Design of a Hybrid Mortgage Lending System

By Considering the Integrative Model of Organizational Trust

MOT2910: Master Thesis Project

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BearingPoint®

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by

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Preface

Writing this thesis, my time as a student at the TU Delft has come to an end. Previously, I graduated with a master's in High-Tech engineering, this will be the second master's I will finish in Delft. It would undoubtedly have been impossible to complete this project without the help of my supervisors, family, friends, and fellow interns at BearingPoint. Thank you all for that!

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Summary

For centuries, traditional finance companies have played a central role in our economy. They provide financial stability and are considered to be reliable as a result of heavy legislation and long-established track records. However, traditional finance (TradFi) companies (e.g. commercial banks, insurance companies, and stock brokers) faces institutional problems due to inefficiencies, limited innovation, privacy concerns, lack of transparency, and dependency on intermediaries. A solution for this could be Distributed Ledger Technology or blockchain. Within the blockchain, Decentralized Finance (DeFi) covers the financial products that are built on top of blockchain and are therefore referred to as a go-to solution within blockchain technology to be eligible to investigate as an alternative for TradFi. This can be done via tokenization which is the process of converting the rights to a physical asset into a digital asset on a blockchain. This allows for fractional ownership of a physical asset in a digital way.

The Dutch mortgage market plays a major role in its financial stability because it is driven by political stimulation, resulting in more than half of the Dutch households having a mortgage. However, the mortgage industry faces institutional problems originating from its complexity and conservatism. These can be covered in the transaction costs, human intervention, and the cost of trust. The transaction costs are classified into search & information costs, bargaining & decision costs, and policing & enforcement costs. Combining these three types, it is seen that the transaction costs for TradFi are higher than DeFi, and could therefore be looked upon. On human intervention, place-based discrimination in The Netherlands is a problem that could be addressed by using blockchain for its benefits of transparency. The cost of trust are considered to be strongly related to transaction costs, where is seen that the cost of trust in TradFi in mortgages is very high. This lead to the objective for this research to investigate the transformation of a mortgage lending system from TradFi to a combination of TradFi and DeFi, a so-called hybrid mortgage lending system while maintaining trust. A theoretical framework on maintaining trust was found by Mayer et al. (1995), namely: The Integrative Model of Organizational Trust (IMOT). This framework is used to guide the hybrid mortgage lending system toward a trustworthy one that still reduces the cost of trust. This has led to the following research question:

What hybrid mortgage lending system can be designed that reduces the cost of trust?

The Design Science Research methodology was chosen for this project. It contains the strategy to build the artifact as a general solution which can be specified to companies in a later stage. The project contains two artifacts to be designed, a trust model and a technological model, resulting in two connected design cycles for the Design Science methodology. Both will be evaluated via expert interviews, where the first design will be post-evaluated and the second pre-evaluated. The second model, the technological model, relies on the input of the first model.

A literature review has been conducted which was divided into three parts: DeFi lending, mortgages, and the IMOT. The core within this framework of the IMOT is its three trustworthiness factors: Integrity, Ability, and Benevolence. Integrity is being honest and doing the right thing. Ability is whether people are capable of doing what they are supposed to accomplish, and benevolence is the way people watch out for each other. For these three factors, research has been done on how these can decrease the cost of trust, how these are applied in TradFi mortgage lending, and finally how they can be contextualized to hybrid mortgage lending. This contextualized trust model was validated through expert interviews. The group of experts was selected to cover three different areas: TradFi experts, consulting experts in banking and capital markets, and DeFi experts. The expert interviews were also used to gather information for the second design challenge, the technology model. The results of the interviews were discussed and compared with the literature, and objectives for the technological model were defined. This resulted in nine meta-requirements for the technological model. A demonstration was shown for the technological design, where a hybrid lending pool was designed that contained various tokenized assets. It contained mixed token pools with different levels of risk. Investors with a lower risk appetite can mix their tokenized mortgages with tokenized bonds and stablecoins. These can be provided by TradFi companies and the ECB. Investors with a higher risk appetite can mix their tokenized mortgages with tokenized stocks, art, and other cryptocurrencies. The distribution of these assets will be based on the risk perception of the retail investors, who will be the lending party in this hybrid model. As part of the technological design, the architecture and stakeholder overview were made to show the interactions within the ecosystem.

Limitations were found in the versatility of the hybrid model, the feasibility of implementing DeFi within mortgage lending, and the regulatory hurdles to overcome. It could be valuable to conduct further research to find ways to generalize this model and look for options to build prototypes. On regulations, it could be considered to look at the possibilities in the short term and how that would be possible on a national level.

The main findings related to four meta-requirements that had a direct impact on reducing the cost of trust. The first was to have the Know-Your-Customer process done by a third party, which is an identification and verification process of the client. The second was that mortgage loans could be tokenized via Non-Fungible Tokens on the blockchain to improve its transparency. Non-Fungible Tokens are digital assets that have a unique design containing proof of authenticity where their ownership can be recorded. Third, DeFi lending pools with different risk models were introduced to invite retail investors to participate in the provision of mortgage loans, thereby distributing the risk to banks. Fourth, Decentralized Autonomous Organizations were introduced to execute rules via smart contracts automatically. These organizations are preprogrammed governance mechanisms that provide community-driven decision-making on the blockchain which can improve the accountability of blockchains so that reliability can be retained.

The remaining five meta-requirements provided three main lessons. The first insight concerns the digital euro, which prevents commercial banks from creating money, and the possible centralized role of the ECB in the blockchain ecosystem. The second relates to the continuity of human interaction in financial advice for mort-

gage lending, and the third insight is the changing role of TradFI in the hybrid lending model, where they are moving towards having only an origination role instead of all processes.

Regarding the theoretical contribution, the interconnectedness of two designed artifacts provides new knowledge on using the design science methodology twice in one research. Individually, on the first design the main theoretical contribution is the contextualization of the IMOT toward hybrid mortgage lending. On the second design, the main theoretical contribution is the demonstration of a functioning hybrid lending model while maintaining trust.

There were also three recommendations for further research. The first was to improve the versatility of the hybrid lending model, the second was for more research into prototyping for specific companies, and the third was for research into the regulatory and technical hurdles. Finally, a recommendation was made to BearingPoint, the consultancy company where this research was written. BearingPoint can use this design to help financial companies promote the adoption of blockchain and encourage TradFi companies to see the benefits in opportunities of blockchain technology in the financial sector.

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Nomenclature

Acronyms

Table 1: List of acronyms used throughout the thesis

Acronyms	Definition
AI	Artificial Intelligence
AMM	Automated Market Maker
BNPL	Buy Now, Pay Later
CeDeFi	Centralized Decentralized Finance
CeFi	Centralized Finance
Dapps	Decentralized apps
DeCeFi	Decentralized Centralized Finance
DeFi	Decentralized Finance
DEX	Decentralized Exchange
DLT	Distributed Ledger Technology
DPoS	Delegated Proof-of-Stake
ECB	European Central Bank
IBFT	Istanbul Byzantine Fault Tolerant
IMOT	Integrative Model of Organizational Trust
KYC	Know Your Customer
NMG	National Mortgage Guarantee
PoA	Proof-of-Authority
PoS	Proof-of-Stake
PoW	Proof-of-Work
RTR	Risk Taking in Relationship
TradFi	Traditional Finance
TVL	Total Value Locked

1 Introduction

1.1. Solution for the institutional problems within traditional finance

For centuries, traditional financial companies have been the backbone of worldwide economies. They offer financial services where they act as intermediaries, manage transactions, provide loans, and ensure financial stability within the centralized financial system. They are considered reliable, mainly due to their heavy regulatory oversight, deposit insurance, and long-established track records of their activities (Dhiman, 2018).

However, the traditional banking system faces institutional problems due to inefficiency, high cost, limited innovation and accessibility, privacy concerns, lack of transparency, and dependence on intermediaries and monetary policies (Berger and Humphrey, 1997). As a result, many are looking for alternatives that can provide a more streamlined and effective service. Fintech companies provide an example of an alternative approach to streamlining financial service processes. However, despite their innovation, institutional problems regarding privacy and security are still present (Gomber et al., 2018; Drew, 1995).

A potential alternative could be the use of Distributed Ledger Technology (DLT), or so-called 'Blockchain Technology' (Trautman, 2016). DLT is a decentralized digital system that records transactions across multiple locations simultaneously. These multiple locations, or nodes, are responsible for maintaining this distributed ledger. There are three types of blockchains: private, permissioned, and public. Private blockchains allow only specific users to access and control them, while public blockchains are open to everyone. Permissioned blockchains are a hybrid version, where control is restricted to a specific group. These blockchains use different consensus mechanisms to achieve agreement among the participants on the validation of transactions or modifications in the protocol. Private blockchains are generally considered more efficient, while public blockchains are less centralized (Martins and Demertzis, 2023). In the literature review, the consensus mechanisms will be explained in more detail (section 3.1.2). When a transaction is confirmed by the consensus mechanism, it is combined with other transactions to form a 'hash', and added to the chain of blocks. The data contained in a validated and hashed block is immutable. This creates a

finished transaction in the blockchain (Wouda and Opdenakker, 2019).

DLT can impact financial services by improving efficiency and transparency while enhancing its security. The secure and immutable 'chain of transaction-blocks' makes it transparent and easy to audit. It could thereby reduce the need for intermediaries, resulting in lower transaction costs (Chang et al., 2020). Decentralized Finance (DeFi) covers financial products built on top of blockchains, and smart contracts are used to settle agreements without intermediaries. Smart contracts are self-executing programs that automate actions. DeFi can be used to offer services such as investing, borrowing & lending, and exchanging digital assets (Schär, 2021; Auer et al., 2023). DeFi could be a solution to the current institutional problems of the traditional finance system.

1.2. The mortgage market

The mortgage market is an important part of the Dutch economy. The Dutch housing finance system is characterized by a high level of national mortgage debt, which is a consequence of the policy of deducting mortgage interest to encourage people to buy a house instead of renting (Elsinga et al., 2016). As a result, around 60% of households have a mortgage on their home (Nederlandse vereniging van banken, 2024). It gives people the opportunity to own their own home. It is considered the largest expenditure in a person's lifetime and is usually paid off over several decades (De Hypotheker, 2024).

The mortgage industry is known for its complexity and conservativeness, often leading to inefficiencies and high costs. These issues arise from manual processes, handling uncertainties and risk, lack of standardization, cost of trust, multiple involved parties, and extensive regulatory requirements (Moloney, 2023). Traditional finance companies take significant risks in providing loans that require households to trust them to receive their issued mortgage back. These risks typically result in higher interest rates that households must pay (Johnston et al., 2021; Aikman et al., 2021). By distributing the risk of mortgage loans, the risk is no longer centralized and concentrated in one party. This benefits both households and lending parties because the cost of trust decreases, thereby reducing interest rates(Castro-Iragorri et al., 2021).

Addressing these institutional problems within the mortgage market could have a significant impact on many households in the Netherlands compared to other financial services, such as derivatives and SME loans. Therefore, solving this problem could have a substantial societal impact (Bracke et al., 2020). Since Dutch households are dependent on traditional finance companies for their mortgages, it would be interesting to investigate the possibility of decreasing its costs while enhancing trust by designing an on-chain alternative via DLT.

The institutional problems of mortgage loans mentioned above will be distinguished into three types: *transaction costs* for the lack of standardization, involved parties, and extensive regulation; *human intervention* for the manual processes and handling uncertainties and risk; and *cost of trust*. Although these are all connected, the following structure will be used. section 1.2.1 will discuss the transaction costs, section 1.2.2 describe the problems of human intervention, and finally section 1.2.3 mentions the cost of trust in TradFi mortgage lending.

1.2.1. Transaction costs

Transaction costs are the fees and expenses involved in buying or selling goods and services. These can be classified into three types: Search & Information costs, Bargaining & Decision costs, and Policing & Enforcement costs, as shown in figure 1.1 (Mahoney, 2004).

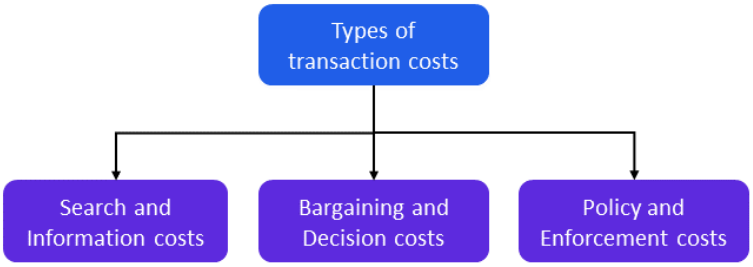

Figure 1.1: The three types of transaction costs

Search & Information costs

These costs refer to the gathering and processing of information needed to make economic decisions. For mortgage loans, it consists of time and research costs to decide whether to close a mortgage. In traditional finance, these could be relatively high as a result of information asymmetries, such as mortgage advisory costs and costs to create and validate credit models (Sun et al., 2020; Wouda and Opdenakker, 2019).

According to Sun et al. (2020), the adoption of DLT in insurance leads to a decrease in search and information costs. The transparency and traceability of DLT significantly reduce validation costs, and exchanging information becomes easier via blockchain.

Martins and Demertzis (2023) mention that DLT can solve information asymmetry problems and search costs, but it also introduces new transaction costs where the instantaneous transactions are highly energy-consuming.

Although the research of Sun et. al has been done on insurance, the same result could be the case for mortgage loans because Martins et. al underlines the conclusion of Sun et. al from a general perspective. Martins et. al however mention that a new type of transaction cost will occur in the form of highly energy-consuming instantaneous transactions of public blockchains. Permissioned or private blockchains could solve this issue by their characteristic of preferred nodes, according to Martins and Demertzis (2023).

Bargaining & Decision costs

These are the costs that are involved during negotiations for an agreement. In the context of mortgage loans, this refers to the negotiation process between the lender and borrower to agree on the loan terms such as interest rates and loan duration. The borrower also has to pay closing costs to the lender and other involved parties (Patel, 2023; Sun et al., 2020).

According to Patel (2023), more transparency in the borrower's credit risk assessment results in a more accurate assessment, leading to more appropriate and efficient pricing of risk. The reduction of information asymmetry could result in less risk of uncertainty and therefore less bargaining costs. On the decision costs, many other

parties are involved such as an underwriter, appraiser, real estate agent, and so on. These additional closing costs for a mortgage could be reduced via smart contracts. Smart contracts can be established with pre-defined conditions, and payments will be automatically executed when those conditions are met (Proskurovska and Dörry, 2022). Sun et al. (2020) underlines this by mentioning that participants can pre-define their interests in advance, which could either be accepted or not. This would lead to lower costs because negotiating is not necessary and the process is automized.

However, in the shorter term, Sun et. al mention that the initial costs for the development of a DLT system and negotiating terms could be costly. For permissioned blockchains, the Bargaining & Decision costs could increase more since there must be negotiated with the preferred nodes. Considering decision-making, Ilbiz and Durst (2019) mention the importance of deciding whether the role of an intermediary is more expensive than the cost of adopting blockchain technology which might lead to uncertainties and higher costs. Catalini and Gans (2020) thereby mention the inefficiencies that might occur in public blockchains where agreement is achieved through a voting process.

In conclusion, the Bargaining & Decision costs could become higher in the short term for DeFi, as a result of investments and additional risk of uncertainties. The immaturity of DLT and lack of track record could give an additional risk and uncertainty to the lender, upon which they could decide to ask for higher interest rates. In the longer term, negotiating could be automized or even taken out, creating a situation where intermediaries could become redundant. On top of that, going from public to permissioned blockchains, the Bargaining & Decision costs may increase more as negotiation with preferred nodes could be required.

Policing & Enforcement costs

These costs are associated with monitoring and enforcing compliance with legal and contractual obligations. For mortgage loans, examples are the cost of regulatory auditors, foreclosure agreements between borrower and lender, and additional risks to the lender due to their Care of Duty to the borrower. For the borrower, there are also notary costs for the transfer deed. In traditional finance, these are considered to be very high (Catalini and Gans, 2020; Sun et al., 2020; Moloney, 2023).

Catalini and Gans (2020) mention the (very) high verification costs that traditional finance intermediaries incur for their services on ensuring the safety of transactions, managing privacy risks, and enforcing contracts. Catalini et. al mention that in DLT the transactions can be verified without exposing information to a third party, making the role of intermediaries redundant. On a public blockchain, any participant can verify transactions, resulting in cheap digital verification.

According to Sun et al. (2020), the monitoring and enforcement costs can be reduced by adopting DLT in mortgage processing. Agreements are automatically checked by smart contracts which reduces the uncertainty of contract enforcement and thereby lowers the monitoring compliance of contracts. They mention that the digitization shift toward blockchain results in transparency, an auditable common shared ledger (since all transactions are visible on the blockchain), and fewer regulatory responsibilities of lenders. They conclude that the combined result should be much lower than the current situation in traditional finance. On top of that, Sun et. al mention that when going from public to permissioned blockchains, the Policing & Enforcement

costs may increase because the verification costs could be higher for preferred nodes.

In conclusion, the Policing & Enforcement costs could decrease with the adoption of DLT in mortgage lending. It could decrease the verification, monitoring, and enforcement costs. The Policing & Enforcement could become slightly higher when permissioned or private blockchains are used instead of public blockchains.

Transaction Costs: TradFi vs. DeFi

All three types of transaction costs are combined and set in table 1.1

Transaction cost type	DeFi	TradFi
Search & Information costs	Neutral	High
Bargaining & Decision costs	High	Neutral
Policing & Enforcement costs	Low	Very High

Table 1.1: Overview of the three different transaction costs for DeFi and TradFi, going from very low - low - neutral - high - very high

Combining all three types of transaction costs, the transaction costs for TradFi are relatively higher than DeFi. It is seen that the Search & Information costs could partly decrease because the information asymmetry can be solved via better transparency and traceability of DLT, while new costs emerge via highly energy-consuming instantaneous transactions. Regarding Bargaining & Decision costs, the short term may be expensive if new deals have to be negotiated with other parties. However, in the long term, costs may decrease as intermediaries become redundant. On Policing & Enforcement costs, costs could decrease heavily because safe and private verification through an intermediary is costly, while digital verification on the blockchain is cheap. Moreover, the transaction costs for public blockchains are generally lower than for private blockchains. Shifting from a public to a private blockchain leads to an increase in Search & Information costs, Policy & Enforcement costs, and Bargaining & Decision costs.

1.2.2. Human intervention

In addition to high transaction costs due to inefficient manual processing and the large number of parties involved (notary, financial advisor, real estate agent), there is also subjectivity in the decision-making process, where human intervention plays an important role. Information asymmetry and economic uncertainty are reasons that can lead to different interest rates (Farías, 2021).

Critics also mention gender bias or even discrimination as playing a major role in the subjectivity of the decision-making process Goldsmith-Pinkham and Shue (2023); Fang and Munneke (2020); Quillian et al. (2020). They believe that mortgage lenders can discriminate because of the lack of transparency, also in the Dutch mortgage market (Hassink and Leuvensteijn, 2007; Aalbers, 2007).

More recently, in 2016, Aalbers (2016) mentions that 'redlining' still occurs in the Dutch housing market. Redlining is place-based discrimination, where mortgage applications are more often rejected by lenders in bad neighbourhoods. In some cases, this is also linked to race, ethnicity, and socio-economic status. In terms of gender bias, Bradley et al. (2021) mention that there is no clear statistical evidence of a correlation

between gender bias and mortgage approval in the Netherlands. This is therefore dismissed as a problem within the Dutch mortgage market.

Nevertheless, place-based discrimination in the Netherlands is an issue that should be addressed. Automating processes via blockchain could lead to better transparency, less human error, less discrimination, and less subjective decision-making.

1.2.3. Cost of trust

The cost of trust refers to the costs that are associated with relying on centralized institutions. In mortgage loans, these are the mortgage lenders that facilitate loans for borrowers. These are strongly connected to the transaction costs, according to Bromiley and Harris (2006) and Barbalet (2009). Trust is considered to be an important factor in relationships between company and client, which is seen rather as a variable on its own and is interconnected with the transaction costs.

In TradFi, it reflects how mortgage lenders try to be the trusted middleman, to connect with customers so they can rely on you. Mortgage lenders take on all the risk of their customers, resulting in higher interest rates. The cost of trust within Tradfi is high because the mortgage market is highly regulated, has high transaction costs, and centralizes risk with mortgage providers (Bromiley and Harris, 2006; Farías, 2021).

Johnston et al. (2021) describes that reliance is not a precondition for trust. He mentions that trust is possible without reliance, which could argue whether centralization of risk is necessary. According to Sazandrishvili (2020), it is possible to tokenize loans to spread the risk across multiple parties. Tokenization is the process of converting the rights to a physical asset into a digital asset on a blockchain. This allows for fractional ownership of a physical asset in a digital way. In the case of mortgages, this would mean multiple lenders owning a fraction of the house, with the borrower repaying each lender over the following decades. For a centralized party, this means that they don't have to take on all the risk associated with a mortgage, reducing their risk and therefore their cost of credit. However, this does not mean that banks and trusted financial institutions will become redundant. People still want to place their mortgage with a trusted party, not a blockchain-based fintech they've never heard of. They tend to value its track record and remain loyal to established TradFi companies (Marx, 2022; Llewellyn, 2005). In addition, blockchain critics mention the immaturity of DeFi as an alternative to TradFi. For instance, Bruhn (2019) mentions the loss of trust that individuals experience from unexpected and significant financial losses, which also happened after the 2021 crypto crash (Shu et al., 2021).

Another way to redefine trust is to shape trust through transparency. Lyons et al. (2017) conducted research on enabling trust in automated systems through the use of transparent designs. Their findings were that trust was highest in the rational, data-driven condition.

In conclusion, the cost of trust in TradFi is very high for mortgages. The tokenization of mortgages could spread the risk rather than centralize it in TradFi companies. However, TradFi companies have a track record in mortgage lending and it is questionable whether people would switch to DeFi overnight. Transparency is also a factor that could fill the gap to enhance trust. This might also work for mortgage loans, where the cost of trust can decrease while enhancing trust through a transparent, data-driven automated design. Therefore, it could be interesting to explore a concept where the

track record of TradFi companies is used to maintain the trust of borrowers, while at the same time reducing the cost of trust by removing the reliance on TradFi companies through the tokenization of mortgages and replacing it with the transparency of DeFi technology to further increase trust.

1.3. Research objective

Based on the introduction of mortgages into traditional lending and their high cost of trust, this section presents the objective of this research to transform the mortgage lending system from TradFi to DeFi while preserving trust. In order to achieve this objective and scope the topic further, the next sections discuss the state-of-the-art. Section 1.3.1 discusses the process of decentralization in TradFi, section 1.3.2 elaborates in more detail on the tokenization process of real assets, and section 1.3.3 how blockchain technologies are implemented in mortgage lending. After that, the state-of-the-art on trust frameworks is explained in section 1.3.4. Based on this outcome, section 1.3.5 describes the literature gap, the scientific contribution, and the narrowed objective of this research.

1.3.1. Process of decentralization in TradFi

This section discusses the state-of-the-art of the transformation process of TradFi to Defi in financial services. First, the role of DeFi within the traditional financial system will be discussed with its pros and cons. These will be reflected on mortgage lending after which the desired level of decentralization for this project will be chosen and further explored.

DeFi within financial services

Martins and Demertzis (2023) discuss in their paper the role of DeFi within the traditional financial system and how it can contribute to reducing transaction costs and thereby create financial growth. It enables the removal of intermediaries while maintaining its safety and validity.

However, Martins et. al mention that when DeFi emergence grows within the financial system, regulators will want to guarantee that it is in line with the same regulations that govern the financial system. According to Martins et al, this could be a huge risk for DeFi. As such, they mention three reasons why DeFi cannot replace the traditional finance system. First, they say that the elimination of intermediaries is not feasible. Although it provides transaction cost reduction by using algorithms to settle transactions, it also introduces very high processing time for transactions, which can be solved by using a more centralized structure to quickly settle transactions via trusted centralized nodes - which contradicts the philosophy of DeFi. The second reason Martins et. al give is that DeFi lacks accountability because it does not allow for legal recourse. They mention the difficulties of holding accountability when the system is decentralized, anonymized, and private. However, they also mention that establishing accountable parties, like Decentralized Autonomous Organizations (DAOs) could be part of the solution (Martins and Demertzis, 2023). DAOs are governance mechanisms that provide community-driven decision-making on the blockchain. These improve accountability by linking the interests and incentives of its community members with the goals of the DAO Deshmukh et al. (2021). Thirdly, Martins and

Demertzis (2023) discuss that the majority of DeFi activities are in exchanging crypto assets. They think that the true creation of economic value is when these crypto assets are exchanged for fiat currencies and used in the traditional financial system, which is currently not the case. Fiat currencies are government-issued currencies, such as the European Euro (€), American Dollar ($), and Chinese Yuan (¥).

Xu and Vadgama (2022) discuss the development of the lending market that occurs from traditional banking to DeFi lending. They mention the large potential of DeFi technology and its efficiency gains on transaction costs and possible removal of intermediaries, but also its strong reliance on the long-established banking system, TradFi. They conclude that the central banks will not disappear and that DeFi currently still faces regulatory and technology maturity issues. Xu et. al also mentions the positive development of the Central Bank Digital Currency (CBDC), which is a digital currency that is provided by a central bank (e.g. ECB, FED). These are connected to their native currency, which is thus the digital euro for the ECB and the digital dollar for the FED. Xu et. al think that the development of CBDCs could accelerate the convergence of the fiat money market and DeFi. This leads to their proposal that they think that traditional financial services companies should incorporate DeFi technologies into their products (Xu and Vadgama, 2022).

Zetzsche et al. (2020) links DeFi to open banking in the context of the traditional financial economy. They mention the efficiency gains of DeFi, but also that decentralization could weaken accountability and reduce the effectiveness of TradFi regulation. Although less TradFi regulation may lead to lower costs of trust, DeFi regulation is still considered necessary to ensure risk control and effective supervision. Zetzsche et. al. provide a new way of designing regulation for DeFi by proposing to build regulatory approaches into the design of DeFi (Zetzsche et al., 2020).

Concerning the transformation process of TradFi to DeFi in financial services, all authors are positive about the development of DeFi technology to reduce transaction costs and foster financial growth by the removal of intermediaries. The main critiques on DeFi that the different authors mention are the regulatory issues and technical immaturity.

As the mortgage market is highly regulated, as discussed under section 1.2, difficulties with regulatory compliance, lack of accountability, and technological immaturity are undesirable because it is such an important part of the Dutch economy which also introduces new types of transaction costs through its decentralized and highly energy-consuming behavior. An approach that only relies on full decentralization will therefor not suit for mortgage lending in The Netherlands. As a result, an alternative will be proposed in the next section where different combinations of TradFi and DeFi will be explored that can be feasible for the implementation of DLT technology in the mortgage market.

Combination of TradFi and DeFi: Hybrid

This section discusses possibilities to combine TradFi and DeFi toward a 'hybrid' financial system. The term hybrid will be used to refer to the mix of TradFi and DeFi aspects within the financial system. It can contain any plausible ratio of TradFi and DeFi aspects. This section also introduces the term CeFi, which stands for Centralized Finance. CeFi is the digital financial ecosystem where centralized parties control digital assets. It can be compared with the digitized version of TradFi, and the coun-

terpart of DeFi. As such, comparisons between DeFi and CeFi can be made in the process of transforming TradFi to DeFi (Qin et al., 2021).

Gartner describes two versions of the combination of both financial systems: CeDeFi and DeCeFi. CeDeFi stands for Centralized Decentralized Finance, where traditional financial institutions offer DeFi financial services to their customers. DeCeFi stands for Decentralised Centralised Finance, where assets are issued by DeFi companies or platforms. Gartner mentions the great potential of CeDeFi, where the innovative functionalities of DeFi can be combined with the regulatory safeguards of CeFi. DeCeFi is considered to be more of a hypothetical concept, with no real practical use cases, and therefore irrelevant (Gartner, 2021; Medium, 2021).

According to Gartner's Litan et al, CeDeFi can impact financial services by eliminating the middleman or central authority by operating on blockchain-based smart contracts, while providing the same customer service that a centralized financial company would have, such as a commercial bank or insurance company (Litan et al., 2022). They mention that financial companies typically differentiate themselves by providing customer service through financial advice because the product itself, a mortgage loan, is homogeneous. Litan et al. believe that CeDeFi could be implemented in 2 to 5 years, which is much faster than 'full DeFi' because CeDeFi can comply with existing regulations. Regulations on blockchain change very slowly within the EU, which also affects the Netherlands (Ringe and Ruof, 2020; Lindman et al., 2020). Within the Netherlands itself, regulatory change is also considered very slow, for example in the case of the abolition of the mortgage interest deduction, which was proposed in 2010. It has been gradually phased out over the years but is still not completely abolished (Bruijsten, 2023). Because the mortgage market has such a large impact on the Dutch economy, abrupt changes are simply not favored (Elsinga et al., 2016).

Oliver Wyman Forum et al. (2022) discuss the concept of institutional DeFi. They state that this concept will provide the efficiency of DeFi protocols to tokenize real-world assets, combined with appropriate safeguards to ensure financial integrity, regulatory compliance, and customer protection. There is also a case study that explores how the financial industry can adopt Institutional DeFi from a business perspective by tokenizing assets and exchanging digital assets. They found that there is no one-size-fits-all Institutional DeFi solution and that design choices need to be tailored to specific, prioritized business objectives.

Institutional DeFi as described by Oliver Wyman Forum et al. (2022) can be seen as a synonym for CeDeFi as described by Gartner (2021). Both papers describe concepts where traditional financial institutions offer DeFi financial services to their customers. As the regulatory changes within the mortgage market are a slow changing process, offering DeFi products through TradFi companies could be a solution to comply with Dutch regulations quickly. Therefore, the hybrid concept can be seen as a feasible option for this project.

The tokenization of real-world assets as mentioned by Oliver Wyman Forum et al. (2022) could apply on mortgages as well, as discussed in section 1.2.3. The next section will provide the state-of-the-art for the tokenization of financial assets to clarify literature gaps.

