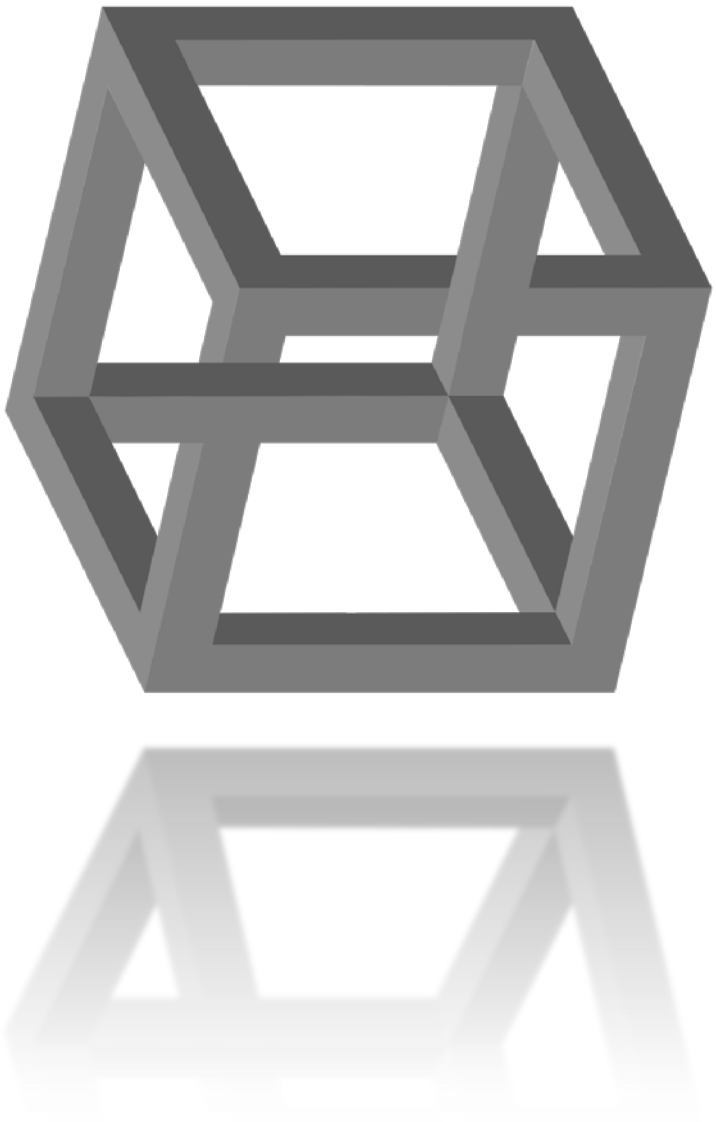
Block and Mortar

A blockchain-inspired business model for a mortgage funding marketplace



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Colophon

Project title

Block and Mortar

A blockchain inspired business model for a mortgage funding marketplace

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Preface

Before you lies the result of eight months of research and design. This report is to show my academic competencies to obtain a master's degree from the department of Management in the Built Environment (formerly known as Real Estate & Housing), at the faculty of Architecture and the Built Environment at Delft University of Technology.

This all started with a slowly increasing interest into financial technology, especially for the domain blockchain technology. Taking note of Bitcoin, obviously, but more importantly seeing major financial institutions turn towards it late 2015. It made me wonder: if it can revolutionize financial transactions could it also revolutionize real estate. Real estate investment was at that point my main focus, being the result of my study and two internships. By 2016 I had found out that real estate wasn't my thing and that not much new happens in real estate, those things being correlated to some extent –or fully. I saw these developments as an opportunity to venture off.

During the summer months and in preparation of my graduation I decided to delve into blockchain and to start calling around and writing some emails. With a little help from long time Bitcoin evangelist Derek I first came into contact with Deloitte. Another option was Rabobank, but I finally settled with ABN AMRO's Innovation Centre. The reason for this was my immeasurable genius to google: blockchain + TU Delft, and finding out about Dr. Johan Pouwelse and his Delft University of Technology Blockchain Lab. He was just about to get himself into a joint venture, and the rest is history really.

Not really. I'd now landed a graduation internship at a bank and a research subject at a computer sciences faculty. If you miss the words real estate, housing, management or built environment, so did my mentor at that time. It was Professor Peter Boelhouwer who saved the day. I found that mortgages are as important to a bank as they are to consumers buying a house. This fitted within my curriculum and with Professor Boelhouwer, who literally is the go-to guy for news outlets having any questions regarding the housing and mortgage market, the team was complete.

With Stephan Hagens as my partner in crime at ABN AMRO we set off to determine the most relevant business case. The mission was now two-folded: one part being this thesis, the other to manage the development of a prototype –a minimal viable product- that made use of the blockchain technology of the Blockchain Lab. Both processes progressing iteratively they would inform each other. Finding out what was what turned out to be a challenge on its own. Being part of a joint venture between the Delft University of Technology Blockchain Lab and ABN AMRO has allowed me to develop an insight in the current state of blockchain technology as well as in mortgage funding, and the financial sector in general. It was Dr. Pouwelse who first introduced the concept of blockchain based mortgage funding and Prof. Dr. Boelhouwer who guided me towards a coherent and structured thesis.

Developing the prototype is not part of this thesis. The end product is a design for a mortgage funding marketplace and its underlying business model. However, because of the extent of involvement it made sense to include more in-depth descriptions of the DUT blockchain technology and its applications –the prototype and the decentral market. These can be found in the appendix.

I want to thank both Peter and Johan for their guidance, insights, constructive criticism and enthusiasm. It has been a little different from normal graduation tracks, I hope I didn't cause you to much trouble. Of course I want to thank Stephan for introducing me into the world that is ABN AMRO Innovation Centre, working together on trying to make this project a success and making this graduation process so much more fun. Everyone at ABN AMRO Innovation Centre for giving me this opportunity, and being incredible supportive, genuinely interested and always willing to take time for a brainstorm or finding new contacts within the bank. Ineke, thanks for watching over me. Sytze and Patrick for the introduction into the mortgage department of the bank. Bram, Michel, Marc and Charissa for the multiple moments I stole some of your valuable time to gain invaluable insights. And of course all my other respondents. Last but not least, and especially important for my survival, my dear Sophie. I genuinely lack any clue as to how you still like me after this, but I love you for it.

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Summary

See next pages.

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Abstract

This research proposes a business model innovation for mortgage funding for Dutch system bank ABN AMRO. A digital marketplace is found to best bring added value for the involved stakeholders, primarily investors, loan originators and borrowers while mitigating the risks found in traditional processes. The digital platform requires a technological infrastructure, for this blockchain technology is researched but currently found underdeveloped to support the complexity of mortgages and mortgage funding. It is concluded that for the project to continue the initiator must decide to either focus on the development of the mortgage funding marketplace or to continue experimentation with blockchain technology frameworks with less complex assets and processes.

Keywords: Mortgage funding, blockchain, marketplace lending, financial sector, business model innovation

Intro

The products and processes in the financial sector are changing. Institutions like banks and their business models are under pressure. There are two factors most influential: technology and regulation. Most banks work with technological infrastructure that is stemming from the 1980's at best, with programming languages first developed in the 1950's (Deloitte, 2008; Mckinsey, 2010; Capgemini, 2017). Blockchain technology is believed to secure data integrity and increase efficiency and simplicity in financial systems (WEF, 2016). Different kinds of policies are implemented; some focused at increasing competition of which PSD2 is an example, and some to lower risk of which Basel III and IV are examples. These have a major impact on the balance sheet positions of Dutch system banks, mainly because of the size of their mortgage portfolio (FD, 2016; FD, 2017). Up to 40% of funding can stem from the capital markets and this is usually through secured debt funding, which apart from being vulnerable is a costly process introducing a variety of risks. It was the secured debt market that primarily caused the great financial crisis of 2008 (Ivashina and Scharfstein, 2010). The low interest rates have had pension funds and insurance companies looking for alternatives to state bonds (DNB, 2015). The rise of these competitors has been swift because of leaner operations, aided by technological advantages the operational costs can be half that of traditional loan originators, so they can better serve the borrower. It is within this context of challenges and opportunities that a new business model should be sought. Technology, such as blockchain, might allow a more efficient process and flexibility to anticipate on changing regulation and market dynamics.

Methods

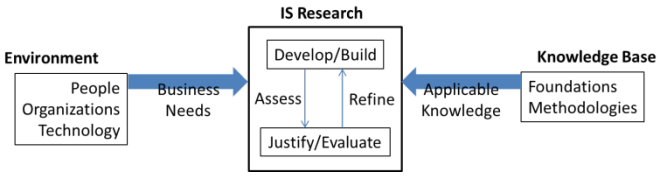


Figure 1 Informatio System Research framework (Hevner et.al, 2004)

This study will propose a business model innovation through a technological infrastructure. It is 'aimed at improving the effectiveness and efficiency of an organization' [through information systems] (Hevner, March, Park & Ram, 2004). To properly conduct and evaluate design research the conceptual framework of Hevner et. al. (2004) is used, this framework structures the thesis. It is made up of three elements: the knowledge base, the environment, and information system research. **The knowledge base** provides the raw materials from and through which IS research is performed (Hevner et. al., 2004). Answering research question number one, chapter 2 describes the domains blockchain technology and mortgage funding.

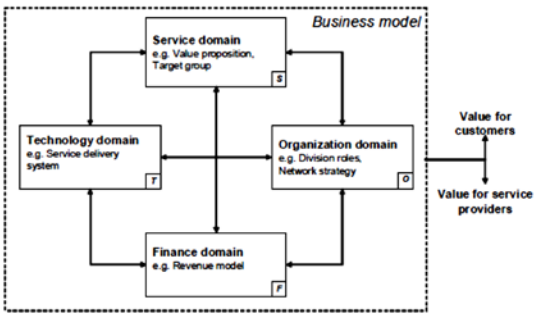


Figure 2 STOF method (Bouwman et.al., 2008)

Research question two provides a theoretical background in the sense of business model theory. The business model theory will provide a framework to address the relevant components of a business model. **The environment** defines the problem space in which the phenomena of interest reside, namely people, organizations and technology (Hevner et. al., 2004). The third research question tests the assumptions for the establishment of the value proposition to see it answers to the goals, tasks, problems and opportunities that define the business needs as people within the organization perceive them. **The information system analysis** is done in two complementary phases, a develop/build phase which is addressed through research question four and five and a justify/evaluate phase which of which question six is the representation. The fourth question establishes the specifications of the platform. The fifth question addresses the business model design, for which the STOF methodology by Bouwman (2008) will be used. It creates the following thesis structure.

Results

The research process was divided into three phases, an exploratory, execution and concluding phase. Each phase followed the structure of Hevner's methodology. In order to find relevant business needs professionals, startups and scholars in the mortgage domain were interviewed. This yielded cases on the consumer as well as the funding side, based on five criteria that included innovation potential, added value and blockchain relevance a funding case was chosen. An initial literature review established the mortgage and blockchain domain as well as the STOF business model design method. It allowed the researcher to make an initial business model design that was reviewed with a focus group interview. The most important and validated pivot was a shift of focus to a business to business proposition for smart contract based funding solutions to counter the capital requirement effects of Basel IV by outsourcing the top 20% of a mortgage to external investors.

In the execution phase consisted of deepening the applicable knowledge base and understanding the business needs to develop and evaluate the infrastructure and business model design. Making mortgage funding more transparent and liquid will add value for involved stakeholders and limit systemic risk. This can be done with a model based on marketplace lending where loans are directly connected to investors, taking the bank's balance sheet out of the equation. User requirements were researched through semi-structured interviews with representatives of insurers, pension funds, asset managers and banks on both the origination as the investment side. The further research on blockchain proved that, while promising, public variants are unsuitable for an institution's requirements and private variants still have to prove their added value. This provided the input for a second design round, the end products of which are described below.

Infrastructure Design

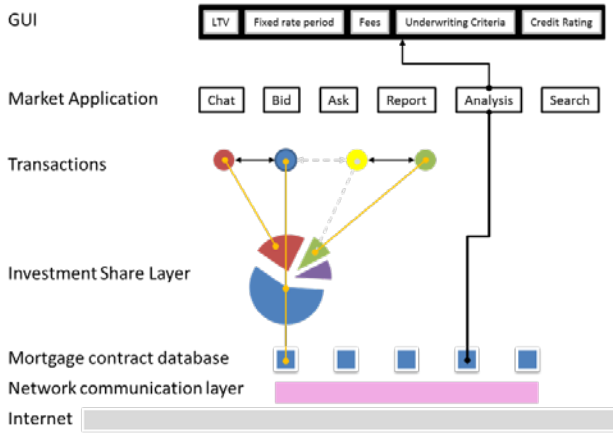


Figure 3 Infrastructure layers (own ill.)

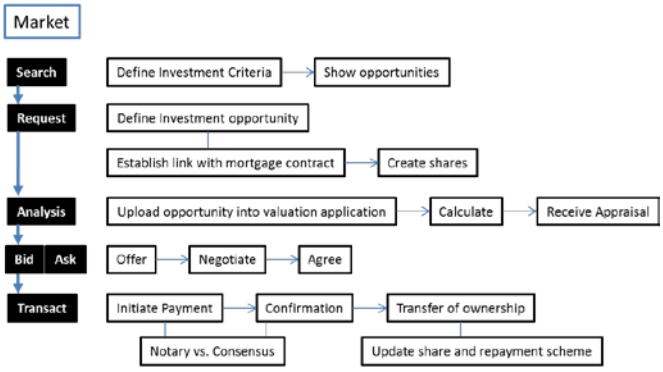


Figure 4 Process flow (own ill.)

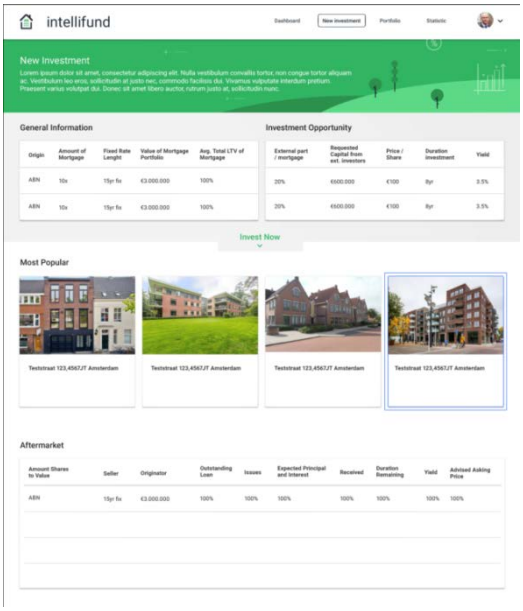


Figure 5 Final Mockup (own ill.)

Service Design

The aim is to challenge the role of the bank in the mortgage domain. We take that to the extreme by eliminating the bank's balance sheet and funding through asset backed securities.

What is the background

Capital market parties are looking for an deposit alternative with a better return than state bonds. Mortgages can be an attractive asset class but current investment process are costly, risky and illiquid.

At the same time current trends in regulation, technology and competition forces banks to reframe their position towards mortgages.

> *Think of Basel IV, PSD2, Blockchain technology, Investment managers and non-bank mortgage labels by and for pension funds, insurers and private individuals.*

The process of debt funding introduces systemic risks and moral hazards while essentially giving capital market parties a deposit alternative in the shape of mortgage market exposure.

> *Refinancing risk because the horizon of the bank's balance sheet is about 7 years. Lack of transparency in valuation and performance. Absence of a secondary market. The process of securitization is costly and involves many specialist actors like lawyers, credit rating agencies and trust funds, who all receive fees.*

Capital Market parties with a conservative investment strategy looking for a deposit alternative are increasingly looking to the Dutch mortgage market for exposure. Yet entry barriers prohibit full involvement.

> *Understanding of the Dutch mortgage system. The variety of products and prepayment policies, the high LTV's and the fiscal subsidies and guarantees. This makes pricing hard and liquidity low.*

Solution description

What is the value proposition?

A marketplace for mortgage funding is proposed. Loan originators (like the bank) will be able to match (to be) issued mortgages with capital from worldwide capital market investors.

Streamlining the transfer of ownership of loan based securities creates more liquidity and therefor fair pricing. This requires full transparency of the underwriting and performance of the loan as well as its audit trail.

This platform creates access through matchmaking, flexibility and speed thru transparency (i.e. efficiency in debt funding) and therefore a liquid market for loan originators and investors alike because:

I. It has the ability to show new investment opportunities and capital offer.
   And facilitate transfer of ownership for liquidation of positions at any time.
II. Creates insight in the performance of the mortgage portfolio through clean data and statistics
III. It increases the ability to find and develop ideal risk/return propositions because of a technological infrastructure that allows for multiple investors in one mortgage.
IV. It creates an immutable audit trail, so ownership can be tracked and cash flows directed to the right investors.

A more liquid market for mortgage funding creates fair pricing, but needs transparency. A transparent yet secure database structure should be used to facilitate and record transfer of ownership in a secure and transparent way.

Stakeholder Journey

How do the stakeholders act on the marketplace?

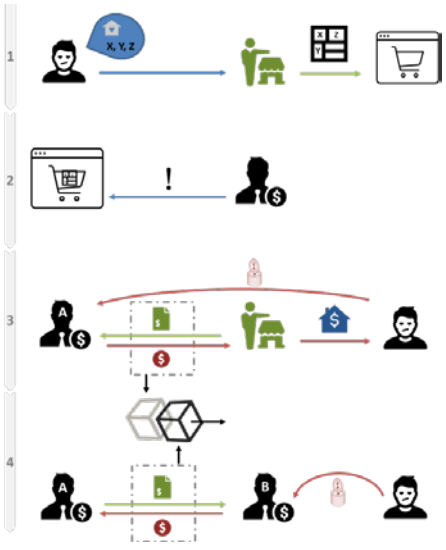


Figure 6 Stakeholder Journey (own ill.)

1. The loan originator places funding-requests on the marketplace. The funding-requests contains the characteristics of the mortgage. At the same time, the investors can indicate their appetite and originator's offer is based on these capital pledges.
2. Investors find investment opportunities that match their preferences

3. The investors invest and get ownership in return. The mortgage is funded and the consumer buys his house.
   The transfer of ownership is recorded in the database
4. Later, when the investor wants to liquidate his position, he sells his ownership to another investor. Principal and interest payments are redirected to the new investor.

Targeting

How to define the target group?

The platform's main usage is a marketplace. There are two user groups here. The loan originator and the investor. It is the aim of the platform to match the two. The loan originator supplies the mortgages and the investor supplies the capital. Note that "the bank" can be both.

The market of loan originators and investors is very broad and international. A platform can neither reach nor facilitate a global audience directly. Initially a small group of selected originators and investors should dedicate their resources to a pilot that showcases the potential of the platform. Preferably originators with a need for experience in creative funding solutions and investors willing to assume a slightly different risk/return proposition. If this pilot succeeds it will yield both learnings as well as exposure, which will create traction among other users. First though, the focus should be on assembling this initial group of customers. The platform creates additional opportunities. Multiple additional services can be offered, such as risk analysis and reporting, but these are second tier services.

Creating value elements

How to create value for the targeted users of the platform?

For a marketplace to function, parties should trust each other. Trust can be achieved by offering quality of service, security through technology, transparency in counterparties and fair pricing.

The marketplace platform offers the users access to the Dutch mortgage market. Dutch mortgages in itself are an attractive investment product with historically low risk and decent return. Liquidity risk premiums are avoided on this platform because the products can be traded in a quick, secure and transparent way. This is because of standard product formats (universal prepayment fines, basic terms and conditions, no insurance policies), insight in the performance of the asset (through monitoring) and benchmarking and appraisal tools.

Table 1 Value elements

Access.
- *Customised exposure* to mortgages for investors
- Access to funding for loan originators
- Intuitive User Interface

Liquidity and Speed
- Transparent standardized products
- Compliance upfront
- Automatic Matchmaking
- Integrated payments
- Always an Exit

Fair Pricing.
- Benchmarking
- Analysis tools
- Standardised product requirements
- Standardised pricing advice

Trust.
- Security through cryptography
- Monitoring Asset performance
- Analysis of market, assets, bechmarks

Additional Services
- Asset Management
- Risk-as-a-service

Branding

The initial branding should focus on assembling the starting coalition. This has more to do with credibility creation than a marketing campaign. It requires a clear pitch and marketing as well as internal sponsors who will bring both credibility and sufficient scale. This proposition is fundamentally different from the bank's current business model and would require senior sponsorship, the executive board.

Customer retention

To stimulate recurrent usage of the service the key unique selling points should be continuously secured. The provider should guarantee liquidity and therefore take the role of market maker. This requires temporarily taking mortgage shares on the balance sheet to smoothly match supply and demand.

Mortgage loans are long term loans and cater to long term capital. This acquire and hold attitude contributes and instigates long term relationships between platform and users. Better maturity matching would benefit the balance sheet of the bank, which is more suited to short term positions.

Finally integration of related services and business needs can contribute to enduring use. Investment advisory could be one of these services.

Technology

This domain describes what functionalities and capabilities are demanded from the technology in use and how these could be achieved. The main functionality of the platform is transfer of ownership.

Security

Authentication and underwriting. Logging onto the platform should require at least multi-factor verification. A public/private key pair should also be made available to show data and make investments only for permissioned and verified actors.

Administration. A mortgage management system, similar to Stater but more flexible, should make sure payments are monitored and fraud is prevented and recognised. Repayment delays should automatically alert special management. The administration should record the various investors and distribute income among these investors. When investors sell their share, the system should automatically update and reroute income to the new beneficiary.

Payments. The safest way for payments currently is a connection with the back-end of a bank, through clearing. This will serve as a connection with the swift, iban or sepa network for bank payments. However this compromises the speed of transaction. A preferred alternative would be a cryptocurrency as the consensus algorithm would solve audit and payment security.

Messaging and documents. The investment bids and asks should be obscured for everyone except those involved. This can be done either by cryptographic securing of the data or the sender and receiver addresses. A TOR-network like solution could be used.

Quality of service

The strategy for user satisfaction is to develop the platform with a starting coalition of users. A maximum of one loan originators, 2 investors and a technology provider. This way the experience in the field of mortgage investment is exploited, the platform is given credibility through serious sponsors who have dedicated resources to bring the platform to fruition and quality of use is assured through software.

Components and applications

Complementary components can be offered through API's (an API provides a link with other computer programs). So new functionalities can be added in modules. For instance a risk analysis model that appraises the value of a mortgage. Through the API a price advice for an investment opportunity can be given. The additional components are tools for risk analysis and pricing; alerts to be send out to special management in case of delay; billing and support for the platform provider requires communication tools.

System integration

It should be possible for the originator to upload all the characteristics of the to be issued mortgage onto the platform, this is the investment product. The originator, investor and provider need to report their results internally and possibly externally. So reports require an export format. The most important information concerns:

I. Underwriting criteria (LTI, collateral appraisal criteria, job security)
II. Product terms (interest rate averaging, relocation options, prepayment fine percentage, quotation period)
III. Quality of regular or special management
IV. Origination and servicing fees

Accessibility for customers

To realise technical accessibility to the platform for the target group the application is web-based with the business logic embedded in the application layer. This way the GUI is just a pass through and can be tuned to the device in use. Mobile devices are excellent for monitoring and quick statistics as well as notifications of issues. Yet when making an investment and uploading information to the platform, the PC is expected to be more useful.

Management of user data

To manage and maintain user profiles the starting coalition must be in possession of dedicated and sufficiently secure servers in fully owned datacentres. Sensitive information by one of those parties should only be saved on one of their own servers. An account of all transactions should also be recorded by the involved parties. Data should only be disclosed by parties with permission, and only to a predetermined degree [as described above]. After view/edit permission it should be collected from the servers of the owner of the data.

Scalability

To be able to scale a modular architecture is preferable. It should offer easy API integration for additional services; be blockchain agnostic to anticipate but not depend on blockchain; be currency agnostic keep traditional connections and anticipate digital currency and finally the database structure should anticipate Artificial Intelligence data analysis.

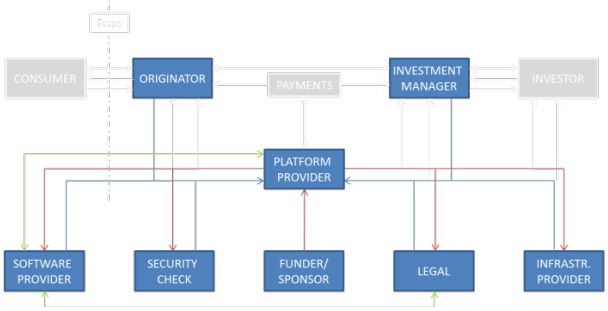
Organization

This paragraph describes what parties you need to build the platform and its services. The initial question is: “the loan originator wants to sell the right to the receivables of mortgages to investors, what do we need to make that happen?”

Actors

Role	Action	Potential Actor
Originator	Origination of loans Underwriting of loans Upload of performance data Customer support (consumer)	AAHG/NIBC/etc. Mortgage service street
Investment Manager	Portfolio management	Originator Mortgage ALM department Independent IM party
Risk reporter	(Continuous) assessor of the mortgage applier	*New role for risk modelling*
Consumer	Request mortgage Pass underwriting criteria	Starters
Investor	Buy-in Portfolio & Performance management Exit	Pension funds, Insurers (Institutionals), Banks
Payments	Transfer of currency Audit Analysis for performance management	Digital currency or API link with back-end of the bank (PSD2) Digital Currency or Cryptographic Hashing of actions Digital Currency or API Link with payments
Legal compliance	Verification Due Diligence Contract making Cadastral registration (?) Notarial registration	Start with sophisticated investors Native to the platform thru transparency Digital Smart Contracts Link with Cadastre
Regulator	Receive reports	DNB, ECB
Platform creator	Development Maintenance	Delft UT, DAH, R3, Hyperledger ABN
Infrastructure provider	Hardware: Servers	ABN or AWS/Google/Azure/IBM
Software providers	Blockchain technology	Delft UT, DAH, R3, Hyperledger
Platform enterprise check	Pen test	Deloitte/PwC/etc.
Funder/sponsor	To finance the complete effort	ABN AMRO

Value Network



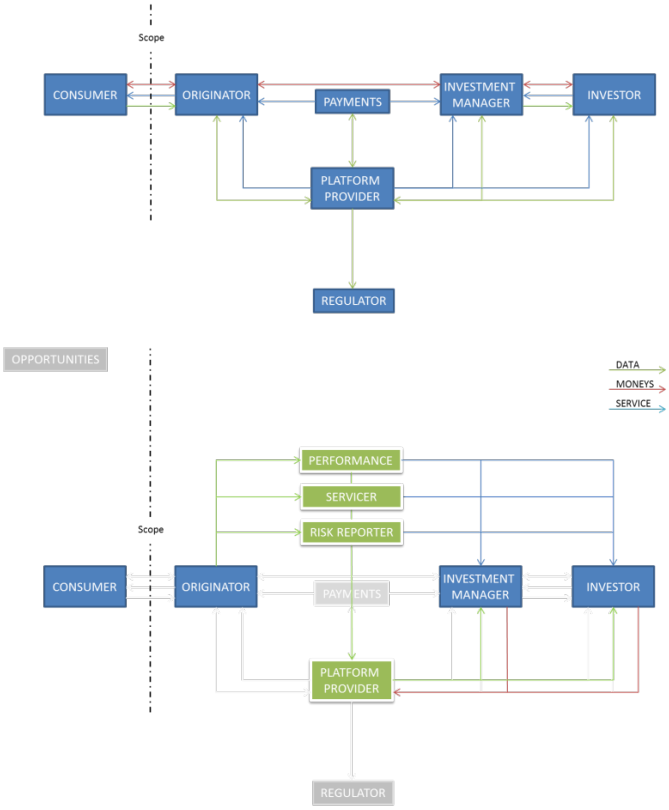


Figure 7 Value Network (a) startup (b) standard (c) opportunities (own ill.)

Partner selection

The partners should be selected based on their willingness to contribute resources to a starting coalition. Resources can be described in financial terms, dedication of people and internal services such as: legal support, hardware, a connection with payments and clearing, and linking the front end of the mortgage originator. The starting coalition should initially be comprised of the initiator/platform provider, one loan originator and multiple investors, and a software provider.

The software provider should develop the functionalities needed to facilitate the transfer of ownership. It is probable that further development will need external company. Once the platform is running its basic capabilities next steps involve the creation of additional services, such as risk analysis.

Network openness

Initially only the starting coalition members are allowed to join the network. The end goal is to make it an open platform, for this we need to create a network effect. New actors in the network can be originators, investors, investment managers, but they can also be service providers. Trade is made easy by working with standard formats. Reporting requirements depend on the stakeholder, regulators won’t have access to the platform,

but stakeholders can export the necessary data when needed.

Additional services will initially be developed internally since these are the new roles the bank should exploit. Later the underlying technology can be opened up for other companies.

The final step would be to allow consumers to join the platform. The platform should at that point have the capabilities to support a consumer, such as advisory and a connection to consumer defence (AFM or the tax authority). The moment that anybody is allowed to join the network a digital identity framework should be in place.

Network governance

The network is led by the initiator, ABN AMRO. ABN provides the keystone, it manages the initial partnerships. It serves as the platform provider. This differs from the software provider, who develops the platform. The platform provider should not be responsible for the deals that are made on the platform. The legal framework has yet to be designed.

Network complexity

To manage increasing number of actors in the value network the foundations should be solid, meaning the asset performance is transparent and the transfer of ownership is legal. All new participants should be reviewed and new roles only added later in the development of the platform.

Internal Governance

To create credibility and sustainability of the platform sponsorship should come from the executive board. Legal and financial boundaries should operationalise the concept and IT and mortgage (funding) market expert should then execute it.

Financial

Investment sources and capital

Platform

Investment sources for the platform are primarily the starting coalition, which would include ABN AMRO, a couple of investors and a technology provider. Capital is both cash an human resources.

Product

For the product the sources of capital are the main stakeholders: the investor, originator/servicer and platform provider assuming the role of market maker.

Cost sources and costs

Platform

Platform costs stem from the development and maintenance of the platform, this includes hardware and software costs. Additionally costs are expected for the branding and marketing of the platform to increase its user base. And finally costs in supporting the users and offering them additional services.

Product

The pricing of the mortgage product is based on four cost sources: operating costs, illiquidity and credit risk premium, funding costs and profit margin. Operating costs should be around 30 bps, credit risk around 5-10bps, illiquidity risk is lower than normal around 40 bps. The funding costs and profit margin include profit for the investors as well as the originator/platform provider and are open to bargain.

Revenue sources and revenue

Platform

Platform revenues stem from a Platform fee per trade, a risk reporting fee per risk report and originator and management fees (if the platform provider is also the originator).

Product

With regard to the product every investor gets a return relative to the amount of risk he is taking. The originator avoids capital requirement costs. By using syndicated mortgages these reserve requirements are lowered and the return on equity increases.

Risk sources and risk

Platform

The most important risks to the platform are competition and attacks resulting in going offline or losing data. If new concepts are used, such as blockchain, there are a lot of unknown unknowns which could result in the platform being compromised. Finally being a market maker introduces balance sheet liabilities, also contradicting the disintermediation the platform aimed to achieve.

Product

Asset risks. The credit risk lies at the investors. The credit risk of Dutch mortgages has proven to be very low, it barely affects the margin. However, this is reasoned from portfolio scale, on micro level it is nearly impossible to predict. This is why diversification is important for the investors.

