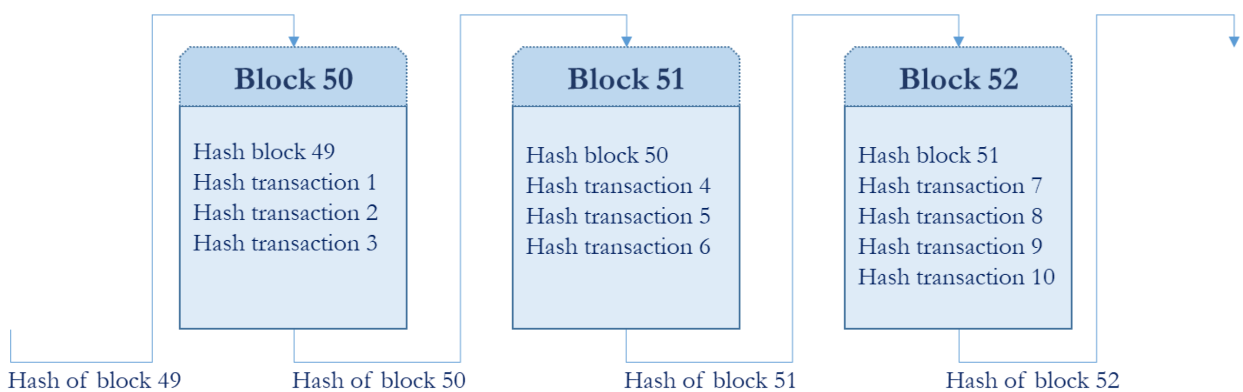


*Figure 6 | Connection of blocks with hash values*

The blocks each contain a header, which is composed of (Tasca et al., 2017, p. 26):

- a hash of the previous header;
- a timestamp (when the block has been added to the blockchain);
- the mining difficulty value;
- a nonce (only for proof of work: a number that is added to the hash block, so that it meets the difficulty level restrictions when rehashed);
- and a root hash for the merkle tree in which transaction hashes are stored for that block.

The hash value of the block header is determined by a SHA-256 encryption of the nonce, the hash value of the previous block header and the hash value of the merkle root.

### *Asymmetric cryptography: the functioning of public and private keys*

Participants in a blockchain use a public key infrastructure (PKI), which is an advanced 'asymmetric' cryptography. Asymmetric here centers around the fact that there is a key pair with two types of keys (public and private) that do not perform the same function: one key is for encryption and one is for decryption. The public key is derived from the private key through hashing and other mathematical techniques and is accessible to all recipients. The private key, however, belongs to an individual actor and is used to access an account and actively execute a transaction. This key should be kept secret at all times and can be regarded as a password. Every key is mathematically related to its paired key such that they must be used together: an individual key is not able to undo its own operation, so the functioning of a key is a one-way operation (hence asymmetric keys). Note that cryptography and hashing are two different operations and are commonly confused: hashing is a *one-way operation* and is intended to be irreversible: a hash should never be back computed into the original content. Contrastingly, cryptography is a *two-way operation*: data is encrypted with the explicit intention to decrypt the ciphertext back into the original content. Hashes also serve a different purpose in blockchain technology, namely to improve integrity, whereas public/private key encryption is used for identification and signing. To improve clarity, the simplified process of encryption and decryption is explained below.

If a sender wants to encrypt a message and send it to the receiver, the recipient's public key is used to encrypt the document. The result is a document with ciphertext (i.e. encoded information). Only the node with the corresponding private key is able to decrypt the ciphertext and to access the original document. Thus, if a file is encrypted with one key, then it is encoded and only the corresponding key can be used to decrypt it. Despite it is *practically* infeasible to decrypt the encrypted file without the corresponding key, this key could in theory be obtained 'brute force': using a significant amount of computing power to guess extremely many keys with the hope of eventually guessing the correct one. Put simply: the public key can be thought of as an email address, and the corresponding private key is the password. Once you combine the right public key with the right private key, then you can enter your email box and send/receive emails. This asymmetric cryptography is simply visualized Figure 7. Note that the sender uses the recipient's public key (which is mathematically connected to the recipient's address) to encrypt the data in such a way that only the recipient, with her private key, can decrypt the ciphertext (Tapscott & Tapscott, 2016).

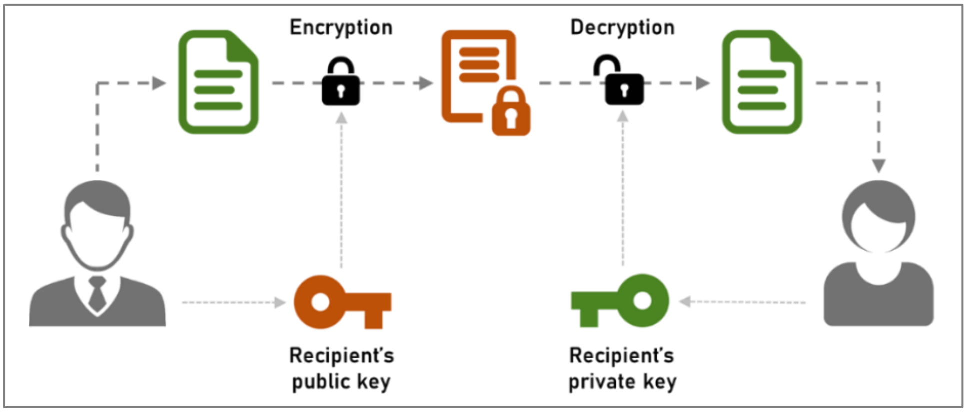


*Figure 7 | Visualization of the encryption and decryption of documents on the blockchain*

### *Digital signatures and signature verification*

As the name suggests, digital signatures are equivalent to handwritten signatures, but are signed digitally using the principles of cryptography. Compared to handwritten signatures, a digital signature is significantly more difficult to forge and thus more secure in that sense. However, if a private key is lost, then all security is lost with respect to being able to proof that a digital signature is yours.

A digital signature combines the concepts of public and private keys with hash functions. It provides the following information to the recipient (PWC, 2016):

- **Authentication**: the document has been signed by a known sender: because the private key theoretically belongs to only one person, any time that the private key has been used, it can be concluded that only the holder of that private key has used it. Thus, the signature confirms the sender's identity because it has been signed using a unique private key.
- **Non-repudiation**: the sender is not able to deny having signed the document, since he is the only one with the private key with which the hash has been encrypted.
- **Integrity**: the document has not altered during the transaction, as this would give different hashes.

Figure 8 and Figure 9 visualize how a digital signature is created and subsequently can be verified. |The visualizations are guided with a simplistic example to enhance their understandability. Suppose that James possesses a document and wants to prove the world that he is the owner of the document. To do so, he can create a digital signature by firstly hashing the document and encrypting the hash using his own private key. The encrypted hash is then called the digital signature (Tasca et al., 2017).

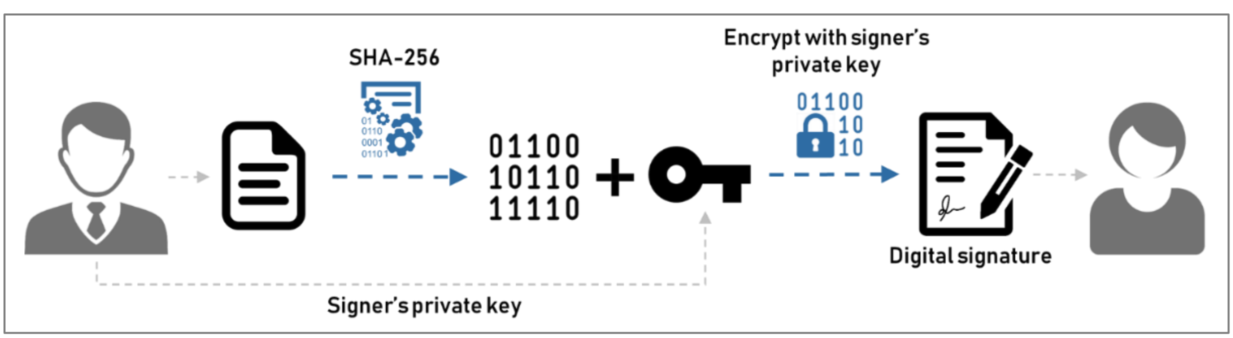


*Figure 8 | Creating a digital signature*

If, for instance, Anna wants to check whether the document really belongs to James, she can request the document. James sends her the document along with the digital signature. First, Anna decrypts the digital signature using James' public key, which results in a hash value of the digital signature. Second, Anna applies the same hash algorithm to the received document, also resulting in a hash value. These two hash values are compared with each other, and if they match, James has proven to be the true owner of the document, as well is proven that the document has not been altered during transit (Tasca et al., 2017).

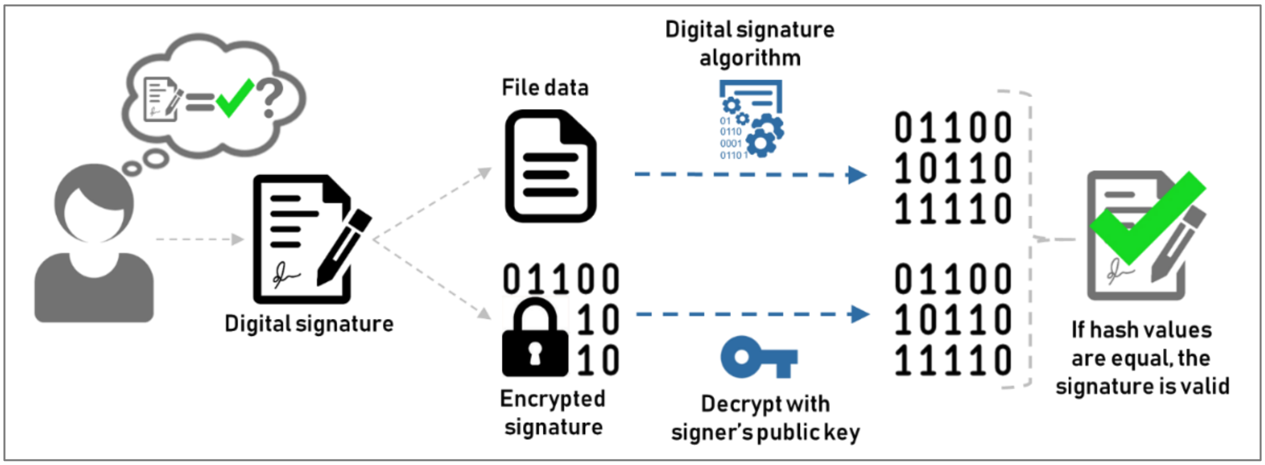


*Figure 9 | Verifying the validity of a digital signature*

An important note is that sometimes either the public key or the private key of a person is required, depending on the specific operation. A private key is not always used for decryption, nor is a public key: it depends on the situation what key is used for what purpose. The only fact that always remains the same is that when a private key is used for encryption, only the corresponding public key can decrypt the ciphertext, and vice versa. For example, the sender must have the recipient's public key to encrypt a document in such a way that only the recipient can open it with his or her private key. On the other hand, to digitally sign a message or transaction, it must have its own private key to encrypt the hash. To avoid confusion, Figure 10 shows which parties needs which key if the case of either signing or encrypting.

| | Sender has | Recipient has |
|---|---|---|
| Signing | Sender private key | Sender public key |
| Encrypting | Recipient public key | Recipient private key |

*Figure 10 | Overview of keyholders when signing and encrypting*

### 3.2.2 Dominant consensus mechanisms

*Proof-of-Work*

The POW algorithm provides a complex mathematical puzzle that is difficult, costly and time-consuming to solve, but can be easily verified by others. In the POW system, 'miners' compete to compute a number, called a *nonce*, and the first miner to compute this number is rewarded. POW thus uses computational power to add a set of transactions, known as a block, to the blockchain, and by doing so, it enhances cybersecurity through preventing DDoS-attacks.

Because miners are being rewarded per mined block, they are incentivized to work more efficiently over time. However, to only allow adding blocks every ±10 minutes, the nonce-to-be-computed becomes proportionally more difficult for each new block. This prevents that too many Bitcoins would be mined in a short period of time, which would devaluate the coins (LeMahieu, 2017; Tasca et al., 2017, p. 18).

*Proof-of-Stake*

The POS algorithm is an alternative consensus protocol, which was first introduced by Peercoin in 2012 (LeMahieu, 2017). It is an algorithm with the same goal as POW (i.e. verifying the legitimacy of the transactions), but the way to achieve this goal is different. Contrary to POW, there is no reward for computing a nonce in POS consensus mechanisms. Instead, the participant with the largest stake has the most voting weight and has the highest probability to be considered a trusted validator. This actor receives a fee for processing the transactions on the blockchain and is inherently incentivized to maintain the honesty of the system or risks losing its investment. The absence of extremely difficult puzzles saves a significant amount of energy compared to POW. To illustrate: a direct result of the POW method is the extra computing power needed to let the miners solve the computational problems, resulting in a current energy consumption annualizing nearly 40TWh (as much as the energy consumption in Qatar), which could get to circa 125 TWh in 2018 (in line with Argentina). This corresponds with 0,6% of the yearly world consumption (Swan, 2015; Tapscott & Tapscott, 2016; Morgan Stanley, 2018).

*Proof-of-Authority*

In the case of POA, certain egalitarian notions involved in other consensus methods are disposed and replaced by digital signatures and business contracts which are backed by the network. A set of authorities is empowered to collaborate 'trustlessly' insofar entities do not have to trust each other; a certain amount of trust is needed to appoint specific authorities with the ability to approve transactions. Some nodes are thus exclusively allowed to create new blocks to subsequently secure the network. POA algorithms fit best in environments that are not fully trustless (such as private networks with a certain relationship-basis, for example real estate transactions where the purchaser and vendor have a certain level of mutual trust) and where certain entities can be preselected to function as a validator in the network. As a result, the P2P-component of a blockchain is severely undermined with this method, as the network is not fully self-contained and independent of a central signing authority (Naumoff, 2017; Tasca et al., 2017, p. 19).

## 3.3 Transacting on the blockchain

### 3.3.1 Regular blockchain transactions: a step-wise explanation

Now that the principal concepts of blockchain are discussed, it is less difficult to grasp the idea of how transactions are executed on a blockchain. This sub-section provides a step-by-step explanation of the transaction process on a blockchain, with a simplified visualization in Figure 11. Note that a 'transaction' can be any transaction of data; it does not necessarily imply a transaction of value. Transactions are recorded on the blockchain according to the following steps as outlined by PWC (2016), Nakamoto (2008) and Gourarie (2017):

1. The sender creates a transaction and broadcasts it to nodes in the network. This transaction contains information about the recipient, and a digital signature to prove the authenticity of the transaction.
2. Each node in the network collects the newly broadcast transactions into a block and decrypts the digital signature. If the hashes of the signature and the file data mutually correspond and are not already spent, the authenticity of the transaction is considered valid.
3. The block, which is created in the previous step (containing a series of transactions), is broadcast to all nodes so that all participants in the entire ledger can now see and verify the block.
4. The nodes in the network receive the block and use cryptography techniques to verify the hash value of the block. If, and only if all transactions in the block are considered valid, the nodes accept the block.
5. Once the validity of the block is approved by the network, the nodes express their acceptance by adding a new block after the block that has just been accepted in the blockchain. This is encrypted and connected via hashes, thus can never be altered anymore. Subsequently, the nodes start working on creating the next block in the blockchain, which also occurs through linking the blocks using hashes of the block headers.

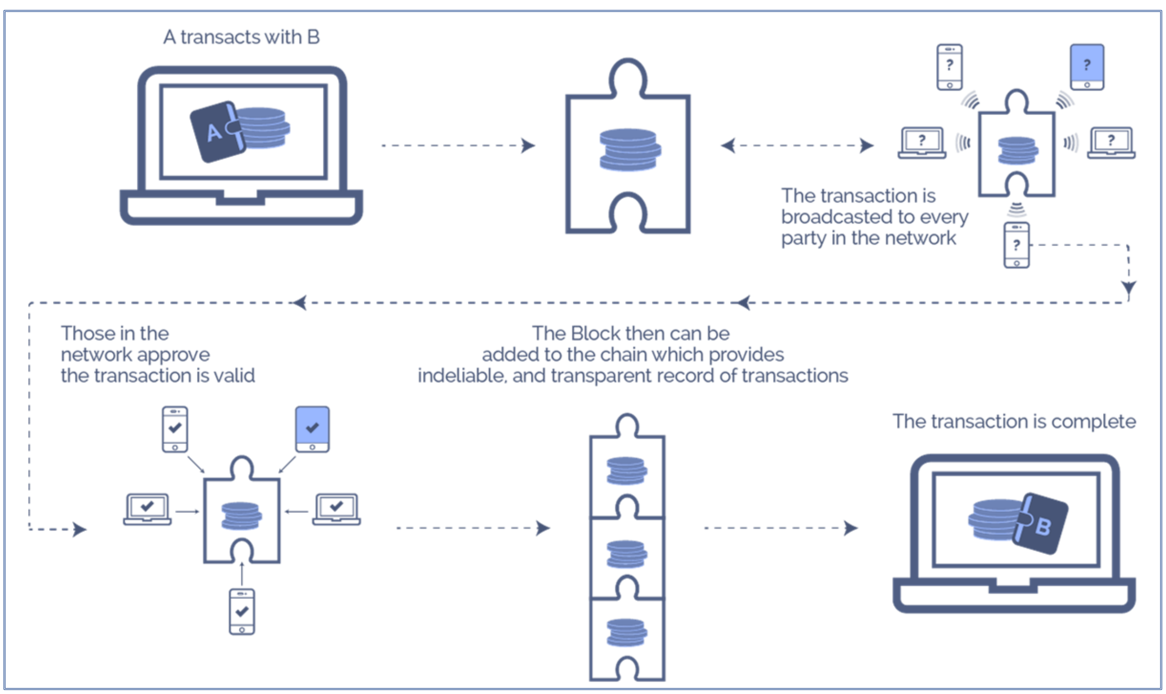


*Figure 11 | Visualization of a transaction on the blockchain, retrieved from Maven Wave (n.d.)*

### 3.3.2 Automated blockchain transactions: smart contracting

Giving birth to the second generation of blockchain, Ethereum founder Vitalik Buterin elaborated on the concept of 'smart' contracts by introducing Ethereum: a blockchain-based platform on which smart contracts can be programmed. Although smart contracts were theorized more than 20 years ago, the development of blockchain in recent years has rekindled excitement about the potential of smart contracts in various markets and industries (Werbach & Cornell, 2017, p. 313). In essence, smart contracts are 'systems that automatically move digital assets according to a set of arbitrary pre-specified rules' (Buterin, 2014, p. 1). Smart contracts are fully digital and consist of computer code that is programmed on the blockchain. These self-triggering contracts are automatically executed without the need for an intermediary and are impossible to change once recorded on the blockchain. Smart contracts can be multi-signed by multiple entities, using digital signatures.

The functioning of smart contracts can best be explained with a simple example. Suppose James wants to play blackjack on the internet with a random stranger, but lacks trust in the website and the reliability of his counterplayer. He decides to code a smart contract that automatically interprets the outcome of the blackjack games. In this smart contract, James and his counterplayer both agree with the prespecified rules of the game, place their bets by depositing an agreed amount of cryptocurrency, and sign the contract with their private keys. When the blackjack game ends, the smart contract is automatically triggered and executed, which in this case entails disbursing the profits to the winner of the game. Figure 12 illustrates what the code of the blackjack-example as described above would look like. As long as the content is properly programmable, smart contracts are useful for various purposes such as insurances, gambling (see example), rental contracts, supply chain management, mortgage loans, employment contracts, and much more.

```
/*
    CONSTRUCTOR
*/

function BlackJack(address deckAddress, address storageAddress, address seedAddress, address tokenAddress) {
    deck = Deck(deckAddress);
    storageContract = BlackJackStorage(storageAddress);
    seedContract = BlackJackSeed(seedAddress);
    token = ERC20(tokenAddress);
}

function () payable {

}

/*
    MAIN FUNCTIONS
*/

function deal(uint value, bytes32 seed)
    public
    gameFinished
    betIsSuitable(value)
    usedSeed(seed)
{
    if (!token.transferFrom(msg.sender, this, value)) {
        throw;
    }
```

*Figure 12 | Example of a smart contract code for blackjack, retrieved from DAO.Casino (2017)*

## 3.4 Benefits and implications of blockchain

Blockchain technology is often considered as a new technological revolution that can fundamentally change the way we transact and will strengthen the market role of individual consumers and producers. The interaction of the core components of blockchain as described in section 3.2 entails several potential benefits - and associated implications - compared to traditional databases and transaction systems (van den Hoven, 2018). This sub-section concisely discusses the most important benefits and implications of blockchain technology (depicted in green and red, respectively) and links these benefits to its core components, which are visualized in Figure 13. An important notice to take into consideration is that benefits and implications are mostly subjective according to the interpretation of the reader, and thus may differ per actor. The most obvious example is *disintermediation* in this case, which is presented as an advantage (for the ones who used to pay for middlemen), while positions of the intermediaries themselves are rather harmed by disintermediation. Based on a literature study, the following general benefits and implications are defined.

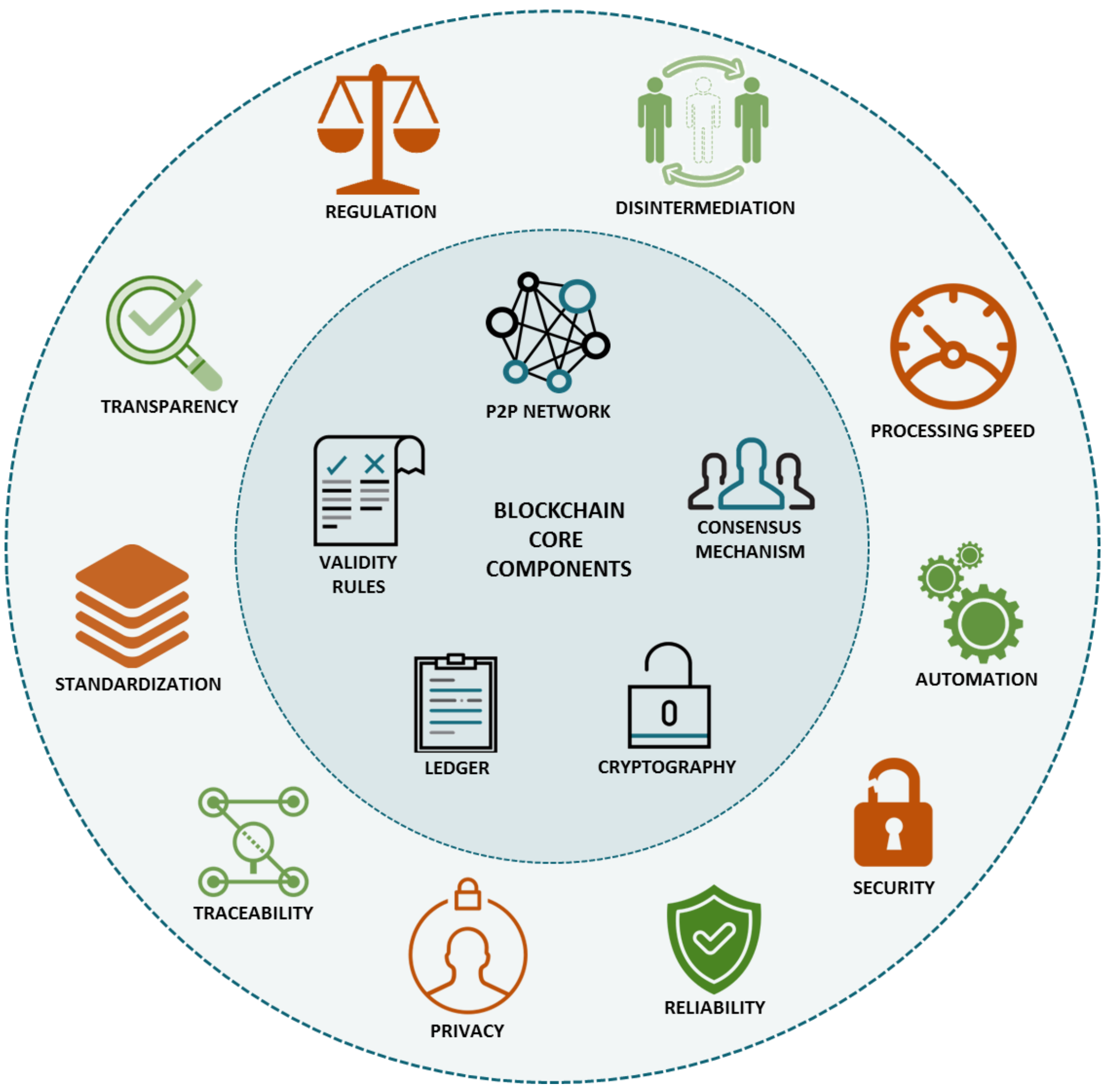


*Figure 13 | Blockchain core components with the inherent benefits and (current) implications*

- **Main benefits**
    - **Disintermediation:** Blockchains omit the necessity of trusted third parties as the P2P-component enables the network to function properly without intermediaries. This is primarily because blockchain is designed to operate in a trustless, decentralized environment, where participants are independent of third party verification when transacting value or data. Disintermediation is considered to be beneficial because some institutions believe that the removal of middlemen is closely tied to reducing the transaction costs as well as the counterparty risk (Hileman & Rauchs, 2017, p. 89).
    - **Automation:** Blockchain contributes to lessening manual involvement as it provides a so-called 'single source of truth' in which all information is encrypted and saved. Transactions in the blockchain are confirmed (or denied) automatically by the network, as well as the provision of information when requested. Moreover, smart contracts were introduced with the second generation of blockchain. These contracts can be programmed and are executed once the arbitrary pre-specified requirements are met. Automation is usually strongly correlated with disintermediation, as the role of intermediaries is often automated, but this is not always the case (Buterin, 2014).
    - **Reliability:** The cryptography-component of blockchain contributes to a significantly more secure and reliable way of storing data than conventional databases. The reliability of the network is inherent to the immutability of the entered data in the blockchain. Through hashing the transactions, which is in theory a one-way operation, the hashed information practically cannot be back computed, and thus are the blocks immutable and tamperproof. This is even more strengthened using timestamps and digital signatures. Through cryptography and the applied consensus mechanism, it is moreover impossible for malevolent actors to compromise the network (without a valid digital signature, private key, and transaction confirmations) by attempting to double spend or to alter information in the blocks, which in turn enhances the reliability of the network (van den Hoven, 2018).
    - **Transparency:** A frequently mentioned benefit of blockchain is the transparency that comes with the technology, which is mainly provided through the (distributed) ledger-component of the network. With all the information secure, visible and immutable on the blockchain, as well as the history of transactions (and data-exchanges), the transparency of information (and the trust establishment) can be greatly improved (PWC, 2016). Important to mention is that this concerns the transparency of the *data transactions,* and in case of a Bitcoin network: the *balances* of a wallet. However, the *owner* of a wallet is unknown, which in fact decreases transparency in this regard, compared to, for example, banks.
    - **Traceability:** Since the blockchain is an open, distributed P2P network, anyone can access the blockchain and follow the transactions on that blockchain. Therefore, the transparency and immutability contribute to the traceability of the transactions on the blockchain. The transparency and traceability of transactions allow regulators for improved regulatory compliance and supervision (Hileman & Rauchs, 2017, p. 79).

- **Main implications**
  - **Regulation:** How government regulation regarding blockchain unfolds could be a significant factor (and risk) in how blockchain will flourish into a well-functioning economy (Swan, 2015, p. 89). The EC is actively engaged in exploring the possibilities of blockchain as well as the potential limitations, in order to subsequently construct suitable regulatory framework. Besides, since blockchain operates in a P2P network, questions regarding responsibility arise as no predetermined actor is responsible for the authorized transactions in the network (van den Hoven, 2018).
  - **Processing speed:** Blockchain requires nodes to operate in order to be able to approve transaction requests. However, because many blockchain networks are new, the number of active nodes is insufficient for grand-scale implementation. Put differently, the transaction processing speed is often lacking for widespread usage, which is partly caused by the intensive communication needed to achieve consensus and to distribute information across the network. Ideally, transactions would be confirmed in a short time window (preferably less than a second), but the reality shows that transactions in Bitcoin and Ethereum sometimes require up to 45 or 15 minutes, respectively, depending on the number of required network confirmations before approving the transaction (Swan, 2015; Hileman & Rauchs, 2017). At the moment, the processing speed is widely examined and expected to be significantly increasing in the coming years. A promising example is Nano (up to 7000 transactions per second), a cryptocurrency that recently gained traction and is based on a *block-lattice* structure, where every account has its own blockchain (account-chain). These account-chains are updated immediately and asynchronously to the rest of the block lattice, which results in higher processing speed and quicker transactions (LeMahieu, 2017).
  - **Security:** Some proponents frequently argue that a blockchain is virtually unhackable due to the complex cryptography, distributed nature of the ledger and the enhanced intrinsic reliability of the network, but blockchain still copes with a number of potential security issues. The most worrisome is the chance of a 51%-attack, to which POW-systems are vulnerable. In the case of a 51%-attack, anyone with more than 51% of the total computing power could gain control over the blockchain network and in theory double-spend previously transacted coins to their own accounts (LeMahieu, 2017; McKinlay et al., 2018). This means, in the case of a POW consensus mechanism, that '*if 51% of the nodes lie, the lie would become the truth*', assuming all nodes have equal computing power. Moreover, private keys are used to decrypt encrypted data and to create digital signatures through encrypting the hash value of a document. These private keys are complex alphanumerical strings, which must be stored safely. If such a private key is lost - and no backup is made - then the owner has permanently lost his access to the data which could be decrypted with that specific private key. An additional threat to safeguarding the security of the network is quantum computing, a new type of computer where the processor uses the principles of quantum mechanics. This 'super computer', which can perform the same calculations in parallel over a very large quantity of data, could theoretically break digital signatures

through back computing the hash values, forge transactions and eventually steal coins by double spending these coins (Castor, 2017). Lastly, security breaches on cryptocurrency-exchanges have occurred in the past as well. In February 2018, about 17 million Nano disappeared from exchange Bitgrail and in 2014, and 850,000 Bitcoins were stolen when exchange Mt.Gox got hacked (van den Hoven, 2018). In late June 2018, another $31 million worth of cryptocurrencies was stolen from exchanges (Russosillo & Jeong, 2018).

- **Privacy:** Transactions of data on the blockchain are unambiguously verified, reducing the risk of system-related accounting errors. Although the data on public blockchains is encrypted and touted as anonymous, the high transparency and traceability in a blockchain are achieved at the expense of privacy. Assuming that the wallets one is using are not anonymous, the ability for authorities to track every transaction results in a loss of anonymity, potentially restraining actors from participating in a blockchain network. A variety of blockchain platforms (among which are Verge, Dash, Monero and ZCash) is dedicated to anticipating to this limitation and proposing alternative approaches to data encryption and storage in order to enable full anonymity. However, this is part of the design process: privacy and transparency/traceability are conflicting design trade-offs of a blockchain application (Yli-Huumo et al., 2016).
- **Standardization:** The last implication of blockchains, at least in their current state, is the lack of standardization. Various blockchain solutions are currently being developed and as a consequence, the technology offered is relatively untrusted (McKinlay et al., 2018, p. 7). Due to its overwhelming success, many types of blockchains with diverging layouts and purposes have emerged in a relatively short time span, since Bitcoin's first introduction a decade ago. This has resulted in multiple protocols that are unfit to collaborate or to interconnect, and thus have to operate separately (Hileman & Rauchs, 2017). Iansiti and Lakhani (2017) add that it will take decades for blockchain to seep into the economic and social infrastructure. To illustrate, they compare the adoption of blockchain with the distributed computer network technology, which laid the groundwork for the development of the internet. Considering the blockchain as a foundational technology rather than a 'disruptive' technology, Iansiti and Lakhani foresee multiple adoption phases which blockchain must go through (i.e. single use, localized use, substitution, transformation) to finally reshape the economy. Blockchain's development and standardization of applications are expected to eventually contribute to educating the community about its features and become more user-friendly over time.

## 3.5 Legal aspects of blockchain

With the introduction and rapid growth of blockchain, numerous legal questions and potential issues arise. Even though the legal framework falls outside the scope of this research, it is important to know the current state of regulations and to understand what aspects deserve extra attention in the case of designing a blockchain application. Hence, this sub-section concisely discusses the main areas of focus.

The European Commission (EC) has stated that the almost limitless list of potential use cases of blockchain makes it both very interesting and challenging and at the same time expressed its support for blockchain technology. However, many European institutions claim that blockchain is still a nascent technology and according to them it is therefore still too early for regulations. The EC wants to be able to make the distinction between a hype and a true opportunity that can improve lives of citizens and businesses, and therefore aims at launching more proof of concepts in various use cases among different domains before starting with regulations (Miseviciute, 2018). Nevertheless, behind the scenes, the EC aims to develop a common approach on blockchain technology for the European Union (EU) in the international area (European Commission, 2017). Furthermore, according to Mark Carney, chairman of the G20's Financial Stability Board, virtual currencies and blockchain technology pose no risk for the financial sector as of now. He stated this in a letter to the G20-countries and argued that there was no need yet to think of regulation (Suy, 2018).