1.3.2. Tokenization process of real assets

The tokenization of real-world assets extends blockchain technology. It allows real assets to be bought and sold digitally on the blockchain. Digitizing real assets creates faster payments and more transparent, liquid, and accessible financial systems. These tokens are representations of securities, or financial instruments, that are provided on the blockchain infrastructure and therefore subjected to jurisdiction on these securities by central banks (ECB, FED). Through tokenization, it is possible to fractionally own securities, resulting in the distribution of ownership of assets to different investors (Sazandrishvili, 2020; Oliver Wyman Forum et al., 2022).

Lavayssière (2023) discusses the tokenization of financial assets where he states that the level of trust-minimization of tokenization depends on its technical, legal, and financial characteristics. He identifies three elements of the tokenization process. The first is the importance of direct tokenization, which connects the token and its underlying asset. Second, the characteristics and infrastructure of the token are discussed. These should guarantee sharedness and trust-minimization. The third element is the representation of ownership through new ways to identify custodianship. According to Lavayssiere, when these three elements are in their strongest, tokenization has both technical guarantees and legal certainty (Lavayssière, 2023). This provides a solution for the problem that was explained in section 1.3.1 of the usage of solely DeFi in financial services.

Several real-world assets are already being tokenized, or in progress to be tokenized. ABN Amro, one of the three largest banks in The Netherlands, registered a digital green bond in September of this year (ABN AMRO Bank, 2023). They used digital wallets with private keys for the investor to access this digital bond where they also provided the digital custody service. Defichain is a blockchain-based company that tokenizes stocks on the blockchain. Examples of stocks that have been tokenized are: $DNVDA, Nvidia Tokenized Stock Defichain, $DTSLA, Tesla Tokenized Stock Defichain, and $DFA, Facebook Tokenized Stock Defichain (Defichain, 2023).

Not only bonds and stocks can be tokenized, but also art. Masterworks allows retail investors to *fractionally* own real art that is accessible via the blockchain (Masterworks, 2023). These tokens can be traded or held in an investment portfolio.

According to Sazandrishvili (2020) and Baum (2021), the same principle could be for mortgage lending as well, where houses are fractionally owned by various investors through tokenization. The next section will discuss the blockchain implementation on the housing market to find a literature gap on the previous discussed topics on cost of trust, hybrid system, and tokenization.

1.3.3. Blockchain implementation on the housing market

In this section, the state-of-the-art on blockchain implementation in the housing market is discussed in order to find a gap in the literature where this research could be continued.

It starts with searching for papers that describe and/or design mortgage lending or land administration systems. Another search term was the consideration of trust, transparency, cost of trust, and tokenization. The aim was to find papers that covered at least some of the above criteria in order to find a link. First, three papers are found that discuss technical issues and legal challenges that blockchain needs to solve for

the housing market. Then, three papers are found that describe an only DeFi approach, after which two papers are found that use a hybrid approach. Only 'CeDeFi' options are considered for the hybrid approaches, as only these are relevant (section 1.3.1).

Proskurovska and Dörry (2022) and Garcia-Teruel (2020) did not design a model, but discussed technical problems and legal challenges that blockchain needs to solve to become a relevant solution. Garcia-Teruel (2020) discuss tokenization, trust, and transparency as legal challenges, but do not go into detail on the impact on trust costs and transaction costs. Proskurovska continued her research on blockchain technology within the housing market in a paper in 2023 (Proskurovska, 2023). Here she discussed a blockchain land management system for the Swedish housing market.

Ali and Smith (2019), Henriquez et al. (2019) and Wouda and Opdenakker (2019) designed 'full DeFi' mortgage lending systems. They did not mention tokenization and the cost of trust. Wouda et. al. covered the improvement of trust and transparency in their model. These papers were selected because the authors used different approaches to their research to get a broader view of the research techniques and results. Ali and Smith (2019) looked at customer relationship management with 3 constructs; people, process and technology. Henriquez et al. (2019) took an action design research approach to see if a new business model could be viable. Wouda and Opdenakker (2019) conducted design science research, validating a proposed model through semi-structured interviews with experts. The use of expert interviews showed validation of the trust and transparency variables for their model.

Zhang et al. (2021) and Bennett et al. (2021) used hybrid approaches where both did not consider tokenization and only Bennett et. al. considered transparency and trust. Zhang et al. (2021) designed a model considering the CBDC, or digital euro, and Bennett et al. (2021) described an overview of land administration and registration systems via blockchain.

1.3.4. Theoretical frameworks on maintaining trust

This section discusses the state-of-the-art different theoretical frameworks for enhancing trust, after which a relevant framework is selected. Generalizable and context-related frameworks that should emphasize the relevance of this research are considered.

Llewellyn (2005) describes trust and confidence in retail financial services. Trust is described here as keeping your promises, behaving predictably and not behaving opportunistically. In finance, trust is described in terms of three dimensions: a consumer's ability to make rational decisions about their own future welfare, trust in specific financial products, and trust in the financial institutions that provide financial services. In short, trust shows three areas of importance: solvency, integrity and competence. The author uses a trust matrix to explain when and why trust is important, and what influences whether consumers have trust or not. The result is how trust affects decision making. The author concludes that it is not possible to regulate trust, but that there is a trade-off between trust & confidence and regulation. He states that trust and confidence must be earned and that all stakeholders in the financial process lose when there is a failure of trust and confidence (Llewellyn, 2005).

Mayer et al. (1995) proposed a model of trust that focused on rebuilding trust after it has been broken, defining three factors of trustworthiness: benevolence, integrity, and ability. Benevolence is the way people look out for each other. Integrity is about whether people do the right thing, even when it is difficult. Ability is whether people are able to do what they are supposed to do. Within the model there is a fourth factor, the trustor's propensity, which has an independent influence on these three factors. By combining these, trust can be defined. Next, trust is linked to risk through the perceived risk of the trustee. The level of trust must be higher than the perceived risk to establish the trust relationship. Control systems can bridge the gap between trust and risk by reducing perceived risk to a level that can be managed by trust. However, if there is a strong control system, this will stop the development of trust because all trustworthy actions will be seen as a result of the control system. Next, the model is designed to be as parsimonious as possible in order to be highly generalizable. The authors have encouraged future researchers to use this model in other contexts by specifying contextual variables that are unique to other use cases (Mayer et al., 1995).

Similarities between (Llewellyn, 2005) and (Mayer et al., 1995) are the trade-off between trust and regulatory parties, and the variables of integrity and ability. Differences are the context-related variable of solvency by Llewellyn (2005), and the more generalizable variable of benevolence by Mayer et al. (1995). Llewellyn (2005) do not provide any quantification as well, where Mayer et al. (1995) do give a quantification. Furthermore, Mayer et al. (1995) puts strong attention on the propensity at the beginning of a relationship (Schoorman et al., 2007). Unlike (Llewellyn, 2005) and (Mayer et al., 1995), Hansen (2012) does not specifically mention the trade-off between trust and regulatory parties. Still, it is in line with the other papers because it puts the relationship between the customer and company in centric for trust. The consumer financial healthiness matches with the solvency as described by Llewellyn (2005). The broad-scope trust is in line with the ability because it believes in someone's competence. Financial knowledge is also in line with ability since it covers the construct of being informed (Elkins et al., 2012). The narrow scope is in line with integrity because that covers the construct of reliability (Elkins et al., 2012). In conclusion, the variables used by Hansen (2012) are more in line with (Llewellyn, 2005) than (Mayer et al., 1995) because the variables integrity, solvency, and ability are covered, while benevolence and propensity are missing.

A third framework is found and discussed, with a focus on consumer financial relationships. Hansen (2012) invented a model on consumer financial relationship trust where the author used factors on consumer financial healthiness, broad-scope trust, financial knowledge, and consumer relationship satisfaction. The author develops a conceptual framework for consumer's trust in their financial service provider. For this, it interrelates the variables of financial knowledge, satisfaction, financial healthiness, and broad-scope trust and researches their influence on narrow-scope trust. Broad-scope trust is defined as "the belief that proper impersonal structures are in place to enable one to anticipate a successful future endeavor" (Hansen, 2012), or trust in the system. Narrow-scope trust refers to the development and maintenance of healthy relationships. In general, this research focuses on established relationships and how financial service providers could keep their customers satisfied (Hansen, 2012).

Both papers ((Llewellyn, 2005) and (Hansen, 2012)) that are related to the context of finance use the variable of solvency and do not cover benevolence and propensity. Considering the context of Defi Lending, it would be interesting to take the propensity into account as a variable, since a high propensity to trust an innovative technology would imply an increase in adoption. Moreover, if there is zero propensity to trust a new innovative technology, the current financial system would remain unchanged. Furthermore, (Mayer et al., 1995) focuses on rebuilding and *enhancing* trust after this is broken, where Hansen (2012) focuses on establishing trust and Llewellyn (2005) only mentions the poor result of breaking trust.

As mentioned in section 1.2.3, the literature gap to be filled is to find a way to decrease the cost of trust while maintaining trust. The theoretical framework of (Mayer et al., 1995) meets this requirement most accurately. In addition, unlike the models of Llewellyn (2005) and Hansen (2012), the model of Mayer et al. (1995) is designed to be as parsimonious as possible in order to be highly generalizable Schoorman et al. (2007). The authors mention the compatibility of defining specific contextual variables for the model that are unique to the study of trust in a particular context. For example, solvency can be added within this model to make it appropriate to the models used by Llewellyn (2005) and Hansen (2012). Combining all the pros and cons of the different models, the model of Mayer et al. (1995) is chosen for research as it covers most variables and can be made context-specific towards financial services to make it compatible with alternative models of trust. This results in the first part to fill the literature gap where the trust model by Mayer et. al will be used to contextualize it toward hybrid mortgage lending.

1.3.5. Knowledge gap and objective

In section 1.3.1, arguments were found that underpin the design of a hybrid model where DeFi applications are integrated into TradFi companies and confirm their advantages on regulatory compliance and people's loyalty. The state of the art in section 1.3.3 shows that a lot of work has already been done to explore and design blockchain-based mortgage and/or land administration systems using various research techniques. It shows a knowledge gap where no clear link has been established between the impact on trust by removing the intermediary and its impact on the cost of trust - and therefore transaction costs. Some authors mention transparency and trust and discuss transaction flows, but do not develop a model that incorporates these aspects. Moreover, the emergence of the cost of trust in mortgage lending is severely underexposed with the assumption that transparency and tokenization are considered by the author. It might therefore be interesting to take these into account in this research. Only Wouda and Opdenakker (2019) covered the enhancement of trust and transparency in the design of his model, but he did not mention the cost of trust and the tokenization of mortgages. Therefore, for this research, a framework is provided in section 1.3.4, where it was concluded that the trust framework of Mayer et al. (1995) was the most appropriate for this research, which is named as follows: The Integrative Model of Organisational Trust. As mentioned in section 1.2.3, the reliance on intermediaries is not a prerequisite for trust and could be replaced by transparency while remaining reliable and trustworthy. The cost of trust could therefore be reduced by tokenizing mortgages in a hybrid lending system where these tokenized assets are

offered by TradFi companies. This leads to the goal of this research which is to:

Design a trustworthy hybrid mortgage lending system that reduces the cost of trust

The research objective can be split into two parts: 'reducing the cost of trust' and 'design a trustworthy hybrid mortgage lending system'. The first part will be achieved by using the trust framework mentioned above: The Integrative Model of Organisational Trust (IMOT) by Mayer et al. (1995). This trust model will be made context-specific on mortgage lending where its focus will lie on replacing reliance with transparency and thereby maintaining trust between borrowers and lenders in The Netherlands. Based on this model, a trustworthy hybrid mortgage lending system will be designed. The emphasis on 'trustworthy' comes from the first part where the trust model is used to steer this design. The mortgage lending system will be a technological design and will show a detailed overview of how tokenized mortgage loans can function within a TradFi environment. It will also be put into an architectural design that shows its place within the whole (hybrid) DeFi ecosystem. Finally, the role of its stakeholders will be discussed via a stakeholder map, which can be linked back to the cost of trust and eventually the transaction cost - which should both decrease within this concept.

1.4. Research Question

To achieve the research objectives and fill the knowledge gap, the main research question and subquestions are formulated below. Answering these questions will result in the desired knowledge that is required to fulfill the purpose of this study (Verschuren et al., 2010). The main research question is derived from the research objective:

What hybrid mortgage lending system can be designed that reduces the cost of trust?

Once the relationship between the trust model and the cost of trust is known, it must be placed in the context of hybrid mortgage lending. The first step is to describe how the trust model is applied in traditional finance. Hence, the first sub-question is the following:

1. How can the IMOT be used to decrease the cost of trust?

Once the relationship between the trust model and the cost of trust is known, it must be placed in the context of hybrid mortgage lending. The first step is to describe how the trust model is applied in traditional finance. This leads to the next sub-question:

2. How is the IMOT applied in TradFi lending?

The result will be used to apply it to hybrid mortgage lending and further contextualize it. The model by Mayer et al. (1995) will be used to set up a visualized trust model that follows from the following subquestion:

3. What IMOT model can be applied to hybrid mortgage lending?

Having an applied trust model, it must first be validated before the process of the second part of the research objective can start, namely the design of the HMLS. The validated trust model will be enriched with complementary information for the design, and in order to understand what should be asked during the expert interviews, it is necessary to identify which aspects are required to build the HMLS. These interview questions should therefor allign with the detailed overview of tokenized mortgage loans, the architecture, and the stakeholder map. A protocol will be written to gather feedback and complementary information from experts. This leads to the following sub-question:

4. What adjustments and complementary information are necessary for the contextualized trust model to design the HMLS?

For the final part, it needs to be analyzed how the information from the interviews on the validated trust model and complementary information can be used to design the HMLS. This leads to the last sub-question:

5. What does the hybrid mortgage lending system look like?

The solution to the main research question is created by combining the answers to all sub-questions. Chapter 2 outlines the research design that structures the process of answering these sub-questions and the main question. It also provides information on the methods used for data collection

2

Research methodology

This chapter elaborates on the methodology that is used for this research. First, section 2.1 explains the approach that will be used for this research. After that, section 2.2 describes the approach to reach saturation for the interviews and data analysis. Section 2.3 describes the different phases of this research based on a visualization of the process.

2.1. Selection of the research approach

As discussed in section 1.4, the process of designing a hybrid mortgage lending system provides an answer to the main research question. Therefore, this research is design-oriented. This leads to exploring design-oriented methodologies that might suit this research.

Design-oriented methodology, or design science, is described as a pragmatic research approach that focuses on the creation of innovative artifacts that solve real-world problems (Hevner and Chatterjee, 2010). This methodology is also referred to as Design-Oriented Science Information Systems Research or alternatively Design Science Research (DSR) (Winter, 2008). The DSR methodology is a relevant approach in information systems, and as such is applicable to both blockchain and mortgage administration systems (Wouda and Opdenakker, 2019; Henriquez et al., 2019).

The design research consists of two separate sets of tasks (Verschuren et al., 2010). The first is the *conceptual design*, which involves determining the objectives of the research project and modeling its content, that is, the answer to the research question. The second is the *technical research design*, which reflects the implementation phase of the project. This answers how the research will be carried out to answer the research questions (Verschuren et al., 2010).

As this section explains the choice of research approach, the technical research design will be discussed. The first step within the technical research design is the selection of the design strategy. The design framework that follows from this strategy is then explained. Section 2.3 will explain the second and third step of the technical research design, which is the research flow that explains the data collection and the research plan (Verschuren et al., 2010).

The design strategy

A DSR project usually has two strategies. The first strategy is to build the artifact as a general solution conceptual design that addresses multiple, different financial services contexts. The second strategy is to solve a problem at an individual level (client/company) by building a concrete artifact and generalizing this solution toward the whole financial services context (Iivari, 2015).

The research objective in section 1.3.5 describes a design challenge arising from a general trend across the financial sector. In addition, this research was carried out at BearingPoint, a management & technical consultancy. For them, it is more relevant to have a framework that can be applied to multiple clients, rather than one specific client. For these reasons, this research will focus on the design of a technological design in the context of mortgage loans in the financial sector of the Netherlands. Therefore, this research will follow the first strategy (Iivari, 2015): This research project starts with building an artifact as a general solution for mortgage lending in the Dutch financial sector. The results can be specified to companies that are active in the Dutch mortgage market.

The design framework

There are different frameworks reflecting a particular genre within the DSR methodology. Examples are laboratory-oriented, intervention-oriented, and practice-oriented approaches. The design strategy that is chosen requires a laboratory-oriented approach because this addresses a general problem through the design of conceptual artifacts which remains primarily 'Design Science' (Goldkuhl and Sjöström, 2018; Hevner and Chatterjee, 2010). Intervention and practice-oriented approaches are more useful in the second design strategy, for instance via prototyping with iterative cycles in Action Design Research and Practice Design Research Iivari (2015); Sein et al. (2011).

Peffers et al. (2007) present a DSR framework that is in line with the first design strategy and laboratory-oriented approach by providing a six-step approach with proof-of-concept-level prototypes (figure 2.1).

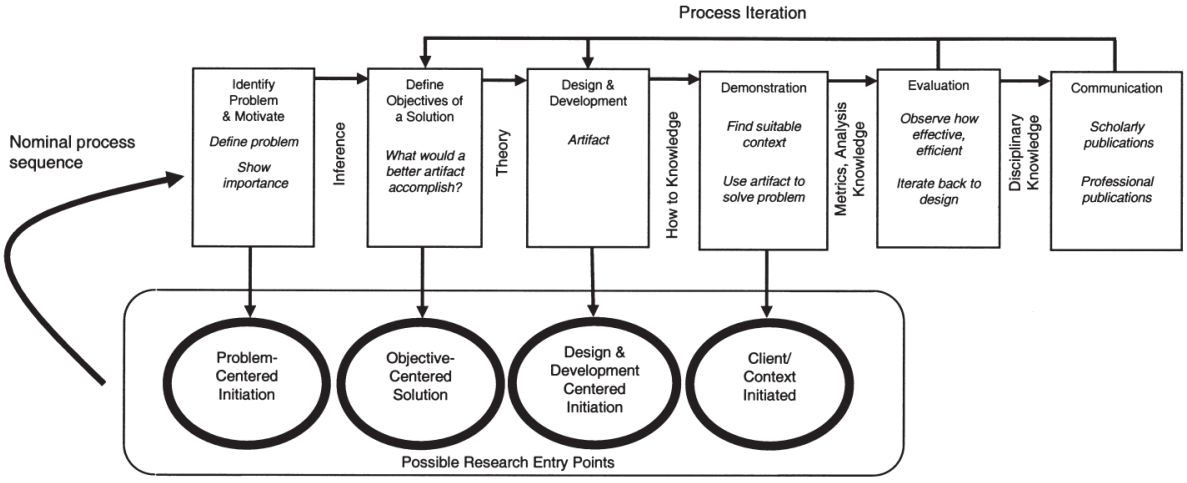

Figure 2.1: Design Science Research Methodology process model (Peffers et al., 2007)

Reflecting on the DSR framework for this research project, it can be said that there is an additional design step to reach the technological design, where the trust model must first be designed and evaluated. As such, two conceptual artifacts require two cycles of DSR to be intertwined. The next section will explain the evaluation method used for this design approach.

Evaluation approach

According to Hevner and Chatterjee (2010), it is crucial to balance the construction and evaluation of artifacts. This is particularly relevant to this research as the evaluation of the first artifact provides the requirements for the second artifact. Hevner and Chatterjee (2010) argues that grounded arguments may be insufficient without a strong evaluation. Venable et al. (2012) offers a framework for evaluation methods in DSR that could fulfill this. Venable et. al describe the difference between formative and summative evaluation methods. Formative evaluation takes place before the artifact is designed, while summative evaluation occurs after. The goal of formative evaluation methods is to produce empirical-based interpretations that provide a rationale for improving the attributes of the research artifacts, whereas the goal of summative evaluation methods is to create common ground about the research artifacts Venable et al. (2012).

Applying this to this research with two artifacts, the first requires a summative evaluation and the second a formative evaluation. Sonnenberg and vom Brocke (2012) shows evaluation activities within a DSR process where coherence can be found for both summative 'ex-post' evaluation and formative 'ex-ante' evaluation. For the ex-post evaluation, the constructs to use the trust model are evaluated. For the ex-ante evaluation, the constructs are evaluated to design the technological model. In Sonnenberg et. al, these are referred to as EVAL 3 and EVAL 2 respectively. (fig. 3, p392 in Sonnenberg and vom Brocke (2012)). The evaluation methods that match for both evaluation activities are benchmarking, survey, expert interview, and focus group.

The research that Wouda and Opdenakker (2019) did with a DSR approach on blockchain in mortgage lending was via expert interviews to validate their proposed model. Hugo Hoffmann (2021) also did DSR on blockchain in the financial sector, but on micro-lending instead of mortgages. The author interviewed blockchain experts and banks to validate their approach.

Another reason to choose expert interviews is the ability to ask follow-up questions immediately, which is not possible with benchmarking and surveys. In focus groups, a benefit is that experts can discuss and form a common ground. Additionally, the group dynamics of a focus group can generate new ideas for the technological model. However, interviews provide a better opportunity to inquire further about specific topics. This can later be used to find common ground by analyzing the results. Moreover, in-depth interviews enable deeper conversations with experts as they tend to feel more comfortable in a 'safe space' without competitors or unfamiliar people. Focus groups, on the other hand, can become chaotic with contradictory opinions and some participants feeling left out when others dominate the conversation (Longhurst, 2003).

Based on previous research and a comparison between interviews and focus groups, the expert interview method is chosen for this research. Semi-structured in-depth interviews will be conducted with experts in the financial sector. The interviews will

consist of two parts: the first part will evaluate the constructs of the trust model, and the second part will evaluate other constructs to design the technological model. This semi-structured approach strikes a balance between the ability to ask follow-up questions and the collection of specific data in an organized manner (Kallio et al., 2016).

2.2. Interview saturation and analysis methodology

(Hennink and Kaiser, 2022) shows that 9 - 17 interviews are required in qualitative research to reach saturation. For this research, this will be used as a guideline where at least 9 interviews will be done. Further saturation of the data will be done based on thematic saturation. This comes from the thematic analysis that will be used to analyze the interviews. The analysis of the interviews will be done according to the four steps Malterud (2012). First, the transcripts are read to get a general impression and identify preliminary themes on the objective of this research project. The themes are directly linked to the interview questions. Second, the coding is defined that symbolize the themes and subthemes. After that, the transcripts are read and linked to the themes and subthemes. Third, the transcripts are grouped into themes and subthemes. Lastly, the quotations are compiled from the descriptions of the participants' impressions and feedback. Excel will be used to set up summary tables to link the participants' quotes to the themes which can be further analyzed. More details on the interview process, saturation, data analysis, data management, and GDPR compliance will be discussed in the result chapter 5.

2.3. Research flow

This section will clarify how the DSR process model from figure 2.1 provides the different steps of this research. As for the DSR process model by Peffer et. al, the research flow diagram in figure 2.2 will contain six steps per artifact. Section 2.3.1 explains the approach for the trust model, followed by section 2.3.2 for the technological model.

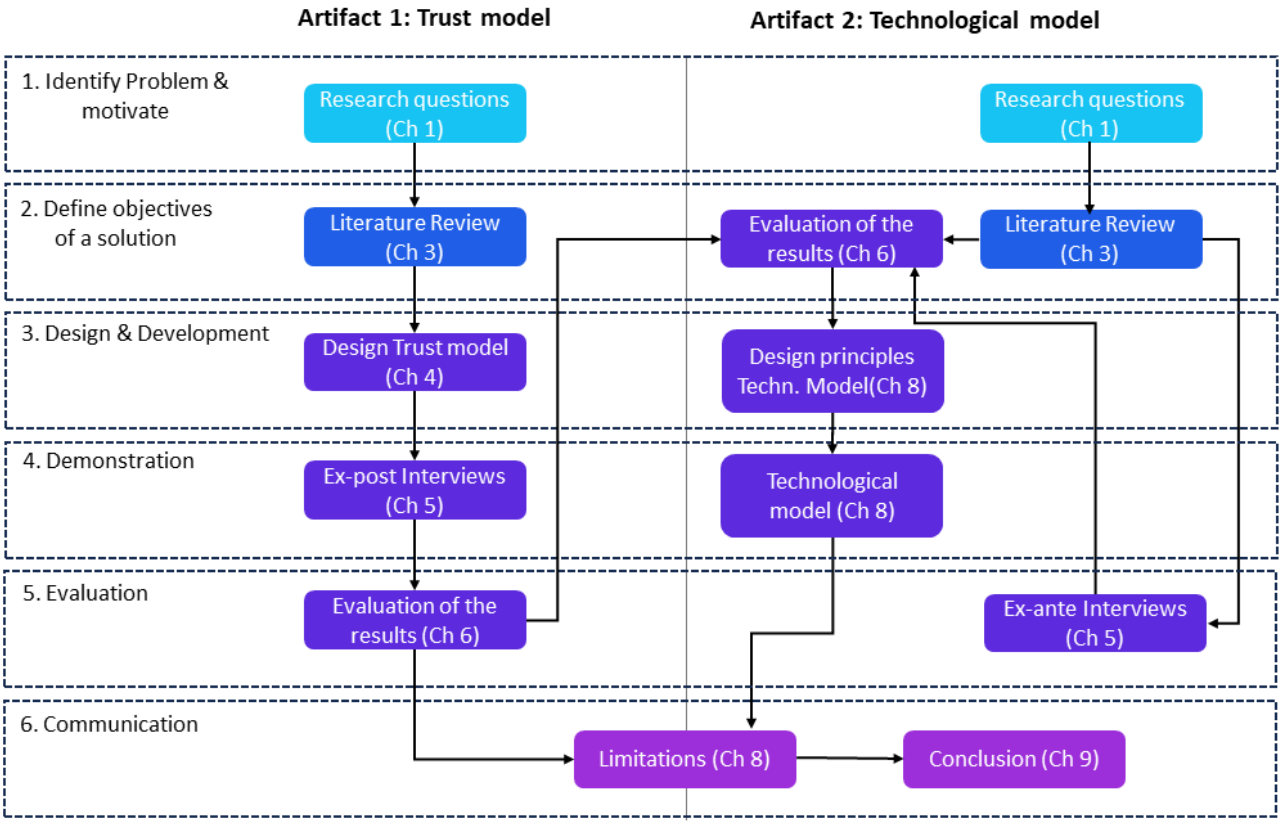

Figure 2.2: Research flow diagram.

2.3.1. Research flow of Artifact 1: Trust model

The research flow of the trust model will be explained by guiding through the six steps as shown in figure 2.2

1. Identify problem & motivate

The problem identification of the trust model is in chapter 1, where the topic is introduced, a knowledge gap is found, and the research questions are determined.

2. Define objectives of a solution

In the second step, the objectives of the solution are presented in the literature review in chapter 3, in section 3.2 which is about the IMOT (Mayer et al., 1995), and section 1.2.3 about the cost of trust.

3. Design & development

In the design & development phase of the hybrid trust model, the first three subquestions will be answered in the third step, using the literature review to form the answers.

The first subquestion can be answered immediately since it is based on the literature section 3.2 and the cost of trust.

1. How can the IMOT be used to decrease the cost of trust?

The second subquestion can be answered using section 3.3 on mortgage lending in TradFi and the IMOT of section 3.2. Moreover, there will be dived deeper into the Dutch banks to see how the trust model is applied in their mortgage lending process:

2. How is the IMOT applied in TradFi lending?

Finally, the third subquestion will be answered in the third phase, where the trust model will be contextualized toward hybrid mortgage lending. This results in the design of the artifact and therefore finalizes the design & development phase:

3. How can the IMOT be contextualized toward hybrid mortgage lending?

4. Demonstration
The demonstration phase of the trust model is where it is presented to the experts on the use case of mortgage lending in a hybrid environment. Section 5.5 shows the results from this demonstration.

5. Evaluation
The fifth step shows the evaluation phase, which is for this model an ex-post evaluation. The evaluation phase compares the objectives in the second step with the results of the demonstration during the expert interviews. This will be discussed in section 6.2.1 of chapter 6 where the evaluated trust model by the experts will be discussed. This provides an answer to the fourth subquestion:

4. How can the contextualized trust model on hybrid mortgage lending be validated?

6. Communication
Finally, the sixth step of the trust model is to communicate the importance of the problem and discuss its utility and limitations, which are discussed in chapter 9. Also, the communication phase of the DSR framework is done by writing this thesis, which will therefore be done throughout the other phases as well.

2.3.2. Research flow of Artifact 2: Technological model

The research flow of the technological model will show a different order than a 'typical' DSR framework, as seen in figure 2.2. This is mainly because ex-ante interviews are used as an evaluation method (step 5) that is used to define the objectives of the solution (step 2), and will occur earlier within this section. Although this section explains the order of the steps performed in this research, these are still indicated with the phases according to the DSR framework to provide consistency throughout the research flow.

1. Identify problem & motivate
The first phase of the technological model is the identification of the problem and is stated in chapter 1, where the topic and research objective are introduced.

5. Evaluation
The second step of the technological model will provide an ex-ante evaluation. The evaluation phase will evaluate the constructs to use for the technological design. The constructs will be discussed by the expert interviews in chapter 5 and evaluated in chapter 6.

2. Define objectives of a solution
The third phase is the definition of objectives for the technological model and will be described in section 7.1. Here, an outline of the objectives of the model will be given based on the literature review and evaluated expert interviews. Based on the evaluation of the results, subquestion five can be answered:

---

5. What other information from experts is necessary to design the technological model?

---

3. Design & development
The design & development phase will follow from the evaluation of the results and will consist of meta-requirements for the technological model in section 7.2. It will describe how the model should be developed and contextualized toward mortgage lending in a hybrid environment.

4. Demonstration
The technological model will be demonstrated in section 7.3, where the meta-requirements are applied in a pseudo-environment. This section shows that the design can not only be described but also demonstrated by displaying the tokenized model, architecture, and stakeholder map of mortgage lending in a hybrid environment. As a result, it provides an answer to the sixth and final subquestion:

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6. How can a technological model be designed based on the validated trust model and expert interviews?