Mortgage market development. One does not simply build 200 billion in new real estate, so the rising house prices trend is expected to continue. Rising house prices and strict regulation decreases the ability for starters to buy a house, which decreases movement in the market and eventually create some form of counter-effect, either a stabilizing or declining effect.

Capital requirements change. If the Basel lobby succeeds and Dutch mortgages retain their excluded status there will be a lot less pressure to change the current business model of balance sheet lending. However, the key value element of the platform, liquidity, remains unchanged independent of the Basel outcome.

Registration of complex syndicated mortgage. Although currently out of scope, there is the risk that mortgage registrars fail to register multiple mortgage funders to one mortgage.

Pilot risk. Mortgages run for 30 years. This can change a pilot into a costly liability, as failure would yield high costs and low income.

Additional risks to the product include investors defaulting and risk and return not aligning for investors.

Pilot

The first pilot case will be the syndicated mortgage. This will allow the mortgage to be cut into pieces and sold to different investors. The advantage is that every investor gets a risk-return proposition to his liking. It creates flexibility for the bank to fund the bottom part of the mortgage reducing the capital requirements from basel and increasing the return on equity. Because of this the borrower can get a much more attractive interest rate offer while still borrowing a 100% of the value of the home.

Step #1 Find the optimal ratio

Based on a dynamic table the optimal LTV ratio is determined. The input is comprised of the current mortgage interest rate levels of the bank and the competition, the fixed rate period, and the Basel IV capital requirements.

The aim is to offer an interest rate that is significantly cheaper than the competition, a difference of 0.2% was chosen.

For a 15 yr fixed period, the aimed interest rate is 2.55% (competition is 2.75% by Delta Lloyd[1]). The optimal ratio is 80% for the bank and 20% for the *external investor(s)*. This is the point where the investor has the highest yield and the bank relatively the most attractive position with regard to Basel.

	Interest Rate
Bank (80%)	2.36%
Investor (20%)	3.19%
Consumer	2.55%
Competition	2.75%

Learning. The model shows that the longer the fixed income period, the harder it is to beat the competition. The advantage for the external investor decreases and the spread for the bank as well.

Step #2 Create repayment schemes

As an example a mortgage of €275.000 was chosen. The mortgage borrower needs a mortgage of 100%. 55.000 euros (20%) will be funded by external investors, 220.000 euros (80%) by the bank. The borrower pays an annuity (principal+interest) of €1093,- monthly.

The 55.000 euros are repaid in 98 months (roughly 8 years), the investor receiving €646,- monthly on principal and interest. This means that for the first 98 months the bank

[1] https://www.hypotheek-rentetarieven.nl (retrieved April, 2017)

receives €447 and from month 99 until 360 the bank receives 1093 euros.

The Basel capital requirements are calculated as costs. The costs are the profit that you could have made with the money that is now in reserve.

€275,000 * RWA * Capital Requirement * Floor = €9,075

The RoE of ABN AMRO was 13% over 2016, this gives:

(9,075 * 0.13)/12 = 98.3

So the income is 1093 – 98.3 = € 995

However

At an LTV of 80% the reserve = €4,620

Monthly cost drop to €50.-

Income for the bank = €397.- for the first 98 months

Step #3 Calculate RoE

To be able to evaluate the proposal the return on equity is calculated. The formula is:

Return on Assets * Equity ratio = RoE

Where return on assets is the yearly turnover divided by the assets (the original investment). And the equity ratio refers to the funding mix for each share. This is **not** the earlier mentioned bank-to-investor ratio.

- This funding mix is currently set at 100% own equity to avoid confusion.
- Since mortgages are a long term investment inflation is considered at a rate of: 1%
- The bank still manages the mortgage, for this the investor pays a monthly fee of: 2%

The result is:

	Return on Equity
Bank (80%)	14.69%
Investor (20%)	13.29%
Benchmark – Bank (100%)	14.27%

The benchmark is a trivial one, it is purely meant to show the effect of Basel on the RoE. Because it describes a situation where the bank would have funded the whole mortgage at 2.55%. However, this is not possible, the lowest rate at LTV100 from the bank is 2.86%, which means it would not have been chosen by the borrower.

Step #4 Scenarios

Keeping other variables equal, scenarios are shown below.

Difference with the competition. It should be researched at what price difference a consumer changes its mind, because of all the internal tweaking this has the greatest effect.

	0.05%	0.20%	0.25%
Bank (80%)	14.95%	14.69%	14.67%
Investor (20%)	13.69%	13.29%	13.16%
Benchmark (100%)	14.56%	14.27%	14.18%

Capital Floor of Basel IV. Logical results, the lower the floor, the higher the RoE.

	50%	75%	100%
Bank (80%)	14.88%	14.69%	14.50%
Investor (20%)	13.29%	13.29%	13.29%
Benchmark (100%)	14.47%	14.27%	14.08%

Inflation. Since the investor is repaid first, the bulk of repayment for the bank comes in year 8 and beyond. The higher the inflation the lower the net present value and the lower the RoE.

	0%	1%	2%
Bank (80%)	17.40%	14.69%	12.49%
Investor (20%)	13.85%	13.29%	12.77%
Benchmark (100%)	16.55%	14.27%	12.42%

Fixed Rate Horizon. Why does the RoE increase on a fixed rate longer horizon. The bank to investor ratio changes from 80/20 to 67/33 which means lower capital requirements for a longer time.

	10yr	15yr	20yr
Bank (80%)	14.69%	14.69%	15.50%
Investor (20%)	13.29%	13.29%	13.20%
Benchmark (100%)	13.36%	14.27%	14.56%

Rising average interest rate. rising interest rates would mean Basel effects are prolonged. A higher interest rate means that principal is repaid more slowly, so assets decrease slower, making Basel more influential and this pilot more attractive. .

Maximum Consumer LTV90. Regulation to cap consumer loan to value ratios to 90% or even 80% would decrease the attractiveness of the pilot as the bank would be comfortable with funding it completely. However, the platform could alternatively be used to offer consumptive credit

Height of the mortgage. Doesn't change anything, since RoE is relative. On a macro scale rising house prices would mean generally higher LTV's at issuance, increasing Basel and the attractiveness of the pilot.

Conclusion

Main research question: Given the changing context in mortgage funding what could a new business model look like and what could the potential role for blockchain be?

A new business model for mortgage funding could be to facilitate marketplace lending. This would mean the bank develops a platform where capital market parties can invest directly in mortgages by buying them from loan originators, either partially, in whole or in portfolios. This has the advantage that the strategy towards mortgages is more flexible and capable to adapt to regulation affecting the profitability of mortgages. It implicates a fundamental departure from the current business model in mortgages (already a complex asset), from an income focused to a return on equity model. This means considerable internal resistance can be expected. The use of a public blockchain architecture would make rapid deployment impossible, it is simply non-compliant with the present day user requirements of financial institutions. Using a consortium or private blockchain or blockchain inspired solution is currently considered unconvincing, it sacrifices data integrity (one of the pillars of blockchain) to comply to financial sector requirements. Using a centralised database can still offer many of the functionalities expected from 'smart contracts'. If you want an egalitarian system for the (conditional) transfer of value, use blockchain. But this comes at the cost of full access, full transparency, a relatively costly economic incentive system, this is what makes blockchain work. If you don't want that, you're probably just desperately looking to update your administration system and cut costs.

With regard to next steps in this project the initiator is left with a couple of options. Either to continue to find an alternative for funding mortgages, or it wants to keep testing with blockchain technology for funding purposes (in the sense of public, open source blockchains). The first could yield a working product within a reasonable time span, from the second such should not be expected. The first option also implies that the bank departs from its comfortable current business model in mortgages, albeit only for an initial pilot. Still for both options some sort of consortium should be created. A base of starting customers (investors and loan originators) of the platform should be gathered to develop and optimize the functioning of the platform itself as well as securing the first line of funding of mortgages. Agreements should be made with regard to the scope (time, volume, profit and cost distribution, exit strategy) of the pilot. This requires cooperation of a wide variety of departments within the bank as well, not least the legal department.

Recommendations

There is enough interest and traction to continue the development of the platform, but it requires also further research. Most prominently business applicability of blockchain and the legal aspects of cutting mortgages into separate investment shares. The most friction came from financial sector user requirements in a blockchain environment. Especially the privacy and confidentiality aspects form the biggest question marks. Additional research should give better insights in the possibilities and limitations that certain blockchain(-inspired) technology frameworks offer. One of the research papers indicated that blockchain transactions have much in common in traditional over the counter markets. It's very well possible that the many of the regulatory framework related questions as well as other subjects are covered in this line of research.

On the mortgage funding side the valuation of individual running mortgages will be the most challenging. Additionally there is the legal part with regard to selling on the shares in a mortgage and the transfer of ownership as well the corresponding obligations. An example of these obligations can be the borrower asking to increase the mortgage. Investors should then be obliged to provide the additional funding. This then changes the repayment scheme, the yield, the risk, i.e. the value of the mortgage. The potential for a marketplace supporting the sale of mortgages with different fixed rate horizons between originators and investors is identified in almost all interviews and definitely worth researching.

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Introduction

Background

The products and processes in the financial sector are changing. Institutions like banks and their business models are under pressure. There are two factors most influential: technology and regulation. Most banks work with technological infrastructure that is stemming from the 1980's at best, with programming languages first developed in the 1950's (Deloitte, 2008; Mckinsey, 2010; Capgemini, 2017). Maintaining these systems are costly, not least because experienced IT professionals are dying of old age. At the same time new financial technologies are on the rise, blockchain technology currently being the most prominent one.

Blockchain is a decentralized transaction and data management technology, mostly known from its application for cryptocurrency (Bitcoin). Blockchain technology is believed to secure data integrity and increase efficiency and simplicity in financial systems (WEF, 2016). Many challenges persist but the technology is increasingly regarded as a means to update legacy systems. The attention has been increasing since 2008 and hit record investment highs in the first three-quarters of 2016, with billions of euros being allocated to Fintech startups, interbank consortia, institutional innovation hubs and academic research alike (WEF, 2016).

Since the great financial crisis in 2008 financial regulation aims to reduce systemic risks and dependencies. Different kinds of policies are implemented; some focused at increasing competition of which PSD2 is an example, and some to lower risk of which Basel III is an example. PSD2 allows consumers and business to use third-party providers, non-banks, to manage their finances. This dramatically lowers the entry barriers to financial services. Basel III sets out international jurisdiction on the amount of capital that a bank needs to have in reserve in relative to its assets, creating buffers for times of crisis. The follow-up, Basel IV, is currently being discussed and could have a major impact on the balance sheet positions of Dutch system banks, mainly because of the size of their mortgage portfolio (FD, 2016; FD, 2017).

The Dutch mortgage debt currently has a value of 650 billion euros, this is double the size of Germany's, and is expected to grow to 850 billion euros in the next ten years. The Loan to Value ratio (LTV) describes the height of the loan compared to the value of the collateral. In the Netherlands LTV's are generally high, until recently it was possible to lend 110% of the home value, now it has been reduced to 100% in 2018. A high LTV is considered risky since decreasing house prices leave borrowers with remaining debt which slows down movement in the market. It is also risky in case of default, as the lender's chances on losses are higher (Boelhouwer & Schiffer, 2015). Although LTV's are high the default losses are low, even during the crisis it only increased to 0.08% losses taken on mortgages (NVB, 2014). Dutch banks are highly dependent on mortgage debt, sometimes up to 50% of the credit book consists of mortgages (DNB, 2015). They take up 87% of the market share on the total mortgage portfolio, and this is primarily divided among three major system banks. Apart from vulnerability to housing market developments, Dutch banks are also vulnerable to international capital market developments as not all of newly issued can be funded with deposits –this is called the funding gap (Engelen, 2015; DNB, 2013). Up to 40% of funding can stem from the capital markets and this is usually through secured debt funding, which apart from being vulnerable is a costly process introducing a variety of risks. In short it was the secured debt market that primarily caused the great financial crisis of 2008 (Ivashina and Scharfstein, 2010).

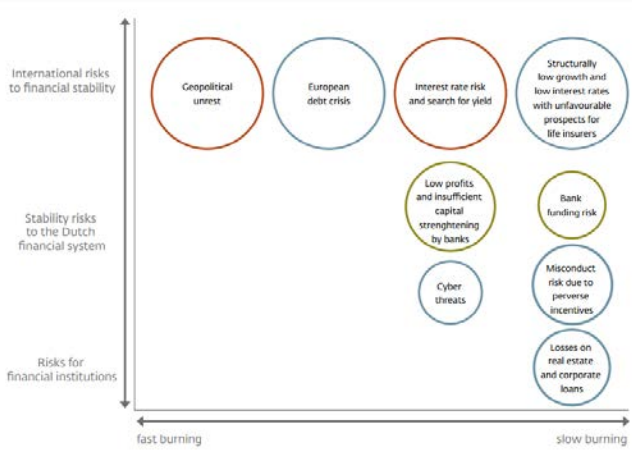


Figure 1 Risk Map for banks (DNB, 2015)

Over the past few years competition has increased in the mortgage market. The low interest rates have had pension funds and insurance companies looking for alternatives to state bonds (DNB, 2015). Asset managers such as DMFCO and Dynamic Credit offer a window to the mortgage market, erecting a mortgage label and management street to issue mortgages with pension fund and insurance capital. This has pushed the market share of newly issued mortgages by banks back to 50% during 2016 (FD, 2016b). Banks are expected to take back market share when volume in the

market increases, increasing the vulnerabilities once more (DNB, 2015). The rise of these competitors has been swift because of leaner operations, aided by technological advantages the operational costs can be half that of traditional loan originators. In the end a mortgage is issued to a borrower. The loan capacity of borrowers has also been limited, partly because of stricter regulation (i.e. the maximum LTV and a loan-to-income guideline) and partly because of a standardization in loan-offers, mainly the result of automatization attempts by loan originators. This has made it very hard for starters, independent contractors and special cases such as houseboats to be financed. Start-ups such as 'Bouwsteen Hypotheken' and 'Jungo' are seen to capitalise on these consumer demands. It is within this context of challenges and opportunities that a new business model should be sought. Technology, such as blockchain, might allow a more efficient process and flexibility to anticipate on changing regulation and market dynamics. This will reduce risks and ultimately benefit the borrower as well.

Problem statement

Due to competition in the mortgage market, technological advancements, and changing client demand as well as ever stricter regulation the traditional role of banks in the mortgage domain is under pressure. For the bank to stay relevant new business models must be researched.

Assumptions

The problem statement includes a couple of assumptions that will need to be tested to create a sound value proposition, which is the core of the business model.

- There are suitable investors for this product and process

It is assumed investors are willing and able to co-invest in Dutch mortgages.

- A new form (or added source) of mortgage funding is necessary

The current way of mortgage funding mitigates risks inadequately because it is dependent on a limited amount of capital sources.

- Co-investments yields benefits for all stakeholders and the system

It is assumed that the platform can bring value to all involved stakeholders: the bank, the investor and the borrower.

- Blockchain technology is capable of providing the necessary infrastructure better than other options

Research goal

Aim

The objective of this research is to design a new business model for a mortgage funding marketplace platform. The technological architecture of the platform should allow more flexible investment solutions, for instance the acquisition of part, a whole or a portfolio of mortgages. The technological infrastructure could be blockchain based, but this should be researched upon feasibility.

Description concepts

Blockchain regulated platform for co-funding: Co-funding of debt requires information symmetry to be efficient. Blockchain technology can be used to create a distributed database with an immutable audit trail of all interactions and transactions between the funding parties.

Dutch mortgages: collateralized consumer loans with housing as collateral issued to increase the accessibility to the housing market and support home ownership.

Business model: a business model is conceived as a focussing device that mediates between technology development and economic value creation (Chesbrough and Rosenbloom, 2002).

Questions

Main research question: Given the changing context in mortgage funding what could a new business model look like and what could the potential role of blockchain technology be?

Q1: What is the status quo with regard to blockchain and mortgage funding and what could blockchain mean for mortgage funding?

The current knowledge base is created from a review of academic and popular writing. It describes to a certain depth what is the status quo of the two domains. The advantages and limitations are discussed and finally an alternative for mortgage funding is posed and the potential of blockchain reflected upon it.

Q2: What does a business model for a platform look like?

This question is posed to establish a theoretical background for the research. Several business model theories are reviewed and compared based on a literature review and artefact specific requirements. The business model theory will provide a framework for both products, in the form of

critical design factors and process in the shape of iterative design and evaluation steps.

Q3: Is a platform for co- investment in Dutch mortgages relevant?

The assumptions described above have to be validated to establish a consistent value proposition for all involved stakeholders. The answer to this question proves both the relevance of the research project as well as that of the proposed solution.

Q4: What are the requirements of the platform and what could it look like?

The design of the platform is informed by the particular context of the mortgage investment case and in his turn influences the design of the business model. This question relates to the design of the platform and seeks to identify its requirements.

Q5: What does the business model look like?

A description of the final business model provides the answer to this question.

Q6: Has a viable business model been created?

The business model's validity is measured by comparing it to the aforementioned critical success factors and established requirements.

Scientific relevance

For the part of mortgage funding this research adds to an existing body of knowledge with regard to funding solutions. Being an explorative research it provides indications of the current challenges and opportunities seen by professionals in the market, both at traditional parties as well as newcomers. The body of knowledge on continental European marketplace lending for mortgages is limited to industry reports by consultant agencies. Finally the research aims to offer an operationalisation towards full reserve banking, acting on indicators described most notably by Van Dixhoorn (2013) and Levitin (2016).

This research contributes to the scientific literature by adding a literature review of blockchain technology and its implications on business model innovation. The literature on blockchain technology, although growing, is mostly limited to computer sciences with 168 papers available in Scopus. A limited amount of specific literature on the use of blockchain technology in business cases and real estate specific cases. Lemieux (2016) analyses the potential of blockchain technology through evaluating Factom's concept of the Honduras title transfer and admits that his account is by no means definitive or comprehensive, thus he calls for further research. The recent call for papers on the subject by leading journals like Elsevier underlines the relevance of blockchain research and includes a wide array of themes such as reputation systems, applications of blockchain, smart contracts and financial services (Elsevier, 2017).

Practical relevance

This research will show the risks, opportunities and limitations of the use of blockchain inspired technology for mortgage funding and how this could challenge and change the traditional business models.

The traditional business model of the bank has always been to attract capital in for x%, lend it for x+y%, where y is the margin for the bank. With ever decreasing margins because of regulation and competition that might now need to change. This research shows that there might be potential in disintermediation, in a Risk-as-a-Service (fee-based) business model of matchmaking.

Rising mortgage interest rates as a result of Basel capital requirements could prohibit homeownership for starters and private contractors, especially in the larger cities. Partially crowdfunding lowers the LTV ratio for the bank, avoiding the capital requirement premiums and allowing for lower interest rates. The investor will benefit from a low-risk investment and return. Validating these propositions will be the practical relevance of the project.By being part of a joint venture between the DUT Blockchain Lab and ABN AMRO whose aim it is to create a minimal viable product for a blockchain inspired application, additional insights are gained that benefit the research in describing the limitations, risks, and opportunities of blockchain in practice.

Research approach

Framework

This study will propose a business model innovation through a technological infrastructure. It is 'aimed at improving the effectiveness and efficiency of an organization' [through information systems] (Hevner, March, Park & Ram, 2004). This is a form of operational research that involves two paradigms, that of behavioural science and design science (March and Smith, 1995), is at the confluence of people, organizations, and technology and creates and evaluates artefacts (Hevner et. al., 2004). To properly conduct and evaluate design research the conceptual framework of Hevner et. al. (2004) is used. It is a popular and cited framework in the realm of design science for information systems (Scopus citations: 4062 by December 2016). Additionally, it also provides guidelines for the design of the artefact.

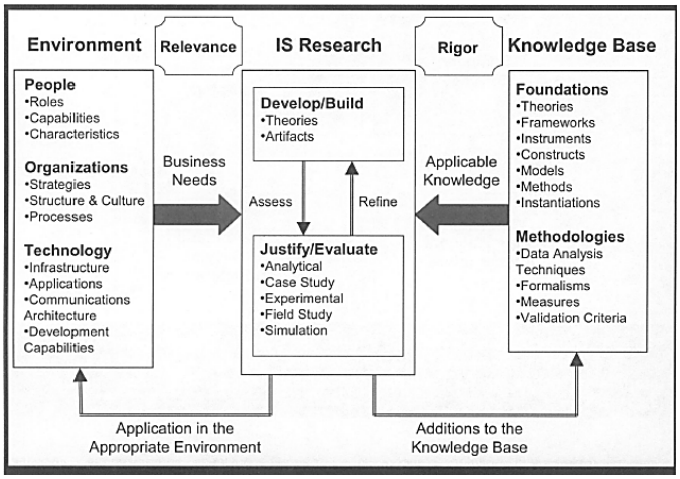


Figure 2 Information Systems Research Framework (Hevner et. al., 2004)

Environment

The environment defines the problem space in which the phenomena of interest reside, namely people, organizations and technology (Hevner et. al., 2004). The third research question tests the assumptions for the establishment of the value proposition to see it answers to the goals, tasks, problems and opportunities that define the business needs as people within the organization perceive them. As such, 'business needs' have to be considered from the platform perspective, not one single company.

Information system research

The information system analysis is done in two complementary phases, a develop/build phase which is addressed through research question four and five and a justify/evaluate phase which of which question six is the representation. The fourth question establishes the requirements for the infrastructure. The fifth question addresses the business model design, for which the STOF methodology by Bouwman will be used. The choice for this methodology is elaborated in chapter three and answers research question number two.

Knowledge base

The knowledge base provides the raw materials from and through which IS research is performed (Hevner et. al., 2004). This is addressed through research question one, to provide a theoretical background in the sense of business model theory. The business model theory will provide a framework to address the relevant components of a business model. Answering research question number one, chapter 2 describes the domains blockchain technology and mortgage funding. The knowledge base is derived from literature review and in the case of blockchain also from gray literature since it is such a young field.

Methodology

1. **Theoretical background**

   A framework is chosen based on a review of relevant literature. The literature assesses business models in general but expands on the specific characteristics of multi-sidedness and its implications for design and related theories.

   Methodology: Literature review

2. **Business needs**

   The previously described assumptions are tested through interviews. Comparable business models are analysed to determine their value proposition and draw lessons from experience. The conclusion leads to the value proposition.

   Methodology: Interviews with (representatives of) stakeholders

3. **DLT Infrastructure design**

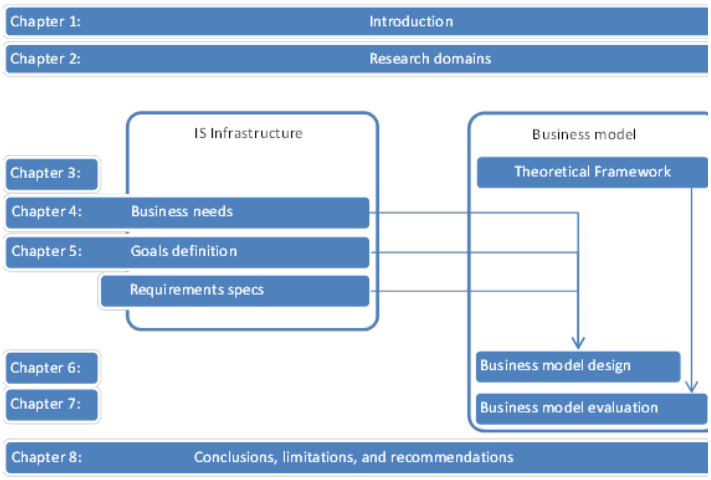
   The blockchain regulated infrastructure needs to be developed according to a set of requirements that are based on goals to be a good (regulatory) fit for its purpose of mortgage co-funding platform. However, these are constraint by the technological aspects. This design process will be done through user requirement interviews and aided by preliminary design prototypes (also called mock-ups).

Methodology: Desk research and interviews for establishing the user requirements

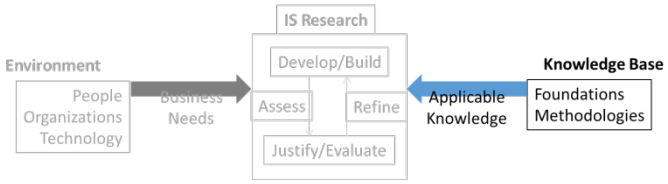
4. **Business model design**
   To explain the new business model underlying the mortgage co-funding platform, the STOF method is used. Chapter 3 explains the choice for this purpose as well as its comparison with other design process oriented business model theories. Every domain (service design, technology, organization, and finance) will have a detailed description based on critical design issues offered by the method.
   Methodology: STOF method by Bouwman et. al. (2008)

5. **Business model evaluation**
   The STOF method offers a way of reflecting on the proposed business model by way of critical success factors. The researcher discusses these issues with experts in semi-structured interviews both during as well as at the end of the business model design process.
   Methodology: Iterative design process with project team (documented in Appendix) and expert interviews

Thesis structure



2. Research Domains



This chapter answers research question number 1. It establishes the status quo of both the blockchain and mortgage funding domain. The final part (2.3) analyses what blockchain could mean for mortgage funding. Blockchain turns out to be a whole set of solutions, all with their own pros and cons, but generally in an infant state. Mortgage funding is complex and creates a variety of risks that are only to a limited extent efficiently regulated. The concept of marketplace lending is introduced to mitigate these risks. Finally it is concluded that blockchain could be used as an infrastructure for such a market, yet currently mostly on a conceptual level.

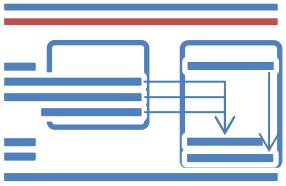
2.1 Blockchain

Intro: What is it

Blockchain technology is all the rage right now. Prominent business leaders in finance and technology have heralded the advent of blockchain as significant as the internet in 1990's. Gini Rometti, CEO of IBM said: "what blockchain will do for transactions is what the internet did for information". This is reflected in numbers, over 80% of banks globally initiated blockchain-related projects, central banks are looking at its potential, consortia have been formed by financial institutions to create standards, thousands of patents have been filed and billions of dollars have been spent (World Economic Forum, 2017).

> *Blockchains offer potential advantages in cost, speed, and data integrity compared to classical methods of proving ownership, and the scale of these potential savings has motivated investments by venture capitalists and by established players in the financial services industry (Yermack, 2016).*

This chapter has two goals. The first is to describe what "blockchain" is. One can only prove its potential by describing how it works. This description's aim is two-folded as it should also nuance some of the more outrageous claims about blockchain. The second goal of this chapter is to determine the potential use of blockchain for the mortgage funding case. It describes the potential advantages, limitations and challenges and finally creates a list of indicators. If these indicators are met in the user requirement interviews it makes sense to consider the use of blockchain technology.



There are many risks in writing about blockchain technology in its current state. It is a technology that is partially coming of age, partially in its infancy, much hyped, generally misunderstood, mostly oversimplified, and biased by business interests of a mammoth scale. This makes even academic literature sometimes more like essays than papers. It is suggested for the reader to keep that in mind while reading this chapter. The chapter is structured to describe the features of particular blockchain solutions like Bitcoin, Ethereum and blockchain-inspired solutions in chronological order. This is because every feature has its benefits and its limitations. Generalising solutions, as is often done, creates a situation where blockchain is the solution for everything. It is an explicit intent of this chapter to avoid this, as to make a an argument for the applicability of blockchain for the mortgage funding marketplace case.

There is no use in giving a general description of blockchain technology, since it is not one thing. Blockchain technology is a collective name for an entire spectre of concepts and "solutions" that were created in the wake of Bitcoin. So that will be the starting point of this chapter.

How does it work

Blockchain is used in a variety of implementations, which are best described in chronological order of appearance. Its first and probably most famous use is that as part of the Bitcoin cryptocurrency protocol. Second generation introduces the ability to encode contracts into the blockchain, creating self-validating and self-executing contracts. The third generation aims to solve limitations and challenges facing the first two, such as speed, energy consumption, scalability and the level of privacy and confidentiality. As businesses seek to adopt blockchain (or

parts of the benefits of blockchain), technology providers have started the development of 'enterprise ready' solutions with the aim of setting the standard for the future.

1.0 Bitcoin Protocol (and cryptocurrencies)

The first application of blockchain technology that made a notable impact is Bitcoin. Bitcoin is a cryptocurrency, which means it allows the transfer of value over the internet from one peer to another without the intermediation of a trusted third party (like a bank). It does this by recording every bitcoin transaction ever made on a ledger, and making the ledger publicly available. The requirement to this ledger is that no one can change its content to "double spend" his bitcoins. Bitcoin proposes a data structure for the ledger which can best be described as a chain of blocks, hence the blockchain.

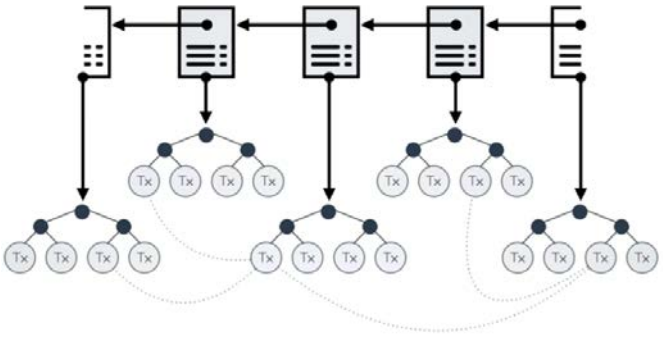


Figure 3 Blockchain visualisation (based on IDRBT, 2017)

As shown in figure 1 the blocks contain one or more transactions, they also contain a hash pointer and a timestamp. The transactions are made by the participants signing an agreement through a combination of public and private keys (read username and password). A hash pointer literally points to the previous block and is a summary of the previous block translated into a hash. The hash (explained in table 1) can provide evidence of tampering with the data. The timestamp proves that the data must have existed at the time in order to get into the hash (Nakamoto, 2008). This makes up the data structure of the blockchain, but still doesn't explain how to avoid double spending. To avoid double spending transactions need to be validated (i.e. the peer that pays is checked to actually have enough bitcoin to do the transaction). For this, all transactions are send to the entire network. And the bitcoin protocol initiates as follows:

Based on Lemieux (2016) and Nakamoto (2008).

1. Bitcoin wallet A proposes the transfer of Bitcoin to another wallet B.
2. The Bitcoin distributed "mesh" network checks the public ledger that sufficient Bitcoin exists in wallet A.
3. If there is sufficient Bitcoin, specialized nodes called miners will bundle the proposal with other reputable transactions to create a new block for the Blockchain.
4. The header of the block becomes the basis for the "proof of work" performed by the miner nodes on the Bitcoin network.
5. When a miner node arrives at a solution to the proof of work, other nodes check it and then each node that confirms the solution updates their own Blockchain with the hash of the header of the proposed block. This becomes the new block's identifying string, now part of the distributed ledger in the Blockchain. Nodes express their acceptance of the block by working on creating the next block in the chain, using the hash of the accepted block as the previous hash (Nakamoto, 2008).
6. Wallet A's payment to Wallet B's transaction, and all the other transactions the block contains, are confirmed.

What is hashing or a hash

Hashing is a central concept within the Bitcoin protocol. It is used to prove that the recorded data is untouched. A hash function translates any piece of data into a fixed amount of completely randomized values. This brings two capabilities: one being the infeasibility of producing the input data from the hash and the other the extreme improbability of producing two inputs that yield the same output. E.g. changing just one letter in a 100 page pdf creates a completely different hash. This is called one-way cryptography.