Legal matters often affect the fundamentals of blockchain, depending on the context in which the blockchain application is used. Based on reports of legal experts such as van Heukelom et al. (2017), Berberich and Steiner (2016), and McKinlay et al. (2018), and in consultation with Lars Stevens, graduating on E-identities recorded on the blockchain, the key legal considerations are the following:

- A first question that arises is which law is applicable to blockchain transactions, which can cross jurisdictional boundaries because the nodes of the network can be located anywhere around the world. For instance, the Dutch civil right is applicable to a transaction within a blockchain that is used by Dutch citizens. However, in the case of a transaction from the Netherlands to Germany, it is conceivable that the German tax authorities levy taxes on that transaction under German tax law. Because only transactions within the Netherlands fall within the scope, in this research the Dutch civil law is applicable. Note that this only applies to situations in which the owners of the wallets are known to the authorities, which is in principle not the case (Hileman & Rauchs, 2017; McKinlay et al., 2018).
- To be triggered, smart contracts must operate in circumstances where it can be assumed that the provided information is accurate. Put differently, smart contracts are intolerant for information ambiguity and only function properly in the case that a consensus exists about the fact that the entered information is correct. Under Dutch civil law, an agreement is reached through offer and acceptance (clause 6:217 Civil Code), thus a smart contract can be a legally binding agreement (van Heukelom et al., 2017, p. 6). However, it is important to question whether signing parties genuinely understand what exact agreement is recorded in the code, because what if the agreement is entered in the blockchain and the will of one party does not correspond with the recorded agreement, or what if the execution of the smart contract is different than intended or expected? Besides, a smart contract does not necessarily have to be a legal agreement, but could also serve another legal significance (such as a unilateral execution of a contract, a suspensory or resolutive condition, or a unilateral act).
- A next question revolves around determining the legal owner of a blockchain. According to the Dutch law, one can only be a legal owner of matters that are susceptible for physical control (clause 5:1 in conjunction with 3:2 Civil Code) (van Heukelom et al., 2017, p. 5). A server that uses software qualifies as such, but the software itself does not. However, under the copyright law, it is possible to be a copyright owner of a blockchain. Public and private blockchains differ

here in the sense that for a public blockchain holds that the contributors own copy rights of each part that they coded, whereas a private blockchain is in most cases built by one party, which is automatically the copyright owner of that private blockchain. Therefore, it is usually relatively straightforward to designate the copyright owner.

- All transactions on a public blockchain are publicly visible, but this does not necessarily imply that the identity of the transaction sender and receiver are publicly known. In practice, this could lead to problems: if you do not know who you are transacting with, it is practically impossible to address this party in court if the transaction - for any reason – fails (for example: one 'zero' too much was entered and 10 bitcoins are transacted instead of the intended 1). This is different for private blockchains, where the identity of the counterparty is usually known (McKinlay et al., 2018).
- Processing personal data on a blockchain inevitably raises legal- and personal data protection issues. Especially since blockchains are almost immutable, no form of data can be deleted from a blockchain once entered. Trying to do so would result in a lack of consensus on the shared state of the ledger. This would be in direct contradiction with the privacy-by-design principles and the General Data Protection Regulation (GDPR) which embodies the "right to be forgotten". Hence, using a blockchain to store private data is unfeasible. A possible solution is to store data outside the blockchain (called 'off-chain'), only storing anonymized and cryptographically protected references to this data on the blockchain. Using these references, the data can be resolved, dereferenced or even deleted at will (Berberich & Steiner, 2016; Sullivan & Burger, 2017).

Blockchain technology is in its infancy and so is the related legislation. As awareness among policy makers is rising and the possible applications as well as legal implications are being investigated, the respective regulatory framework are expected to develop in the near future. Nevertheless, a few considerations regarding personal data protection, responsibility and data accessibility should be taken into account when thinking of the design of a blockchain application.

## 3.6 Determining suitable use cases for blockchain

Blockchain allows mutually mistrusting entities to transact with each other without relying on a trusted third party while at the same time providing transparency, integrity and protected (immutable) data storage. Although praised as a technological innovation that may revolutionize how the market and economy will perform, it is often questioned how applicable blockchain really is. Moreover, as blockchain expert Olivier Rikken (2018) stated, "even though we can think of multiple use cases, there are more cases in which blockchain is not *adding value* than cases in which it actually does". So, when is blockchain useful in the sense that it adds value and when is it not? In this section, a decision path is presented that supports decision makers with determining the suitability of a blockchain-based application given certain situations. Before doing so, the first sub-section outlines the properties of different blockchain types (i.e. public vs. private and permissioned vs. permissionless). Based on this analysis, the second sub-section discusses in what cases a blockchain is useful and if so, what type of blockchain would be most suitable. Finally, to prevent common misconceptions, the third sub-section establishes some dominant misconceptions and explains why these do not hold for blockchain.

### 3.6.1 Blockchain types: public, private, permissioned, permissionless

Depending on the purpose and the environment of the blockchain application, the designer must consider two important design options regarding the accessibility to read and write information on the blockchain. Participants of the blockchain can assume different roles (Wüst & Gervais, 2017, p. 1), namely:

- a *writer* is any entity that writes the state of the database, mostly corresponding to a participant that is involved in the consensus mechanism and helps to maintain and grow the blockchain, commonly referred to as a validator. The writer helps accumulating the transactions in blocks and subsequently helps appending full blocks to the blockchain.
- a *reader* is denoted as any entity that is not extending the blockchain, but participates in the blockchain by either reading, analyzing or auditing the blockchain.

An accurate elaboration and definition of public, private, permissionless and permissioned blockchains can be found in the work of Garzik (2015, p. 10). In essence, a public blockchain has no restrictions on **reading** blockchain data and on submitting transactions for inclusion into the blockchain. Contrarily, private blockchains maintain limited direct access to reading blockchain data and submitting transactions to a predefined list of allowed participants. With regards to the permission to **write** on the blockchain, a permissionless blockchain has no restrictions on identities of transaction processors (i.e. participants that are eligible to accumulate transactions and append the blocks to the blockchain). Clearly, opposed to a permissionless blockchain, transaction processing on a permissioned blockchain is performed by a predefined list of subjects with known identities. Figure 14 summarizes these design considerations into a blockchain typology based on the read and write access of participants. Note that a blockchain with permissionless write access and private read access is depicted as *not applicable*, since the combination of these design choices make it improbable that the blockchain would properly function. This is because in this case anyone could overwrite the data on the blockchain, but only the predefined list of actors with read access would be eligible to see the information on the blockchain.

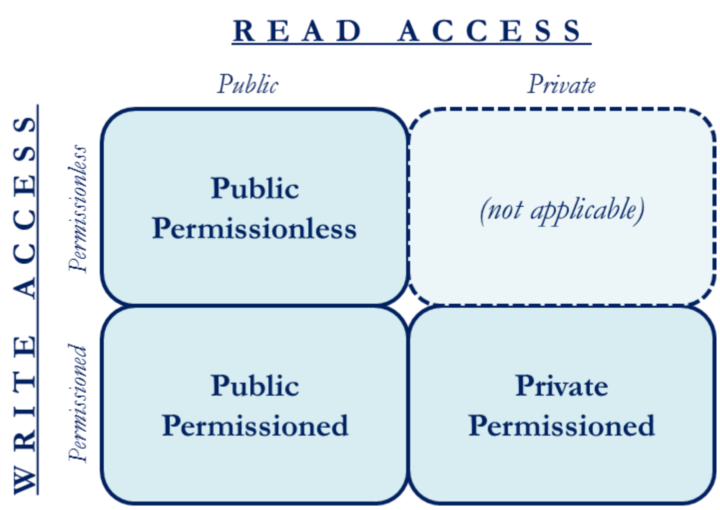


*Figure 14 | Different blockchain types, retrieved from van den Hoven (2018, p. 12)*

### 3.6.2 Decision path for blockchain applicability assessment

Section 3.3.2 extensively discussed the benefits and implications of blockchain according to the visualization in Figure 13. Although blockchain is frequently argued to increase transparency, automation, to disintermediate, and to increase traceability and reliability, it is not given that blockchain is genuinely the most suitable IT-solution for every use case in view of its limitations. This sub-section presents a decision path (see Figure 15), inspired by a combination of frameworks of Meunier (2018), and Wüst and Gervais (2017) (see Appendix I), and step-wise discusses the series of specific questions that have to be answered to determine whether blockchain is an suitable IT-solution given particular circumstances.

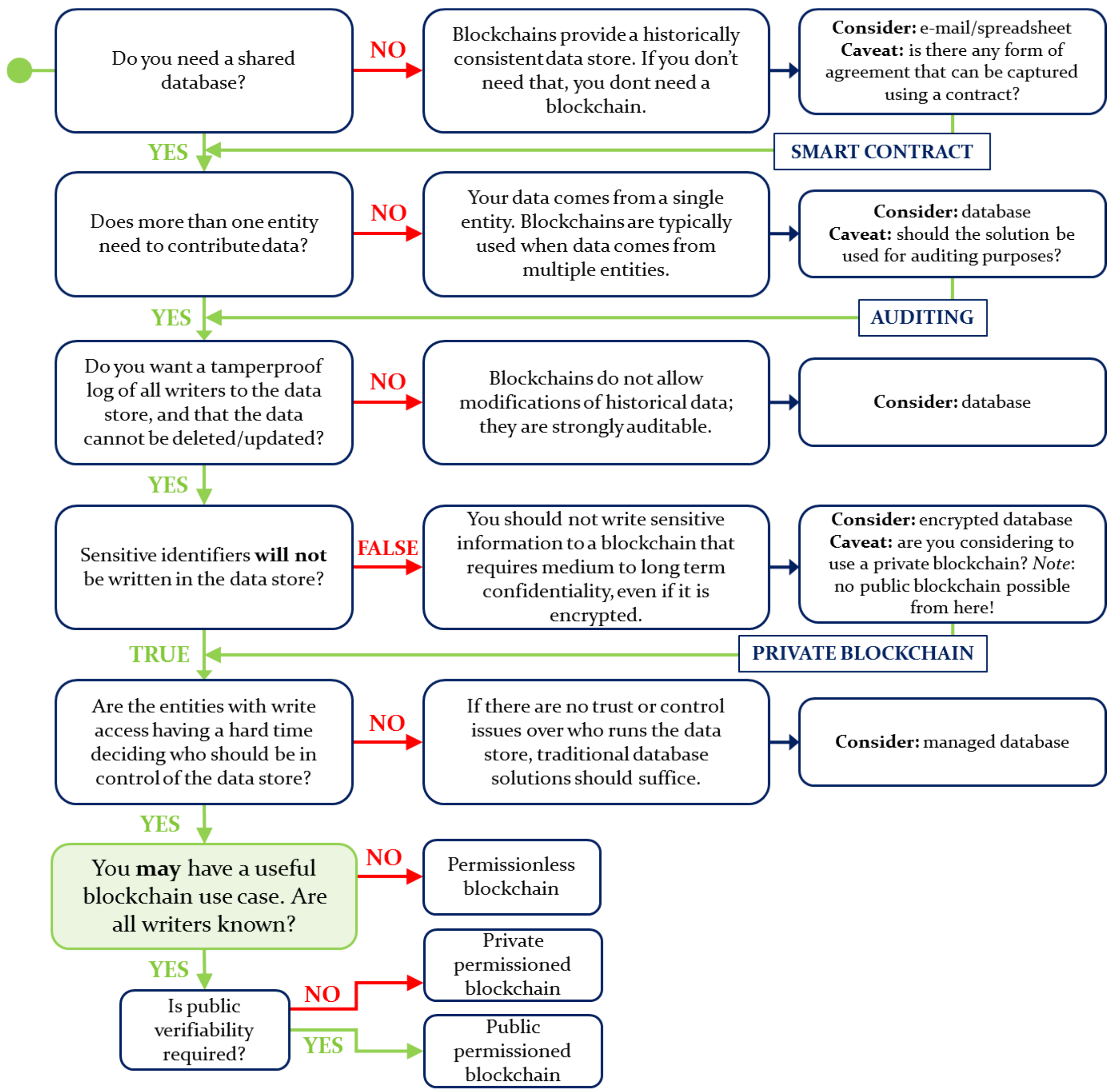


*Figure 15 | Decision path for determining blockchain applicability, source: own depiction*

First, it needs to be determined whether there is a need for a consistent, shared database. Blockchains provide a historically consistent data base as they are made immutable through applying cryptography. This is useful in cases where it is important to ensure that data cannot be altered. If this is not needed, e-mail or spreadsheets could be considered. Caveat: where a regular blockchain application requires a shared database, one can also opt for deploying a smart contract on the blockchain. In this case, the first question would be answered negatively, but it should still be proceeded to the next question if the answer to the following question is yes: 'Is there any form of agreement that can be captured using a contract?'. Note that this only applies to the case of smart contracts.

Second, it is questioned if more than one entity needs to contribute to the data store. Since blockchain is a P2P-network with a key feature that any (permitted) entity can add data to the distributed ledger, cases with only one entity do not require a blockchain; a regular database would suffice here. Note that this question can be skipped in case of auditing, because this would also work for one entity as well as for multiple entities.

Third, blockchains have the characteristic that they are immutable: once entered, the data cannot be altered. Because blockchains do not allow modifications of historical data, it must be questioned if the data should be able to delete or modify. If so, a regular blockchain would not apply. However, there are some ways to circumvent this, through for example working with hyperlinks to off-chain data that can be deleted or updated at will.

A fourth question revolves around the sensitivity of the data, thus the context of the data that is to be recorded in the blockchain. Since the blockchain provides full transparency (assuming a public, permissionless blockchain, like the one of Bitcoin), sensitive data should not be stored on a blockchain, even when it is encrypted. An encrypted database, only accessible to permissioned entities, would be more suitable here. However, this would not account for a private blockchain because a private blockchain is not publicly accessible.

Fifthly, if the entities with write access can easily agree upon who should be in control of the data store, thus when there is trust among the participants, a blockchain would not be best-suited in this case. Blockchains are emphatically designed (and suitable) for trustless environments. A managed database would suit better in this case.

If until now all the questions have been answered with 'yes' (or 'true'), then a blockchain-based application is likely to be suitable for the concerning case. If the writers are known, a (public) permissionless blockchain would be most suitable. Lastly, it should be questioned if public verifiability is required. In that case, a public permissioned blockchain is recommended, and if not the case, a private permissioned blockchain.

### 3.6.3 Rectification of common misconceptions about blockchain

After the explosive growth of the cryptocurrency market cap and the vast number of scientific articles about blockchain, it is safe to assume that blockchain is somewhere around the top of its hype cycle. There are many situations in which conventional databases, encrypted or not, seem to be more suitable than a blockchain-based application. Still, partly because the technology is so novel and currently tremendously hyped, there exist some misconceptions about the potential of blockchain that need to be rectified. This sub-section briefly mentions four major misconceptions and explains why they do not hold for blockchain.

### *Misconception 1: Blockchain makes entries on the ledger trustworthy*

There is a common confusion about the validity of the data recorded in the blockchain. Blockchains are particularly suitable for the transfer of assets or data native to the blockchain, but a blockchain cannot assess whether certain entered data from the 'outside world' is accurate or not. In other words, the *truth* of the contents of the ledger is an entirely different matter: blockchain does not magically make the entered data itself trustworthy, let alone the writers of the data (Wilson, 2016). This is in accordance with the garbage in, garbage out (GIGO) principle: information ambiguity should be assumed as a given; if the input is inaccurate, blockchain will treat it as any other input, hash it and record the mere hash value in the blocks. Blockchain only assures that the data is not changed. Therefore, a consensus about the validity of the entered data is important (for example by a trusted third party) in order to assure that true information is recorded in the blockchain. As long as there is no efficacious governance, it must be accepted that the application requires tolerance for information ambiguity.

### *Misconception 2: All documents and cryptocurrency are saved on the blockchain*

When taking a close look at blockchain, it turns out that blockchain does not do what most people think it does. Generally, there is nothing (in terms of documents or cryptocurrencies) 'on' the blockchain, but all it holds is a record of data- or cryptocurrency-movements and the associated metadata. The only authoritative record of anyone's cryptocurrency balance is recorded on the blockchain. The same accounts for documents: the blockchain has no data stored on the blockchain, but rather a package of transaction- or document hashes. Storing documents (PDF, Word, Excel, etc.) on the blockchain would require too much storage space and become impractical for peers and participants to download (Wilson, 2016). This thus means that on the blockchain, it is only visible whether data has changed for the hashed documents, but it cannot be retrieved what the data was before. Also, once the data itself is destroyed, it is not possible to recover the data using the hash value as saved on the blockchain.

### *Misconception 3: Blockchains are entirely trustless*

Blockchains do help reduce the need for trust and also allow the participants to transact in a trustless environment, but it is not true that they completely remove the need for trust (Meijer, 2017). Namely, at the bare minimum, trust is placed in the underlying cryptography, the validators of the network (which are automated nodes), the software developers, and the parties that are involved in the consensus process. In the case of a permissioned blockchain, the network is not fully decentralized because not every actor is allowed to participate in the network. This blockchain type enables participants to independently validate transactions and verify the state of the network, but with a (certain) minimum amount of trust (Hileman & Rauchs, 2017, pp. 17-18).

### *Misconception 4: Blockchains are immutable, 'tamper-proof' and 100% secure*

Like blockchains are not entirely trustless, they are also not absolutely immutable, nor 100% secure. The 'immutable transactions'-illusion stems from its append-only data structure in which it is suggested that data can only be added to, but not removed from, the blockchain. However, theoretically, in the case of a 51%-attack, blocks comprising transactions can be reversed. In the case of private blockchains, this may even be easier since it is less difficult to achieve 51% of the hash rate as the network of a private blockchain usually contains less participants than a public blockchain. To prevent blocks containing transactions from being reversed and transactions from being altered or cancelled, private blockchain actors are usually bound by legal contracts and agreements that dis-incentivize the participants to collude or perform other types of malicious activities. In general, the higher the level of decentralization of a blockchain network, i.e. the more the hash power is distributed among pool-less miners, the more the blockchain can be considered tamper-resistant. This is inherent to the security of the blockchain network: cryptography is applied for authentication, permission enforcement, integrity verification and other activities on a blockchain, but cryptography does not automatically enhance the network security. The network may be increasingly resilient as data storage is more distributed, but compromising private keys of network participants could provide attackers with full access to the shared database, including the ability of a 51% attack. Therefore, decentralization and a proper management of private keys is of crucial importance to maintain network secure (Hileman & Rauchs, 2017, pp. 17-18).

## 3.7 Conclusions of Chapter 3

Based on the literature study as outlined in this chapter, the first sub question can be answered: *'What are the core components of blockchain technology and how can it be determined whether a blockchain-based solution is applicable for a given use case?'*. Five core components of blockchain technology are found: 1) ledger, 2) P2P network, 3) cryptography, 4) consensus mechanism, and 5) validity rules. Blockchain is a distributed *ledger* that is updated synchronously among all participants of the network. This network requires no trusted third party to validate transactions, enabling participants to make direct, peer-to-peer transactions in a so-called *P2P network*. Transactions in this P2P network are validated according to the standards of a specific *consensus mechanism*, a means of achieving consensus as to the validity of a transaction. The consensus is reached if, and only if, the transaction complies with a predetermined set of *validity rules*. In order to achieve consensus, participants must be able to trust each other, even if they are mutually unknown. Trust is therefore created and based on *cryptographic* proof. Once consensus is reached about the validity of a transaction, a new block containing that transaction is added to the chain of blocks and cannot be altered or deleted anymore based on the applied cryptography.

The insights derived from the first part of the question are used to answer the second part: '… *and how can it be determined whether a blockchain-based solution is applicable for a given use case?'*. Blockchain is defined by a combination of the abovementioned core components, leading to ancillary benefits of blockchain technology, such as potential disintermediation, automation, increased reliability, traceability and transparency of data. However, it is found that a blockchain-based application is not the most suitable solution for every given use case. Depending on certain case-specific properties, blockchain is either a suitable solution that outperforms conventional solutions, or not. This can be determined based on the decision path as presented in Figure 15. If the following questions can be answered positively (with 'yes' or 'true'), a blockchain-based solution is expectedly suitable for the given use case:

- Do you need a shared database? Caveat: smart contract
- Does more than one entity need to contribute data?
- Do you want a tamperproof log of all writers to the data store, and that the data cannot be deleted/updated?
- Sensitive data will **not** be written in the data store?
- Are the entities with write access having a hard time deciding who should be in control of the data store?

Subsequently, following the same decision path, it can be determined what type of blockchain would fit best given the situation. If the writers are known, a (public) permissionless blockchain would be most suitable. If not, it should be questioned if public verifiability is required. In that case, a public permissioned blockchain is recommended, and if not, a private permissioned blockchain fits best. The decision path resulting from this chapter is used in order to determine whether blockchain would be a suitable solution to lower the transaction costs incurred during commercial real estate transactions. But to assess that, the next chapter first explains what commercial real estate is, how a due diligence process fits within commercial real estate transactions and how the transaction costs in such a due diligence process are allocated.

# 4 DUE DILIGENCE PROCESSES IN COMMERCIAL REAL ESTATE TRANSACTIONS

Purchasing shares on a stock market differs fundamentally from acquiring (commercial) real estate properties in several ways. For example, a share is a homogeneous product that is more frequently traded with a predetermined market price. However, the characteristics of real estate make the acquisition process of real estate relatively complex and labor-intensive. As Williamson (1979, p. 234) eloquently stated when explaining transaction costs, '*the assessment of transaction costs is a comparative institutional undertaking*.' Transaction costs should be identified through comparing an activity with other similar activities, rather than observing them without any reference.

This chapter aims at providing an adequate answer to the second sub-question, which is formulated as follows: *"How is a due diligence process positioned within a CRE transaction and what are relevant characteristics, phases and transaction costs of a due diligence process?"*. To do so, this chapter extensively discusses the characteristics of real estate and how these are different from other investment classes such as shares (section 4.1), followed by an explanation of the function of a due diligence investigation and a justification why it is needed, particularly in large commercial real estate transactions (section 4.2). Next, the chapter combines the previous findings and therewith zooms in on the transaction costs to break down the allocation of transaction costs incurred during the DD process (section 4.3). For a better understanding of the Dutch CRE market, see Appendix III. Finally, the last section answers the abovementioned research question and concludes this chapter.

## 4.1 Introduction to the types and characteristics of real estate

### 4.1.1 Definition and types of real estate

The significance of the real estate market is demonstrated by the fact that it has been estimated to represent approximately one-half of the world's total economic wealth (Ling & Archer, 2012, p. 2). But what is real estate? When people think about real estate, they mostly think of their homes or the office building they work in, but real estate is more than just buildings. The Oxford Dictionary (2018) defines real estate as "a property consisting of land or buildings". It is a piece of land plus natural or artificial improvements attached or added to that land. Among these natural and artificial improvements are for example trees, oil, sidewalks, buildings, minerals, raw materials, or contamination; anything that would normally be considered part of the land. A commonly less understood concept is the term 'real property', which refers to real estate with the addition of a bundle of rights. This bundle of rights is comprised of the five different rights of a property owner; the right to possess, control, enjoy, exclude and to dispose (Segal, 2018).

Within the world of real estate, property assets can be assigned to different categories. Investopedia (n.d.) defines commercial, residential and industrial real estate as the major categories. In general, commercial real estate is exploitation-driven and revolves around generating income for the investor; it is solely used for business purposes and is leased out to function as a working space rather than a living space for the occupier. By way of contrast, residential real estate has in principle no profit objective for the investor and is used for living purposes by the occupier, and industrial real estate is used for the manufacture and production of goods. However, the leasing and renting of residential real estate has been growing steadily over the past 5 years, which in fact falls under commercial real estate because it adjudicates a profit motive. Amadeo (2018) adds 'land' as a fourth type of real estate, covering vacant land, working farms and ranches. This research focuses on commercial real estate, which is used with the purpose of producing income. Instances of commercial real estate are: office buildings, restaurants, hotels, shopping malls, leasing and renting of residential, et cetera.

### 4.1.2 Fundamental characteristics of real estate

The characteristics of real estate assets are unique in such a way that they differentiate real estate from other investment products such as shares. The two primary characteristics of real estate are immobility and heterogeneity. Although these characteristics are *physical* in nature, they impact the economics of the marketplace (Ambrose & Lusht, 2008, p. 2). Consequentially, Ling and Archer (2012, pp. 13-15) define localized markets, segmented markets and privately negotiated transactions with high transaction costs as the *non-physical* characteristics of real estate assets. These five characteristics are elaborated below.

- **Heterogeneous assets:** In contrast to homogeneous products such as shares and gasoline, real estate is heterogeneous of nature. This implies that each real estate asset has unique features like the age, size, building design, and the location. The latter heavily determines the value of a property; prices per square meter in the inner city of Amsterdam are significantly higher than in the rural area of Friesland. A result is that real estate markets are localized, as elucidated below.
- **Immobility:** A second characteristic that differentiates real estate from other assets is its immobility. This increases the importance of the property's location, which in turn contributes to the heterogeneity of real estate assets. The difference in location of properties is explained by the immobility of real estate and is a large factor in explaining land use patterns and values. When acquiring real estate, it is therefore important to take the accessibility (partly depending on the available infrastructure) into consideration: for households, the important factors are school, work, and shopping centers, while commercial properties should be rather accessible to clients, employees or suppliers.
- **Localized markets:** Clearly, the immobility of real estate is associated with localized markets. Competition from other real estate assets is often limited to properties located in the direct vicinity. This is evident for a neighborhood shopping center, where the market is considerably localized, since one is not willing to drive an hour extra for cheaper milk or apples. By a way of contrast, some properties with a commercial purpose can be more 'footloose', which implies that the exact location only matters to a small extent. For those properties, users may be willing to travel a greater distance within a certain metropolitan area or even among multiple metropolitan areas.
- **Segmented markets:** Heterogeneous products contribute to the market segmentation, which occurs based on both price and quality (or features) in CRE markets. Features of a property are important, because a household that is searching for a two-person apartment will generally not consider a property with 5 bed rooms, let alone a property with a built-in office space. The

price of properties also segments residential and commercial real estate markets. CRE markets are segmented by both users and investors; more valuable or costly properties are often referred to as institutional-grade or investment-grade properties. This segment, with property values exceeding €20 million, is often targeted by institutional rather than private investors and is specifically important for this research.

- **Privately negotiated transactions with notably high transaction costs:** Real estate is a complex asset class associated with complicated transactions. The bundle of rights attached to each property cannot be standardized due to the heterogeneity of real estate, which invokes case-specific legal constructions and warranties. Moreover, transaction costs increase as real estate agents, lawyers, tax specialists, appraisers, technical experts and property inspectors are usually involved in a transaction process of CRE. Additionally, the negotiation process between the buyer, the seller, their lawyers, and their advisors can be lengthy and cumbersome, driving up the costs of the transaction itself even further. Thus, there are costs and time requirements in nearly every CRE transaction that are absent in transactions of other asset classes, which are predominantly caused by the involvement of a vast amount of trusted third parties.

In addition to the five characteristics as described above, Geltner et al. (2001, pp. 11-13) and Vazquez (2015) argue that real estate is illiquid because it cannot be 'easily and immediately sold without a substantial loss in value'. Illiquidity thus means that it is generally not possible to determine today that you want to sell your property tomorrow due to incurred transaction costs for finding an investor and closing the deal. Because these costs are mostly charged to the purchaser, the illiquidity contributes to making real estate a fairly stable and appreciating asset class for medium- to long-term investors. Where public markets are liquid (i.e. asset share prices can adjust rapidly to relevant news for their value), private markets do not feature the ability to quickly respond to relevant news. This is commonly referred to as market informational inefficiency: the inefficient way of sharing property-related information in CRE transaction processes drives up the transaction costs incurred during the transactions. Inherent to this is the inelastic supply curve in the short to medium term, an often-mentioned characteristic of real estate assets, causing the relatively slow reaction of supply changes in demand. Figure 16 visualizes our view on the first- and second order characteristics of real estate and schematically elucidates their interconnection.

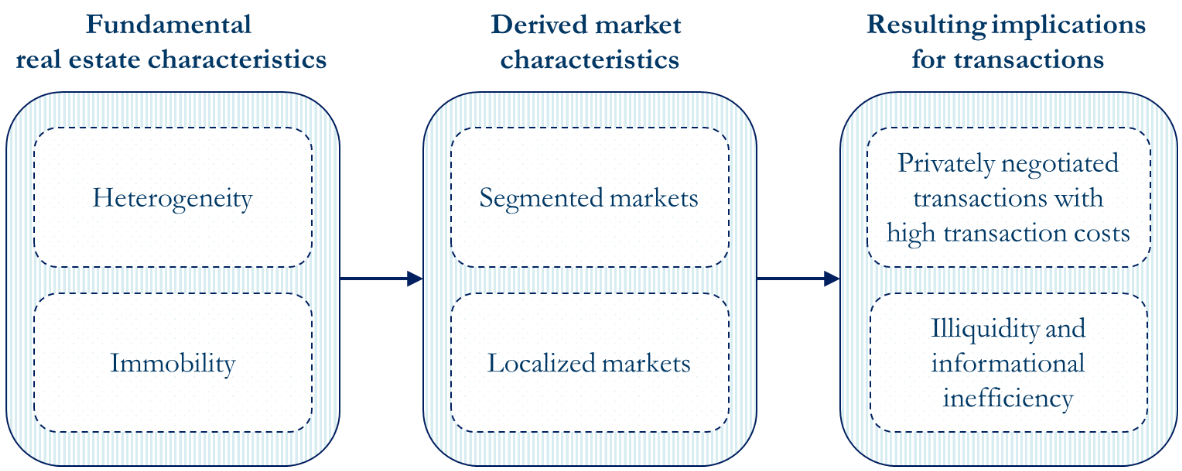


*Figure 16 | Influence of fundamental real estate characteristics on the market*

Finally, the space market and the asset market are typically distinguished. The space market is the market for the usage of real estate and describes the physical nature of real estate. The characteristics of the space market are often tied to its ultimate use; the 'residential' space market is used for housing and the 'offices' space market is used for commercial purposes and to conduct businesses. The space market is often referred to as the rental market or the usage market. Due to the immobility of real estate, space markets are segmented and bound to the location of the properties. The observable price in the space market comprises two components: rents and occupancy. According to the fundamental law of economics, this price is determined by the interaction of supply of existing real estate and the ultimate end users who determine the demand for space. A last noteworthy characteristic of the space market is the shape of the supply curve. Normally, the traditional supply curve is upward sloping (i.e. higher prices lead to greater supply), but for this market, the short term real estate supply curve is kinked, reflecting a fixed nature of the market (Ambrose & Lusht, 2008, p. 9). Thus, the space market is illiquid, there exists a slow price-discovery mechanism, and the supply of real estate cannot expand instantaneously to reflect changes in user demand. This results in potential, location-bound imbalances in supply and demand. The asset market is equally important and often referred to as the property or investment market. This is the market for ownership and investment activities of real estate assets. Because, from an economic perspective, future cash flows and yield requirements play a decisive role (e.g. the rents assets can generate and the risk associated with those assumptions), as these assets compete in the capital market with stocks and bonds. Therefore, the real estate asset market is part of the capital market, in which assets of all types are traded. The asset market is linked with the space market through the expected future cash flows of the real estate properties. The rental price is determined in the space market by the demand of tenants and supply of real estate, whereas at the same time certain buildings are bought and transacted in the asset market. To conclude, the space market is of fundamental importance as it determines the rental prices and occupancy, which is an essential input value for the cash flow that determines the value and the yield of a property in the asset market (DiPasquale & Wheaton, 1992, p. 181; Geltner et al., 2001).

With the abovementioned characteristics, a comprehensive overview of real estate has been drafted. However, it is important to specify why real estate differs from shares, in order to give better understanding of why CRE due diligence processes are so complex and accompanied with such high transaction costs. Therefore, these differences are elucidated in Table 4 based on a comparison between the characteristics of real estate and the characteristics of shares. Taking the fundamental differences into consideration, as stated in the rightmost column, it can be concluded that real estate is fundamentally different from other asset classes, which explains the lengthy and cumbersome transaction processes as currently encountered.