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6. Communication
As for the trust model, the sixth step for the technological model is to communicate the problem's importance, as well as the utility and its limitations. Additionally, the main research question will be answered in the conclusion, where the model's relevance and innovativeness will be discussed in chapter 9. This will address the problem identified in the first step.

3

Literature Review

This chapter shows the literature review which consists of three parts that form the basis of this research project: DeFi lending (section 3.1), the IMOT (section 3.2), and mortgages (section 3.3.2). The goal of the literature review is to provide information that will be used as input for the trust model in chapter 4. It will also be compared with the results of the interviews and discussed in chapter 6. Finally, sections 3.1 and 3.3.2 will be used to design the technological model in chapter 7.

3.1. Definition of DeFi Lending

This section will explain the working principle of DeFi lending. First, DeFi itself will be explained which will be done by elaborating on the 'stack of five layers', the consensus mechanisms, and the three different types of stablecoins. After that, DeFi lending will be explained according to the Protocol for Loanable Funds (PLFs) approach, followed by the different types of protocols and interest models. Finally, the risks of DeFi lending will be discussed.

3.1.1. Introduction to DeFi

Decentralized finance, or DeFi, refers to a system of financial applications built on top of blockchain technology that allows users to transact and interact with financial instruments and services in a decentralized manner without relying on traditional intermediaries such as banks or other financial institutions. DeFi is built on a variety of blockchain networks of which Ethereum is the largest network, but there is also competition from Binance Smart Chain, Solana, Avalanche, and Cardano. (Auer et al., 2023; defiprime.com, 2023).

The core of DeFi is the use of smart contracts, which are self-executing programs that can automate the transfer of digital assets, allowing financial transactions to be executed without the need for intermediaries. Smart contracts are very transparent and minimize arbitrage and risk of manipulation (Schär, 2021). Smart contracts are responsible for managing the rules and regulations of the DeFi platform, such as the lending and borrowing protocols, liquidity pools, and other financial instruments. DeFi also includes other financial instruments such as derivatives, insurance, and prediction markets. Derivatives are financial contracts that enable traders to speculate on

the price of an underlying asset. Insurance products protect users against risks such as hacks or smart contract failures. Prediction markets enable users to bet on the outcome of future events, such as election results or sports matches (Harvey et al., 2021; Auer et al., 2023).

One of the key advantages of DeFi is its accessibility. Anyone with an internet connection and a digital wallet can access DeFi platforms, regardless of their location or financial status. This allows for greater financial inclusion, especially in regions where traditional financial services are unavailable or expensive (Harvey et al., 2021).

DeFi can be explained as a stack of five layers, with each layer corresponding to a separate part of DeFi that fulfills a different purpose (Rossi, 2023). The different layers are mentioned and explained below. Since different names are used throughout the literature that refer to the same layer, they are mentioned to not raise any ambiguity. Relevant definitions that are stated to explain these five layers are elaborated on and referred to afterward.

Layer 1: Settlement or Consensus Layer
Layer 2: Asset or Smart Contract Layer
Layer 3: Protocol or Gateway Layer
Layer 4: Application Layer
Layer 5: Aggregation or Governance Layer

Layer 1: Settlement or Consensus Layer

The first layer is the Settlement or Consensus layer, which consists of the Blockchain distributed ledgers and includes the blockchain networks such as Ethereum, Binance Smart Chain, Solana, Avalanche, and Cardano (defiprime.com, 2023). These provide the infrastructure for executing smart contracts, storage of data, and securing transactions through these consensus mechanisms. A consensus mechanism is a procedure where transactions are validated on the blockchain (Zaisan, 2023). Different consensus mechanisms will be explained in section 3.1.2.

Layer 2: Asset or Smart Contract Layer

The asset or smart contract layer focuses on the creation and management of digital assets and smart contracts. It involves the issuance and representation of assets on the blockchain, including cryptocurrencies, stablecoins, NFTs, and other tokenized assets. The key characteristic of all operating protocols in layer 2 is their programmability and atomicity, where the trade-off lies between autonomy and efficiency. Section 3.1.3 explains the different assets as mentioned above, such as stablecoins and NFTs.

Layer 3: Protocol or Gateway Layer

The protocol or gateway layer includes the core DeFi protocols and platforms. These protocols establish the rules and logic for a variety of financial operations such as lending & borrowing, DEX, and yield farming for the wallets (Rossi, 2023).

Layer 4: Application Layer

The application layer is built of user-facing applications and decentralized applications (DApps). Users can use these interfaces to communicate with the protocol layer and access specialized DeFi services such as trading and providing liquidity to DEXs, Credit, Derivatives, and Insurance (Rossi, 2023; Deshmukh et al., 2021).

Layer 5: Aggregation or Governance Layer

The aggregation or governance layer is responsible for aggregating and improving the DeFi user experience. Aggregation platforms collect data from several protocols and provide customers with a uniform interface to access various DeFi services. Governance mechanisms like Decentralized Autonomous Organizations (DAOs) provide community-driven decision-making and protocol governance via asset and yield management (Rossi, 2023; Deshmukh et al., 2021).

As mentioned above, popular use cases within DeFi are the different lending and borrowing platforms, which allow users to lend and borrow cryptocurrencies without the need for a traditional financial institution. In DeFi Lending platforms, users can deposit their cryptocurrencies and earn interest, while in borrowing platforms, users can borrow cryptocurrencies by providing collateral (Aramonte et al., 2022).

DeFi Lending focuses on the problem of over-collateralization within traditional finance (Aramonte et al., 2022). The tokenization of real assets is necessary for DeFi lending to participate in the real economy. This reduces reliance on collateral based on borrower information.

3.1.2. Consensus mechanisms

There are four main consensus mechanisms: Proof-of-Work (PoW), Proof-of-Stake (PoS), Proof-of-Authority (PoA), and Delegated Proof-of-Stake (DPoS) (Sedlmeir et al., 2020; Zaisan, 2023).

Proof-of-Work (PoW)

This is the consensus mechanism of a public blockchain and for the first application of blockchain technology, the cryptocurrency Bitcoin (Nakamoto, 2008). For PoW blockchains a new block is created by solving a difficult cryptographic computational problem, a process called mining. This leads to the voting weight being linked to a scarce resource, namely computing power, which prevents Sybil attacks. PoW is therefore designed to be energy-intensive. Everyone is allowed to participate and mine which makes the consensus permissionless. However, only the first miner (or group of miners) that solves the problem for the current block gets rewarded with an amount of cryptocurrency. The computational power increases for every new block, resulting in enormous energy consumption for PoW blockchains. Furthermore, the number of transactions per block is limited, which makes the technology difficult to scale and unsustainable (Sedlmeir et al., 2020).

Proof-of-Stake (PoS)

For this consensus mechanism, there is a scarce resource of capital instead of computing power. For blockchains with the PoS mechanism, there is a random generator that determines who is allowed to generate the next block and is rewarded with an amount of cryptocurrency. The probability of getting selected is determined by the amount of cryptocurrency that the node has deposited and is locked (or staked). Everyone is allowed to stake and get a chance to get selected to generate the next block, which makes the mechanism permissionless. The computational complexity of PoS is low and therefore more energy efficient. It could be argued whether it is less safe than PoW since it is possible to own 51% of the total supply and 'dominate' the consensus mechanism (Sedlmeir et al., 2020).

Proof-of-Authority (PoA)

This has a similar working principle as for the PoS, only that there is a restricted group of participants that can take part in consensus, the validators. PoA is therefore a permissioned blockchain. The validators can be chosen based on their identity and/or reputation, and their election could vary across the different PoA blockchains. There are usually different levels of security involved, from fully fault-tolerant mechanisms like Paxos (Lamport, 2001) over semi-fault-tolerant algorithms like Istanbul Byzantine Fault Tolerant (IBFT) (Moniz, 2020), to crash-tolerant mechanisms like RAFT (Ongaro and Ousterhout, 2014). A more secure consensus mechanism results however in a higher energy consumption (Sedlmeir et al., 2020).

Delegated Proof-of-Stake (DPoS)

This has again a similar working principle as for the PoA, but the validators are chosen through voting (Zaisan, 2023). The validators take turns creating the blocks without having to compete against each other, making it a permissioned blockchain.

3.1.3. Different digital assets

As mentioned in section 3.1.1, different digital assets can be created within the second layer of the DeFi stack. For this section, stablecoins, FTs, NFTs, and governance tokens will be discussed.

Stablecoins and collateralization

Stablecoins are cryptocurrencies designed to remain 'stable' as their name already reveals. Unlike other cryptocurrencies, it does not show large volatilities or unpredictable behavior which makes it a valid digital alternative for financial activities such as buying/selling goods, or in this case: for mortgage lending. Stablecoins generally try to maintain a stable value toward a real-world asset they are pegged to, such as the Euro or US dollar (Baughman et al., 2022).

Stablecoins can be distinguished into two different types of mechanisms: collateralized and non-collateralized. Collateralized stablecoins are backed by a certain asset which can be further divided into off-chain and on-chain stablecoins. Off-chain stablecoins are backed by 'real assets' from the TradFi system, such as Fiat currencies (€,$) or Commodities (Gold). On-chain stablecoins are collateralized via cryptocurrencies like Bitcoin. The collateral of on-chain stablecoins is held in smart contracts, whereas the collateral of off-chain stablecoins requires a custodian for safekeeping. Non-collateralized stablecoins are stabilized via algorithms, of which an example is the TerraUSD stablecoin. Figure 3.1 shows an overview of the different types of stablecoins that are discussed above (Liu et al., 2023; Mita et al., 2019; Baughman et al., 2022).

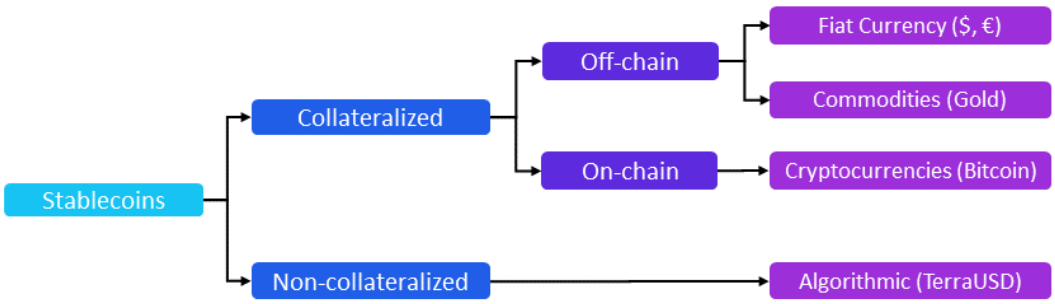

Figure 3.1: Stablecoins divided into different categories

Mita et al. (2019) further distinguishes non-collateralized stablecoins into a protocol and application-stabilized algorithm since these are the layers they have toward their approach (Layers 3 and 4). Changing applications is easier than changing protocols since Layer 4 is built on top of Layer 3. For price stabilizations of these algorithmic stablecoins, there are possibilities to intervene in the protocol and/or application layer.

An infamous example of an algorithmic stablecoin is TerraUSD, causing a crash in May 2022 when its algorithm turned out to be poorly designed, as described by Liu et al. (2023). This resulted in cautious policy toward stablecoins, and in particular such algorithmic stablecoins (Baughman et al., 2022).

FTs

Fungible Tokens (FTs) are digital assets that are non-unique and divisible. They represent the value that is stated on it, just as for currencies (Gudgeon et al., 2020). Stablecoins are examples of FTs.

NFTs

Non-fungible Tokens (NFTs) are digital assets that are designed such that it is a unique token that contains proof of authenticity. The process of transferring ownership is automated via smart contracts. The ownership information is recorded on the blockchain, which makes it a transparent and verifiable proof of ownership (Wang et al., 2021; web3 studios and Block stories, 2022).

Use cases for NFTs could be on digital art, or they could be linked to real assets, such as tracking the ownership of luxury goods or monitoring supply chains. For example, products could receive a sustainable NFT token that is verifiable.

For mortgage lending, the ownership on the investment side could be tracked via NFTs.

Governance tokens

Governance tokens give the right to its holders to participate in the decision-making process on the development of the blockchain protocol or platform. There are various governance tokens within a protocol that grant rights to develop DAOs, the platform, or requirements for the smart contracts Fan et al. (2023).

3.1.4. The working principle of DeFi lending

The key component within DeFi Lending is the Protocol for Loanable Funds (PLFs) that is used for DeFi lending pools. PLFs exist in the third layer of the DeFi stack and

they make it accessible for users to lend & borrow digital assets in a decentralized fashion. Smart contracts are central here and behave as middlemen between lenders and borrowers.

Generally, three parties are involved in DeFi Lending systems: Lenders, Borrowers, and Liquidators (Huber and Treytl, 2022).

Lenders provide liquidity to the lending platforms by depositing their digital assets into lending pools or smart contracts. In return, they earn interest on their deposited assets (Huber and Treytl, 2022; Bartoletti et al., 2021).

Borrowers Borrowers obtain a loan in exchange for making interest payments. For most DeFi Lending platforms, the borrower is required to deposit cryptocurrencies as collateral for their loan - and thus DeFi Loans are then collateralized loans, where normally the collateral is higher than the amount borrowed (Huber and Treytl, 2022; Bartoletti et al., 2021).

Liquidators are usually computer programs that ensure the stability and integrity of the DeFi Lending ecosystem. They monitor debt positions and identify under-collateralized or ”unhealthy” loans. Liquidators are designed to automatically detect loans where the collateral value falls below the required threshold. For these circumstances, liquidators step in and start the liquidation procedure. They take away the collateral provided by the borrower and sell it on the market at a discount. By doing so, liquidators recover the loaned funds for lenders, reducing the risk of default and protecting the funds of lenders. The rewards for liquidators provide a strong drive to monitor the lending platform and take actions if necessary constantly (Huber and Treytl, 2022; Bartoletti et al., 2021).

A generalized PLF is shown in figure 3.2, where the role of the liquidators is not visualized since it is programmed within the Lending Pools’ Smart Contract.

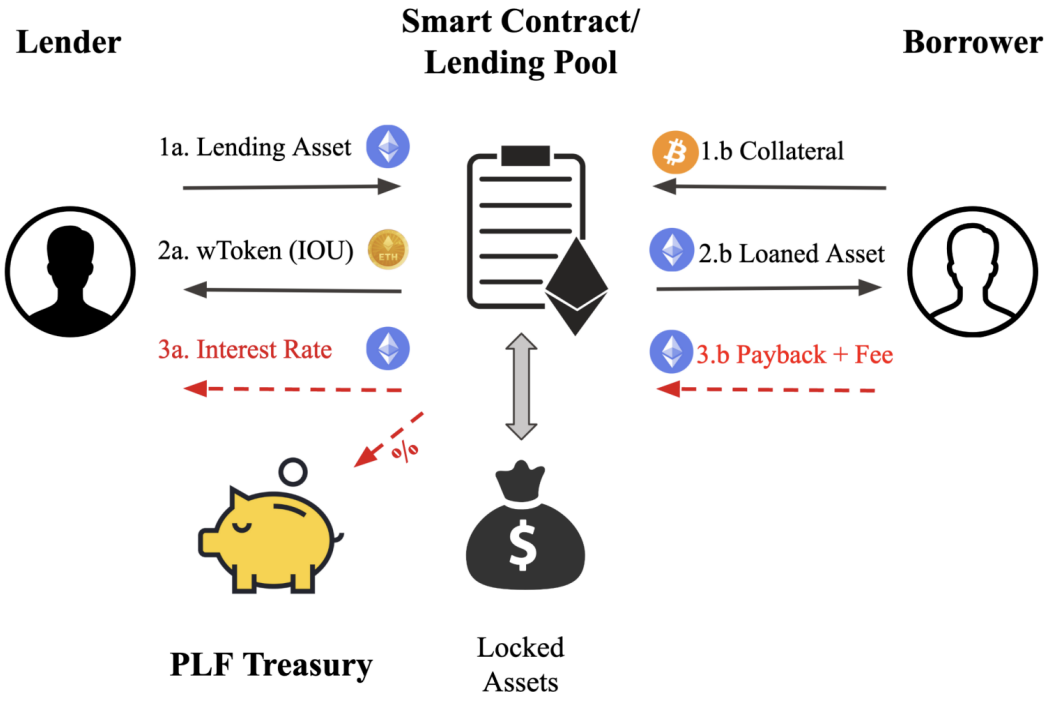

Figure 3.2: A typically generalized PLF by Xu and Xu (2022). It clearly shows the 'intermediation role' of smart contracts between lenders and borrowers, together with the presence of locked assets and revenue for the PLF itself.

Next to the lender, borrower, and smart contract, there are locked assets and a treasury within the PLF. Total Value Locked (TVL) represents the total amount of digital assets locked through smart contracts, which can consist of different collateralized or lent cryptocurrencies. TVL is a measure of the platform or protocol's trustworthiness because lenders require certainty in receiving their digital assets within agreed timeframes. The interest rate model of a lending pool can be linear, non-linear, variable, or kinked (Gudgeon et al., 2020).

In practice, the generalized form of a DeFi lending model can be extended with additional actors in various DeFi lending protocols to increase its efficiency and security. For instance, Maple (Maple, 2023) has *Pool Delegators*, which are users that manage the pools. These delegators are rewarded with management fees for the evaluation of potential borrowers and funding loans. It also contains security actors, like a *Governor*, the main administrator of the protocol, *Security Admin* who can pause every function in the protocol if critical incidences happen, and *Keepers*, who are external actors who perform as liquidators in times of illiquidity. Their role could be compared with that of the arbitrageurs. These actors must prevent token holdings are not concentrated in a small set of accounts to possibly make the market illiquid, or manipulate the market in other ways.

3.1.5. Risks

In general, two major categories of risk can be distinguished, systematic and unsystematic risk. Systematic risk includes risks that affect an entire market equally, for instance by macroeconomic factors such as regulations, external events, and (disruptive) technological innovations. Unsystematic risks include risks that are focused on

a specific unit of analysis, which can be a protocol or company. For this project, both are taken into account since both shape the level of trust in this technology. Examples of systematic risks are market and regulatory risks, examples of unsystematic risks are smart contract, oracle, and governance risks (Huber and Treytl, 2022).

Different risks that concern DeFi Lending are gathered from related work and listed and described below.

Market Risk

DeFi lending often involves borrowing and lending in highly volatile cryptocurrencies. Heavy price volatility can result in borrowers being unable to repay their loans or lenders suffering losses. Although this is solved via overcollateralizing loans as a buffer against price fluctuations, it is still debatable whether this is a sustainable business for such highly volatile products (Martins and Demertzis, 2023; Johnson, 2022).

Liquidity Risk

Insufficient liquidity is mainly a risk in DeFi lending during market breakdowns or extreme price volatility, which can cause an accelerated effect. During these periods, the markets may be illiquid to meet borrowing and lending requirements. This can lead to delays, higher costs, and limited access to funds. It also increases the risk of collateral liquidations, which contributes to price volatility (Gudgeon et al., 2020).

Counterparty Risk

Counterparty risk refers to the possibility of a counterparty failing to fulfill its obligations, such as repaying a loan or settling a transaction. In DeFi Lending, the counterparty risk primarily faces credit risk, which is the borrower's ability to repay the loan. Credit risk could influence the volatility of digital assets, resulting in under-collateralization. The ease of creating credit in DeFi can lead to solvency risks, while the algorithmic determination of interest rates can introduce inaccuracies, as what was seen during the Terra Luna crash (Liu et al., 2023; Pauwels et al., 2022).

Smart Contract Risk

Smart contract risk refers to vulnerabilities or coding errors within the smart contracts that underlie DeFi lending platforms. could result in financial losses or the manipulation of lending and borrowing procedures (Schär, 2021).

Governance Risk

Governance risk relates to the decentralized governance frameworks used by many DeFi lending platforms. The community votes on changes in the protocol. To participate in the governance process, users and investors must purchase a token on a liquid marketplace that has been allocated protocol governance powers. Holders of these tokens can utilize them to vote on protocol modifications and participate in deciding its future direction. Governance risk concerns include issues such as voter apathy, centralized decision-making power by owning a majority (51%), and conflicts of interest, all of which can have an impact on the platforms' stability and efficacy (Morrison et al., 2020).

Oracle Risk

Oracles store off-chain data securely on the blockchain. They are required for activities such as asset price determination and liquidation. Oracles are the bridge between off-chain data and the blockchain and therefore considered as most vulnerable to attacks. Oracle risks refer to the potential manipulation, inaccuracy, or compromise of the data provided by oracles, which could lead to wrong valuations and liquidations. Here, arbitrageurs could benefit from it (Huber and Treytl, 2022).

Scaling Risk

Scaling risk is a crucial problem within DeFi lending, and clearly proves why this technology falls behind current Tradional Financing (TradFi) such as Visa and Mastercard. As the popularity of DeFi platforms grows and more participants engage in lending activities, the underlying blockchain infrastructure faces scalability challenges. Most DeFi lending protocols operate on public blockchains like Ethereum, which have finite transaction processing capabilities. As of today, Ethereum can handle 30 transactions per second Worldcoin (2023), while Visa can handle 65000 transactions per second (Visa, 2018). The restricted data transfer capacity and increased traffic load can lead to higher transaction fees and slower transaction confirmation times, which can affect the efficiency and accessibility of lending activities. Additionally, scalability concerns may expose DeFi lending platforms to network congestion, system instability, and security vulnerabilities. To mitigate scaling risks, various solutions are being explored, including layer-2 solutions, such as sidechains and off-chain protocols, that aim to enhance transaction throughput and reduce costs. Moreover, ongoing research and development in blockchain technology are focused on improving scalability to ensure the long-term viability and stability of DeFi lending ecosystems (Harvey et al., 2021).

DEX Risk

DEXs rely on smart contracts to automate and execute transactions, which is done via AMMs. Smart contract vulnerabilities can result in the loss or theft of funds, putting lenders at risk. Another risk for the AMMs is the high risk of slippage and volatility as a result of low volumes in the market (or illiquidity market). Furthermore, the lack of centralized authorities or regulatory oversight in DEXs increases the possibility of fraudulent activities, such as the use of fake tokens or price manipulation by malicious actors (Martins and Demertzis, 2023; Johnson, 2022).

Flash Loan Attack

Flash loans allow users to borrow large amounts of capital without collateral, as long as the borrowed funds are returned within a single transaction. However, flash loans can be used to manipulate markets or launch attacks on lending platforms if the platform is not properly secured (Gudgeon et al., 2020).

Custodial Risk

While DeFi aims to eliminate the need for intermediaries, some DeFi lending platforms may require the custody of assets for lending purposes. This introduces custodial risk, where lenders entrust their funds to a centralized entity within the DeFi ecosystem. There are three types of custody: self-custody, partial custody, and third-party custody. Self-custody involves users developing their own solutions to store their private

keys securely, such as using offline storage devices. Partial custody combines self-custody with an external solution, where the external provider holds some information to recreate the private key in case of loss. Third-party custody refers to custodial services offered by companies in centralized finance who are extending their services to DeFi, such as Dutch bank ABN Amro (ABN AMRO Bank, 2023; Harvey et al., 2021).

Regulatory Risk

DeFi lending operates within a rapidly evolving regulatory landscape, which poses regulatory risks for participants. As regulators strive to catch up with the innovation in DeFi, there is a lack of clarity and uncertainty regarding the legal and regulatory framework. Regulatory risks include potential restrictions, licensing requirements, and the introduction of new regulations that could impact the operations and viability of DeFi lending platforms (Pauwels et al., 2022; Liu et al., 2023).

Regulatory arbitrage also occurs, where participants take advantage of regulatory loopholes or differences between jurisdictions to conduct lending activities in a decentralized finance (DeFi) ecosystem. This could cause risks since authorities may catch up and introduce new regulations that specifically target these loopholes. Current players can then be penalized since they are non-compliant with existing or emerging regulations (Deshmukh et al., 2021).

3.2. Explanation of the IMOT

To recall from section 1.3.4, Mayer et al. (1995) presented the IMOT with its primary goal to rebuild trust after that has been broken. Figure 3.3 shows the Model of Trust the authors proposed and table 3.1 a definition list that corresponds with this model,

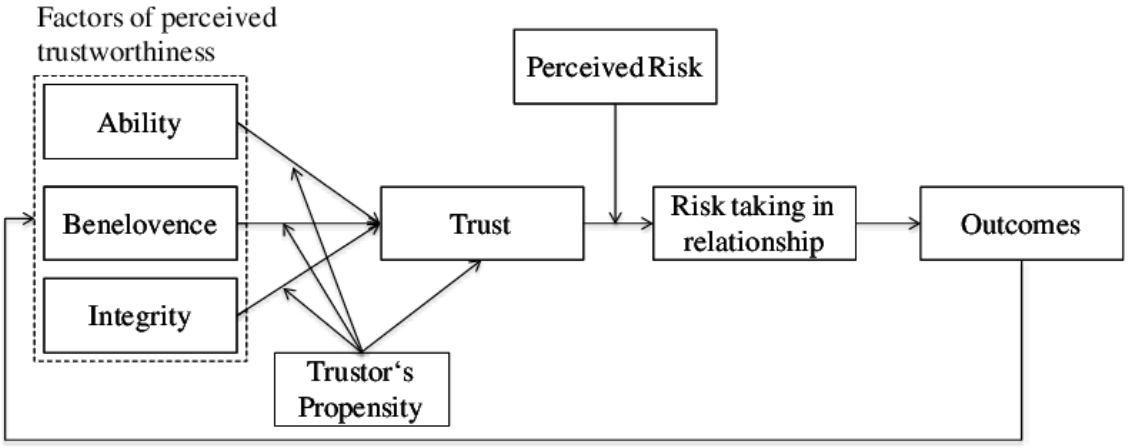

Figure 3.3: Visualization of the IMOT (Mayer et al., 1995).

Table 3.1: Definitions and explanations corresponding to figure 3.3, ordered from left to right, top to bottom (Mayer et al., 1995; Schoorman et al., 2007).

Definition	Explanation
Ability	Whether people are capable of doing what they are supposed to accomplish
Benevolence	The way people watch out for one another
Integrity	Doing the right thing, even when it gets difficult
Trustor's Propensity	Characteristic that leads to a generalized expectation of others' trustworthiness
Trust	Willingness to take risk
Perceived Risk	The level of risk that someone experiences, it moderates the relationship between trust and risk
Risk Taking in Relationship	Whether or not take the risk in a relationship
Outcomes	The result of risk that has been taken in the relationship

From figure 3.3 can be seen that there are three Factors of Perceived Trustworthiness: Ability, Benevolence, and Integrity, which are also referred to as the 'Three Pillars of Trust' due to the central role these play.

Mayer et al. (1995) proposed a model of trust that aimed to focus on rebuilding trust after that has been broken where three factors of trustworthiness were defined: benevolence, integrity, and ability. Benevolence is the way people watch out for one another. Integrity discusses whether people do the right thing, even when it gets difficult. Ability is whether people are capable of doing what they are supposed to accomplish. Within the model, there is a fourth factor, the trustor's propensity, which has an independent influence on these three factors. Combining these, the trust can be defined. Next, the trust is connected to the risk via the perceived risk of the trustee. The level of trust must be higher than the perceived risk to take on the relationship of trust. Control systems can bridge the difference between trust and risk by lowering the perceived risk to a level that can be managed by trust. However, if there is a strong control system, this will stop the development of trust because all trustworthy actions are seen as a result of the control system. Next, this model is designed to be as parsimonious as possible to be highly generalizable. The authors reached out to future researchers to use this model in other contexts by specifying contextual variables that are unique for other use cases.

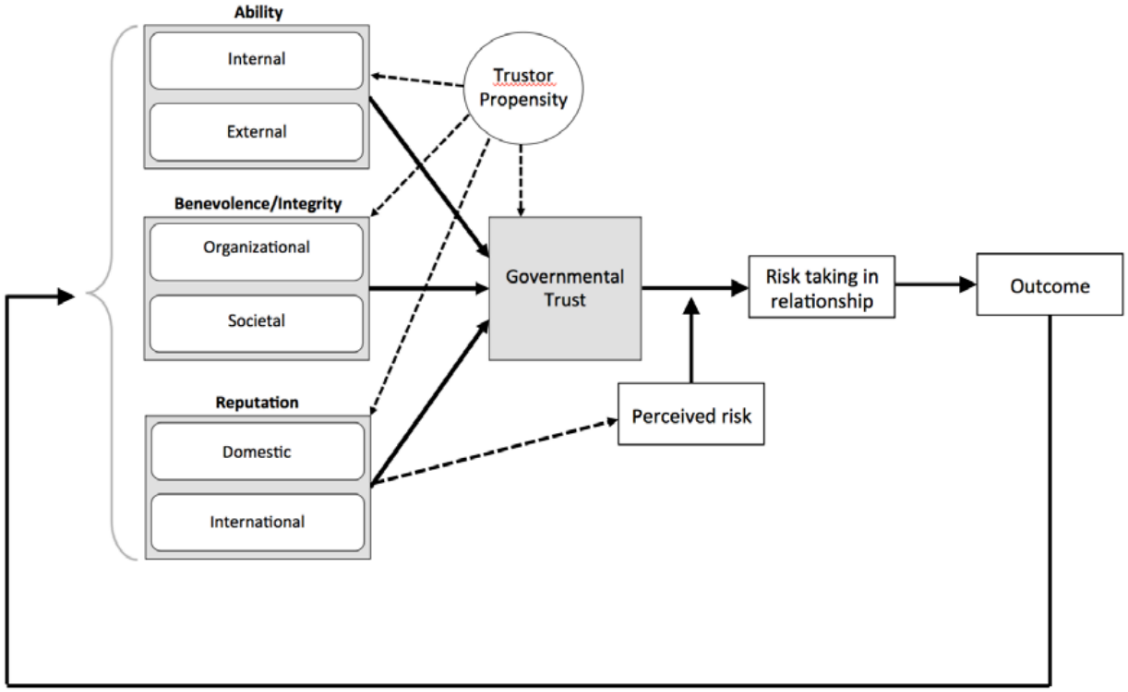

Figure 3.4: Visualization of the Integrative Model of Governmental Trust (Fricker Jr et al., 2014).

A variation on the IMOT is shown by Fricker Jr et al. (2014) in figure 3.4. It shows an example of how the model from figure 3.3 can be brought into context for a specific use case, which is here to understand trust in governments. It consists of three grouped variables, where all three have two parameters.