Proof-of-work is a verifiable demonstration that they have paid a cost in computation time (Barrdear & Kumhof, 2016). It is essentially a puzzle that produces an outcome which, when hashed, creates a value starting with a predefined amount of zero's. And while the puzzle is hard to solve, the verification is easily done through with a hash. As described above, when proof-of-work is satisfied a block is broadcast to all network participants and is added to the chain. This creates *consensus,* the acceptance of a single true version of the transaction history.

Once the proof-of-work is satisfied it will take an equal amount of energy (computing power) to change a block and its content. Since the rest of the network keeps adding blocks, the work to change a block would include redoing all blocks that come after it within the time a new block is added (about ten minutes). This is how the proof-of-work mechanism incentivize honest behavior, as for every verified and validated block the validator (called the miner) receives a mining reward and for all other situations it costs him computation power – i.e. energy. The result is a leaderless network, incentivized to maintain the truth of a transaction ledger without a need for trust.

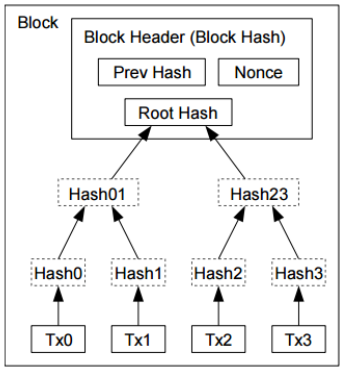


Figure 4 Merkle tree (Nakamoto, 2008)

So what does that bring – the benefits

Bitcoin is trustless. The proof-of-work mechanism removes the need for peers to trust each other. This is the biggest achievement of Bitcoin, as it also removes the need for trusted third parties like banks, notaries, accountants, brokers, and clearing houses to establish trust between parties in transfer of value. Different from current clearing and settlement, which can take up to three days, a Bitcoin transaction is settled in 10 minutes. The transaction is fully transparent and can be traced back, it is forever recorded on the blockchain creating an immutable audit trail. The protocol assures that the counterparty actually has the bitcoin to pay you, which creates compliance upfront. Since the ownership address of Bitcoins will be changed to the new owner, once it is changed, it is impossible to revert. Since only the new owner has the associated private key, only he/she can change ownership of the coins. This ensures that there is no risk involved when receiving Bitcoins (Stanford.edu, 2017). Finally, it can be accessed from anywhere in the world as long as there is an internet connection. 4 billion people currently that don't have a bank account suddenly have the means to store and transfer value. The increased adoption of Bitcoin in Africa, Asia and South America is proof of this[1].

Challenges, limitations, etc.

All of the benefits above makes people see massive potential, yet it is important to realize these benefits come with certain challenges and limitations. The next part describes some of the major issues confronting Bitcoin (and cryptocurrencies in general).

Where does the value come from?

The explanation why Bitcoin has value is not only because of its technical features described above, the tamper-proof transfer and recording of data. Bitcoin (and all cryptocurrencies) have value because it is seen as a currency, an equity and a social network. Which means it can be seen as a transferer of value, like a euro in your pocket. It can be seen as an investment product, much like gold. Bitcoin has a finite supply of 21 million bitcoins, which means it is subject to deflation as usage increases. But lastly as a social network, it has value because it is used and backed by its users, consider the value of Facebook without users for instance (Investopedia, 2017). In short it is popularity that determines the value of Bitcoin. And this makes it vulnerable to anything that influences its usage, be it regulation, speculation, global events, competition. But also its own limitations such as scaling throughput, reliability, storage requirements, privacy and manageability (Ren, Erkin, Cong and Pouwelse, 2017).

Incentives, energy usage and geographic risk

Every ten minutes only one block is added to the chain, this means that only one miner receives the award. The bigger your computational capacity the higher the chance you find this block first and can broadcast it. This has created overinvestment in computing power and connectivity, increasing energy usage to levels equivalent to Ireland (Barrdear & Kumhof, 2016). As a result it has concentrated mining power in geographical areas with either low energy costs (like Eastern China) or good connectivity (like Iceland). Concentration of mining power makes the network vulnerable to national regulation. Consequently the value of bitcoin reacts heavily on every mention by the Chinese government.

Throughput, storage requirements

Throughput depends on a maximum number of submissions and the maximum number of validated transaction/blocks by the network, additionally there is also validation latency which depends on the consensus mechanism (Kakavand and Kost de Sevres, 2017). The bitcoin network is currently able to process 7 transactions per second, this is rather limited compared to private payment networks such as VISA that handle up un the order of tens of thousands transactions per second (Barrdear & Kumhof, 2016). Solutions for scaling throughput have been proposed in the shape of larger block sizes and off-chain validation, although this would affect security and reliability. As long as there is no plan for scaling, the use of bitcoin will stay relatively limited (Ammous, 2016).

[1] http://www.nasdaq.com/article/how-bitcoin-is-helping-to-protect-wealth-in-economically-distressed-countries-cm780522

Privacy and confidentiality

Bitcoin provides trust in a distributed environment, but this comes at the cost of privacy. All transactions are public, also for those with malicious intent. The public can see that someone is sending an amount to someone else, but without information linking the transaction to anyone (Nakamoto, 2008). However, Bitcoin is not fully anonymous but rather pseudonymous, positions can be reversed engineered through analysis of the blockchain. New cryptocurrencies like Zcash and Monero made the biggest steps in anonymization, though this comes at the cost of larger amounts of data. Privacy shall be further elaborated upon at the end of this chapter since stays central throughout the next generations.

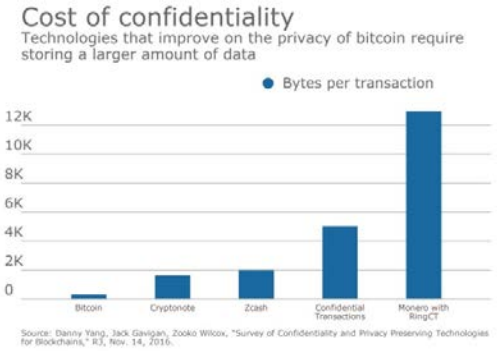


Figure 5 relative cost of confidentiality (R3, 2017)

Manageability

Bitcoin is managed by all its stakeholders, these include miners but also wallets (the programs wherein people store their bitcoins), developers, and exchanges. Changes are proposed by developers and tested on the Bitcoin testnet which runs parallel. Implementation requires the participants to "vote". Voting happens through the adoption of new software by stakeholders. When an adaptation is only partially adopted the network runs the risk of "forking" into two separate chains, both supported by part of the network.

Security risks

If an attacker has more than 50% of the computing power of the network he can reverse transactions that he sends while he's in control (double spending of previous transactions). He can prevent transactions from gaining confirmation and prevent miners from mining any valid blocks (Bitcoin.org, 2017). However, when holding 51%+ an attacker also has a big chance of finding blocks, thereby increasing his wealth. An attack would surely devaluate bitcoin, so this is a disincentive.

The Denial-of-Service (DOS) attack entails sending lots of data to a node so he can't process transactions anymore, the protocol is now mostly protected against these attacks. A Sybil attack would have an attacker create a situation where you only connect with his malicious nodes, that could disconnect you from the network, filter out transactions, in short make you vulnerable to double spending.

Hashing is a fundamental part of Bitcoin. The transactions are hashed, the pointer uses a hash. If this hash algorithm is broken, that would pose a serious security issue. Bitcoin uses the SHA-2 algorithm for hashing. There a two threats, a slow and sudden threat: recently the SHA-1 protocol was "broken", two different inputs created the same output after 9,223,372,036,854,775,808 tries, but still (Hackaday, 2017). SHA-2 will also be broken at some point, though it'll take many attempts. A machine that does a lot of trying at once is a quantum computer, this poses the sudden threat. There incentive is (currently) 23 billion dollars in prize money (total market cap Bitcoin). For Bitcoin to adapt the protocol must change, which might entail creating a completely new chain.

The highest vulnerability still is in the ecosystem of bitcoin and less in the Bitcoin protocol. the marketplaces, exchanges as well as the wallets where people store their bitcoin are much more likely places where people lose their coins. The Mt. Gox debacle of 2014 is an example of a situation where the platform was hacked and over 600,000 coins were lost (coindesk, 2017). It shows that in cryptocurrency, other than in centralized institutions (such as banks), there are no guarantees, there is no legal support, no government backing because there are also no entry rules and regulation.

Conclusion

The first generation of blockchain technology achieves to function as a fully decentralized digital currency, being independent from trusted third parties like banks to control the transfer of value. It has proven its worth in eight years of uninterrupted service and gaining ever more market cap. For it to work though speed, privacy, and energy efficiency are sacrificed, limiting its scalability. Risks can still be found in geopolitical and value volatility liabilities. The main issue remains if Bitcoin will be able to scale to facilitate global usage, if not, it might lose its primary driver of value: popularity. Bitcoin has completely changed the paradigm of trust in a decentralized environment like the internet, and has instigated possibly the greatest amount of proof of concepts in start-ups and corporates alike.

Ethereum and Smart Contract Code

The next step in the evolution is in expanding the use beyond peer-to-peer transactions. Apart from solving some issues of the first generation, the next generation of blockchain wants to make representations of assets and record them on the blockchain. You can think of commodities, derivatives, deeds of real estate. Additionally and most interestingly, rather than static representations it could also be dynamic, in the sense of self-executing contracts. These are called smart contracts. Ethereum is one of the platforms that facilitate smart contracts and is therefore excellent to illuminate the second generation of blockchain.

Ethereum is in many aspects similar to Bitcoin, it has a coin called ether and it also has a proof-of-work mechanism. But it is designed to do more than just transactions. Some smaller tweaks are no limit to the block size but a higher cost for larger contracts, faster block times – around 14 seconds, and SHA-3 hashing instead of SHA-2. With Ethereum there is no cap on the total amount of ether, where there is a 21 million cap on bitcoin. Also, Ethereum was set up so that anyone with a graphics card can run a client and process transactions, to avoid the geopolitical issue described with Bitcoin (Coindesk, 2016). Apart from solving some of Bitcoin's downsides the ideology of Ethereum extents to creating a foundational layer for the internet of value, allowing for protocols to be built on top (Coindesk, 2016).

In time Ethereum plans to change the consensus protocol of Proof-of-Work to Proof-of-Stake. PoS doesn't use a mining process, heavily reducing energy consumption. Holders of the network's tokens own stakes in the network. Based on percentage of ownership they vote to validate and include blocks in the blockchain. This should make the barrier to entry lower as you are not required to have heavy and costly mining equipment. The risk is that is relatively low-cost to start cheating. Ethereum's solution is to let people pledge an amount which they lose if they cheat.

The major difference on a technological level is that Ethereum works with contracts. These contracts programmatically execute when they receive instructions. They can push and pull funds, and request these actions from other contracts, calling on the code to perform dynamic actions (Coindesk, 2016). You can think of smart contracts as basic IF-THEN structures, they wait for the predetermined kind of input and produce a certain output.

For the implementation of smart contracts Ethereum uses a script languages which allow agreements to be written in code that can be executed by the network. These self-enforcing agreements independently control and automate the exchange of value according to predetermined rules based on predefined inputs (Digital Asset, 2016). The contracts are executed by the entire network. This means that everyone can see the transactions and the terms of the contract. This is a consequence of the protocol and the consensus mechanism, which are aimed at trust without intermediaries. The smart contract language is capable of an infinite amount of outcomes, which is a lot, and has proven to introduce unintended consequences –the heist of 50 million dollar in ether.

The term smart contract is –as so many things in the realm of blockchain- a vague description, as there are two options. In this case we are talking about smart contract *code.* It refers to a program running on a blockchain, capable of controlling blockchain assets and executed by the blockchain – meaning it will always execute as written and cannot be altered. In many cases, smart contract code is not used in isolation but as part of an application, a decentralised application (DApp). While blockchains don't guarantee that all entries will be true, the immutable and permanent nature of the entries into the data structure forces those entering data into the environment to put their reputation on the line with each entry (Coindesk, 2016). In business and law smart contracts are perceived as a legal contract, though this is just a use case of smart contract code – using blockchain technology to complement or replace existing contracts (Coindesk, 2017). These are called smart legal contracts.

Smart legal contracts

An example of a functioning smart contract: You want to buy a bunch of bikes and sign an agreement with a bike builder in China for a certain amount of money, and possibly other terms and conditions. You could incorporate into the smart contract the condition that the agreed price is only transferred when the bikes are on the ship, and the ship has arrived in the harbour of Rotterdam (which could be measured with GPS). This might seem trivial for one set of bikes, but consider the millions of tons of goods arriving in the harbour, at that scale it makes sense.

It is the potential of smart contracts that attracts the interest of financial institutions. Most often it is this functionality that people refer to when talking about blockchain. As R3 (2017) describes it: *there are significant benefits from the adoption of smart contracts by the financial sector, it could lead to improved efficiency, cost*

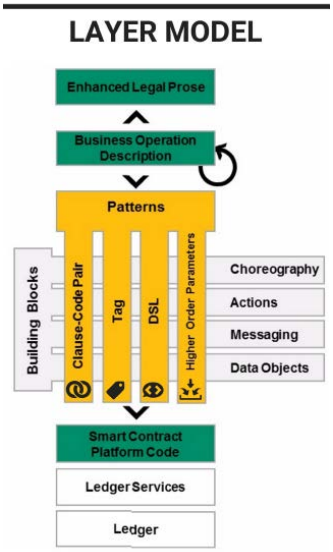


Figure 6 Smart Legal Contract Layer Concept (R3, 2016)

reduction, cost avoidance, reduced risk and enables innovation.

For smart contracts to be *adopted* it should be possible to translate business logic and processes (i.e. your desired result) into code with a legal certainty. This is quite plainly a business requirement. So the code must be clearly programmable and readable. Frameworks and templates are being developed to aid this. Already during the 1990's Ian Grigg developed a framework for translating prose to code, with the aim of making code legally enforceable with his triple of prose, parameters and code. Key operational parameters are extracted from the legal prose and passed to the smart contract code (Clack, Bakshi and Braine, 2016). These parameters bridge the gap between clause and code so to speak. Currently templates are being developed to modularise and standardise legal contracts, develop a language that can be used in legal prose as well as executed on the platform. Finally contracts should be verified and validated to test the correctness and be certified by a writing entity (Clack, Bakshi and Braine, 2016; R3, 2016).

Private and consortium blockchains

Although the discussion and research on smart legal contracts has been given a boost by the blockchain hype its relationship with **public** blockchain frameworks (the likes of Ethereum) is far from obvious. The challenges for smart legal contracts have to do with the adaptation of regulation, the need for a standardised and reliable identity framework, the legal and technical debt (which is the huge investment in existing contracts and current IT infrastructure). To formulate a better fit with regular business requirements some companies have taken the main concepts of blockchain and created permissioned or enterprise blockchains. These enterprise solutions get rid of the full transparency (for obvious competitive advantage reasons) and limit the energy usage, while increasing speed and try to retain data integrity and auditability. The appendix offers an overview of the most notable enterprise blockchain solution providers, including R3 Corda, Hyperledger, Chain and Ripple. All take a different approach and find a different niche for their solution. However compared with public blockchain solutions there are some generalities, these are summarised in table xx. It seems the choice for institutions is almost unquestionable in favour of private blokchains. However, even in an institutional context, public blockchains offer a lot of value. Public blockchains provide a way to protect users against developers, since there are certain things the developers have no authority to do. In other words there is no way for anyone to create a backdoor (for the NSA for instance). This quality creates trust.

Table 1 Strengths and Weakness Inventory (own table)

	Public		**Enterprise**	
	Strength	*Weakness*	*Strength*	*Weakness*
Ledger	Immutable ledger	Irreversable transactions	Permission based edits	Hackable
Speed	Relative fast settlement time (10 mins)	Slow clearing (7 transactions/ second)	Faster	Lower certainty
Security	Reduced security risks compared to centralisation trusted third party	More vulnerable to attacks (51%, spam, DDOS)	Approved Participants	Security risks associated with walled garden approach
	Easy to audit	Reduced privacy	Full privacy	No real consensus
	Reduced need for trust	Energy consumption	Efficient solution	Lower certainty
Identity	Anonymous/Pseudonymous	Criminal activity	Known identities	Third party entry requirements
Asset	Native Assets	Limited representation	Any Asset	Still customised solutions

Additionally, public blockchains are open, and therefor are likely to be used by many entities and gain network effects (Buterin, 2017). As ever the options are not binary. Consortium blockchains form a middle way between public and private blockchains and can be considered partially decentralised. Such a consortium could consist of a number of financial institutions and could implement a more customised consensus mechanism, limiting viewing permissions but allowing content to be validated. To a large extent the aim is to lower the amount of copies being sent around and replace it with one secure data source for permissioned stakeholders, as figure 7 shows.

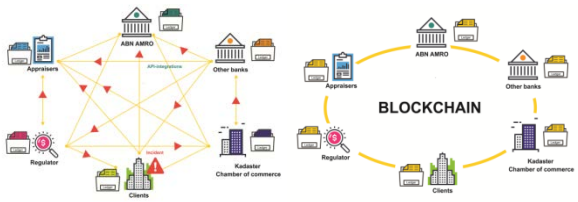


Figure 7 Old vs New Proposition Example (ABN AMRO, 2017)

The most notable ideas to enhance the privacy of data are the mix network and zero-knowledge proofs. A mix network (known best from the TOR-network) encrypts a message in an onion-like fashion, each layer of the onion has a key which is owned by a randomly selected participant. When decrypted the onion layer reveals the address of the next onion layer and the next hop can be made. This system obfuscates sender and receiver, but at the cost of higher latency and exposure to failed network nodes(Hearn, 2016). Finally, zero-knowledge proof is considered the holy grail of privacy in decentralised systems. It is a set of algorithms that establish proof that a program (e.g. a smart contract) was correctly executed, without knowing the exact content. Currently this is not yet practical as the algorithms take too much time, development progresses swiftly however (Hearn, 2016). The implementation of zero-knowledge proof in the cryptocurrency Zcash is not without danger, it yielded a private key which is supposed to be destroyed by the developers, but could be used to create counterfeit coins. Obviously this doesn't align with decentral trust ideology.

Figure 8 Blockchain based layer stack (BraveNewCoin, 2017)

The other, and currently more implemented solutions introduces layer, and moves off-chain. It uses the blockchain layer underneath for recording actions and transactions as hashes but the majority of data is stored in private databases. This is because the blockchain can't handle large pieces of data and be efficient, and increases privacy. The blockchain is reduced to an audit trail and the real valuable data is still stored on private databases. This model is used for instance by Digital Asset Holding and their Global Sync Log. You could wonder what the value of a validated transaction is if you don't know anything about the transaction other than that it followed the correct process.

Final notes on blockchain adoption

As Iansiti and Lakhani (2017) handsomely point out, blockchain is not necessarily a disruptive technology. Rather it is a foundational technology, it has the potential to create new foundations for our economic and social systems. What this means is that the highly transformative solutions will take time to be invented and adopted and requires a high level of adoption. In similar kind that the internet's greatest innovations only came after everyone had adopted its initial product: email.

This then is also a word of caution with regard to start-ups claiming to have built asset management platforms and raising money through Initial Coin Offerings (ICO's). The fact that ICO's are unregulated says something about the extent to which such a platform considers regulation. At the same time a blockchain consortium consisting of only banks and looking to increase settlement speed by bypassing clearinghouses are not without danger. Clearinghouses have a controlling role and more importantly: no skin in the game. Leaving this role to market parties *with* skin in the game looks more like cartel creation and opens instead of closes the door to fraud. Remember Libor, high frequency, subprime, and other scandals.

Conclusion

Through its general use architecture, Ethereum has shown the expanded possibilities of blockchain technology. The ability of smart contracts is to automate and enforce the execution of code. This is what has triggered the financial sector, as it opens up a more secure and cost efficient future. However, the context of business requires legal embedding and a certain level of privacy, qualities not apparent in public blockchains. But one should realise that if you want a censorship resistant, immutable ledger for the transfer of value between non-trusting participants you need to incentivize good behaviour economically and need to verify and validate good behaviour through transparency. Public blockchains make you trust the network instead of its participants, if you already trust the participants why use blockchain? Many parties are currently trying to find the best solution for these issues, so the verdict is still out. One of those parties is the Delft University of Technology Blockchain Lab, who are working on a third generation version of blockchain, a more in depth description of this technology can be found in the appendix. The chapter now continues with an assessment of the mortgage funding domain. The chapter analyses the current constraints and pain points. Part 2.3 depicts the potential future state of mortgage funding when using blockchain.

2.2 Mortgage Funding

2.2.1 Introduction

This first part of this chapter will describe the mortgage system from a funding perspective. It describes the various ways mortgages are currently funded, what the associated risks and regulatory constraints are. The chapter concludes with an argument for an alternative way of mortgage funding. Chapter 2.3 assesses the feasibility of using blockchain technology to facilitate this alternative mortgage funding concept.

2.2.2 How does a bank fund a mortgage?

A mortgage is a loan issued by a loan originator –usually a bank- with the purpose of financing the purchase of a house. The originator accepts the house itself as collateral, which means he has a claim on the house in case of default. With an annuity mortgage this claim decreases over time, as the borrower repays the loan's principal along with a certain interest rate. The process of issuance is as follows: borrowers seek a mortgage, which is issued by a loan originator. This loan originator, has a front, mid and back office. The front office handles the communication and service to the borrower, the mid office performs a check on the borrower and the back office registers, transfers and monitors mortgage. Before an originator is willing to issue a loan, a borrower must have a certain creditworthiness and trustworthiness. The credit part is tested with a Loan-to-value (LTV) ratio and Loan-to-income (LTI) ratio. The LTV describes to what degree the loan covers house value. The LTI is the capability of a borrowers income to pay the monthly principal and interest. Trustworthiness is derived from an identification check, employers check, and so on. When everything is in order a mortgage management system (like Stater for instance) issues the mortgage. The notary receives the money on a dedicated bank account and transfers the ownership. The borrower then repays his principal and interest over the years by sending money to the loan originators bank account which is managed by Stater. In case of delays or default it is the Stater system who alerts special management.

In this thesis we are interested in the way a loan originator raises funds for the issuance of mortgages. This is a process that happens out of sight of the borrower. Banks are a special kind of institution when it comes to funding loans. When banks issue a loan it does not always channel existing money to new uses. Banks can either use the deposits of their clients or raise funds on the international capital markets. Through a process called debt funding a bank can newly create money that did not exist. *What makes this 'creative accounting' possible is the other function of banks as the settlement system of all non-cash transactions in the economy* (Werner, 2004). Apart from deposits and debt funding banks can also raise capital through equity, either with common shares that are traded on the stock market or preferred shares. But both are relatively expensive instruments and are only used for acquisitions or emergency balance repairs.

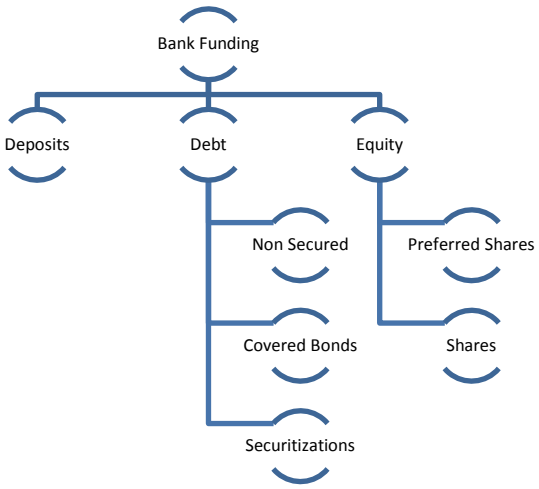


Figure 9 Bank Funding (own ill.)

Most of the time banks use debt instruments. Either debt that is backed by assets or unsecured debt. Unsecured debt is issued solely based on the creditworthiness of the bank and usually receives a higher interest rate than secured debt. Asset-backed debt is issued through securities and come in two flavors, bonds and securitizations. Bonds and securities are baked by for instance mortgages, SME loans etc. The income of the loans can provide the principle and interest repayment of the security. The main difference between the two is that bonds are still on the balance sheet of the bank and the securitization is not. Therefore bonds create a double recourse quality (in case of default of the asset, the bondholder can go to the bank). This is not the case with securitizations. With securitizations the mortgage loans are sold to a Special Purpose Vehicle (SPV). This SPV in term issues shares (securitizations) to investors. To bring it back, it is the capital raised through the sale of securitizations that is used to fund the mortgage.

The structuring of bond and securitization programs are costly and involve many stakeholders such as attorneys, trust offices, rating agencies, different departments within the bank. But then again, these programs will usually

include 50 billion euros in assets. There are two types of structurings, pass-throughs and collateralised mortgage obligations (CMO's). Pass-throughs are structured like a trust fund. CMO's spread the risk the mortgages through pooling in tranches. These tranches create a different exposure to the risks mentioned above. All the principal and interest of the mortgage borrowers is collected and the senior tranche is paid off first, the junior tranche is paid off last. These tranches get a credit rating and a return proposition fitting the rating. The advantage is that investors can pick exactly the amount of risk and return they want to take.

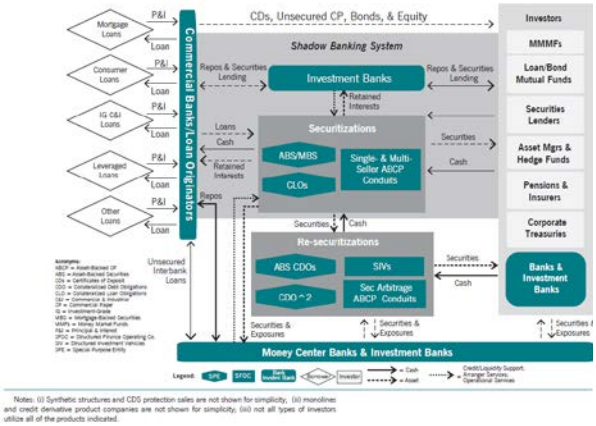


Figure 10 Shadowbank system (Culp, 2013)

Asset backed securities (ABS) form an attractive investment opportunity as they offer exposure to the mortgage market without the hassle of managing a complete mortgage street. The institutions buying these securities are called shadow banks, who are essentially parties on the capital markets ranging from pension funds and insurers to investment banks. These parties are looking at asset backed securities as *deposit alternatives*. They figure that with a limited amount of risk they can have a more decent return. So investors are encouraged to view shadow banking products such as ABS's as substitutes for bank deposits. ABS's often also have a more favorable regulatory treatment (Levitin, 2016).

The top tranches of mortgage backed securities are almost always graded as AAA and will usually trade for the same price (yield) as state bonds, but with an added risk premium. The risk premium mostly reflects illiquidity risk and credit risk. Academics such as Culp (2013) maintain that the shadow banking system also serves as an important disciplining mechanism on the relatively more opaque commercial banking system. He says: *Despite being called the "shadow" banking system, many of the transactions (though admittedly not all) in this system are more transparent than corresponding financial products in the classical banking system* (Culp, 2013). Conversations with professionals have proven this statement better to be taken with a grain of salt. This is because of a limited frequency in trades, as well as the difficulty in the valuation of security portfolios.

2.2.3 Valuation

When securities are sold the underlying assets have to be appraised. Mortgages are a difficult asset to appraise for a couple of reasons. First mortgages are loans that mature in 30 years but people choose a fixed interest rate horizon that is usually shorter than thirty years. The bank tries to match the mortgage interest rate horizon with that of their funding, but changes happen. Mortgages have the risk of prepayment due to refinancing, house sale or foreclosure. Finally there is always the risk of default. The complexity and relative unpredictability make why the valuation of mortgage securities resembles that of a stock much more than that of a loan. It is influenced by three things: the interest rate, the event of prepayment and the probability of default.

Interest rate

A consumer can choose a fixed interest rate horizon for periods of one to thirty years. When this period ends a rent reset follows – i.e. the consumer will be asked to choose a new fixed rate horizon. Interest rate offers for consumers change over time and this brings a prepayment risk. When interest rates increases people will usually stick with their mortgage and not prepay, when interest rates decrease people will usually start looking for cheaper mortgages. This is called contraction risk. However, a sudden rise in mortgage rates after a period of low interest rates will usually spark a wave of prepayments because people feel they will miss an opportunity.

Prepayment

The yields on mortgage backed securities must always be established with respect to some prepayment assumption. Prepayment is one of the most influential variables in Mortgage Backed Securities (MBS). The historical annual rate at which a pool of mortgages prepays is expressed as CPR and it is a percentage of the current outstanding principal level. Prepayment probability is influenced by the refinancing incentive (is the interest rate attractive to switch), seasoning (dependent on the age of the mortgage), a monthly probability multiplier (summer is more attractive than Christmas) and a burnout multiplier (if you haven't

prepaid when you could have, you probably never will). This is the computationally most intensive part of pricing an MBS.

Probability of Default

The loan-to-value ratio (LTV) is a risk driver for mortgages. Research by Kroot and Giouvris (2016) performed on a dataset of ING, one of the three system banks in the Netherlands, show empirical proof of the relationship between LTV and probability of default (PD). The observed defaults are the averages per bucket and the graph shows that for higher LTV the number of observed defaults was also higher. The trend line with the best fit is a logistic function with R^2=99% (Kroot&Giouvris, 2016). Statistics from the Dutch mortgage market show a similar trend with regard to LTV. The losses increase with a factor of almost 20 from 90% LTV compared to 110% (Boelhouwer & Schiffer, 2015). Its effect is displayed in figure 13.

Interest-to-income is the second important risk driver. The dataset shows that the probability of default increases sharply in the mid-range of the graph, indicating that while those with a high interest to income are definitely more susceptible to default this group is also quite large. The difference in default level between the left and right side of the graph is a factor three (Kroot&Giouvris, 2016). Interestingly they have not chosen to visualize loan-to-income and the probability of default, this has however become an important focal point for Dutch governmental policies aimed at reducing risks in the mortgage market. In the end, it is loan height and interest combined that create the payment pressure that is felt by the consumer.

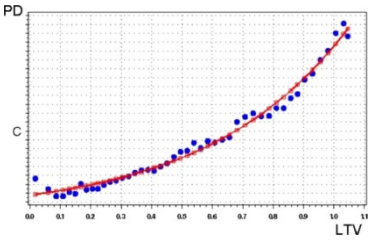


Figure 11 LTV to PD (Kroot&Giouvris, 2016)

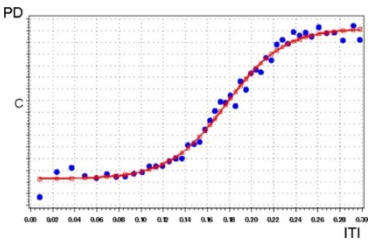


Figure 12 ITI to PD (Kroot&Giouvris, 2016)

People that are more often in arrears are more probable to default. The graph below shows customer groups who have not been in arrear since one month (A) until eleven months (K). Label L is the group that hasn't been in arrears at all. The size of the bubble indicates the size of the group. It also shows that those who have been in arrears more recently have also defaulted more often.

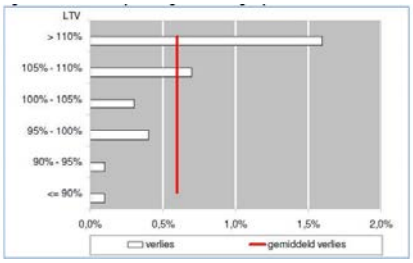


Figure 13 LTV to Loss (Boelhouwer&Schiffer, 2015)

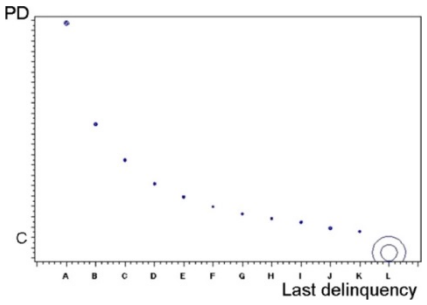


Figure 14 Delinquency to PD (Kroot&Giouvris, 2016)

Apart from these internal factors, external ones also have an impact on the probability of default. You can think of development and growth rate of GDP, unemployment and the average house price. But research by Kroot and Giouvris (2016) has shown the relatively small role these play.