*Table 4 | Comparison of characteristics of real estate and shares, source: own depiction*

| Real Estate | Shares | Explanation of difference |
|---|---|---|
| Heterogeneity | Homogeneity | Shares are homogeneous in the sense that no difference is made between one and another, whereas real estate properties are mutually different due to property specific locations, ages, sizes, materials, et cetera. |
| Immobility | Mobility | Shares are non-physical assets and thus not bound to certain locations. They can in fact be transported to the other side of the world within seconds, contrary to real estate, which is location-bound. |
| Localized markets | Geologically independent markets | For shares applies that theoretically, aside from any regulations, the Chinese market can directly compete with the Dutch exchange market. Stock exchange markets are thus geologically independent, inherently linked to the mobility-characteristic. |
| Segmented markets | Partially segmented markets | Shares are homogeneous assets, so the respective markets are not segmented. However, looking at the bigger picture: clearly a distinction can be made between a share of ABN AMRO Bank and its competitors (e.g. ING Bank), which therefore partially segments the market. |
| Privately negotiated | No negotiation possible | The market price is given as a function of supply and demand in the case of shares. No negotiation is needed because products are mutually homogeneous (contrary to real estate properties): "your share is not worth more than your neighbor's share". |
| Illiquidity | Liquidity | Where real estate properties cannot be standardized due to heterogeneity, shares can. This implies that no third parties are required to draft case-specific contracts and lengthy negotiation processes are omitted. Therefore, shares are liquid: easily tradable against a predetermined market price at any given moment, without cumbersome DD processes. |

In line with the characteristics as delineated in section 4.1.2, Stapenhorst and Just (2018) define four factors based on which real estate can differ: the location (immobility), asset class (heterogeneity), financing and risk-return. The first two factors have been addressed already. The third factor, financing, is about the fact that real estate transactions are bulky by definition. Financing can be classified according to the underlying financing structures. Generally, there are five ways to finance a real estate acquisition, assigned to the following three categories:

- **Equity-based financing**
    - Public equity (via exchange-traded vehicles)
    - Private equity
- **Debt-based financing**
    - Public debt (asset- or mortgage-backed security)
    - Private debt (bank loans, debt funds, leasing)
- **Mezzanine**
    - Convertible mortgage or participating mortgage

Distinguishing the financing structures underpinning real estate transactions is important because the associated transaction costs are different. Bank loans in a debt-based financing structure, for example, are issued after the bank has thoroughly checked the loaner. This can be seen as a customer DD (checking creditworthiness and compliance check), which in turn entails transaction costs (De Nederlansche Bank, 2012). By way of contrast, family businesses usually have private capital to invest with (equity based financing) and logically do not have to perform a compliance DD of themselves.

The fourth and last factor on which real estate transactions can differ, is the expected risk-return of a property. The risk-return is largely determined by the asset class and the location of the property, but the structure of the tenancy, vacancy and the quality of the design also play an important role. As a rule of thumb, a low risk investment comes with a low return. Figure 17 depicts a classification of four investment types in terms of risk-return as used in the CRE industry. Core properties have a low expected risk, thus a low expected return. The lower the risk and return, the more attractive the investment opportunity becomes. However, this classification is not always a good help as the categories are determined on the basis of historical data, while this is not a guaranteed mirror of the future (Stapenhorst & Just, 2018, p. 5). The intensity of a DD process is commonly related to the risk-return of a property. Less information available during the DD period means more uncertainty, thus more assumptions, resulting in more risk taken by the purchaser. Consequently, an investor will demand a higher return to compensate for the risk taken.

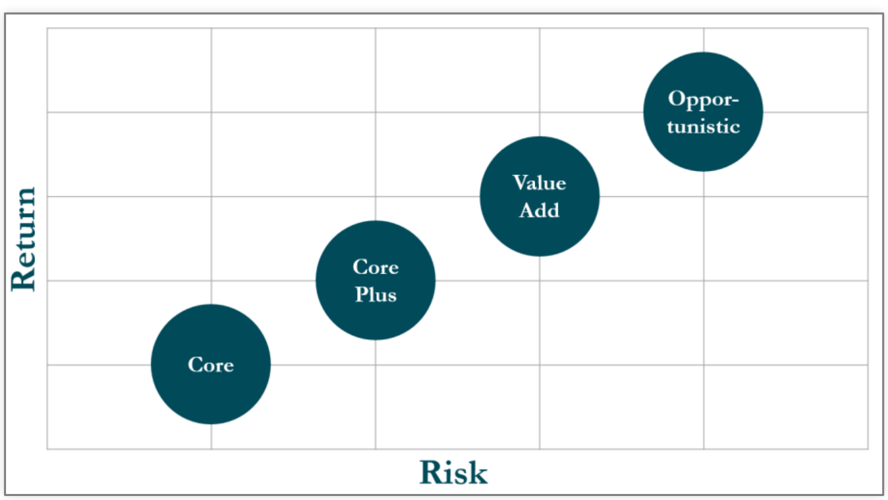


*Figure 17 | Classification of real estate investments based on risk and return*

### 4.1.3 Transacting real estate

Before diving deeper into the process of transacting real estate, it is important to distinguish the real estate transaction process from the transaction process in financial markets. Where real estate assets are heterogeneous and thinly traded over relatively long holding periods, the classical financial market is exactly the opposite: a homogeneous and thickly traded market. Prices are determined by market clearing and for any product there is an unrestricted availability of buyers and sellers at the market price, since they are homogeneous. Market prices exist at any given time in financial markets, whereas prices are privately negotiated in a real estate market. Concretely, the offered price by the buyer should be at least the same price as the seller's reservation price - i.e. the price for which they are willing to sell their asset - otherwise the transaction will not be executed. Another difference is that commercial real estate investors not only face price risk, but also marketing period risk as they sometimes have to wait significant amounts of time before having found a potential buyer (Lin & Vandell, 2007, p. 297).

Because real estate transactions are seemingly different, there is no unambiguous step-by-step list to follow in order to do a transaction. Literature differentiates various, mostly overlapping, stages within real estate transactions. Crowston and Wigand (1999) defined five stages; listing, searching, evaluation, negotiation and execution. During the listing stage, in case of an on-market opportunity, the potential sellers put their property on the market. Second, the searching phase starts, where potential buyers review the properties on the market to find those that might be suitable in terms of location, price, size, and other characteristics. In the third phase, the properties are evaluated, often after a walk-through and a technical inspection of the building. Then, if the property is found to be desirable, the negotiation phase starts. The potential buyer here makes an offer based on an initial evaluation of the property. As the negotiation phase is a highly strategic phase, the buyer often involves an advisor into the process. Eventually, in the last stage, the sale can be closed after all contractual issues are resolved: the execution of the deal. Likewise for the negotiation phase, this last phase usually includes a trusted third party to streamline the process, mostly a lawyer or notary. Shimizu et al. (2016) agree with this, but add that the advisor is normally involved from the beginning to help the seller with a property valuation and starts marketing after having determined the reservation price of the seller. In line with the abovementioned categorization, Dijkstra (2017, pp. 50-52) divides the CRE transaction process into four stages: preparation period, marketing period, due diligence period and exchange to completion.

The transaction process of real estate is largely comparable with that of shares, except for the negotiation phase due to the homogeneity of shares. The other phases are largely similar: the vendor decides to sell his shares and offers them on the market for a predetermined reservation price. A potential investor researches investment information about the concerned shares, reviews balance sheets, annual reports and other relevant financial ratios. When the results are satisfactory, the investor decides to buy the shares for a by him determined price. As soon as his price meets the price of the vendor, the shares are transacted for the agreed price. If the offered price is lower than the reservation price, the transaction is not executed and one of the parties must adjust its bidding/asking price to let the transaction succeed. For shares, the due diligence period is usually a matter of a couple of hours reading and investigating, without necessarily involvement of financial advisors. However, for real estate, this is different: the due diligence period is often associated with high transaction costs; €100,000, sometimes exceeding a million euros for a professional due diligence is no exception (Dijkstra, 2017, p. 52).

## 4.2 The DD process in CRE transactions

A detailed description of real estate, its characteristics and how real estate is transacted is provided in the previous section. Every real estate transaction process is different due to the heterogeneous characteristic of real estate. As a result, no unambiguous definition of the phases of a real estate transaction could be given. Even though literature describes various (overlapping) phases of a real estate transaction, the due diligence process is often explicitly mentioned as a separate phase. This section aims at diving deeper into the concept and raison d'être of due diligence in CRE transactions.

This section discusses the function, types, involved actors and the phases of a due diligence process. To gather useful information about the due diligence process in Dutch CRE transactions, a number of institutional investors is interviewed. The following topics were included in the interviews: function, goal, types, phases, involved actors, costs, duration, inefficiencies, and desired situation. The results, together with a literature study, are elaborated in this section. For a more detailed – yet anonymized – overview of the interview results, see Appendix V.

### 4.2.1 Goal and function of due diligence

If you would ask a real estate investor or transaction manager what due diligence is, it is variously described as a time-consuming, boring, and expensive process in which a significant amount of money is spent to finally hear something that they already knew. But what is it exactly? The term 'due diligence' describes a process in which is a detailed examination, analysis and assessment of the circumstances of the property in fact and in law are conducted (Stapenhorst & Just, 2018). As the DD process is increasingly getting important in capital markets, it resembles more and more the corporate transaction, both in direct (asset deal) and indirect (share deal) investments. Hennessey (2015, pp. 8-9) defines the purpose of the DD process as "to discover the potential problems with a property, reveal any hidden profit potential, and verify all information that you have obtained". Howson (2017) stated that there is no dictionary definition of due diligence, nor a standard legal definition, but he claims that it is the way that buyers make sure they understand exactly what they are buying, and deal makers might add that it also revolves around reducing execution risk (i.e. the risk of an acquisition that fails). However, there are multiple definitions at hand of the due diligence process. Lajoux and Elson (2010) cite some definitions that stem from the legal origins of due diligence, and note that the precise origins of diligence clearly go back to the Roman law concept of diligentia, in Dutch translated as 'ijver' (zeal) or 'zorgvuldigheid' (diligence, care). Diligence can be low, high, common, ordinary, reasonable, proper, utmost, but an obvious question that arises is: what is meant with *due* diligence? Simply said: it depends. Some circumstances require a *low* diligence, others require a *proper* or *thorough* diligence. Hence, it is a question of the context and subject's complexity how diligently the process must be performed.

The starting point of a DD process is, according to Stapenhorst and Just (2018), the information gap between the potential parties to the transaction contract. Both seller and buyer can initiate a DD, which differ from each other due to the difference in their interest. Hence, the function and objective of a

DD depend on the perspective one is looking from: the seller is often not tempted to reveal strategic information about the property, whereas the buyer aims at obtaining as much relevant information as possible. That being said, the overall function of a DD process is "to determine, analyze, assess and control various risks and the opportunities connected with them" (Stapenhorst & Just, 2018). For this research, the objective of a DD process in general is defined as 'to analyze and identify the risks and opportunities of acquiring a certain real estate property, in order to be able to make a well-substantiated decision whether to buy the property or not.' This is in line with the responses of the interviewees, who described the objective as 'risk management', 'know-what-you-buy', 'gaining insight into the real estate you wish to buy', and 'determining whether the property fits within the long-term perspective you have, as an institutional investor' (see Appendix V).

### 4.2.2 Types of due diligence

DD processes are far from uniform around the world. Roughly, they can be categorized into two distinct forms: the 'Anglo-Saxon' process (USA, Europe) comprises comprehensive legal and financial DD and a significant disclosure before signing an agreement. On the other hand, there are non-Western processes (Middle-East, Asia) which mainly aim at building trust, often leading to provisional agreements (Rosenbloom, 2010). Clearly, this research focuses on the Anglo-Saxon type of DD processes in which contracts and agreements are emphatically signed and agreed upon.

#### *4.2.2.1 Who is the initiator?*

According to Stapenhorst and Just (2018), a seller's DD process can be divided into reverse DD, pre-sale DD or a vendor-side DD (VDD). The commonly used term and form is a VDD, which is used in case the seller has the objective to either lighten the administrative burden of the potential investors, to make the bids of the potential investors comparable, and to remove own uncertainties concerning the property. One respondent endorsed this and pointed out the risk that when certain relevant information is not known among all the bidders, that the highest bidder might refrain from his bid as he finds out that, e.g., the property contains asbestos. A result would then be that the vendor has to come crawling back to the second, or even third highest bidder, who in turn probably either lower their bid, or as well refrain from the deal. Contrary to the VDD, most DDs are initiated by the potential investors. This is regularly referred to as a buy-side DD. Figure 18 shows the categorization of DDs based on the initiator, as discussed above.

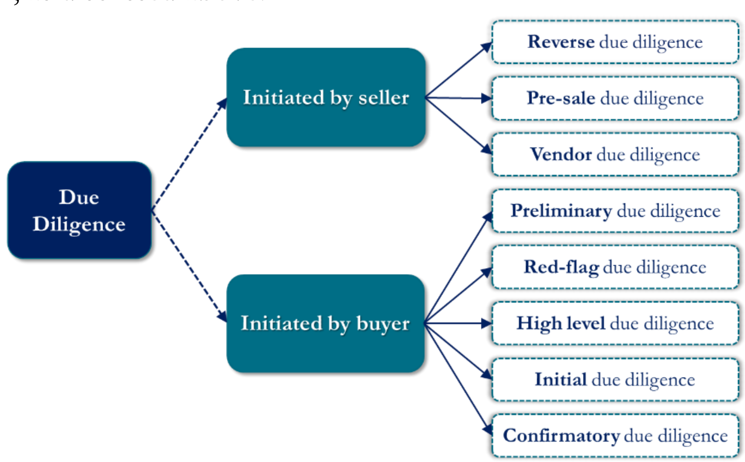


*Figure 18 | Categorization of DDs based on initiator*

It is commonly not sufficient to (merely) conduct a VDD and because the buyer usually requires more information than the seller initially provides. Hence, the buy-side DD processes are the focal point of this research. Preliminary or initial DD consists of assessing the information as presented in the IM or teaser and usually takes place before the official DD period commences. Red-flag DD is in this study considered as a phase within the DD process (called red flag assessment), where experts assess the severity of identified red flags in terms of potential to 'break' the deal. High level DD is, as the name suggests, not into detail but conducted in order to be able to quickly assess the viability of the investment and the fit within the portfolio strategy. Lastly, confirmatory DD is conducted by the buyer during the official DD period: it mainly centers around confirming and validating assumptions made by the seller (i.e. generally de information as presented in the IM). In essence, this DD-type is comparable with the DD process that starts after signing the LOI and ends with signing the SPA.

#### *4.2.2.2 What is the status of the building?*

A second distinction made by the respondents revolves around the status of the property, which can roughly be *new development* or *existing*. The history of the property is inherent to its age, and so is the amount and availability of documentation associated with a building.

There is a difference between buying standing investments and making a turnkey purchase. The latter implies a process where the seller still has to develop the building and therefore does not yet have all documentation in order. Example: there are no sprinkler certificates yet, because the building is not yet there. Instead of involving that into a DD, the buyer mostly postpones it and checks it as the time goes by. However, the buyer tries to ensure that the turnkey agreement covers all the relevant aspects so that there is zero development risk. According to the respondents, the biggest differences between new development and existing buildings can be defined as follows:

- In a DD process regarding a new development building, the buyer tries to influence the design process to let it fit within their requirements and strategy, whilst in the case of an existing building, the buyer rather assesses the documents to determine if it fits within their strategy. For existing buildings, the buyer seeks to identify deficiencies and shortcomings of the building, whereas for new development the focus is more on determining: 'What do I buy, does it comply with the requirements and the zoning plan? I need a professional to consider these technical construction drawings.'
- The advantage of turnkey new development buildings over existing buildings is that 1) the buyer can influence the design process through incorporating their program of requirements and 2) the buyer is assured that the information obtained is accurate and up-to-date and therefore reduces the risk of unforeseen circumstances. The disadvantage is that the DD process for new development buildings takes longer because of the lengthy design and development phase, in which the buyer seeks multiple moments to negotiate. In the case of existing buildings; if the vendor has properly organized the data room (an online tool where the vendor and his advisors put confidential information at the disposal of the purchaser during an agreed period), the DD process tends to be much less time consuming.

- Regarding new development buildings, not all documentation is available (such as elevator certificates and fire safety certificates), because certain permits and certificates can only be issued once this has been physically tested. On the other hand, in existing buildings, certain documentation is often lacking or untraceable due to the use of multiple information management systems, resulting in an incomplete data room.

#### *4.2.2.3 From what discipline is the DD performed?*

Howson (2017) distinguishes a plethora of DD types, including financial, legal, commercial, human resources, management, pension, tax, environment, information technology (IT), technical, operational, property, antitrust and insurance/risk. In any DD process, some of these types may be more important than others, dependent on the type of investment, the interests of the seller, the requirements of the buyer and the information at hand. According to Lajoux and Elson (2010), a DD process regarding real estate should cover at least commercial, technical and legal aspects. This has been validated by interviews with transaction- and acquisition managers from different institutional investment companies. Some respondents noted that, besides commercial, legal and technical, two more types should be taken into consideration; environmental and fiscal, although it was later added that these could be partially classified amongst technical and legal, respectively. Corresponding with this, Stapenhorst and Just (2018, p. 12) state that usually in practice, there is no strict delimitation, rather a purposeful overlapping of several disciplines. Assuming that these five (commercial, technical, legal, environmental, and fiscal) are the most relevant types of DD in a CRE transaction, the function and objective per DD type follows in Table 5.

Note that since this research focuses on institutional investors, there is an important DD type that is performed prior to signing the letter of intent (LOI) and prior to commencing with the other DD types. This is the compliance DD (also called KYC process, customer DD or client DD). Compliance DD revolves around thoroughly checking the counterparty in order to be sure that one is doing business with well-functioning and bona fide companies. It is not property- or tenant-bound, yet an important first step before executing the DDs as described below.

*Table 5 | Function and objective per relevant DD type*

| Type DD | Function | Objective (buy-side perspective) |
|---|---|---|
| **Commercial** | Provide information on the commercial well-being and economic opportunity of the specific property through investigating all the relevant commercial documents. | Reducing information asymmetry between buyer and seller, supporting the valuation, reducing risk for decision makers, identifying adequate risk mitigation measures and supporting the strategic rationale of the buyer. |
| **Legal** | Provide legal security for the findings being decisive and forming the basis for the entrepreneurial, business and commercial decision of the buyer. | Limiting the liability of the acting persons and the contracting parties. Buyer tries to avoid situations in which disadvantageous circumstances remain unknown as a result of negligence on his part. The Anglo-Saxon legal principle ‘caveat emptor’ stresses this; it is in principal up to the buyer to know the ins and outs of the property. |

| Type DD | Function | Objective (buy-side perspective) |
|---|---|---|
| **Technical** | Gaining a proper understanding of the condition, the status and the context of the property in order to reduce the information asymmetry between the buyer and the seller. | Assisting the buyer in making adequate decisions by gathering, assessing and evaluating all relevant technical information regarding the property that could have an impact (be it material or financial) on the planned transaction, given the specific circumstances, the timeframe, the information at hand and the budget for the DD. |
| **Fiscal (tax)** | Provide fiscal security in the transaction of real estate, regarding both asset and share deals, and optimize the tax structure of the property and the transaction. | Identifying financial risks connected to the relevant properties or companies so as to take them into account for the calculation of the purchase price or to cover them by demanding additional securities. |
| **Environmental** | Provide information about the environmental impact and footprint of the building, the energy performance certificate (EPC), compliance with regulations and liabilities. | Objectively assessing the environmental impacts, environmental issues and the compliance with regulation in order to subsequently determine the business consequences as a result of past, current and future organizational activities. |

### 4.2.3 Phases of the due diligence process

A variety of due diligence types is outlined in the previous sections. Especially when taking the characteristics of real estate into consideration, it logically follows that there is no one universal DD format that prescribes the required phases of every DD process. According to the respondents, the composition of phases in a DD process primarily depends on the following variables:

- Initiating party of the DD; vendor (VDD) or buyer (buy-side DD)
- DD type: commercial, legal, technical, environmental, fiscal, a combination, or otherwise
- Property status: new development buildings or existing buildings
- Relationship, history and experiences between buyer and seller
- Size, value and other relevant characteristics of the property
- Purpose of the asset: industrial, residential, commercial, and then: office, retail, hotel, et cetera
- The marketing of the property; off-market requires more own assumptions than on-market
- Nature of selling (counter-)party: private investors tend to provide ill-structured information in contrast to institutional investors, who attach more value to well-organized administration
- The market conjuncture; is it a seller's or a buyer's market? Influences 'as is where is' deals vs. additional guarantees required by purchaser

The brainstorm session resulted in a draft customer journey that distinguishes six separate phases within the DD process (pre-DD, collect data, data structuring, check data, considering substantive risks, negotiating), is depicted in Figure 29 in Appendix II. For each sub phase, a description is provided as well as the involved actors, the associated needs, the feelings and barriers. This customer journey is used as a discussion topic for validation during the interviews, but because it is from an advisor's perspective, it turned out not to be fully applicable to and corresponding with the perception of the interviewees (i.e. a potential investor). The respondents agreed to a certain extent with the presented DD phases and described what activities are undertaken during each phase. The comments and dissenting opinions of the respondents are succinctly described below.

- Data collection should not be considered a separate phase; the buyer wishes to be facilitated by the vendor or sales broker: 'You should tell me what information is relevant, I am not going to collect it'.
- Data structuring is something that in principle the vendor should do, but can more or less be defined as a separate phase because the buyer (or purchase broker) is often burdened with the associated administrative hassle.
- Controlling whether the data (i.e. documents) is complete and accurate should not be defined as a separate phase: 'as a buyer, you may assume that the data is accurate'. This is also recorded in the LOI as a disclaimer, as one of the respondents said: "It's your building, you are going to sell it. I don't have a report of your building, so you tell me what data is correct and if it is complete".
- Phases run parallel rather than sequential, otherwise the process becomes very time consuming.
- In addition: technical, commercial and legal DDs run parallel as well (especially with existing buildings; with new development buildings, this is often more phased).
- Pre-DD is also called 'acquisition phase' or 'market analysis'; as a buyer, you search around and work towards exclusivity. Then, the official DD (and associated spending) starts.
- Negotiating is not really a phase that comes at the end of the DD period; you run your DD and at the same time, you negotiate about red flags. Formally, negotiations take place in the beginning (LOI phase) and indeed in the end, if interesting things show up (SPA renegotiation phase). So, you start with negotiating, this lasts for the entire process, and it only stops when signing the SPA.
- After pre-DD, the LOI is drafted and signed, and only then the buyer or purchase broker starts collecting, checking and assessing data. In general, the DD does not start without guaranteed exclusivity and a signed LOI or Head of Terms (HoT).

Based on the expert brainstorm, a literature review and the abovementioned feedback of the interviewees, the seven phases of a DD process are defined (sales process, market analysis, commercial negotiations + signing LOI, data check, red flag assessment, SPA negotiations, and closing the deal: signing the SPA). These phases are extensively elaborated below.

### *Phase 1: Sales process (from a seller's perspective)*

According to the respondents, a first distinction should be made between an on-market and an off-market disposition. In the case of an on-market opportunity, the buyer is often provided with basic information (through an investment memorandum (IM) or a teaser) and assumptions regarding commerce or rents. When a property is for sale off-market, the buyer has to make his own assumptions regarding the commercial field. For now, it is assumed that the property is marketed, thus it is assumed that the buyer receives an IM or teaser with basic information. Moreover, as discussed earlier, sometimes the seller performs a VDD that provides relevant information to all potential buyers and reduces information asymmetry, so that the bids are more or less aligned. In some cases, this makes certain activities as described below unnecessary. On the other hand, the buyer apparently rather pays extra and has certain aspects double-checked, than fully trusting the VDD report provided by the selling party and being confronted with biased or inaccurate information in the end. For that reason, it is assumed that no VDD has taken place, and even if it has, the buyer still follows protocol (duty of investigation) and lets its own advisors perform the entire DD. It is however important to distinguish a VDD from the 'homework' of the seller prior to the due diligence, which predominantly comprises gathering and structuring the relevant data, preparing the data room and drafting an IM or teaser with preliminary information. Setting up a marketing strategy, making assumptions about the expected price of the property and assessing the property's salability come under the homework of the vendor, and is also done during the preparation phase.

Detailed information about the sales process can usually be found in a separate process letter, which is sent to the qualified parties along with the IM or teaser and the non-disclosure agreement (NDA) in order for buyers to access the data room. The process letter describes the time schedule of the DD period as well as the requirements of each step in the sub phases of the DD. The package of information that is sent to each potential buyer at the end of the first phase, comprises at least the following documents (Stapenhorst & Just, 2018, p. 13):

- IM or teaser with preliminary information about the property or portfolio
- Fact sheet per property
- Rent roll (separate from IM) and often a list of expected capital expenditures (CAPEX), if technical VDD is performed

*Phase 2: Market analysis (pre-DD phase)*

When the IM and required documents are ready to be distributed, the vendor or sales broker approaches a number of potential investors. With the presentation of the IM or teaser, the pre-DD phase commences, often referred to as the market analysis phase. In many cases, the purchasing party makes sure that this phase is completed in-house, i.e. without the involvement of third advising parties. However, in some cases a commercial advisor is needed to draft the LOI and support with the bidding rounds. Mostly, as described in the process letter, the potential buyers have predetermined period (e.g. 6 weeks) to finalize the pre-DD and come up with an initial bid. The potential investors now start researching the property (or portfolio) for sale. All available (public) data, next to what is presented in the IM, is collected in order the gain preliminary understanding of the property at stake. Several aspects and key indicators are assessed and calculated, such as rent rolls, yields, expected cash flows, tenant credit ratings and covenants (Chamber of Commerce (CoC), financial statements), the property status and counterparty compliance- or know-your-customer (KYC) checks. In some cases, an appraiser or broker is involved to make general assumptions, but not to make a thorough taxation. Further considerations are among others the location: does the investor purchase at all at the given location? What are the location-related facilities, accessibility and reachability? Does the property fit within the long-term strategy and the portfolio direction? Does it meet the yield requirements? Is this type of investment (core, core plus, opportunistic, value add) supported by the investment committee? In the end, the investor determines the investment intention: is the investor willing to further investigate this opportunity, or are there in advance already indications to refrain from the deal without further research? If, and only if, the investor decides that the preliminary results are positive and that there are substantiated indications to engage into a further investigation, an initial bid and subsequently a LOI (also called a HoT, a term sheet or a memorandum of understanding) is drafted to formally express the intention to buy the property.

*Phase 3: Commercial negotiations + signing LOI*

With the investor's decision to further investigate the property, this phase commences. First, the purchaser discusses the detected red flags with the vendor and negotiates about the red flags or about the price. When the outcome is successful for both parties, the investor wants to formally express its intention to buy the property under reservation of the DD results and board approvals. Often in a market like we encounter now (seller's market), before the investor drafts a LOI, there is a round of initial bids of multiple potential buyers. During this period, the potential buyers separately bid on the property and the sales broker or vendor determine the highest bids. After one, two or sometimes three bidding rounds, one 'winner' with the highest bid is chosen. This party then drafts a LOI and generally includes the following matters in this document (Stapenhorst & Just, 2018, p. 30):

- The name of the purchaser, vendor, property, land registry and area
- The leased status, ultimate transfer date and deal structure (asset deal or share deal)
- The bidding price with a definition of the incentives, costs, turnover tax, transfer tax, conditions purchaser and conditions purchaser & vendor
- Amounts in escrow, the involved notary, delivery status and confidentiality agreements (NDA)
- The bid is non-binding and under reservation of the DD results, red flags and board approval
- The official DD period commences only when the data room is complete and all information is correct
- The period of the DD is a certain number of weeks (mostly six)
- During the DD period, the undersigned buyer enjoys exclusivity, which means that there are no other potential buyers that conduct a DD at the same time
- Undersigned buyer assumes that all information in the data room is complete and accurate; sometimes a liability statement is included as a security for the buyer
- The bid is renegotiable under provision of the DD results and identified red flags
- Certain resolutive clauses with respect to the bidding price are included in the LOI

If the vendor agrees with the terms and conditions in the proposed LOI, the document is signed by both the vendor and purchaser. After signing the LOI, the DD period officially starts. The potential purchaser now enjoys exclusivity and selects legal and technical advisors. The broker is often already involved in the process of bidding and drafting the LOI. The selection of advisors is predominantly based on internal experiences, price, reputation, and tendering. This selection process also entails making price agreements with the (to be) selected advisors.

*Phase 4: Data check*

The DD period officially commences after signing the LOI. The data room is now opened by the sales broker or the vendor (or data is sent via data sharing systems, such as WeTransfer), as well as a Q&A list. When the data room is opened, the purchaser or purchase broker checks if all required information is available; a first check on completeness. The purchaser in principle assumes that all relevant information is available and provided by the vendor. Yet, in practice it turns out that there are always missing or incomplete documents. For this reason, the Q&A list is set up to ensure that all questions arising during the process and answered accordingly. The Q&A list is sent over between buyer and seller throughout the entire DD process. In the meantime, the purchaser and his advisors check all available documents on ambiguities and identify any substantial risks, called 'red flags'. After checking the data, the (mostly technical) advisors usually physically inspect the building. At this stage, they have interpreted the information and know what aspects of the building must be taken into consideration.

*Phase 5: Red flag assessment*

After the data check, mostly in week 4 of the official DD process, the red flag assessment phase starts. At this moment, the advisors determine the severity of the identified risks and decide whether they are of fundamental risk for the viability of the deal (so called deal breakers or show stoppers). These *potential* deal breakers are defined as red flags and are listed in a red flag report. First, the red flag report is presented to the purchaser and an internal go/no-go decision takes place after a superficial assessment. In general, three outcomes are possible: 1) severe red flags identified; purchaser refrains from the deal, 2) mediocre red flags identified; purchaser plans to require additional guarantees for red flags or a decrease in price, or 3) no/insignificant red flags detected; purchaser skips renegotiating based on red flags and uses LOI as input for the SPA. The treatment of red flags differs per investor, their experience and the type of real estate they wish to purchase in terms of risk-return. For some investors, red flags are priced in the initial bidding price as recorded in the LOI, while other investors tend to refrain from a deal, because the risk increases due to red flags, in turn causing their investment committee (IC) to reject the proposal. These parties are often looking for a stable mid- to long-term cash flow for 10-20 years, instead of a risky but highly profitable cash flow for the short term.

*Phase 6: SPA negotiations*

SPA negotiations commence after the red flags are identified by the purchase broker and subsequently internally assessed as 'negotiable' and not of fundamental importance for the viability of the deal. The purchaser and his advisor now reach out to the vendor and his advisor with the question for explanation or clarification for any ambiguities or potential red flags, which is discussed during the red flag meeting. In the case of many red flags, the purchaser renegotiates the purchase price as mentioned in the LOI or requires additional guarantees from the vendor (e.g. a certain amount in escrow to remove asbestos). After these negotiations, the purchaser must internally request an approval for the acquisition. The bidder who was granted exclusivity is then requested to submit the final bid in the mark-up version of the SPA, which is stored in the data room by the vendor.

### *Phase 7: Closing the deal; signing the SPA*

At the moment that the purchaser formally receives an approval from their board, IC, or shareholders, the purchaser brings out a final bid as requested by the seller. This best and final bid comprises a binding offer to the seller for acquisition of the real estate. The notarization of the final negotiated SPA follows and then the SPA is ready to be signed by both buyer and seller. Usually, the binding offer contains the following elements (Stapenhorst & Just, 2018, p. 46):

- Name and legal form of the bidder
- Information on the holding structure
- The binding purchase price offer, take into consideration that ancillary transaction costs are borne by the purchaser
- Binding proof of financing
- Mark-up version of the draft SPA
- A statement of approval by the board (and sometimes investment committee and shareholders)

In some cases, the SPA includes the setup of an escrow for additional guarantees or promises by the vendor (e.g. removal of asbestos, cleaning polluted soil, et cetera). The SPA is only valid if it has been notarized and executed by notarial deed, which must include the entire SPA with all ancillary agreements. Formally, the agreement on the SPA of a property is closed after the title has been changed in the land registry. The DD period ends with closing the SPA, and the conditionality and exclusivity of the buyer expire.

The entire DD process with all outlined phases is visualized in Figure 19.