Comparing with 3.3, the authors combined benevolence and integrity toward one grouped variable for their use case and added an alternative, namely reputation. For the structure of their trust model, they visualized multiple parameters on the different grouped variables. For instance, it shows clearly that within the ability there has been looked at internal and external factors and their influence on governmental trust. Therefore, the structure of 3.3 will be used to bring the IMOT by Mayer et al. (1995) into context for the use case of DeFi lending on mortgages.

3.3. Mortgage lending

The third section of the literature review is on mortgage lending. First, the stakeholders and lending process will be explained after which the distribution of mortgage providers in The Netherlands will be discussed. The stakeholders and process will be used to find aspects where this system could become more efficient via DeFi technologies. The distribution of mortgage providers sketches the competitive landscape that DeFi companies must enter.

3.3.1. Mortgage lending process

To describe the process of mortgage lending, the stakeholders will first be explained (Obvion hypotheken, 2023):

- **Borrower**: The person who is seeking a mortgage loan. They provide personal and financial information to the lender.

- **Lender**: Financial institution that provides funding for the borrower's mortgage. They assess the borrower's creditworthiness and ability to repay the loan.
- **Real Estate Agent**: Helps the borrower find a house and negotiates the purchase terms.
- **Notary**: The notary prepares the documents that complete the transfer, such as the deed of transfer and mortgage deed. They also handle the financial aspects. A notary may also draft a cohabitation agreement or a will on your behalf.
- **Advisor**: Intermediary who guides the borrower through the mortgage process. The first advisory meeting is usually free and indicates the proposal. The second advisory meeting is paid where all information from the borrower is discussed in more detail, after which usually a proposal is being set up.
- **Appraiser**: The appraiser determines the value of a house. Sometimes this is already done by the Real Estate Agent.

The mortgage processes of three Dutch mortgage providers ((ING bank, 2023; Nationale Nederlanden, 2023; NHP, 2023)) are combined with a research paper (Ali and Smith, 2019) which has led to the following process in 5 steps:

1. **Orientation**: The borrower can use mortgage calculation tools that require basic financial information as input. This gives a first indication to the borrower to know what is the maximum amount they can borrow with a certain mortgage type and interest rate. This application can be done online or with a mortgage advisor. Generally, the orientation phase is non-committed by mortgage advisors.
2. **Searching for a house**: A Real Estate Agent can help to find a house that fits the financial situation of the borrower.
3. **Application for mortgage quotation**: An application for a mortgage quotation will be issued by the mortgage advisor, who is now committed to the process and thus will charge for their services. The borrower brings all relevant financial documents to the advisor to set up the quotation. The application will be sent to the lending party.
4. **Notary**: If the lender proceeds with the terms, the notary will prepare the documents and complete the house transfer.
5. **Insurance**: Often, the lending party also provides cross-sell activities like insurance which can be offered afterward or during the application process itself.

3.3.2. Mortgage providers

Next, an overview of the distribution of mortgage providers in The Netherlands will be discussed. It will be used to get an idea of the competitive landscape which can later be used to find possibilities for DeFi lending in the mortgage market from this angle.

The distribution of the Dutch residential mortgage market is monitored by the Dutch Central Bank (Dutch: DNB) (DNB, 2023). They show data since 2012 where the total amount of residential mortgages is shown and the amount of the different types of mortgage brokers. From the data of the DNB, table 3.2 is made. The different types of mortgage brokers are divided by the total amount of residential mortgages for each of the five quarters. The dates taken in this table are the start and end dates of the whole data set, with 3 dates in between that are distributed evenly.

Year	2012 Q1	2014 Q4	2017 Q3	2020 Q2	2023 Q1
Banks	64,5%	67,7%	70,6%	68,9%	69,1%
Insurers	5,0%	6,9%	7,9%	8,7%	8,4%
Investment institutions	0,3%	1,0%	3,9%	7,3%	10,1%
Other financial institutions	28,5%	23,2%	16,7%	14,1%	10,9%
Pension funds	1,7%	1,2%	0,9%	1,0%	1,4%

Table 3.2: The table shows the market share of the different segments of the residential mortgage market in The Netherlands between 2012 and 2023, mentioned per quarter (Q). Data from each quarter between 2012 and 2023 of (DNB, 2023) has been exported to Excel, where 5 evenly distributed dates were chosen for this report. From the 45 rows that were present in the Excel file, row numbers 1, 12, 23, 34, and 45 are taken. These fractions are calculated with the numbers that are shown in Appendix A.

The table shows a dominant position for banks that has slightly increased from $\approx$ 65% in 2012 to $\approx$ 70% in 2023. The insurers show an increase as well from 5% in 2012 to $\approx$ 8.5% in 2023. The investment institutions show a large increase, from almost zero percent in 2012 to 10% in 2023. The other financial institutions show a big decrease over the years. In 2012, they had a share of almost 30%, of which $\approx$ 11% is left in 2023. DNB (2023) mentions as a reason that mortgage brokers had to show securitized residential mortgages more frequently on their own balance sheet because of anti-usury regulations that caused a shift from 'Other' toward banks. Lastly, the pension funds were rather stable during the years with a market share of around 1-1.5%.

Based on this table, it is not possible to conclude about how the competition has changed because this data set does not indicate how the 'other financial institutions' segment has shifted towards the other segments due to the anti-usury regulations. However, it does demonstrate that investment institutions gained more than twice the market share compared to banks and insurers. During the interviews, experts will be asked to provide their objective evaluations of changes within the competitive landscape of mortgage lending. This will enable us to conclude this topic.

4

Design of the trust model on hybrid mortgage lending

This chapter will design the trust model for hybrid mortgage lending. This will answer the first three sub-questions mentioned in section 1.4. First, there will be a description of the three trustworthiness factors within the IMOT in the context of mortgage lending in order to describe the concepts in section 4.1. Section 4.2 then explains how the IMOT can be used to reduce the cost of trust. Section 4.3 discusses how the IMOT can be applied to TradFi mortgage lending, and finally, Section 4.4 contextualizes the IMOT for hybrid mortgage lending.

4.1. IMOT: The context of mortgage lending

As an introduction, the three trustworthiness factors within the IMOT will be described in the context of mortgage lending to describe the concepts. This will help in the remainder of the chapter to link the IMOT in the context of mortgage lending toward the cost of trust, TradFi mortgage lending, and hybrid mortgage lending.

Integrity

Boatright (2011) describe the integrity in banking by maintaining ethical practices, honesty, and transparency throughout the lending process. Boatright et. al mentions that banks have an intermediating function, which requires a high level of integrity toward their clients (Boatright, 2011). Borrowers trust that the lender will not take part in fraudulent activities, for instance, the money laundering scandals of the ING Bank between 2010-2016 (FIOD Belastingdienst, 2018). Lenders trust that the borrower will not hold back any debt or loan and will disclose all relevant financial information, for instance, students who lie about their student debt RTL (2018). This could have consequences for their National Mortgage Guarantee (NMG) when they proceed to lie about it. The NMG is insurance on the mortgage. If the borrower is not able to pay back their mortgage, the NMG will take action such that the borrower can not be forced to sell their house (Rijksoverheid, 2023a). Moreover, Thakor and Merton (2018) discusses the reputation of (non-)banks in (mortgage) lending. They mention that a track record can build trust in terms of integrity.

Ability

Thakor and Merton (2018) discusses the ability in mortgage lending which is whether the lender can execute the lending process and whether they are qualified and well-informed. This involves the creditworthiness of the lender, and its ability to determine interest rates, manage risk, and offer appropriate service. The lenders check the creditworthiness of the borrowers and the borrowers trust the lender's ability to assess their financial status correctly (Thakor and Merton, 2018). As an example, in The Netherlands, people tend to receive benefits on their mortgage with a positive credit registration (in Dutch: BKR) because they have proof they are able to pay their debts (BKR, 2024). Also, (external) mortgage advisors must be qualified in The Netherlands to be allowed to give financial advice (AFM, 2024).

Benevolence

In terms of benevolence, Harker and Horton (2022) discusses this concept, which is that borrowers trust that the lender will look after their best interests when granting loans. In the Netherlands, mortgage lenders already have a Duty of Care towards borrowers, where they are legally obliged to protect their customers who apply for a mortgage loan (Rijksoverheid, 2024). The borrower should feel that his financial well-being is being looked after and not that the lender is trying to make a profit. Lenders should offer fair terms to borrowers and not discriminate between individuals. For example, the example in the introduction (section 1.2.2) where the lack of transparency led to place-based discrimination in the Dutch mortgage market, according to Hassink and Leuvensteijn (2007) and Aalbers (2007).

4.2. IMOT: Decrease the cost of trust

This section will discuss how the three trustworthy factors of the IMOT can decrease the cost of trust as explained in section 1.2.3. It will thereby give answer on the first subquestion in section 1.4.

Integrity

On integrity, the cost of trust can be decreased by redefining trust through transparency, as mentioned in section 1.2.3. From the literature is seen that DeFi offers transparency improvements via smart contracts, NFTs, and the tokenization of real assets (section 3.1.1 and 3.1.3). Applying this to mortgages, the houses can be tokenized toward unique NFTs on the blockchain, a process called minting. The ownership of these NFTs is transparent on the blockchain, where the process of transferring ownership can be automated via smart contracts.

Ability

On the ability, the cost of trust can be decreased by automating the process of checking the creditworthiness of the borrower. Currently, lenders must perform a creditworthiness check on their own which is labor intensive and sometimes paired with (unintentional) discrimination, as seen in section 1.2. The high costs as a result of complexity and inefficiencies cause high cost of trust, while it could be possible to automate the creditworthiness process on mortgage loans. According to Malhotra et al. (2022), the Know-Your-Customer (KYC) process can be automated via blockchain. The KYC process is used to verify a customer's identity, but could also be used to

securely store financial information. Customers may have their private key to access their financial information, which could be shared with lenders. This would enable lenders to quickly see the customer's financial situation, reducing the risk of uncertainty and potentially leading to lower interest rates.

Benevolence

On benevolence, the cost of trust can be decreased by distributing the risk that lenders perceive in TradFi lending. Lending parties take a risk by trusting someone for a loan, which gets further increased by the Duty of Care they are obliged to. The tokenization of mortgages can distribute this obligation, and therefore distribute the risk toward the lending party.

To conclude, the IMOT can decrease the cost of trust by the benefits of blockchain through the transparency of the blockchain. The tokenization of mortgages via NFTs can thereby provide an increase in efficiency and distribute risk to the lender. The KYC process can also be automated to reduce costs on credit checks.

4.3. IMOT: Applying in TradFi mortgage lending

This section will discuss how the three trustworthy factors of the IMOT are applied in TradFi mortgage lending. It will also provide an answer to the second sub-question in section 1.4.

The second largest Dutch bank, De Rabobank, was taken here as an example with regard to its mortgage loan conditions (De Rabobank, 2022) and information on 'Sustainability Discounts' for building or renovating houses (De Rabobank, 2023).

Integrity

On the integrity in TradFi lending, a situation has been sketched regarding the student loan system that occurred in The Netherlands where there was debate about the integrity of both borrowers and lenders (RTL, 2018). The Dutch government requires borrowers to be transparent about their student loan debt, which the banks cannot see for themselves and must rely on the borrower's word. If the lender asks the borrower if they are in debt and they lie about it, their warranty for the NMG expires (Rijksoverheid, 2023a). However, lenders must be honest to ensure fairness when making lending decisions. Although the Dutch government suggested that student loan debt would not affect future mortgages (Brandsma and Vissers, 2018), in practice it can have an impact of up to 1.5 times the student loan (Verstegen, 2018). According to Leenders & Gielen Adviseurs (2022), banks can increase the interest rate on student loan debt up to five times. This is because banks have no obligation to the Dutch government and are solely focused on receiving justified payment for the risk they take. However, borrowers may view this as unfair as they are left to bear the consequences and pay the extra fee resulting from the failed loan system. This situation may cause students to be less forthcoming about their debt when applying for a mortgage, which could result in them being denied the National Mortgage Guarantee.

Reliability, honesty, and transparency are trust values within integrity that cannot always be kept here, sketched by this situation on the student loans in The Netherlands.

Ability

In general, this discusses the agreements made between lender and borrower concerning the ability to pay the costs and taxes on time. To reflect on the Terms and Conditions for a mortgage loan at De Rabobank (De Rabobank, 2022), Chapter 2 Section 3 shows the 'Cost of the collateral'. Here, it mentions that the borrower must ensure that all costs and taxes for the collateral will be paid on time, which thus concerns the ability of the borrower. It also consists of the ability of the borrower to pay their long-term debts, thus the income of the borrower, or 'solvency'. The situation mentioned for the integrity also affects the ability, because the borrowers do not tell the truth about their ability to pay their student debts.

Benevolence

Typically, borrowers go to the bank in-person to discuss their mortgage with financial advisors or the originating party. However, execution-only mortgages are also available for borrowers who can apply for a mortgage loan without advice (ABN Amro, 2024). Although this is cheaper, not all mortgage loan providers provide this service, for instance, De Rabobank. The main reasons given for not going for an execution-only option would be the lack of professional advice, lack of accountability because there is no Care of Duty, and the risk management could not be well managed. The execution-only option could therefore only be seen as a valid option for people with professional knowledge Kramer (2018).

A second perspective on benevolence is that the mortgage loan must actually be used for its intended purpose, which requires evidence. For example, when buying a house, it is necessary to prove that the mortgage loan has actually been used for the house and not for other purposes. This is also stated in Chapter 2, Section 3, the cost of collateral, in the terms and conditions of De Rabobank (De Rabobank, 2022). In addition, there is an aspect of ability where the borrower must ensure that he is able to pay all costs and taxes for the collateral, proof of payment is required to show that the borrower is paying the cost of the collateral. This is to prove the good faith of the borrower. The same applies if it has been agreed that part of the construction or renovation of the collateral has been paid for with the borrower's savings. The lender (De Rabobank) can demand proof that the borrower has actually used his own savings before the mortgage loan was used to pay these costs (De Rabobank, 2022). It is also possible to take out a mortgage with a sustainability discount, which requires a sustainability declaration (De Rabobank, 2023). This declaration can be requested, for example, by builders and project developers. There are standards that the houses must meet, such as a BENG 2 standard or the use of sustainable wood. A third party, the SMK Foundation, checks that the BENG 2 calculations and the wood are correct and issues a validation (SMK, 2023). Finally, De Rabobank will carry out random checks on the new projects that have received the sustainability declaration, in order to verify that the contractors and project developers are fulfilling the purpose of the loan according to what was promised (purchase of a house) and that the social/environmental improvements are perceived as benevolent actions.

4.4. IMOT: Contextualize to hybrid mortgage lending

This section will contextualize the IMOT to hybrid mortgage lending. First, three trustworthy factors of the IMOT are discussed and what aspects should be present within this hybrid model. Moreover, a fourth factor will be added to the model, under the category *Others*. After that, the trust model on hybrid mortgage lending will be designed which will provide an answer to the third subquestion mentioned in section 1.4

On each trustworthiness factor, there will be looked how the IMOT is applied in TradFi lending from section 4.3 individually, and how its cost of trust can be decreased by considering the analysis from section 4.2. The section will aim to establish coherence and discuss the various aspects that make up the three trustworthiness factors.

Integrity

On integrity, it is seen from the case of TradFi mortgage lending that three aspects are central: reliability, honesty, and transparency.

On the reliability, further automation via smart contracts could be suggested which is in line with the analysis made in section 4.2, and also underlined by Malhotra et al. (2022) and Wouda and Opdenakker (2019). The research by Malhotra et al. (2022) was on the investigation of automating the KYC process which also makes the loan process more reliable because the uncertainty of wrong estimation decreases. Wouda and Opdenakker (2019) mention the role of standardization, which can be achieved by automating processes to eliminate repetitive errors and thus improve reliability.

For the honesty aspect, the example of place-based discrimination in the Netherlands was used to outline the problem statement. Glaesser (2018) mentions for this aspect, that blockchain must be seen as part of an integrated design solution for honesty. Based on the transparency of the technology, it aims to increase the legitimacy of algorithms, restore accountability, and shape the progressive evolution of algorithms. Consequently, creating an honest, data-driven system requires time (and data).

Considering the transparency, the analysis of section 4.2 already explains how the cost of trust could be decreased according to the IMOT, where it mentions the benefits of the transparency behavior of the blockchain. This part of the blockchain could therefore be implemented in the hybrid system.

Ability

Considering the second trustworthiness factor of the IMOT, ability, two aspects are considered for the hybrid model: adaptability and solvency.

The first is the importance of adaptability in decision-making. For the reliability aspect, the benefits of standardization are discussed. Although DeFi can be seen as an optimal and most robust solution for standard situations, there are still human interventions necessary for non-standardized situations. Especially in cases where there is no relevant data required to base a decision upon, logical thinking is required by humans (Nassar and Kamal, 2021; Patel, 2023). Mortgage loan providers must be able to adapt to those situations.

The second aspect concerns solvency, as mentioned in section 4.3. The homebuyer's income and debts determine their ability to pay the mortgage costs. As discussed in section 4.2, there are process automation opportunities to reduce the cost of trust, for example in the credit assessment process, where an automated KYC process is a possible option.

Benevolence

Regarding benevolence, the model considers two aspects: humanity and validity.

In section 4.3, the aspect of humanity is described where personal advice tends to be more preferred than execution-only practices. Therefore, for the hybrid lending system, it will be proposed that the role for mortgage lenders is that they keep their advisory role. In this context, the cost of trust can here not be reduced since advice gets paired with responsibility and with Duty of Care, as explained in section 4.2.

Section 4.3 also described the second aspect of benevolence, *validity*. It explains what evidence a borrower needs to show that he has spent his mortgage on his home or essential items. This process could be automated through smart contracts, which can specify the products for which the money can be spent. Once the borrowing party meets the conditions, the lending party will receive automatic confirmation, eliminating the need for in-person checks.

Others

In order to specify the context of the trust model in relation to mortgage lending, another factor is added to this model. Zaheer et al. (1998) and Young-Ybarra and Wiersema (1999) discuss trust in transaction cost economics and both mention the importance of *predictability*. It concerns external, sometimes unexpected, events that create uncertainties for the predictability of the market, like COVID-19 or war. Although it is not an event that the lender or borrower causes, it still influences their propensity to trust the other party and therefore interpreted differently from the inter-organizational relationships. The predictability can however be increased by choosing a rate lock between 5 and 30 years that makes the interest rate unaffected for these external events (Murphy, 2022).

4.4.1. Design of the trust model on hybrid mortgage lending

This section summarizes the aspects to be considered when designing the trust model for hybrid mortgage lending and explains the rest of the model. Figure 4.1 shows the contextualized IMOT toward hybrid mortgage lending.

The aspects of *Honesty*, *Reliability*, and *Transparency* are chosen on integrity. Considering the factor of ability, the aspects of *Adaptability* and *Solvency* are taken. On the third factor, benevolence, there is chosen for *Humanity* and *Validity* as aspects. Lastly, the fourth factor that consist of other aspects it is chosen to take the *Predictability*.

The IMOT is further contextualized in relation to hybrid mortgage lending and can be explained from both the borrower's and lender's perspectives. For instance, when a borrower applies for a loan, the following example illustrates how this would be applied from their perspective.

When a borrower applies for a loan, they assess the integrity, ability, and benevolence of the lending party, as well as the predictability of the economy. The trustor's propensity is determined by how they value these trustworthiness aspects. For example, a bank may lack transparency and be dishonest, but if the borrower does not place a high value on these aspects, they will still trust the bank. The borrower's risk appetite is a measure of the borrower's perception of risk. The economic climate directly influences this perceived risk. If the lender's offer is below the risk the borrower is willing

to take, the borrower will accept the risk. This acceptance is documented in the 'Deed of Trust', which is used in real estate transactions.

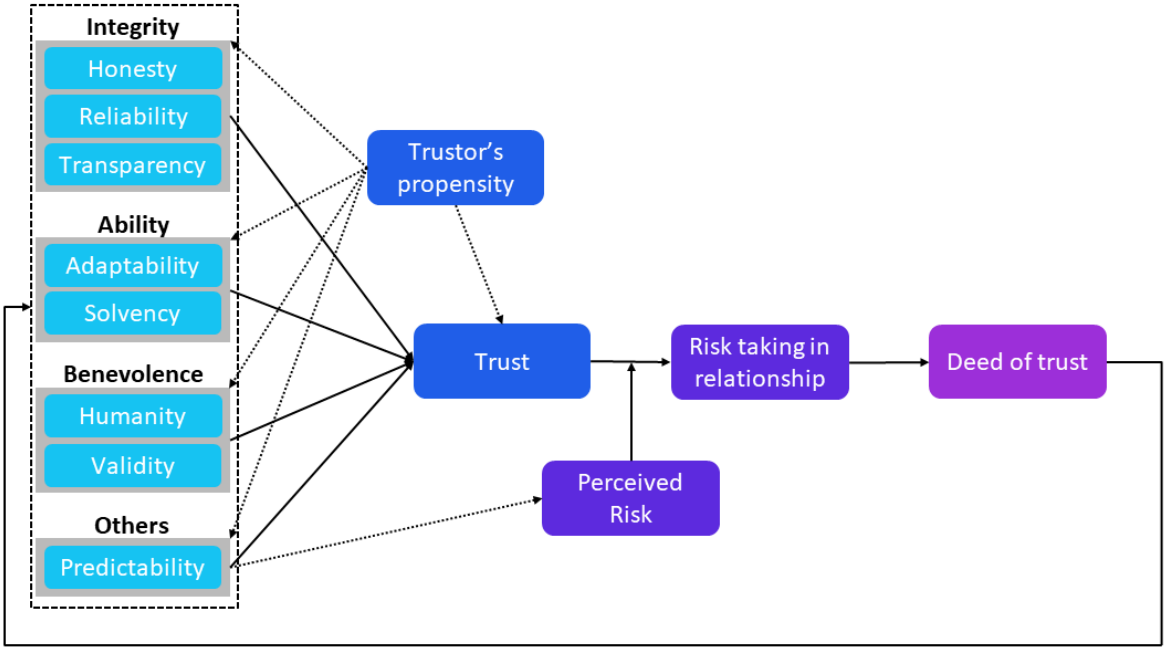

Figure 4.1: The Integrative Model of Trust in Hybrid Mortgage Lending

This model will be demonstrated to the experts as described in the research approach (section 2). The next chapters will discuss the evaluation of the experts on this trust model, whereafter it can be modified and used for the technological model.

5

Results

This chapter will describe the results of the interviews. At first, the interview process will be explained in section 5.1. After that, section 5.3 shows the interview questions and themes. Then, the different themes are discussed in sections 5.4 to 5.8.

5.1. The interview process

The interview process starts with its structure explained in section 5.2. Thereafter, the recruitment of participants is discussed in section 5.2.1. Section 5.2.2 talks about the data collection and section 5.2.3 the data management. After that, section 5.2.4 discusses the process of how the data is analyzed, and finally section 5.2.5 mentions the GDPR compliance and how this research fulfills the ethical standard of the TU Delft.

5.2. Interview structure

Before the interview, the participants were given additional information with a one-pager which is shown in Appendix B. In the invitation mail, it was mentioned that the participants could ask for the consent form (Appendix C) before the interview happened, or otherwise, it would be taken care of at the start of the interview itself.

The interview started with an introduction from the interviewer, with a question to the participants about their role and experience in the finance sector. This resulted in the demographics of the participants, which is explained in more detail in section 5.2.2. After the introduction, the research was explained with the motivation and objective for this project. Then, the trust model from section 4.4.1 was presented and demonstrated in a pseudo-environment where mortgage lending would be carried out via a hybrid system. After that, the interview questions were asked where first was asked about the demonstrated trust model, and the other questions concerned the technological model. For the interview questions, a semi-structured approach was used where it was split into two parts, a pre-determined part, and follow-up questions. For the pre-determined part, topics were used that followed from the literature review. Questions were asked on topics such as the integrity of TradFi, level of competition, integrability, and adoption. These topics are a consequence of what has been discussed in the previous chapters. The follow-up questions were based on the responses of the

participants. Summaries of the interviews are shown in Appendix D.

5.2.1. Recruitment

Section 2.2 showed that a minimum of 9 participants must be required in qualitative research to reach saturation, whereafter the desirable saturation level would be based on thematic saturation. Here, thematic saturation is reached at 11 interviews because no new themes were mentioned by the final participants whereas existing themes were only enriched with additional perspectives. The participants are divided into 3 groups (G1, G2, and G3).

- G1: Experts of the traditional finance (TradFi) sector
- G2: Consulting experts with a specialization in the finance sector
- G3: Experts of the decentralized finance (DeFi) sector

Candidates were recruited on the basis of their expertise in mortgage and/or DeFi lending. A further requirement was that they worked in the financial sector in order to have sufficient affinity and experience with the topic. The candidates were also recruited based on their different roles and amounts of experience in the finance industry. The distinction between these three groups and differences in experience was chosen to create diverse perspectives on a hybrid mortgage lending system in order to create higher validity. Experts from the DeFi sector might be progressive, as they would benefit most from a radical change and the entry of new players in the credit market. On the other hand, experts from the TradFi sector could be quite conservative, as they have the least to gain from changes in the credit market and the entry of new players. Consultancy experts view these trends from both sides, looking for opportunities or avoiding threats. In total, 30 candidates have been approached. 23 candidates were cold-emailed or approached via LinkedIn with one reminder after one or two weeks if there was no response. This resulted in four participants. The remaining seven participants were acquired via colleagues at BearingPoint and my supervisor. The recruitment and interview process occurred from July 2023 to October 2023, where the magnitude of weekly interviews depended on the response rate and availability of the participants.

5.2.2. Data collection

Nine out of eleven interviews happened online, of which eight were via Microsoft Teams and one was via Google Meet. These were video recorded by an in-built tool within the software. The other two interviews happened in person and were audio recorded. The interviews lasted approximately 45 to 60 minutes. For this research, these are personally identifiable information (PII) [name, e-mail address] and associated personally identifiable research data (PIRD) [audio, video, transcript]. The video recordings were automatically stored in a secure and private TU Delft Onedrive which is only accessible by a small set of TU Delft Employees associated with this project. The audio recordings and PII data were transferred manually. The demographic data that was achieved from the introduction of the interview is summarized in table 5.1:

Participant	Code	Years in finance	Role	Country
1	G1-1	5	Blockchain and Digital Assets specialist	Netherlands
2	G1-2	14	Market Infrastructure Expert in digital currencies	Netherlands
3	G1-3	6	Senior Valuation Specialist in Mortgage Lending	Netherlands
4	G1-4	22	CIO in Rental Housing Mortgages	Netherlands
5	G2-1	10	Senior Manager in the Banking and Capital Markets	Germany
6	G2-2	3	Consultant in the Banking and Capital Markets	Netherlands
7	G2-3	25	Partner in the Banking and Capital Markets	Netherlands
8	G2-4	20	Manager in the Banking and Capital Markets	Germany
9	G3-1	10	CEO of a DeFi lending platform	Brazil
10	G3-2	5	Consultant in Web3/Blockchain consultancy	Netherlands
11	G3-3	9	Manager in Crypto Banking Services & Blockchain technology in Financial Services	Switzerland

Table 5.1: List of the participants for this research

From the table can be seen that each participant received a code based on their group. It is also seen that the participants have different roles and experiences in the finance industry. As an example, on G2, there has been recruited for a consultant, manager, senior manager, and partner in the Banking and Capital Markets segment. It also shows that 4/11 participants were not from The Netherlands.

5.2.3. Data management

After the interviews, transcripts were made of the collected video and audio recordings in Microsoft Teams and Microsoft Word and stored on the TU Delft Onedrive. The transcripts were handled according to the 6 steps defined by Azevedo et al. (2017). The participants will be anonymized in the report to preserve their privacy and the anonymized summaries of the interviews are approved by the participants beforehand. As part of the anonymization process, the participants received codes that were used for quotations (see table 5.1). The PII and PIRD that have been collected will be removed no later than 1 month after this research study is finished. The data can be stored for up to 2 years if the TU Delft finds additional purposes with the outcome of this research, but only if the domain of research remains in the same direction.

Two summary tables were used to manage PII data. The first contained a list of approximately 30 potential candidates that were considered for this research. The second summary table was made for the eleven participants. During the interview

process, this list was used to structure the PII data and manage the steps that had to be taken. The number of participants based on the transcripts was linked to that of the thesis with participants' codes because the interviews were not done in chronological order of the thesis. To give an example, the second interviewee was part of the third group of table 5.1. For the structure of the thesis, the second interviewee became Participant 9 with the code [G3-1]. Furthermore, the summary table consisted of PII information of the participants, namely their name, email, company, country, years in finance, role, and filename for the informed consent. The date when the interview occurred was in the summary table as well, with an in-built function of +2 weeks in another column where the deadline for the summary of the interview was shown to send out to the participant, with a Yes/No column to cross these off. Lastly, a column showed the names of the recording files for each participant that were saved in the private TU Delft OneDrive.

5.2.4. Data analysis

In the beginning, all video recordings were processed toward audio recordings and saved on the TU Delft Onedrive before transcribing. Then, the interview data is analyzed according to the 4-step approach by Malterud (2012) as explained in section 2.2. First, the audio recordings were transcribed via Word with an in-built transcribe function. These were listened to and read simultaneously to modify confusing typos. Relevant quotes were highlighted in red to be used in a later stage and first thoughts to link an answer to a certain theme were added at the end of a paragraph in green with [brackets] to prevent confusion with the original text.

Based on the interview questions and answers, five themes with each two subthemes were identified. These were set up in a summary overview in Excel. Every theme was set on a different Excel tab where the codes and underlying quotes were collected for each participant in tables. Using the filter function in Excel, the codes with their underlying participant's quotes could be gathered. Per subtheme, the participants who mentioned a certain code could be taken out and further analyzed from their perspective by reading the underlying quotes. As a result, the coding tree in figure 5.1 and tables 5.3, 5.5, and 5.6 were made. The codes emerged primarily based on the quotes of the participants. For the coding tree of subtheme 2.1 (figure 5.1), the codes were already known since the design variables were already present in the Trust model of DeFi in mortgage lending on which direct feedback was gathered (figure 4.1). Therefore, the quotes could linked to these design variables. The perception of the participants has also been retrieved from the transcripts and linked to subthemes which resulted in table 5.4.