2.2.4 Issues with Debt Funding

This paragraph will describe the challenges facing the bank in its debt funding process. Debt funding introduces a variety of risks into the system. Most prominently refinancing risk, which is created by the maturity of an issued loan not matching with the maturity of the raised funding. The size of debt funding programs creates a variety of risks that relate to transparency. These internal risks are compounded by an external factor. This is the fact that a lot of money is made of fees when debt funding programs are set up. It is these interests by external parties that have contributed to the increase of debt funding, and its associated risks. Debt funding increases the interdependencies among an increasing group of counterparties, failure of one quickly has systemic effects. The insights are based on the literature that followed the

Great Financial Crisis (GFC), the next paragraph will describe the regulatory actions that have been taken to counter these issues.

Refinancing risk

The biggest problem with this way of funding is that the duration of raised capital (out-flows) varies from the assets i.e. the mortgages (in-flows). Mortgages usually go for 30 years and have a fixed interest rate horizon of 10, 15, 20, or even 30 years. The bank's funding cycle on average collected for seven to ten years, and thus a refinancing risk is created. *While these institutions were investing in long-term securities, they refinanced themselves by issuing asset-backed commercial paper, i.e., very short-term debt, and were in constant need of refinancing* (Hellwig, 2008). Indeed, funding cycles have a major impact on lending rates (Kara, Marquez-Ibanez, Ongena, 2016). There are two rules for immunizing a zero surplus fixed income portfolio against a change in the level of interest rates: 1) match the duration of cash inflows (assets) and out- flows (liabilities); and, 2) set the asset cash flows to have more dispersion (convexity) than the liability cash flows around that duration (Poitras & Zanotti, 2014). Until 2003 the Danish mortgage system was actually based on matching mortgages with bonds of the same characteristics, which has proven to be favorable for the stability of the system (Schilder, 2012). The convexity argument relates to moving risk and return of the underlying asset over time, making sure you create a buffer around the time the funding matures. Hellwig (2008) underlines the risks associated with refinancing. *If there is any shock to the availability of funds for refinancing, the individual institution is in trouble because it needs funds to repay its short-term debt. If it cannot find an alternative source of finance, it must have a fire sale of its long-term assets.* This fire sale has a negative effect on the asset prices in the market, putting pressure on all other institutions invested in them (Hellwig, 2008).

Transparency

It is commonplace to lay a good part of the blame for the crisis on the poor transparency that accompanied the massive issues of asset-backed securities (ABS), such as mortgage-backed securities (MBS) and collateralized debt obligations (CDO): see, for instance, Financial Stability Forum (2008) and IMF (2008) (Pagano & Volpin, 2012). Indeed, multiple academics researched the relation between transparency and (systemic) risks in the domain of debt solutions. The information (a)symmetry effects manifest in high liquidity on the primary and low (to frozen) on the secondary markets (Wittenberg-Moerman, 2008;Pagano & Volpin, 2012). A lack of skills and tools to process the amounts of data at unsophisticated investors made these investors rely on credit ratings that are by definition too coarse (Pagano&Volpin, 2012). The ECB concludes: "*The provision of more detailed information would help the market assess the risks associated with ABS ... it would unquestionably benefit all types of investors, as well as the general level of liquidity in the market"* (European Central Bank 2010, p.1). Apart from the apparent lack of tools and reporting, the tranche structure also did not help. As explained, tranches synthesize risk by first pooling all income and then repaying the most senior tranches first and the most junior tranches last. These tranches were rated by credit rating companies (more on them in a moment) and often, investors looked no further than this rating. However, default probabilities for senior and mezzanine tranches were significant because packaging did not provide for sufficient diversification of returns on the assets in mortgage-backed portfolios (Hellwig, 2008). The returns on different mortgages in the pool are necessarily correlated because not all variables can be diversified away, they are macroeconomic so they introduce a correlated risk in all properties in the pool.

Skin in the game

The biggest external factor increasing risk in the debt funding business is the moral hazard stemming from a lack of ownership which can be seen throughout the mortgage value chain. The value chain being all actors in the process of debt funding. Empirical evidence has shown that loan originators that planned to sell mortgages for securitization colluded more often with appraisers and borrowers to defraud the banks than when the originator was planning to hold the mortgage himself. If there's a default risk, debt finance provides an incentive to take excessive risks (Hellwig, 2008). Further on in the value chain other parties also benefited from the securitization game. In order to erect a SPV multiple agents are involved, who for every billion euros securitized gained about ten million euros in fees (Engelen, 2015), as shown in the table below. All these agents benefit from continuing this process, however at some point the good mortgages run out. What happened next is the introduction of competition between credit rating agencies (as pictured perfectly in the movie *The Big Short*) in order to keep the securitization machine running mortgage pools are rated well above their actual performance.

Table 2 Stakeholder fees 1996-2008 The Netherlands (Based on Engelen, 2015)

Agent	Activity	Fees (€ million)
Banks	Securitization	3500
Law firms	Management	211
	Legal Advice	354
Trust corporations	Management	211
Credit Rating Agencies	Risk Rating	NA
Total		4276

On a macro level

The value of mortgages has risen at the same pace as securitizations and interbank funding since the 1990's, whereas before that it was similar to the household deposits. Some scholars, such as Engelen (2015) argue that a combination of deregulation and financial innovation – such as securitization programs- stimulated and facilitated excessive consumer lending and rise in house prices in the nineties and zeros. Additionally Engelen sees here the root of the Great Financial Crises (GFC). In the Netherlands deposits are not a risk-free safe haven for banks though, 85% of Dutch saving deposits are without fixed duration (CBS, 2017).

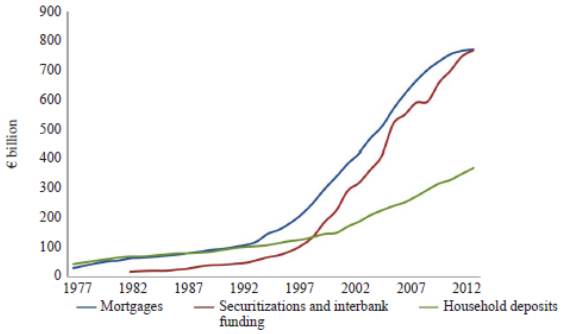


Figure 15 Mortgage funding (Engelen, 2015)

2.2.5 Wasn't all this regulated by now?

As a reaction to the GFC, Basel III was designed to give banks a stronger capital position and liquidity buffers. This regulation is accorded by the G20 and had a Europe-specific follow up in the shape of the Capital Requirements Directive IV. The most important aspects are the Risk weighted assets (RWA), anti-cyclical buffers, and the leverage, liquidity coverage and net stable funding ratio (BIS, 2017a; 2017b; 2017c).

To control the solvability of the bank Basel works with Risk weighted assets (RWA). A difference is made for Tier 1 (shareholder equity and retained earnings) and Tier 2 (revaluation reserves, hybrid capital instruments etc. i.e. less reliable capital). RWA's are calculated based on credit risk of an asset. This includes probability of default, loss given default and exposure at default. Under Basel III standardized approach mortgages require an RWA of 35% (regardless of the LTV). However, banks are free to use their own models. This is especially useful in the Dutch case, where LTV's are high but defaults are low. Additional Buffers are anti-cyclical buffers that force banks to create buffers in good times, to counter 'bubbles' and anticipate on a banks relevance to the system. The latter assesses balance sheet size, interwovenness with other banks, complexity, substitutability and international activity.

Finally there are ratios to indicate the health of positions on the bank's balance sheet. The leverage ratio is non-risk-based. It is aimed at discouraging banks to create large credit positions. Because it isn't based on risk the relative effect is most crude on low risk assets like bonds (and mortgages). The Liquidity Coverage Ratio affects the banks liquidity and prescribes buffers to satisfy short term obligations. The Net Stable Funding Ratio is aimed at stimulating banks to attract sufficient long term funding to reduce refinancing risks.

New Basel (IV)

The current implementation roadmap of Basel III and CRD IV stretches to 2019. After a strong lobby effort Dutch mortgage portfolios (especially the NHG portfolios) were largely exempted from these two regulations. Chances are that this will change with Basel IV. The three most important threats are the inclusion of Dutch mortgage portfolios (including NHG) under regulation, the changed RWA for mortgages LTV buckets, and a prescribed calculation method instead of a bank's own methods (PWC, 2017). The RWA is expected to increase with a factor 2.5 on the average portfolio. The effect will be that the regulatory cost (i.e. the cost of reserved capital) doesn't reflect the actual risk of the mortgage. As shown in the –already relatively low- Dutch default rates, most losses are incurred above LTV100 (Boelhouwer&Schiffer, 2015).

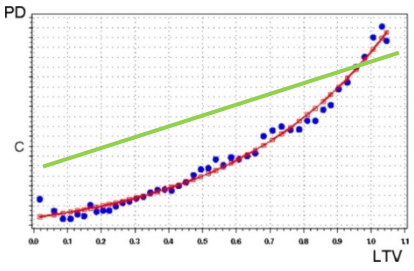


Figure 16 Basel Implementation (own ill.)

Still Basel IV is (almost) linearly implemented, meaning high capital requirements for LTV80-100 mortgages, while the

risk is relatively low. The problem banks have with Basel is best shown in figure xx, capital requirements are considered too high for low risk assets, as sketched with the green line. As a result banks will increase the premiums on high LTV mortgages, reducing chances for new homebuyers to secure a mortgage. This effect is compounded by consumer regulation restricting the consumer to a maximum LTV of 100%, a LTI guideline, and rising house prices.

2.2.6 Marketplace lending as an alternative

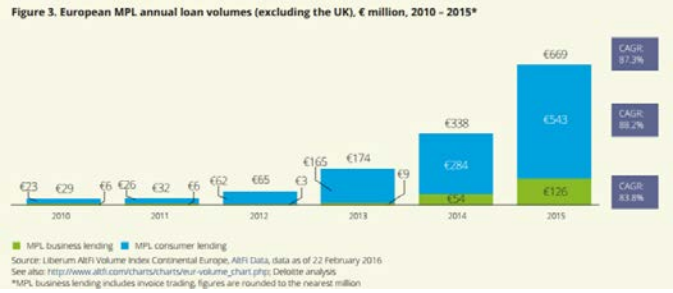
The final part of this chapter will discuss an alternative for debt funding. The alternative needs to satisfy the requirements of stakeholders and also take away the risks, all while fitting within the regulatory framework. If we consider the requirement of an investor, like a shadow-bank (a pension fund or an insurer), investing in mortgage backed securities, he basically wants exposure to the mortgage market. His consideration is that mortgages represent a limited risk and therefore make a decent deposit-alternative. The requirement for the bank is to keep making money with mortgages, while creating less systemic risk. The proposed alternative is marketplace funding, in the spirit of full reserve banking.

Full reserve banking was first raised as a solution to credit crises in the wake of the Great Depression during the 1930's. Also known as the Chicago plan, it was a plan by top economics to avoid the financial sector crashing as a result of a credit squeeze. It advocates the division between the deposit and lending function in commercial banks (Levitin, 2016). A watered-down version eventually became the Glass-Steagall act, only separating investment and commercial banking activities.

However, every time a credit crisis happens the plan is raised as an alternative that brings more stability to the financial sector and envisions a larger role for capital market parties in the provision of credit. As described in this chapter, many loans are already funded through the capital markets via debt funding. Further developing a deep and efficient capital market will enable a transition to a more rational and stable market structure, one where the deposit and lending functions are separated (Levitin, 2016). Reflecting on the 1997 Asian Financial Crisis, Nobel laureate M.H. Miller repeated that "having a wide spectrum of financial markets available keeps a country from having to put all its development eggs in one basket… and, in particular, from relying too heavily on commercial banking" (Culp, 2013). Miller viewed traditional commercial banking as fragile and said that a greater reliance on non-banks for credit provision would lessen the impact of crises.

Van Dixhoorn (2013) describes steps towards a full reserve banking system, since changing a system overnight is impossible. She says that policy should stimulate more mutual fund type investment funds and socially embedded 'banks' to improve the awareness and transparency about what savings are used for. Also, the systemic dependencies could be diminished by increasing competition in the sectors, for instance by easing bank license regulation (Van Dixhoorn, 2013). Look at the introduction of PSD2 regulation, a European directive that lowers the entry barriers in the payments industry allowing for more competition. It will also force banks to have their API's available for usage by payment initiators, this basically means that any party with a license can initiate payments between banks. It seems that from a regulatory perspective the momentum it there. While relying on capital markets was until recently impossible as volume and particularly access formed a problem for market parties. Yet with the aid of internet this has become significantly easier, and it's called *marketplace lending.*

Marketplace lending is the process of matching non-originator investors with borrowers. Marketplace lenders (MPLs) take no risk upon their balance sheet, and they receive no interest income from borrowers. Rather, it's a fee based model generated from matching borrowers with investors. And it is seeing increased popularity, aided by internet technology in accessing both capital and markets. Marketplace lending is taking advantage of wider trends that are reducing barriers to entry and thus enabling the rapid deployment of capital into hitherto restricted asset classes (Deloitte, 2016). The most widely adopted model in marketplace lending is the so-called notary model: (1) borrowers apply for a loan on the platform; (2) accepted applications are then originated by a partner bank. The platform performs the underwriting in accordance with criteria of the partner bank. (3) platforms purchase the loan from the bank. (4) the platform issues a note to investors – intead of a contract (IOSCO, 2014). Some of the platforms even offer a secondary market



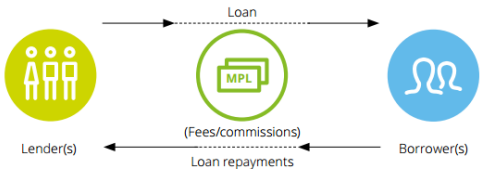


Figure 17 Marketplace Lending (Deloitte, 2016)

The current market in continental Europe is relatively small, with 669 million euros in loan volume, compared to almost 23 billion dollars in the US (Deloitte, 2016). It covers both secured and unsecured personal and SME loans. The advantages of marketplace lending are: a lower-cost operating model, a better use of data, a superior customer experience (both borrower and investor) and finally an increased flexibility in risk management (Deloitte, 2016). Another benefit is that marketplace lending allows for greater transparency than was previously available to investors in these types of lending products. Providing loan-level credit and performance data is an integral feature of marketplace lending (Neu, Egan & McGrath, 2016). Finally, some MPLs already have a secondary market in which investors can liquidate their investments before maturity. Though these are yet underdeveloped they would generate increased liquidity (Deloitte, 2016).

Concluding

Adopting a marketplace lender business model for mortgage funding would generate value for both the bank and the investors. It changes investment in mortgage backed securities into direct investment in mortgages, which eliminates the role of the bank's balance sheet –in the spirit of full reserve banking. It would provide in the sole need of investors to have exposure to the mortgage market. Risk would be limited through increased transparency and higher liquidity. As described in this chapter, higher liquidity would in term create fair pricing, benefiting the borrower. The bank can adopt multiple roles in supporting this platform, it can be the loan originator performing the underwriting and servicing of mortgages. The bank could provide sophisticated risk advisory for investors. Most importantly it can be the platform provider, further streamlining the American 'notary model' as you could skip the purchasing of the loan by the platform since you are the platform. This model can be tested independently from business-as-usual in a pilot project and create new windows to market. Over time it can decrease the dependency on debt funding, and thereby limit the associated (systemic) risks. Even more fundamental, it gives the bank the opportunity to explore the implications of a system where the deposit and lending functions are separated, while still being able to put experience and business functions such as risk advisory and mortgage management to use.

That being said, mortgages are a highly complex asset class and mortgage funding a complex process. The valuation happens on a portfolio scale, simply because that's when the statistics start to work. The variety of terms and conditions further complicate valuation. Currently the market for mortgage investment is highly illiquid, opaque and has high entry barriers. The volume of the Dutch mortgage market is currently expected to grow from 650 to 850 billion euros over the next ten years. Seems like a good time to question tradition…

2.3 What does Blockchain mean for mortgage funding

This part describes the potential implications that blockchain technology could have on the mortgage funding domain, specifically what it could do for the marketplace funding concept described in chapter 2.2. The implementation is dependent on a set of internal and external factors that can be viewed as limitations and challenges. These pros and cons yield a list of indicators that are to be used in the user requirement interviews to assess the usefulness of implementing blockchain technology in a platform for mortgage funding. In other words, to find out if investors and originators are willing to make the tradeoffs associated with implementing blockchain technology.

Why would you use it?

This part describes the advantages of a blockchain based system for mortgage funding.

Perhaps most importantly, blockchains could provide unprecedented transparency to allow investors to identify the ownership positions of debt and equity investors (including the firms' managers) and reduce the opportunity for rent-seeking or corrupt behavior by regulators, exchanges, and listed companies (Yermack, 2016). Transparency being indicated as one of the most important factors driving liquidity in a (secondary) market, this quality is beneficial to mortgage marketplace funding concept. Indeed Malinova and Park (2016) in their *Market Design with Blockchain Technology* paper describe that the most transparent scenario yields the highest investor welfare mostly through increased liquidity. Since increased transparency over the inventory will benefit finding investment opportunities and increase efficiency in asset allocation. A reduction of information asymmetry reduces the competitive advantage of parties that profit from opacity (brokers, insurance, credit rating agencies). Additionally it has an effect on the cost of leverage, it reduces the possibility of using the same asset as collateral for multiple occasions. Finally an increase in transparency is beneficial to the relationship between regulators and financial institutions, it could reduce friction and improve outcomes (WEF, 2016). The transparency argument only holds if financial institutions are indeed willing and able (think of personal data restrictions) to share the data. The fair pricing as a result of market liquidity, as discussed in chapter 2.2, is to a large extent dependent on the transparency in the credit risk of assets.

Analysis

This analysis assesses the potential of blockchain in the investment process on marketplace platform.

To aid the process of investment, one could automate the funding mix. Investors can program their investment criteria such as risk appetite and equity availability into a smart contract, pledging automatically when a request comes in that meets those criteria. *This means that the underwriting system of a loan originator must be connected to the platform*. But this could sharply reduce due diligence costs as risk analysis and underwriting on the investor's part can be automated*. It would require an appraisal tool capable of assessing risk on individual mortgages though*. Trade execution and clearing and settlement will become the same thing, as the transfer of ownership and cash happens simultaneously. *This requires standardized data requirements among the participants to make universal trading possible.* The actual closing time of the funding procedure can be reduced from typical clearing and settlement –taking three days– to almost immediate, this will reduce interest rate risk between borrower and investors. *But only if you are able to transfer cash on the blockchain platform or create a workaround with multiple bank accounts at different banks.*

During the lifetime of the loan counterparty risk can be limited as the disbursement of the principal and interest payments is automated. The administration of loans is automated, is viewable for both investors, loan originator but also regulators (if needed) and is capable of sending updates to associated actors if special management of the loan is needed. This reduces operational cost. *But requires a significant consideration in legal and technical debt, as there are huge investments in current administration providers like Stater.* Regulation could also be embedded into the smart contract, restricting activities that go beyond what is allowed. Moreover, every (trans)action is recorded, establishing an immutable audit trail, this is expected to create a significant reduction in disputes. *But requires a legal and dispute resolution framework. Although while the history is fully transparent, disputes around contracts are inevitable.*

On adoption

With regard to adoption there are three perspectives to be considered, the infrastructure replacement, the legal/regulatory/governance framework and competing interests. Deep collaboration is required between all three. The infrastructure replacement can be driven by the fact

that the financial institutions are dependent on a legacy infrastructure in place since the 1980's and working with programming languages first designed in the 1950's (Wyman, 2016; Deloitte, 2008). Obviously maintaining these systems is costly, but replacing them is not only risky from a technological and financial perspective, it considers also organisational changes. The replacement of a financial institution can best be compared to open heart surgery or replacing the engine of a driving car.

There is nothing about public ledger platforms that makes the governmental and public demand for regulation and consumer protection lower for financial services businesses based on the public ledger rather than traditional platforms (Evans, 2014). Rather, new and adjusted policies need to be developed to anticipate the expected higher pace of the financial sector. Up until now, regulators such as the European Committee have taken a relatively absent stance towards blockchain technology, recognizing its innovation potential and not wanting to limit research and development (EC, 2016). So there is no regulatory framework for blockchain solutions, only policies aimed to prohibit undesired situations from the past. With possible changes in policy in mind, it makes it hard for highly regulated institutions, such as banks, to initiate serious investments and commitments on the level of overhauling their core banking systems for instance.

Finally, there are a lot of (powerful) intermediaries that have rather big interests in safe-guarding the status quo. Though usually a loser's game in innovation, this is a compounding effect on the two perspectives mentioned above. Because of regulation, accountants, clearinghouses, notaries, credit rating agencies and so on have become more than supporting functions, rather they are enable financial markets to function. These parties won't dig their own grave, so to speak. Yet, when some adjust their business model, they will enhance the network effect.

When does it make sense to implement it?

This part describes the indicators of a situation where blockchain makes sense. During the user requirement interviews with investors and loan originators the added value of the proposed platform is discussed. The participants make indications of what is more and less important. If these indications are met, it makes sense to consider the use of blockchain or distributed ledger technology.

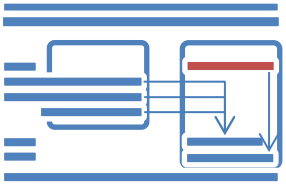
Table 3 User requirement indicators (own table)

Is it a digital business/can it be digitized	Only digital assets can be traded
Is it an intermediated business	Trust is required and is currently established through third parties
Is there a business opportunity	Operational, liquidity product premiums are relatively high.
	Process costs are relatively high
	New companies are seen capitalizing on this space
Would it benefit from real-time settlement	Current match, clearing and settlement time is measured in days/weeks
	Comparable investment products are more easily traded
Would the sector benefit of transparency	Regulators demand insight
	Pricing is currently ambiguous
	Benchmarking possibilities are limited
Is reporting required?	There is a need for clear reporting internally as well as to investment partners
Does it require a lot of manual intervention?	The current process requires a lot of human activity and is expensive because of this.
	The current process is only possible on a large portfolio scale because of the associated costs
Is it a capital intensive procedure?	Is capital locked up as operating collateral?
Is the process dependent on legacy infrastructure?	The technology in use is in need of an update
	An update would yield more benefits as it could anticipate emerging technologies (like Artificial intelligence)

Conclusion

What this means for the case is that the integration of blockchain technology should be highly modular. The potential is such that the platform definitely should anticipate the integration of blockchain. However some major steps have to be taken before a case could go live, these steps include: the introduction of cash or representations of fiat currency like Central Bank issued Digital Currency and/or the ability to move real money and assets on a shared ledger; an identity framework; involvement and agreement of regulators; a (kickstarted) network effect in shape of a starting coalition or consortium. This requires collaboration with an infrastructure technology provider that understands the business reality –including regulation and practices- but has an open mind towards it as well as towards new blockchain solutions being introduced. Combined with the complexity that is the mortgage domain the case should be seen as conceptual and be tackled in a piece by piece strategy. For example some stakeholders in the mortgage domain such as cadasters and notaries have to update themselves before a they can easily provide in data requests. Such demands are initially out of the influence of this project.

3. Business models



Intro

This chapter will illuminate the concept of a business model and how it is designed. It is found that there are multiple ways to design a business model, we decide to use critical design issues (CDI's) as guidelines for a complete business model design. A set of CDI's is developed to cover the business model in general, and the characteristics of this project specifically.

The chapter first describes the concept of a business model and business model design methods. Next, the the concept of a multi-sided platform is discussed. This characteristic determines the choice for a specific method as it influences the set of CDI's that are either found within the design method or added. The STOF method is chosen as the leading framework, with additions from the ADR method. These yield a set of CDI's. Finally the effect of blockchain on business models is assessed and given a place within the STOF method framework.

Methodology

The aim of this chapter is to establish the theoretical framework for business model design. The theoretical framework is researched through a literature review.

Literature review

Over the past years, the literature on the concept of the business model has seen an almost exponential increase since the advent of the internet. Despite this, scholars do not seem to agree what precisely a business model is and have yet to come up with an accepted definition (Zott, Amit, Massa, Zott, & Massa, 2011). Zott et. al. (2011) propose themes to generate more unified fields of study, it is used to give a structured business model literature review and shows the use of the concept.

Themes

In their comprehensive literature review Zott et. al. (2011) can discern four different emerging themes: (1) the business model as a new unit of analysis, (2) a system level approach and holistic view of how firms do business, (3) the activities of a focal firm and its partners play a significant role in the various conceptualizations of business models and (4) business models seek to explain both value creation and value capture.

The concept of the business model is used in literature to explain different phenomena. Zott et. al. (2011) find that there have been three major streams:

(1) *Business models in e-business* mainly focused on the gestalt of firms engaging in internet based ways of doing business and the (new) roles that these companies play in their respective ecosystems. Their description highlight the notion of value, financial aspects and network (stakeholder) architecture and are framed either in generic BM representations or typologies/taxonomies (Zott et al., 2011).

(2) About *strategy* and the networked nature of value creation as well as the relationship between business models and firm performance and the distinction between the business model and other strategy concepts. Business model design and product market strategy are complements, not substitutes. Product market strategy has an emphasis on competition, value capture, and competitive advantage, whereas the business model concept focuses on cooperation, partnership and joint value creation (Zott et. al., 2011)

(3) In the *Technology and innovation management* field the BM is seen as both a vehicle for innovation (commercialization of innovative ideas) as well as the subject of innovation (introducing new ways of cooperation and collaboration). It is therefore very functionalistic and meant to further a company. It asserts that technological innovation is critical for firms, but it might not suffice to guarantee business success (Doganava & Eyquem-Renault, 2009). Technology is an enabler.

The business model revolves around customer focused value creation (Zott et al., 2011).

Relevance to the project

The project of the Delft University of Technology with ABN Amro fits into the third phenomenon –technology and innovation management- as it creates something of economic value based on new jointly generated ideas that emerge from sharing information and knowledge. This is called open innovation. It is an example of the increased consensus among traditional corporates that business model innovation is key to firm performance (Demil & Lecocq, 2010; IBM Global Business Services, 2006; Ireland,

Hitt, Camp & Sexton, 2001; Johnson, Christensen & Kagermann, 2008; Sosna, Trevinyo-Rodriguez & Velamuri, 2010).

The aim of this thesis is to design a business model; this means there is an operational approach requiring a framework. The business model is a strategic tool, rather than a description of the infrastructure design (chapter 5), where the platform is specified structurally.

Multi-sided platforms

However, the business model literature mentioned above is representative of any form of business, be it vertically integrated firms, resellers or input suppliers. Most business model frameworks currently do not consider the effects of (digital) platforms; they are new and different thus leading to new affordances, structures, and rules (El Sawy & Pereira, 2012). A platform is an infrastructure that creates value by reducing distribution, transaction, and search costs (Pagani, 2013). A platform goes beyond traditional business models as it aims to enable direct interactions between two or more distinct sides and each side affiliates with the platform(Hagiu & Wright, 2015). It means that the two or more different sides retain control over the key terms, such as the pricing, bundling, marketing and delivery of the goods or services traded. Affiliation means that users on each side consciously invest to be able to interact with one another, this could, for instance, be an access fee, expenditure of resource or an opportunity cost (Hagiu & Wright, 2015).

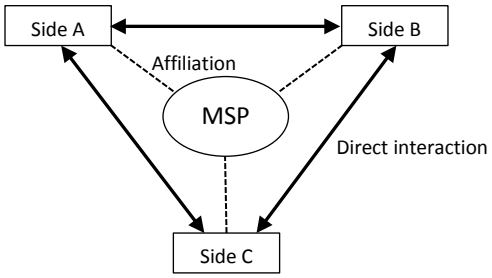


Figure 18 Adaptation of Hagiu & Wright's (2015) Multi-Sided Platform (Own ill.)

Multisided platforms face four strategic challenges Hagiu (2014) explains; onboarding, MSP design, pricing structures and governance. These problems describe the balancing act between external contributions (or dependencies) and maintaining platform control. Literature indicates a continuous trade-off between the two which ought to be balanced through an accurate definition of governance mechanisms. Consistent with Pagani (2013) and Hagiu (2014,2015) Osterwalder and Pigneur (2010) state that business model design for multi-sided platforms must develop a customer value proposition and (cost and) revenue stream for every stakeholder.

Business model design methods

Business model design is the operationalisation of the business model concept, and although several authors highlight the importance of the business model concept, research has not addressed the methods and tools for business model design in detail (Giessmann et. al., 2016). Giessmann is referring to a step by step plan, also called a meta-theory for business model design relevant to the case of business model innovation of a multisided platform through information technology. Apart from Giessmann et. al.'s meta-theory there is one other meta-theory which incorporates these characteristics, namely the STOF method by Bouwman et. al., 2008.

STOF method

The STOF method is made up out of four parts:

1. Service domain: encompassing the value proposition and market segment;
2. Technology: a description of the technological functionality;
3. Organisation: the structure of the multi-actor value network required to create and distribute the service and the firm's position within the network;
4. Finance: a description of the way a value network generates revenue and the way risks, cost and revenues are distributed among the actors

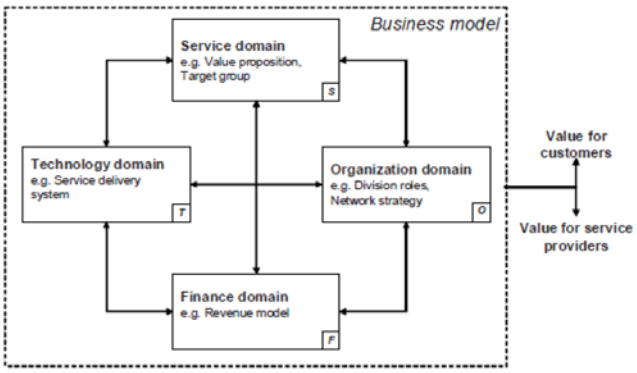


Figure 19 STOF business model framework (Bouwman, 2008)

This is a rather high-level approach, but it is operationalised through a four-step plan:

1. Quick scan of the domains (STOF) to give a description
2. Evaluation of the quick scan with critical success factors
3. If the critical success factors (CSF) are not up to standard, critical design issues are formulated to iterate the CSFs.