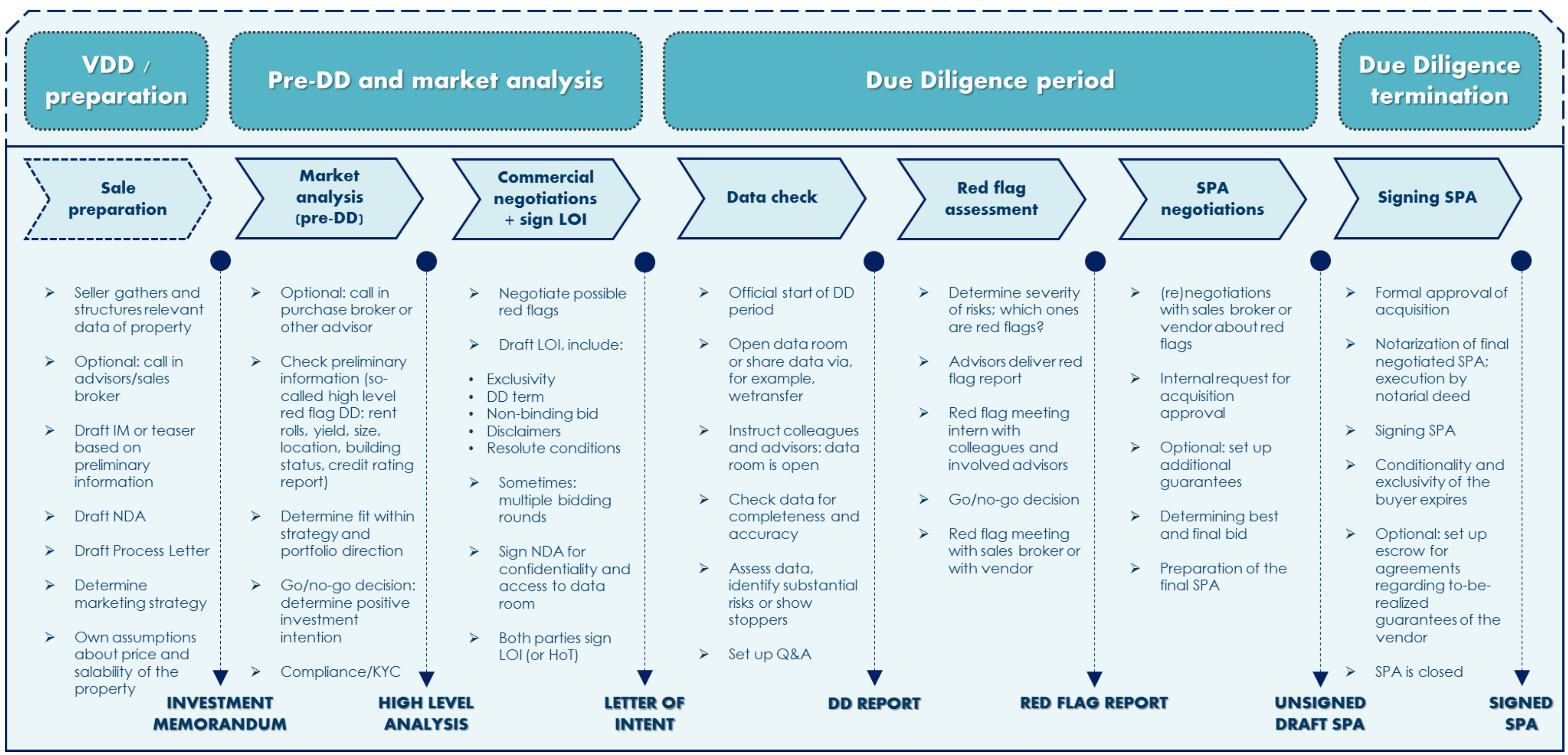


*Figure 19 | Final phasing of the DD process*

### 4.2.4 Tools used for DD

The interviewees pointed out that the tools (i.e. IT-solutions and programs) used during due diligence trajectories are widely varying. Most respondents indicated that depending on the advisor, the type of tools or data rooms are set up, but that this is not initiated by the investors themselves. In most cases, the investors have their own DD-checklists, i.e. a list with required documents, that need to be filled at bare minimum in order to start with the DD period, although it seems that the more experienced transaction managers do not use a DD-checklist, but know the required documents by heart. When specifically asked for tools or IT-solutions, mostly document-management systems were mentioned and types of data rooms, such as Yardi, I-Rooms, T-Rooms, Virtual Volts, WeTransfer for sharing documents, Property Network, Governance Web and SharePoint. Notably, Q&A lists and Excel were also indicated as 'currently used DD tools', which are clearly not IT-solutions that are particularly designed for DD-processes, but by default are considered as the tools that are currently in use. This clearly demonstrates that there is no one single system that works best for every party.

### 4.2.5 Actors involved in the DD process

The transaction process of real estate, and particularly the DD process, involves various actors with diverging interests, means and perspectives. The DD process is a multi-actor environment because it is presumed that no individual single actor can unilaterally impose their desired solution onto the others. Involved actors are interdependent because some form of cooperation is required (Enserink et al., 2010, p. 79). With respect to the design considerations of an intervention, an actor analysis is useful to create ideas for alternative strategies and tactics. This helps the designer to identify common ground, shared values and conflicting interests, as well as possibilities for compensation or to mitigate these conflicting interests.

The customer experience of the investors is mainly determined by the time, costs and effort that are required for a successful DD process. As the main research question aims at decreasing transaction costs, the actor analysis is predominantly focused on identifying actors that are directly impacting (or affected by) in- or decreasing transaction costs of the entire DD process. Taking this into consideration, the following selection of the most important actors has been made:

- **Investor**: Investors commit capital in real estate with the aim of financial returns. A distinction is made between private and institutional investors. Due to the changing role of actors, the investor can assume two important roles: the role of purchaser and the role of vendor. This distinction is important since the interests of a buyer are also influenced by its future role as a vendor. Therefore, institutional investors are subdivided into two actors:
    - **Purchaser**: the purchaser buys real estate as an investment in return for annual cash flows from tenants and for a potential future increase in value of the property (Dijkstra, 2017, p. 49). Contrary to the vendor, the purchaser aims at paying the lowest possible price on the one hand, but wants to be certain (commercial, legal and technical) that his expectations about the purchase are fulfilled (Stapenhorst & Just, 2018, p. 8).
    - **Vendor**: the investor who determines to sell his property or portfolio assumes the role of vendor. According to the respondents, big Dutch institutional investors mostly sell properties between the €20 million and €200 million and therefore their interest is in

obtaining a highest possible market-conform counter value with a secure transaction and legal certainty.

- **Broker**: The main task of a broker is to bring demand and supply in the real estate markets together, both in space and asset markets. Depending on the role of their client, a broker can assume two distinct roles, namely a purchase- and a sales broker.
  - **Purchase broker**: this actor acts in the acquisition process on behalf of the purchaser. The purchase broker reviews and analyzes local listings to determine what properties are best suited in accordance with the purchaser's preferences. This actor is often involved throughout the entire DD process and helps the purchaser with drafting LOIs, bidding, strategic negotiating, identifying and assessing red flags, and negotiating about the SPA. The purchase broker usually works on a 'no cure no pay' basis and charges a certain percentage of the transaction price.
  - **Sales broker**: a broker involved in the disposition process of a property is called a sales broker. This actor supports with listing the property, analyzing the market, determining the property value and the marketing of the property on behalf of the vendor. Usually, the sales broker works on commission basis and only receives a payment upon consummation of the sale.
- **Advisor**: In many cases, especially when transaction prices are relatively high, professional real estate advisors are involved to provide both purchaser and vendor with (strategic) advice concerning the property. Irrespective of the client of the advisor, the primary interests and objectives of the advisor remain the same. The commercial and financial analysis, i.e. advice about rent rolls, cash flows, yields and risk-return analysis, are usually performed by the purchase or sales broker. There are two more relevant advisors: technical/environmental advisor and legal/tax (fiscal) advisor. These are discussed below.
  - **Technical/environmental advisor**: the technical advisor performs technical DD and assures that the property is in good condition with respect to technical aspects. This actor inspects installations, the EPC, the construction of the property, property features, CAPEX and repair cost schedules. Finally, the technical advisor delivers a technical red flag report with potential risks and a recommended action plan. Although neglected and not well understood before the 1970s, environmental issues have become more important over the past decades. Environmental DD has more or less been a part of the technical DD until the 70s, then been separated and since the early 2000s merged with technical DD again (Stapenhorst & Just, 2018, p. 148). Therefore, this research views environmental as a part of the technical discipline. The environmental advisor pursues a healthy environment and particularly pays attention to contaminated land or building contaminants causing material costs to owners.
  - **Legal/tax advisor**: the legal advisor aims at providing legal security for its client; be it the purchaser or the vendor of the property. Every discipline, be it commercial, technical, environmental or fiscal, is subject to legislation and thus is the legal aspect of fundamental importance. With respect to the vendor, the legal advisor enables to fulfil pre-contractual duties to inform the buyer on essential circumstances. As regards

to the purchaser, the task of a legal advisor is to avoid losing rights for the reason that disadvantageous circumstances remain unknown to the purchaser, leading to unexpected and unnecessary expenditures for the purchaser (Stapenhorst & Just, 2018, p. 21). The tax DD is usually performed as a part of the legal DD, thus is not viewed separately from legal DD. The tax advisor tries to identify financial risks in order to take them into account for the calculation of the purchase price and/or to cover these risks in the SPA by way of additional guarantees, tax indemnities or hold backs (Stapenhorst & Just, 2018, p. 51).

- **Lender**: Properties with tickets exceeding €100 million are often eligible for financing. In this case, the purchaser involves lender (mostly a bank) into the process, who is able to finance the project through issuing a loan. The underlying asset functions as a security in case the investor is unable to meet its financial obligations towards the credit provider due to insolvency.
- **Appraiser**: When the value of real estate has to be determined, the appraiser gets involved. The appraiser provides a valuation based upon, but not limited to: location, surrounding properties, amenities, accessibility, property construction, and the size of the property (expressed in sq.m. lettable floor area (LFA)).
- **Notary (signing agent)**: The notary has several key functions in real estate transactions. They are authorized by law to write deeds of sales (notarizing the SPA) and therewith finalize the transaction between purchaser and vendor. In the beginning of a transaction process, the notary verifies the property title deeds to check if the vendor is legally the owner of the property to be sold.

In addition to abovementioned actors are the land registry and the CoC, which are considered facilitating actors without direct (financial) objectives in CRE transactions. The land registry (cadaster) collects and registers administrative and spatial data about properties, as well as the involved property rights, in order to protect legal certainty. The information collected and maintained by the cadaster is publicly available through their website. The CoC officially registers companies and provides them with advice and support on commercial and fiscal matters. Their main task is to maintain the commercial register.

Actors involved in the entire DD process each have their own - often mutually conflicting - objectives, especially when it comes down to the allocation of transaction costs in the DD process. The interests are the issues that matter the most to an actor, and are similar for all involved parties: economic continuity, thus economic profit. Opposed to objectives, an interest is not directly linked to a concrete problem situation. Objectives namely indicate what actors wish to achieve in certain situations and which changes they would want to realize (or to maintain) (Enserink et al., 2010, pp. 92-93). Table 6 shows a schematic overview of the actors and their associated objectives.

*Table 6 | Actors and their objectives (desired situation) in CRE transactions*

| Actor | Desired situation/objective |
|---|---|
| **Purchaser** | • Viable investment<br>• Low transaction costs<br>• Far reaching guarantees<br>• Low execution risk<br>• Lowest possible transaction price<br>• Smooth process with accurate and up-to-date information |
| **Vendor** | • Highest possible sales price; high revenue<br>• Low transaction costs, fast transaction process<br>• Low execution risk<br>• Smooth process without many red flags and Q&A |
| **Purchase broker** | • Low execution risk; winning the bidding rounds<br>• Low internal expenses for performing the DD<br>• Lowest possible purchase price |
| **Sales broker** | • Low execution risk<br>• Low internal expenses for performing the DD<br>• Highest possible sales price |
| **Technical / environmental advisor** | • High internal expenses for performing the DD<br>• Discover all technical/environmental defects and ambiguities during DD process |
| **Legal/tax advisor** | • High internal expenses for performing the DD<br>• Legally/fiscally complex/time consuming DD process |
| **Lender** | • High credit rating of investor<br>• Proper insight into the quality of the property<br>• Low insolvency risk of borrower |
| **Appraiser** | • Depending on payment structure: High or low internal expenses for appraising the property |
| **Notary** | • High internal expenses for notarizing the SPA |

Two important conclusions can be drawn from the actor analysis; one regarding the payment structure of the advisors and one regarding the position in relation to the transaction costs in the DD process.

First, because the payment structure differs per advisor, their objectives mutually differ as well. Commercial advisors (i.e. sales broker, purchase broker and sometimes appraisers) are paid on a success basis according to the 'no cure, no pay' principle, and therefore the only thing that counts from an economic point of view is successfully closing the deal, irrespective of the resources and amount of fulltime-equivalent (FTE) used to close the deal. In some cases, so-called 'kickers' are used to incentivize the purchase broker (or the sales broker) to realize an as low as possible (or as high as possible) transaction price of the property, respectively. For example, when the vendor thinks the maximum transaction price is €45 million, a kicker of 5% can be applied for any amount that is paid above €45 million, additional to the initial brokerage fee. So, if the brokerage fee is 1% of the transaction price (and a kicker of 5% is applied from €45 million onwards), and if the property is sold for €50 million, then the sales broker receives the initial brokerage fee plus the kicker: (0.01 * €45 million) + (0.05 * €5 million) = €450,000 + €250,000 = €700,000. Contrary to the commercial advisor, the other advisors (legal, tax technical, environmental, the notary and sometimes the appraiser) often work on an hourly basis, which means that there is no fixed but a variable fee. As a result, the objectives of these advisors are conflicting with those of a commercial advisor. Where the commercial advisor prefers a smooth and efficient process, in order to quickly close the deal and receive the fixed brokerage fee, the other advisors - in case of a variable fee - prefer a complex situation for which they can record more hours and thus receive a larger payment, irrespective of the outcome of the deal (successfully executed or not). This leads to strategic behavior: advisors that are paid on an hourly basis try to work as many hours as possible. If the costs and benefits of the involved actors are in balance, it can be expected that strategic behavior is less than in the case of an imbalance between the costs and benefits of the involved actors.

Second, the actors have diverging objectives when it comes down to the amount of transaction costs associated with a DD process. For every actor applies that economic continuity is their core interest. However, the investors (i.e. both purchaser and vendor) achieve this in the case of low transaction costs, whilst the intermediaries want to maintain them high since they thrive on transaction costs. This conflict about the allocation of transaction costs is of decisive importance for this study.

## 4.3 The price of due diligence: applying TCE

In order to examine the applicability of a blockchain-based solution for reducing the transaction costs of a due diligence, it is helpful to have an overview of the sources of transaction costs and a better understanding of the difference between the transaction costs of a CRE DD process and a stock-exchange market DD process. These topics are clarified in this section by firstly outlining the sources of market frictions (or transaction costs) and secondly combining the conclusions of previous sections, establishing a comprehensive overview. Finally, this section determines the allocation of transaction costs, based on the cost drivers, and concludes with assigning these transaction cost drivers to transaction cost categories.

### 4.3.1 Encountered pain points during DD processes

The DD process in CRE transactions is often unnecessarily delayed due to various inefficiencies. Exploring these inefficiencies contributes to a more substantiated assignment of the transaction costs and helps understanding which factors impact the sources of transaction costs and to what extent they do so. To illustrate, if respondents would indicate that the vendor often does not disclose all relevant property-related information and they encounter this as a pain point, this could be linked to information asymmetry in the context of transaction costs economics. During the interviews, the respondents were explicitly asked to describe the pain points they encountered during the process, from their own perspective as institutional investor. Although the interviews were focused on buy-side commercial DDs, the respondents inevitably expressed the entire spectrum of pain points they encountered, irrespective of the category or type of the concerning DD process. Hence, the results are emphatically from a commercial perspective, but also comprise inefficiencies that are experienced during technical and legal DDs. Below, an aggregation of the key paint points is presented as indicated by the respondents, and, if applicable, linked to the associated source of transaction costs (for a more comprehensive overview of the interview results, see Appendix V).

- **'Time-consuming and labor-intensive'**
  - Transaction managers must keep track of the information supply through constantly – multiple times – requesting the required documents for the data room, which can take up to weeks since signing the LOI. Besides, they often depend on an examining instance, such as certified inspectors that issue elevator certificates or fire safety guarantees → *asset specificity/interdependence, resulting from the heterogeneous characteristic of real estate.*
  - The ongoing exploitation of the portfolio leads to continuously arising problems and new inputs for negotiation. For example: a tenant cancels his rental agreement, a leakage is caused, or other additional concerns arise during the DD process.
  - The speed of a DD depends on the extent to which the selling party has supplied the right information, which introduces the next pain point: quality of data.
- **Quality of data**
  - Checking data for accuracy, unambiguity, and up-to-dateness is time-consuming, even if it is the job of the seller to supply accurate data. In order to get a complete picture of the property, it is required to have complete and up-to-date information. To give an example: the purchaser does not want to see an expired guarantee, an unsigned rental agreement, or a rental agreement without appendices or with missing clauses → *asset specificity leads to many aspects on which properties can differ, resulting in multiple unique property-related documents.*
  - Too little standardized and structured data; documents are hosted on disparate systems (especially in the field of commerce).
  - Too much missing or incomplete documents. For instance, when an asset manager requests a certificate of refurbishment and this gets approved, but he leaves the certificate in his email inbox instead of entering it into the data base, this could cause complications in the future (during a DD process, when this data needs to be available).
  - Technology-wise: unclear data room structure, empty folders, many clicks needed, user-unfriendly programs, strange file structures that cannot be (easily) opened.
- **Advisors**
  - External advisors that do not know the ins and outs of the deal, and subsequently assess irrelevant documents → *information asymmetry, driven by bounded rationality: advisors are not capable of asking the right questions due to information misalignment between investor and advisor.*
  - Commercial advisors think along with you and want the transaction to succeed, while it sometimes feels that legal advisors care less about whether the deal executes or not, 'as long as they can write hours', which is directly related to the difference in their payment structure → *driven by opportunistic behavior.*
  - Involving external advisors and letting them negotiate with your counterparty sometimes affects the relationship between the investors, as your counterparty might say: 'we are doing business with you, not with your law firm/commercial advisor!' – advisors tend to drive a harder bargain on behalf of their clients.
  - Advisors have different agendas because they also have other projects, which sometimes results in slow responses or the feeling that your project has no priority.

- **Process-wise**
  - A pain point arises when investors (in this case the transaction manager) do not know or understand the documents they read because of lacking expertise, increasing their dependency on the external advisors → *asset specificity/interdependence, driven by bounded rationality*.
  - Many costs are already incurred before the investor even knows whether the transaction will succeed or not. This is linked to the summarized information offered in a DD and to the internal risk assessment based on that information → *uncertainty*.

The fact that investors usually are not sure what they are buying justifies the existence of due diligence processes, which aims at increasing the available information to reduce uncertainty and the risk of a bad bargain. Transactions in which the total of the production- and transaction costs are as low as possible, are called 'efficient transactions'. Given that the DD process could be seen as the perpetrator of the transaction costs, the need to perform DD hampers efficient transactions. In other words; reducing the transaction costs of the DD process leads to more efficient CRE transaction processes. Additionally, since the transaction costs are caused by frictions in the market and are borne by the purchaser, lower transaction costs lead to a better functioning market and thus imply that real estate would have a relatively higher value.

### 4.3.2 Unicity of CRE DD processes and its relation to complexity and transaction costs

The purposes of exercising due diligence when acquiring a property reach further than merely revealing hidden profit potentials and verifying information obtained from the vendor. Particularly institutional investors are increasingly being obliged to perform due diligence on the counterparty to combat, for instance, money laundering or corruption, but also due to increasing requirements of the investment committee (Hennessey, 2015). A proper due diligence establishes the accuracy of the provided information, identifies the risks, red flags, and opportunities if the property to be acquired and avoids unforeseen circumstances in retrospect. Irrespective of what type of good is bought, due diligence is to a greater or lesser degree exercised during any acquisition process: be it comparing the price of mobile subscriptions, choosing between two similar cars, or selecting an airline to book a ticket. However, the purpose, scope, and depth of due diligence processes vary in the sense that acquiring a twenty-year-old multi-tenant building requires another type of due diligence than acquiring, for example, a mobile phone for which the technical specifications are clearly delineated.

But what makes such DD process unique? Based on which characteristics is a DD process exercised differently in a real estate transaction than in acquiring a mobile phone? Answering this question elucidates the significance and unicity of the due diligence process in CRE transactions and can be used to explain why transaction costs of a CRE DD process are significantly higher than other acquisition processes. The unicity of the DD process in CRE transactions is twofold. On the one hand, it is attributable fundamental characteristics of real estate markets, and on the other hand to the fundamental characteristics of a DD process, and the determinants that impact the complexity of such process. This section explains both concepts, starting off the with the process indicators.

A number of key indicators that directly impact the DD *process* can be identified that predominantly determine the complexity of a DD process. A higher socio-technical complexity of the context directly impacts the complexity (and significance) of the due diligence phase of any acquisition. Important process complexity indicators are concretized as follows, inspired by a literature study (Cardoso et al., 2006; Diao & Bhattacharya, 2008; Kermanshachi et al., 2016):

- The availability of required information; the extent to which the vendor manages to completely file both the necessary documents and requested specifications, which directly impacts how many assumptions must be made by the purchaser. To illustrate, purchasing a mobile phone is not too complex because the main technical specifications are at hand (type of platform, processor, battery, display). As a result, mobile phones are relatively easily comparable, whilst requested property-specific documents are regularly missing in CRE transactions.
- The number of features based on which the to be acquired good can be distinguished from competitors, or, put differently; the potential extent of asset heterogeneity. This is directly correlated to the complexity of the good.
- The consequential impact when the acquisition turns out to be a 'bad bargain', mostly caused by bounded rationality as the purchaser is not always capable of making the most economical choice, or adverse selection due to information asymmetry.

Resulting from the indicators as discussed above, the number of actors that is necessarily involved in the acquisition process can be considered inherent to increasingly complex acquisition processes. These intermediaries, experts, or advisors are involved to ease the process for the purchaser as outlined in previous sections. Projecting the characteristics of a CRE DD process to the abovementioned indicators confirms the high complexity of such process. Together with the characteristics of CRE markets, it can be concluded that the factors contributing to increasing process complexity concomitantly are the characteristics on basis of which a CRE DD process can be distinguished from other DD processes.

Based on the influence of the following factors on the sources of transaction costs, it can be explained how the characteristics of both *markets* (CRE and stock exchange) lead to opposite results in terms of transaction costs:

- the process indicators of a DD process (discussed above)
- the characteristics of real estate (section 4.1.2)
- the values of shares for those characteristics (Table 4)
- the pain points as encountered during the DD process (section 4.3.1)

The finding that the CRE DD process entails higher transaction costs is important as it clearly demonstrates the actual sources of transaction costs in a CRE transaction, which can be used as input for determining the requirements for an eventual blockchain application. To illustrate, Figure 20 provides a comprehensive visualization of the relations between the abovementioned elements.

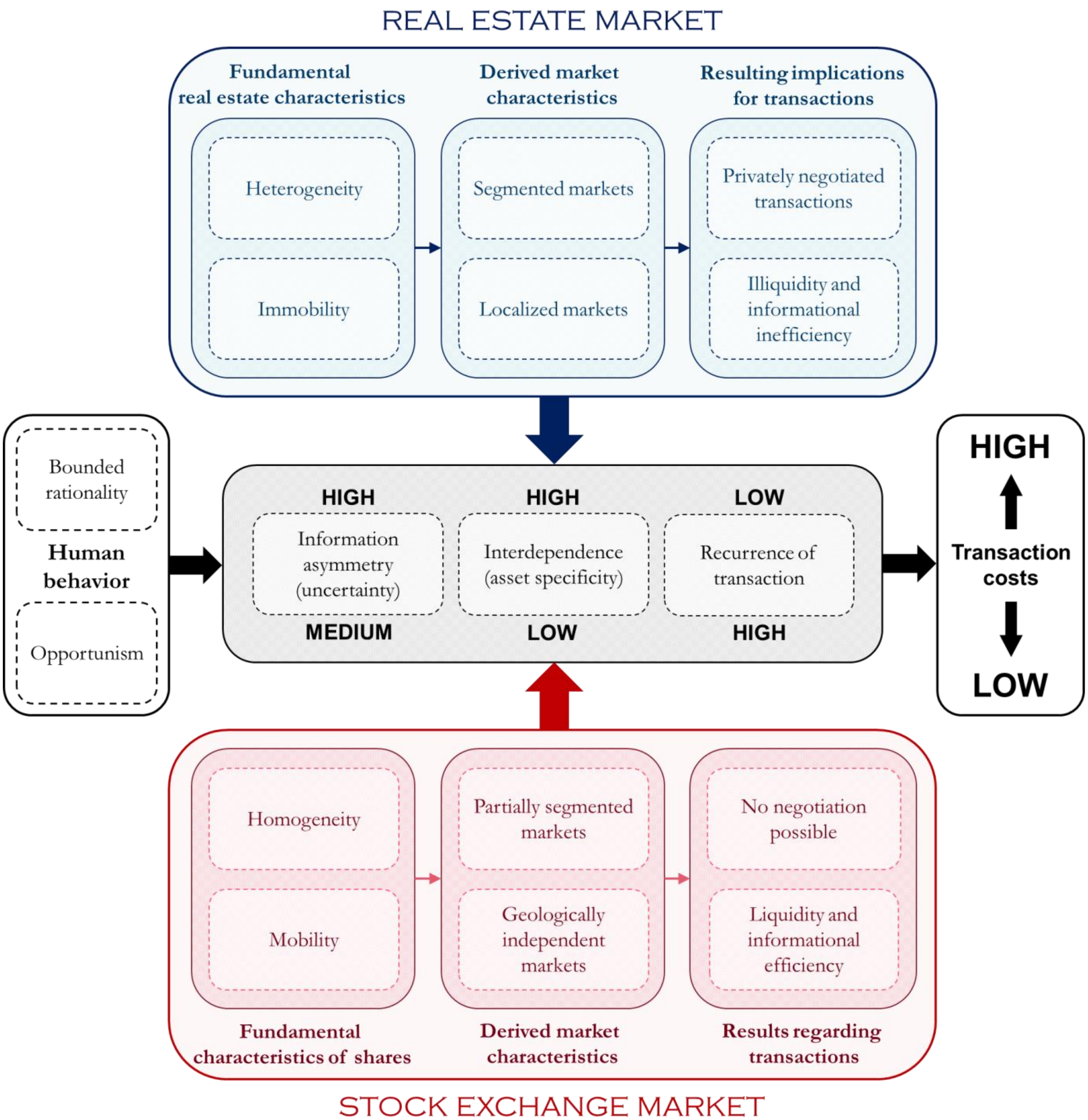


*Figure 20 | Aggregated visualization of determinants and sources of transaction costs for CRE and stock exchange transaction processes*

Figure 20 is an aggregated visualization in which a set of generalized assumptions (e.g. 'real estate is heterogeneous', and 'stock markets are partially segmented') is combined with the fundamentals of transaction cost economics. This schematic overview provides includes a set of assumptions of mutual relationships, of which the most important are concretized and elaborated below.

- **Assumption 1**: Heterogeneity of real estate results in segmented markets (e.g. markets for offices, retail and residential housing), whereas the homogeneity of shares results in partially segmented markets: two shares of company X do not mutually differ, while a share of company X is totally different from a share of company Y. Hence, the markets are partially segmented.
- **Assumption 2**: The immobility of real estate causes markets to be localized as the assets are location-bound, whereas shares are non-tangible and geologically independent.
- **Assumption 3**: Complexity in real estate transactions rises partly due to assumptions 1 and 2, resulting in illiquidity and informational inefficiency, whereas low asset-related complexity in stock markets provides informational efficiency and liquidity.

Assumptions concerning the influence of real estate market (and stock exchange market) characteristics on sources of transaction costs:

- **Assumption 4**: Heterogeneity of real estate implies a high asset specificity, thus increasing the transaction costs. Contrarily, homogeneity of shares implies a low asset specificity and does thus not increase the amount of transaction costs.
- **Assumption 5**: Segmented real estate markets increase the interdependency of buyers and sellers: investors looking for an office form no match with vendors of e.g. a hotel. This in turn increases the eventual transaction costs. By way of contrast, the partial segmented stock exchange markets (because of the homogeneous goods) do not increase interdependency because any seller of a share of company X meets the needs of someone who is willing to buy a share of company X.
- **Assumption 6**: Illiquidity and informational inefficiency of real estate markets together with the degree of heterogeneity contribute to very complex transactions, resulting in a high level of uncertainty for CRE investors. This uncertainty is taken away by intermediaries, resulting in high transaction costs. Conversely, shares are homogeneous with informational efficient markets, causing transactions to be less complex. Still, investing in stocks or shares requires a certain minimum degree of knowledge about the functioning of the market, and sometimes financial advisors are involved in strategy- and portfolio management, but entail significantly lower transaction costs.
- **Assumption 7**: Opposed to transactions of shares, the informational inefficiency and the high degree of real estate asset complexity lead to a low transaction frequency, in turn resulting in high transaction costs.

This sub-section explained what the unique characteristics of a DD process are, reasoned from both a process-oriented approach as well as a market-oriented approach. The process-oriented approach gave insight in the entire DD process and the determinants of the process complexity, whereas the market-oriented approach concluded that the CRE DD process invokes relatively high transaction costs based on the fundamental first-order and second-order characteristics of the market. The next sub-section assigns the three sources of transaction costs (recurrence, interdependence and information asymmetry) to the DD phases that entail transaction cost drivers and based on that information seeks to determine where blockchain could best be applied compared to conventional IT-solutions.

### 4.3.3 Allocation of transaction costs in a due diligence process

The previous sub-section reasoned how transaction costs of CRE transactions can be significantly higher than asset transactions such as shares. Apparently, due to complex characteristics of real estate assets, the DD process is commonly much more extensive (and informational inefficient), requires professional advice and is thus accompanied with high transaction costs. Transaction costs arise in multiple phases throughout the entire DD process, irrespective of the fact that they are eventually passed on to the purchaser. This sub-section defines the types and allocation of transaction costs, the parties by whom these costs are generated, and the so-called categories of transaction costs.

#### *4.3.3.1 Allocation of transaction cost drivers in the DD process*

Each phase in the due diligence process entails transaction costs, invoked by different actors. The following listing elucidates these transaction costs and assigns the cost component per phase. In order to be as complete as possible, each and every driver of transaction costs is defined.

- **Sale preparation:** performed by the vendor in order to get the required documents in place, to make assumptions regarding commence, rents, the physical state of the building, and to reduce information asymmetry in a later stadium of the DD process. The transaction cost component here is search and information, as relevant information for the sales process is collected. Mostly, the vendors aim at performing a VDD in-house, while some cases require expertise knowledge from external advisors (technical reports, or legal or commercial advice).
  - **Cost drivers**: collecting documents, assessing documents, technical inspection, draft teaser/IM, draft process letter, draft NDA.

- **Market analysis (pre-DD):** the phase in which potential purchasers are brought into contact with the vendor, often through the network of a sales broker (search cost component) and where, based on the presentation of the IM or teaser, preliminary research takes place in order to place an initial bid (information cost component). In the previous phase, the vendor aims at performing a VDD in-house, and the same accounts for this phase: the purchaser collects preliminary information and conducts high-level analyses in-house in order to avoid having high costs in a highly uncertain phase with respect to the acquisition. Occasionally, when the situation demands it, a commercial advisor or appraiser is involved to provide a second-opinion or to calculate e.g. rent rolls, cash flows, or an indicative value of the property/portfolio.
  - **Cost drivers**: matching sellers and purchasers, check preliminary information, compliance/KYC.

- **Commercial negotiations and signing LOI:** the first results and potential red flags that stem from the preliminary research are used to determine the bidding price and to start first negotiations about the price under reservation of the DD results (bargaining cost component). In the case of satisfactory negotiation results, the purchaser formally expresses its intention to buy the property through a LOI (decision cost component). The LOI exists in standard formats and it usually drafted by a commercial advisor or internally by a legally qualified actor.
  - **Cost drivers**: negotiate preliminary red flags, draft and sign LOI.

- **Data check:** Once the LOI is signed, the purchaser enjoys exclusivity, which implies less uncertainty of 'losing the deal' due to competitive bids. In this phase, technical and legal advisors are involved along with the commercial advisor in order to collect, check and assess all relevant documents and provide the purchaser with a substantiated advice concerning the acquisition (search and information cost component). The less efficient this phase is (for example due to inaccurate, un-updated or incomplete information supply by the vendor), the higher the transaction costs associated with this phase (especially with legal and technical advisors who are paid on an hourly basis).
    - **Cost drivers**: collect required data, assess data.

- **Red flag assessment:** usually in week 4 of the official DD process, the advisors present their findings from the previous phase in a red flag report, which is assessed by the purchaser. Based on these findings, the purchaser makes a go/no-go decision (decision cost component) about the acquisition and in case of a 'go-decision', the parties proceed to the next phase in which negotiations take place. It depends on the severity and amount of the red flags to what extent the external advisors are involved in this phase.
    - **Cost drivers**: assess red flags.

- **SPA negotiations:** depending on the red flags that stem from the previous phase, the purchaser, and mostly the commercial advisor start (re)negotiating about the SPA. The more red flags, the more this will be priced in by the purchaser and thus the less the final bid in the SPA will be compared with the initial bid in the LOI (bargaining cost component).
    - **Cost drivers**: draft SPA, negotiations about red flags.

- **Closing the deal; signing the SPA:** after successful renegotiations and after internal board approval for the acquisition, the SPA is drafted and must be signed by both the purchasing and selling party. In some cases, the SPA includes the setup of an escrow for additional guarantees or promises by the vendor (monitoring deal compliance cost component). The SPA is only valid if it has been notarized and executed by notarial deed, which must include the entire SPA with all ancillary agreements. Hence, a notary is involved in this phase.
    - **Cost drivers**: sign SPA, set up and maintain escrow.

Figure 21 summarizes the transaction cost components per phase as well as the actors by whom the transaction costs are invoked. Note that this differs per DD process, based on multiple variables as indicated in section 4.2.3. To get an impression about the quantity of transaction costs, Appendix VI shows a fictitious real estate transaction is which is presented to a technical, legal, and commercial advisor with the question to make a cost estimate for a basic DD process from their perspective.