5.2.5. GDPR compliance

The following actions were taken to ensure GDPR compliance and the ethical standards of the TU Delft. Before the interviews were conducted, the participants were requested their consent by signing a form that informed them about the usage, possible risks, and storage of the interview data. The informed consent and Data Management Plan had been approved by the Human Ethics Committee (HREC) of the TU Delft. Detailed information about these procedures and the consent form are provided in Appendix C.

5.3. Interview questions and themes

The list of the questions that were used for the semi-structured interviews.

1. For how long do you work in the finance sector and what is your role? (0)
2. Do you believe that a DeFi lending system can increase trust within the financial system? (1.1)
3. How could the current trends on regulations on the Digital Euro/Identity influence the current financial system, and in specific mortgage lending? (1.2)
4. What is missing within this DeFi Lending system? (2.1)(2.2)
5. Do you think that it makes sense to design a lending system based on trust? (2.2)
6. Why would a person trust DeFi over TradFi? (2.2)(3.1)
7. What is necessary for DeFi lending services to become competitive with traditional lending services? (3.1)
8. What would become the role of financial institutions in the future? (3.2)
9. Can DeFi lending be integrated into the current financial system? (4.1)
10. What would be the impact of this/a DeFi Lending system on the current financial system for mortgage lending? (4.2)
11. Would you trust this system to close your mortgage? (5.1)
12. What would be needed for you to increase trust in a system like this? (5.1)
13. What would be the challenge for the adoption? (5.2)

The themes that emerged from the interview questions are shown in table 5.2.

Theme 0:	**Demographics of the participants**
Theme 1:	**Current problems on trust and regulatory trends**
	Subthemes:
	1.1 Level of trust within current TradFi lending systems
	1.2 Regulatory trends on current TradFi lending systems
Theme 2:	**Relevance and perception**
	Subthemes:
	2.1 Completeness of the design
	2.2 Relevance of DeFi lending systems
Theme 3:	**Competition**
	Subthemes:
	3.1 Competition between DeFi and TradFi
	3.2 Future's role for TradFi
Theme 4:	**Implementability**
	Subthemes:
	4.1 Integration of DeFi lending into current TradFi lending systems
	4.2 The impact of DeFi lending systems on current TradFi lending systems
Theme 5:	**Usefulness and adoption of this technology**
	Subthemes:
	5.1 Intention to use a DeFi lending system
	5.2 Adoption of this technology

Table 5.2: The themes and subthemes that emerged from the interview questions

At the start of this interview, a warm-up question is asked to the participants on whether they think that a DeFi lending system can increase the current TradFi lending system. On this question, eight out of eleven participants think that DeFi can increase the integrity of the current TradFi lending system. Participant [G1-2] reacted slightly positively to this question, and Participants [G1-4] and [G2-1] reacted slightly negatively to this question. The following sections will elaborate on the results of each theme by quotations and impressions of the participants.

5.4. Theme 1: Current problems and trends within TradFi

The first theme appeared when the participants were asked from a general perspective to get insight into the perception and experience of the participants toward Defi, TradFi, and the current trends.

Subtheme 1.1: Level of trust within current TradFi lending systems

This subtheme emerged on the question of whether DeFi can increase the integrity of the traditional financial system. Besides a yes or no to this closed question, the participants substantiated their answers with arguments that are discussed for this subtheme.

Participants [G1-1], [G1-3], [G2-3], [G3-2], and [G3-3] all mentioned the transparency of DeFi lending models that can positively influence the integrity of the current lending systems. Participant [G1-1] emphasizes the pseudonymized properties of DeFi lending systems that decrease discrimination. Participant [G1-3] mentioned the distrust toward the way TradFi determines their interest rates. They say that although most of the decisions are regulated by the authorities, there are still small interest gaps where TradFi companies can make their decisions based on their risk assessment models. Participant [G2-3] said for these risk assessment models that the models are integer, but the underlying data could be leading and subjective because it is primarily based on caucasian men and could therefore result in a discriminatory and gender-biased output. Furthermore, they mentioned the role of independent auditing firms that check the integrity of these transparent DeFi lending models because that strengthens its objectivity on risk assessment. Participant [G3-2] mentioned the automated, transparent fashion causes the model to behave more predictably, and less like a 'black box' as for the current TradFi systems. Participant [G3-3] emphasizes the irrational human behavior that is present in the financial markets, and that transparency, decentralization, and automation can increase the integrity by taking out human interaction.

Subtheme 1.2: Regulatory trends on the current TradFi systems

The second subtheme emerged when the current trends on regulations of the European Commission on the Digital Euro/Identity influence were discussed and how it could impact the future of mortgage lending.

Participants [G2-4] and [G3-3] emphasized the centralized aspect of the Digital Euro. Participant [G2-4] calls it a centralized tool for the European Commission to stay in control of the money circulation. Participant [G3-3] mentioned that it is still centralized because there are not many nodes in the infrastructure, but that it could create efficiency for financial markets.

Participants [G1-2] and [G1-3] mentioned the future problems for the current concept of the Digital Euro, where it will be more difficult for banks to lend out money since they can not create money with this currency. Participant [G1-2] thinks that this results in economic decline because there will be less money available within the markets. Participant [G1-3] mentioned the problems of the Digital Euro for banks, but that in general there will be improved efficiency,

> *"I think, in the beginning, it will be tougher for banks to provide credit because, if you persist in digital euros, it disappears from their balance sheet. This reduces the lending capacity for banks [...] But I believe that if the European Central Bank chooses to do so, the move towards blockchain becomes more feasible, and real innovation can happen with smart contracts and programmability. This way, transparency can be achieved, and things can genuinely improve."* [G1-3]

Participants [G1-2] and [G2-3] mentioned that the Digital Euro can bring the necessary innovation to the financial markets and that it can make systems much more transparent.

Furthermore, five out of eleven participants mentioned the slow process of regulatory trends in Europe. Especially in The Netherlands, the highly regulated mortgage market is not likely to change drastically.

5.5. Theme 2: Participant's impressions about the proposed DeFi lending system

The second theme emerged when the conceptual DeFi lending system was demonstrated and discussed. This conceptual model was in the form of the IMOT that has been brought into the context of DeFi lending for mortgages, as shown in figure 4.1.

Subtheme 2.1: Completeness of the design

The second subtheme emerged when the participants were questioned about the completeness of the design in figure 4.1. For this theme, a coding tree will be made that results from the coding process. The feedback is first divided into the right segment as shown in figure 4.1, after which these are allocated toward the right design parameter. The coding tree is shown in figure 5.1, which shows the results on where participants' feedback is distinguished in the three trustworthy factors and the factor for other design parameters.

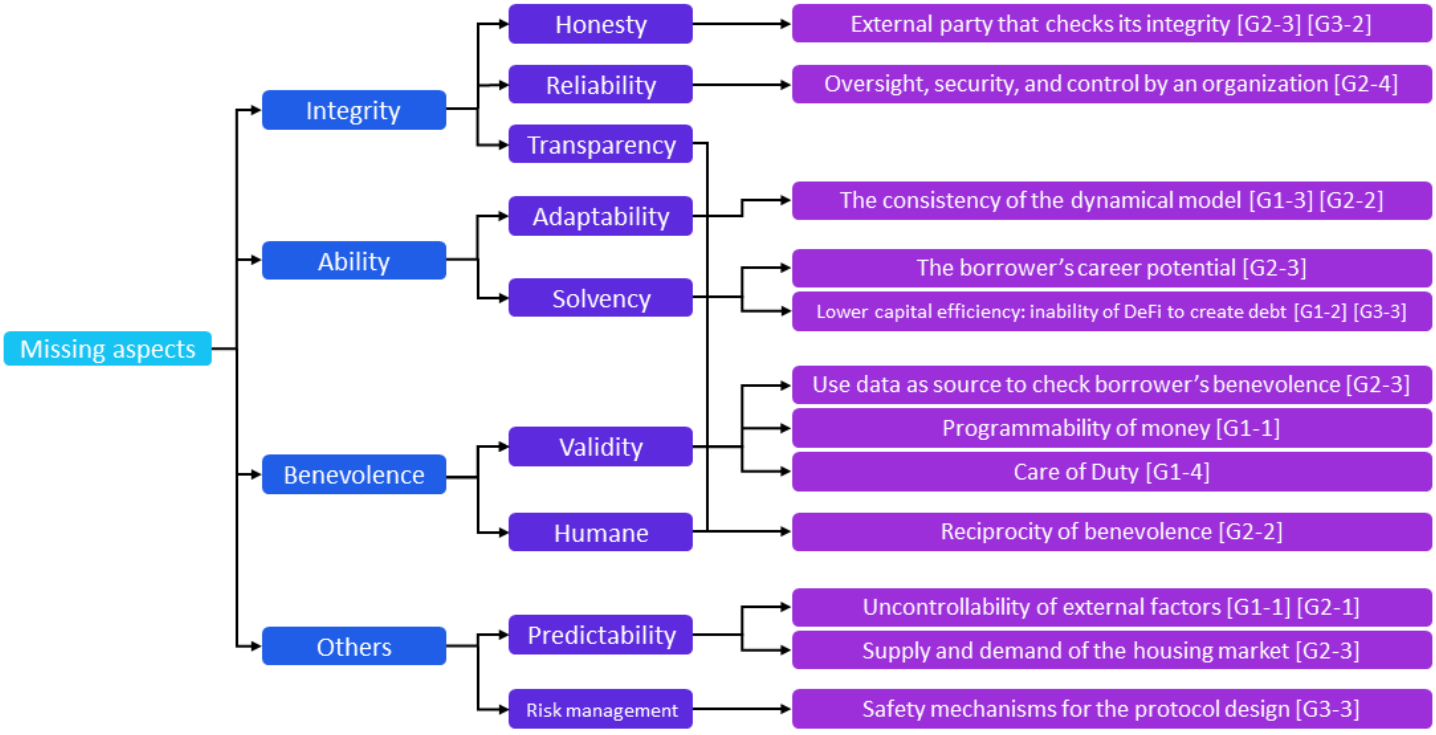

Figure 5.1: Coding tree for the completeness of the design

Participants [G2-3] and [G3-2] mentioned the necessity to have external parties check the integrity of the (open-source) protocol design. They say that crypto auditing

companies could fulfill this task, by having a similar approach as traditional auditing companies. On top of that, Participant [G3-2] proposes a system where there are incentives for anyone to find errors in the code and receive a reward for being honest in reporting these.

Considering the reliability of this DeFi lending system, Participant [G2-4] mentioned their need for oversight, security, and control by an internal organization. A Decentralized Autonomous Organization (DAO) is mentioned as an example of this as stated by this quote:

> *"Running a decentralized finance system for lending, the first question would be, is there a DAO behind who is responsible for the requirements, the rules, and the framework? Because 'decentralized' from my perspective is worldwide, there has to be some kind of organization behind who is making the rules and who is voting on this. [...] If that is only these computer programs to observe something, from my point of view it's too few, there has to be more."* [G2-4]

Participants [G1-3] and [G2-2] discuss how consistent the adaptability of the model can be, and for which mortgage lending cases it might break as a result of lack of data. They wonder to what extent the model can become a consistent dynamical model.

Participant [G2-3] mentioned taking the borrower's career potential into account as an additional source of information, they say it can help in decision-making for doubtful cases in determining someone's solvency. Participants [G1-2] and [G3-3] discuss the dilemma of capital efficiency and financial risk. Where in TradFi, debt can be created by banks which increases their capital efficiency, this is currently not possible in DeFi where a balance must be found:

> *"It's a dillema. You need close to 100% collateralization or over-collateralization. And so if you do that, it means you don't have capital efficiency. You want to be able to use that capital to make more money, it's about finding that balance."* [G3-3]

Considering the proof of benevolence, three participants gave feedback that concerned the validity of a DeFi loan. Participant [G2-3] talks about the usage of data to check the borrower's benevolence. They mentioned that for instance for an additional mortgage fund on sustainable investments for a house, the energy bills can be easily checked from which a suggestive opinion can be formed on the borrower's benevolence to prevent costly housing visits. Participant [G1-1] mentioned the programmability of money as an additional tool to automate mortgage lending much further from the validity perspective:

> *"Regarding benevolence, you could also take it further by providing proof that you are truly buying a house with your mortgage by adding the programmability of money."* [G1-1]

Participant [G1-4] discusses the Care of Duty where mortgage providers are obligated to keep toward their customers, and how this will roll out in a decentralized fashion where personal data can be pseudonymized. They mentioned the importance of the KYC process in DeFi lending.

On the humane aspect of the benevolence aspect, Participant [G2-2] mentioned the reciprocity of benevolence. They mentioned the importance that there should be transparency on whether mortgage providers are not getting the most out of someone. They say that it might be a trap that the borrower delivers too much data to the mortgage provider, causing them to get a worse deal.

For the predictability of the model, Participants [G1-1] and [G2-1] mentioned the uncontrollability of external factors which is doubted whether this can be taken into account carefully.

Participant [G3-3] mentioned a different aspect that is coded as 'risk management'. They mentioned the importance of safety mechanisms for the design of the protocol. An example they give here is the way collateralization ratios are defined.

> *"You need safety mechanisms in your protocol to create trust. [...] by defining the collateralization ratios you're considering in your protocol."* [G3-3]

Subtheme 2.2: Relevance of DeFi lending systems

This subtheme emerged when the participants were asked whether they thought it was relevant or if it made sense to have DeFi lending systems on mortgages. The focus here has been put on the social aspects to see what feelings the participants received from such a DeFi lending system and how it could benefit society.

The general view toward DeFi lending systems was quite positive. Besides the technical and regulatory challenges, the participants saw the relevance of this technology for the financial sector.

> *"Imagine, with a DeFi lending system, you can also involve more people in it. [...] This makes it more accessible, cheaper, and more profitable for everyone."* [G3-2]

Several aspects are mentioned individually, which are coded and grouped in table 5.3

Code	Participants
Cost efficiency	[G1-1] [G1-2] [G1-3] [G1-4] [G2-1] [G2-3] [G2-4] [G3-2] [G3-3]
Transparency	[G1-1] [G2-3] [G3-2]
DeFi lending pool	[G1-4] [G3-2]
KYC	[G1-4] [G3-1]

Table 5.3: Other aspects mentioned considering the relevance of DeFi lending systems

Nine out of eleven participants mentioned the cost efficiency that DeFi could bring to mortgage lending. They mentioned it could be done via smart contracts ([G1-2], [G1-3], [G2-3], [G2-4], [G3-2], and [G3-3]) which can lead to lower costs for the financial companies. Three participants mentioned transparency as a relevant factor for DeFi lending systems which can lead to less discrimination and less necessity for trust. Participant [G3-2] mentioned the relevance of DeFi lending from the perspective of DeFi lending pools. They mentioned the increased accessibility where more people can join to invest.

Participants [G1-4] and [G3-1] mentioned the relevance of the Know-Your-Customer (KYC) process for DeFi lending systems. According to Participant [G1-4], the current Know-Your-Customer process for mortgage providers is very inefficient. TradFi has to gather its own data and assess the risk based on the information it receives. Uncertainties can lead to higher interest rates because the mortgage providers have to cover themselves. Participant [G1-4] said that it could become much more efficient if a trusted party, the goverment or a third party, specializes in the KYC process and provides a validation for the mortgage loan. The result could be that it is more difficult for borrowers to lie about their (student) debts so that there is less fraud.

5.6. Theme 3: Competition of new entrants on DeFi within TradFi

The third theme became apparent when it was identified whether it is possible for new entrants can compete with the traditional finance companies by using blockchain technology.

Subtheme 3.1: Competition between DeFi and TradFi

The third subtheme emerged when the participants were asked if DeFi could already be competitive with TradFi. Table 5.4 shows the answers that the participants gave for this subtheme. It shows that four out of eleven participants replied negatively and none positively. Seven out of eleven participants replied less certain about the situation which resulted in a division of four out of eleven to be slightly positive and three out of eleven participants to be slightly negative.

Opinion	Participants
Positive	None
Slightly positive	[G1-3] [G2-2] [G2-4] [G3-1]
Slightly negative	[G1-4] [G2-3] [G3-3]
Negative	[G1-1] [G1-2] [G2-1] [G3-2]

Table 5.4: The opinions of the participants on whether DeFi could already be competitive with TradFi

The participants describe TradFi as conservative and necessary. Banks, in particular, are mentioned to have a competitive advantage because they can maintain debts, create money, and still have a lot of loyalty from their customers. They mentioned that this results in a dominating position for them.

> *"The power of the bank now is that they can create debt. In fact, you can simply create money and give it away, which provides enormous power, allowing the bank to control how every system, such as mortgages, operates as it desires."* [G1-2]

Participant [G1-4] said that this high level of regulation and their numerous activities causes limitations to remain competitive in fast-changing markets.

Participant [G3-1] said that they see shifts occurring from the investment side, where there are not only funds allocated in TradFi but also in DeFi via digital assets.

Participant [G3-3] mentioned that relatively progressive countries in Europe such as Swiss already try to become frontrunners, but are backed down because of regulations.

Subtheme 3.2: Future's role for TradFi

The third subtheme emerged when the future role of banks and other financial institutions was discussed in mortgage lending. The focus was laid on the economic perspective to see how the competition will look in the future.

In general, the participants stated that TradFi will still play a role in the future, mostly because of their reputation and track record. Customers view banks and other established financial institutions as trusted well-known parties. Furthermore, human interaction is mentioned as an important aspect that financial institutions bring, especially for mortgage lending which is considered to be someone's biggest spend of their life, together with the value of continuity instead of radical disruption.

5.7. Theme 4: Implementability of DeFi within the current TradFi systems

The fourth theme became known when the integration of DeFi lending systems into current TradFi lending systems was discussed, together with the impact that DeFi could have on TradFi lending.

Subtheme 4.1: Integration of DeFi lending into current TradFi lending systems

The fourth subtheme emerged when the participants were asked whether DeFi could be integrated into current TradFi lending systems. Eight out of eleven participants replied positively and two out of eleven negatively.

Participants [G2-1] and [G3-3] replied negatively, where Participant [G2-1] mentioned the strong need for additional security before being integrated to lend out money and its form of collateral. Participant [G3-3] mentioned the problem of regulation, which does not allow the integration of DeFi within TradFi.

Participant [G2-4] replied with a different opinion than the other participants. They said that DeFi should not be integrated into TradFi, but that DeFi should replace TradFi and that we are now in a transformation phase. Participants [G2-3] and [G3-3] also believe in a replacement of TradFi by DeFi, but that it starts with a transition phase where two systems will live in parallel.

Concerning the integration, Participant [G2-2] said that they can look at how Fintech entered the mortgage market which could be useful to DeFi companies. Four out of eleven participants mentioned that the next step would be to slowly integrate DeFi components within the TradFi infrastructure.

Subtheme 4.2: The impact of DeFi lending systems on current TradFi lending systems

The fourth subtheme emerged when the impact of DeFi lending systems on the current TradFi system was discussed from a hypothetical view. Also, there is asked what

would be necessary to reach that state from a technological perspective.

The general opinion of the participants is that they think that it is inevitable for this technology to be rolled out into the current financial system. The participants think it will be done in incremental steps and that will be more of an evolution, than a revolution. Some participants called the implementation rate a 'slow revolution', implying that over 50 years it will look like a revolution, but the results we see now year by year are marginal to be called revolutionary. All these expressions fall under the same umbrella of a slow integration of DeFi aspects into the TradFi system.

On top of that, the participants named several factors where DeFi lending systems would have an impact on the current TradFi system, and the most relevant ones are listed below:

Code	Participants
Ecosystem	[G1-1] [G1-3] [G2-1] [G3-2] [G3-3]
Tokenization	[G1-1] [G1-2] [G1-3] [G1-4] [G3-2] [G3-3]
Notary	[G1-1] [G1-3] [G1-4]

Table 5.5: Other aspects mentioned considering the impact of DeFi lending systems on the current TradFi systems

Five out of eleven participants mentioned that they think the impact of DeFi on the TradFi lending system will cause the formation of ecosystems.

> *"Banks could potentially participate in a DeFi market as well. They're on the money side, so they could become part of the system. Probably not on the steering wheel, but maybe they are with people who have money to lend it out."* [G2-1]

Participant [G2-3] mentioned the originator role for banks and continued on the possibilities where they can operate between borrowers and retail investors in the form of lending pools. They say that within such an ecosystem, banks don't take the risk but the retail investors do. Banks could make different types of products depending on the risk appetite of the retail investors, to make sure that it could fit any risk appetite of a retail investor. Participant [G3-3] also mentioned the occurrence of ecosystems and said that there are two parallel ecosystems to merge progressively where in the end everything will be tokenized.

Six out of eleven participants discussed the role of tokenization in DeFi lending. The general opinion is positive, where attention has been put to the range of possibilities that this technique could bring.

Participant [G1-4] believes in a tokenized infrastructure which could open up new possibilities on the business model for mortgage lending. Participant [G3-3] also thinks that a business model on DeFi can become competitive and disruptive, where it will generate revenue for the protocol. The protocol can then be issued by the bank on which they generate revenue for themselves.

> *"The token holders get the yield from their staked tokens and on the other side, you have the assets that generate higher yields because you take a spread on the difference. That's how the protocol will generate revenue."* [G3-3]

Participants [G1-1], [G1-3], and [G1-4] discuss the role of the notary which could be partly automized via smart contracts. Participants [G1-1] and [G1-4] are cautious about full automation because it could conflict with the land registry that is being done in old systems. These could imply special cases where automation might be redundant or even impossible. Still, they are convinced that many standardized tasks are left where smart contracts could automate these.

5.8. Theme 5: Usefulness and adoption of this technology

The final theme emerged when there was asked about the participant's view on using a DeFi lending system, and how they think this is viewed from a general perspective. It also contains challenges to overcome in adopting this technology.

Subtheme 5.1: Intention to use a DeFi lending system

The last subtheme emerged when the participants were asked about their intention to use a DeFi lending system to apply for a mortgage loan.

Participant [G3-1] replied positively and mentioned the strong growing trend in Brazil for DeFi lending protocols, which also occurs already in mortgage lending. Participants [G2-1] and [G3-2] replied negatively, where Participant [G2-1] mentioned their strong concerns about the security and current legal framework on not meeting the obligations of both parties. Participant [G3-2] mentioned they rather have an intermediary party which makes it easier to have contact with rather than a decentralized concept to which is unclear who you are talking.

The remaining 8 participants replied tentatively. Most of them, five out of eight, were slightly positive and mentioned as the most important condition that they want some evidence or track record that it works.

> *"First I want to see that it works."* [G2-2]

Three out of eight participants replied slightly negatively. Participants [G1-1] and [G1-3] mentioned the legal framework that would not make it possible to use a DeFi lending system for your mortgage. Participant [G1-4] explains that there have already been a lot of new entrants in the mortgage market, so the problem does not lie on the user side. They mentioned that the investment side shows the largest problem, showing where the money is coming from.

Subtheme 5.2: Adoption of this technology

The fifth and last subtheme emerged when the participants were asked about the biggest challenges for the adoption of DeFi lending systems, and what is necessary to increase trust in these lending systems.

The general opinion of the participants is that it is important to have a good reputation and track record to provide mortgages via Defi loans, which simply takes time. Time and attention must be invested in carefully implementing this technology into the finance system.

Participants [G1-3], [G2-2], [G3-1], and [G3-2] mentioned the importance of easy and better products because a good user experience is highly valued by these partic-

ipants. According to Participant [G1-3], it should go in small changes because customers do not want to adapt to completely different products than they are used to.

Participants [G1-2], [G1-3], [G3-1], and [G3-2] say that the customers don't have to understand the technology itself. The technology can be implemented at the back end so that the user does not see any differences. The current financial processes are also too complicated for the regular user, so they do not care if the back-end processes change as well, according to Participants [G1-3] and [G3-1]. The user interface must remain as easy as possible.

Furthermore, there were specific factors mentioned on what was necessary to increase trust and the challenges for adoption. These are shown in table 5.6.

Code	Participants
Collateralization	[G2-1] [G3-2] [G3-3]
Education	[G2-2] [G2-4] [G3-3]
Low-hanging fruit	[G1-1] [G1-2] [G1-3] [G1-4] [G2-1] [G2-2] [G2-3] [G3-2]

Table 5.6: Other aspects mentioned considering the adoption of DeFi lending systems

Considering the collateralization, they mentioned problems to be solved there. They said for the current situation, a full- or overcollateralized loan can be considered trustless because it gives no risk for the lending party, but it is not capital efficient. There should be a better way to generate revenue and still gain enough trust from the lenders to be willing to lend their money to a DeFi lending system. Participant [G2-1] also had doubts about the way money is collateralized and puts emphasis on additional security for the people who lend out money to lower their risks. Participant [G3-2] discusses an alternative method of investigating the possibility of under-collateralizing. They said that it might be possible to set up lending pools for different risk profiles. Every lending pool can have its own risk/interest ratio where retail investors can participate based on their risk appetite. Finally, Participant [G3-3] mentioned the role of algorithmic stablecoins, which were bad desgined because there was no collateral behind it.

> *"There were algorithmic stablecoins, so they were not well designed because there was no collateral, there was nothing behind it. So, it was just thin air."* [G3-3]

Eight out of eleven participants mentioned starting with easier products rather than one of the highest regulated products, which are mortgages.

> *"A more realistic step would be to start with the low-hanging fruit, to see how it works there before implementing it across all processes."* [G1-1]

According to these participants, it would be better to start with products that require less trust and contain less regulation. They think it is easier to innovate with less dependency on rules and trust. For mortgage lending, it is presumable to first have a track record to see that the technology works as it should.

6

Evaluation of the results

This chapter will discuss the results from chapter 5 and link these with the relevant literature from chapter 3. The same order for themes and subthemes will be followed as for the results section. Section 6.2.1 provides an answer on the fourth subquestion provided in 1.4 that is on the evaluation of the trust model by the experts.

6.1. Evaluation of theme 1

The interview started with a warm-up question where eight out of eleven participants thought that DeFi lending systems could increase the integrity of the current TradFi lending system. This will be elaborated on in the first subtheme.

The second subtheme will mainly discuss the Digital Euro because this turned out to be an important aspect of the outroll of DeFi lending for several reasons technological, economic, social, and regulatory aspects. It also elaborates on the slow processes of (European) regulation, geographical differences, and the potential emerge of digital infrastructures with interoperability in between.

6.1.1. Subtheme 1.1

For the first subtheme, five out of eleven participants mentioned the importance of the transparency of DeFi lending models that can positive effect the integrity of the mortgage lending system. The participants mention different reasons why it can increase transparency, for instance on risk assessment methodologies on the lending side and providing true data from the borrower's side. They mention that currently, there are uncertainties present within these risk assessment models that are partially caused by transparency, leading to higher risks for the lender, higher costs, and thus higher interest rates for the borrower. Increasing the transparency could therefore lead to lower interest costs for the borrower.

6.1.2. Subtheme 1.2

For the second subtheme, the Digital Euro was discussed. There is a lot of uncertainty about how the ECB is going to roll out the CBDC, the participants mention that the current form could heavily affect European banks because it makes it impossible for them to print money. This is confirmed by the report of the EDPS in March 2023 that

mentions that the CBDC is 'of superior quality than other form of money created by commercial banks because it does not depend on the solvency of the private issuer' (European Data Protection Supervisor, 2023). It follows the proposal in 2020 of Ulrich Bindseil, a Director at the European Central Bank, where he proposed to 'reduce moral hazard of banks by downscaling the role of the banking system in money creation' (Bindseil, 2020).

However, it remains unclear whether the ECB is going to build its own blockchain protocol or will use an existing decentralized protocol. According to Participant [G3-3], it is most likely that the ECB will make its own blockchain protocol, which is meant as not the most efficient solution. Bouchaud et al. (2020) from ConsenSys, a blockchain software company, agrees and mentions the benefits that Ethereum could bring as a top-layer solution for the outroll of the CBDC. Still, the latest report of the ECB in October 2023 shows that they will be investigating building its own blockchain protocol, which thus could be for now considered as the most likely scenario (European Central Bank, 2023). Another argument for not wanting to choose Ethereum as a top-layer solution is the governance risk as explained in the section 3.1.5 of the literature. Decentralized blockchains are dependent on community votes for changes in the protocol. For a Central Bank Currency, it is risky to not have full control over the decisions of your own currency because theoretically, owning 51% of Ethereum gives power to that party to have full authority on the future of Ethereum and the projects running on this blockchain.

To conclude on the digital euro, apart from the fact that there are still uncertainties about the future rollout, it can be assumed that commercial banks will no longer be able to create money and that the CBDC will be built on a blockchain protocol constructed by the ECB.

Then, five out of eleven participants mentioned the slow process of regulatory trends in Europe. Especially in The Netherlands, the highly regulated mortgage market is considered to have a lot of continuity where old systems are still used.

6.2. Evaluation of theme 2

The first subtheme merged for direct feedback on the Integrative Model of Trust in DeFi for mortgage lending from figure 4.1. It discusses the feedback from all participants on several topics, where it follows the structure of the topics from figure 4.1.

The second part discusses the perception of the participants on the relevance of DeFi lending systems. Here, the topics of cost efficiency, transparency, DeFi lending pools, and the KYC process are discussed.

6.2.1. Subtheme 2.1

For the first subtheme, the feedback of the participants for every design variable was shown in figure 5.1. This section will discuss all quotes by the participants which will decide whether to adapt the trust model for it.

Integrity

On the first trustworthy factor, there were three design variables in the model: Honesty, Reliability, and Transparency.

Honesty Participants [G2-3] and [G3-2] mentioned the need for an external party to check the algorithm and protocol design on its integrity and errors, or smart contract and oracle risks as mentioned in the literature section 3.1.5. On top of that, Participant [G3-2] proposed a system of rewarding private individuals for reporting bugs and errors because it is an open-source system.