4. Evaluation by way of business model stress testing. A scenario analysis is used to test for uncertainties.

The STOF method's goal is to guide business model designers through the STOF domains to propose a robust, viable and feasible BM design (Bouwman, Vos, et. al., 2008)

Action Design Research Theory (Giessmann et. al., 2016)

The theory by Giessmann uses the business model canvas by Osterwalder and Pigneur (2010) for the components of the business model. It is based on four pillars: Product Innovation, Customer Relationship, Infrastructure Management, and Financial Structure and divided into nine components:

1. Customer segments: identifying the customers that the firm expects to create value for via their products and services. Can be both B2C and B2B;
2. Value Propositions: the reason for a customer buying the product/service, answering to the requirements of the customer segment;
3. Channels: how is the product or service brought to the client, channels could be defined as the means to the customer's value proposition
4. Customer Relationships: can be defined as the types of relationships and commitments a company establishes with specific Customer Segments. This relationship can be Personal, Dedicated, Self-Service, Automated or Co-creation type
5. Revenue Streams: process of creating cashflow to cover the costs of creating the product or service and channeling it to the customer
6. Key Resources: these enable the company to conduct any activity, like marketing, delivering the value proposition, maintain customer relations, create and offer the value proposition. Resources can be of physical, intellectual, human or financial form;
7. Key Activities: they are required to build and offer the Value Proposition, reach markets, maintain Customer Relationships, and earn revenues. Key activities can be related to production, organizational operations, and maintenance;
8. Key Partnerships: every company needs partners that help the company produce and deliver intended value to their customers. There can be different intentions of a company to tie up with a partner or supplier, and there can be different ways to enter these partnerships
9. Cost Structure: This element describes all the cost incurred while operating the BM to acquire the key resources and execute the key activities (Osterwalder & Pigneur, 2010).

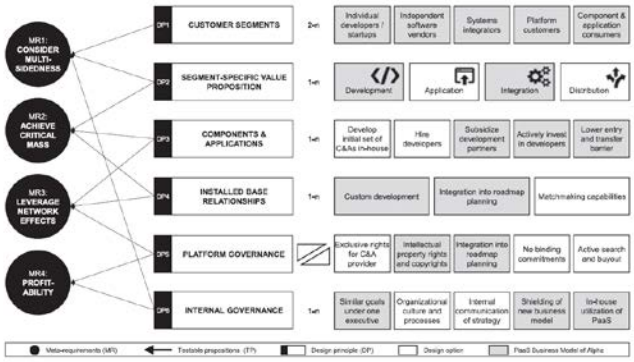


Figure 20 ADR framework (Giessmann, 2016)

The Action Design Research theory operationalises the business model in six steps:

1. Purpose and scope: establishing the causa finalis and the related meta requirements
2. Constructs: representations of the entities of interest (based on the business model canvas)
3. Principles of form and function: six design principles describing the focal aspects of the business model (customer segments, segment-specific value proposition, components and applications, installed base relationships, platform governance, internal governance);
4. Artifact mutability: identify the design options for each Design principle through BIE cycles, discussion, and literature;
5. Testable propositions: truth statements of experts relating the design principles and meta requirements
6. Justificatory knowledge: insight from literature for validation (Giessmann et. al., 2016).

The design theory's purpose is to provide practitioner-oriented guidance on how to develop business models in order to establish a flourishing ecosystem.

Comparison ontologies

To compare the two ontologies, a set of criteria has been developed. The ontology needs to be:

- Focused on innovation;
- Address multi-sidedness;
- Have Digital Platform functionality;
- Be suitable for iterative design & providing guiding steps;
- Used for similar products;

Both business model design theories have been designed with a focus on business model innovation: …*To develop insight into how organizations can design 'balanced' business models, designers need to understand the design issues involved and their interdependencies* (Bouwman,

2009). And: *Our primary research contribution is a set of design principles that guide software providers to define a viable PaaS business model…*(Giessmann, 2016) They intrinsically take multi-sidedness into account, the application, however, differs, the STOF method has been applied in use cases focused on mobile platforms (Karippacheril et. al., 2015;De Reuver et. al., 2015). These cases include mostly innovation at telecom providers as well as cooperation cases with banks, whereas the ADR theory has been developed and tested for a Platform as a Service setting. PaaS allows external developers to deploy and run their complementary software components; it enables software providers to tap into the benefits of value co-creation and harness outside expertise on an unprecedented scale (Giessmann & Legner, 2016).

This seems at first to be related more strongly to the decentral nature of blockchain software infrastructure. However, PaaS is meant to facilitate the development, testing and management of software components, it is therefore almost exclusively focused on the technology aspect concerning predetermined design choices. In that sense, it limits the exploration of the organizational and financial aspects that are very much relevant to the envisioned result as an investment platform.

Therefore it is more useful to apply the STOF method as a design methodology for the development of a business model for mortgage funding through a blockchain regulated decentral market, but look at the ADR theory for inspiration concerning design choices related to the multi-sided platform and platform governance.

Creating a strategy document (and a thesis) iteratively

The fact that results of the business model design can change the requirements to the technology made this not a typical technology push project. Instead it is an iterative process where the various domains inform each other throughout the duration of the project. Therefor the STOF method is used in a prescriptive manner (i.e. as guidelines) to create a strategy document. The theoretical framework of this thesis will be modelled after an exemplary case with similar context, described in the book by Bouwman et.al. (2008).

The STOF model and method guide the stages of definition of requirements and assumptions, as well as determining structural preferences. The design method explicitly addresses questions regarding the four domains and takes into account Critical Design Issues (CDIs) as well as Critical Success Factors (CSFs) related to creating customer and network value (Bouwman et.al., 2008, p.255).

As such, the usage of the STOF method smoothly aligns with the design research framework by Hevner et.al. (2004) which structures the thesis. But, where the end product of the STOF design method would be an assessed and refined business model, the thesis structure means that the business model outline (chapter 6) is the state of the model before evaluation, and chapter 7 is the actual evaluation that obviously yields necessary iterations.

CDI's

The overview and explanation of Critical Design Issues to be covered in the business model outline to present a strategy document is shown below.

	STOF	ADR	Description
Service Design	Targeting*		How to define the target group?
	Value Elements*		How to create value for the targeted users of the service?
	Branding		How to promote or brand the service?
	Customer Retention		How to stimulate recurrent usage of the service?
		*Provider Value proposition**	How to make platform development and maintenance worthwhile?
Technology	Security		How to arrange secure access and communication
	Quality of Service		How to provide for the desired level of quality
	System Integration		How to integrate new services with existing systems
	Accessibility for Customers*		How to realize technical accessibility to the service for the target group
	User Profile Management		How to manage and maintain user profiles
		Components & application	How to anticipate for complementary components and applications
	Standardization/ scalability		*To what extent is the technology standardized and or scalable*
Organisation	Partner Selection		How are partners selected
	Network Openness		Who is allowed to join the value network
	Network Governance		How is the value network orchestrated? Who is the dominant actor?
	Network Complexity		How to manage an increasing number of relations with actors in a value network?
		*Internal governance**	How to create credibility and sustainability
Finance	Pricing		How to price the service for end-users and customers?
	Division of Investments		How to divide the investments among business partners?
	Value Contributions and Benefits		How to measure and quantify partners' contributions and benefits
	Division of Costs and Revenues*		How to divide the cost and revenus among business partners

*Giessmann (2016) describe these as specifically relevant for multi-sided platforms.

Blockchain

How does blockchain tech affect business model logic

Although blockchain technology is a young technology and it has yet to prove its sustained added value in any use case except for cryptocurrency, some researchers have already shed light on the implications of blockchain technology on business models. In 2016 Seppälä concluded that it is mainly the 'trust' element that is of importance, he said: *blockchain is most disruptive when trust is part of the value proposition.* He identified three effects of using blockchain, namely: disintermediation, transparency and new partnership models. It seems attractive to describe what it means to use blockchain in the business model outline. However, the sensibility of using blockchain is assessed in user-requirements interviews in the infrastructure design chapter, which results in structural specifications. Blockchain is a means. It therefore doesn't create new CDI's, but it is integrated in the CDI's of the business model. It must be considered as an alternative to existing systems, since everything you can do with blockchain you might do without it. The effect of this integration is disintermediation, transparency and potentially new partnership models with the aim of increasing trust and scalability (Seppälä, 2016). The hallmarks of blockchain technology as described in chapter 2 are linked to existing CDI's. Specific functionalities brought on by blockchain are thus explicitly discussed in the business model outline of chapter 6. Whether or not the

aimed effect is best achieved through blockchain technology can then be discussed with experts.

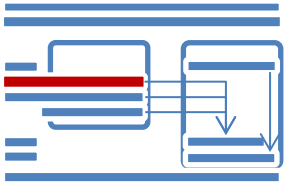
Table 4 Blockchain CDI's (own table)

Domain	Existing CDI	Blockchain Functionality	Aimed Effect
Service	Value Proposition	Confidentiality	Trust
Technology	Components&Applications	Matchmaking	Disintermediation
Technology	Scalability	Interoperability	Scalability
Organization	Network Complexity	Smart Contracts	New partnership Models
Organization	Selection of partners	Scalability	New partnership Models
Finance	Investments/Internal governance	Compliance/Reporting	Disintermediation
Finance	Risk	Monitoring	Transparency
Finance	Costs&Revenue	Audit trail	Transparency

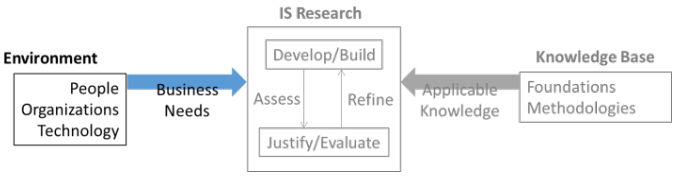
Conclusion

This chapter had the aim to establish the concept of a business model as a strategy document. A method to create this is chosen based on a literature review of two of the more relevant design methods. The relevancy stems from its application to digital multi-sided platforms, completeness, alignment with the operational nature of the thesis structure, and inclusion of exemplary cases. The STOF method was chosen and supplemented with CDI's from the ADR method. It is concluded that to fit the STOF method within a thesis structure the evaluation step must segregated from the business model outline chapter, meaning this chapter does not reflect the final product. The usage of blockchain does have an effect on the business model, but as it is an infrastructure its functionalities are used to achieve strategic goals. It is not a strategic goal in itself.

4. Business needs



Intro



This chapter describes the business needs. These are the drivers for the artefact and business model to be developed. Two rounds were held. The first round was exploratory, through interviews and desk research it was determined that the most relevant mortgage domain case was with regard to funding. The second round of interviews were held with mortgage consultants and focussed on the mortgage funding domain, this round was basically meant as an evaluation/justification of the chosen direction. The start of the research described a set of assumptions driving the original idea, these are reflected upon and finally discussed in the conclusion. Most important findings were the need for liquidity in the market and the major influence of operating costs on the margins.

Methodology

To gather the information, interviews were held with selected respondents. During the first months the focus was on finding the most relevant case. The exploratory interviews were held with Start-ups Jungo and Bouwsteen hypotheken, ABN AMRO business departments AAHG (mortgage group), Asset and Liability Management, Mortgage Balance Sheet Management and Debt Solutions, and academics from the mortgage and housing domain. Descriptions can be found in the appendix on page 111.

The second round comprised of a focus group session with mortgage consultants. The Focus group method has been used widely in market research to explore a specific topic in depth. This is also how it differs from a normal group interview. In focus groups participants are able to bring to the fore that they deem to be important and significant (Bryman, 2008). The moderator only steered slightly with themes and asked follow-up questions to get more in-depth. A recording device and a project colleague allowed the researcher/moderator to fully focus on the interview. All interview participants were asked if they were comfortable being recorded.

Identified themes

The first months of the research were focussed on finding a relevant business case within the mortgage domain. The case would have to have significance for five drivers: innovation, client value, business value, decentral market and 'multichain'. These five drivers represent the aims of the initiators of the project. Innovation reflected the need for a completely new business model, so optimization cases like improving the mortgage street or the customer experience were dropped. Client value (or borrower value) represented the added value of the proposition for the client, whereas the business value represented the added value and relevance for the bank. Finally the decentral market and 'multichain' (now trustchain), reflected expected relevance of the case with regard to the technology element provided by the DUT.

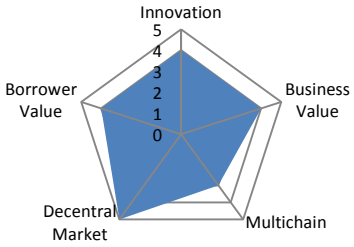


Figure 21 Crowdfunded Mortgages (own ill.)

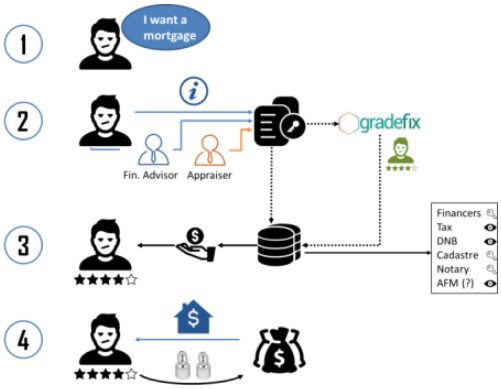


Figure 22 One of the initial Stakeholder journeys (own ill.)

Different cases were assessed with a combination of methods like exploratory semi-structured interviews and desk research. Two process-based solutions and three

mortgage (funding) products were considered A complete overview is included in the appendix. Finally the crowdfunded mortgage case was chosen. This creates a business case where multiple investors are funding a single mortgage. This calls for a matchmaking engine (decentral market) and a transparent audit trail (blockchain element). Additionally it creates value for the client in the shape of return for an external investor, and a lower interest rate for the borrower. The bank can create more creative funding mixes, thereby avoiding high capital requirements. Finally it creates a completely new proposition for involved stakeholders and it allows the bank to discover new roles aside from its balance sheet lending activities.

The most important conclusions and learnings of the primary phase were with regard to bank balance sheet funding. The issuance of mortgages and funding of mortgages at banks is not one on one, nor does it come from one source. The bank's balance sheet allows this by balancing assets and liabilities, where issued loans are seen as assets. Only later the newly issued assets have to be balanced with liabilities. Funding can come from deposits (about 60%) and debt issuance. However, the average horizon of liabilities is often around seven years, whereas that of a mortgage is often longer, which creates refinancing risk. All respondents indicated that Basel IV could have a significant impact on the position of the banks with regard to mortgages in the Netherlands. Lowering the LTV is really the only way to limit the impact of Basel, as its effect is toughest on high LTV loans. Therefor Basel is a relevant driver for the tactic of outsourcing the top risk. Innovation in the mortgage domain can be best sought in disintermediation, match making in funding mixes and looking for new roles. An example of a new role is for instance risk advisory. It was found that consumer inclusion in the funding process has shown limited success. The obvion 'met-elkaar-hypotheek' has so far been sold to less than 10 persons. ABN AMRO has been looking for similar products but have up until now seen limited results in customer development. And finally the startup Jungo, after more than two years still have not launched. Launching new private investment products takes a lot of time because of regulators like AFM and the Tax authority. Debt and equity solutions for affordability are experienced by consumers as being complex. "The cleverness needs to happen on the funding side, obscured for the consumers."

Pivot I

After the most relevant business case was determined to be in the funding domain deeper research followed. More exploratory interviews were done with respondents from the departments of Mortgage Balance Management and Capital Markets Debt Solutions (CMDS). The first being concerned with the asset and liability strategy of the mortgage portfolio of the bank and CMDS is concerned with structuring advisory of securitization programs, among other things. The concept of blockchain based mortgage funding with multiple parties was further conceptualised, and yielded an initial design for stakeholder journeys and value network as can be seen in the figures below. The value network also shows the new roles the bank can assume, such as servicer and risk reporter.

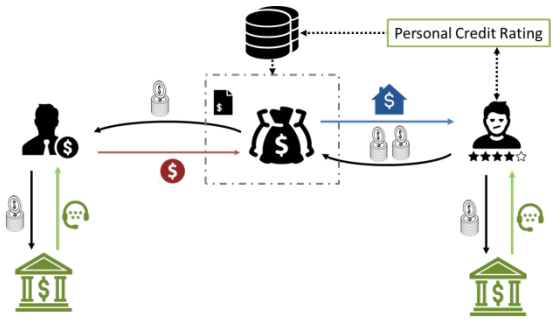


Figure 23 Value network v2 (own ill.)

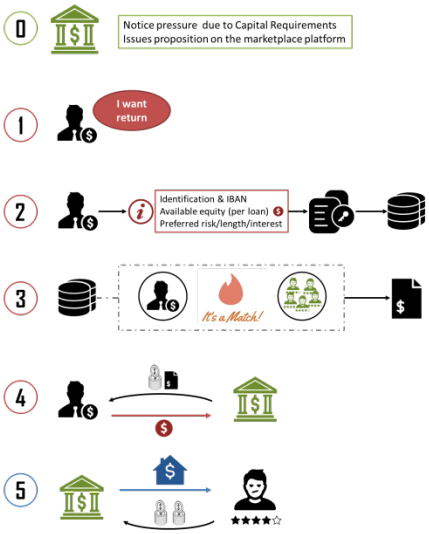


Figure 24: Stakeholder Journey v2 (own ill.)

Focus Group Results

To evaluate and justify the design choices a focus group was held. This also helped to identify additional trends and challenges in the mortgage funding domain. The focus group interview was held with a mortgage consultancy company located in The Hague. The activities vary from project management, research to training days. The

consultants have worked with and for major national mortgage issuers and funders. The training days in their offering introduce clients to the complete spectre of the mortgage market from consumer to funder. Five consultants were present at the focus group session which lasted little over an hour.

The consultants identified the key value proposition to be to provide exposure to the mortgage market for investors. To lower the barriers several steps have to be made, some can be provided by the platform and others are external. Standardising the mortgage product would make it easier for investors to understand the assets and the market they are investing in. Take NHG rules as an example, by taking into account the risk of the creditor. Clarify and standardise the prepayment rules, for instance by allowing a maximum of 10%. Base the penalty on a set calculation determined by the government. "You want to increases the volume, this increases liquidity and causes better pricing." A ***secondary market*** would be indispensable for this and is really a missed opportunity. But currently the products are so different from each other that benchmarking is utterly impossible. The government has started the first policies for standardisation in the shape of a maximum LTV, only annuity mortgages instead of all sorts of polis constructions. And has started the discussion about the height of prepayment fines, which will hopefully yield a standardised construction. On the other hand standardization also has downsides, most prominently on the consumer side. There is segmentation in demand from consumers, they aren't catered to as before. An example is the partly absence of a mortgage solution for floating homes. Many mortgage originators have automated under operating cost reduction measures through standardisation and are potentially missing valuable consumer groups.

The DNB expects 200 billion euros of growth in the Dutch mortgage market in 10 years. There is a total collateral of 1100 billion euros on a current volume of 650 billion euros. One could conclude that there is enough room for investment. At the same time more and more international parties are interested in Dutch mortgages. They are catered to by asset managers like DMFCo, Dynamic Credit, CMIS, and Blautrust. The experience is that the largest barrier is understanding how Dutch mortgages work, and getting comfortable with high LTV's. The only thing that can limit the demand is the fact that there is a maximum that a pension fund of insurer will dedicate to mortgages in its portfolio, this currently hovers around 7-8%. Once this is filled, it is filled. A pension fund simply has the mandate to diversify their portfolio to spread risk. Speed Is integral to optimizing operating cost. Both at the consumer as the funding side. The funding side experiences incredible lag in investments**.** It can take up to 9 months for an investment goal is reached thru the issuance of new mortgages.

The consultants agreed that a platform for flexible mortgage funding could significantly reduce costs, most importantly on operating and liquidity cost. The most important cost driver behind the mortgage interest rate in the Netherlands is operating cost, "*for the system banks this is 65 basepoints (bps) of primary operations and up to 65 extra bps for additional cost throughout the process of holding the mortgage."* New investment managers have around 30 bps for operating costs. This shows the potential of optimizing operations. At the same time shadow banks investing directly in mortgages face illiquidity risk. Sale after a few years is nearly impossible for a decent price. In a liquid market investors would take a lower yield for granted because he can always sell. This would in turn lead to better prices for consumers. For direct investment in mortgages pension funds currently demand +75 bp on mortgages compared to state bonds to cover illiquidity mostly, and a little bit of prepayment risk. ***Credit risk at the same time is 3-5 bp maximum.*** To spread the risks diversification is the only way right now. And diversification only works in large portfolios because it is only then that the statistics start to work. Also, it is only at large portfolio sizes that the structuring costs are covered. Structuring costs are spend on lawyers, trust companies, credit rating agencies, etc. The inexperience with and mindset towards smaller scale investments might limit feasibility of micro-level investments.

There is room for new concepts as there is room for growth in the Dutch mortgage market. To an extent companies are already capitalizing on the demand. The asset itself remains the largest barrier. Direct investment in mortgages creates relative high yields, but only relative to statebonds, while these bonds have the advantage of being infinitely more liquid than mortgages. Investment in mortgages is completely different from investment in securitizations or covered bonds as investors are more exposed to the risks. These risks could be mitigated by standardizing the product, making it easier for investors to understand them. The Dutch government promotes this by prescribing heights of penalty, only annuity and linear mortgages and limiting LTV ratios for consumers.

Assumptions

The problem statement includes a couple of assumptions that will need to be tested to create a sound value proposition, which is the core of the business model. The assumptions (in bold font) were made at the start of the research and can now be assessed.

There are suitable investors for this product and process
It is assumed investors are willing and able to co-invest in Dutch mortgages.
It is clear that there are parties willing and able to invest in mortgages, these include national and international pension funds and insurers. Junior tranches in asset backed securities even attract private equity and hedge funds. There are signals that there could be demand for co-investment and/or syndicated constructions, but this is yet to be validated. Private individuals are not interested in investment because of the duration, and low yield.

A new form (or added source) of mortgage funding is necessary. The current way of mortgage funding mitigates risks inadequately because it is dependent on a limited amount of capital sources.
Under current regulation it is still very attractive for banks to issue mortgages from their balance sheet. Basel IV is expected by all interviewees to significantly change that both with regard to issuance and portfolio. For now mostly covered bonds and deposits make up the primary funding mix for banks, securitizations only take a minor role and is mostly used for cleaning up the balance sheet. Demand for new forms of mortgage funding come from both the bank and investors, but it is more a need for liquidity and flexibility to adapt to new regulation such as Basel IV.

Co-investments yields benefits for all stakeholders and the system. It is assumed that the platform can bring value to all involved stakeholders: the bank, the investor and the borrower.
The interview did not explicitly cover co-investment or syndicated structuring for institutional parties. The examples of Jungo, as well as initiatives for funds of private individuals were mentioned. It indicates that the asset class is being considered. However, the greatest barrier for institutional (and private) investors is the investment duration of 30 years. The current form of using funds (where you can co-invest) considered very illiquid.

Blockchain technology is capable of providing the necessary infrastructure better than other options
Participants had a basic understanding of the technology and saw that it could definitely yield benefit for the process. One of the consultants did mention the potential of blockchain during the session. It is concluded that the use blockchain was not to be validated in this session.

Pivot II

The evaluation with the mortgage consultants affirmed the choice for a more business-to-business focus, highlighted the opportunities and demand for more liquid and more efficient mortgage investments. Combined with the insights from the literature review, the concept of marketplace lending was developed. The marketplace matches loan originators and investors. This way the communication and service towards the consumer stays uninterrupted and the consumer notices very little of the funding construction. A marketplace funding model would also represent a major departure from the current mortgage funding business model at banks. Focussing on cost reduction and return on equity instead of volume. It aligns with the aim to challenge the bank through innovation and adding both business and customer value. The result of the second pivot is shown in an updated stakeholder journey and value network in the figures below.

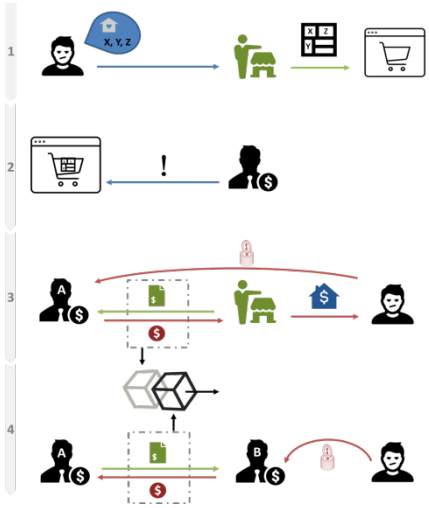


Figure 25 Stakeholder Journey v3 (own ill.)

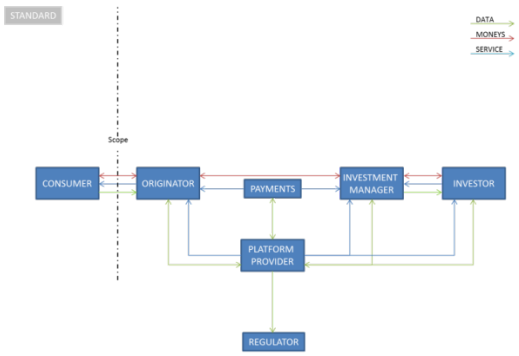


Figure 26 Value Network v3.1 (own ill.)

Conclusion

The research started with an explorative phase to find and validate an initial consistent value proposition for all involved stakeholders. The answer to this question proves both the relevance of the research project as well as that of the proposed solution. The primary phase yielded a choice for *crowdfunded* mortgages as a relevant business case because of the applicability of blockchain technology (matchmaking and audit trail) and adding value for investors, the bank and consumers. The case would also be sufficiently innovative for the bank.

The secondary phase yielded significant insight in mortgage funding through a focus group with mortgage (funding) consultants. This validated preliminary assumptions and agreed with the desk research of chapter 2. As a result the crowdfunded mortgage case was iterated: the consumer shall not be part of the scope in detail, instead it was concluded from the interviews that the consumer seeks three important aspects: clear communication, some speed and above all a competitive deal. The aim of the business model is now to match loan originators and investors on a marketplace. This marketplace will increase access to the mortgage market, increase speed of investment and liquidation, increase transparency to better serve benchmarking and monitoring, provide flexibility to buy and sell parts of, complete and portfolios of mortgages all the while securing data integrity.

5. Infrastructure design

Intro

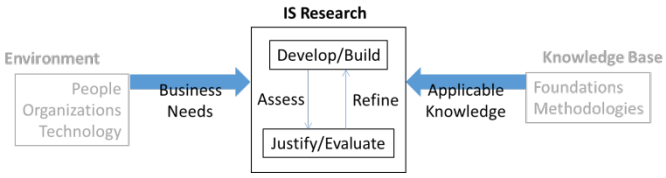


Figure 27 Place in thesis structure (own ill. based on Hevner, 2004)

The result of this chapter is a design for a marketplace platform. The previous chapters have shown the viability and relevance of such a marketplace platform. This chapter will describe what it looks like. The research of chapter 2 in the mortgage funding domain and the validation of assumptions in chapter 4 provided the input for drawing up goals and an initial design. This has resulted in a mock-up, which is the preliminary user interface of the platform. This mock-up is then used in interviews to find out what the user, functional and business requirements of the platform should be. Representors of key actors (the originator and investor) were interviewed for this purpose. Structural specifications yield the design of the platform and satisfy the outlined requirements. With this the chapter aims to answer the research question: "*what does the platform look like?*"

Parallel to the thesis research the Delft University of Technology (DUT) Blockchain Lab built a prototype. This has been part of the project of ABN AMRO and DUT Blockchain Lab, as introduced in the preface. The goal of the prototype development is to assess the potential of the Trustchain and Decentral Market, both being developed by the Lab. The researcher was involved in the design and development of this prototype and provided information on user, functional and contextual requirements. The description of the prototype and its process can be found in the appendix. The differences between the prototype and the structural specifications are commented upon. To some extent the prototype provides an insight in the feasibility of the platform, but should be seen as separate from this thesis.

Methodology

The chapter first describes in short the goal of the platform and who are involved to achieve this goal. Then, representors of the two main stakeholders are interviewed to determine requirements. And finally the requirements are translated into specifications of the system.

User interface mock-up

The requirements research will be aided by user interface mock-ups. Mockups are special form of prototype, it is used as a means to make discussions about the functional and the users requirements less abstract (Stapleton, 1997). Mock-ups are only designed to look like the real system, and do not have the functionalities that are found in prototypes (Bouwman et al, 2008). Working with User interface (UI) mockups is an iterative analysis technique in which users are actively involved. Mockups are used as an analysis artifact that enables the exploration of the problem and solution space with stakeholders. Additionally it also lays a potential foundation from which to continue developing the system with interested stakeholders (Ambler, 2004).

These will also be updated throughout the process, informed by the information from the interviews about the preferred process, tools, and data. The initial mock-up was designed with input from both a team brainstorm session, examples of peer-to-peer lending websites and the most important risk factors of mortgages from the domain research.

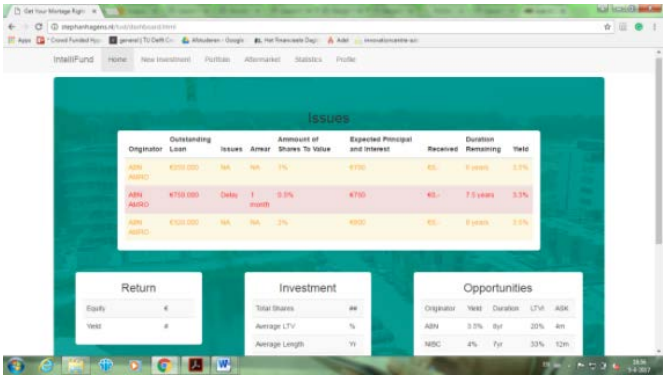


Figure 28 Mock-up GUI (own ill.)

First Idea

Goals

The original idea was to facilitate a crowdfunded mortgage on a decentralised market. During the exploratory interviews and desk research the scope changed to a marketplace platform for mortgage funding, where one pilot case is the syndicated mortgage (a mortgage with multiple financers).

Loan originators (like the bank) will be able to match (to be) issued mortgages with capital from worldwide capital market investors. The goals of this platform are: (1) ACCESS to make it easier for investors to gain exposure to mortgages and for loan originators to match their mortgage issuance with funding. (2) SPEED to facilitate this process more quickly than traditional fundraising (3) TRANSPARENCY to create greater transparency so investors know what the products are they invest in. (4) FLEXIBILITY to make it possible for originators and investors alike to buy and sell mortgages at any strategically preferred time and in any form. (5) SECURITY to have impeccable data integrity so investors and originators are comfortable with making payments through the platform. It is reasoned that streamlining the transfer of ownership of the loan creates more liquidity and therefor fair pricing.

Key actors

The loan originator issues the mortgage. He manages his mortgage street, which means he communicates with the consumer, provides the underwriting, attracts funding for the mortgage and registration of the mortgage (and its owners) at regulators. The platform facilitates attracting of funds and registration at regulators. For this the loan originator must be able to upload the underwriting of the loan and a proposed funding structure. The investor invests in mortgages. He seeks an attractive risk/return proposition aligned with his strategy. To do so he: Creates an investment strategy with yield demands, seeks out an opportunity, performs due diligence and prepares a bid, after successful investment he manages his portfolio and liquidates parts when he sees fit.

User, functional and business requirements

Functional requirements

Functional requirements describe parts of the platform that enable it to perform given the goals. For example, given the platform's goal to increase the ability to find an ideal risk/return proposition for the investor's balance sheet strategy, the platform should enable and support high detail risk assessment.

All users should be able to trace the ownership and payments at any time. The originator must have continuity is his offerings to the consumer. This means the interest rate for the consumer is fixed and the profit margin varies based on the funding costs that are achieved. Thus, the platform should show the profit margin of a loan originator. Then it should distribute the additional profit (or loss) as a result of funding costs among investor and originator.

I. It creates an immutable audit trail, so ownership can be tracked and cash flows directed to the right investors.

It should be clearly explained what the process of investment is. Some investors want to acquire complete mortgages to have full control over their own portfolio. Other investors might seek the security of spreading risk and would want to invest in part of an already established portfolio. The platform should make it easy to evaluate both opportunities with regard to risk. It should be easy for investors to determine a strategy and search, find, invest and manage this. So it should also be possible to gain an idea of what the characteristics of the co-investors are. For banks being loan originators it makes sense to make a connection with their internal funding system, that means Asset and Liability Management (ALM). ALM would then have a role similar as external investors.