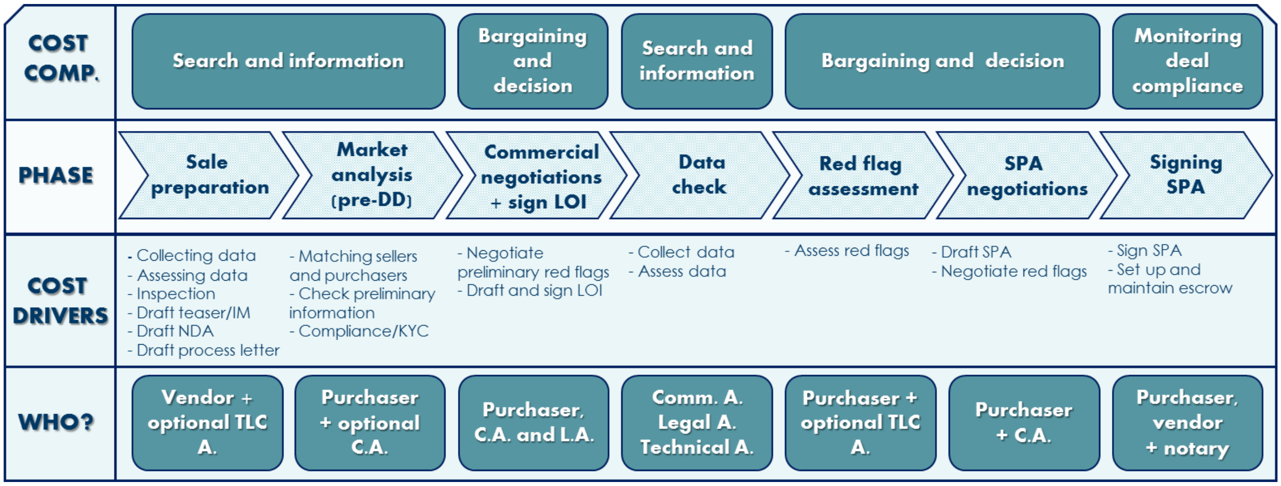


*Figure 21 | Phase-specific allocation of transaction costs in a CRE DD process*

#### *4.3.3.2 Transaction costs categories: intermediaries and technological inefficiencies*

One could state that the high transaction costs in a CRE DD process are a direct result from the involvement of intermediaries, but it is important to realize that when an investor would entirely perform the DD analyses in-house, the eventual transaction costs would be significantly higher, because otherwise – according to the principles of transaction costs economics - intermediaries would not exist. Compared to when a DD would be performed in-house, intermediaries apparently have a positive impact on either reducing the uncertainty associated with information asymmetry, the asset specificity and the associated interdependence, the recurrence of a transaction, or a combination of the aforementioned. This research presumes that intermediaries in general can fulfil multiple roles that make them indispensable, which can be roughly divided into two categories:

- **Applying expertise:** intermediaries and advisors are often involved for their expertise, particularly in fields where the client lacks required knowledge. With respect to real estate transactions, involving advisors reduces uncertainty and information asymmetry by indicating red flags, supporting with negotiations, drafting, summarizing and controlling legal contracts, inspecting the building, et cetera. Surely, an investor cannot be expert in all these fields, thus advisors are increasingly required as transactions become more complex. Also, second opinions, networking (bringing purchaser and vendor together), lease- and investment comparables, and market information fall within applying expertise. Expertise comprises both explicit (public, tangible, accessible data) and tacit (know-how, experience, intuitive, hard-to-communicate) knowledge. Especially tacit knowledge is the type of expertise that the investor lacks and the advisor provide in this context.
- **Exercising a right or authority:** another function of intermediaries is to exercise a right or authority that the client does not have, literally enhancing the indispensability of the concerning intermediaries. To illustrate, banks verify transactions between two parties, an SPA is notarized by the notary and is only legally valid if it is executed by a notarial deed, and LFA measurements can only be performed by certified parties according to the NEN-2580 measurement norms.

Intermediaries are a direct source of transaction costs and are required either because of their expertise or because they possess a certain right to do something that the investor is not eligible of. Another direct source of transaction costs was indicated by the respondents, which in this research is called **'technological inefficiency'**, an umbrella-term for all the problems that the respondents encounter and that stem from the technology (or better: lack of proper IT-solutions) that is used before, during, and after DD processes. Referring to sub-section 4.3.1, examples of these technological inefficiencies are the fact that documents are hosted on disparate systems, lacking standardization, un-updated documents, user-unfriendly data rooms, et cetera. The transaction cost drivers that are defined in this sub-section are assigned to a certain category of transaction costs: *intermediary* (expertise or right/authority) or *technological inefficiency*. This makes it insightful what the actual sources of transaction costs are and to what extent disintermediation is conducive for expediting the DD process. Simply said: sometimes the client lacks the required knowledge (expertise needed), sometimes the client is not authorized to do something (authority/right needed), and sometimes the client does not succeed in what he tries to achieve (due to technological inefficiencies).

*Table 7 | Transaction cost drivers assigned to cost categories*

| Sub process | Transaction costs category | | |
|---|---|---|---|
| | Expertise | Authority/Right | Technological inefficiency |
| Collect data (phase: sale prep.) | | | ■ |
| Assess data (phase: sale prep.) | ■ | | |
| Inspection/measurements | ■ | ■ | |
| Draft teaser/IM | ■ | | |
| Draft NDA | ■ | | |
| Draft process letter | ■ | | |
| Matching sellers and purchasers | ■ | | |
| Check preliminary information | ■ | | ■ |
| Compliance/KYC | ■ | | |
| Negotiate preliminary red flags | ■ | | |
| Draft and sign LOI | ■ | | |
| Collect data (phase: data check) | | | ■ |
| Assess data (phase: data check) | ■ | | |
| Assess red flags | ■ | | |
| Negotiate red flags | ■ | | |
| Draft and sign SPA | ■ | ■ | |
| Set up and maintain escrow | ■ | ■ | |

Table 7 assigns the transaction cost drivers in a DD process to the categories of transaction costs. By doing so, it can be concluded at a glance that the vast majority of transaction cost drivers within the DD process is attributable to a lack of expertise, in this case mostly *tacit* knowledge: non-transferable internal knowledge such as know-how, experience, skills, network, or intuition. These findings were not surprising as it is demonstrated earlier in this section that the CRE DD process-related characteristics as well as the principal characteristics of real estate (heterogeneity and asset-specificity) increase the complexity of transactions, which is inextricably linked to uncertainty and information asymmetry between buyer and seller. As a result, intermediaries are involved to apply expertise, in the broadest sense of the word, which in turn is a direct source of transaction costs. Particularly in the CRE DD process, which primarily comprises evaluating the content of documents and assessing potential risks that may show up when acquiring the property, this expertise is required. The importance of the finding that most of the transaction cost drivers can be assigned to a lack of expertise is significant, because this inherently raises a new question: to what extent can blockchain obviate the expert knowledge as applied by the intermediaries? The next chapter zooms in on this dilemma and assesses the applicability of blockchain in the CRE DD process.

## 4.4 Conclusions of Chapter 4

This chapter concretized the findings with respect to the due diligence process that were outlined in the theoretical background during expert brainstorm sessions, a literature study, and expert interviews with institutional investors. With the insights derived from this explorative case study, the second research question is answered: *"How is a due diligence process positioned within a CRE transaction and what are relevant characteristics, phases and transaction costs of a due diligence process?"*. Literature study and interviews pointed that the due diligence process is the period between signing the LOI and signing the SPA. The brainstorm sessions with commercial, legal, and technical advisors resulted in a draft customer journey (Appendix I) that was presented to the institutional investors during the interviews. The recommended adjustments in combination with insights obtained during literature review have been combined into a final phasing of the DD process, including the phases as depicted in Figure 22.

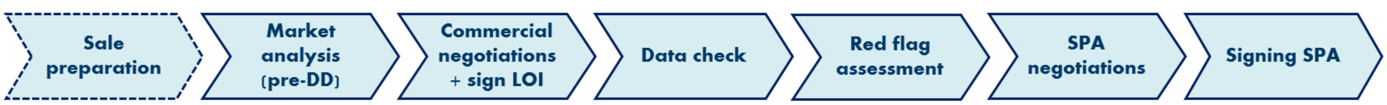


*Figure 22 | Defined DD phases*

The transaction costs have been determined according to the transaction cost theory framework of Williamson (1979) supplemented with the dimensions of transaction costs as mentioned by Coase (1937). It is demonstrated that the characteristics of real estate impact the sources of transaction costs in such a way that the eventual transaction costs are relatively high in comparison to stock exchange markets. Three transaction cost categories are defined to which the transaction costs within DD processes are attributable. Subsequently, the transaction cost drivers as defined in the DD process are set off against these categories. By doing so, we concluded that the largest part of transaction cost drivers within the DD process is attributable to a lack of expertise, more specifically *tacit* knowledge. The findings derived from this chapter in combination with the decision path of chapter 3 serve as input for the next chapter, in which the applicability of a blockchain-based solution in a CRE DD process is assessed.

# 5 APPLICABILITY OF BLOCKCHAIN IN THE CRE DD PROCESS

Transaction costs economics question why some transactions occur in hierarchies (i.e. firms) rather than in a market. According to Coase (1937) and Williamson (1979), this is because some transactions are more efficiently conducted in hierarchies than in markets as a result of uncertainty, asset specificity, and frequency of dealings. The efficiency of governance institutions can thus be determined and expressed with the application of transaction costs economics.

Applying TCE to *blockchain* can bring the same insights, by asking the extended question: 'why would some transactions be executed on a blockchain (e.g. via a smart contract), rather than in firms or in markets?'. Previous chapters explained the functioning of blockchain, the role of the DD process in real estate transactions and the allocation of transaction costs as incurred in the DD process.

This chapter aims at answering the third sub-question, which reads as follows: *"How can the applicability of blockchain-based applications for lowering the transaction costs of the due diligence process in commercial real estate transactions be assessed*?". To gain a better understanding, blockchain is firstly considered through the lens of economic and contract law theories. Applying this approach explains why blockchain reaches further than merely the technology underpinning Bitcoin. Next, the applicability of a blockchain-based application is determined for the DD process in its entirety, following the decision path as presented in Figure 15. Also, suitable use cases for smart contracts are explored, based on the defined transaction cost drivers, following the same decision path. With this information, an extended decision path is proposed that incorporates the expected impact on transaction costs by involving transaction costs categories and the sources of transaction costs. Furthermore, three smart contract use case are discussed and the impact on the eventual transaction costs following the extended decision path is assessed. Finally, section 5.4 answers the research question as posed above and concludes this chapter.

## 5.1 Blockchain technology through the lens of economic and contract law theories

### 5.1.1 Contractual relations on the blockchain: capturing (relational) contracts into code

With the emergence of smart contracts and the inherent expansion of possibilities to enter into a secure contract with unknown entities, the significance and convenience of contracting processes is brought into a new dimension. The classical contract law considers exchange transactions to be discrete; entirely separate from all other present and future relations. This implies that discrete transactions could only occur between total strangers without any relational history, who were brought together by chance, and who are completely sure of never seeing each other again or having any other type of connection with each other (Macneil, 1977, p. 856). With discrete transactions one end of the spectrum, contractual relations can be found on the other end. Introduced by the neoclassical contract law as a variation from discrete transactions, the neoclassicals distanced themselves from the assumption that any legal or social system could achieve pure discreteness. According to them, contracts are more relational in nature and involve standards, direct third-party determination of performance, one-party control of terms, and costs as a compensation for goods or services (Macneil, 1977, pp. 865-870). As the interviews reveal, commercial real estate transactions very closely parallel the contractual relations as described above. In addition to 'hard' contractual relations, the interviewees indicated several 'soft' relations, such as previous experiences, credibility, alignment of interests, and mutual understanding, playing a significant role during transactions and the selection of a counterparty. Transacting real estate can be well explained through the lens of neoclassical contract law, but as relational contract law suggests, the discreteness and presentiation (i.e. a way of looking at things in which the effect of the future is perceived on the present) will not disappear from life (or law) simply because firms are composed of complex sets of interconnected contractual relations, which become the organizational mode of dominating economic activity (Macneil, 1977, p. 887). Put differently; although contracts tend to be increasingly relational, a certain extent of discreteness will always remain within transactions. For this reason, when implementing smart contracts in the DD process of CRE transactions, both relational context and transactional discreteness must be taken into consideration.

Smart contract solutions are being developed for an array of markets by both startup companies and major enterprises, purporting to offer a digital bypass around traditional contract law. Given that both relational context and transactional discreteness must be incorporated and captured in smart contracts, a significant question is posed: are smart contracts a superior solution to the problems as addressed by contract law? Werbach and Cornell (2017) answer this dilemma in the negative by analyzing the larger question that contract law is initially theorized for. Ostensibly, the role of courts as enforcement agents are removed with smart contracts, because once the smart contract is coded, the machinery for its execution is supposedly unavoidably set in motion. However, if involved actors make use of the possibility to multi-sign the contract (called *multi-sig*), they still maintain control over the contract execution to a certain extent. Moreover, relational contracting involves altering contracts prior to performance, contract modifications, renegotiations, additional warranties, and so forth. Such modifications tend to be problematic for smart contracts, as well as incorporating relational (and tacit), confidence-based agreements. Therefore, in complex environments where communication and transactions are entangled within a relational context, smart contracts require profound programming skills in order to effectively be deployed.

### 5.1.2 Blockchain as a market-enhancing technology for economic coordination

The invention of blockchain was in first instance intended to function as the technology facilitating Bitcoin, world's first cryptocurrency. It was a way to combine P2P networks with cryptography to create an immutable time-stamped distributed ledger (Swan, 2015). The inventive part here was that this technology could create consensus among unknown participants without the intervention of any third party, and therefore is referred to as a 'trustless consensus engine' and a 'distributed ledger technology'. An economic analysis of blockchains should not revolve around 'cryptocurrencies' or blockchain as a payment system – which was only the first instantiation of blockchain – but blockchain can be better understood through considering it as a public database, or a distributed ledger, because ledgers are a foundational institutional technology of market capitalism (Davidson et al., 2016; De Filippi et al., 2018).

Analyzing blockchain through the lens of a new technology raises the question: what type of technology is blockchain? De Filippi et al. (2018) argue that there have been two categories of answers: some claim that blockchain is a general-purpose technology, meaning that it will be widely implemented and have a broad application in multiple market segments and contribute to a multiply productive growth. Not disagreeing, but approached from another (Coasian) perspective, are the economists who place the emphasis on how blockchain could reduce transaction costs through costless verification and disintermediation. The first approach understands blockchain as a production technology (general purpose view), where the latter approach regards blockchain as an exchange technology (market-enhancing or Coasian/Schumpeterian view). This study approaches blockchain from a transaction costs perspective, thus a Coasian 'market-enhancing' view, in order to be able to delineate the sources of transaction costs to subsequently construct a decision path to determine the suitability of a blockchain-based application.

According the theories of Coase (1937) and Williamson (1979), goods and services are voluntarily exchanged between buyers and sellers (i.e. both parties agree on the price and conditions). To agree on the price and conditions of assets before exchanging them, the involved parties need to verify key attributes of the asset, such as the quality of the good and the authenticity of the cash. Typically, only the bank functions as intermediary in the process through distributing and backing the cash that is used during the exchange. In the case of a more complex transaction, such as real estate, usually more than one intermediaries are involved to verify documents, contracts, provide and assess information and mobilize their network on behalf of the purchaser. The fee that is charged in exchange for their services is the cost of intermediation and according to Coase (1937) and Williamson (1979) is one of the transaction costs purchasers and vendors incur when the lack knowledge or capabilities to efficiently verify the information of the specific transaction themselves. Intermediaries become more indispensable as markets scale in size, grow geographically and as the number of involved actors increases. Resulting from higher transaction costs, the frequency of asset exchanges decreases as less purchasers and vendors are able to execute a profitable transaction. Ultimately, if the transaction costs outweigh the profits of the transaction (which is essentially a cost-benefit analysis), markets fall apart. This happens when there is asymmetric information between the contracting parties (where the purchaser is not able to assess the true value or provenance of the property) or where moral hazard contributes to unraveling. Current solutions rely either on an intermediary for third-party verification, on forcing additional disclosures or guarantees by the vendor (in the LOI and SPA), on enforcing contract clauses such as warranties in the SPA, or to perform monitoring and deal compliance (Catalini & Gans, 2016). Blockchain possibly has the potential to reduce these transaction costs through disintermediation, immutably recording data, reducing verification costs, and expediting the process. It may be clear in what phases of the DD process transaction costs occur, but the question remains how and where blockchain could (and could *not*) contribute to reducing these costs. This is assessed in the next section.

## 5.2 Assessing blockchain applicability in the DD process

In sub-section 3.6.2, a generic decision path is presented that can be followed to determine the applicability of a blockchain-based solution. It would be impractical – and for now unnecessary – to apply this decision path to each and every defined cost driver in the DD process because it should first be determined whether the DD process in its entirety would meet the requirements for a blockchain-based solution. This is gradually assessed in sub-section 5.2.1. Next, sub-section 5.2.2 explores blockchain use cases for automation with smart contracts.

### 5.2.1 Determining the applicability of blockchain for the DD process as a whole

For this DD-process, it is assumed that it concerns a regular CRE transaction of one large property (i.e. with a value exceeding €20 million) in the Netherlands, where purchaser and vendor know and trust each other.

1. **Do you need a shared database?**
   **Yes.** Currently, the commercial advisor of the purchaser (i.e. the purchaser broker) manages and controls a data room in which all relevant documents are shared with respect to the property. In this data room, the purchaser with his legal, commercial and technical advisors work together and assess the data as presented by the vendor and his advisors. Hence, this shared database is crucial for the potential investor to be able to conduct a profound DD on the property.

2. **Does more than one entity need to contribute data?**
   **Yes.** Large CRE properties in this study are multi-tenant buildings with usually a plethora of documents, certificates, permits and drawings. These should in theory be maintained and updated in databases, but the interviews revealed that these are hosted on disparate systems and controlled by multiple entities in practice. At the moment a sales preparation starts (first identified phase of the DD process), all these documents are collected and requested at multiple entities, in order to fill the data room. This thus means that multiple entities need to contribute data to the (shared) database.

3. **Do you want a tamperproof log of all writers to the data store, and that the data cannot be deleted or updated?**
   **No.** Although a tamperproof log of all writers to the data store could be useful, the inability to update data hampers efficient data sharing and management. Unlike transactions or other information that should never be changed in order to maintain its validity, certificates, rental contracts, and certain permits expire and should be updated or deleted at will. The fact that blockchains do not allow for modifications of historical data is useful in case someone wants to proof the existence of a document, but not when someone wants to always have the latest up-to-date version of the cashflow calculation or a rent roll. However, let's assume that there will be new types of blockchains in which certain data fields can be overwritten.

4. **Sensitive identifiers will not be written in the data store?**
   **No, but it could if a private blockchain is used.** The data room of a property as used by the purchaser and vendor (and their accompanying advisors) in principle contains all relevant data for a thorough assessment by the purchasing party. This means that also sensitive information such as rent rolls, rental contracts, creditworthiness checks, privacy-related data, and so forth is included. As blockchains are transparent and the content thus is visible to all participants of the network, personal (privacy-sensitive) data should not be entered on a public blockchain. An alternative would be using a private blockchain, and would be suggested here with respect to personal data protection. If we assume that a private blockchain (or property-related smart contract) is used, we can proceed to the next question.

5. **Are the entities with write access having a hard time deciding who should be in control of the data store?**
   **No.** Blockchains are particularly suitable for facilitating trust in a trustless environment with mutually unknown actors (think of transacting value with a random person somewhere around the world). In that case, writers cannot reach consensus about which party should be assigned to be in control over the data store, and a P2P-network based on blockchain would be ideal. However, this is not the case in CRE transactions. The purchaser and vendor trust each other, and the writers of the data (i.e. the vendor and its advisors) have no reason for mutual mistrust. If there are no trust issues over who controls or maintains the database, traditional database solutions should just suffice.

Quite surprisingly and somewhat in contrast to earlier expectations, a blockchain-based intervention does not seem to outperform conventional databases in the case of a CRE DD process, as of now. This is mainly because of three reasons, namely:

1) The actual sources of transaction costs in CRE DD processes are largely caused by the need for the knowledge, network, assessment skills, negotiation skills and experiences of professional intermediaries. Blockchain technology is not capable of assessing complex information and making strategic considerations like professional intermediaries do based their expertise and experience. It could at most support investors (or experts) in auditing whether certain documents have existed and at what time.
2) With respect to the 'technological inefficiencies' (generally: the pain points) as indicated by the respondents, the main problems revolve around inefficient data sharing systems, un-updated databases, incomplete/inaccurate/missing documents, in short: property owners fail in properly maintaining all property-related documents up-to-date and are only incentivized to do so when the moment of disposition commences. Blockchain is not the right solution to updating information or making 'wrong information right' (which is a common misconception, see section 3.6.3), because blockchain does not have the ability to assess whether entered data is right or wrong; garbage in, garbage out. It is thus not true that 'everything on the blockchain is just right'; this can only be assumed in case the writing party is fully trusted by the other participants of the blockchain.
3) Even when blockchain would have the ability to update information, or put differently: writers would be permitted to overwrite certain data fields in the blockchain such that the new data has precedence over the old data, the blockchain would be *mutable*, challenging the 'immutability'-core component of blockchain. As established in section 3.2, use cases for which blockchain is eminently suitable are those in which a tamperproof record of historical data is required in environments without trust, and *not* in cases where a mutable database is requested in environments where no trust-related issues exist.

It is important to bear in mind that this research is initially set up to explore the possibilities of blockchain in lowering the transaction costs associated with a DD process in CRE transactions. This section has just demonstrated that blockchain appears not to be the most suitable technology to remedy the problems and transaction costs that are associated with current DD processes. It appears that a conventional (distributed) database, without the incorporation of blockchain, in theory should suffice. This does not automatically mean that blockchain is of no good at all in DD processes. Even though it does not store documents (but hashes) and even though tacit knowledge is required for proper assessment of information, blockchain should not be entirely written off directly. Next to applying blockchain as a tamperproof decentralized ledger, there is an application of blockchain in the context of contracting, as introduced in section 3.3.2. This application deserves a closer look and is therefore scrutinized in the next sub-section.

### 5.2.2 Identifying smart contracting use cases for automation within the DD process

Where blockchain is seemingly unfit for improving the quality of data provision, applying expertise in information assessment, or providing a one-click fully up-to-date property-specific database containing all relevant documents, smart contracts are often expected to be a suitable technology for process-automation. Smart contracts are a promising application of blockchain where contracts are automatically executed once a set of prespecified conditions has been met. Various contracts or agreements are signed by the purchaser and vendor during the DD process, among which are the LOI, the SPA and an escrow. These contracts could in theory be replaced with smart contracts and thus automate procedural components of the DD process. In this section, the role of smart contracts for these cases is explained and subsequently the viability is assessed following the decision path as presented in section 3.6.2.

#### *Smart LOI and Smart SPA*

LOIs exist in a variety of company-specific standard formats and could form a potential blockchain use case: a 'smart-LOI' could be drafted that is multi-signed by the involved parties and immutably stored on the blockchain so as to preserve its authenticity. In fact, the LOI is de predecessor of the SPA and in ideal situations the same as the SPA (i.e. no red flags were found, so additional renegotiations were unnecessary).

Building on the smart LOI, a smart SPA includes the entire sales- and purchase agreement and would also be multi-signed by the involved actors. Instead of a notary drafting this SPA, a programmer would be hired to program the rules of the contract into a smart SPA under supervision of – and in collaboration with – a jurist. After signing the smart-SPA, which can be seen as a notarial deed, the ownership rights are automatically transferred from seller to purchaser and this is recorded in the land registry. With this action, the deal is closed.

#### *Smart Escrow*

Additional guarantees set by the seller are recorded in an escrow, which is in theory perfectly suitable input for a smart contract. No party is accessible to the funds reserved in a smart escrow at any point of time, assuring the P2P-component of the network. When buyer and seller agree on the terms of a trade through multi-signing the SPA, and also agree on setting up an escrow, the purchaser transacts a part of the investment to the seller and enters another part in a smart escrow. If any incidents as recorded in the smart SPA occur (e.g. leakage, discovered asbestos or unexpected expenditures), these expenses are automatically covered with the funds that are saved in the smart escrow. After a prespecified period, for instance a year, the residual value of the escrow is automatically transferred to the seller.

Following the decision path as presented in section 3.6.2, the applicability of blockchain for abovementioned the smart contract use cases is assessed and the corresponding results are depicted in Table 8. The first five questions determine whether blockchain is applicable at all, and the last two questions aim at specifying the type of blockchain on which the eventual smart contract should be built. At a glance, it can be seen that for all use cases, blockchain appears to be applicable. The first boxes are orange because in principle, a shared database is not required, but when considering smart contracts, this question can be ignored. In this case, it should be asked: *'Is there any form of agreement that can be captured using a contract?'*, to which the answer is 'yes'. The next two questions are also answered positively: more than one entity need to contribute 'data' (in this case: signing the contract), so there are multiple writers. Also, a tamperproof log of all writers to the data store is needed. The next boxes are colored orange as a contract typically contains sensitive data, but when considering a private blockchain, it can be proceeded to the next question. The last box is green: even though there exists no actual lack of trust, each actor obviously wants to have control, accessibility and possession over signed contracts. Put differently; an institutional investor wants to be able to access the contract everywhere and anytime. Because all writers are known and no public verifiability is required, it is recommendable to build the smart contracts on a private permissioned blockchain.

*Table 8 | Confrontation matrix of decision path questions and smart contract applications*

| | Do you need a shared database? | Does more than one entity need to contribute data? | Do you want a tamperproof log of all writers to the data store? | Sensitive information will not be written in the data store? | Difficult to decide who should be in control of the data store? | Are all writers known? | Is public verifiability required? |
|---|---|---|---|---|---|---|---|
| Smart LOI | Caveat | Yes | Yes | Caveat | Yes | Yes | No |
| Smart SPA | Caveat | Yes | Yes | Caveat | Yes | Yes | No |
| Smart Escrow | Caveat | Yes | Yes | Caveat | Yes | Yes | No |

## 5.3 Proposing an extended decision path for assessing the applicability of blockchain and the impact on the sources of transaction costs

The previous section pointed out that, as of now, blockchain appears not to be applicable for the DD process in its entirety. However, two specific use cases within the DD process are suggested for which smart contracts appear to be applicable. To assess their potential for reducing transaction costs, this section proposes an extended decision path that incorporates the impact of blockchain-based solutions on the transaction costs. Subsequently, following this decision path, it is assessed to what extent the transaction costs of the suggested use cases are expected to be reduced with smart contracts.

### 5.3.1 Explanation of the extended decision path

The decision path comprises two components; a general component (delineated with a blue dotted line) and a case-specific component. The first component is general in the sense that this decision path can be followed for decision making processes entailing multiple actors and a type of database in order to determine whether blockchain is a suitable solution at all (see section 3.6.2). If so, the decision path proceeds to a case-specific component that works towards a statement regarding the impact on transaction costs. The composition of this component depends on the objective of the researcher. For this study, the aim is to reduce the transaction costs of a business process. Hence, the extended component of the decision path works towards a statement with respect to the impact on transaction costs. However, if the research for instance revolves around increasing efficiency, trust, transparency or customer experience, another component could be added to the delineated decision path. For now, the extended version regarding transaction costs is treated.

After assessing the most suitable type of blockchain, it is first asked to what category the case-specific transaction costs are attributable. For CRE transactions, three categories are distinguished: expertise, right/authority, and technological inefficiencies. These categories are well-explained in section 4.3.3.2. In the case of expertise, it is relevant to understand whether this concerns tacit knowledge or explicit knowledge. Because tacit knowledge cannot be expressed by definition, it is presumed that this type of knowledge is not programmable in a blockchain, and therefore the decision path redirects to the red box stating that blockchain is not likely to reduce transaction costs. When the transaction costs are attributable to the category 'right/authority', it must be determined whether the application complies with the current legislation and thus fits within the regulatory framework. For instance, smart contracts are not (yet) legally binding and thus cannot (yet) substitute current contracts (see section 3.5). If it does comply with legislation, the decision path proceeds to three general questions that concern the sources of transaction costs, in accordance with assumptions and figure in section 4.3. Note that this is based on expectations and requires a minimum level of insight into the consequences of a blockchain-based application. If the application is expected to increase the frequency of transactions, decrease the extent of interdependence, or reduce informational asymmetry, it can generally be expected that the blockchain-based application will reduce at least a *part* of the total transaction costs. The more of these questions can be answered with 'yes', the more likely it this that assumption holds true and the higher the extent is to which it will eventually impact the actual transaction costs.

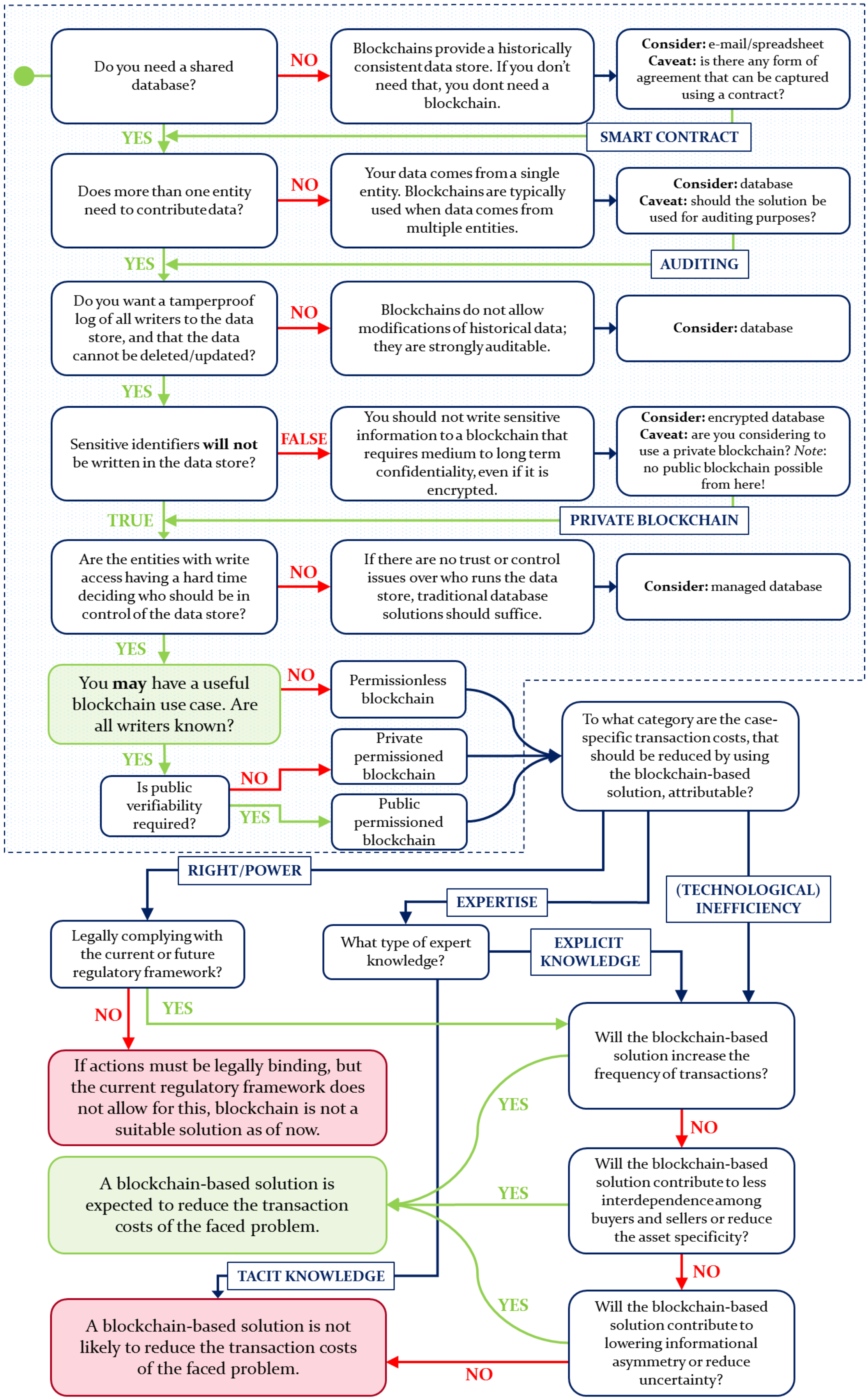


*Figure 23 | Decision path to assess the applicability of blockchain in lowering transaction costs*

### 5.3.2 Determining the impact of smart contract use cases on transaction costs

The extended decision path is used for a substantiated assessment of the impact of applying smart contracts on the eventual transaction costs. For the sake of clarity and a good overview, the questions are concisely answered, with a focus on the transaction cost component of the decision path. For the answers on the first general component, see the explanation in section 5.3.1. The results, bearing in mind that the starting point is the end of the first component and it has just been determined that the smart contracts should be implemented on a private permissioned blockchain, are listed below.

*The impact of a smart LOI on transaction costs*

Although there are multiple standardized formats LOIs, the actual LOI is sometimes drafted by a legal advisor, but mostly by a commercial advisor due to the asset-specific complexity of CRE transactions. By way of explanation, for the commercial advisor this is part of the guidance of the entire transaction, while the legal advisor writes extra hours for drafting a LOI. A smart LOI requires in principle no right or authority and neither is it a technological inefficiency. However, expertise is needed to set up a LOI and therefore the next question revolves around the type of knowledge that is required. It can be argued that a combination of tacit and explicit knowledge is needed to draft a LOI: on the one hand it entails tacit knowledge (know-how and experience) to properly set up an all-encompassing LOI, whilst on the other hand explicit knowledge is needed (the price, type of deal, land register details, et cetera). Contrary to tacit knowledge, the explicit knowledge-component can be coded and therefore, at least for that part, a smart contract would be suitable. Proceeding to the next questions demands for an estimation of the consequences of this smart contract. Although a part of the process is likely to be expedited using a smart LOI, it is not expected that the frequency of transactions will increase. Moreover, neither the asset specificity will be reduced, nor will the interdependency between buyer and seller decrease with a smart LOI: the properties remain the same complex properties that are traded in unchanged segmented markets. Lastly, also uncertainty or information asymmetry is not expected to decrease using a smart LOI. Indeed, blockchain is transparent and immutable, but a smart LOI will not reduce the investor's uncertainty about the acquisition (and the potential consequences of such a complex asset). In the end, following the decision path, it is expected that a smart LOI will not impact the transaction costs.