According to European Data Protection Supervisor (2023), the vulnerabilities of open-source protocols gives security risks. For this, they point out that the growth of crypto auditing companies would encourage adoption and reduce risks in DeFi (Roukny, 2022). These security risks were also the main concern of Participant [G2-1], who mentioned the strong need for additional security to protect the lending party before DeFi can be integrated into TradFi, which can be referred to as the counterparty risk as mentioned in literature section 3.1.5.

It can be said that putting more emphasis on improving security is more of a need rather than a desire. Current TradFi companies are also obligated to be subjected to auditors, thus for DeFi companies there should also be the same regulatory framework. Crypto audit regulation could be a tool to set clear rules for a secure roll-out of blockchain technology. Last February, a US watchdog also mentioned the lack of jurisdiction of crypto audit regulation because most activities are still unregulated, emphasizing that proper regulation is necessary (Maurer, 2023). Participants [G3-1] and [G3-3] also underline the importance of regulation because it currently prevents the integration of DeFi within TradFi. They mention that regulatory bodies must become progressive toward DeFi lending because otherwise, Europe will fall behind Asia and Brazil on these trends.

To summarize, the design variable of honesty should incorporate the inclusion of *crypto auditing companies*, possibly via regulation.

Reliability Participant [G2-4] mentioned their need for oversight, security, and control by an internal organization, like a DAO. From the literature can be seen that for a typical DeFi architecture, the DAO is present in the fifth layer of the DeFi 'Stack' as mentioned in section 3.1.4, which is the Aggregation or Governance Layer. The DAO gives community-driven decision-making and protocol governance through asset and yield management. In section 1.3.1, Martins and Demertzis (2023) also mentioned that DAOs can improve the accountability of blockchains where they link the interest and incentives of its community members with the goals of the DAO.

Transparency On the transparency, the reciprocity of benevolence is linked which was mentioned by Participant [G2-2] for the humanity aspect of this model. It contained that there should be transparency on whether mortgage providers are not making too much profit out of someone. This point has also been made by Participant [G1-2] who mentioned that people generally try to find a way to earn more money which could result in unjustified behaviour. In TradFi lending, regulations state how much a person can borrow and which interest percentage it has to protect the borrower, according to Participants [G1-3] and [G1-4]. There are some tolerances here, but most of the cases are already clear.

Ability

On the second trustworthy factor, there were two design variables in the model: Adaptability and Solvency.

Adaptability Participants [G1-3] and [G2-2] had concerns about the consistency of the adaptability of the model and to what extent it could perform autonomously in a dynamic way.

It is indeed debatable whether a DeFi lending model could perform fully autonomously, especially because there is an uncontrollability of external factors, as mentioned by Participants [G1-1] and [G2-1] in section 6.5.1. That is why the trust model was initially proposed to solely automate the 'standard' use cases in which enough data is available to be objective. Participants [G1-3] and [G1-4] mentioned that this is indeed possible, and actually is already being done right now. In section 5.4, Participant [G1-4] said that 90% of mortgages have already been automated via computer programs. This process can be replaced by smart contracts.

Solvency On the solvency, there were two feedback points to be discussed. At first, Participant [G2-3] mentioned the borrower's career potential which has already been noted in section 6.1.1.

Taking someone's career potential into account for mortgage lending can give valid estimated guesses in doubtful cases. Still, Participant [G2-3] also said, that it should not be a decision parameter, but an indication. Suppose a mortgage tends to be quite risky at the moment for the borrower, but its sector and level of education have a track record of good performance. In that case, there is a high possibility that the borrower will be able to pay its mortgage payments. As said in section 6.1.1, junior employees do not take these risks since they do not want to take unnecessary risks for themselves, therefore, the model itself should involve the career potential of borrowers.

The second point that has been mentioned is the inability to create debt within a DeFi lending system. In the literature section 3.1.5, this is referred to as the counterparty risk that is present in DeFi lending, that for under-collateralizing loans the creation of debt can lead to solvency risks. Participants [G1-2] and [G3-3] emphasized the problems that could face for DeFi lending if you need full- or over-collateralization to provide a mortgage to minimize the risks of the lenders. This lowers the capital efficiency, implying that less money can be lent out, resulting in less revenue from interest. Also, the 'money-creating' characteristic from banks results in higher circulation of money which results in economic growth, as stated by Participant [G1-3]. However, the status quo of the Digital Euro implies that banks cannot create money in the future anymore, which seeks alternatives to explore (European Data Protection Supervisor, 2023). Still, the participants have a valid reason to say that the collateralization of digital assets results in lower capital efficiencies which might ask for an alternative approach. In section 6.5.2, there will be put more attention on the collateralization of digital assets.

Benevolence

On the third trustworthy factor, there were two design variables in the model: Validity and Humanity.

Validity Participant [G2-3] proposed to use the financial data of borrowers to check their benevolence. The participant mentioned an example of an additional mortgage to make a house more sustainable. For this, the energy bills can be checked to see if these decrease for the long term.

It is debatable whether such assumptions should be made on financial data because there is an information asymmetry. It could happen that although the borrower did use the additional mortgage to make their house more sustainable, they also bought electronics or an electric vehicle that consumes a lot of energy.

Of course, tracking this data is a simple tool to have a first estimated guess on whether the borrower does show benevolent behavior, but it cannot considered to be 'proof of benevolence'. It could be said that it could optimize the sample selection for the company to check the implementations of their mortgage investments in their houses, which might raise the question of whether this would lead to discriminatory behavior. An argument for that would be made that because your energy bills are not decreasing, you tend to have a higher chance of being a fraudster which is indeed a leading argument.

However, having constant energy bills while your house is more sustainable is not logical and thus is a valid reason to have a better incentive to check their house. To prevent discriminatory behavior here, this method should just be used to have a better incentive/higher chance to check the implementation of someone's investments in their houses before conclusions are drawn. In the end, it is not illegal to check someone's house to see if they show benevolent behavior, but as a company, you want to do this as little as possible because it is labor intensive. Ideally, these tasks are automated and data-driven.

Second, the programmability of money was proposed by Participant [G1-1]. They mentioned that via smart contracts the fund for the mortgage lending can be programmed such that it can be primarily used for the house (and notary costs, furniture, etc.). From a technical perspective, it sounds intriguing because it could increase efficiency by reducing manual actions. However, from an ethical perspective, it might sound scary that money can be programmed such that it is only possible to spend it for a certain good.

Elsden et al. (2019) presented in 2019 a paper on a qualitative study of the integration of a mobile banking app where the development of programmable money on automation has been taken into account. They mentioned the efficiency benefits of programmed money to be used for mutual insurance or localized collective agreements but were also cautious about how this automation could potentially be used for control where the user loses their autonomy.

There are good use cases for this technology, for instance on mortgage lending or donating to charity - cases where you want to trust that it will be indeed used for a good cause. It is however also possible to control people with obesity not to buy fast food or alcoholics with alcohol. Elsden et al. (2019) mentioned the combination of credit-scoring and payment monitoring to gain full control over someone's spending, especially when all money is digitized like for the Digital Euro.

To conclude, it would be better, for now, to not include the programmability of money as technology to automate the mortgage lending process. Good incentives

and regulatory frameworks must become clear to minimize the threats where authorities can gain full control of the users.

Thirdly, Participant [G1-4] mentioned the importance of the Care of Duty that mortgage providers have toward their borrowers. They mentioned the difficulties that could arise when a mortgage is performed in a decentralized fashion with pseudonymized and/or anonymized data.

According to Dutch law, the Financial Services Act, (Article 51 wft) (Rijksoverheid, 2007) and the Financial Supervision Act (Article 4:34 wft) (Rijksoverheid, 2023b) state that lenders should prevent over-crediting of borrowers. For this, the lenders must judge the financial situation of the borrower before a loan is offered.

These Acts embody the Care of Duty for crediting, on which could be argued how this will take form in a decentralized approach with distributed ownership. Currently, people deposit money in their banks which are used by banks to provide credit. If this system changes with a Digital Euro, it could result in alternative forms of credit lending where retail investors might share ownership over mortgages. However, according to Participant [G1-4], this is currently not possible because every credit provider must be licensed for this at the Netherlands Authority for the Financial Markets (Dutch: AFM). If they are licensed, the party that provides credit bears the Care of Duty. This would imply that this group will have a distributed Care of Duty.

To conclude, the Duty of Care should be taken into account, and considering the technological model, its limitations will be discussed.

Humanity On the humanity aspect, Participant [G2-2] mentioned the reciprocity of benevolence which has already been discussed in the transparency parameter above. However, important to distinguish now is the difference between reciprocity of benevolence and the Care of Duty. For the Care of Duty, it says that the borrower should not be over-credited, but that does not mean that their mortgage costs and annual interest rates are bound. The latter affects the reciprocity of benevolence, where you want as a borrower to be assured that the lender handles fair prices on the interest and closing the mortgage.

Others

On the last factor that contains the remaining design variables, two have been identified for the model: Predictability and Risk management.

Predictability On the predictability of the model, Participants [G1-1] and [G2-1] mentioned the uncontrollability of external factors, and Participant [G2-3] mentioned the supply and demand of the housing market. The supply and demand of the housing market can be seen as a result of the uncontrollability of external factors because it is something that is determined by governmental decisions, Covid-19, and external events such as the current wars. Therefore, it can be grouped within the uncontrollability of external factors.

Risk management This factor was mentioned by Participant [G3-3] who mentioned the importance of safety mechanisms for the protocol design. This factor can be seen

as a way to tackle the uncontrollability of external factors which is mentioned above because it includes managing external risks by applying safety mechanisms. However, 'risk management' is not a design variable, but more a mechanism to cope with other design variables. Every design variable contains internal and/or external risks on which a safety mechanism should describe how to manage that. Therefore, 'risk management' will not be a parameter for the trust design, but will be worked out within every design variable for the trust model and technological model.

6.2.2. Subtheme 2.2

The general view of participants toward DeFi lending systems was positive and the Participants mentioned how DeFi lending could bring a positive impact on transparency and (cost) efficiency.

To underline their arguments, they mentioned several topics of which the most relevant are discussed.

First, nine out of the eleven participants mentioned that DeFi lending systems could bring cost efficiencies to the financial markets. Six of them also mentioned the role of smart contracts here. Section 3.1.1 of the literature underlines the cost efficiencies that DeFi lending can bring where smart contracts are the core of this technology.

Second, three participants mentioned, again, transparency as relevant for DeFi lending systems. It is in line with what has been mentioned in the first discussion topic in section 6.1.1. The recurrent theme of transparency underlines the importance of this design variable for the trust model and in a broader sense the objective of this research.

Participants [G1-4] and [G3-2] mentioned DeFi lending pools to be relevant within DeFi lending that could replace the TradFi lending system. In section 6.1.2, the assumption was made for the technological model that commercial banks will become unable to create money because of the Digital Euro. This implies that an alternative business model should be found within the DeFi space. This alternative could be for DeFi lending pools.

From the literature in section 3.1.4, the working principle of DeFi lending pools is explained. There is explained how it can decrease the risk for lenders, the incentives for retail investors to provide credit, and for borrowers to take a loan. Participant [G3-2] mentioned the possibility of applying segmentation in risk appetite via junior and senior tokens, which can extrapolate this concept further. Within this context, it can lower the risks for banks because they do not have to fulfill the role of investor, but as an originator.

Lastly, the KYC process is mentioned by Participants [G1-4] and [G3-1]. The current process is considered to be very inefficient because every company has to verify this on its own. According to Participant [G1-4], it can be optimized by involving a third party to perform the KYC process such that TradFi companies can solely focus on their core businesses. The necessity of focusing on core businesses has also been underlined by Participant [G2-3] in section 5.6, where he said that banks have 3 core functions advice, funding, and risk assessment. The KYC process is not involved there as well.

The optimization of the KYC process via DLT has also been mentioned by (Parra Moyano and Ross, 2017). They said that it could reduce cost of trust, increase trans-

parency, and improve the borrower's experience. To add to that, Pauwels et al. (2022) published a paper that proposes a zero-knowledge KYC approach (zkKYC). This approach requires no personally identifiable information such that it can be considered as a solution for the trade-off in KYC on regulatory transparency against user privacy.

Altogether, it can be said that the KYC process could be done by a third party for the DeFi lending model. It can reduce cost of trust, increase transparency, and thereby improve the borrower's experience. For TradFi companies, it does not belong to their core competencies, which increases their efficiencies when each company does not have to do a KYC process on their own.

6.3. Evaluation of theme 3

This first part will discuss whether DeFi could already be competitive with Tradfi and elaborate more on the market position of banks in the mortgage lending sector.

The second part discusses the future of TradFi and which type of company they think would lead the innovation within mortgage lending.

6.3.1. Subtheme 3.1

For the first subtheme, it was asked whether DeFi could already be competitive with TradFi. The general impression was negative, of which most of the participants, seven out of eleven, were doubtful. Reasons to be negative were the strong competitive advantage of banks because their role is very centered in our society. Banks have the loyalty of their borrowers. The financial market, and especially mortgage lending, is considered to be a highly regulated market that strongly depends on reputation and a strong track record. These fit the parameter of benevolence for the trust model. Overall, TradFi, and mainly banks, are in a dominating position on mortgage lending.

The literature confirms this in section 3.3.2. Here, the data from the Dutch Central Bank was discussed where turned out that as of today, 70% of the mortgages are credited via banks. However, it also showed that new mortgage brokers are entering the mortgage market via insurers and investment institutions but the data set could not confirm whether this was because of the anti-usury regulations or because of shifts within the competitive landscape.

It can thus be said that however the banks are still dominating which is fueled by loyalty and a strong reputation, more competition has come during the past years where new mortgage brokers are differentiating themselves with an improved borrower's experience. This is a trend that could be continued in the future.

6.3.2. Subtheme 3.2

For the second subtheme, the audience was asked how they see the future's role for TradFi, and in particular banks concerning mortgage lending and their other activities. This question was meant to get an overview of future trends within the competitive landscape and where there are opportunities for DeFi lending.

The general opinion was that TradFi, and in particular banks, will still play a role in the future. This is primarily driven by their reputation and track record, which can be linked to the benevolence aspect of the Trust Model. The Participant mentioned that borrowers highly value human interaction in the form of a mortgage advisor, implying

that not all processes can be automated. Participant [G1-3] mentioned that there are automated mortgage advisory options like 'execution-only', but Participants [G1-1], [G1-2], and [G1-4] contradict this argument because they mentioned that this is still a small fraction of all provided mortgages because borrowers want to have that personal interaction.

6.4. Evaluation of theme 4

The first subtheme discusses the integration possibilities of DeFi lending within TradFi lending, whereas the second part sheds light on the impact of Defi lending systems on the current TradFi lending systems. Here, it discusses the role of ecosystems, tokenization, and the notary for mortgage lending.

6.4.1. Subtheme 4.1

For the first subtheme, eight out of eleven participants replied positively on whether they thought DeFi lending could already be integrated into the TradFi lending system. Participant [G2-4] even mentioned that it should replace it, rather than being integrated.

Four out of eleven participants also mentioned that the integration should happen at a slow pace and start with easier products that require less trust. This is in line with the results as discussed in section 6.3.2, where Fintech companies should not enter all financial markets at once, but start with the products that require less trust. The two participants who replied negatively mentioned technical and regulatory blockades to overcome before integration is feasible. These are also in line with previous and coming discussion topics. The regulatory blockades have already been discussed in section 6.1.2. The technical blockades will be discussed in section 6.5.2.

To conclude, it can be said that the technical and regulatory blockades result in the infeasibility of integrating DeFi lending within TradFi lending. However, some components within DeFi lending could already be integrated as of today. For example, on smart contracts to optimize processes and the KYC process, as mentioned in section 6.2.2.

6.4.2. Subtheme 4.2

The participants were asked about the impact of DeFi lending systems on the current TradFi systems. In general, their reactions were that this technology was inevitable for the finance industry, which strengthened its relevance. They think that it will be an evolutionary progress in incremental steps. A lot of processes are being done in really old systems, as said by Participant [G1-3]. Over a long time, the impact will look like a revolution because it is such a disruptive innovation.

The tokenization of real assets into the digital world has been thoroughly treated by the participants. Six out of the eleven participants mentioned it of which some got into technical details. Remarkably, everyone from TradFi, and two out of the three DeFi participants mentioned tokenization and none of the consultancies.

The participants mentioned its cost efficiencies and liquefication of the markets to increase accessibility. The increased accessibility as mentioned by the participants was also a design objective in section 1.3.5. This can thus be obtained by for instance

tokenization of assets. An increase in the liquefication of the markets, thus higher trading volumes, is also convenient for decentralized exchanges that run via Automated Market Makers (AMMs).

An increased accessibility also results in more liquid markets which is most convenient for decentralized exchanges that work with Automated Market Makers (AMMs). This is an important factor in preventing the risk of illiquid markets as explained in the literature, section 3.1.5.

Participant [G3-3] went into potential business models on how tokenized assets could create yield from new business perspectives. They mentioned how the protocol could generate revenue by taking a spread on the difference between the bid and ask prices. Participant [G1-4] said that it was important to have a certain level of trust because the token infrastructure had to prove itself where the biggest hurdle lies in regulations.

Participants [G1-1], [G1-3], and [G1-4] discussed the future role of the notary of which became clear that some tasks could be automated via smart contracts. Some tasks still remain necessary because it could not be beneficial to automate the very old systems of land registry.

To conclude, it can be said that DeFi lending will have a big impact on the TradFi lending system. It is inevitable for the disruptive innovation of the finance industry which will be rolled out carefully in incremental steps toward new ecosystems. It is a time-consuming and resource-intensive process where the tokenization of real assets could contribute to these new ecosystems. The role of the notary could be partially automated as well.

6.5. Evaluation of theme 5

For the final theme, there will first be discussed to the participant's intention to use a DeFi lending system itself to apply for a mortgage loan, or what is necessary for that.

After that, the adoption of DeFi lending systems will be discussed. The main factors that are mentioned and thus will be discussed are: collateralization, education, generation gap, and low-hanging fruit. There will also be discussed who should take the lead in fostering the adoption. From this, the participants mentioned Fintech companies, frontrunners from TradFi, and the government.

6.5.1. Subtheme 5.1

The participants had divided responses when they were asked about their intention to use a DeFi lending system for their own mortgage.

Participant [G3-1] replied very positively and took as an example its own business, which could therefore be considered quite biased. The other participants replied more reservedly to wait and see how this technology would be rolled out. They mainly mentioned getting a track record, that there is evidence that it works.

Participant [G1-4], who replied slightly negatively, mentioned that the problem does not lie on the demand side because the mortgage market shows a lot of new players. They said that the investment side is an issue, where the money is coming from. This is connected to the problem of collateralization, which will be discussed in the next section (6.5.2).

6.5.2. Subtheme 5.2

In general, the participant replied that a good reputation and a track record are important to providing mortgages via DeFi loans. This refers to the benevolence factor for the Trust model of figure 4.1. As a reason, they mention the high level of regulations and it contains a loan that borrowers do 'once in a lifetime', so they prefer a well-trusted party to pay a little more for good service. Also, four participants mentioned the importnance of ease and better products because a good user experience is important. They mentioned that this is where financial companies can distinguish themselves.

Participants [G2-1], [G3-2], and [G3-3] mentioned the problem of collateralization to be solved before DeFi lending systems could be adopted. Currently, a loan should be full- or overcollateralized to reduce or eliminate the risk of the lending party, which is not a capital-efficient solution. Banks within TradFi have the power to create money and thereby increase its capital efficiency. The possibility of under-collateralizing loans could be a trade-off solution to cope with this problem. Since the Digital Euro will not enable banks to create money anymore, it could be that these DeFi solutions become a better alternative for lending. Participant [G3-2] proposed to set up lending pools with different risk profiles, which could be a good starting point in serving any type of retail investor based on their risk appetites.

From the literature in section 3.1.3, it was shown that the DeFi lending system should be designed for stablecoins because these do not have strong volatility which is undesired for lending. Different ways to control the stablecoin was via collateralizing and stabilizing. From the literature in section 3.1.2, it can be seen that stabilization is unwanted because stabilization algorithms on stablecoins are not mature enough. This has also been confirmed by Participant [G3-3], who mentioned that the algorithmic stablecoin proved to be wrongly designed since there was no collateral behind it. So, the design of the stablecoin should be collateralized instead of stabilized.

Most participants, eight out of eleven, proposed to start at easier products for DeFi, rather than immediately on mortgage lending. This is to match the borrower's needs and to be in line with regulations. By starting on easier products, or the low-hanging fruit, it is much easier to gain a track record and reputation. It is also how fintech companies did, like how Klarna and Afterpay did it as mentioned in 6.3.2. They started with a BNPL service to gain brand awareness, built a reputation and track record on it, and are now going for other segments, like SME loans. The same principle can be used on DeFi, by starting with securities, as mentioned by Participant [G2-1]. The first pilots on the tokenization of securities have already been done in pilot cases by ABN (ABN AMRO Bank, 2023) and DBS/J.P. Morgan (Oliver Wyman Forum et al., 2022) as mentioned in literature section 3.1.3. This underlines that it is already feasible to integrate these products within the current TradFi system.

Finally, some participants also discussed which party they thought should take the initiative to foster the adoption of DeFi lending systems, of which the responses were rather divided.

Several participants mentioned that the initiatives should come from TradFi. They said that big banks have the people, resources, and connections with regulations to make this change. They also mentioned that it is risky to be a frontrunner because it is

costly to run two parallel systems, which is something that can only be done by really big banks. An example of this is the initiative by DBS and J.P. Morgan (Oliver Wyman Forum et al., 2022), where they wrote a report on tokenized real-world assets and the implementation of DeFi protocols. Participant [G1-1] said that the government should take the lead in fostering adoption. This is underlined by Participant [G2-3], who said that regulation should drive this technology, implying that they should have a more progressive attitude - which is in line with the outcome of section 6.1.2.

Participant [G1-2] mentioned a hybrid solution and said that every aspect is very important in creating these ecosystems. They proposed that there should be frontrunners from TradFi that work together with fintech in developing ecosystems. The systems should run in parallel with the current systems to not interfere with these and eventually merge them when the DeFi systems are mature enough. Universities and governments should also be included in these developments. This view is in line with the research goal of this project to design a *Hybrid* Mortgage Lending System

7

Hybrid Mortgage Lending System

This chapter will set up a technological design for the HMLS based on the feedback on the Integrative Model of Trust in DeFi for mortgage lending from figure 4.1, combined with the other information that has been given during the expert interviews that have been discussed in the evaluations chapter 6.

First, the objectives for the technological model will be defined in section 7.1. This section will answer the fifth subquestion as proposed in section 1.4. After that, 9 meta-requirements will be proposed in section 7.2 whereafter these are demonstrated in sections 7.5, 7.3, and 7.4. These will answer the sixth and last subquestion on how the technological model can be designed.

7.1. Objectives for the HMLS

The objectives for the HMLS are formed by the conclusions of the discussed results from chapter 6. It describes what the technological model of the HMLS should accomplish to adhere to the goals of this research. The following objectives result from the discussed results and are explained below:

(a) Transparency is where DeFi lending systems can distinguish themselves from TradFi lending systems

(b) Slowly integrate DeFi components into TradFi by incremental changes

(c) Actively involve TradFi companies within the HMLS

(d) User experience of lending products is key to distinguishing yourself

(e) Emergence of new ecosystems by incorporating the tokenization of real assets

(f) Create awareness in the short-term to gain a track record in the long term, via marketing and (re-)education

(g) Retain governmental authority

Table 7.2 is presented to illustrate which sections discuss the abovementioned objectives.

Sections of evaluation chapter	Objectives
6.1.1	(a)
6.1.2	(b)
6.2.1	(a)
6.2.2	(a)
6.3.1	(b), (c)
6.3.2	(c)
6.4.1	(b)
6.4.2	(b), (e)
6.5.1	(c)
6.5.2	(c), (d), (f), (g)

Table 7.1: Overview of the sections of the evaluation chapter where the objectives are discussed

With regard to the first objective, section 6.1.1 concluded that the transparency of DeFi lending models can have a positive impact on the integrity of the system. In section 6.2.1, the reciprocity of benevolence was also mentioned as an optional methodology to increase transparency, where both the borrower and lender should be transparent about their financial information. They stated this can reduce the cost of trust since there will be less trust required for the mortgage agreement. An example is given in section 6.2.2, where the optimization of KYC processes was mentioned as possibility to increase transparency and lower the cost of trust. From this, the DeFi lending systems can distinguish themselves by becoming more transparent to lower the cost of trust, which is the first objective for the HMLS (a).

Considering the second objective, section 6.1.2 concluded that the European regulatory framework is slow-paced and conservative. A main reason for this is that the mortgage lending market is highly regulated, as mentioned in section 6.3.1. In section 6.4.1, a solution for this is mentioned to slowly integrate DeFi components into the TradFi lending system if the technology and regulations allow it. This is complemented by the discussion in section 6.4.2, where it was described as an evolutionary process with incremental steps. Over a longer time span, it will then look like a revolution since it is such a disruptive innovation throughout the whole mortgage system. Altogether, this gives the second objective for the HMLS: Slowly integrate DeFi components into TradFi by incremental changes (b).

For the third objective, section 6.3.1 discussed that the dominance of traditional finance companies still holds in the mortgage market. In section 6.3.1, it was concluded that customers are very loyal to established firms by having a mortgage application. They also still prefer a personal conversation instead of an automated mortgage advise, as mentioned in section 6.3.2. In sections 6.3.2 and 6.5.1, it is mentioned that the track record is very important, where TradFi companies benefit from a big advantage over TradFi companies. In section 6.5.2, some participants proposed that TradFi should take the lead in fostering the adoption of blockchain in mortgage lending. Therefore, it is important to actively involve TradFi companies within the HMLS, and benefit from their high benevolent trust. This leads to the following objective: Ac-

tively involve TradFi companies within the HMLS (c)

The fourth objective originates from the importance of the user experience of lending products as discussed in section 6.5.2. It was mentioned that having easier and better products is important for financial companies to distinguish themselves. This leads to the fourth objective: User experience of lending products is key to distinguishing yourself (d). It also complements the fourth objective where starting with financial products that require less trust could result in a better competitive advantage for TradFi companies in order to gain market share.

The fifth objective is the emergence of new financial ecosystems. In section 6.4.2, it is mentioned that new ecosystems emerge as a result of the disruptive innovative forces from DeFi. It contains the (partly) elimination of intermediaries, for instance, notaries, and the integration of tokenization. It was concluded that the tokenization of real assets can create yield from new business perspectives and better liquefication of the markets due to increased accessibility. This results in the fifth objective: The emergence of new ecosystems by the incorporation of real assets (e).

Sixth, it was concluded that awareness and the purification of the image of blockchain were necessary to gain a good reputation in the long-term. In section 6.5.2, it was mentioned that it received a bad reputation as a result of financial scandals and pump-and-dump practices from highly volatile cryptocurrencies. In fact, blockchain technology is much more than making easy profit and therefore requires awareness which could be done via marketing or (re-)education of people, leading to the sixth objective (f).

Considering the seventh and final objective, in section 6.5.2 some participants discussed that the government should take the lead in fostering the adoption of blockchain technology in the mortgage market. Since the mortgage market is such a high regulated market, change in regulation should drive this technology in that field. It is said that governments should change their attitudes toward progressiveness, as mentioned in section 6.1.2 as well. This is also in line with the centralized aspect that is the goal of this research for the HMLS. This leads to the seventh objective for the HMLS: Retain governmental authority (g).

7.2. Meta-requirements for the technological model

This section will provide the meta-requirements based on the objectives from section 7.1 and detailed aspects from the evaluation of the results of chapter 6. These meta-requirements provide guidelines and principles to guide the design process for the demonstration of the HMLS technological model. 10 meta-requirements are derived for the design of the HMLS. These are enumerated below and further explained.

1. Commercial banks are no longer in a position to create money
2. The CBDC will be built on a blockchain protocol that is constructed by the ECB
3. KYC process is done by a third party
4. Presence of human interaction during the mortgage lending process
5. Partially automation of the notary via smart contracts
6. Tokenization of real-world assets
7. Setup of a hybrid DeFi ecosystem with TradFi as the originator
8. DeFi lending pools for different risk models
9. Incorporation of DAOs

Table 7.2 shows the sections and/or objectives from which the meta-requirements are derived.

Meta-requirement	Objectives	Sections of discussion chapter
1	-	6.1.2
2	(g)	6.1.2, 6.5.2
3	(a)	6.2.2
4	(c), (f)	6.3.2, 6.5.2
5	(b), (e)	6.4.2
6	(b), (e)	6.4.2, 6.5.2
7	(c)	6.1.2, 6.3.1, 6.3.2, 6.5.1
8	(d), (e)	6.1.2, 6.5.2
9	-	6.2.1

Table 7.2: Overview of the sections of the discussion where the meta-requirements are disussed

The first meta-requirement is based on the trend discussed in section 6.1.2, the ECB's CBDC. It was concluded that the ECB's possible adoption of the CBDC would prevent commercial banks from creating money as they do now.

The second meta-requirement is also based on the CBDC, but also on objective (g) to aim for good regulatory compliance where there is a proactive role for governments and the ECB. In section 6.1.2, it was mentioned that the ECB aim to build their own centralized blockchain protocol of which is suggested that should be used by financial companies. Having this meta-requirement is in line with this regulatory compliancy and having a centralized blockchain protocol is also in line with the hybrid lending system as proposed for this research.

The third meta-requirement is based on increasing transparency and decreasing the cost of trust as mentioned in objective (a). By doing the KYC process at third parties, mortgage providers can focus on their core competences.

The fourth meta-requirement is derived from objectives (c) and (f), where it was mentioned that borrowers still prefer personal attention rather than an execution-only approach, but also to create awareness for blockchain technology. For most people, this is the biggest purchase of their lives and they want financial advice from a professional. TradFi firms already have a track record and can use this to rebrand the image of blockchain technology and take the lead and gain from first-mover advantages.

The fifth is derived from both objectives (b) and (e). For objective (e), it is mentioned that new ecosystems will emerge and, as an example, that the role of the notary could be partially removed. With regard to objective (b), it is possible to think about some first steps to gradually change TradFi towards a hybrid form of DeFi. In section 6.4.2, it was said that the standardized tasks of notaries could be automated via smart contracts. However, some tasks remain necessary, as it was not considered beneficial to automate very old systems of land registration in the Netherlands.