II. It increases the ability to find and/or develop ideal risk/return propositions for the balance sheet strategy

Management also entails the sale of investments later on. To find a mortgage the investor should be able to define his risk appetite, this includes the LTV ratio and the investment horizon as well as the amount of equity he has available. There should be a screen where he can define these variables. It should then give an overview of the possible investment opportunities or give him the choice to leave it as an offer for a defined time, if a loan originator requests funding under similar risk it can then directly be matched. Finally when the investor wants to unload his assets he must be able to make a match with a new investor to transfer the ownership to following the same procedure.

III. It has the ability to show new investment opportunities and facilitate transfer of ownership for liquidation of positions

The investor wants to see the performance of his portfolio and act if necessary. These acts either mean the unloading of assets or management of assets. So service, support and special management functions should be available. The investor should be able to give these parties a mandate to act. To give the investor input on his portfolio performance a connection with the administration system is required, for instance through an API connection.

IV. Creates insight in the performance of the mortgage portfolio through clean data and statistics

User requirements

User requirements describe the activities that need to be fulfilled on behalf of the future users of the artefact. These describe the demand of the investor and the originator for tools and applications that support them in their activities on the platform. To find out what these requirements are, originators and investors are interviewed. A semi-structured interview with investors will cover the process of investment. With originators the funding process is assessed. Both interviews are aided by the user interface mock-up. During these interviews themes will arise that are relevant or even indispensable for the platform. The respondents were selected to be representors of the users of the platform, so either they had affiliation with direct mortgage investment and mortgage securities or with originating and managing mortgages. Some respondents, like DMFCo and NIBC had explicit experience with both. DMFCo is an asset manager for Dutch pension funds and introduced their label Munt Hypotheken in 2014. Aegon AM is part of the insurance company Aegon and allows investors to invest in their Dutch mortgage fund. Aegon has a full mortgage street for issuance and management of the mortgages. NIBC follows the same dual strategy of both originate and hold as originate and manage mortgages. Finally ABN AMRO has multiple labels and mostly originate and holds and keeps mortgage on its balance sheet, which also allows them to use them as collateral for covered bond programs.

Table 5 Respondents

Company *Department*	**Role**	**Description**
NIBC	Originator, Investor	Interviewed both a representative of the mortgage and securitization department
ABN AMRO *Debt solutions*	Investor	Debt solutions securitizes and sells mortgage portfolios as a service
ABN AMRO *Residential*	Originator,	Residential is the mortgage group of ABN AMRO, they issue and service
Aegon *insurance/asset mngmt*	Investor	An insurance company, interviewed their capital management department
DMFCO	Originator, Investor	As a mortgage asset manager they stand right in between investors and originator

Opportunity discovery

The loan originator sells the mortgage to investors, so the loan originator should provide the investors with the information they need to make a decent investment decision. An originator is allowed to share this information as long as it's impossible to trace it back to a specific person. An investor makes an investment decision based on credit risk and duration, the data he requires is shown in table 2. It was noted by one of the investors that it would be helpful to work with personal credit ratings, as this would speed up the process of issuance and matching.

Table 6 Minimum investment memorandum requirements (own table)

Theme	**Specific data**
Asset	LTV, fixed rate period, nominal value, liquidity risk premium, profit margin
Underwriting criteria	LTI, collateral appraisal criteria, job security
Product terms & conditions	Interest rate averaging, relocation options, prepayment fine percentage, quotation period, annuity/linear/interest-only, duty of care conditions
Quality of regular or special management	An assessment of the originator's reputation
Origination and servicing fees	Quantification of fees as part of the cost structure

Apart from the loan originator posting funding requests the investor should have a means to show what kind of investments he has appetite for. This would ease the process of matchmaking, as loan originators could then anticipate and adjust their offers to consumers. The risk being that it results in a homogeneous offering when investors all want the same risk profile. However, one of the respondents noted that leaving this to the market would in the end result in another investor seeing an arbitrage opportunity in less liked risk profiles (i.e. those being underpriced).

There are two competing views on continuity towards consumers. Banks feel the obligation to always be able to offer you a mortgage, where newer loan originators are more pragmatic and offer as long there is funding. Considering that the consumer underwriting procedure takes time. It can take multiple months from first indication to issuance. This influences the moment when you post your funding request on the platform. Too late and you risk not arranging the funding, so this is only an option for

originators who can take mortgages on their balance sheet. Once again, a personal credit rating could speed up the underwriting and the matchmaking of funding.

Pricing, bidding and payments

There should be a calculator tool that incorporates probability of default and prepayment, servicing costs, as well as the exact portfolio. This tool then gives an indication of the price range. The difficulty is because of the various LTV height and Fixed Rate combinations there are a lot of options and all need significant volume to create predictive benchmarking curves. So only on the long term, when there is sufficient volume to create meaningful price points, benchmarking can be done based on completed transactions.

One of the more difficult risks to counter is prepayment risk, so these costs and indicators should be clearly addressed on the platform. It is best shown by a risk assessment based on product terms and conditions such as interest rate averaging, the prepayment fine and the conditional prepayment rate (CPR). The respondents agreed that it will still be very hard to predict on a micro level.

The loan originator is not obliged by an investor to have the sharpest pricing, this is because investors just want a decent return and not necessarily the largest market share. This differs from the strategy of a bank, who do explicitly steer on market share. To keep the pricing in the benefit of the consumer it was suggested to introduce a auction tool. For the consumer that means your interest has a max, but could get lower. Coincidentally, this also increases the amount you can borrow. You can expect outbidding to increase as the quotation risk decreases.

The act of investing requires communication between supply and demand, such means a message system and integrated payment solution. There should be a way for loan originator and investors to negotiate a price. Originators and investors must have a way of communicating with each other to bargain over the price. The platform should therefore have a messaging system. The platform should have a secure payment channel connection. A loan originator explained that currently all mortgage payments flow to one bank account, and only later this is split out to investors. The situation where a consumer needs to repay all investors separately should be avoided. The consumer must only have to communicate with the loan originator of his choice, all funding related issues should happen out of sight, most respondents agreed. To keep the pilot uncluttered and clear it is probably best to start with a standard, limited terms and conditions, stripped mortgage to gain volume and scale on the platform. This will make reselling on the aftermarket easier. The pricing will probably be based on the current capital market price (AAA state bond) plus the risk premiums.

Table 7 Current rough return requirements ABS (own table)

Tranche	LTV	Return requirement
AAA	0 - 90	30 - 40bps
AA	90 - 92	80 - 120bps
A	92 - 94	250 - 300bps
BBB	94 - 97	450 - 600bps
BB	98 - 100	Junior tranche.

Under current market conditions the investors would find a 3.5% interest rate on the top20% part of the mortgage fair at minimum. In the end though, it is the market who makes the price. Two aspects complicate the resale of mortgage namely the terms with regard to additional funding and interest rate reset. The investors should agree on additional funding when borrowers want to increase their mortgage, for instance in case of renovation. This debtor risk needs to be transparent for secondary buyers. There should be a guideline for interest rate reset, most likely the reposting of the mortgage on the market for new investor to refinance the mortgage.

Monitoring, reporting and management

These functions are suggested to make communication about the investment or capital request portfolio clear. For internal reporting there should be a way to quickly report the current total invested amount, the average interest rate, the average risk assessment variables of the portfolio and the return on equity. An investor also would like to see the projected and achieved cash flow. This is best shown in graphs and statistics that also include a certain benchmark. The benchmark can be created over time, based on the data collected from previous transactions.

Accounting flows differ per lender, Stater has up to 130 different journal entry shapes for all their different customers. It is wisest to make the datasets as flexible as possible as every investor and originator has analyse their data and determine their strategy. When flexibility in products increases you want more metrics for overview, one respondent indicated.

In case of delay you will still need special management. This means that the administration system sends out an alert of delay and special management starts a procedure with the consumer. Thus, it requires payment monitoring. This is basically a mortgage management system, like Stater. It

should be assessed if integration of Stater or new development yields the most benefit in a start-up phase. Eventually you will want to have your own mortgage management system. The preferred situation would be continuous monitoring of the borrowers spending pattern, which would allow for proactive special management.

Platform governance

There are some functions that make a user interface intuitive and easy to use, some suggestions were concluded from the interviews; a search function and the use of drill down menus. It is expected that there shall be a huge list of investment offers and funding requests. It is therefore useful to have an elaborate search function. One that can order the entire database on the specific criteria that a user wants to see. These criteria are obviously the risk assessment variables described above. To create a clear user interface the relevant information should be immediately visible, more details should be findable after clicking on a specific mortgage. This is called drill down menus. For all users of the platform all costs should be clearly broken down, differentiating between the asset transfer costs and cost for using the platform. All respondents agreed that platform fees are paid per trade, so a user pays for the actual use of the platform.

It is expected that it will be mostly asset managers doing the investment work on behalf of investors. Finally one of the respondents indicated that the Top20% pilot case could also be interesting for retail investors, because of a short duration, depending on the payment scheme. And that sooner or later the consumer will enter this platform. Since the added value can be found in connecting investors with borrowers. While the researcher agrees with this view, opening the platform up to retail investors and consumers creates a whole new set of requirements with regard to consumer protection, underwriting and guarantees and are therefore currently out of scope.

Business requirements

These requirements describe the business context. This means the extent to which capabilities of the platform are constraint by regular business strategy, regulation, and the political and economic environment. As a result strategies should either change or the platform is required to formulate an answer to these requirements. A result of the platform is increased transparency. Generally that is a good thing yet some limitations were offered during the interview, notably with regard to competitive advantage, privacy and data security.

At this moment the strategy of loan originator is determined on a weekly basis. The strategy is limited to one variable, namely the interest rate. The interest rate should cover costs such as operational expenses, and since these are rather constant, the funding costs are relatively the most volatile factor. Additionally the strategy is influenced by the overall balance sheet strategy of the bank, and possibly most important, the interest rate of the competition. A loan originator worried that this means that too much transparency can cause the competition to anticipate your strategy and outmanoeuvre you. So a competitor loan originator or competitor investor should not be able to view the funding offers and requests, as he would be able to anticipate and gain advantage.

Personal data is protected by law. Yet, this data offers valuable information on the credit worthiness of the borrower and the (potential) value of his house. If a consumer wants mortgage he is required to submit this data to the loan originator. For a regular consumer this includes an ID, income statement, employment statement, an appraisal report and a mortgage advisory report with detailed information on the collateral. This way the loan originator determines the credit worthiness of the consumer, but only at the very start. At a later point in time, when an investor wants to buy this mortgage from the originator, the consumers situation could have completely changed and this creates a risk. It is considered illegal to place detailed personal data on the platform as part of an investment memorandum. A solution has to be sought in the anonymization of data. A credit risk report with a credit rating could be one of the solutions. Connected to the privacy issue is that of data security. Mortgage information has one the highest security demands of the bank. The risks are operational, legal and reputational and are quantified in a high so-called CIA rating. Although it depends on aggregation level since one mortgage is considered less of a problem than the entire portfolio.

If the loan originator is a bank and it keeps (a part of) the mortgage on its balance sheet then it should be able to give regulators full insight in their activities, agreements, and so on. If the mortgages are kept in a fund structure it only needs to answer to the AFM. Shareholders in the fund have their own regulation, pension funds for instance are checked by the DNB. The four institutions that are most important for a bank are (1) the Tax Authority with whom consumer data like interest payments, deb height and advisory costs needs to be shared. (2) the financial markets authority (AFM) who mostly checks on the originator if

consumer care is in order on topics like personal data and prepayment fines. (3) the Dutch Central Bank (DNB) who takes a look at the structural positions like the balance sheet, the solvency and liquidity ratios. And finally (4) the European Central Bank that takes both a customer care and structural approach, warning for long term issues like the consequences of interest-only mortgages for pensionado's in fifteen years.

Blockchain technology as a solution?

Based on the user requirements and the information that has been gathered in the domain chapter on blockchain we can now design and assess a blockchain based version of the platform. For this we use the checklist first introduced in chapter two, as well as a short recap of what the current mortgage funding process looks like. Then, based on the input we create the most ideal situation with blockchain which will then help to clarify where the unknowns and steps to implementation lie.

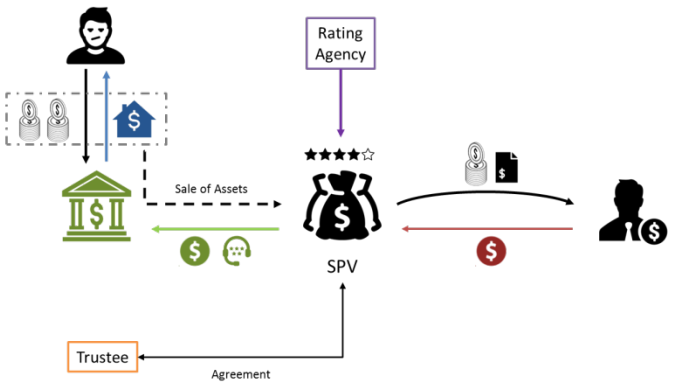


Figure 29 ABS creation Value Network (own ill.)

Currently the business of indirect mortgage investment, meaning through securitizations, proves to be an intransparent sector one respondent said. The credit rating of tranches and the lack of further inquiry by investors laid the basis for the financial crisis. And still now, where state bond prices can be easily found on the internet, the benchmarking of securitization portfolios comes in through the backdoor. The literature is clear that more transparency creates more liquidity and better pricing. More liquidity means a higher volume of trades, it makes sense then to adjust the process more to a stock market platform, which would benefit from a digital right of ownership that is easily but securely transferred. But right now the sales process can take several months, both with securitization as with setting up a fund structure, it involves a plethora of stakeholders such as credit rating agencies and trustees and every transaction is heavily customized to avoid liabilities.

Table 8 Asset Backed Security (ABS) process (based on Giddy, 2000)

Month	Action
1	• Determination of structure • Information Memorandum
2	• Commencement of documentation • Detailed cash flow analysis • Preparation for rating process
3	• Result of cash flow analysis • Determination of eligible receivables
4	• Approach rating agencies and introduction of the structure envisaged • Founding of the SPV
5	• Initiation of stock exchange approval process (in case of a Bond issuance) • Draft of Offering Circular (in case of a Bond issuance) • Comments of the Rating agencies (Rating confirmation)
6	• Determination of funding strategy • Publication of Offering Circular (in case of a Bond issuance) • Marketing (in case of a Bond issuance)
7	• Completion of documentation • Purchase of receivables and issuance of securities

These liabilities are so important because of the scale of the transaction, a securitization program usually holds billions of euros in mortgages. A smaller scale would decrease these liabilities as well, the respondent agreed. Regulators however require very limited insight in the mortgage investment process or currently managed portfolios, at most the AFM wants high level insight and certainly not do-over any work two of the respondents said.

Table 9 Usefulness of Blockchain (own table)

Requirement	Description	Relevance 1-5
Is it a digital business/can it be digitized	Only digital assets can be traded	●●●●○
Is it an intermediated business	Trust is required and is currently established through third parties	●●●●○
Is there a business opportunity	Operational, liquidity product premiums are relatively high.	●●●●○
	Process costs are relatively high	●●●●○
	New companies are seen capitalizing on this space	●●●○○
Would it benefit from real-time settlement	Current match, clearing and settlement time is measured in days/weeks	●●●●●
	Comparable investment products are more easily traded	●●●●●
Would the sector benefit of transparency	Regulators demand insight	●○○○○
	Pricing is currently ambiguous	●●●●○
	Benchmarking possibilities are limited	●●●○○
Is reporting required?	There is a need for clear reporting internally as well as to investment partners	●●○○○
Does it require a lot of manual intervention?	The current process requires a lot of human activity and is expensive because of this.	●●●●○
	The current process is only possible	●●●●○

	on a large portfolio scale because of the associated costs	
Is it a capital intensive procedure?	Is capital locked up as operating collateral?	●●●●○
Is the process dependent on legacy infrastructure?	The technology in use is in need of an update	●●●○○
	An update would yield more benefits as it could anticipate emerging technologies (like Artificial intelligence)	●●●●○

So what would it look like?

The system would resolve around a smart contract representing the mortgage. The smart contract would run on a blockchain network with nodes among the originator, regulators and investors. Most importantly the smart contract would have the capability of issuing and linking a multitude of shares to multiple investors, verifying and validating the transfer of ownership. The complete process can be preprogrammed in the smart contract, preventing anomalies.

Initiation.

Figure 30 Smart contract value network initiation (own ill.)

A potential borrower requests a mortgage from the loan originator. The investors have indicated their preferred opportunity characteristics. The initial request holds enough information for the smart contract to match enough interested investors to fund the loan.

Dilligence

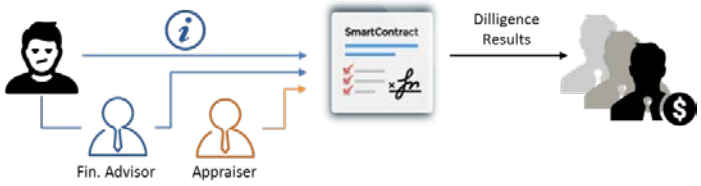


Figure 31 Smart contract value network DD (own ill.)

Due diligence is automatically taken care of as the borrower and his advisors upload information to the portal. Not all information is stored in the contract and on the blockchain, however an underwriting template with links to the servers holding the complete datafile can be included. Permission is granted only to those preprogrammed in the contract.

Closing and Servicing

All assets must exist on chain to make the contract code function, this means cash and all forms of registry of ownership. Payments by stakeholders are monitored and registered creating a clean audit trail. Shares are issued based on a transaction and a underlying mortgage contract, linked with official regulators. All support is handled by the originator/service party and happens off-chain.

Figure 32 Smart contract value network closing and service (own ill.)

Benefits

By directly funding the mortgage through smart contracts this process is completely different from the traditional ABS funding process, and investment fund approach, that both take months to establish. The main point is that the Smart Contract is the central asset, it will be the same asset for the investors, the consumer, kadaster, the notary, the servicer and so on. The integration of automated diligence programs reduces the operational costs significantly. Business rules and legislation can be preprogrammed avoiding any illegal constructions. Since actions are validated and executed by the smart contract, the role of trusted third parties, such as Trustees is limited. Additionally, since transactions are automated, operational risks such as counterparty risk are limited as well. It promises to increase efficiency, speed, and transparency.

Blockchain requirements conclusion

The biggest friction point is the business requirement with regard to transparency and competitive advantage. It was indicated by investors and loan originators alike that full transparency on this part is infeasible. Also the regulatory and legal demands for mortgage investment are extremely

high. Almost all public blockchain solutions create full transparency and limited anonymity, which means that anyone can analyze and determine the portfolio positions and consequential strategies of competitors. Additionally public blockchains lack legal embeddedness. A solution framework should thus be chosen that facilitates the obfuscation of transaction and identity data for stakeholders that are not involved in that specific agreement. Technology solution providers like Digital Asset Holdings, Chain and most recently Hyperledger's Burrow project have made significant steps towards such an infrastructure. Digital Asset, for instance, moves most of the sensitive data off chain and still keep it on private servers. Companies working on enterprise blockchains also constantly consider legal embeddedness. However, none of the solutions are currently anywhere near enterprise-ready (meaning they can handle the responsibility of millions or even billions of euros in mortgages).

Several Dutch startups are currently working on registering economic participations on the blockchain, to do so they collaborate with lawyers. Bloqhouse, in collaboration with DLA Piper aims to register participations in real estate assets, making them more easily tradable and lower entry barriers. It must be noted though that these efforts are on a private blockchain. For representations of cash multiple banks have been working with tokens, but Ripple could also be a viable option for experimentation. At the same time Intel has been working on marketplace platforms within the hyperledger framework. Also, and maybe most promising, hyperledger burrow works with public ethereum. Finally for identity, Sovrin (or hyperledger indy) might be worth experimenting with.

An important driver to increase feasibility of blockchain based solutions is adoption. Blockchain with its distributed architecture only makes sense when adopted by multiple parties. A consortium approach including an IT partner and multiple business partners and even a regulator seems currently the best way to approach this. Adoption will lead to better understanding and discovery of new opportunities. Apart from adoption, the concept of ownership should be researched. What does it mean to record something on the blockchain from a legal perspective, and how could this then be made tradable. This will undoubtedly lead to questions on digital identity, a subject for years. Finally, for smart contracts to work in the classical sense of blockchain based smart contract code both the asset and currency should be on the same chain. So apart from the concept of registered ownership described above, some form of cash representation should be present.

The conclusion therefor is that although blockchain holds great promise, it has yet to deliver. The technology is too young to facilitate a foundational infrastructure to such an sophisticated case. The effect for the usecase is that for the development of the platform the blockchain dependencies should be lessened, the implementation layer made modular. For instance to anticipate but not depend on cryptocurrency. It is advised to cut the case into little pieces and start experimenting with blockchain on that level.

Structural specifications

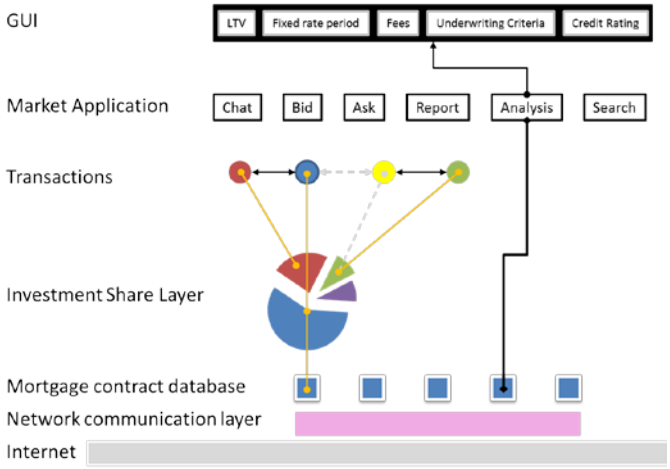


Figure 33 Infrastructure layers (own ill.)

Technical architecture

The structural specifications are derived from the requirements. This part describes the structure or technical architecture of the platform, i.e. the different parts that make up an decentralised marketplace platform for mortgage funding

Backbone infrastructure

The backbone infrastructure is the software and hardware that allows participants to *find and communicate* with each other. The backbone infrastructure is made up of a network and hardware component. The base component is the internet, allowing users to access the platform from any given location. The hardware component is a set of servers that run the application. In a decentralised application these servers are called nodes. Every participant in the network will be required to run a node and between these nodes network is established, see this as a (messaging?) layer on top of the internet. To initiate this network (i.e. for the nodes to find each other in the vastness of the internet) a

known starting point is needed, which is called a bootstrap server. In a sense nothing is truly decentralised.

Infrastructure technology – databases

The infrastructure technology essentially refers to the databases, *how and what data is being stored where.*

Databases hold the mortgage contracts, an account of the distribution of the participations of different investors and an audit trail of the transactions. The mortgage contract is an abstraction of the contract between a mortgage originator and a consumer, the abstraction means that only information relevant to the investment decision is shown. It says something about the characteristics and performance of the contract. The original contract is saved on the originator's own private database and the abstraction is uploaded to the network. The contract is linked to the "investment share layer" which holds the information on which investors have invested in this particular mortgage. Holding a participation means that the investor has access to the characteristics and performance of the mortgage contract. This participation can be traded, for this the participation has to be made public and transactions have to be facilitated. Recording these transactions (both send and received) are the inputs to provide proof of ownership i.e. if you have send the agreed amount and it is received, the ownership is transferred.

Agreement over sending and receiving payments can be achieved through a cryptocurrency-like system, where the network controls the validity and verification of the transaction or through a notary node. The first option means that the network knows of the transaction and its participants, which influences the competitive position of investors and originators. The second option requires a third party to oversee the transaction, for instance with clearing and settlement on a regular banking system, which introduces dependencies and slows the process down.

Service platforms

Service platforms refers to the different functions of the platform. Service platforms collect data from different sources and use it to perform actions. It describes what you do with the data in the databases.

The investment share and transaction data make up a smart contract, it basically says: there is proof in the transaction record database that you paid the previous holder of the participation, so now you get (and the previous owner loses) the rights to view the mortgage contract and receive principal and interest payments appropriate to your share in the mortgage.

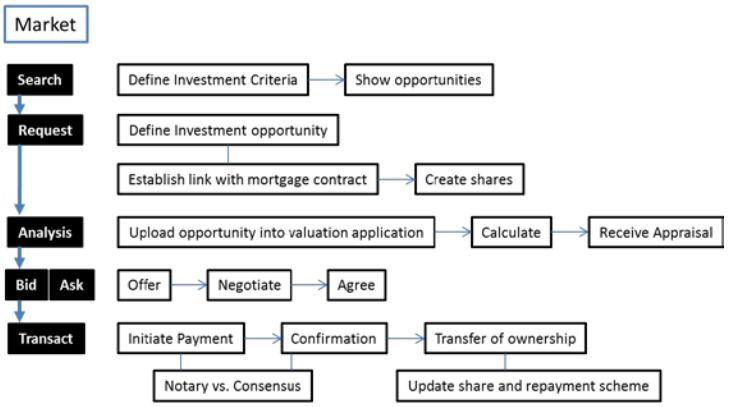


Figure 34 Flow Chart Functions (own ill.)

The platform has a market functionality, which means functionalities support the searching an investment opportunity and requesting funding, appraising the opportunity, bargaining a price level, concluding the deal with payment. Searching means describing you investment criteria and then getting an overview the opportunities that match those criteria. Requesting funding means a loan originator publishes a mortgage contract and associated shares, so it's found by potential investors. Before making an offer the value of a share should be appraised, this can be offered as a service by a credit risk rating party through an API – later more on this. The bargaining phase requires communication between the two parties before they reach an agreed sales price. When the agreement is reached the transaction is initiated. When confirmed, the transfer of ownership takes place with an update in the investment share information so repayments now flow to the new owner.

The audit and report function translates transaction data of an investor into an overview so he can easily assess aspect such as the profitability of his investments, his total investment over time, etc. This requires the platform to do some calculations with the data to produce statistics, not to different from the analysis function described above. But an export function should be added for the integration with reporting applications already used. Note that regulators do not need to be connected to this analysis function but could do with a permission for the raw data.

After acquiring the investment needs to be managed, this requires performance monitoring and the ability to act if there is a payment delay for instance. This requires a connection with the mortgage payment administration, now handled externally by Stater. The connection can be set up through an API, which allows you to look into the Stater system and retrieve the necessary data. The Stater system

itself has an automatic function for special management, it sends out a letter to the borrower when he is in delay and it alerts the mortgage servicer.

Finally the platform has a support function for communication with the platform provider. This includes billing of platform fees and user information management. Not everyone is allowed to enter the platform just like that, both originators and investors need to be checked and verified by the platform owner to establish the identity and creditworthiness. The platform should therefore be connected to relevant data sources, (e.g. chamber of commerce, tax authority).

Interface

The platform should be usable in a web browser. This is possible since the infrastructure facilitates the actions and services. The interface is then nothing more than an organised view processing demands to retrieve certain bits and pieces of information. The platform can therefore be accessed from mobile devices and personal computers. A GUI guides the users through the process of investment, to optimize this it will be designed in collaboration with the end-users.

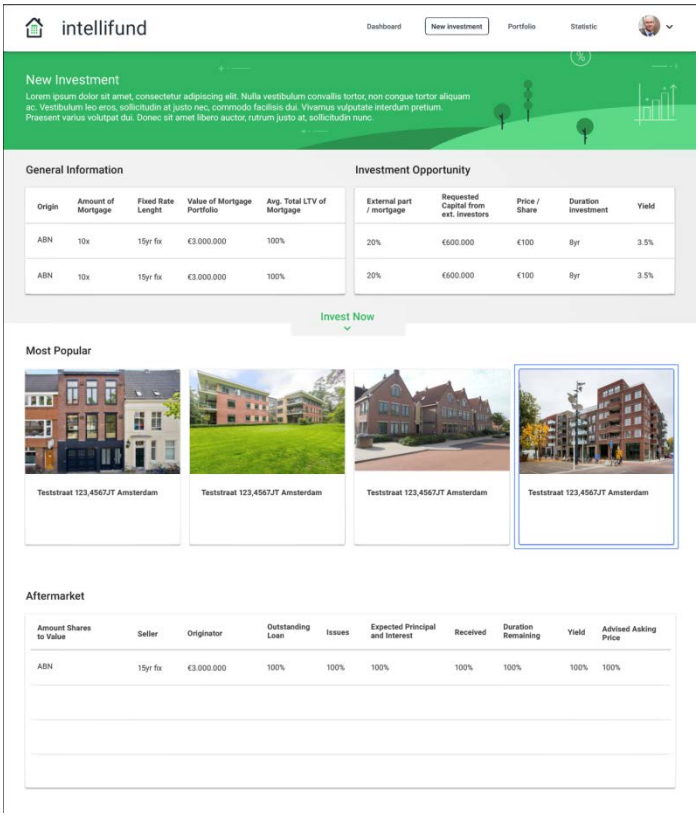


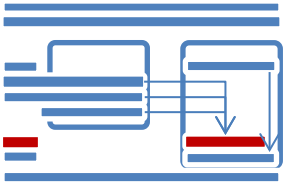
Figure 35 Mock up final GUI (own ill.)

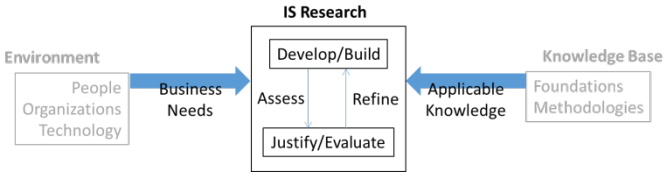
Conclusion

To find out what the platform should look like the requirements were researched. This started with determining the goals for the platform –i.e. what do we think the platform should do?- and with the creation of a mock-up reflecting that. The goals and mock-up were based on the knowledge gathered in the domain (chapter 2) and business needs (chapter 4) research. The goals are summarised in creating access to the mortgages and funding in fast and transparent way, offering a secure and flexible way of managing investments.

With the use of a preliminary design the requirements could be researched. This was done through user interviews with a set of respondents represent of the key stakeholders: investors and loan originators. The requirements cover functional, user and business requirements. Functional referring to essential parts of the platform. User requirements refer to the activities that need to be facilitated. And finally business requirements describe the context, covering the business, regulatory, political and economic reality. Finally the usefulness of blockchain was assessed and found relevant. The infancy of blockchain means that the usefulness was only found on a conceptual level. The actual implementation depends on a choice for a blockchain technology framework that can offer a part but currently not all of the advantages. The requirements were then translated to structural specifications which describe the technical architecture of the platform and deepen out the process of investment and management. These are visualised in an updated graphical user interface. These specifications aid the further development of a prototype. Additionally the requirements form input for the business model outline described in the next chapter.

6. Business Model Outline





This chapter (6) describes the business model outline with the help of the Critical Design Issues described in chapter 3. It discusses four themes to come to a complete business model: Service Design, Technology, Organization, and Finance. It is based on the information gathered in the previous chapters. Throughout the research, the business model outline has been revised several times as a result of new insights and discussions. The business model outline is a strategic document that sets out guidelines for the development of the proposed platform.

A digital marketplace is proposed. On this marketplace platform investors can buy mortgages from loan originators. They can later sell them to other investors. It is even possible to buy and sell parts of a mortgage. The technological infrastructure facilitates this process. It offers increased access and flexibility for mortgage investments since it allows investors to keep mortgages for as long as they are beneficial to their balance.