*The impact of a smart SPA on transaction costs*

Building on the smart LOI, a smart SPA includes the entire sales- and purchase agreement that is multi-signed by the involved actors. Despite a notary possesses tacit knowledge regarding the mark-up of contracts, the transaction costs of a smart SPA are primarily assigned to the category 'right/authority'. Namely, without a notary the SPA cannot be notarized and is thus not legally binding. The next question in de decision path aims at determining whether the blockchain-based application is compliant with current legislation. For now, this is not the case. According to the current regulatory framework, a smart contract is not legally binding and thus not applicable. However, assuming that the legislation will change and smart contracts become legally binding (with for example a digital signature of the notary), then it must be considered what the consequences are on the sources of market frictions. For the very same reason as with the smart LOI, a smart SPA will unlikely positively impact the frequency of transactions. At most, the closing process of the deal would be expedited. Neither the asset specificity, nor the inherent interdependence, will decrease. However, if a notary is not required anymore, there is no room anymore for opportunism (i.e. charging high hourly rates because of a monopoly-position). The notary cannot use its informational advantage as he will be (partly) disintermediated, which in turn reduces the transaction costs. Note that the introduction of smart contracts comes along with new transaction costs. Less money is paid to the notary, but the programmers coding the smart contracts are expensive as well. The impact on the transaction costs is therefore expected to be insignificant compared to the property value, but it requires further research to quantitatively substantiate this.

*The impact of a smart escrow on transaction costs*

In accordance with the two abovementioned use cases, a smart escrow by and large resembles the initial purpose of a smart contract: predefining a set of conditions on the one hand, saving an agreed amount of funds on the other hand and disbursing the funds proportionally to the extent to which the prespecified set of conditions is met. With respect to the category of transaction costs, a smart escrow can best be assigned to 'informational inefficiencies'. Currently, escrows have to be set up in a cumbersome fashion such that a specific company is involved to construct and maintain the escrow and to make sure that the funds are properly paid to the right parties, given the conditions as entered into the agreement. A smart escrow will not increase the frequency of transactions, neither will it decrease the interdependence between the purchasing and selling parties, but it will increase trust and transparency and thus decrease uncertainty and the need of a trusted third intermediating party. Therefore, smart contracts can positively affect the transaction costs by directly cutting out an intermediary, which is in this case the escrow company. Implementing smart contracts thus seems to be the most applicable in the latter use case, i.e. a smart escrow.

## 5.4 Conclusions of Chapter 5

By combining the results and insights from previous chapters, this chapter answers the third and last research question: "*How can the applicability of blockchain-based applications for lowering the transaction costs of the due diligence process in commercial real estate transactions be assessed*?". The currently used DD process with the defined phases and characteristics is taken as a starting point.

We developed an extended version of the decision path in order to structurally assess the impact on the sources of transaction costs, after having established that blockchain is a suitable IT-solution for a specific use case. By using the extended decision path, we showed that blockchain is not the most appropriate technology to obviate the incurred transaction costs during the DD process in its entirety. The advantages that blockchain has over conventional (distributed) databases do not hold for the current DD process and therefore a conventional database should suffice in at least expediting the process through more efficient way of storing, structuring and sharing relevant documents. Although blockchain is demonstrated to be inappropriate for improving the quality of data provision, applying expertise in information assessment, or providing a one-click fully up-to-date property-specific database containing all relevant documents, we showed that only a *smart escrow* has the potential to lower transaction costs. To conclude, the next section presents the conclusions of this research as well as the suggested areas for further research.

# 6 CONCLUSIONS AND RECOMMENDATIONS

In 2017 Cushman & Wakefield, Stibbe, ABN Amro Bank, Deloitte, FRIS, and Sweco started a joint project to investigate the possibilities and added value of combining forces to perform a complete DD process from different disciplines. Central to the joint project is the exploration of overlap between the disciplines and the room for improvement. This project is performed in addition to the joint project between the abovementioned parties and has taken blockchain as a starting point for an explorative, solution-oriented approach. The DD process in CRE transactions is explored in a case study to identify the applicability of blockchain. The main research question is defined as follows:

> "To what extent could a blockchain-based solution be applicable in a CRE DD process and how could it impact the transaction costs?"

This penultimate chapter concludes this research and contains recommendations for future research. First, the answers to the sub questions of this study are presented in section 6.1 to finally answer the main question. Next, a reflection on the research process, methods, relevance and link with the master program is provided in section 6.2. To conclude, the limitations of this research are discussed in section 6.3, directly followed by a set of recommendations for further research for anyone who is interested in combining the fields of blockchain and the (commercial) real estate sector.

## 6.1 Conclusions

The main research question has been specified using sub-questions, which represent the structure of the report and therefore correspond with the build-up of the chapters in this report. The sub-questions formed a guideline for this research and the process of gaining knowledge, understanding, and insights that contribute to a proper answer to the main question. This section provides an overview of the steps taken in this research and concludes by answering the main research question.

*Sub-question 1 – Introducing blockchain technology and assessing its applicability*

Blockchain is a disruptive technology underpinning, among others, Bitcoin, which was introduced to the world by Nakamoto (2008). Compared to a classic intermediary role, one of the unique features of blockchain is that it maintains reliability in a decentralized and distributed management system without the need for a trusted third party, even with the presence of malicious actors in the network. Based on the literature study as outlined in chapter 3, the first sub question is answered: *'What are the core components of blockchain technology and how can it be determined whether a blockchain-based solution is applicable for a given use case?'*. Five core components of blockchain technology are found: 1) ledger, 2) P2P network, 3) cryptography, 4) consensus mechanism, and 5) validity rules.

Blockchain is a distributed *ledger* that is updated synchronously among all participants of the network. This network requires no trusted third party to validate transactions, enabling participants to make direct, peer-to-peer transactions in a so-called *P2P network*. Transactions in this P2P network are validated according to the standards of a specific *consensus mechanism*, a means of achieving consensus as to the validity of a transaction. The consensus is reached if, and only if, the transaction complies with a predetermined set of *validity rules*. In order to achieve consensus, participants must be able to trust each other, even if they are mutually unknown. Trust is therefore created and based on *cryptographic* proof. Once consensus is reached about the validity of a transaction, a new block containing that transaction is added to the chain of blocks and cannot be altered or deleted anymore based on the applied cryptography.

The insights derived from the first part of the question are used to answer the second part: *'… and how can it be determined whether a blockchain-based solution is applicable for a given use case?'*. Blockchain is defined by a combination of the abovementioned core components, leading to ancillary benefits of blockchain technology, such as potential disintermediation, automation, increased reliability, traceability and transparency of data. However, it is found that a blockchain-based application is not the most suitable solution for every given use case. Depending on certain case-specific properties, blockchain is either a suitable solution that outperforms conventional solutions, or not. This can be determined on the basis of the decision path depicted below in Figure 24.

If the following questions can be answered positively (with 'yes' or 'true'), a blockchain-based solution is expectedly suitable for the given use case:

- Do you need a shared database? *Caveat: smart contract*
- Does more than one entity need to contribute data? *Caveat: auditing purposes*
- Do you want a tamperproof log of all writers to the data store, and that the data cannot be deleted/updated?
- Sensitive data will **not** be written in the data store? *Caveat: private blockchain*
- Are the entities with write access having a hard time deciding who should be in control of the data store?

Subsequently, following the same decision path, it can be determined what type of blockchain would fit best given the situation. If the writers are known, a (public) permissionless blockchain would be most suitable. If not, it should be questioned if public verifiability is required. In that case, a public permissioned blockchain suits best, and if not, a private permissioned blockchain is recommended.

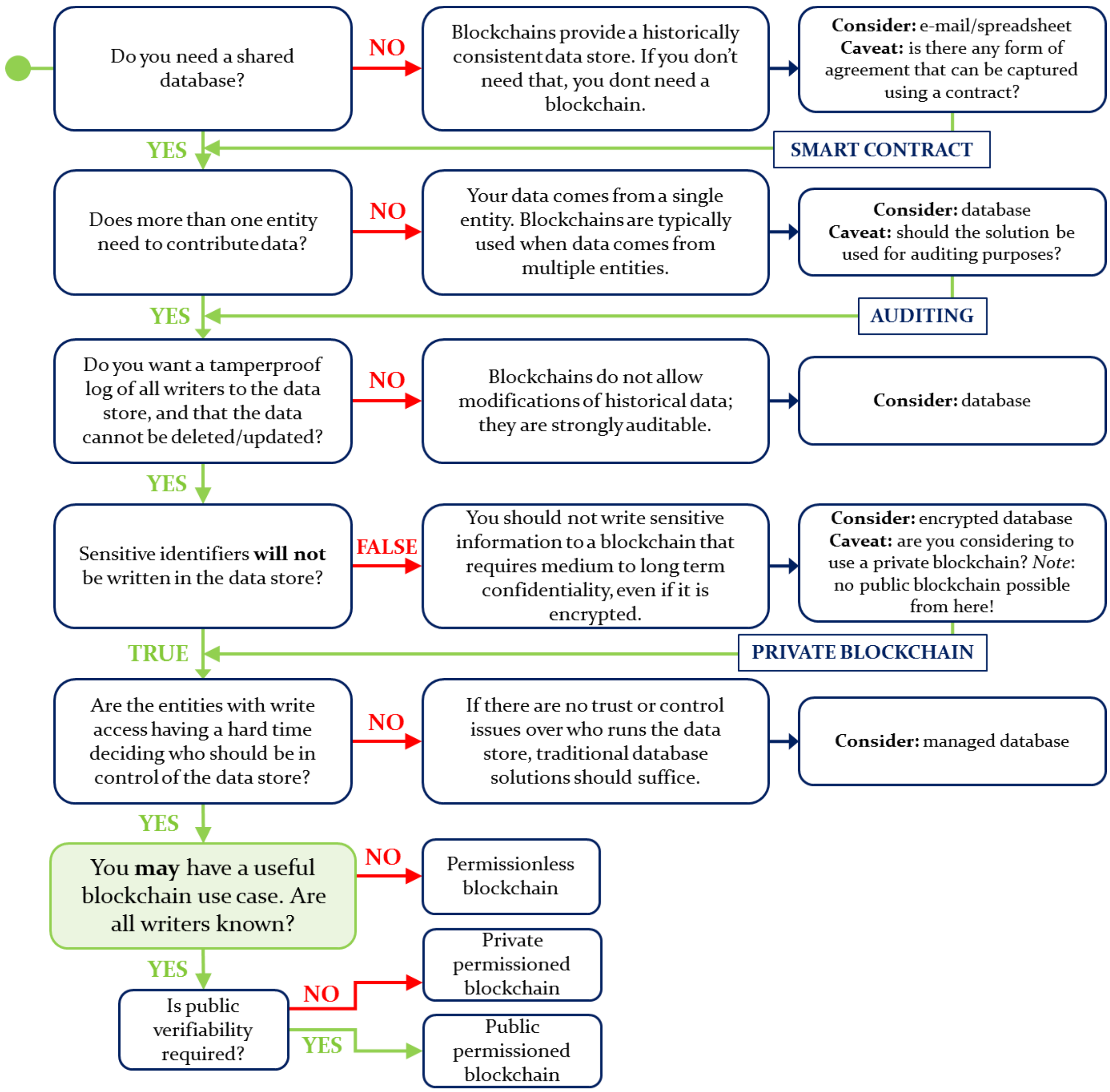


*Figure 24 | Decision path for determining blockchain applicability, source: own depiction*

### *Sub-question 2 – Characteristics and transaction costs allocation of DD process*

Chapter 4 confirmed the findings with respect to the due diligence process that were outlined in the theoretical background during expert brainstorm sessions, literature study, and expert interviews with institutional investors. With the insights derived from this explorative case study, the second research question is answered: *"How is a due diligence process positioned within a CRE transaction and what are relevant characteristics, phases and transaction costs of a due diligence process?"*. Literature study and interviews pointed out that the due diligence process is the period between signing the LOI and signing the SPA. The brainstorm sessions with commercial, legal and technical advisors resulted in a draft customer journey (Appendix I) that was presented to the institutional investors during the interviews. The recommended adjustments in combination with insights obtained during a literature review have been combined into a final phasing of the DD process, including the phases as depicted in Figure 25.

The defined phases are briefly elucidated below.

- **Sale preparation:** seller makes the decision to sell the property and starts collecting and structuring relevant documents. Also, the selling party drafts an IM or teaser with basic information regarding the property.
- **Pre-DD (market analysis):** in this phase, diverse potential purchasers are approached by the seller or sales broker, and provided with some preliminary information in the form of a teaser or IM. The potential purchaser investigates and collects relevant and accessible information in order to make the preliminary investment decision. If the property fits within the portfolio strategy, a LOI is drafted.
- **Commercial negotiations + sign LOI:** Initial red flags are discussed and negotiated about. When the outcome is successful for both parties, the investor wants to formally express its intention to buy the property under reservation of the DD results and board approvals. After the bidding rounds, the 'winner' gains exclusivity when both parties sign the LOI.
- **Data check:** When the LOI is signed, the DD period officially commences. The data room is now opened and the purchaser (and his advisors) start investigating the property. This phase results in a DD report with all relevant and demanded information concerning the property.
- **Red flag assessment:** At this moment, the advisors determine the severity of the identified risks and decide whether those risks are of fundamental risk for the viability of the deal (so called deal breakers or show stoppers). These deal breakers are indicated as red flags and are listed in a red flag report.
- **SPA negotiations:** If the purchase broker has indicated a set of red flags as 'negotiable', the purchaser and his advisor now reach out to the vendor (and his advisor) with the question for explanation or clarification for any ambiguities or potential red flags, which is discussed during the red flag meeting. After successful renegotiations and after the acquisition is internally approved, a best and final bid is agreed upon, followed by a mark-up of the SPA.
- **Signing SPA:** The best and final bid comprises a binding offer for acquisition of the real estate to the seller. The notarization of the final negotiated SPA follows and then the SPA is ready to be signed by both buyer and seller. After signing the SPA, the deal is closed.

The transaction costs have been determined according to the transaction cost theory framework of Williamson (1979) supplemented with the dimensions of transaction costs as mentioned by Coase (1937). According to these economists, the sources of market frictions (and thus transaction costs) are either caused by (a combination of) 1) interdependency between buyer and seller due to asset specificity, 2) a low transaction frequency, thus a low recurrence, or 3) uncertainty due to asymmetric of imperfect information. We have demonstrated that the characteristics of real estate impact these sources of transaction costs in such a way that the eventual transaction costs are relatively high in comparison to stock exchange markets.

To gain insight into the actual sources of transaction costs for this case study, we defined three transaction cost categories to which the transaction costs within DD processes are attributable: sometimes the client lacks required knowledge (**expertise** needed), sometimes the client is not authorized to do something (**authority/right** needed) and sometimes the client fails in what he tries to achieve (due to **technological inefficiencies**).

The transaction cost drivers as identified in the DD process are set off against these categories. By doing so, we concluded that the vast majority of transaction cost drivers within the DD process are attributable to a lack of expertise, in this case mostly *tacit* knowledge: non-transferable internal knowledge such as know-how, experience, skills, network, or intuition (see Table 9). These findings were not surprising as we demonstrated earlier (in Figure 20) that the principal characteristics of real estate (heterogeneity and asset-specificity) as well as three CRE DD process-related characteristics increase the complexity of transactions, which is inextricably linked to uncertainty and information asymmetry between buyer and seller. As a result, intermediaries are involved to apply expertise, in the broadest sense of the word, which is a direct source of transaction costs. Especially in the DD process, which primarily comprises evaluating the content of documents and assessing potential risks that may show up when acquiring the property, this expertise is required.

*Table 9 | Transaction cost drivers assigned to cost categories*

| Sub process | Transaction costs category | | |
|---|---|---|---|
| | Expertise | Authority/Right | Technological inefficiency |
| Collect data (phase: sale prep.) | | | ■ |
| Assess data (phase: sale prep.) | ■ | | |
| Inspection/measurements | ■ | ■ | |
| Draft teaser/IM | ■ | | |
| Draft NDA | ■ | | |
| Draft process letter | ■ | | |
| Matching sellers and purchasers | ■ | | |
| Check preliminary information | ■ | | ■ |
| Compliance/KYC | ■ | | |
| Negotiate preliminary red flags | ■ | | |
| Draft and sign LOI | ■ | | |
| Collect data (phase: data check) | | | ■ |
| Assess data (phase: data check) | ■ | | |
| Assess red flags | ■ | | |
| Negotiate red flags | ■ | | |
| Draft and sign SPA | ■ | ■ | |
| Set up and maintain escrow | ■ | ■ | |

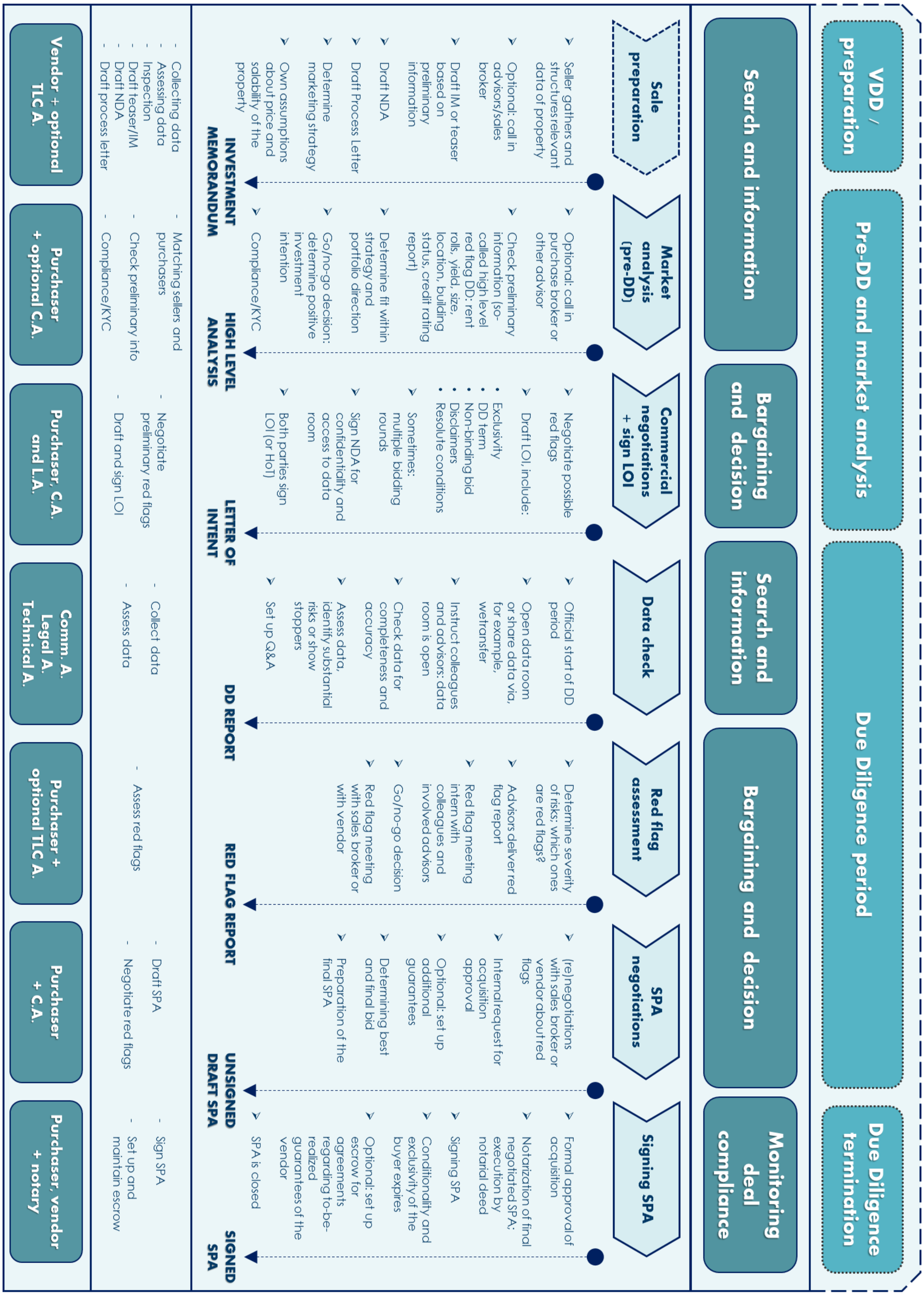


*Figure 25 | DD phases, cost drivers, actors and transaction cost components*

### *Sub-question 3 – Assessing the applicability of blockchain-based solution of DD process*

By combining the results and insights from sub question 1 and 2, chapter 5 answers the third and last research question: *"How can the applicability of blockchain-based applications for lowering the transaction costs of the due diligence process in commercial real estate transactions be assessed?"*. To answer this question, the currently used DD process with the identified phases and characteristics is taken as a starting point.

We developed an extended version of the decision path as presented in the answer to sub-question 1 in order to structurally assess the impact on the sources of transaction costs, after having established that blockchain is a suitable IT-solution for a specific use case. The decision path comprises two components; a general component (delineated with a blue dotted line in Figure 26) and a case-specific component. The first component is general in the sense that this decision path can be followed for decision making processes entailing multiple actors and a type of database in order to determine whether blockchain is a suitable solution at all (see Figure 24). If so, the decision path proceeds to a case-specific component that works towards a statement regarding the impact on transaction costs. The composition of this component depends on the objective of the researcher. For this study, the aim is to reduce the transaction costs of a business process. Hence, the extended component of the decision path works towards a statement with respect to the impact on transaction costs. However, if the research for instance aims at increasing efficiency, trust, transparency or customer experience, another component could be added to the delineated decision path.

The second component builds on the results stemming from the answer to sub-question 2. After assessing the most suitable type of blockchain, it is first asked to what category the case-specific transaction costs are attributable. In the case of expertise, it is relevant to understand whether this concerns either tacit knowledge or explicit knowledge. Because tacit knowledge cannot be expressed by definition, it is presumed that this type of knowledge is not programmable in a blockchain, and therefore the decision path redirects to the red box stating that blockchain is not likely to reduce transaction costs. When the transaction costs are attributable to the category 'right/authority', it should be determined whether the application complies with the current legislation and thus fits within the regulatory framework. For instance, we found that smart contracts are not (yet) legally binding and thus cannot (yet) substitute current contracts. If it does comply, the decision path proceeds to three general questions that concern the sources of transaction costs. Note that this is based on expectations and requires a minimum level of insight into the consequences of a blockchain-based application. If the application is expected to increase the frequency of transactions, decrease the extent of interdependence among actors, or reduce informational asymmetry, we expect that the blockchain-based application will reduce at least a *part* of the total transaction costs, following the TCE framework of Williamson (1979). The more of these questions can be answered with *yes*, the more likely it is that this assumption holds true and the higher the extent is to which it will eventually impact the actual transaction costs. The extended decision path is depicted in Figure 26.

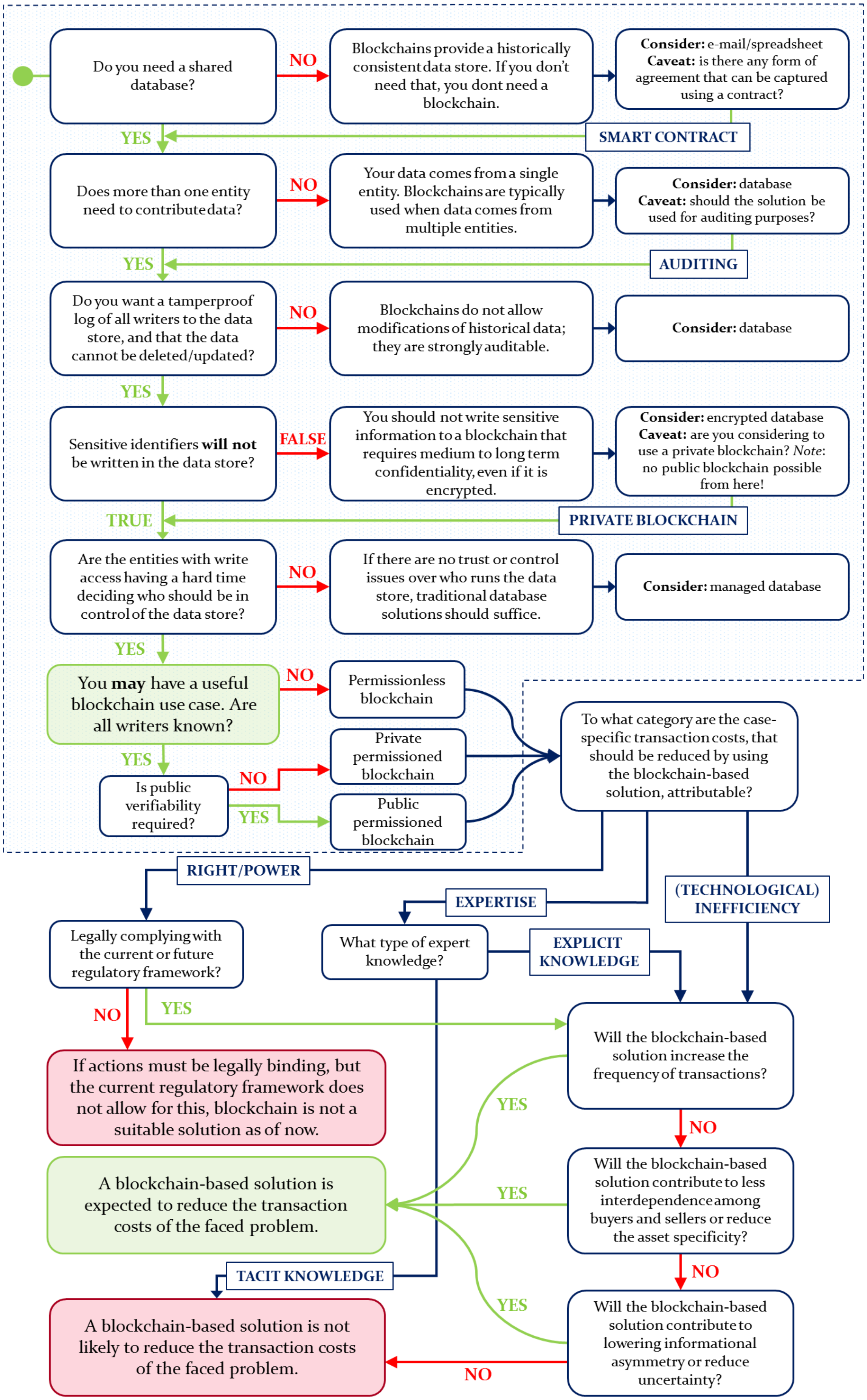


*Figure 26 | Decision path to assess the applicability of blockchain in lowering transaction costs*

*Main research question – Assessing the impact of a blockchain-based solution on transaction costs*

The answers to the three sub-questions are combined to form the answer to the main research question of this study, which is formulated as follows:

> "To what extent could a blockchain-based solution be applicable in a CRE DD process and how could it impact the transaction costs?"

To properly answer the main research question, we first followed the first component of the decision path in order to establish whether there is a potential fit between blockchain and the entire DD process at all. For this DD-process, it is assumed that it concerns a regular CRE transaction of one large property (i.e. with a value exceeding €20 million) in the Netherlands, where purchaser and vendor know and trust each other. By doing so, we showed that blockchain is not the most suitable technology as of now. The advantages that blockchain has compared to conventional (distributed) databases do not hold for the current DD process and therefore a conventional database should suffice in at least expediting the process through a more efficient way of storing, structuring and sharing relevant documents. Although blockchain is demonstrated to be unfit for improving the quality of data provision, applying expertise in information assessment, or providing a one-click fully up-to-date property-specific database containing all relevant documents, we showed that a number of cost drivers are suitable for improvement (or automation) using smart contracts, as can be seen in the table below.

*Table 10 | Confrontation matrix of decision path questions and smart contract applications*

| | Do you need a shared database? | Does more than one entity need to contribute data? | Do you want a tamperproof log of all writers to the data store? | Sensitive information will not be written in the data store? | Difficult to decide who should be in control of the data store? | Are all writers known? | Is public verifiability required? |
|---|---|---|---|---|---|---|---|
| Smart LOI | Caveat | Yes | Yes | Caveat | Yes | Yes | No |
| Smart SPA | Caveat | Yes | Yes | Caveat | Yes | Yes | No |
| Smart Escrow | Caveat | Yes | Yes | Caveat | Yes | Yes | No |

The first five questions determine whether blockchain is applicable at all, and the last two questions aim at specifying the type of blockchain on which the eventual smart contract should be built. At a glance, it can be seen that for all use cases, blockchain appears to be applicable. The first boxes are orange because in principle, a shared database is not required, but when considering smart contracts, this question can be ignored. In this case, it should be asked: *'Is there any form of agreement that can be captured using a contract?'*, to which the answer is 'yes'. The next two questions are also answered positively: more than one entity needs to contribute 'data' (in this case: signing the contract), so there are multiple writers. Also, a tamperproof log of all writers to the data store is needed. The next boxes are colored orange as a contract typically contains sensitive data, but when considering a private blockchain, it can be proceeded to the next question. The fifth box is green: even though there exists no actual lack of trust, each actor obviously wishes to have control, accessibility and possession over signed contracts. Put differently; an institutional investor wants to be able to access the contract everywhere and anytime. Because all writers are known and no public verifiability is required, it is recommendable to build the smart contracts on a private permissioned blockchain.

After we established that the three identified smart contract applications are in theory suitable to implement in the current DD process, each smart contract application was projected to the tailor-made transaction cost-component of the decision path to assess the impact of those applications on the sources of transaction costs, following the last two columns of Table 10.

A smart LOI requires in principle no right or authority and neither is it a technological inefficiency. However, expertise is needed to set up a LOI and therefore the next question revolves around the type of knowledge that is required. It can be argued that a combination of tacit and explicit knowledge is needed to draft a LOI: on the one hand it entails tacit knowledge to properly set up an all-encompassing LOI, whilst on the other hand explicit knowledge is needed (the price, type of deal, land register details, et cetera). Contrary to tacit knowledge, the explicit knowledge-component can be coded and therefore, at least for that part, a smart contract would be suitable. Proceeding to the next questions demands for an estimation of the consequences of this smart contract. Although a part of the process is likely to be expedited using a smart LOI, it is not expected that the frequency of transactions will increase. Moreover, neither the asset specificity will be reduced, nor will the interdependency between buyer and seller decrease with a smart LOI: the properties remain the same complex properties that are traded in unchanged segmented markets. Lastly, also uncertainty or information asymmetry is not expected to decrease using a smart LOI. Indeed, blockchain is transparent and immutable, but a smart LOI will not reduce the investor's uncertainty about the acquisition (and the potential consequences of such a complex asset). In the end, following the decision path, it appears that a smart LOI will not impact the transaction costs.

Building on the smart LOI, a smart SPA includes the entire sales- and purchase agreement that is multi-signed by the involved actors. Despite the fact that a notary possesses tacit knowledge regarding the mark-up of contracts, the transaction costs of a smart SPA are primarily assigned to the category 'right/authority'. Namely, without a notary the SPA cannot be notarized and is thus not legally binding. The next question in the decision path aims at determining whether the blockchain-based application is compliant with current legislation. For now, this is not the case. According to the current regulatory framework, a smart contract is not legally binding and thus not applicable. However, assuming that the legislation will change and smart contracts become legally binding (with for example a digital signature of the notary), then it must be considered what the consequences are on the sources of market frictions. For the very same reason as with the smart LOI, a smart SPA will unlikely positively impact the frequency of transactions. At most, the closing process of the deal would be expedited. Neither will the asset specificity (nor the inherent interdependence) decrease. However, if a notary is not required anymore, there is no room anymore for opportunism (i.e. charging high hourly rates because of a monopoly-position). The notary cannot use its informational advantage as he will be (partly) disintermediated, which in turn reduces the transaction costs. Note that the introduction of smart contracts comes along with new transaction costs. Less money is paid to the notary, but the programmers coding the smart contracts are expensive as well. The impact on the transaction costs is therefore expected to be insignificant compared to the property value, but it requires further research to quantitatively substantiate this.

Compared with abovementioned two use cases, a smart escrow by and large resembles the initial purpose of a smart contract: predefining a set of conditions on the one hand, saving an agreed amount of funds on the other hand and disbursing the funds proportionally to the extent to which the prespecified set of conditions is met. With respect to the category of transaction costs, a smart escrow can best be assigned to 'informational inefficiencies'. Currently, escrows have to be set up in a cumbersome fashion such that a specific company is involved to construct and maintain the escrow and to make sure that the funds are properly paid to the right parties, given the conditions as entered into the agreement. A smart escrow will not increase the frequency of transactions, neither will it decrease the interdependence between the purchasing and selling parties, but it will increase trust and transparency and thus decrease uncertainty and the need of a trusted third intermediating party. Therefore, smart contracts can positively affect the transaction costs by directly cutting out an intermediary, which is in this case the escrow company. Implementing smart contracts thus appears to be the most impactful in the latter use case, i.e. a smart escrow.