The sixth meta-requirement is also derived from objectives (b) and (e), as the tokenization of assets contributes to these new ecosystems. The first steps in the tokenization process have already been taken by TradFi firms, as discussed in section 6.5.2, and provide an example of the first incremental changes in the integration of DeFi components into TradFi.

The seventh meta-requirement originates from objective (c) which is to actively involve TradFi companies within the HMLS. In objective (c) it was discussed that TradFi should keep its active role in the mortgage lending process and to benefit from their track record. This can be done by providing them with an originating role within the hybrid mortgage lending ecosystem. It is also in line with the possible CBDC outroll from section 6.1.2 where was suggested that financial companies should use the centralized blockchain protocols of the ECB. TradFi can actively take the lead in building new ecosystems and take the originating role in searching for lenders and borrowers, building DeFi products on top of the ECB blockchain, and providing financial advice to all stakeholders.

The eight meta-requirement is proposed in section 6.5.2 and stems from objectives (d) and (e) and the adoption of the ECB's CBDC that prevents commercial banks from creating money (section 6.1.2). For this money creation problem of commercial banks, it has been suggested that one could think of creating lending pools with different risk profiles. This can reach different types of investors, resulting in more participation and better liquidity. By creating a good user experience for lending products, it can become competitive with traditional lending products.

The ninth and final meta-requirement is derived from the discussion of the trust model in Section 6.2.1. For the integrity of the model, the inclusion of DAOs was discussed to improve the reliability of the model. It was said that DAOs can improve the accountability of blockchains, which will therefore be used as a meta-requirement for the HMLS.

7.3. Demonstration of the HMLS

This section provides a demonstration of the HMLS via a technological design of the tokenized model, architecture, and stakeholder map. Within the demonstration, the 9 meta-requirements mentioned above are referred to with parentheses, for example (1) to refer to the first meta-requirement.

The technological design of the DeFi lending model has a hybrid form where decentralized products are made on top of a centralized blockchain protocol, or CeDeFi (2). This is done to keep the reputation-based trust in the financial system, which is necessary to build trust in the form of awareness within a new technology. The problem of the blockchain trilemma as discussed in section 6.5.2 will also be less present with this hybrid solution, because the focus will lie on security and scalability, instead of decentralization.

With the arrival of the CBDC, or Digital Euro (d€), commercial banks are not able to create money anymore (1), an alternative is found in DeFi lending pools where retail investors can participate. Within these DeFi lending pools, mortgages are tokenized and divided through various lending pools which creates fractional ownership of mortgages by retail investors (6). This could be done by tokenizing houses via NFTs and linking these with property rights. The Duty of Care that mortgage providers have can automatically being tracked on the blockchain. The NFTs can be transferrable from one house owner to another house owner, where also its land could be registered and a track record of large maintenance is verifiable. Since NFTs can be divided into smaller, tradeable units, these can be fractionally owned via lending pools where the borrower pays a fee (mortgage interest) to give yield to the retail investors. This could be a solution for the problem of fractionalizing property rights as discussed in section 6.4.2. The borrower pays monthly its interest and repayment, and therefore starts owning more and more of the NFT, and thus of the house. Just like in a regular mortgage lending process.

To keep the trust in these DeFi lending pools, these will be managed by TradFi. TradFi has a solid track record on risk assessment and can therefore set up different risk models (8) that suit a broad spectrum of retail investors. These different risk models are formed by including other tokenized assets, like bonds, stocks, art, and cryptocurrencies to create mixed pools of tokenized assets, as mentioned in section 3.1.3.

Hybrid ecosystems will be formed to distribute the different roles within the lending process. Besides retail investors, there are validators for the KYC process (3) and TradFi as originators (7). Fintech can fulfill the role of a servicer to provide the payment infrastructure. The token providers can be either TradFi or DeFi. Depending on the complexity of the tokenization process, TradFi can tokenize its own mortgages and offer these within the lending pools. The remaining tokenized assets that are present in the pool can either be tokenized internally or be taken from external parties that already offer these products.

The borrower should not feel any additional complexity with the arrival of these lending pools. The user experience is key and the products should remain simple and understandable. The borrower still wants human interaction during the mortgage lending process (4) because for them it is a huge expense that requires attention from true advisors. Therefore, the mortgage lending process from the borrower's side should remain the same. Small changes are possible, like better user experience or easier products, but most of the advancements should happen at the back end. A small adjustment that could already be made is partially automating the activities of the notary via smart contracts (5). An example of this is mentioned above, where houses could be tokenized to NFTs where their land is registered.

Figure 7.1 shows an example of a hybrid lending pool that contains decentralized products and is managed by a centralized (TradFi) company.

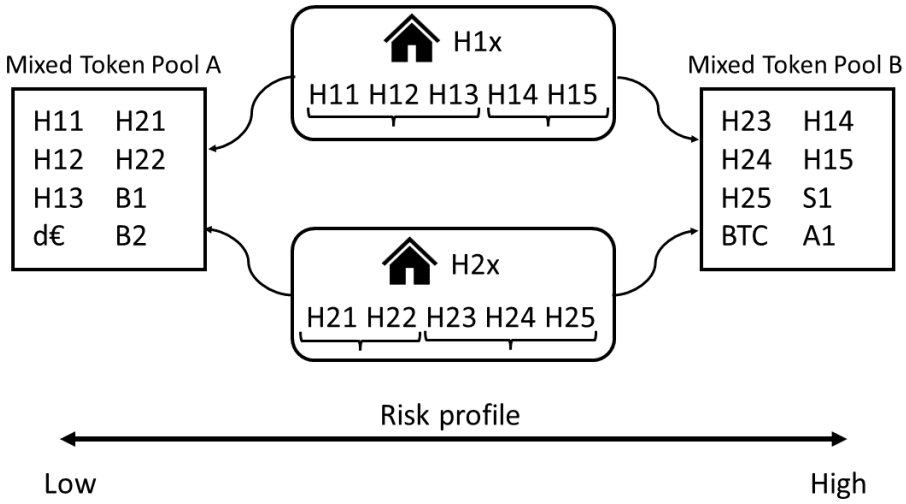

Figure 7.1: Example of a hybrid lending pool

This model works the following, Assume that houses H1 and H2 are tokenized in 5 units toward H11 up to H15 and H21 up to H25. These can be divided into token pools and filled up with other tokenized assets, such as bonds (B1, B2), stablecoins (d€), stocks (S1), art (A1), and cryptocurrencies like bitcoin (BTC). From this, mixed token pools emerge which can contain different amounts of risk. Investors with a lower risk appetite can mix their tokenized mortgages with tokenized bonds and stablecoins. These can be provided by TradFi companies and the ECB. Investors with more risk appetite can mix their tokenized mortgages with tokenized stocks, art, and other cryptocurrencies.

7.4. Architecture

The architecture of these Mixed token pools is visualized by putting these into a 'five-layer stack' system, as been explained in the literature section 3.1.1. It aims to show the working principle of the hybrid mortgage lending concept from a top-level view.

First, the architecture is shown in figure 7.2 where all individual components are explained and how these are retrieved and used from literature and expert interviews. After that, figure 7.3 shows the steps within this architecture where the process will be explained.

7.4.1. The components

This section shows the basis for the architecture of the HMLS, which is an inspiration of the architectures used by Deshmukh et al. (2021) and Wieandt and Heppding (2023). Figure 7.2 shows the basis of the 'five-layer stack' architecture where the components within the different layers are explained below:

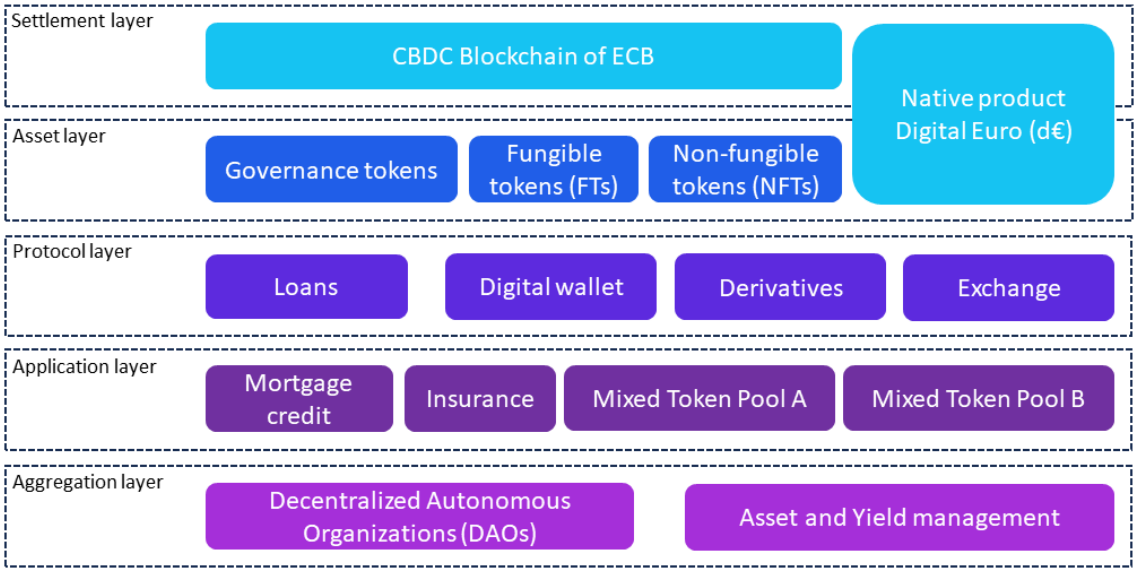

Figure 7.2: The architecture of the Hybrid Mortgage Lending System. The architecture is built in five layers, each layer having its own colour for the blocks.

Settlement layer

The top layer of the hybrid DeFi ecosystem is the settlement layer where lies the CBDC blockchain of the ECB with their cryptocurrency. It determines the consensus mechanism that lies within the CBDC Blockchain protocol of the ECB and provides the infrastructure of executing smart contracts, data storage, and securing transactions. It also determines the native digital currency of the protocol, which is here the Digital Euro (d€).

CBDC Blockchain of ECB For the consensus mechanism of the settlement layer, there were four main mechanisms as explained in section 3.1.2. In section 6.2.1, it was discussed to choose a permissioned blockchain to keep the control within the ECB over the Digital Euro, but increase the efficiency by automating decision-making. It was said that there were two permission blockchains from the literature section 3.1.2: Proof-of-Authority (PoA) and Delegated Proof-of-Stake (DPoS). In PoA, the validators are chosen based on their identity and/or reputation, and in DPoS the validators are chosen through voting where the validators compete against each other. In this case, the validators should be chosen based on their identity because the control should be kept at the ECB. Therefore the DAO could be designed with the PoA consensus mechanism. Having this, The ECB could still remain in control of decision-making while benefiting from the automated decision-making of a DAO.

Native product Digital Euro (d€) is the digital currency that is expected to be used as CBDC by the ECB. Dutch mortgage originators use this digital currency to perform their business activities.

Asset layer

For the second layer of the architecture, digital assets and smart contracts are built on top of the blockchain protocol of the ECB. These digital assets consists of governance, fungible, and non-fungible tokens, as explained in literature section 3.1.3.

Each different token is designed with its own smart contract, and therefor follows its own rules.

Governance tokens The governance tokens should be exclusively handed toward the ECB and the originating party. The governance mechanism of the HMLS should be centralized to become able to comply with strict mortgage regulations and not be corrupted by (anoynymous) outsiders. It also provides clear responsibility and accountability to the ECB and originating party if things go wrong, which provides security of guarantee for the borrowers. The governance tokens will therefor not be present within the mortgage application and transaction flows.

Fungible tokens (FTs) The FTs are digital assets that can be created by the originator and can be used for payments, just as for fiat money in traditional finance. In the first and second meta-requirements of section 7.2, it was stated that the CBDC is a digital asset provided by the ECB which makes the creation of own FTs redundant for mortgage providers in this case.

Non-fungible tokens (NFTs) The NFTs can function as administration systems for the houses. Tokenizing the houses into various NFTs where each NFT holds a partially ownership, transfer of these NFTs are tracked on the blockchain. As such, it can be seen who owns what part of the house. The mortgage contract that will be settled between the originator and the borrower implies the terms on which the borrower buys back these NFTs from the lenders, resulting in full ownership when the house is payed off. The smart contracts for these NFTs also contain the Care of Duty that the NFTs owners hold for the borrower, to be compliant with Dutch regulation on mortgage lending. Thus, transfer of these NFTs also means transfer of the Care of Duty to the new owner. These NFTs are minted on the CBDC blockchain of the ECB. Minting is the creation of a unique token on the blockchain.

Protocol layer

Within the third layer, the protocol layer, the rules are written out for loans, exchanges, derivatives, and digital wallets. It contains the operational protocols that are required to operate the business model of the HMLS

Loans The first operational protocol are the loans of the borrower. These are required for the borrower to pay back its debts to the lending parties.

Digital wallet The second is an overview of the digital assets of an user. From the perspective of a house borrower, it shows their income from loans, amount of NFTs of their house, and other digital assets.

Derivatives The third that incorporate derivatives such as stocks and bonds. The tokenized model in figure 7.1 showed the lending pools where derivatives can be part of these pools.

Exchange The fourth is where digital assets can be exchanged with other digital assets, for instance the Digital Dollar - a digital asset of the FED fro the USA. This makes it possible for investors in USA to participate in lending money to Dutch house borrowers.

Application layer

The fourth layer that is build on top of the operational protocols is the application layer. This layer applies the rules on loans, exchange, derivatives, and the digital wallet to build user-facing and decentralized applications.

Mortgage credit The first application that provides the interface to credit mortgages for the HMLS.

Insurance The second is to provide insurance on the house which is a predominant cross-sell product for the house that can be originated by the issuer of the house as well. For the HMLS, it is necessary to provide the insurance with the mortgage contract, because the level of insurance of the house determines the risk that lenders are willing to take since they partially own the house as well.

Mixed Token Pool A The tokenized model in figure 7.1 showed the Mixed Token Pool A which is an application for the HMLS and should therefor be built upon the operational protocols.

Mixed Token Pool B The same principle holds for Pool B.

Aggregation layer

The fift and last layer is the aggregation or governance layer. It is responsible for governing, aggregating, and improving the user experience. The governing mechanims that is used are provided by the DAO and can have design requirements of the ECB. The ECB can then regulate on the actions that the DAO is allowed to do, and its goal it should aim.

Decentralized Autonomous Organization (DAO) The DAO will set smart contracts between the different applications within the fourth layer and the asset and yield management to execute the rules it is designed to. In this HMLS architecture, its funcion is to control the payments performed by the borrower. It receives the mortgage payments and divides it to the insurance party and both token pools. It gets informed by the asset and yield management to know what amount of yield it should pay to the lenders for their collateral. Outside this architecture, they also present to the lenders the house with insurance and provide them NFTs with preprogrammed, fair risk/interest ratios upon they can decide to buy these or not.

Asset and Yield management This is also a part of the aggregation, where yield on savings and return on investments can be tracked and optimized. These include the lock-up yields for the NFTs, which are interests that must be payed for the collateral that the lenders provided.

7.4.2. Mortgage application and transaction process

This section describes an example of a mortgage application process and transaction process that occur within the HMLS between the originating party and borrower. A visualizaton of the application process is shown in figure 7.3, and a mortgage transaction process in figure 7.4

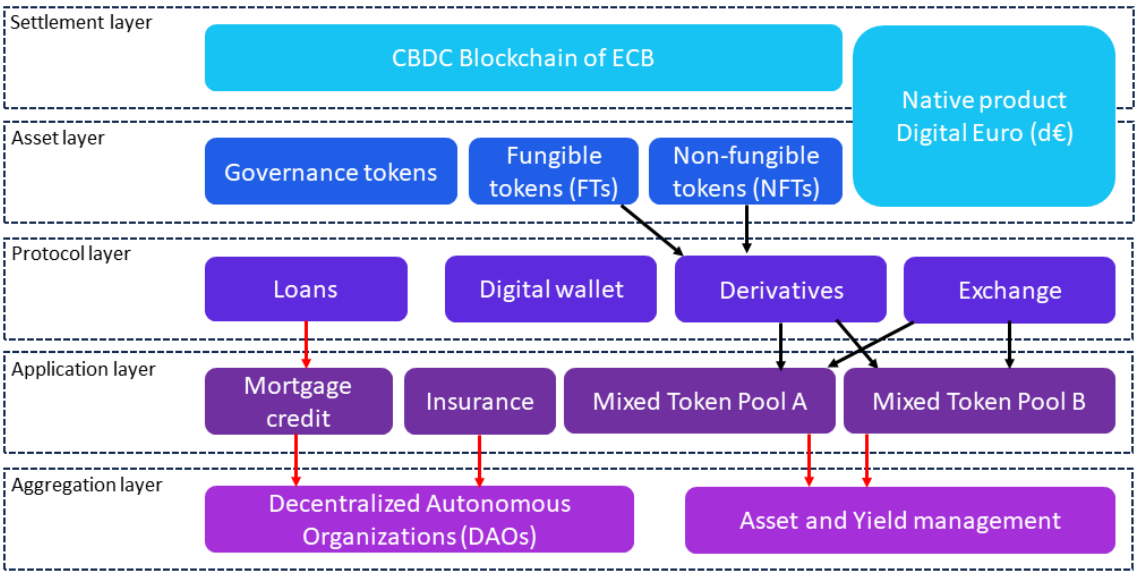

Figure 7.3: A mortgage application process in the architecture of a HMLS. The black arrows indicate financial flows and the red arrows represent information flows of digital assets.

For the mortgage application process, it can be divided in two parts: filling the mixed token pools with digital assets and informing the DAO to be able to make decisions for the mortgage payments. The black arrows that are used within figure 7.3 represent financial flows and information flows of digital assets are colored red.

To start from the top with the financial flow, it starts between the originating party and borrower with the creation of NFTs for the tokenized mortgage that is minted through the CBDC blockchain of the ECB, and has the currency in Digital Euros. These NFTs are considered to be derivatives so they are tradeable. These derivates end up in Mixed Token Pools A and B. These pools are completed with other digital assets as shown in figure 7.1 (bonds, stocks, CBDCs, art, or cryptocurrencies). These digital assets come from other exchanges and must therefor be exchanged before they can be transferred into the token pools. This results in Mixed Token Pools A and B with derivatives that are generated by the originater, and digital assets that have been exchanged.

For the information flow, the loans indicate to the mortgage credit application on the solvency of the borrower. The DAO gets then informed on the solvency of the borrower, the cost of the house and insurance costs. The DAO will act outside this architecture to present the lenders the mortgage proposal with the house and insurance with a preprogrammed and fair risk/interest ratio to see where it can find investors for the mortgage. These lenders will put in their collateral through the exchanges in the protocol layer.

Figure 7.4 shows the financial flows when the first mortgage payment is done.

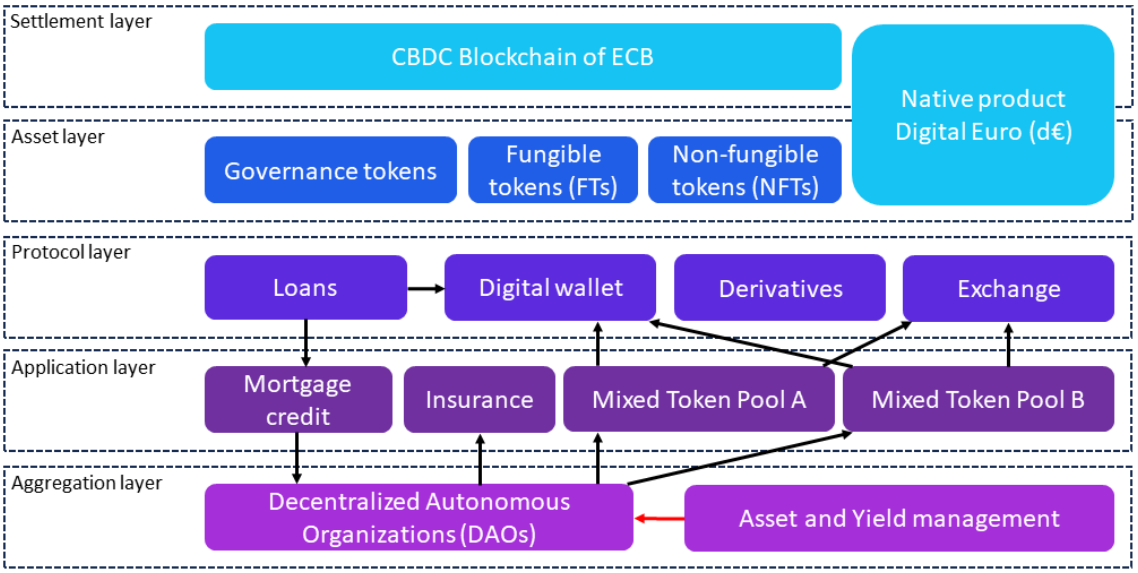

Figure 7.4: A mortgage transaction process in the architecture of an HMLS, where the borrower makes a payment to the lender. The black arrows are financial flows and the red arrow illustrates an information flow.

A mortgage transaction process can be a monthly payment from the borrower to the lender. The payment starts with the loan of the borrower, which is partially used to pay for the mortgage credit and the remainings goes to the borrower's digital wallet. Then, the mortgage credit payment goes to the DAO, that divides the payment to insurance costs and both mixed token pools. Before the DAO performs the payments to the mixed pools, it gets informed by the Asset and Yield management so that it knows how much interest it must pay to the lenders' yield on their collateral.

As such, the mortgage payment to the mixed token pools consists of repaying the NFTs with interest. A part of the NFTs that are paid for will go from the mixed token pools to the digital wallet of the borrower. The lenders that participate in the mixed token pools receive their payment by the exchange of digital assets of the mixed token pools to their own digital wallets go outside this architecture, toward the exchange block.

7.5. Stakeholders within the ecosystem

In section 7.3, it has been explained that retail investors, originators, servicers, and token providers are necessary to set up the DeFi part of the hybrid lending model. To make it applicable to mortgage lending, the stakeholders from the current mortgage lending process of section 3.3.1 will be taken into account to set up all stakeholders that are necessary for a hybrid lending model on mortgages.

The stakeholders within the hybrid lending model are shown in figure 7.5.

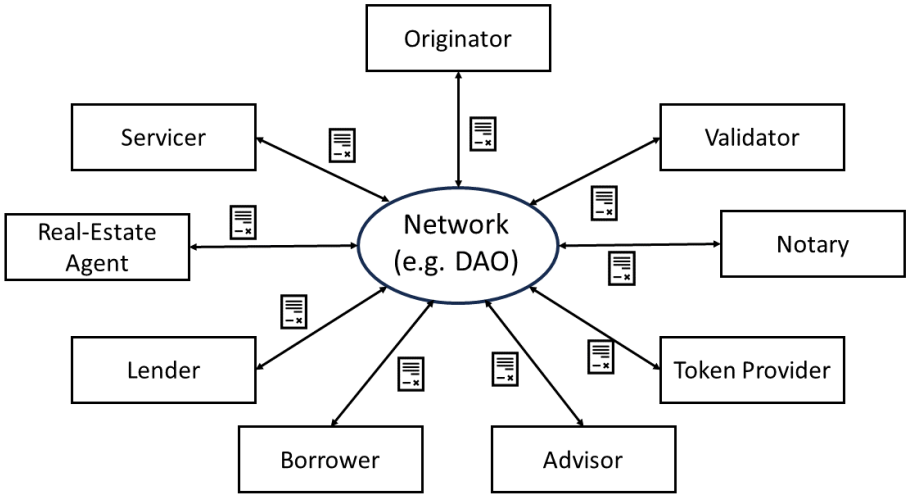

Figure 7.5: Visualization of the stakeholders in the hybrid lending system on mortgages

The roles of the stakeholders are explained below:

- Originator: TradFi party that underwrites the transaction
- Validator: Third party that signs the transactions between lender and borrower. They also perform the KYC process and confirm the collected funds by the borrower and transaction toward the lenders
- Notary: Role remains partially necessary in mortgage lending
- Token Provider: TradFi/DeFi to tokenize the assets
- Advisor: Providing face-to-face advice to the borrower
- Borrower: A person who wants to buy a house
- Lender: Retail investors
- Real-Estate Agent: Role remains necessary in mortgage lending
- Servicer: Fintech party that collects the payments.

Note that the Notary, Advisor, and Real-Estate Agent are specified toward mortgage lending. The stakeholders for other types of lending should be revised and changed. The icons next to every connection line symbolize smart contracts. It is seen that a DAO can control the network to set up smart contracts to oversee all communication lines. Smart contracts in general will have a prominent role in automating the (mortgage) lending process. As mentioned in the introduction in section 3.1.1, smart contracts are very transparent and thereby minimize arbitrage and risk of manipulation. This has also been confirmed during the expert interviews in sections 6.2.1 and 6.2.2.

8

Reflection

This chapter presents the reflection on this project. It discusses alternative outcomes for the HMLS when other research or design choices have been made for this project. The reflection will consist of four parts: problem definition, the design process for the first artifact, the validation procedure, and the design process for the second artifact. After the reflection, the lessons learned are presented in section 8.5

8.1. Problem definition

The problem definition was based on the definition of the institutional problems in traditional finance. Certain choices have been made to scope this research. Alternative choices could have been made which will be explained below. This section explains three alternative choices: An alternative design strategy, another use case, and going for a design that only focuses on DeFi instead of both TradFi and DeFi.

8.1.1. Choose a different design strategy

For this research, the design strategy for the DSR framework was chosen to build the artifact as a general solution for mortgage lending in the Dutch financial sector (section 2.1). The alternative would be to focus on a specific mortgage provider and generalize the solution to the whole Dutch financial sector. In this case, it would be a hypothetical experiment, as the thesis was written at a consultancy and not at a financial institution. This could have resulted in not being able to obtain the right data to carry out the research. It would also require to gather data based only for that specific company, implying that the expert interviews should have been recruited from there.

8.1.2. Choose a different use case

For this project, mortgage lending has been chosen as use case, but other financial products were possible as well, like SME loans, insurance products, or stock trading. Moreover, from chapter 6 was also concluded that any security or form of lending could be tokenized and divided following the same principles done for this project. This makes it possible to perform this concept in a shorter term because realistically, mortgages will probably be one of the last financial products to be tokenized on the

blockchain.

In chapter 6, it was made clear by the ongoing trend where more competition was coming for established TradFi companies which provides opportunities for DeFi companies (6.3.1). Section 6.4.1 confirmed this plausible trend where FinTech companies entered the financial market and takes over activities done by TradFi. Sections 6.4.1 and 6.5.2 mentioned that the objective for implementing new technologies should be to start with financial products that require less trust to build a track record and reputation. These products have also less negative impact by mistakes then. Mortgages were said to be the financial product that requires the most trust, and were therefore considered to be integrated as one of the final products. It could therefore be said that choosing a different use case could make the outcome of this project better in the shorter term.

8.1.3. Only DeFi

An alternative option for this research would have been to go for a full decentralized approach rather than a hybrid approach. Going for this approach, the design of the trust model would not become very different because a different lending approach does not change the desired customer experience and their expectations from their mortgage provider. Because an execution-only approach was not desired, there was still need for financial advisory that should had been implemented anyway in the system. Deciding to go for only execution-only approaches would save costs, but is also not scalable throughout the whole mortgage market because there is less demand for. However, the perception of borrowers could be changed by rebranding, which still takes time since a reputation and track record must be built. The design of the second artifact would however become much different because the dependency of the ECB's blockchain protocol can be eliminated. It can lead to much more freedom of choice because there is less regulation, leading to lower costs of trust and thus a decrease in transaction costs.

A full DeFi approach does need a strong incentive of a first mover that is willing to take a risk in reshaping the whole mortgage market. They could take the same approach as FinTech companies, which is to start with easier products and build a track record on this to eventually provide mortgages in the longer term.

8.2. Design process for the first artifact

Considering the design process of the first artifact, an alternative trust framework could have been used for this research. For instance, the trust model designed by Hansen (2012) could have been used. Hansen et. al designed a model to understand trust in financial services where they studied the effect of financial healthiness, financial knowledge, broad-scope trust, and consumer relationship satisfaction on narrow-scope trust. The narrow-scope trust is defined as the customer's expectation that the financial institution is reliable and can be relied upon to deliver on its promises.

A benefit of this approach is that deeply focuses on the narrow-scope trust, making it a goal-oriented approach. It could have resulted in very specific conclusions on the customer's expectations for mortgage providers. This could then be used for the design of the HMLS to make it customer-oriented so that the solution would align

better with the customer's needs. It would also mean that not only mortgage providers, but also the customers, house borrowers, should have been interviewed to get their expectations clear.

8.3. Validation procedure

For the validation procedure, two topics will be discussed: the interview process and an alternative to the expert interviews.

8.3.1. Interview process

After showing the participants the model, the interview started with a warm-up question which can be considered as a leading question. However, the purpose of this (closed) question lay more in the way they built their argument by asking follow-up questions. The goal was to let the participants start thinking about ways to increase integrity and trust in a lending system and current (regulatory) trends in a more general perspective before diving into more specific topics. It was to make sure they feel connected to thinking about DeFi lending models from a 'trust' perspective before asking for direct feedback on the DeFi lending model in the second theme.

8.3.2. focus groups

The first and second artifacts were validated via expert interviews. However, an alternative could have been chosen, namely focus groups. An advantage of using a focus group rather than in-depth interviews is that the group dynamics would provide a common ground for generating new ideas for the technological model. It would make data analysis less complex, as design decisions are discussed among the participants, rather than having to go through a coding process and link the different arguments during analysis. It also allows participants to complement each other during the discussions or to write down ideas where the majority does not agree. However, a major disadvantage is the possibility that not everyone will dare to speak up, as everyone has obligations to their employer, especially if the focus group consists of participants from different companies.

The focus groups would therefor have been a better option for the alternative design strategy mentioned in section 8.1.1. In that case, the participants of the focus group would be from the same company which might give them more confidence in telling competitively sensitive information. There is also a chance that they know each other, so that they are aware of eachothers personalities and knowledge can improve the overall quality of the discussions.