To illuminate the flexibility of the platform one pilot case is outlined. Here the loan originator is the bank, and the bank decides that it is beneficial to keep the bottom part of a mortgage and sell the top (most risky) part to external investors. It is proven that this is indeed beneficial to both bank and investor.

The outline will be evaluated in chapter 7. As such, this chapter does not describe the final version of the business model. This is a consequence of operational iterative research and the linearity of a report.

Service Design

The aim is to challenge the role of the bank in the mortgage domain. We take that to the extreme by eliminating the bank's balance sheet and funding through asset backed securities.

What is the problem background

Current trends in regulation, technology and competition forces banks to reframe their position towards mortgages.

> *Think of Basel IV, PSD2, Blockchain technology, Investment managers and non-bank mortgage labels by and for pension funds, insurers and private individuals.*

The process of debt funding introduces systemic risks and moral hazards while essentially giving capital market parties a deposit alternative in the shape of mortgage market exposure.

> *Refinancing risk because the horizon of the bank's balance sheet is about 7 years. Lack of transparency in valuation and performance. Absence of a secondary market. The process of securitization is costly and involves many specialist actors like lawyers, credit rating agencies and trust funds, who all receive fees.*

Capital Market parties with a conservative investment strategy looking for a deposit alternative are increasingly looking to the Dutch mortgage market for exposure. Yet entry barriers prohibit full involvement.

> *Understanding of the Dutch mortgage system. The variety of products and prepayment policies, the high LTV's and the fiscal subsidies and guarantees. This makes pricing hard and liquidity low.*

Solution description

What is the value proposition?

A marketplace for mortgage funding is proposed. Loan originators (like the bank) will be able to match (to be) issued mortgages with capital from worldwide capital market investors. Streamlining the transfer of ownership of the loan creates more liquidity and therefor fair pricing. This requires full transparency of the underwriting and performance of the loan as well as its audit trail.

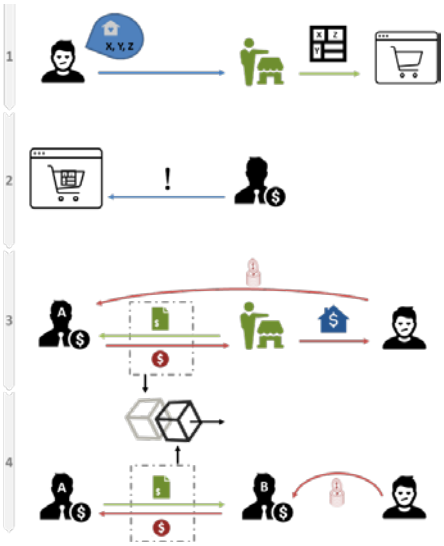
This platform creates access through matchmaking, flexibility and speed thru transparency (i.e. efficiency in debt funding) and therefore a liquid market for loan originators and investors alike because:

I. It has the ability to show new investment opportunities and capital offer.
   And facilitate transfer of ownership for liquidation of positions at any time.
II. Creates insight in the performance of the mortgage portfolio through clean data and statistics
III. It increases the ability to find and develop ideal risk/return propositions because of a technological infrastructure that allows for multiple investors in one mortgage.
IV. It creates an immutable audit trail, so ownership can be tracked and cash flows directed to the right investors.

A more liquid market for mortgage funding creates fair pricing, but needs transparency. Distributed ledger technology is used to facilitate and record transfer of ownership in a secure and transparent way.

Stakeholder Journey

How do the stakeholders act on the marketplace?



1. The loan originator places funding-requests on the marketplace. The funding-requests contains the characteristics of the mortgage.
2. Investors find investment opportunities that match their preferences
3. The investors invest and get ownership in return. The mortgage is funded and the consumer buys his house.
   The transfer of ownership is recorded on the blockchain.
4. Later, when the investor wants to liquidate his position, he sells his ownership to another investor. Principal and interest payments are redirected to the new investor.

Targeting

How to define the target group?

Users. The platform's main usage is a marketplace. There are two user groups here. The loan originator and the investor. It is the aim of the platform to match the two. The loan originator supplies the mortgages and the investor supplies the capital. Note that "the bank" can be both.

The market of loan originators and investors is very broad and international. A platform can neither reach nor facilitate a global audience directly. Initially a small group of selected originators and investors should dedicate their resources to a pilot that showcases the potential of the platform. Preferably originators with a need for experience in creative funding solutions and investors willing to assume a slightly different risk/return proposition. If this pilot succeeds it will yield both learnings as well as exposure, which will create traction among other users. First though, the focus should be on assembling this initial group of customers. The platform creates additional opportunities. Multiple additional services can be offered, such as risk analysis and reporting, but these are second tier services.

Creating value elements

How to create value for the targeted users of the platform?

For a marketplace to function, parties should trust each other. Trust can be achieved by offering quality of service, security through technology, transparency in counterparties and fair pricing.

The marketplace platform offers the users access to the Dutch mortgage market. Dutch mortgages in itself are an attractive investment product with historically low risk and decent return. Liquidity risk premiums are avoided on this platform because the products can be traded in a quick, secure and transparent way. This is because of standard product formats (universal prepayment fines, basic terms and conditions, no insurance policies), insight in the performance of the asset (through monitoring) and benchmarking and appraisal tools.

Table 10 Value elements

Access.
- *Customised exposure* to mortgages for investors
- Access to funding for loan originators
- Intuitive User Interface

Liquidity and Speed
- Transparent standardized products
- Compliance upfront
- Automatic Matchmaking
- Integrated payments
- Always an Exit

Fair Pricing.
- Benchmarking
- Analysis tools
- Standardised product requirements
- Standardised pricing advice

Trust.
- Security through cryptography
- Monitoring Asset performance
- Analysis of market, assets, bechmarks

Additional Services
- Asset Management
- Risk-as-a-service

Branding

How to promote or brand the service?

The initial branding should focus on assembling the starting coalition. This has more to do with credibility creation than a marketing campaign. It requires:

Clear pitch. With value network and stakeholder journey. In order to explain the value proposition a short digital pitch is prepared.

Internal Sponsors. Determine the right people and departments for the development. Will bring both credibility and sufficient scale.

Achievements. Success needs to be celebrated.

Customer retention

How to stimulate recurrent usage of the service?

Long term products. Mortgage loans are long term loans and cater to long term capital. This acquire and hold attitude contributes and instigates long term relationships between platform and users.

Value add services. Integration of related services and business needs can contribute to enduring use

Aftermarket possibilities. The fact that you can liquidate your position at any time creates comfort for the investor Provides an exit and therefor comfort.

Originator Guarantees. Complete off-balance placement has proven costly in the past. With traditional mortgage backed securities Investors (and credit rating agencies) prefer it when the originator either keeps some skin in the game or guarantees buy-back.

Technology

This domain describes what functionalities and capabilities are demanded from the technology in use and how these could be achieved. The main functionality of the platform is transfer of ownership. The technology should primarily support this.

Security

*How to arrange **secure** access and communication?*

Authentication. Logging onto the platform should require at least multi-factor verification. A public/private key pair should also be made available to show certain data and make investments.

Payments. The safest way currently is a connection with the back-end of a bank, through clearing. This will serve as a connection with the swift, iban or sepa network for bank payments. However this compromises the speed of transaction.

A preferred alternative would be a cryptocurrency as the consensus algorithm would solve audit and payment security, this would require a digital equivalent of the euro to exist. The dawn of central bank issued digital currency is inevitable so the implementation needs to be anticipated.

Audit. Security against (auditory) fraud is countered through the use of blockchain. A consensus mechanism either prohibits or evidences fraudulent activity.

Malice. To lower the risks of fraud incremental payments are used which means that trades are cut into pieces and sent sequentially, minimizing the loss in case of malicious intentions.

Smart contracts. Simple, clear consequential coding is needed to avoid exploits like the Ethereum DAO hack last year, which was mostly a result of over engineered code.

Adding partners. The starting coalition will consist of known and trusted partners. But when scaling to global, an authorization and verification system needs to be native to the system. A reputation based system is proposed by the DUT, yet this still has to prove its practical use in finance.

Messaging. The investment bids and asks should be obscured for everyone except those involved. This can be done either by cryptographic securing of the data or the sender and receiver addresses. A TOR-network like solution could be used.

Documents. Only a limited amount of documents need to be transferred, however to do this securely libutp is advised.

Quality of service

How to provide for the desired level of quality?

Development strategy. The strategy for user satisfaction is to develop the platform with a starting coalition of users. A maximum of 2 loan originators, 2 investors and a technology provider. This way the experience in the field of mortgage investment is exploited, the platform is given credibility through serious sponsors who have dedicated resources to bring the platform to fruition.

Quality. Should be accomplished by working with a technology provider with a strong financial business focus. The feasibility comes from alignment of technology with the business and regulatory reality.

Components and applications

How to anticipate for complementary components and applications?

Complementary components can be offered through API's (an API provides a link with other computer programs). So new functionalities can be added in modules. For instance a risk analysis model that appraises the value of a mortgage. Through the API a price advice for an investment opportunity can be given.

Risk analysis. This requires the monitoring of repayments, disclosure on the specifics of the mortgage borrower and real estate. A connection should be made with the loan management systems like Stater for instance.

Pricing tool. To give an valuation advice. This tool assesses the probability of default and prepayment, the servicing cost, and needs the exact specifics of the mortgage.

(Special) management. This party can be involved when issues with the individual mortgage arise and should only then get permission to the specific details. Except for viewing permission, the manager should be able to communicate with the investors invested in the mortgage.

Investment management. An external investment manager that gets the permission of one (or more) investors to handle the portfolio. He should get similar permissions as the investor role.

Platform providing. Billing for the usage of the platform per trade.

Support. When an investor or originator spots issues within his portfolio a support tool should be available. One can imagine a virtual assistant in the shape of chatbot. It can provide possible solution directions.

While attractive to keep full control and ownership, it is advised to consider working with existing platforms and add functionalities.

System integration

How to integrate new services with existing systems?

Investment Memorandum. It should be possible for the originator to upload all the characteristics of the to be issued mortgage onto the platform, this is the investment product. The most important information concerns:

I. Underwriting criteria (LTI, collateral appraisal criteria, job security)
II. Product terms (interest rate averaging, relocation options, prepayment fine percentage, quotation period)
III. Quality of regular or special management
IV. Origination and servicing fees

Reporting. The originator, investor and provider need report their results internally and possibly externally, even though mortgage security positions don't need to be reported at a regulator. Reports require an export format.

Data Analysis. The system should anticipate the usage of AI. It should also have standard performance statistics functionalities.

Payment integration. The system should anticipate the usage of digital currency as well as traditional payment handling services.

Accessibility for customers

How to realise technical accessibility to the platform for the target group?

The application is web-based with the business logic embedded in the application layer. This way the GUI is just a pass through and can be tuned to the device in use.

Mobile devices are excellent for monitoring and quick statistics as well as notifications of issues. Yet when making an investment and uploading information to the platform, the PC is expected to be more useful. The platform should thus be viewable on both, but with different emphasis. The desktop version should receive priority in development.

Management of user data

How to manage and maintain user profiles

The starting coalition will be in possession of dedicated and sufficiently secure servers in fully owned datacentres. Sensitive information by one of those parties should only be saved on one of their own servers. An account of all transactions should also be recorded by the involved parties.

Data should only be disclosed by parties with permission, and only to a predetermined degree [as described above]. After view/edit permission it should be collected from the servers of the owner of the data.

Scalability

How to anticipate scaling up?

Scalability is primarily understood as the capability to adapt to growth in demand. It should be able to cope with changes or updates in the used technology architecture in the future. Therefore the core functionalities should be independent from additional services. One way to achieve this is a modular architecture. Requirements to this architecture are:

- Easy API integration: to allow the integration and disintegration of services.
- Being blockchain agnostic: by working with REST API's it is possible to switch from blockchain technology provider.
- Currency agnostic: It is both possible to make payments through traditional clearing and settlement connections as well as the integration of crypto- or other digital currencies.
- The data structure should anticipate intensifying use of artificial intelligence to analyze data and make decisions based on those analyses.

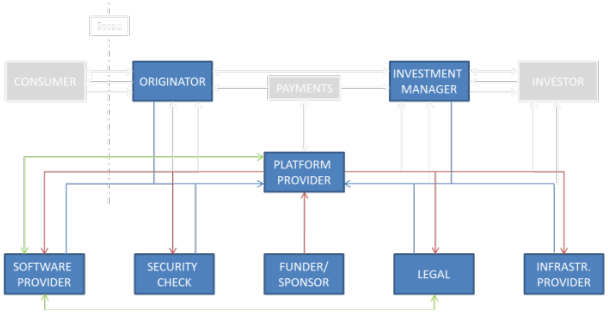
Organization

This paragraph describes what parties you need to build the platform and its services. The initial question is: “the loan originator wants to sell the right to the receivables of mortgages to investors, what do we need to make that happen?”

Actors

Role	Action	Potential Actor
Originator	Origination of loans Underwriting of loans Upload of performance data Customer support (consumer)	AAHG/NIBC/etc. Mortgage service street
Investment Manager	Portfolio management	Originator Mortgage ALM department Independent IM party
Risk reporter	(Continuous) assessor of the mortgage applier	*New role for risk modelling*
Consumer	Request mortgage Pass underwriting criteria	Starters
Investor	Buy-in Portfolio & Performance management Exit	Pension funds, Insurers (Institutionals), Banks
Payments	Transfer of currency Audit Analysis for performance management	Digital currency or API link with back-end of the bank (PSD2) Digital Currency or Cryptographic Hashing of actions Digital Currency or API Link with payments
Legal compliance	Verification Due Diligence Contract making Cadastral registration (?) Notarial registration	Start with sophisticated investors Native to the platform thru transparency Digital Smart Contracts Link with Cadastre
Regulator	Receive reports	DNB, ECB
Platform creator	Development Maintenance	Delft UT, DAH, R3, Hyperledger ABN
Infrastructure provider	Hardware: Servers	ABN or AWS/Google/Azure/IBM
Software providers	Blockchain technology	Delft UT, DAH, R3, Hyperledger
Platform enterprise check	Pen test	Deloitte/PwC/etc.
Funder/sponsor	To finance the complete effort	ABN AMRO

Value Network



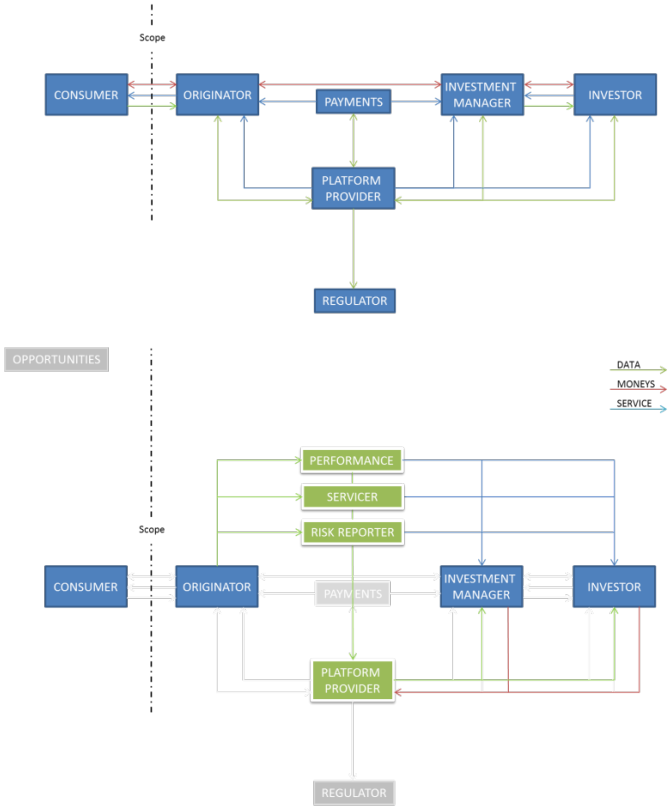


Figure 36 Value Network (a) startup (b) standard (c) opportunities (own ill.)

Partner selection

How should partners be selected?

The partners should be selected based on their willingness to contribute resources to a starting coalition. Resources can be described in financial terms, dedication of people and internal services such as: legal support, hardware, a connection with payments and clearing, and linking the front end of the mortgage originator. The starting coalition should initially be comprised of the initiator/platform provider, the two user groups, and a software provider. ABN AMRO is obviously the initiator/platform provider. ABN AMRO and NIBC, both are banks and house a loan origination function and associated services. APG and AEGON could be two investors. We are currently in conversation with all of these parties, initially as part of the research but with an eye on future partnerships.

The software provider should bring the blockchain based functionalities needed to facilitate the transfer of ownership. Currently the *prototype* for the market platform is developed by the Delft University of Technology. This is however a research facility and not an enterprise software development company. While the technology and its ideology are promising, it is probable that further

development will need another company, like Digital Asset Holdings or one of the Hyperledger frameworks.

Next steps in partner selection are likely to be internal within ABN AMRO to focus on the legal and security feasibility with regard to payments and transfer of ownership, and the monitoring of borrower repayments (performance measurement). Once the platform is running its basic capabilities next steps involve the creation of additional services, such as risk analysis. Only after that one can start to allow others to join the network.

Network openness

Who is allowed to join the network?

Initially only the starting coalition members are allowed, which is fine and feasible for the prototype phase. The end goal is to make it an open platform. The more open a platform is, the more it attracts new users, the more it is used. New actors in the network can be originators, investors, investment managers, but they can also be service providers and one can even imagine that consumers will at some point be allowed to join the platform and arrange their own funding. New originators and investors will have to comply to an investment product format since a standardised format allows the mortgages to be easily appraised and traded.

There seems to be a discrepancy in the power of the regulator, who is allowed to view everything form service, contracts, advice reports, and data on the mortgage whereas no explicit oversight is required for MBS security transactions.

Additional services will initially be developed internally since these are the new roles the bank should exploit. Later the underlying technology can be opened up for other companies to supply API's, which will increase the customer base of the platform.

The final step would be to allow consumers to join the platform, they would then essentially take the place of the loan originator and arrange their own mortgage peer2peer. The platform should at that point have the capabilities to support a consumer, such as advisory and a connection to consumer defence (AFM or the tax authority). The moment that anybody is allowed to join the network a digital identity framework should be in place.

Network governance

How is the value network orchestrated

The network is led by the initiator, ABN AMRO. ABN provides the keystone, it manages the initial partnerships. It serves as the platform provider. This differs from the software provider, who develops the platform. The platform provider should not be responsible for the deals that are made on the platform.

With regard to legal compliance we are currently drawing a complete blank. It has not been part of the scope, but should be very much considered when proceeding. It is expected that completing a legal framework takes more time than developing the software.

Network complexity

How to manage increasing number of actors in the value network?

Health of Underlying Asset. It doesn't matter how many investors or originators join the platform as long as the underlying asset that's traded is transparent in the sense of performance and contractual agreements. It doesn't necessarily make the network more complex since it is the same kind of actor that joins. A number of actors will also leave the value network after the startup phase, such as the Pen-testers.

New regulation. Some assumptions have been made here with regard to the legality of digital contracts as well as the possibilities of API's for payment transfer initiation. While these are not a reality as of now, they will be in the near future. The latter because of the PSD2 directive that allows third party payment providers to access payment accounts, and the former because of the efforts of blockchain enterprise consortia like R3 working on a standard for digital 'smart' contracts.

Additional roles. Since the end goal is an open market it will very well be possible of middle men to appear at some point. People who act on behalf of the original investors. It should be further researched what the effect of brokers and investment managers is on the workings of the market.

Internal Governance

How to create credibility and sustainability

Internal Sponsor. ABN AMRO's processes and values (its departments) should support the business model in order to be credible to the outside and attractive to new network members. This requires an internal sponsor, preferably executive level, who safeguards internal communication and strategy to avoid conflicts of interest.

Financial

This paragraph describes the financial domain on a high level for the platform and more in detail for the pilot case.

Investment sources and capital

Platform

Delft UT. The university invests human resources as well as technological capacity such as hardware (servers) and software.

ABN AMRO. The bank has initially invested in the research and development at the university as well as dedicated a small team for the business case side of the experiment. Further development will require dedication from specialized mortgage funding departments as well as IT. Possibly additional investment is needed when new technology is required.

First partners. When new partners join for the pilot stage, they will be required to dedicate resources to the project.

Product

Investors. Obviously these parties will need to bring their capital for investment in mortgages. Basically all services are aimed to be integrated into platform, for which the investors will pay a platform, access and management fee.

Originators. These parties function as the front-end towards the consumer, they will need to have a mortgage service street that is capable of uploading the right datasets per mortgage in order for them to be sold on the marketplace.

Cost sources and costs

Platform

Development. Fixed costs would entail the dedication of a team of developers and business analysts. With a blockchain developer, a front end developer, a dedicated business analyst and a flex pool of support from relevant business departments this is estimated to be 4.0 FTE (full time employees).

Maintenance. As the aim is to scale, maintenance is a relative term here, but can expected to be 1.0 FTE at the beginning.

Branding and Targeting. Being a financial platform with known partners, the branding budget is not as high as that of a consumer platform. However, branding and targeting can be understood as ligning up partners and maintaining relation management. This is expected to need 3.0 FTE at the start.

Support. In the beginning this role can have overlap with all of the above, yet it is important to have a support function on the team: 1.0 FTE.

Additional services. ***What does it cost to write risk reports***

Product

Operating costs - Reporting, HR, etc. Operating costs per mortgage can range up to 130 basepoints (1.3%) of the total mortgage interest rate. Starting with 65bp for basic servicing and underwriting, but adding 65bp more through regulation, marketing and so on. To compare, modern mortgage investment managers tend to keep operational costs to 30 basepoints. Operating costs take the biggest piece, so this is where the potential is greatest.

Credit risk. Credit risk margin takes up some 5-10 basepoints of the interest rate. This is because the credit risk in the Netherlands is barely relevant as explained in the mortgage domain chapter.

Funding costs. Funding either comes from savings, which are currently at 30 basepoints or debt funding, where a recent funding round for 15 years fixed was secured for a 100 basepoints. In the correct proportion cost of funding would take approx. 58 bp.

Profit Margin. The profit margin can therefore be up to 93 basepoints

Revenue sources and revenue

Platform

Platform fee. Access being the key value proposition it makes sense to exploit that with a platform fee. Although one could also imagine this being part of the fee of the different services offered.

Risk reporting fee. This could be one of the additional services offered by the bank, which could be part of the underwriting as well as the performance analysis process.

Originator and management fee. This contain the service costs of issuance, consumer contact and the performance management of the mortgage portfolio.

Product

Return on stake. Every investor gets a return relative to the amount of risk he is taking. Initially there will be two tranches, one for the main investor, the one taking the largest share. And a tranch for secondary investors, these will be compensated for taking a higher risk, being second in line for collateral repayment in case of default.

Savings on capital requirements. The Basel IV capital requirements make high LTV loans less attractive for the balance sheet of a bank. By using syndicated mortgages these reserve requirements are lowered and the return on equity increases. *Yet to be proven…*

Risk sources and risk

Platform.

Competition. Already, platforms like Loan Clear by Dynamic Credit and Blackmoon.fg exist, also Digital Asset Holdings is creating a blockchain based platform for trading. If these platforms create traction and scale fast enough, chances are that by building your own platform you will waste valuable resources.

Under attack/Offline. Being an online platform makes you vulnerable to attacks from all over the world. The bitcoin network has been fighting off attacks daily, simply because the prize money for a successful attack would be gargantuan. Similar situations aren't far-fetched for the proposed platform.

Loss of data. A straightforward risk for both off- and online business is the loss of data. There are different ways of saving data either on dedicated corporate servers, in the cloud (which means Amazon or Google's servers), or a distributed version with globally saved data. The where the first is more secure with regard to privacy, the last is more secure with regard to safety –if something (a power cut, disaster, war, etc.) happens on one location, data will also be saved on others.

Risks to new concepts. Blockchain(-inspired) technology is a young and mostly untested field. This means that there could be now unknown but comprimisable flaws in the system. An example was the bug in Ethereum's DAO which allowed a hacker to exploit and walk away with 150 million dollars. It might also turn out that blockchain tech is not efficient enough for the financial sector, and the blockchain quest is abandoned. There are also risks native to the specific system the Delft UT has designed (as described in the domain chapter), such as Sybil attacks, which allow you to trick the system into thinking you are reputable. This is not necessarily a threat to the concept of a platform for mortgage investment.

TU Delft is not a production company. Finally, as mentioned before, the UT Delft is a research facility and not an enterprise software developer. They will not service and maintain enterprise software for the upcoming years. If market parties don't act on the innovations of UT Delft –i.e. copy and further develop it- an alternative should be chosen.

Product

Default, prepayment, interest risk. The credit risk lies at the investors. The credit risk of Dutch mortgages has proven to be very low, it barely affects the margin. However, this is reasoned from portfolio scale, on micro level it is nearly impossible to predict. This is why diversification is important for the investors that buy in on the top part of the mortgage, it's better to have 20 shares of 1% than 1 share of 20% LTV.

Mortgage market development. Currently the Dutch mortgage market resembles a value of around 650 billion, the indication from the government that this will grow in the coming years to 850 billion. If you consider that the total residential real estate stock already resembles a value of 1100 billion euros there seems to be enormous potential. But one does not simply build 200 billion in new real estate, so the rising house prices trend is expected to continue.

Rising house prices and strict regulation decreases the ability for starters to buy a house. This decreases movement in the market and eventually causes house prices to decline. A result is that households are left with negative equity, further locking movement in the market. While it doesn't change much to the fixed income cashflow, high LTV mortgages will be hard to unload on the proposed aftermarket. Additionally in a locked market no new mortgages are issued. So this scenario also has its effect on aftermarket liquidity.

Default of the funder. When the funder defaults the mortgage will be transferred to that funders credit holders. Usually a credit holder will want to liquidate these new positions since they rarely align with his strategy. However, with a mortgage that is not possible. So either a buy-back guarantee or a back-up fund should be erected which can hold the mortgage in these rare situations.

ALM Risk. The originator needs compensation for his ALM risk, because he attracted expensive funding that needs to be broken down.

Capital requirements change. Basel IV will dearly affect the positions of Dutch system banks with regard to their mortgage portfolio. But if the lobby succeeds and Dutch mortgages retain their excluded status there will be a lot less pressure to change the current game.

Interest rate changes. It was recently announced that the TLTRO program by the ECB has had its final round. The FED in the USA has also started an interest rate hike. This means that the years of cheap (free) funding have come to an end. The mortgage interest rate is influenced by its funding costs, so the MIR will probably rise. Probably stronger than the cost of funding since banks will want to hedge for an uncertain future. Rising interest rates combined with strict lending regulation prohibit a generation of starters to enter the market, eventually affecting the market liquidity.

The risk/return proposition of the syndicated mortgage doesn't align. The investors might not be willing to invest in the most risky part of the mortgage for the return that they get. It could very well be more attractive for both the pension fund/insurer and the bank to turn the proposition around. Where the bank holds the top 20% for 7-8 years and an institutional keeps the 80%. Also the might disagree as to who has the first right of pledge.

Registration of complex syndicated mortgage. Although currently out of scope, there is the risk that mortgage registrars fail to register multiple mortgage funders to one mortgage.

Pilot

The first pilot case will be the syndicated mortgage. This will allow the mortgage to be cut into pieces and sold to different investors.

The advantage is that every investor gets a risk-return proposition to his liking. It creates flexibility.

It means that the bank can originate a mortgage and fund one part and attract funding form external investors for the other parts. This can come in useful when you anticipate on Basel IV capital requirements that weigh more heavily on high LTV mortgages.

Because of this the borrower can get a much more attractive interest rate offer while still borrowing a 100% of the value of the home. The aim of this specific case is to lower the LTV ratio so that capital requirements drop and the Return on Equity rises.

How does it work

Step #1 Find the optimal ratio

Based on a dynamic table the optimal LTV ratio is determined. The input is comprised of the current mortgage interest rate levels of the bank and the competition, the fixed rate period, and the Basel IV capital requirements.

The aim is to offer an interest rate that is significantly cheaper than the competition, a difference of 0.2% was chosen. For a 15 yr fixed period, the aimed interest rate is 2.55% (competition is 2.75% by Delta Lloyd). The optimal ratio is 80% for the bank and 20% for the *external investor(s)*. This is the point where the investor has the highest yield and the bank relatively the most attractive position with regard to Basel.

	Interest Rate
Bank (80%)	2.36%
Investor (20%)	3.19%
Consumer	2.55%
Competition	2.75%

Learning. The model shows very clearly that the longer the fixed income period, the harder it is to beat the competition. This has to do with the optimal horizon of bank funding.

Step #2 Create repayment schemes

As an example a mortgage of €275.000 was chosen. The mortgage borrower needs a mortgage of 100%. 55.000 euros (20%) will be funded by external investors, 220.000 euros (80%) by the bank. The borrower pays an annuity (principal+interest) of €1093,- monthly.

The 55.000 euros are repaid in 98 months (roughly 8 years), the investor receiving €646,- monthly on principal and interest.

This means that for the first 98 months the bank receives €447 and from month 99 until 360 the bank receives 1093 euros.

The Basel capital requirements are calculated as costs. The costs are the profit that you could have made with the money that is now in reserve.

€275,000 * RWA * Capital Requirement * Floor = €9,075

The RoE of ABN AMRO was 13% over 2016, this gives:

(9,075 * 0.13)/12 = 98.3

So the income is 1093 – 98.3 = € 995

However

At an LTV of 80% the reserve = €4,620

Monthly cost drop to €50.-

Income for the bank = €397.- for the first 98 months

Step #3 Calculate RoE

To be able to evaluate the proposal the return on equity is calculated. The formula is:

Return on Assets * Equity ratio

Where return on assets is the yearly turnover divided by the assets (the original investment). And the equity ratio refers to the funding mix for each share. This is **not** the earlier mentioned bank-to-investor ratio.

- This funding mix is currently set at 100% own equity to avoid confusion.
- Since mortgages are a long term investment inflation is considered at a rate of: 1%
- The bank still manages the mortgage, for this the investor pays a monthly fee of: 2%

The result is:

	Return on Equity
Bank (80%)	14.69%
Investor (20%)	13.29%
Benchmark – Bank (100%)	14.27%

The benchmark is a trivial one, it is purely meant to show the effect of Basel on the RoE. Because it describes a situation where the bank would have funded the whole mortgage at 2.55%. However, this is not possible, the lowest rate at LTV100 from the bank is 2.86%, which means it would not have been chosen by the borrower.

Step #4 Scenarios

Keeping all other variables equal, some scenarios are shown below. In order of appearance on the page above.

Difference with the competition. It should be researched at what price difference a consumer changes its mind, because of all the internal tweaking this has the greatest effect.

	0.05%	0.20%	0.25%
Bank (80%)	14.95%	14.69%	14.67%
Investor (20%)	13.69%	13.29%	13.16%
Benchmark (100%)	14.56%	14.27%	14.18%

Height of the mortgage. Doesn't change anything, since RoE is relative.

	€175,000	€275,000	€375,000
Bank (80%)	14.69%	14.69%	14.69%
Investor (20%)	13.29%	13.29%	13.29%
Benchmark (100%)	14.27%	14.27%	14.27%

Capital Floor of Basel IV. Logical results, the lower the floor, the higher the RoE.

	50%	75%	100%
Bank (80%)	14.88%	14.69%	14.50%
Investor (20%)	13.29%	13.29%	13.29%
Benchmark (100%)	14.47%	14.27%	14.08%

Funding mix. Shows the massive effect of leverage, though funding costs are not taken into account here.