Many businesses are exploring and evaluating blockchain technology. It is important to ignore the associated hype, to take a step back, and to take the time to understand what blockchain exactly does (and what it does *not*), as well as to take enough time to understand all the things that blockchain leaves to be done by other systems. Instead of focusing on the current DD process and investigating whether blockchain fits as a solution to this process in its current form, another perspective could be chosen in which the property is the central element and where the DD process (entangled with a potential blockchain-based application) are designed based on its current potential. When looking at blockchain from this perspective, it seems that there still may be a bright and prosperous future ahead for blockchain in (commercial) real estate.

## 6.2 Reflection

To reflect on this research, this section firstly provides a reflection on the research process on the basis of four scientific quality criteria as defined by Verschuren and Hartog (2005). Next, the scientific and societal relevance are reflected upon with an explanation about how the identified knowledge gaps are filled with the findings in this research. Lastly, a reflection on the link between this research and the COSEM MSc program is provided. A personal reflection on the methods, objectives, process and ambitions is provided in Appendix VII.

### 6.2.1 Reflection on the research process

Verschuren and Hartog (2005) have defined four scientific quality criteria to critically reflect on a research process: *validity, reliability, researcher-independence* and *verifiability*. Below, each of these criteria are concisely elaborated.

*Validity*

The validity of the research refers to the question whether the conclusions correspond to reality. During this research, validity is achieved by using multiple data resources. First, both subject fields of *blockchain technology* and *due diligence* were explored with an extensive academic literature study. Next, the findings derived from the literature study were complemented with expert brainstorm sessions regarding due diligence in CRE transactions, as well as expert consultation with respect to the potential and functioning of blockchain technology. These results are subsequently validated with nine different expert interviews about the DD process, based on which a final phasing of the DD process is defined. A decision path for assessing the blockchain applicability is presented, composed of multiple existing decision paths. This initial decision path (*not* the extended decision path; this should be done in further research) is validated in an interactive expert brainstorm session with external and independent blockchain expert Olivier Rikken in order to refine the model to improve its validity.

*Reliability*

The reliability of the research is based on the question whether the same outcomes are yielded when other researchers would do the same research. A CSR is a research strategy oriented at gaining a profound insight into one or several processes that are confined in time and space (Verschuren & Doorewaard, 2010, p. 178). The scope of this research is narrowed down to commercial due diligence processes in *commercial* real estate transactions. As it is performed for Cushman and Wakefield, it was particularly interesting to explore the potential use cases of blockchain from a commercial perspective. Other researchers that for example approach this explorative case study from a technical, environmental, or legal perspective, emphasize other findings of the interviews and potentially identify other, perspective-specific use cases. However, reliability of this research is as much as possible achieved through avoiding bias and subjectivity by departing from theoretical and expert knowledge and have these findings validated with expert interviews. Also, the replication logic of this research is enhanced by systematically validating findings and by maintaining weekly contact with advisors (legal, technical, fiscal and commercial), internal supervisors at the university, and external supervisors (and various colleagues) at Cushman & Wakefield.

*Researcher-independence*

This study was performed by only one person, supervised by multiple internal and external supervisors. The researcher was independent of other researchers, mandatory process, methods, or outcomes, as the research is conducted using an explorative approach in the study of blockchain technology in the commercial real estate market. The explorative expert interviews, brainstorm sessions and consultations have provided a multifaceted impression of both blockchain and its potential, as the phases and actors involved in a DD process. It is intentionally opted for a research supervised by multiple parties in order to withhold the research from becoming too theoretical or too practical, as well as to ensure the impartial nature of this study. Lastly, Cushman & Wakefield as the commissioning organization has not imposed any form of prescribed outcomes, nor a required design of the research. This affirmed and strengthened the researcher's independence.

*Verifiability*

The last quality criterion refers to others' ability to verify the correctness of this study. Verifiability of this research is achieved through referring to all sources as used in the literature study and documenting all results of the interviews with the institutional investors. The findings derived from the literature study have, together with the results of an expert brainstorm, resulted in a preliminary phasing of the DD process and this is validated during the interviews. Appendix V contains a summary of the results from these interviews. In addition, all documents that served as input for the case study are documented in Appendices I and IV. Also, the criteria for selecting the respondents and the boundaries of the case study are concretized. However, the transcripts of the expert interviews are excluded from this report because of strict confidentiality requirements of the respondents. If the concerning respondents assent, these are still available upon request to the author.

### 6.2.2 Reflection on societal and scientific relevance

This study is societally relevant because the insights derived from this research contribute to forming a critical stance towards the applicability of blockchain, but simultaneously also to better understanding its potential. Various use cases for blockchain applications in CRE DD processes have been assessed with respect to the potential of lowering transaction costs. These applications could ultimately expedite CRE transaction processes and increase efficiency in the real estate market. The technology may still be in its infancy, but intermediaries must anticipate potential blockchain developments and rethink their current position as well as figure out how to position themselves in the value chain in a different way than they currently do. Especially these parties, who fulfil an intermediating role in this process, are benefitting from the insights - derived from this study - into how blockchain could impact the entire market and particularly the fashion in which DD processes are organized.

The scientific body of knowledge about blockchain is increasing in a high pace, but the number of academic articles that address both blockchain technology and commercial real estate (or due diligence, let alone transaction cost economics) is still limited. The scientific relevance of this study is threefold. First, it applies Williamson's TCE framework to the CRE DD process, a unique and novel combination of scientific fields. Applying TCE helps explaining why a transaction in real estate markets invokes significant higher transaction costs than a transaction in a stock exchange market. This is substantiated with 1) a set of propositions regarding the influence of the characteristics of both CRE markets and stock exchange markets on the sources of transaction costs, and 2) an enumeration of determining factors concerning the unicity of a DD process, applied to CRE acquisitions. Second, this study presents an extensive decision path that can be followed to firstly determine whether (and what type of) blockchain is the most suitable 'database'-solution for a given use case, and if so, to secondly obtain a comprehensive idea about the expected impact on the transaction costs of the concerning process. Third, the phases and transaction cost drivers within current CRE DD processes and exposed after which it is explored how blockchain should be deployed to directly affect the sources of these transaction costs in a positive way using the abovementioned decision path. These insights are remarkably relevant because they do not only provide an all-encompassing overview of the phasing of a DD process and its fit and significance within CRE acquisitions, but also because novel insights regarding the threefold combination of *transaction cost drivers (TCE)*, *blockchain*, and *(CRE) DD processes* are presented in this thesis.

In earlier work, Veuger (2018) and Dijkstra (2017) explored the theoretical applicability of blockchain in the entire CRE management and transaction process, based on the proclaimed characteristics of blockchain technology (predominantly efficiency, process automation, reliability, and transparency). This study, however, takes the research a step further and provides an actual decision path that supports with structurally determining the applicability of blockchain as a solution and the subsequent expected impact on the sources of transaction costs in addition to exploring the potential use cases.

### 6.2.3 Link between this research and the COSEM program

As a final point, the link between the Complex Systems Engineering and Management (COSEM) Master's program and this research is elaborated. On a high level, the COSEM MSc curriculum revolves around acquiring knowledge and insight into designing and managing systems in complex technical environments, in which both multi-actor complexities and systems complexities arise. To be more specific, this section explains how this research flawlessly fits within this program.

The case study performed in this thesis is an excellent example of what is taught during the COSEM MSc program: exploring design options by combining a highly *complex technological environment* (blockchain as an untapped, unexplored and emerging technology) with a highly institutionalized, multi-actor, *socially complex environment* (the commercial real estate market, with financial, legal, technical, fiscal and environmental stakeholders and objectives). This is a *socio-technical* environment as pure as it can be.

The basis of this thesis is formed with the methods, techniques and analysis tools as taught during the first and second year of the COSEM MSc program, combined with knowledge from my specialization in Economics and Finance. A selection of courses that have contributed to properly performing this research is listed below. Note that this also comprises courses from the former SEPAM program, which were followed during cohort 2015-2016:

- *Legal aspects of MAS design:* exploring and understanding the legislation and regulatory framework with respect to blockchain-based applications.
- A combination of former *MAS design from engineering perspective* and *MAS design from actor perspective*: conducting interviews, performing an actor analysis, mapping actor-specific desired situations and objectives, constructing a confrontation matrix, research blockchain technology and the potential of blockchain-based applications, and determining the applicability from a combined actor/engineering perspective.
- *Institutional Economics for designing sociotechnical systems:* applying transaction cost economics to identify and allocate transaction costs within the CRE DD process. Also, it is explained why blockchain is a market-enhancing technology for economic coordination and how blockchain can perfectly be approached through the lens of TCE and (relational) contract law theories.

Lastly, the COSEM MSc program has taught us to use creativity, structure, theoretical and empirical knowledge, critical thinking and critical reflection, and an actor- and an engineering perspective to academic standards. These are skills that are not always explicitly taught, but are at least of equal importance in forming the fundamentals of a proper research and contributing to the academic debate.

## 6.3 Limitations and recommendations for further research

Commercial real estate properties tend to be highly heterogeneous and complex, and so are their (segmented and localized) markets. A consequence is that transactions of such complex assets require expertise from various disciplines and tend to be lengthy, cumbersome processes. By focusing on the DD process, this study aimed at capturing a part of those transactions and exploring to what extent blockchain could add value for this process. However, despite the extensive in-depth case study, this research has a few limitations that can be translated into suggestions for further research. This section discusses these limitations and subsequently defines the derived recommendations for further investigation.

*Studies on applying blockchain in (commercial) real estate*

As demonstrated in section 1.2, it may be evident that blockchain is rising in popularity. From 2013 to 2017, the number of scientific publications containing blockchain has approximately tripled every year, stressing the increasing popularity. However, even though publications about real estate can be found in extensive amounts, the combination of blockchain and real estate is used in a mere 1.2% of all publications containing 'blockchain'. This is an important finding as it underpins the fact that the current body of academic knowledge lacks publications about blockchain and real estate. The combination 'blockchain + real estate + due diligence' returned no search results in Scopus. Lacking availability of scientific articles implies that there were no 'shoulders of giants to stand on', and that this research is the very first to combine the concepts of blockchain and the CRE DD process.

This study has paved the way for both blockchain and real estate experts to start investigating the possibilities of blockchain-based applications in real estate. Where this study was limited to the DD process and to transaction costs, there exist numerous conceivable application fields that can be scrutinized in the future. Suggested future research questions can therefore be:

- *'To what extent can blockchain-based applications improve transparency (or e.g. efficiency or trust) in commercial real estate transactions?'*
- *'To what extent will the benefits of implementing blockchain-based applications exceed the costs of actually implementing those applications?'*
- *'To what extent is blockchain applicable in commercial real estate management and transactions, other than during DD processes?'*

*Applicability and validation of proposed extended decision path*

The main deliverable, which is the extended decision path to gain insight into the impact of a blockchain-based solution on the transaction costs, is particularly designed for cases concerning properties with a certain size and complexity. These complex transactions involve for instance the assessment of financial structures of the company that wishes to acquire the property, return requirements, approvals of the investment committee, and fit within the portfolio strategy. The first part of the proposed decision path is generally applicable, but the second part is limited in the sense that it particularly focuses on the impact on transaction costs and includes questions that assume the inclusion of professional advisors. Hence, if the question is about increasing trust, transparency, or efficiency, this decision path is not applicable and the second component should be replaced by another 'block' with respective questions. These are not explored in this research. Also, the extended decision path is created diligently with knowledge that was acquired during this research and has been peer-reviewed by blockchain experts, yet it is still based on theory and has not been tested and validated with real-world uses cases. It is expected that the decision model can be further specified and refined by validating it with real world use cases and therefore serves as an interesting input for validation in further research. Moreover, it is suggested to design and validate other components than the transaction cost-component as proposed in this study. Potential future research questions are defined as follows:

- *'How can the proposed decision path for assessing the impact on transaction costs of a blockchain-based application be validated in order to refine or optimize the model?'*
- *'How can the applicability of blockchain-based applications for increasing efficiency (or trust, or transparency) in commercial real estate transactions be assessed?'*

### *Research approach: brownfield thinking versus greenfield thinking*

The conclusions resulting from this study indicate that blockchain as a state-of-the-art technology currently seems to be too nascent and too unfit to function as an efficacious solution to today's DD processes. These conclusions are drawn with the implicit assumption that the status quo of the DD process will remain the same in the future. This is called *brownfield* thinking: the DD process as performed these days is taken as a given, and from this starting point it is researched whether, and to what extent, blockchain could be deployed in this process to decrease the eventual transaction costs. A limitation of this approach is that is does not take possible out-of-the-box ideas into consideration that might also innovate the way current DD processes are performed.

Instead of putting the current DD process central and investigating whether blockchain fits as a solution to this process in its current form, it is interesting to approach this case from a different angle in which the property is the central element and where the DD process (and potentially a blockchain-based application) are designed based on its current potential, which is called *greenfield* thinking. It is therefore suggested to further research this topic, but from a different perspective. Follow-up questions for further research are formulated as follows:

- *'What would a DD process look like when each property has its own individual digital passport and what role could blockchain play in this process?'*
- *'What impacts would tokenization of commercial real estate assets have on CRE investment market and what would the potential consequences for the size of this market be?'*
- *'What would the allocation of transaction costs be in a newly designed DD process in CRE transactions and how would this impact the role and added value of the current intermediaries?'*

### *Extending the scope: legal & technical DD, private investors, sell-side DD, and non-Dutch markets*

Since the combination of blockchain and real estate is a broad, untapped field in which a wide range of combinations can be researched, the scope of this research is narrowed down to commercial, buy-side DD processes in Dutch markets by institutional investors. These limitations have on the one hand resulted in an in-depth exploration of this type of due diligence in a predefined market, but on the other hand leaves space for further research.

Even though it is demonstrated that the different disciplines, as well as buy-side and sell-side DD processes, tend to be overlapping to some extent, it is expected that, e.g., private investors are less conservative or risk averse than institutional investors. Therefore, as part of exploring possibilities beyond the scope of this study, we have formulated the following research questions for further research:

- *'What are the relevant phases of a legal (or technical) due diligence process in large commercial real estate transactions and how are the associated transaction costs allocated?'*
- *'What are the differences between private and institutional investors in the Netherlands in terms of risk taking and requirements and how does this affect the phasing and complexity of the DD process?'*
- *'To what extent are the activities of the buy- and sell-side due diligence in commercial real estate transactions overlapping and how can these activities be standardized?'*
- *'To what extent is the extended decision path (presented in this research) applicable from a vendor perspective for sell-side due diligence processes?'*

### *Technological standardization of document management systems*

From the interviews with institutional investors, it appears that one of the principal pain points is the lack of standardization when it comes to storing, sharing, and organizing property-related documents. When purchasing a property, the DD-checklists of the legal, technical and commercial advisors seemingly overlap for a significant part, which in turn demands from the selling party to send the same document to various parties. Additionally, there is no single taxonomy with respect to the property-related documents and the general terms used in the CRE market. Advisors use multiple terms to indicate the same document (e.g. 'cadastral information', 'land register details', and 'cadastral plot plan'), even though they might slightly differ. Moreover, the involved advisors use various IT-systems for sharing and assessing documents during the DD process.

In this study, we have concluded that there is an actual lack of standardization on different aspects; on the one hand a lack of technological standardization, referring to the standardization of (and interoperability between) databases, and on the other hand a lack of unambiguous terminology (taxonomy). Both the infrastructure and the content/data that is shared on that infrastructure is subject to improvement by standardization. Hence, we expect that an efficacious document management system that applies one universal taxonomy can expedite the currently cumbersome DD process. Therefore, we suggest looking deeper into the possibilities and added value of a universal solution with a universal taxonomy. Recommended questions for further research are therefore defined as follows:

- *'To what extent could an all-encompassing taxonomy be constructed in order to standardize the language of the legal, commercial, technical, environmental and fiscal disciplines?'*
- *'How could a universal document management system be designed in order to efficiently store, share, organize, and update property-related data and what role could blockchain play in this system?'*
- *'To what extent can the costs of designing and implementing a universal document management system be counterbalanced by the amount of reduced transaction costs by this system?'*

Building on this recommendation, it could be insightful and interesting to investigate the causes of information ambiguity in the information provided by the seller at the moment that the DD phase commences and the data room opens. How do you determine the cause of the poor quality of provided property-related information? Some respondents suggest that it is because the vendor does not prioritize the proper structuring of the property-related documents, while others state that it is attributable to the transition from hardcopy to digital documents (years back). It appears to be a significant pain point for the purchaser, but at a certain moment in time, this purchaser becomes a seller of the same property and can expect the same questions he asked the erstwhile vendor. It is conceivable that the poor information provision results from the high amount of associated administrative burden in the first place, and secondly because the current market is a *seller's market*; i.e. the demand is higher than the actual supply, resulting in a privileged position of the sellers. Put differently, if a purchaser demands too much, the seller refrains from the deal and has a dozen of other willing purchasers to choose from, leaving the other purchaser with un-invested capital. The current information ambiguity (and poor quality of information provision) should therefore also be incorporated in further research. This is important since the result of poor information quality results in more billable hours by the legal and technical advisors, whose payment structure is on an hourly basis.

# 7 DISCUSSION

This study is diligently carried out according to academic guidelines and followed an explorative CSR approach supplemented with the principles of transaction cost economics. Based on a variety of interviews, an extensive literature study, and expert consultations, the DD phases and respective allocation of transaction costs are accurately delineated, as well as the concept of blockchain, its functioning and its applicability. Building on the findings arising from this case study, we explored to what extent blockchain could in general be applicable in the DD process as defined in this study. Perhaps unfortunately, we concluded that the technology is not yet suitable to mitigate the transaction costs as currently incurred in the DD period, apart from one or two seemingly insignificant use cases. Important to notice here is that we have presumed the status quo of the DD process as a predefined, immutable process. This approach is often referred to as '*brownfield thinking*': exploring possibilities within the boundaries of a given process or system. The conclusions of this research thus possibly do not hold when a different, more innovative, 'thinking-out-of-the-box'-approach was followed, which is perhaps less academically substantiated and rather based on assumptions. This less common approach is the so-called *'greenfield thinking'*: 'a term that describes a software project that is developed from scratch rather than built from an existing program' (Hopkins & Jenkins, 2008). Approaching the case study from this perspective could lead to new, interesting insights with respect to the applicability of blockchain in commercial real estate: what if blockchain as a solution is given, and the DD process would be designed retrospectively? What if the property would be treated as the central subject of analysis in this research instead of the DD process? Would a blockchain-based solution then still be deemed inapplicable? What are conceivable use cases for this technology outside the boundaries of the DD process? In this discussion, we try to look at the problem from a different angle and discuss a few emerging blockchain possibilities when taking this perspective.

### *Tokenization of properties: colored coins*

A first conceivable instantiation of blockchain combines the principles of cryptocurrencies with real estate, and is called *tokenization.* Tokenization essentially corresponds to the digitization of real estate properties and splitting a property down into multiple digital shares (called *colored coins*) that each represent a fraction of the property. These colored coins can be fractions of for instance a Bitcoin, but also special-purpose tokens for real estate. Tokenization makes it easier and less expensive to invest in assets as it removes geographical restrictions, transaction costs paid to intermediaries and minimum investment amounts. The characteristics of real estate in this case become more like the characteristics of stock exchange markets: homogeneous tokens, geologically independent markets, partially segmented markets. We expect that the transaction times are positively impacted with tokenization, since property sellers can sell fractions of a property, as opposed to the need to find one appropriate investor for the entire property. Moreover, tokenization lowers barriers to enter the (commercial) real estate market, implying that huge new capital inflows can be unlocked through tokenizing properties. A blockchain-based application would allow programming fractions of a property and thus taps into an untapped market: new definitions of property ownership and rental contracts will arise from these new business opportunities (Vidal, 2017).

*Digital property identity with smart tenancy and smart rental contracts*

In this study, we have analyzed properties that are usually worth over €20 million and include multiple tenants. Managing the cashflows of these large properties (or portfolios) entails a high administrative burden. However, inspired by Midasium (n.d.), we expect that using smart contracts for rental payments and tenancy overviews may partly automate this process with blockchain. Smart contracts add value because they enable property owners to spend less time reconciling transactions for rent payments and property expenses, provide full transparency and control for overseeing (and approving) property expenses, and finally reduce the costs of accounting, compliance, and property management. In theory, applying smart rental contracts can work according to the following steps:

1. Property owner creates a smart tenancy contract and includes key tenancy information such as the rental price, payment frequency, terms and conditions, rental contract and tenant details.
2. The tenant reviews the rental contract just like any other conventional legal contract, so no code is displayed in order to prevent misunderstanding of the content.
3. Tenant agrees with the rental contract and digitally signs the contract with their personal key.
4. The property owner signs the contract as well with his private key. Now the contract is multi-signed by both parties and subsequently recorded on the blockchain. This document is now considered legally binding and cannot be altered anymore.
5. Tenant deposits his funds and the smart contract places this in a secure account (like smart escrow), which, if both parties agree, only allows the funds to be reversed to the tenant's account or an agreed proportion disbursed to the property owner's account.
6. Every month, the smart contract automatically debits the tenant's account and the funds are instantaneously dispersed to the property owner's account. Reparations, maintenance work and other expenses that are agreed to be reimbursed by the tenant can also be settled in the smart contract.
7. Upon termination of the lease, the tenant's funds are disbursed to the tenant and to the property owners according to what has been agreed upon in the smart contract.

A smart rental contract as described above can be part of a bigger blockchain-based solution. Shifting the focus from the DD process to the property, a potential smart contract application is a digital property identity, or a '*digital building passport*', where one smart contract is connected to every (qualified) large CRE property. This digital property identity can be regarded as an asset-specific database that records the financial and legal history (i.e. the transactions of the property and the former owners), the location, and the title details of a property. A smart contract built on top of a private permissioned blockchain would perfectly suit here: a preselected number of writers can add proofs of permits, inspection reports, title registration, and cadastral details to the private asset-specific blockchain. On top of this smart contract, multiple other smart contracts could be built that represent a part of the building, for example a smart rental contract, a smart escrow, a smart SPA, or inspection details that can be multi-signed by the property owner and the inspector. The hashes of these documents are saved and are only accessible to permitted actors with the right private key. A digital building identity would perfectly function as a 'proof-of-existence' database with timestamped hashes.

Note that such property passport is merely able to provide information about the *completeness* and *accuracy* of the documents, not about the *content* of the documents. This might be difficult to grasp and is therefore illustrated with a straightforward example. Suppose that a property is built in 2000 and has 10 tenants, who all joined between 2000 and 2005, and never left. All relevant property-related documents and smart rental contracts are signed, hashed and entered in the digital property passport. If you wish to acquire this property, you can immediately see that the array 'rental contracts' comprises 10 hash values, implying that there are seemingly 10 tenants currently renting a space in the building. Also, these rental contracts are multi-signed by the property owner and the different tenants, thus it can be proved that those are the signed versions of rental contracts, which avoids potential disputes. Furthermore, it can be seen with the timestamp that for instance 8 tenants signed the contract in 2002, and 2 in 2004. This timestamp also applies to inspection reports (multi-signed by inspector and owner), certificates, installation reports, warranties, et cetera.

Let's now go back to you, as an investor. Without any prior knowledge about the property, a quick preliminary assessment can be made of the most basic property information. As soon as the data room is opened or when preliminary information is issued to potential investors, you can directly determine whether the documents *provided* are *complete* (did you actually receive 10 rental contracts?) and *accurate* (are those contracts indeed signed in 2002 and 2004?). However, what the blockchain does not tell you is anything about the content of those contracts: are these legally binding, are all clauses included, are the rental prices market-competitive, and are the tenants creditworthy? This is called *tacit* knowledge and needs to be assessed by experts. Therefore, we expect that by assigning smart contracts to large CRE properties, a significant amount of data checking for completeness and accuracy can be taken away, which expedites acquisition processes, but a thorough assessment of the documents inevitably requires the involvement of (multidisciplinary) intermediaries. The difference between an asset-specific blockchain with all cashflows and tenant overviews is that those documents must be updated and the blockchain does not allow for those modifications (at most adding new blocks with updated information), thus would be more suitable for documents that are not altered after recording on the blockchain. The distributed, tamperproof, and encrypted nature of blockchain makes it difficult for mischievous actors to commit fraud to the entered documents, and thus blockchain is a suitable, security-increasing technology to store data as *proof of existence,* but not as a database that requires continuous updates (and more important: deletions of outdated and privacy-sensitive information).

To come full circle, it is interesting to think about the impact of such an application on the transaction costs of the DD. This can be assessed by determining the impact on the sources of transaction costs (see Figure 26). Will it reduce uncertainty? Probably, as the basic information is captured in the blockchain. Will it reduce asset specificity? Not really, as the properties will retain their asset-specific complexity, but the *process* is expected to be simplified with a higher quality of the provided documents. Lastly; will it increase the frequency of transactions? Although it is debatable, we expect that the barriers (in terms of money, time, and process complexity) to acquire and sell properties can be significantly lowered, resulting in a shorter throughput time of the DD process and shorter intervals between transactions of a property. In the end, we see a reasonable chance that the eventual transaction costs can be significantly lowered. However, this is open for discussion and deserves further research.

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# APPENDICES

## I. Original decision paths for determining applicability of blockchain-based application

Figure 15 in chapter 3 is composed of a combination of two different frameworks. The first part until the green box is inspired by the framework of Meunier (2018), depicted in Figure 27, and is slightly adapted in the sense that some questions are either combined or removed. It combines the questions '*Data records, once written, will never be updated or deleted*' and *'Do you want a tamperproof log of all the writers to the datastore?'* into one question as blockchains do not allow for modifications of the log, nor for modifications of the historical data (i.e. the hashes) as recorded on the blockchain. Combining these questions result in: '*Do you want a tamperproof log of all writers to the data, and that the data cannot be deleted/updated?'*.

Two caveats added after the first and fourth question, which are not included in Figure 27. First, the first question '*Do you need a shared database?'* may in the case of a smart contract be answered with 'no', depending on the way a 'shared database' is interpreted. A smart contract is a contract that can be signed by more than one party, but not necessarily requires a shared database in the sense that multiple actors need to add data or documents to the smart contract. Therefore, we assumed that in some cases, the first question could be answered with 'no', while it concerns an actual use case for smart contracting. Hence, the caveat 'smart contract' is added. Second, sensitive information should indeed not be stored on a *public* blockchain, where the information is accessible to anyone participating to the network. However, if the designer aims at using a *private* blockchain, the question can be ignored as the information on the blockchain is protected against unauthorized use, thus excluded from the outside world. Hence, in the case a private blockchain is aimed to be used, it can be proceeded to the next question. Note that if the answer is 'yes' to the next question, the only possible option is a private permissioned blockchain, and thus the writers should be known and there may not be any public verifiability required.

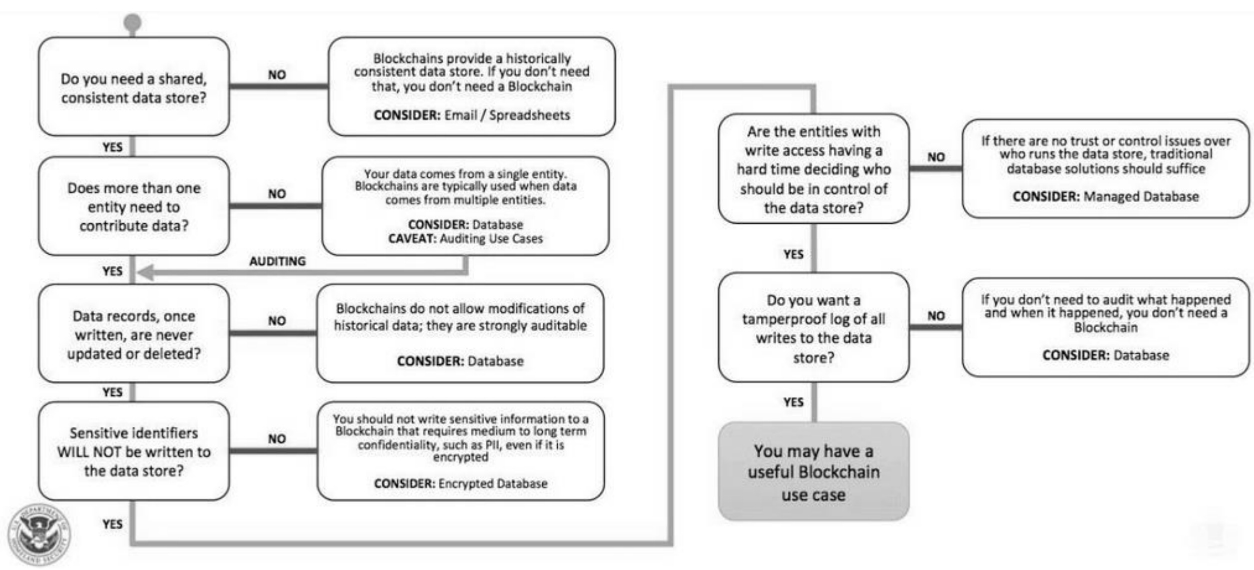


*Figure 27 | Original blockchain decision path, retrieved from Meunier (2018)*

The second part of the decision path in Figure 15, from the green box onwards, is inspired by the framework of Wüst and Gervais (2017), depicted in Figure 28, and specifies the type of blockchain that could be suitable for the specific use case. One question is left out, namely '*are all writers trusted?',* which had an answer '*don't use blockchain'* if the answer was 'yes'. The last question before the green box already addresses this problem and therefore the question became obsolete.

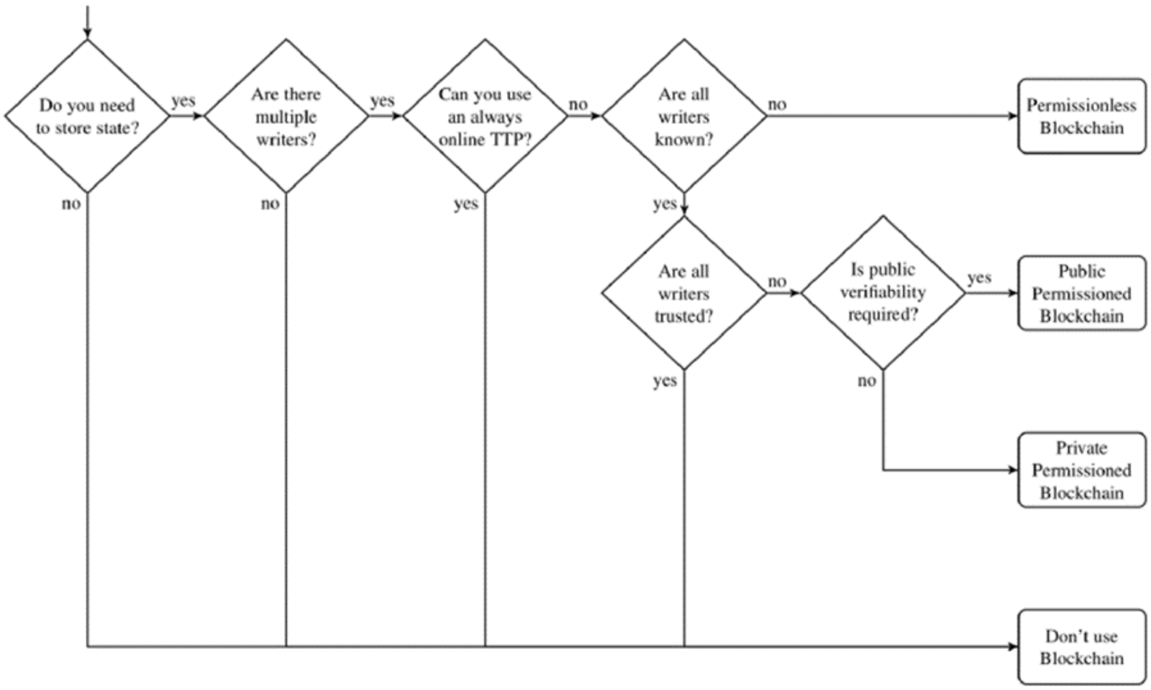


*Figure 28 | Original blockchain decision path, retrieved from Wüst and Gervais (2017)*

## II. Results of the expert brainstorm session about DD phases

A brainstorm session with professionals from various disciplines has taken place in order to define a set of generally applicable phases in a DD process, regardless of the DD type as described in sub-section 4.2.2.3. The experts, who work for multiple advisors, are:

- Timco Toppen (Analyst, Cushman & Wakefield)
- Rick Hoogervorst (Executive Director, FRIS Real Estate)
- Vivienne Barneveld (Manager Client Innovation, Stibbe)
- David Orobio de Castro (Partner & Head of Real Estate, Stibbe)
- Esther Stomphorst (Business Innovation and Technology, Deloitte)
- Oscar Smeets (Manager Indirect Tax, Deloitte)
- Martin Smit (Product owner of CRE Eco System, ABN AMRO Bank)
- Hilde van Egmond (Business Innovator, ABN AMRO Bank)

The result of this brainstorm session, which took place on 11 December 2017, is depicted in Figure 29. The phases as indicated during this brainstorm session have served as an input for the interviews: we showed the respondents the phases (which were empty, i.e. without descriptions) and asked to what extent they agree with this phasing of the DD process. The questionnaire that was used is presented in Appendix IV and the anonymized results are shown in Appendix V.