8.4. Design process for the second artifact

The design of the HMLS was based on the opinion of experts and the state-of-the-art. However, alternative choices could have been made that would have influenced the outcome differently. This section explains two alternative choices for the HMLS design: regulatory arbitrage and the elimination of DAOs.

8.4.1. Regulatory arbitrage

The first is the possibility to go for regulatory arbitrage toward the regulatory framework the ECB is providing on the CBDC. In section 7.2, the first meta-requirement of the HMLS was that mortgage providers do not create money any more. To solve this problem, participation pools were defined to provide collateral from other parties besides the mortgage providers.

However, there could be thought of a loophole where mortgage providers can create money via stablecoins that are pegged to the Digital Euro. Their stablecoins will then become on-chain collateralized by a cryptocurrency, as can be recalled from figure 3.1. The reason for choosing for collateralization was discussed in section 6.5.2 where was mentioned that stabilization algorithms are not mature enough. As such, the collateralized stablecoins preserve their ability to create money, just as for the current traditional finance system. The usage of stablecoins also provides efficiency benefits, because not every transaction is forced to go from the fifth to the first layer but can be stacked up in the second layer. The design of the stablecoin should then incorporate its transaction surplus or shortage and communicate this to the first layer from the ECB.

8.4.2. Elimination of the DAO

A second design choice alternative would be to not go for a DAO within the design of the architecture because it is debatable whether decentralized governance should be implemented in a trusted mortgage market. Morrison et al. (2020) investigated the role of DAOs in corporate governance and mentions its governance risks as explained in the literature in section 3.1.5. He mentions that in general, governance is focused on the proper distribution of risk and allocation of decision rights to certain individuals. Effective governance is described as good incentives from decision-makers that are in line with the goal of the company. DAOs distribute these decision rights, making it difficult to set someone accountable for poor decision-making. DAOs use smart contracts to execute rules and do not require trust since it does what they have been programmed to do. This makes it difficult to react to unforeseen events involving smart contracts because there is no legal framework or central authority. Especially for the financial markets, and in particular the mortgage market, you want to keep control in times when you have to be able to react quickly. The author emphasized that the benefits of good governance are that there is not only clarity on who are the decision-makers but also who has the accountability. The author put also doubts on the transparency of DAOs since the distributed accountability was difficult to track down on a decentralized blockchain. However, Morisson et. al mentioned that DAOs do work for loosely-focused missions where there is information asymmetry between members and extremely flat organizational structures.

Reflecting on mortgage lending in the Netherlands, it can be said that DAOs are not a useful technology to advance in its *current* shape but could become in the near future. The conservative TradFi companies usually have a vertical organizational structure (Ferri et al., 2015), also because of the numerous activities they are in, according to participant [G1-4] (section 5.6). TradFi companies also have a clear vision for their company and decision-makers must be held accountable for inappropriate actions because it concerns money from borrowers. However, there could be explored possibili-

ties of using permissioned blockchains as explained in section 3.1.2. In permissioned blockchains, the validators are chosen which could decrease the governance risk if the assigned party is a trusted validator, for instance, the ECB. Proof-of-Authority (PoA) and Delegated Proof-of-Stake (DPoS) are the permissioned blockchains that could be considered. Permissioned blockchains decrease the level of decentralization within the system, which is a trade-off to be made for the final model.

8.5. Lessons learned

Based on the reflection, there are three main lessons that can be described below

8.5.1. First lesson: Contextual change can have a big impact that requires a new research approach

The first lesson is that changing the context of the project has a big influence of the whole project itself. It is not self-evident to change the use case of mortgage lending toward SME loans, or going for full DeFi instead of hybrid. It requires a reflection on the research approach, and possibly the design strategy itself.

8.5.2. Second lesson: The architecture design requires a lot of in-depth technical knowledge

Prior to this research project, I did not have much in-depth technical knowledge of DeFi lending or blockchain technologies. Designing the architecture of a complete mortgage lending system required a huge deep dive into how blockchain works in a decentralized manner. It stood out to me how many possibilities there are, of which is still uncertain what could become the mainstream. To cope with this, assumptions and design choices must have been made, which is the third main lesson of doing this project:

8.5.3. Third lesson: Freedom of choice gives trade-offs and uncertainties

This project provided a lot of freedom of choice because it is a disruptive innovation and we are at the beginning of it. This freedom of choice also gives many trade-offs and uncertainties. It is not obvious to make a choice since there is no evidence of how it actually works in practice. The advantage is that there is room to be creative and inspiring, but challenging to remain feasible and aware of the other aspects that influence the adoption of blockchain in financial services. For instance, on the out roll of the CBDC by the ECB, the assumptions were made based on a report by the ECB which has not been made final yet. Therefore, many factors could change - and possibly will - along the way since governance is also an iterative process.

9

Conclusion

The main goal of this research is to design a trustworthy hybrid lending system that reduces the cost of trust.

Section 9.1 presents the main findings that provide an answer to the research questions, section 9.2 provides theoretical contributions to the literature, and section 9.4 provides recommendations for further research. Finally, the practical implications will be discussed which is for BearingPoint on how they can use this framework for future opportunities in section 9.3.

9.1. Main findings

The main findings reflect the answer to the main research question that was formulated as:

How can a trustworthy hybrid mortgage lending system be designed that reduces the cost of trust?

A trustworthy hybrid mortgage lending system that reduces the cost of trust can be designed by following nine meta-requirements. These meta-requirements follow from the post-evaluation of a contextualized trust framework toward hybrid mortgage lending, combined with pre-evaluated constructs that are taken from the literature.

Four meta-requirements directly influence the reduction of the cost of trust. The first is where the KYC process is done by a third party. This would enable lenders to quickly see the borrower's financial situation, resulting in a lower risk of uncertainty. Therefore, this process would require less trust for the lender, thus a reduction of the cost of trust. The second is where mortgage loans can be tokenized via NFTs on the blockchain to improve its transparency. A more transparent process means less risk of uncertainty, thus lowering its cost of trust. Thirdly, the introduction of DeFi lending pools with different risk models invites a broad spectrum of retail investors to participate in lending money for mortgage loans. This distributes the risk for banks since they do not have to bear the risk of the whole mortgage loan, resulting in a lower cost of trust. The fourth and last meta-requirement that reduces the cost of trust is the incorporation of DAOs. DAOs use smart contracts to execute rules and do not

require trust since it does what they have been programmed to do while they improve the accountability of blockchains so that reliability can be retained, resulting in a lower cost of trust.

The five remaining meta-requirements do not directly affect the cost of trust but rather support its feasibility or are consequences of plausible trends that must be addressed. These meta-requirements provide three main insights. The first insight concerns the Digital Euro, where the design includes a boundary condition that prevents commercial banks from creating money. This led to the solution of inviting retail investors to participate in the lending pool. One plausible consequence of the Digital Euro is that the blockchain protocol must be built on top of the top-layer solution provided by the ECB. The second main insight is that human interaction must remain present in the mortgage lending process. lending process, as borrowers value getting advice from financial experts. However, this results in a sustained Care of Duty for lenders, which has a negative impact on the cost of trust. Automating this process could reduce the cost of trust, but it is not advantageous in this context. The third main insight is the changing role of TradFi within the hybrid lending model, where they primarily act as originators.

A demonstration of how the hybrid mortgage lending system would work was shown in a pseudo-environment that included the lending pool, architectures with and without a DAO, and a stakeholder map for the ecosystem. It was designed to be a general solution for mortgage lending in the Dutch financial sector, which could be specified for a specific mortgage lender to bring into practice.

9.2. Theoretical contribution

The main theoretical contribution is the interconnectedness of the two designed artifacts. The first artifact creates a knowledge base for the second artifact, giving the adjective of trustworthiness for the second artifact. It provides new knowledge where a blockchain-based model can be designed based on trustworthiness factors instead of business- and technology-driven factors to solve institutional problems.

Regarding the first designed artifact, the main theoretical contribution is the contextualization of the Integrative Model of Organizational Trust toward hybrid mortgage lending. Mainly all blockchain-based mortgage lending models were based on economic or technical aspects. By considering this institutional problem from the perspective of maintaining social relationships, new insights were gained that could lead to this contextualized trust model.

The second designed artifact presents a technological model demonstrating how hybrid lending could function while maintaining trust. This study differs from previous ones that focused primarily on business, political, and technological aspects. By including trust as a fundamental value, infeasible solutions that assume people can solely trust computers and algorithms are excluded.

9.3. Practical implications

In terms of BearingPoint, it provides them with a structured approach to understanding, analyzing, and implementing DeFi-based lending solutions. The demonstration of the HMLS provides them with an example of how it would work in practice, which can be

used to develop use cases for blockchain lending. The reduction of transaction costs and its impact on current lending processes can be explored.

It can also be used to educate potential clients on possible threats and opportunities and it can also help clients to understand the technical aspects of an architectural structure and how regulations might influence their current way of doing business. It could motivate them to become first movers and take advantage from that in the future when regulations will indeed be changed.

There can also be collaborated with clients to develop proof-of-concept on other loan practices besides mortgages based. This design can be used as guideline for the design and evaluation of those projects.

BearingPoint could also form strategic alliances with other companies to actively implement this concept that includes banks, software developers, and regulators.

Finally, if BearingPoint decides to use this framework in its practices, they can continuously integrate the framework based on insights gained from real client cases. Incorporating feedback from clients can improve the framework to remain relevant and effective.

9.4. Limitations and recommendations

This section will discuss the limitations and provide recommendations for further research.

9.4.1. Limitations

The first limitation is the importance of cybersecurity. Its increase in importance is already on the rise, mainly as a result of an increase in digitization and political tensions. Although DLT minimizes certain security risks that occur in traditional finance, others will appear and another crypto scandal has not been ruled out. Besides these new types of security risks, new technologies must be adopted in parallel with the current system, or potentially integrated. These can cause temporal vulnerabilities to the security levels. The growing urgency of improved cybersecurity as a result of improved attendance of DLT in financial services has not been attenuated accurately and therefore requires more research.

Secondly, it became clear that regulatory confusion is a major hurdle to the adoption of DeFi lending in general, and especially in a highly regulated segment such as mortgage lending. However, this was not just a barrier of what was unclear, but also what was clear but could not be captured because it was outside the scope of this project. For example, the Duty of Care was mentioned in the interviews and was therefore identified as an important factor to consider in order to make this technology feasible for implementation. Also, participants contradicted each other on mortgage regulations which made it difficult to choose the truth. An example of regulatory confusion is the programmability of money, which was decided not to be included in the automation of mortgage lending. It needs to be clear that there are good incentives for this technology and what the status quo of the regulatory framework is. It could be that this is an example of a grey area where regulatory arbitrage could occur.

Thirdly, it was suggested that mortgage lending will not be the first financial product to be tokenized. It is a reality that it is currently not feasible to implement it because

regulations do not allow it and customers are not trusted with this technology yet. To give an example, DAOs are proven to be immature, although they show a lot of potential. Currently, it cannot be ruled out to depend a model solely on DAOs, but it should be taken into consideration because these innovations are also developing. It requires time to prove to the customers that there are better alternatives, of which the first step is to create awareness and build up a track record via the tokenization of securities.

9.4.2. Recommendations

There are three recommendations for further research, which are the extension of the limitations: 1) Research to improve the versatility of the hybrid lending model, 2) Research on prototyping the model, and 3) Research on the regulatory and technical hurdles to make it implementable.

1) Research to improve the versatility of the hybrid lending model

Further research should be done on the versatility of the hybrid lending model to other forms of lending. As previous mentioned, a limitation of the model is the current versatility of the hybrid lending model, resulting in a low generalizable outcome toward other forms of lending.

Technically, any type of financial loan could be tokenized and fractionally owned as shown in section 7. Still, some steps need to be done before it can be said that the technological model can be used for other types of loans:

- Identification of the stakeholders for the lending ecosystem
- Insight into the regulations
- Required level of security to comply with jurisdiction

However, the research had been done solely on mortgage lending. So, to find a generic and versatile DeFi lending model and rule out assumptions as above, more research should be done on other types of lending.

2) Research on prototyping the model

As a limitation, it was said that it is a big risk for banks to roll out their own DeFi lending system next to their own financial infrastructure. However, research should proceed by creating prototypes of models to encourage innovation and replace outdated financial systems. For instance, it could be demonstrated in a specific company to fulfill its theoretical usefulness in practice.

It should be investigated more in the application of DAOs because it is such an immature technology yet it is believed to have a large potential in developing more efficient financial infrastructures.

Also, 'lower security' sectors such as the energy market may benefit from DAOs in a better way because these open markets find a better fit for DAOs to unleash their full potential.

In developing countries in Africa where the centralized governance is poor, a decentralized approach would work and could potentially be a great area to start prototyping. Incentives could come from developed countries to build financial infrastructures

there. It helps the African society build a trusted financial system and thereby builds a track record for the technology itself to eventually replace the old financial systems in the Western world.

3) Research on the regulatory hurdles

Another limitation was the lack of clarity in the regulatory frameworks. More research should be done on the status quo of these regulatory frameworks to know to what extent these hybrid lending pools are already feasible and whatnot. It could be that more decisions should be made at a national level, rather than a European level because they are too conservative. MiCa is already a step in the right direction, but more is probably necessary to have enough certainty that it is legal to proceed with DeFi services.

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A

Distribution Dutch mortgage market

This table shows the numbers that are used for table 3.2. The numbers in the table are in millions of euros.

Year	2012 Q1	2014 Q4	2017 Q3	2020 Q2	2023 Q1
Banks	421764	444783	498609	504317	552594
Insurers	32815	45165	55601	63740	67153
Investment institutions	2144	6653	27679	53319	80987
Other financial institutions	186761	152398	117713	103508	87415
Pension funds	10805	7854	6284	7209	11507
Total provided residential mortgages	*654289*	*656853*	*705886*	*732093*	*799656*

Table A.1: The table shows the market share of the different segments of the residential mortgage market in The Netherlands between 2012 and 2023, mentioned per quarter (Q). Data from each quarter between 2012 and 2023 of (DNB, 2023) has been exported to Excel, where 5 evenly distributed dates were chosen for this report. From the 45 rows that were present in the Excel file, row numbers 1, 12, 23, 34, and 45 are taken.

B

One pager

You are being invited to participate in a research study titled Designing a DeFi Lending System on Mortgages Considering the Integrative Model of Organizational Trust. This study is being done by Stefan van der Maarel from the TU Delft in collaboration with BearingPoint NL. The role of BearingPoint NL is to provide access to the available knowledge inside the firm and provide additional coaching during the project.

The purpose of this research is to validate my design for a DeFi Lending system which will take you approximately 60 minutes to complete. The data will be used for the evaluation of the proposed design, compared with the literature to identify differences, and compared to other interviews to identify differences among the participants. We will be asking you to participate in this interview and describe your view on the design of DeFi Lending systems, preferably on mortgages. The focus will lie on the perspective of trust within these lending systems, but alternative perspectives are much appreciated as well that fit this direction. We will also discuss the feasibility and how likely the proposed design will succeed in your opinion.

Based on your preference, the interview will be either audio or video recorded, transcripted, and whether the interview takes place online or in person.

As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential. We will minimize any risks by collecting and storing as little personal data as necessary and storing the data on a secure and private TU Delft OneDrive location, only accessible by a small set of TU Delft employees associated with this research project.

Before being published in the thesis report, the data from the interviews will be anonymized. The set of TU Delft employees has access to the following data: name, email address, audio/video recordings, transcripts, and anonymous summary. People of BearingPoint outside the TU Delft do not have access to any of the above data except for the anonymous summary that will be shared in my final thesis as an appendix. Their existing network of clients could be used to find participants for this research. The content of the interview will be aggregated and used for the result section of my thesis. The master thesis containing the summaries will be publicly available in the TU Delft Repository. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions.

A summary of the interview will be provided to you within 2 weeks after the interview. You are free to request the removal of parts of the summary before publication in the thesis report. All other personal data collected (audio/video recording, notes, participant list) will be removed not later than 1 month when this project is finished. The deadline for this project is expected to be the end of October 2023. The data can be stored for up to 2 years under the same restrictions as mentioned above if the TU Delft finds additional purposes with the outcome of this research, but only if the domain of research remains in the same direction.

If there are any questions or concerns regarding this research, please contact us:
Stefan van der Maarel (Researcher), s.j.m.vandermaarel@student.tudelft.nl , or Mark de Reuver (Responsible researcher), g.a.dereuver@tudelft.nl

C

HREC

The Human Research Ethical Committee (HREC) of the TU Delft checks the research that involves human participants. The procedure is done to ensure that all GDPR criteria are followed during the data-gathering process. To get this approval, the following documents are delivered immediately after the kick-off to make sure that the HREC has sufficient time to process the application to get it approved before the start of the interviews. The following documents were delivered to the HREC:

- HREC checklist: to evaluate the risk associated with the research.
- Informed consent form: issued to inform the participants prior to the interview process since it includes collection and storage of personally identifiable information (PII) [name, e-mail address] and associated personally identifiable research data (PIRD) [audio, video, transcript]. It also entails that the participants have the freedom to not cooperate anymore during the interview.
- Data management plan (DMP): An appointment has been scheduled with the faculty data steward (Nicolas Dintzner) to evaluate the data management plan which was approved afterward. It contained that the data would be stored on a secure and private TU Delft Onedrive.

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If there are any questions or concerns regarding this research, please contact us:
Stefan van der Maarel (Researcher), or Mark de Reuver
(Responsible researcher),

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated 03/07/2023, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves • an audio or video recorded interview • a transcript of the interview • a summary of the interview based on the recording	☐	☐
4. I understand that the study will end October 2023	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that the following steps will be taken to minimise the threat of a data breach and protect my identity in the event of such a breach and protect my identity in the case of one. A small set of TU Delft employees associated with this research project is the only group with access to the recordings with safe data storage on the TU Delft OneDrive, and the anonymized interview summary before release.	☐	☐
6. I understand that taking part in the study also involves collecting specific personally identifiable information (PII)[name, e-mail address] and associated personally identifiable research data (PIRD)[audio, video, transcript] with the potential risk of my identity being revealed.	☐	☐
7. I understand that personal information collected about me that can identify me, such as name and e-mail address, will not be shared beyond the TU Delft.	☐	☐
8. I understand that the (identifiable) personal data I provide will be destroyed at the latest 2 years after the project is finished.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
9. I understand that after the research study, the de-identified information I provide will be used for delivering a master's thesis. This thesis will be publicly available in the TU Delft repository, in which only the summary of this interview is included within the appendices.	☐	☐
10. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
11. I give permission for the summary of the interviews that I provide to be archived in the TU Delft repository so it can be used for future research and learning.	☐	☐
12. I understand that access to this repository is publicly available	☐	☐

Signature

_____ _____ _____

Name of the participant Signature Date

Study contact details for further information:

Stefan van der Maarel

[redacted]

s.j.m.vandermaarel@student.tudelft.nl

D

Summaries of the interviews

D.1. Participant 1

The participant mentions that DeFi lending systems have the potential to enhance the integrity of the financial system by removing personal information and ensuring transparency in lending decisions. The model can be complemented on the benevolence part by adding the programmability of money. Overall, there is still a high level of trust in established financial institutions, because they have a track record that remains important, particularly in the mortgage market.

Concerning the current trends and regulations, it is slow but incremental steps are taken toward digitalization in finance. Especially in the highly regulated mortgage market, the process is much slower compared to other activities. Considering The Netherlands, they mention that speeding up the (DeFi) process can only be achieved by investing time and attention and that there are more choices at the national level rather than coming from Europe.

Tokenization can be applied very well to the mortgage market by breaking down a mortgage into smaller pieces, allowing retail investors to get involved more easily. Legal adjustments are necessary to realize this because it might involve the transfer of property rights on a more frequent basis.

The participant believes that the government should play a leading role in adapting legislation and regulations to allow for DeFi in the mortgage market. A more realistic first step would be to start with the low-hanging fruit, to see how it performs before implementing it across all processes.

D.2. Participant 2

The participant mentions the strong importance of transparency to gain trust. They are cautious on the question of whether DeFi can increase the integrity of the system because, in the end, people try to earn more money.

The impact of the Digital Euro on the financial system has been questioned. They mention the introduction of it can have both positive and negative consequences, and that it depends on how it is implemented and regulated. Nevertheless, the participant sees that regulations are making progress toward more digitalized ecosystems, while still a lot must be done.

The participant mentioned their difficulties of creating debt in DeFi and blockchain-based systems, the traditional system is built on that, and it is challenging to disrupt that. A crisis could be a reason that will lead to this change because then it will become clear what system works in difficult times. An alternative concept is discussed where the mortgage loan can be performed through fractional loans by tokenizing these assets, which could become more accessible for starters, for example.

Finally, it discusses how blockchain technology can be applied in the financial sector and how banks can distinguish themselves in a changing ecosystem in which blockchain plays a role. The speaker emphasizes that trust, transparency, and collaboration are crucial for the successful implementation of blockchain technology in the financial sector. They think the technology is ready for it and that there must be thought of ways to bring this technology to the general public.

D.3. Participant 3

The participant mentions that DeFi could lead to cost efficiency by being able to remove intermediaries via smart contracts.

They discuss that the financial sector is a conservative market, it concerns large amounts of money which must be handled carefully. This makes change difficult and slow. Nevertheless, the financial market is changing, but in incremental steps.

Competition could be a big driving force to speed up the process. Although most people are loyal since they highly value the reputation of traditional finance companies, new entrants could focus on user-friendliness and ease of processing. Marketing could be a good method to gain attention effectively.

They also mention the difference in generations on the perception of trust toward DeFi and TradFi. Younger generations tend to trust DeFi much more.

They say that RMBS (Residential Mortgage Backed Securities) and mortgage funds are already existing ways for investors to invest in (parts of) mortgages. For the tokenization of mortgages, there are still steps to take, but it is based on the same concept

The participant thinks that the influence of the Digital Euro is marginal, and is in its current form problematic for the European Central Bank because it could decrease the overall money flow.

The role of traditional finance companies is that they are direct competitors because they offer the same product. They can distinguish themselves by user-friendliness, customer service, and ease of processing.

To adopt DeFi technology, society must see proof that it really works and is indeed a better alternative. The first steps can be made by competitive players but should be done carefully and in incremental steps.

D.4. Participant 4

The participant discusses the current situation where every financial institute performs its risk assessment based on its data. They propose there should be verifiable data from the government or a selected trusted party that can provide GDPR-compliant data, which could be used by other companies and thereby lead to efficiency advantages.

They mention that more accessible data improves transparency, results in less uncertainty and hindrances, and could eventually lead to lower interest rates. The KYC process is an example where such efficiency advantages could be gained with blockchain technologies. The impact of a DeFi lending system could be that there will be less fraud and that the mortgage providers have a better overview of who can be trusted.

The duty of care of mortgage providers should be considered carefully within the DeFi lending system.

Although Dutch banks currently have a competitive advantage because they can borrow money cheaply from the ECB, their position is challenged by new market players. The participant thinks that startups and fintech will probably take the innovation lead. TradFi must remain competitive by being innovative, which will be challenging for the frontrunners since they are large established firms.

The adoption of new technologies requires a balance between trust, regulation, and efficiency improvements.

D.5. Participant 5

The participant believes that DeFi's impact on the integrity of the financial system depends on how it's constructed. A shift towards DeFi would require building a good reputation over time, demonstrating real use cases, and low default rates. Here, DeFi needs to prove its capability in both low and high-interest rate scenarios.

They discuss the need for additional security in DeFi, particularly related to collateral value monitoring to cover potential losses in case of defaults.

They mention that the current financial system has been built over decades and is efficient, especially in the security and derivative capital markets area. Traditional finance companies have a lot of credibility due to their long history and experience in risk assessment. DeFi might be seen as an alternative for those who struggle to get loans from traditional finance companies.

The participant mentions the strong reliance on a track record for DeFi to be applied to the mortgage market. Starting with securities that require less trust is a better alternative to start building a reputation.

D.6. Participant 6

The participant discusses the level of consistency for the model which is an extension of the predictability parameter to make the model more dynamic and automated. They are curious about the adaptability of the model itself in times of changing economies. Traditional finance builds their models based on risk management, which is sometimes done subjectively.

Competition was identified as a significant challenge for newcomers in the mortgage market, particularly among established players. Making processes easier, faster, and more user-friendly will help new entrants to stand out. This approach has already been proven to be effective for fintech companies.

Experience emerged as a vital element in gaining users' trust. People tend to be cautious early adopters, but once they see others successfully using a service, they're more likely to do the same.

The participant mentions that building trust in DeFi lending systems requires a combination of factors, including user experience, transparency, and time to establish a track record of reliability, all while facing heavy competition in the mortgage market and addressing potential generational differences in adoption.

D.7. Participant 7

The participant emphasizes the importance of supervision of blockchain technologies, similar to how traditional finance companies are audited by accountants. If tasks will be standardized through algorithms, supervision is necessary to enhance the quality.

They also mention the subjectivity within the data set used by traditional financial companies which could lead to a biased model, resulting in differences in mortgage allocations.

User's transactions can also be used as an additional source of information, even though it is only indicative since it is one-sided. Furthermore, they suggest that banks should look more at customers' lifestyle development and career prospects when granting mortgages, in addition to traditional financial data.

They mention the loyalty that banks currently hold, which could change over generations. Banks have three key tasks which are advice, funding, and risk management because they distinguish themselves on customer satisfaction and user-friendliness. Other tasks like processing transactions and operations can be replaced by innovative technology such as fintech and DeFi.

The potential impact of DeFi on the financial sector is the importance of transparency and integrity within DeFi projects. New entrants could benefit from having less legacy to deal with.

The digital euro could have a positive effect on innovation within the financial sector, although traditional finance companies are not favored by it.

The biggest challenge for adoption lies in gaining the trust of the people by proving it with a track record, which requires time.

D.8. participant 8

The participants emphasized the importance of having a Decentralized Autonomous Organization (DAO) behind a DeFi lending system to set rules and requirements and it must be clear where the money is coming from. Next, it should mention if the system is based on Fiat or cryptocurrency.

Trust was identified as a crucial factor in DeFi lending, with transparency, clear rules, and predictable consequences for non-payment being essential to building trust.

They expressed their belief that for a DeFi lending system, the reliance on banks should be completely eliminated since they are centralized and prioritize their own interests over their customers. The terminology should change as well because for DeFi you would talk about fees rather than interest rates. People must understand the clear difference.

The participant mentions that we are currently in a transformation phase and every generation has their own perception of distributed ledger technology. Here, the European Commission tries to stay in control by rolling out the Digital Euro.

The decentralized finance system could work if the people are educated. This

education must be understandable to everyone. They emphasized the need to strike a balance between regulations and user-friendliness in DeFi lending systems.

Overall, the participant's perspective focused on making DeFi lending systems accessible, understandable, and trustworthy, while minimizing unnecessary regulations and the involvement of traditional financial institutions like banks.

D.9. Participant 9

The participant believes that the integration of DeFi within the current financial system will be more evolution than revolution. The new infrastructure based on DeFi can then be implemented within the current financial system.

They discuss the role of regulations in shaping DeFi lending infrastructure, mentioning that regulators are increasingly interested in integrating DeFi into existing financial systems while still ensuring compliance with rules such as KYC (Know Your Customer) and anti-money laundering.

While they acknowledge the current necessity of banks in society, they note the limitations imposed by regulations and suggest that capital markets and private capital markets can play a crucial role in exploring opportunities beyond traditional banking.

They mention the geographical differences in trust in the financial system. Where Europe, problems are more concerned with privacy or the accessibility of users' data, while Brazilian users are more concerned about security because of higher crime rates. Also, the interest rates are generally higher, which opens the possibility of trusting new solutions and therefore having more competition. This results in it is more difficult to enter the financial market in Europe rather than Brazil.

The participant highlights the importance of improving user experience, reducing costs, and creating better DeFi products to drive adoption in the financial sector.

D.10. Participant 10

The participant believes that a DeFi lending system can enhance the integrity of the financial system because it is predictable and automated. The system operates in a transparent and automated manner, reducing the need for trust in intermediaries and providing clear information on lending and borrowing.

They discuss the emergence of lending pools as an example of how this technology can be implemented in a decentralized manner. It can make borrowing money cheaper and more accessible for individuals while also enabling better returns for lenders. It allows for greater transparency and accessibility, potentially opening up lending opportunities to a broader range of participants. Considering the trends in regulation, these are not entirely clear among the whole DeFi space. DeFi lending remains a relatively gray area in the context of such regulations.

The participant mentions that banks may evolve their role in response to DeFi, potentially becoming intermediaries that provide loans into larger lending pools for investors, shifting some of the risk from the bank to investors. Banks could still have a role but might need to adapt to the changing landscape.

The transition to DeFi lending might require a shift in people's perceptions and trust. Currently, individuals often rely on established banks, and convincing them to trust a new DeFi system may be a challenge since banks have a strong reputation.

Considering the adoption of DeFi lending systems, companies need to build strong brand images and user-friendly interfaces, ensuring that users don't need to fully understand blockchain or DeFi to use the system effectively.

D.11. Participant 11

The participant believes that automation, decentralization, and transparency in DeFi can help increase integrity in financial markets, taking out unhealthy human behavior.

They mention that the biggest hurdle is on regulation, where MiCa could accelerate it forward because it brings regulatory clarity. A change in mindset and generation gap can impact DeFi adoption by traditional financial institutions and regulators. They also think that Europe lags in digitization to other regions like Asia.

The structure of the Digital Euro is quite uncertain now, but the participant is convinced that it can increase efficiency in the financial markets. The future should however not be dependent on the Digital Euro, but on protocols that have proven to be well designed such as Ethereum and Aave. Solving the blockchain trilemma will be groundbreaking for the technological advancement of DeFi.

The participant discusses the future of the financial system, where they see it first as a hybrid phase where two ecosystems (DeFi and TradFi) will run in parallel and merge progressively where eventually everything will be tokenized. They mention the large potential for automation and smart contracts to optimize processes in the traditional financial system.

The participant mentions that building trust in DeFi is important for its adoption, and trust can be enhanced through protocol design and safety mechanisms. These mechanisms are for instance on the collateralization rations, which is again a trade-off between capital efficiency and stability.