# Draft Customer Journey Due Diligence

| Stages | 1 Pré-DD | 2 Collect data | 3 Data structuring (checklist) | 4 Check data for accuracy | 5 Considering substantive risks | 6 Negotiating |
|---|---|---|---|---|---|---|
| | • Create a conditional agreement<br>• Draw letter of intent<br>• Determine the price<br>• Decide: buy or not | • Prepare checklist and send it to customer<br>• Receive data from owner | • Check whether receiver data is complete<br>• (Possibly) Add Memo 'data not applicable'<br>• (Possibly) Request external data | • Buyer starts technical inspection<br>• Create red flags report (i.e. where are the risks?)<br>• Request external data | • Discuss red flags | • Finalize Due Diligence project |
| Who's involved? | • Seller / Owner<br>• (potential) buyer<br>• Broker / Commercial advisor<br>• Technical Administrator<br>• Legal advisor | • Seller / Owner<br>• Facility management<br>• Technical administrator | • Seller / owner<br>• Technical advisor<br>• Legal advisor<br>• Chamber of Commerce, Municipality, Land Registry | • Seller / owner<br>• Buyer<br>• Technical advisor | • Seller / owner<br>• Buyer<br>• Commercial advisor<br>• Technical advisor<br>• Legal advisor | • Seller / owner<br>• Buyer<br>• Facility manager<br>• Technical administrator<br>• Commercial advisor<br>• Technical advisor<br>• Legal advisor |
| Needs | • Quick scan red flags/ issues (potential price impact items) | • Determine which data is necessary and then determine as efficiently as possible which is available and relevant. | • Unambiguous checklist<br>• Verified documentation | • Streamlined process (data is ready)<br>• Sufficient lead time | | • Comfort feeling that available information reflects the complete truth |
| Feelings | • Doubt whether all information is correctly displayed in IM / OM | • "Not a fantastic job"<br>• "Unprofessional" | • "Not challenging"<br>• "It's a must"<br>• Time-consuming | • Time-consuming | | • "Glad it's finished" |
| Barriers | | • Quality of internal processes of the vendor are not in order<br>• No standard checklist available | • Pass-through portfolios<br>• Mediocre preparation of sales<br>• Dependence on different parties | • Short lead time<br>• Quality of data seller and quality of management is mediocre | • Red flags can seriously delay the process if additional research is needed | |
| Notes | • In the pre-DD phase, an IM / ON (Information / Offering Memorandum) is launched on the basis of which potential buyer can make bids | • Buyer accepts higher risk due to incompleteness of data | • Check for a small building yourself<br>• External advisor checks at a large building<br>• Strong dependence on different parties | • Incorrect or incomplete data frustrates and impedes deal making | | |

*Figure 29 | Initial draft of the Customer Journey of a buy-side DD Process*

## III. Background: CRE market in the Netherlands

To gain a general understanding of the Dutch CRE market, this Appendix provides a quantitatively substantiated description of investment volumes per CRE investment class, the allocation of investors and the Dutch CRE investment structure.

The aftermath of the global financial crisis, which was highly interrelated with the burst of the housing bubble, seems to be totally vanished these days. The global real estate market has been growing ever since the crash and amounted in 2017 to a total value of more than $230 trillion (Cushman & Wakefield, 2018a). In Europe, the volume of all CRE transactions peaked in 2015 at €241 billion, i.e. double the volume of 2012 (Stapenhorst & Just, 2018). Also in the Netherlands, the real estate sector plays an important role and is closely connected to the financial sector. Figure 30 visualizes the rapid rise of the real estate investment volumes over the past 5 years. In 2017, the total amount of CRE transactions amounted to more than 10,000 (Cushman & Wakefield, 2018b).

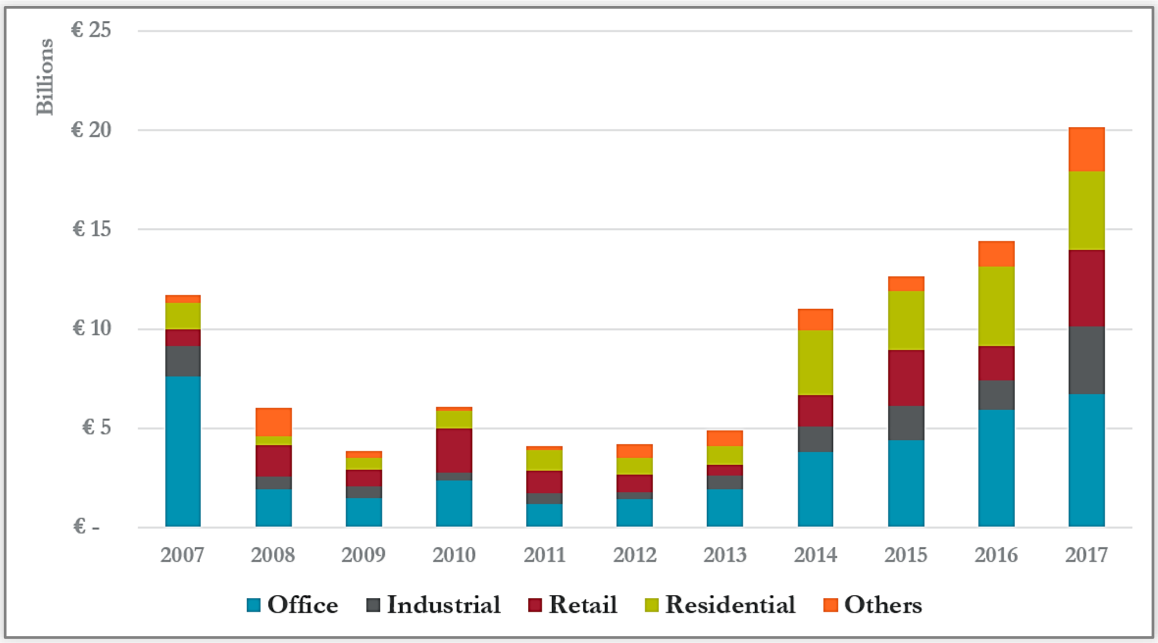


*Figure 30 | Dutch real estate investment volumes, retrieved from Cushman & Wakefield (2018b)*

With the aim of increasing the transparency of the Dutch real estate sector, De Nederlandsche Bank (DNB) and het Planbureau voor de Leefomgeving (PBL) published a report providing insight into the size, structure, and the finance of real estate investments in the Netherlands.

The size of the CRE investment market in the Netherlands is around €75 billion. Dutch institutional investors (i.e. retirement funds, insurers and real estate funds) account for two-third of the investment market with more than €47 billion invested in real estate (Nijskens et al., 2017, p. 3). Figure 31 shows the allocation of real estate investments in the Netherlands per investor type, numbers displayed in billion €.

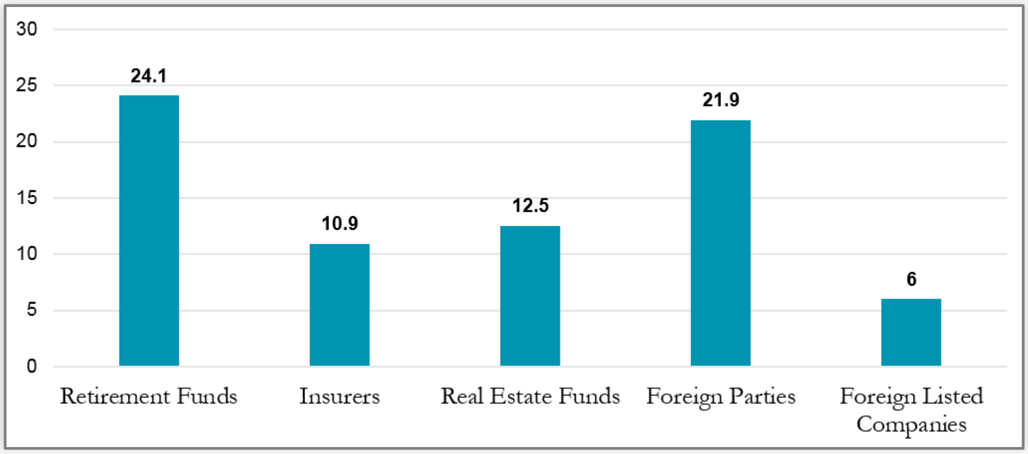


*Figure 31 | Dutch CRE investment market, retrieved and adapted from Nijskens et al. (2017)*

Shifting the perspective from the Dutch real estate market towards Dutch institutional investors, which fall within the scope of this research, it can be noticed that their investments have remained fairly stable since 2013. Although insures and real estate funds respectively invested 10% and 15% percent less, the investments of pension funds have grown by some 7% between 2013 Q1 and 2016 Q3, coming down to a growth of approximately 2% per annum. The total real estate investments (both Dutch and foreign) of pension funds have grown by more than one-third between 2013 and 2016 as well as the share of real estate in their total investments. This is in all probability related to the 'search for yield': as discussed, the return on real estate has grown steadily over the past years, while interest rates on other assets in the capital market (e.g. stocks and bonds) have declined further (Nijskens et al., 2017; NVM, 2017). Moreover, an important factor behind the recovery of the investment volume is the wide availability of investable capital. The term 'wall of money' appears again in the investment world, to indicate the enormous amount that investors have available in liquid assets. This substantial capital position is largely caused by the buy-back program of the European Central Bank (ECB), also known as quantitative easing (QE) (Buitelaar, 2017, p. 17).

Investments in real estate are often divided into so-called 'direct' and 'indirect' investments, also known as asset deals and share deals, respectively (Stapenhorst & Just, 2018, p. 7). In the Netherlands, a large part of the real estate investments is indirectly invested via pension funds. These funds are entrusted money from mainly institutional investors to subsequently invest it in real estate. Non-institutional investors, such as Dutch companies, family businesses and financial institutions mainly invest in direct real estate funds. An important notice is that a shift is taking place from direct to indirect investments. The percentage of indirect investments of Dutch institutional parties has increased between 2013 Q1 and 2016 Q3 (Nijskens et al., 2017). The general investment structure in Dutch real estate, as explained above, is depicted in Figure 32.

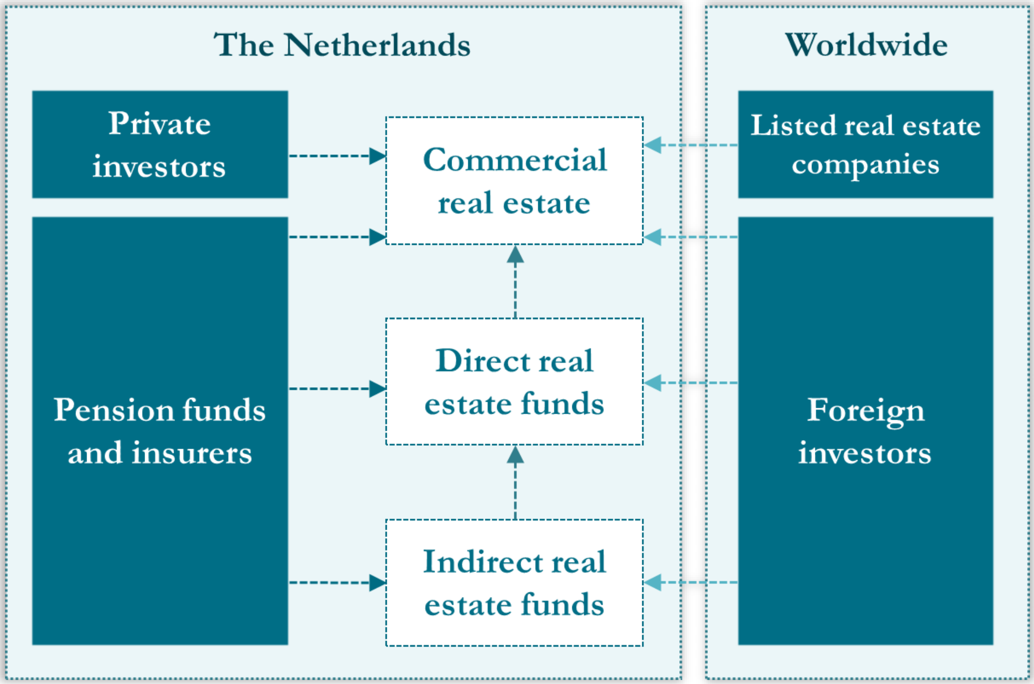


*Figure 32 | Dutch CRE investment structure, retrieved and adapted from Nijskens et al. (2017)*

# IV. Questionnaire used for interviews

As discussed, to validate the assumptions made during the literature review and to gain insight into the state of affairs in a DD process, a number of interviews is performed during this research. During these interviews, a significant amount of private- and business sensitive information is shared with the interrogators to substantiate claims and to elucidate the point of views. This has openly been shared with the proviso that the information shared would be treated as confidential and therefore no direct citations to interviewees are made in this report. Instead, to the interviewees is referred as 'respondent' in case of quotes, and not at all in case of claims or visions.

The interviews have been conducted by Floor Seuren and Eduard van Wijk, consistently accompanied by one of the experts from the DD working group, as mentioned in Appendix I. The following questionnaire has been used as guiding document in order to ensure that the same questions are asked to all respondents and thus the answers are well comparable:

### *Introductie*

Fijn dat u ons heeft uitgenodigd voor dit gesprek. In dit onderzoek kijken wij naar het due diligence proces in commerciële vastgoedtransacties. Met de resultaten van deze interviews proberen wij de customer journey in kaart te brengen om vervolgens te kijken naar mogelijkheden om het proces verder te optimaliseren.

- Het interview gaat ongeveer 1 tot 1.5 uur duren
- De resultaten worden volledig anoniem verwerkt
- Gaat u ermee akkoord dat dit interview opgenomen wordt om de resultaten nauwkeurig te kunnen verwerken?
- Heeft u nog vragen voordat we met het interview beginnen?

### *Huidige situatie (generiek)*

- Wat is het doel van het (laten) uitvoeren van een DD?
  - Wat hoopt u met een DD te bereiken?
  - Wat is de functie van een DD?
- Wij hebben een onderscheid gemaakt tussen de meest voorkomende typen DD's, namelijk commercieel, technisch en juridisch.
- Herkent u deze type DD's? Voert u deze DD's ook uit?
- Uit welke subfases bestaat het DD proces volgens u?
  - *Vervolg (praatplaat laten zien)*: Wij hebben een aantal subfases geïdentificeerd binnen het DD proces. Bent u het hiermee eens? Zo niet, wat moet er toegevoegd of verwijderd worden in uw ogen?
- In welke gevallen voert u een DD uit? Waarop baseert u dit?
- In welke range van aankoopbedrag vallen de panden die u aankoopt?
- Welk systeem (of programma) gebruikt u voor het DD-proces? Is dit voor elk (soort) DD hetzelfde?
- Neemt u een adviseur in de arm?
  - **Zo ja**, wat verwacht u van uw adviseur?
  - **Zo nee**, wat is de reden dat u dit niet zelf doet?
- Waarop baseert u welke adviseur u in de arm neemt?

*Identificatie pijnpunten*

- Bent u tevreden met hoe het DD nu gaat?
- Zo niet: wat vindt u over het algemeen het meest complex aan het DD?
    - En wat vindt u het vervelendst?
- Bij welke fase hoort dit? Aan welke fase kunt u dit toewijzen?
- Over de andere fases: wat veroorzaakt in uw ogen het grootste oponthoud?
- Per pijnpunt: waardoor wordt dit volgens u veroorzaakt?
    - Kan je een situatie schetsen waarin oponthoud plaats vond?

*Huidige situatie (casus)*

- Wanneer was het laatste DD dat u heeft meegemaakt?
    - Wat voor type DD was dit?
- Hoe begon dit proces?
    - Wie zet dit in? Wanneer wordt dit ingezet?
- Kunt u in het kort beschrijven hoe iedere subfase verloopt in het huidige DD proces?
- Per subfase: welke partijen zijn de belangrijkste betrokken partijen?
    - In welke fase zijn deze partijen betrokken?
    - Welke partijen spelen nog meer een rol?
- Per subfase: wat voel je bij deze subfases? Welk gevoel komt er naar boven?

*Gewenste situatie (indien tijd over en de rest volledig beantwoord is)*

- Kunnen de door u genoemde pijnpunten verbeterd worden? Zo ja, hoe?
- Wie is verantwoordelijk voor deze verandering?
- Hoe ziet een ideaal DD proces er in uw ogen uit? Dezelfde subfases?
- Wie zouden er wel of juist niet betrokken zijn per subfase?
- Wat is in uw ogen de grootste uitdaging om een ideaal DD proces te verwezenlijken?

Wij willen u vriendelijk bedanken voor uw medewerking aan dit onderzoek.

- Wij sturen de resultaten zodra deze er zijn
- De resultaten worden volledig anoniem verwerkt
- Wilt u aangehaakt blijven bij het onderzoek?
    - Bent u bereid om evt. vervolgvragen te beantwoorden (papier dan wel interview)?

# V. Interview results

In total, nine interviews have been conducted on the basis of the questionnaire as shown in Appendix III. This Appendix contains an overview of the responses by the respondents on the posed questions and give a better understanding of the function, sub-phases and the so-called 'pain points' of a DD process, as encountered by institutional investors. In coordination with the respondents, the results of the interviews are anonymized and used solely for this research. For insight into the fully elaborated interview results (the transcriptions) or for more information, the interview results can be requested.

The main topics of the interview were predetermined and during the interviews these topics formed the guideline for the interview. These topics are included in the figures as presented below, and include the following questions (for the entire list of the questions asked during the interviews, see Appendix III):

1) What is the function of a DD?
2) What are the most common types of DD processes in your opinion?
3) What types of DD do you conduct?
4) Of which sub-phases does a DD process consist in your opinion?
5) What is the range of purchase prices that you acquire?
6) What systems (read: IT-solutions) you do currently use during DD processes?
7) On the basis of which requirements do you choose which advisor to involve?
8) What are the main pain points of a DD process?
9) What would an ideal DD process look like, according to you?

| Resp. | What is the function of a DD? | What are the most common types of DD processes in your opinion? | What types of DD do you conduct? | Of which sub-phases does a DD process consist in your opinion? |
|---|---|---|---|---|
| 1 | Risk management, know what you are buying, checking if it is true what the vendor claims he is offering. | Commercial, legal (fiscal), technical (environmental) | Commercial, legal (fiscal), technical (environmental) | Depends on on-market and off-market. On-market: IM, preliminary assumptions, LOI, instruct advisors, data check, red flag meeting, renegotiating, drafting SPA, signing SPA, transport |
| 2 | Gaining insight in what you wish to buy. Assessing if the property matches with your long-term strategy as investor. Making sure there is no catch and thus no risk of a bad bargain. | Commercial, legal (fiscal), technical | Commercial, legal (fiscal), technical | Low execution risk, quick execution. Mostly a period of 2-3 weeks. LOI, then after 1 week draft, red flag assessment. Go/no-go moment. Sometimes: renegotiation and then SPA signing. |
| 3 | Partly compliance-related: who are you doing business with? And partly commercial: are the tenants creditworthy and will they pay their bills in 15-20 years? | Compliance, legal, fiscal, commercial, technical | Compliance, fiscal, commercial, legal and sometimes technical with existing buildings. For new development buildings, technical is more of a quality check. | Starting with checking the IM, annual reports, credit checks, compliance checks. Then LOI, further research, and SPA. In case of red flags, it is mostly a deal-breaker and we refrain from the deal |
| 4 | Avoiding having unforeseen surprises (that could have been foreseen) after transacting the property. Prevent paying more than the market price. Finding all the red flags. | Commercial, legal, technical, environmental | Commercial, legal, technical, environmental | Select suppliers & advisors, arrange the data room, instruct advisors, let them work and discuss red flags. Go/no-go decision (renegotiate) during red flag meeting, if it is all good; draft and sign SPA. |
| 5 | VDD: make the deal as clean as possible, make the relevant accesible to the purchasing party. Avoid questions. Goal: LOI = SPA. Purchase: know what you are buying. | Technical, legal, commercial and fiscal (tax) | Technical, legal, commercial and fiscal (tax) | VDD: Internal phase preparing sales. Decide whether or not to include advisors. Marketing, LOI, red flag meeting, internal approvals, SPA. |
| 6 | Know what you are buying. Making the cashflow prognosis as specific as possible in order to resemble the reality as much as possible. Compare the property to your expectations. | Commercial, legal, technical, but they are very overlapping. | Commercial, legal, technical, fiscal (taks) | Approached by a vendor, pre-DD, carry out a bid, exclusivity, assign a team (intern and extern, i.e. advisors) of different disciplines. Red flag meeting, SPA. |
| 7 | Being sure about what you intend to acquire, really is what you are acquiring. Mitigating risks of a bad bargain. There are always risks, so build in additional guarantees, clauses and warranties. | Commercial, legal, technical, fiscal (tax) and spatial planning-aspects. | Commercial, legal, technical, environmental (spatial planning) and fiscal (tax) | Quick scan (pre-DD), investigation phase (DD), negotiation phase (red flag meeting), drafting and signing SPA. |
| 8 | You want to know what you are buying. DD differs for existing properties (controlling everything) and development properties (inspecting drawings and design). | Existing and development buildings. Technical, legal, fiscal (tax), commercial. | Client DD, commercial, legal, technical, but this depends on the type of the building (existing vs newly developed) | LOI or HoT (exclusivity, price and follow-up phase), commercial headlines determination, start DD-trajectory when signing HoT/LOI, SPA when DD is completed to satisfaction. |
| 9 | VDD: the more transparent you are, the less risk is associated with the deal, the less assumptions the purchaser makes in his bid, thus the more reliable the carried-out bid is during the DD process. | Commercial, legal, technical | Commercial, legal, technical, these may overlap a bit in the execution (e.g. the checklists of various purchase brokers and legal advisors have certain required documents in common) | VDD: preparing the sales process ("doing homework"), deliver IM, enter data into dataroom, buyers do market analysis, bidding rounds, LOI, DD (partly exclusive), SPA. |

*Figure 33 | Anonymized interview results part 1/2*

| Resp. | What is the range of purchase prices of the property that you acquire? | What system do you currently use for DDs? | On the basis of what requirements do you choose which advisor to involve? | What are the pain points of a DD process? | What would an ideal DD process look like according to you? |
|---|---|---|---|---|---|
| 1 | €20 million + | Datarooms, check lists, no other specific systems | Price, reputation and experience, all advisors must be tendered. | Amount of required time, outsourcing tasks means constantly asking for updates. Controlling if information is accurate. External advisors assess unimportant data. | Shorter process. Standardizing and optimizing processes prior to the DD process (i.e. data structuring before decision to sell property). Mandatory central archiving would help. |
| 2 | €20 million + | Yardi, I-Rooms, T-Rooms, Virtual Volts. Depends on de vendor (or his advisor); they set up the data room and decide what systems are used for sharing data. | We let them bid. Mostly based on price, quality and trust. And experiences from the past. | Time pressure. Moral hazard due to payment structure (legal works slower than commercial) . Unclear and user-unfriendly data rooms. Poorly structured data. Imcomplete data. | A database that is always up to date. With complete information and a filter to filter out irrelevant documents. Unambiguous information. Specific property-bound pasports. |
| 3 | €6 million - €40 million | Not initiated by us. Depends on the party who organizes (=sells) it. A dataroom is often preferred over emails or wetransfers. | Internal experience. | Ambiguous data. Incomplete information. Terminated rental contracts which are presented as up to date. Information (like annual reports) looks back, but you want to look ahead. | Counterparties who are involved in the deal, know what they are doing and have their work organized. Better data quality and selection of the right information. |
| 4 | €10 million - €200 million | Excel, property network, Q&A list | Experience, quality of delivered work and against what price (is this acceptable?). Depends on the property sometimes (in the case of a 'medieval' property, we hire experts for those properties) | Process-wise: no pain points, because of the tight schedule I maintain. Usually information is missing: this should be avoided. Costs lots of time the first weeks to gather relevant information. | Webbased program with audit trail: who adjusts what document at what moment? And instantly being able to see which advisor answers which question. Having all info available on day 1. |
| 5 | Everything; €1 million to €500 million | Depends on the advisor. | Complexity of the deal and the relationship with the advisor (and counterparty). Sometimes, a purchase broker is a useful buffer between you and the vendor: hard negotiations are now possible. | Some advisors are not sharp enough when reading contracts; they sometimes oversee certain clauses. Limited expertise (bounded rationality). Also: unanswered questions that you have as purchaser. | Utopia would be no DD process at all. One digital document that contains all the information that is ever entered, which is automatically updated. Making real estate liquid: ability to sell tomorrow. |
| 6 | €5 million - €200 million | n/a | n/a | Information is unavailable, inaccurate or requires additional investigation, leading to overdue processes and unmet deadlines and high costs without certainty about execution of the deal. | Few to no red flags, better predictability of the property. This would entail that the LOI would turn out to be the final SPA, since findings of the DD have no influence on the final SPA. |
| 7 | 300-400 properties (houses/apartments) per acquisition. 6000 in existing portfolio, 1000 with the intention to acquire. | n/a | Legal: permanent partner (Houthoff). Regarding the other advisors; experience and price. | Relationships can be affected when advisors act on behalf of you, since they are harder in their negotiations with the counterparty. | Some say that negotiations are not good, but I think that 'slamming with some doors' is stimulating a healthy process; as long as this is not done, the contract can never be good enough. |
| 8 | €10 million - €200 million | Mostly the vendor, developer or advisor has a data room. We don't have special IT-solutions | Depending on the issues at stake, complexity, availibility of own personell (thus need for intermediaries) and size of the project. | Speed of DD process is heavily depending on the supply of correct information. On the other hand: if the counterparty has not well-prepared his administration, ammunition for negotiation. | Having all the relevant information at hand, without having to request it multiple times. |
| 9 | €50 million - €100 million (sales residential portfolio) | Own internal database, but mostly depending on the broker. Governance web (doc. management system) and sharepoint. | Long list with brokers, we let them bid and give a presentation. This results in a short list and from that list, we finally make a choice. | Case-specific example: one small legal inaccuracy (€30.000) costs a lot of time on a deal of >€60 million. Compliance and privacy regulation is also a pain point: everything must be anonymized. | Instantly retrievable property-related information (both public and private) which is up to date. DD process is most valuable if you have the relevant information quickly at the right place. |

*Figure 34 | Anonymized interview results part 2/2*

## VI. Quotation request fictitious real estate transaction

**Qualifications scenario 1:**

- Construction year 2000
- 10,000 sq.m LFA (conform NEN-2580 measurements)
- 5 floors
- 1 lot
- Freehold property
- Multi-tenant: 3 tenants (lease agreements on the basis of ROZ-model)
- 150 parking spaces on own lot
- Located in Amsterdam city center
- No significant technical, legal of commercial findings/defects
- Estimated transaction price: €50.000.000
- Yearly rental income: €2.500.000 (i.e. €250 per sq.m LFA)
- Gross Initial Yield (GIY) of 5%
- *All requested documents are present, accurate and up to date.*

Unfortunately, it appears that not all documents are always completely present, nor always up to date. As a result, the DD requires more time for some advisors than intended. To gain an insight into how this affects the quotation, an additional scenario has been included:

**Qualifications scenario 2:**

- The same characteristics as scenario 1, but:
- *80% of the requested documents are present:* some important documents are missing or cannot be guaranteed to be the most recent contracts / rental flows / certificates. Does this change the quotation, and if so, how much?

The results are shown below in Table 11. Immediately noticeable is the seemingly high costs of a commercial DD, but this is because of two reasons: first because of the payment structure, commercial advisors work on a no-cure, no-pay basis and if the deal breaks, they are not paid whereas the technical and legal advisors are paid for their services. This is thus priced in by the commercial advisor. Second, the commercial advisor usually oversees the entire transaction (i.e. finding suitable investors, drafting and negotiating the LOI, and assisting with SPA negotiations) instead of merely providing lease- and investment comparables, market rents, calculating rent rolls and cash flow prognoses, and analyses or summaries of the rental contracts. Besides, the estimate of the technical DD assumes that it is performed conform NEN-2767 requirements and that the establishment of a long-term maintenance plan is excluded. With respect to the legal DD, the quotation is exclusive of VAT and 6% office expenditures and disbursements, and it is assumed that no descriptions, summaries, tables or overviews must be made, neither that there are specific (operating-)licenses to be considered. In case of identified issues, the consultation concerning possible solutions is also excluded.

*Table 11 | Quantitative estimation of transaction costs based on quotation*

| Advisor | Quotation scenario 1 | Quotation scenario 2 |
|---|---|---|
| Legal | > €11.000 | > €13.500 |
| Technical | > €12.550 | > €13.230 |
| Commercial | 0,75% = €375.000 | 0,75% = €375.000 |
| **Total** | **€398.550** | **€401.730** |

# VII. Personal reflection on methods, objectives, process and ambitions

### *Reflection on the research methods and objectives*

The methods to be used for this research have been subject to continuous change. In the first instance, the aim of the research was to identify the potential for blockchain-based applications within the DD process and to sub sequentially design (or even develop) an applicable blockchain-based solution to the identified problems. The initially chosen research strategy concerned applying Design Science Research; a research methodology that 'primarily focuses on the development and performance of artifacts with the explicit intention of improving the functionality of that particular artifact' (Johannesson & Perjons, 2014, p. 14).

In addition, bearing in mind that the transaction process of real estate properties involves a lot of sensitive information, we assumed that it would be useful to determine the context of the information in order to be able to assess the type of blockchain that would me most suitable for that particular context. For that reason, the Context-Aware Systems Design approach was added as a part of the Design Science Research approach. This method is proposed by, among others, PhD candidate Sélinde van Engelenburg and mainly revolves around defining the context in order to assure that the designed artifact and adapts to the relevant part of the environment (i.e. the context). In a later stadium, when the focus of the research shifted from increasing efficiency towards lowering transaction costs (to ultimately achieve the aforementioned), TCE was added to the research approach in order to reveal the incurred transaction costs during the DD process. In the conclusive phase of this study, it appeared that blockchain technology is less applicable than initially thought and thus nothing could be designed. This forced me to entirely change the research approach from a Design Science Research approach to an explorative case study approach. The Design Science Research approach is a very useful approach, but not for explorative studies. It is only useful in the case when something is actually designed, whether this is the eventual application, a list of requirements, or a design framework. The same holds for the design of context-aware applications; this is of prescriptive rather than explorative nature. An explorative case study therefore is more suitable in this study to *explore* the potential of blockchain.

With respect to the research objectives, many changes have been made during the process. Because it was evident that the applicability of blockchain was going to be explored, commonly used core values are transparency and efficiency. Hence, those were initially taken as the core values for this study. Later, transparency appeared to be difficult to express and it turned out that the actors involved in the DD process encountered numerous so-called pain points, thus maximizing the customer experience in DD processes replaced the aim to increase transparency of the information that is shared during DD processes. Yet once again, it was found that the customer experience was also difficult to measure (and thus express) and to compare the customer experience before and after a potential blockchain-based intervention, particularly when it could not be measured as this research would not actually implement and monitor the performance of a blockchain-based solution. Later, after constantly (though legitimately) being asked 'whose efficiency do you mean, and how do you measure this?', it was decided to replace optimizing efficiency for lowering transaction costs and the customer experience was also left out. By applying the principles of TCE, it was possible to assess and build theory on the impact on transaction costs and to determine the types of transaction costs as well as the cost drivers within the DD process.

*Personal reflection on research process and ambitions*

Scoping and demarcating the boundaries of this study was way more difficult than initially expected. During the entire study, we have written countless reports and performed a plethora of studies. However, determining the scope and deliverables of this project was entirely different. First, it is tricky to estimate feasible deliverables of such a large project; most of the reports we have written took no more than 1 or 2 months and were usually in a group composition, such that the tasks could be distributed among the group members. Second, a graduation project is par excellence the best opportunity so show that you have the capabilities, commitment, knowledge and the clear-sightedness to combine these factors into a piece of outstanding work. Bearing this in mind, it is not uncommon to start over-ambitiously with the project, which was the case for this project. I wanted to explore the DD process, the associated phases, involved actors, actor-specific allocation of quantified transaction costs, potential of blockchain, design requirements for implementing a blockchain-based solution, a design framework for eventual designers and if possible, I was considering learning a program and code blockchain next to my regular graduation project time and try to actually program a blockchain-based application in the evenings. In retrospect, this was simply too much. During the entire process, the scope has been narrowed down as well as my ambitions that were continuously adjusted downwardly. Personally, I think this is a good sign, even though it sometimes feels disappointing to decide that you cannot address every single problem that you formulated in the beginning. It is a good sign because you started with a broad spectrum of possibilities, considered every conceivable aspect, and gradually found out that some aspects were not applicable for this particular study, whilst other unconsidered aspects were. To illustrate; during my thesis proposal, I came up with eight sub questions to answer my main research question. Eventually, only 3 of these questions remained. Scoping down is also relevant as it stresses the fact that the problem you are trying to solve is in essence significantly more complex and wicked than initially expected: it is simply not possible to answer such a dynamic and technologically and socially complex issue right away. It just requires a profound approach.