	60%	100%	-
Bank (80%)	24.48%	14.69%	-
Investor (20%)	22.15%	13.29%	-
Benchmark (100%)	23.79%	14.27%	-

Inflation. Since the investor is repaid first, the bulk of repayment for the bank comes in year 8 and beyond. The

higher the inflation the lower the net present value and the lower the RoE.

	0%	1%	2%
Bank (80%)	17.40%	14.69%	12.49%
Investor (20%)	13.85%	13.29%	12.77%
Benchmark (100%)	16.55%	14.27%	12.42%

Management fee. Obviously impacts the investor to a larger extent than the bank. And as expected the benchmark is not affected.

	0%	2%	3%
Bank (80%)	14.62%	14.69%	14.72%
Investor (20%)	13.56%	13.29%	13.15%
Benchmark (100%)	14.27%	14.27%	14.27%

Bank takes 20% instead of 80%. The idea behind the turnaround is that an eight year horizon would better suit a bank's funding cycle. As refinancing risk is not a factor in the model the exact effect stays invisible. The RoE does not par with the benchmark, yet it is slightly above the bank's last year average.

	20%	80%	-
Bank (80%)	13.37 %	14.69%	-
Investor (20%)	15.19%	13.29%	-
Benchmark (100%)	14.27%	14.27%	-

Fixed Rate Horizon. Why does the RoE increase on a fixed rate longer horizon. The bank to investor ratio changes from 80/20 to 67/33 which means lower capital requirements for a longer time.

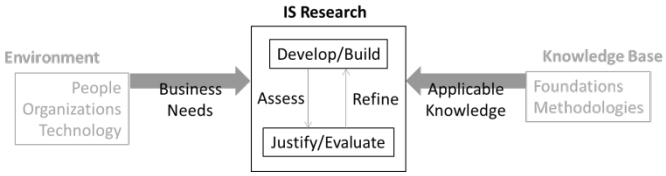
	10yr	15yr	20yr
Bank (80%)	14.69%	14.69%	15.50%
Investor (20%)	13.29%	13.29%	13.20%
Benchmark (100%)	13.36%	14.27%	14.56%

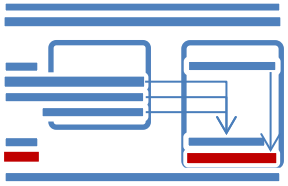
Rising average interest rate. What happens when the interest rates rise. This shows the blind spot of the cash flow model, namely the fact that the costs of funding, operations, profit etc. aren't input variables. With higher interest rates this model therefor shows a return on equity increase, while one would expect none since funding costs would also increase. Showing this would thus be non-information.

Conclusion

This question was answered with the use of the STOF method by Bouwman et.al. (2008). By describing Critical design issues in the domains of service design, technology, organization and finance a design of a business model was fleshed out. The design was based on the research results of chapter 2, 4 and 5. Which consisted of both desk research as well as multiple interview rounds with consultants, start-ups, investors and loan originators in the mortgage funding domain. The pilot shows the financial validity of increased flexibility in funding structures, it shows an opportunity for anticipating on changing regulation with regard to capital requirements. The robustness is tested in several scenarios and is proven, but only to this limited level of detail. If there is potential for this case, steps have to be taken to elaborate the model by distinguishing cost sources for instance. In the next chapter handles the evaluation of this business model design proposal to fine-tune the design. This final design is then included in the management summary.

7. Business model evaluation





Intro

In this chapter the business model outline of chapter 6 will be reviewed. It turns out that for a bank total income is an important indicator, this makes a return-on-equity focused solution a difficult departure compared to the current business model in mortgages. Such fundamental changes within an asset class that is indispensable for the bank complicate decision making. Apart from that the use of blockchain technology would not necessarily make things easier on the short term. Among other things, it is concluded that the initiator and potential partners in a joint venture should reconsider the scope of the project.

Methodology

Together with experts the business model will be reviewed. A set of predetermined criteria is used. The experts will be handed the business model (i.e. chapter 6) and the criteria a couple of days beforehand. The result of the interviews will be analyzed and linked to critical design issues to improve the business model proposition. The improved business model outline is described with the end products.

Criteria

The criteria for evaluation are the critical success factors of the STOF method. The criteria cover internal and external aspects of the business model. The experts will be asked to reflect on the general detail of the business model, are there aspects that were completely missed. An important aspect of any business model is its scalability, is the described infrastructure capable of supporting growth, these will be assessed by the technology experts. Adaptability and robustness are dependent on externalities, these are discussed through scenarios. The viability of the business model is internally dependent.

General. Sufficient detail.

This criterion assesses the completeness of the business model. The respondents are asked if they found anything missing or inconsistent within the domains and between the domains.

Scalability

Scalability looks at the capability of the business model to react on increased demand, this is especially relevant to the technology and organization design. Is the underlying infrastructure capable to change and to grow in a modular way and are the financial and human resources designed to support this?

Adaptability

Other from scalability, adaptability looks at how the value proposition can be changed or optimized to better appeal to target groups or changing target groups. It also reflects on the competitive advantages and unique selling points with regard to the competition.

Robustness in Scenarios

The robustness is tested by letting the respondents describe what would happen with the attractiveness of the proposition in certain external scenarios. These scenarios are based on the drivers of the proposition and cover the effects of Basel IV, changing interest rates, house prices and inflation and changing consumer regulation on the Loan to value ratio.

Viability

Apart from the above the critical success factors (CSF) from the STOF method are evaluated, these are described below. The CSF's indicate to what extent the proposition is attractive to provider and customers alike.

Table 11Key Success Factors (Bouwman et. al., 2008)

Compelling value proposition	Is the value proposition sufficiently attractive to customer groups from each platform side? Do additional complementary services make the value proposition more attractive to demand side customers? Does a large customer base on the demand side make the value proposition more attractive to supply side customers?
Clearly defined target group	Are the target groups for each platform side sufficiently clear? Do we know enough about each customer group in terms of their needs, preferences, capabilities, available resources, and sensitivities? Is the strategy on how to start the market dynamics between the different sides of the platform clear?
Unobtrusive customer retention	Is subsidizing going to be used as a retention mechanism? Is it clear which customer groups should be subsidized and how?
Acceptable profitability	Is it clear who will incur the customer subsidy costs if such exist?
Sustainable network strategy	Is there a common goal to which all business ecosystem members can adhere and strive to?
Acceptable division of roles	Is there a keystone actor willing and capable to lead the value network?

Respondents

CC. Is a senior product owner at the residential housing group of a major financial institution in the Netherlands. It is her job to evaluate new ventures for business development within the residential housing group. Her main focus is on mortgages, and stimulating reconsideration of the traditional residential mortgage value proposition. Her background, experience and day-to-day focus make her an excellent expert for the review of a new business model for mortgage funding.

JO. Is the Chief Operations Officer at a Fintech in Amsterdam. The Fintech has started a non-bank mortgage originator as well as a mortgage bond trading platform, and successfully issued up to eight billion euros in mortgages over the past few years, while attracting funding from all over the world. The aim of the company is to make mortgages a commodity. His experience as a serial entrepreneur makes and his affiliation with the mortgage domain make him an ideal expert.

MH. As a business performance consultant at the residential housing group of a major financial institution he has recently developed a new mortgage proposition derived from similar drivers as this project. The proposition was also aimed at lowering the LTV of the mortgage. The proposition is currently being tested in the field as a pilot. His expertise on structuring mortgage for balance sheet steering make as well as new business developer make him an excellent expert.

BT. As a senior balance sheet manager at the residential housing department of a major financial institution he has an insight in the nuances of the contextual drivers of this business model design. For example the effects of Basel IV regulation on the strategy of the financial institution, and the strategies followed for the volume and horizon of mortgages being issued and ending up on the balance sheet.

RS. Is a solution architect and part of the blockchain technology efforts of a major financial institution. In this role RS is working as development lead for projects using the R3 Corda framework. Previously he has worked with Hyperledger frameworks. He is a key advisor to the business with regard to blockchain based projects.

Interview

In order to use the time as efficient as possible experts are only asked about fields of expertise. All interviews will be recorded and all participants are notified of this, their explicit consent is requested when specific quotes are needed. The results are covered in the next paragraph.

Results per criterion

General/sufficient detail/consistency

To a large extent the proposition was understood, especially the pilot was. As BT explained: you avoid, which is legal, the regulatory cost and offer investors a return for helping you do that. By anticipating on the Basel capital requirements you increase your Return on Equity (MH). But the pitch can be clearer, there is too much talking from the technology perspective, too much academia, you should visualize the proposition (CC). Most of the respondents agreed that the funding platform should stay out of sight of the consumer. The consumer should have a good deal and clear

communication. This does however mean that the investors cannot have a contract with the consumer, as this would require the presence of a notary as well (CC). Therefore the use of the term "ownership" is unclear. The consumer is the owner, and investors are pledgeholders, CC explained. Furthermore, the investment process should be clearer and address the element of speed. MH said: ultimately, it is better to secure the funding in advance to reduce interest rate risk for the originator. Finally CC feared that opening the platform for all loan originators could create a cartel-like situation, where the focus lies on an attractive proposition for investors instead of for the consumer. Though this idea has been countered by an investor in the user interview, as investors would always look for arbitrage opportunities this eventually levels the playing field through market dynamics.

The evaluation of the technology domain very much focused on the usefulness of blockchain technology and what the implications would be. RS plainly questioned the added value of a blockchain based solution. He said what you propose can be built with the consortium frameworks like Corda or another, but it is probably more efficient in a centralized solution. BT agreed in similar vein: *it seems to me that this proposition can do with and without blockchain.* Using a 'real' blockchain solution like Ethereum would completely change the situation, but would never be accepted by institutions and their current regulatory framework RS explained. This opinion was underlined by the respondents questioning the level of privacy and anonymization blockchain could offer, and if that could ever align with current risk standards (BT/MH). RS continued by explaining what it would mean to use a public blockchain solution like Ethereum. The results reinforce the conclusion of chapter 5 and the decision to lessen the blockchain dependencies in the business model. For the evaluation it means that a blockchain-specific part is added.

In the organization domain the list of stakeholders was considered more than complete. Some elaboration on the exact roles could be beneficial. It should be clearer who the loan originator is, and that this party services the mortgage, this is where consumers go with questions and issues (MH). Also, the reporting duties towards regulators were questioned, since if a mortgage is not on the balance sheet, the bank does not have to disclose the details to regulators. Disclosure and reporting policies relate to those having the mortgage on the balance sheet (MH). Finally CC didn't think that it is really diversification to invest in several loan originators, as the asset stays the same. This is true when all the terms and conditions are similar. Starting with a standard product/label would mean that you only need one loan originator.

The financial domain will also be discussed with regard to profitability within the viability criterion. Here it refers to the correct- and completeness of the finance domain. MH and BT, both financial experts, assessed the cash flow model to some extent and concluded it was correct. Most importantly with regard to the costs of the Basel capital requirements. The model could (and should) be elaborated to better reflect the effects of different cost sources (BT). The financial proposition is clear for the pilot with an 80/20 ratio. Yet, when there are more shareholders the financial proposition is not yet clear (MH). From a process point of view it was unclear who determines the interest rate for the consumer at the moment of origination and at an interest rate reset (BT). You risk that investors are dependent on the strategy of the loan originator. It was suggested to look at the Danish model and see how they anticipate rate resets.

Scalability

Scalability from a business perspective has to do with the ability of stakeholders to enter and make use of the platform. The platform should facilitate the process for these stakeholders. For the investors CC noted that they might not have the means to appraise single mortgages as the platform represents a leave from traditional portfolio based investment. Much like platforms such as Uber and Airbnb, this platform is dependent on network effects, which in practice means that there should be a strategy for limiting bad news. This is why underwriting criteria for investors should also be considered. The scalability depends on the integration of existing processes (MH). It should be explained how this platform compares or connects to existing services like Stater. Finally scalability also means considering exits (BT). For instance how do you manage a failed pilot product. You should consider clauses describing this in investor contracts.

Adaptability

With regard to adaptability suggestions were made for potential adjustments to the value proposition. This then could increase the chances of adoption of the idea, first within the bank and during execution. To convince stakeholders within the bank the horizontal scalability could be noted, mortgages are just one asset class that can be serviced through this platform (CC). Tranches of low and high risk within the mortgage could be considered to attract different types of investors (MH). Also a possibility is a generic funding model, where terms and conditions and the

product towards the consumer stays the same. The interest rate is dependent on the lowest interest rate offered by external investors in a weekly competition. You would then need a servicer to manage the mortgages (BT). Several alternatives remain for the top 20% in the pilot. Instead of external investors it could also be covered by personal credit, personal pension savings or an insurance (BT). An opportunity was revealed with regard to PSD2; if non-traditional capital-able parties -like Google for instance- make a move towards mortgages, they lack the experience and access. This platform could facilitate that, as the mortgage market is strictly regulated so partner for origination and management is indispensable (BT/CC).

Robustness

The robustness of the proposition depends mainly on two issues: the competition in the mortgage market and the elaboration of Basel IV. Solvency II, which is the regulation for insurers and pension funds currently still gives an advantage on high LTV loans compared to Basel. However, it is expected and to a degree already visible that the competition, pension funds and insurers, are incapable of answering the demand. There is a maximum to their investment in mortgages because of diversification. So it is to be seen how competitive they will position themselves when the time comes (MH/BT). The effectiveness of this proposition with regard to Basel was assessed in three scenarios . When the maximum LTV for consumers is lowered to 90%, the pilot proposition loses most of its value. The bank will be perfectly capable of funding those mortgages on its own (MH). But this does not affect the access to the mortgage market you create for investors and it might even create an opportunity for offering consumptive credit combinations (BT). When the interest rate rises, the Return on Equity for the bank decreases as Basel will have a more profound effect for a longer time. So this increases the attractiveness of the pilot proposition (MH). Finally, rising house prices lowers the portfolio LTV of the bank, limiting the capital requirements on that part while increasing them for newly originated mortgages.

Viability

Compelling value proposition.

There is a value proposition for two main stakeholders here: the investors and the loan originator. With regard to investors the respondents found that “more than solving a problem you are offering added value for the investors: exposure to mortgages, diversification, cheaper because of loss of intermediaries.” It is very much a financial decision for investors, they focus on return, so the advantages should be made very clear. Additionally, adding services like investment advisory could add significant value to the platform (CC). From the bank’s perspective the platform was primarily seen as a way to create a new label with competitive pricing, a new window to market (CC/BT). The problem for the bank, apart from capital requirements, is matching maturities. The demand for 20 year fixed interest rate mortgages is currently very high, but the bank’s funding cycle is around 10 year max. If you facilitate agreements between investors over maturities, this would greatly increase the attractiveness for the bank (BT/MH). The issue of capital requirements was deemed potentially too insignificant and too far away to be the only value driver. For a bank, the current mortgage business model is simply too profitable to consider disintermediation (like this platform). The profitability, as well as the short term focus on benefits rather than return on equity, make it very hard for a bank to change course. This proposition won’t replace the bank’s core business, but could serve as an addition.

Clearly defined target group.

In general the target groups were clearly defined and understood. But questions remain with regard to the requirements of investors, such as: if investment in multiple loan originators count as diversification. The respondents underlined the importance of a start-up strategy for the initial use and development, but found the starting coalition a sufficient strategy.

Unobtrusive customer retention.

The key to customer retention is secure the unique selling point: liquidity in mortgages. To guarantee liquidity means there should always be a buyer. This is a difficult requirement for a market, so a mechanism to provide liquidity should be described. The platform provider (the bank) should probably assume the role of market maker, buying back to some degree as offers to sell and buy will not always come at the same time (MH/BT). This incentivizes stakeholders to keep using the platform, and invites new kinds of investors. With enough liquidity also investors with a shorter investment horizon can join, making it very interesting indeed (BT). This part should be further developed as it will create a whole new set of risks. As CC said, your target group is relatively simple, they’re happy as long as they can make return. T

Acceptable profitability.

The current business model for mortgages is hard to beat, “a managing fee is less profitable than the return we currently make on mortgages” (MH). The operational costs

turned out lower than expected, and the current return on equity is around 30%. Although that includes the anticipated higher costs in the future as a result of Basel IV. The risk weighted assets will then increase with a factor 2.5. All of these cost sources should be further researched and implemented in the cash flow model to strengthen the pitch. Within the cash flow model it should be considered that investors might have a different appraisal approach. This could influence their perceived profitability.

With regard to the pilot, a 0.2% difference with competitors seems sufficient, yet differs per target group (CC). The scenario where the bank assumes 20% as opposed to 80% doesn't make sense, as you still risk losing 100% of your investment. This would create much higher capital requirements and thus affect the return on equity (MH). A pilot track with mortgages can last 30 years. This is a risk, you would have to sustain a program with high cost and limited volume and benefit. Also, creating the legal framework, which would be similar to securities, requires a considerate investment. On the other hand, mortgages scale quite easy with regard to volume (BT). The consumers need to be protected against investors going into default, so apart from investors being scrutinized in an underwriting process, there should be some sort of guarantee structure. Consider that a guarantee structure for consumer protection must be able to attract funding on short notice, which affects profitability for the bank (CC).

Sustainable network strategy.
The sustainable network strategy considers the alignment of interests of the stakeholders. CC noted that viewed from the perspective of traditional institutions the goals are not aligned, this platform might cost many people their job, but that's innovation. It is threatening indeed. On the other hand, the mortgage department of the bank's goal is to help people buy property, this goal is not affected by the platform. As earlier described the respondents do not expect this proposition to be fully adopted by the bank. This is because the shareholder satisfaction of the bank depends on dividend, which depends on absolute profit. The senior management therefore focuses on benefits rather than return on equity, which makes the argument for a fee-based model very difficult (MH/BT).

Acceptable division of roles.
Currently there are no inconsistencies, further development with stakeholders will reveal the interests and pain points. This plan bridges the corporate and the retail side of the bank. A central actor must understand the mortgage market, he or she must protect the business value of the mortgage department. The development of such a platform within an organization like the bank is a mammoth task. It takes serious commitment from stakeholders and resources, so it should be viewed by senior management as both a necessity and an opportunity. You would have to start with the Executive Board and the Asset and Liability Committee. After they have given priority to this project, you would need to include people from ALM, Debt Solutions, Treasury, Mortgages, Risk and Controlling&Accounting to operationalize the proposition. CC agrees and adds: "the development would come in two stages, operationalization of the business assumptions with departments like risk and legal and execution with IT, corporate marketing and ALM."

Real blockchain alternative

As explained, the technology domain evaluation focused on the usability and feasibility of blockchain and concluded that a private blockchain isn't really a blockchain. The respondent went on with describing what a 'real' blockchain solution for mortgage funding would look like and would need.

RS: Issuing loans on a blockchain would require both representations of value to exist on the same ledger. This means the 'cash' as well as the collateral. Additionally you would need smart contract code holding the logic and terms of the agreement, for instance: IF there is no repayment, THEN collateral moves to the lender. The cash component can be ether, and later possibly Central Bank issued Digital Currency. The collateral should linked to official cadaster information. Connecting multiple lenders (investors) to the loan is relatively easy, this has already been done with Ethereum. The underwriting procedure of the borrower is suggested to happen off the blockchain. The lender asks for identification and verification separately and adds the borrowers blockchain address in their own system.

Property title registration and Central Banks issuing cryptocurrency are still a long way away, before that more fundamental problems need to be tackled. Ownership, identity, scalability, privacy and most of all adoption. Ownership really doesn't exist on the blockchain as the keys are random, they don't offer finality on uniqueness. It is possible, though very unlikely, that someone else generates the same private key. There is no jurisdiction in the sense of a link with a government approved identity framework, so there is no real proof of ownership. Scalability is dependent on the blockchain platform, Ethereum's scalability is far from unbounded at this point. A pilot project can be tested

as it would not demand too much from the network. With regard to privacy you would not be required to but actual documents on the blockchain, yet it will be difficult to make trades confidential. So traditional competitive advantage is lost. But the biggest challenge is to create widespread adoption of blockchain. Only then will transformative innovation take place. If people don't use it for buying a meal, it is certainly not ready for property titles.

Conclusion

This chapter answers the final research question: *Has a viable business model been created?* The answer to that question is mixed, apart from gaps there are some more fundamental conclusions. The most important conclusion was that adoption by a bank is not expected and that blockchain based technology is not the most efficient solution. These and more conclusions lead to a description of the next steps for optimizing the business model.

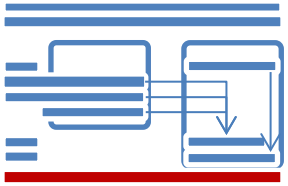
On a general level the proposition can be better communicated by elaborating the stakeholder journeys, this would clarify the pitch. The pilot case is clearly explained and though the cash flow model can be elaborated it is sufficient to show the effects of different cost sources. Scalability depends on the choice of technology. It will be a lot harder to scale a decentralized (blockchain-like) solution than a centralised one. The potential of horizontal scaling (i.e. using the platform for other assets) could be a major influencer in convincing the development of the platform. A generic funding model could serve a wide range of different stakeholders and assets and increase flexibility. The marketplace funding idea is also immune for changing trends in the mortgage domain, where the pilot case obviously is.

It is a compelling value proposition for loan originator, investor and the platform provider. Only if the initiator is a bank, he must be willing to depart from the comfortable current business model for mortgages. The target group was sufficiently clear. Customer retention was not satisfied, mainly because a strategy for continuous liquidity was absent. The profitability of the pilot was satisfactory from a return on equity perspective but unsatisfactory from the total benefits perspective. The network strategy was deemed satisfactory and disruptive towards current business models. The roles were sufficiently divided. Development of the platform comes in two stages an operational one, where the boundaries are set by senior management, partners, legal and risk and an execution where the platform is actually build.

What should happen is the initiator reconsidering his goals. It leaves the initiator with a couple of options. Either the initiator (ABN AMRO) wants to find an alternative for funding mortgages, or it wants to keep testing with blockchain technology for funding purposes (in the sense of public, open source blockchains). The first could yield a working product within a reasonable time span, given that you employ professional software developers or acquire a marketplace lending startup. The first option also implies that the bank departs from its comfortable current business model in mortgages, albeit only for an initial pilot. From the second an enterprise ready product should not be expected on the short term. A fully public blockchain solution really doesn't seem to align with business requirements.

Still for both options some sort of consortium should be created. A base of starting customers (investors and loan originators) of the platform should be gathered to develop and optimize the functioning of the platform itself as well as securing the first line of funding of mortgages. Agreements should be made with regard to the scope (time, volume, profit and cost distribution, exit strategy) of the pilot. As indicated this requires cooperation of a wide variety of departments within the bank, not least the legal department. Rather than blockchain based transfer of value a traditional fund structure is expected to be more efficient.

8. Conclusion



The aim of this thesis was to design and validate a business model for a mortgage funding marketplace platform and assess the usefulness of blockchain technology facilitating this aim. To do so a total of six sub-questions were asked to answer the main research question of this thesis:

> Given the changing context in mortgage funding what could a new business model look like and what could the potential role of blockchain technology be?

Conclusions

Q1: What is the current state in blockchain and mortgage funding and how could blockchain affect mortgage funding?

Bitcoin fundamentally changed the concept of trust. It is a trustless system through decentralized security through computation. It replaces a concentric security model, based on centralized trusted institutions and access and control, with one that is inside out, open and accessible to anyone. A security model based on market forces. That is what takes the intermediaries out. Ethereum works similarly and can execute more complex program-like code (smart contracts). But those smart contracts only work if you don't have to trust intermediaries to execute the contract. For the system to be trustless you need transparency, economic incentives and costs and a consensus algorithm to secure data integrity. This makes the system relatively slow, lacking in privacy and confidentiality, and consuming a lot of energy. Not qualifications that fit financial sector requirements. However the promise of fraud-resistant self-validating and executing contracts have excited the financial sector. Many companies are now looking to recreate those qualities, while reducing transparency working with permissioned participants. Even though this foregoes the entire idea of blockchain and looks more like a database.

This makes the mortgage investment market highly illiquid. Mortgage funding is partially done with debt funding. Secured debt funding packages loans, which are assets on a bank's balance sheet, and securitizes them –i.e. sells them to capital market parties, often shadow banks (insurers, pension funds, etc.). The process is complex and costly because of involved stakeholders such as lawyers, credit rating agencies and trust funds. It introduces a variety of risks, such as refinancing risk, a lack of transparency and moral hazards. All while capital market parties just need exposure to the mortgage market as a deposit alternative. Adopting a marketplace lender business model for mortgage funding would generate value for both the bank and the investors. It would provide in the sole need of investors to have exposure to the mortgage market. Risk would be limited through increased transparency and higher liquidity. Higher liquidity would in term create fair pricing, benefiting the borrower. The bank can adopt multiple roles in supporting this platform, it can be the loan originator performing the underwriting and servicing of mortgages. It cuts operating costs and generates revenue form fees. With a return on equity focus it would be the opposite of the current mortgage strategy.

It will take time for blockchain technology to handle a complex process and product like mortgages. The potential is such that the platform definitely should anticipate the integration of blockchain. However some major steps have to be taken before a case could go live, these steps include: the introduction of cash or representations of fiat currency like Central Bank issued Digital Currency and the ability to move real money and assets on a shared ledger; an identity framework; involvement and agreement of regulators; a kick-started network effect in shape of a starting coalition or consortium.

Q2: What does a business model for a platform look like?

This chapter had the aim to establish the concept of a business model as a strategy document. A method to create a business model is chosen based on a literature review of two of the more relevant design methods. The relevancy stems from its application to digital multi-sided platforms, completeness, alignment with the operational nature of the thesis structure, and inclusion of exemplary cases. The STOF method was chosen and supplemented with Critical Design Issues from the Action Design Research method. It is concluded that to fit the STOF method within a thesis structure the evaluation step must segregated from the business model outline chapter, meaning this chapter does not reflect the final product. The potential usage of

blockchain can have an effect on the business model, but as it is an infrastructure its functionalities are used to achieve strategic goals. It is not a strategic goal in itself.

Q3: Is a marketplace platform for investment in Dutch mortgages relevant?

The research started with an explorative phase to find and validate an initial consistent value proposition for all involved stakeholders. The answer to this question proves both the relevance of the research project as well as that of the proposed solution. The primary phase yielded a choice for *crowdfunded* mortgages as a relevant business case because of the applicability of blockchain technology (matchmaking and audit trail) and adding value for investors, the bank and consumers. The case would also be sufficiently innovative for the bank.

The secondary phase yielded significant insight in mortgage funding through a focus group with mortgage (funding) consultants. This validated preliminary assumptions and agreed with the desk research of chapter 2. As a result the crowdfunded mortgage case was iterated: the consumer shall not be part of the scope in detail, instead it was concluded from the interviews that the consumer seeks three important aspects: clear communication, some speed and above all a competitive deal. The aim of the business model is now to match loan originators and investors on a marketplace. This marketplace will increase access to the mortgage market, increase speed of investment and liquidation, increase transparency to better serve benchmarking and monitoring, provide flexibility to buy and sell parts of, complete and portfolios of mortgages all the while securing data integrity.

Q4: What are the requirements of the platform?

The design of the platform is informed by the particular context of the mortgage investment case and in his turn influences the design of the business model. This question relates to the design of the platform and seeks to identify its requirements. Based on the goals of the platform, the mortgage and blockchain domain research and the business needs from chapter 4 a preliminary design was made, called a mock-up. With this the requirements could be researched through user interviews with a set of respondents from the investor and loan originator side. The requirements cover functional, user and business requirements. Functional referring to essential parts of the platform. User requirements refer to the activities that need to be facilitated. And finally business requirements describe the context, covering the business, regulatory, political and economic reality. Finally the usefulness of blockchain was assessed and found relevant, although the infancy of blockchain means that the usefulness was only found on a conceptual level. The actual implementation depends on a choice for a blockchain technology framework that can offer a part but currently not all of the advantages. The requirements were then translated to structural specifications which describe the technical architecture of the platform and deepen out the process of investment and management. These are visualised in an updated graphical user interface mock-up. These specifications aid the further development of a prototype. Additionally the requirements form input for the business model outline described in the next chapter.

Q5: What does the business model look like?

This question was answered with the use of the STOF method by Bouwman et.al. (2008). Critical design issues were described in the domains of service design, technology, organization and finance. The design was based on the research results of chapter 2, 4 and 5. Which consisted of both desk research as well as multiple interview rounds with consultants, start-ups, investors and loan originators in the mortgage funding domain.

Q6: Does the business model answer to the expectations?/Has a viable business model been created?

The most important limitations to the success of the business model is the fact that it is not expected the bank will adopt such a business model, primarily because the bank focuses on income and benefits and this model is more about increasing return on equity. Nevertheless the potential of horizontal scaling (i.e. using the platform for other assets) could be a major influencer in convincing the development of the platform. With regard to the platform, the value proposition was clear for all stakeholders, however because a strategy for continuous liquidity was absent the proposition for investors was incomplete. If initiated the development should come in two stages, an operationalisation stage for risk assessment and an execution stage where the platform is actually build and tested.

With regard to next steps in this project the initiator is left with a couple of options. Either to continue to find an alternative for funding mortgages, or it wants to keep

testing with blockchain technology for funding purposes (in the sense of public, open source blockchains). The first could yield a working product within a reasonable time span, from the second such should not be expected. The first option also implies that the bank departs from its comfortable current business model in mortgages, albeit only for an initial pilot. Still for both options some sort of consortium should be created. A base of starting customers (investors and loan originators) of the platform should be gathered to develop and optimize the functioning of the platform itself as well as securing the first line of funding of mortgages. Agreements should be made with regard to the scope (time, volume, profit and cost distribution, exit strategy) of the pilot. This requires cooperation of a wide variety of departments within the bank as well, not least the legal department.

Main research question: Given the changing context in mortgage funding what could a new business model look like and what could the potential role for blockchain be?

A new business model for mortgage funding could be to facilitate marketplace lending. This would mean the bank develops a platform where capital market parties can invest directly in mortgages by buying them from loan originators, either partially, in whole or in portfolios. This has the advantage that the strategy towards mortgages is more flexible and capable to adapt to regulation affecting the profitability of mortgages. It implicates a fundamental departure from the current business model in mortgages (already a complex asset), from an income focused to a return on equity model. This means considerable internal resistance can be expected. The use of a public blockchain architecture would make rapid deployment impossible, it is simply non-compliant with the present day user requirements of financial institutions. Using a consortium or private blockchain or blockchain inspired solution is currently considered unconvincing, it sacrifices data integrity (one of the pillars of blockchain) to comply to financial sector requirements. Using a centralised database can still offer many of the functionalities expected from 'smart contracts'. If you want an egalitarian system for the (conditional) transfer of value, use blockchain. But this comes at the cost of full access, full transparency, a relatively costly economic incentive system, this is what makes blockchain work. If you don't want that, you're probably just desperately looking to update your administration system and cut costs.

Limitations

This research has an explorative and operational character, that means it primarily meant to give the reader an indication of the field of mortgage funding and the implications of blockchain, but it is by no means definitive. The limitations are mostly a result of a wide scope and the relatively young research field of blockchain technology. Additionally some aspects, such as legal, were omitted on purpose.

The most important limitation to the research is the chronology of the setup and the role of blockchain as an infrastructure technology. Starting out in a general direction of mortgages meant 1.5 months were needed to research the business needs, to find the most relevant business case within the mortgage domain with applicability for business model innovation and blockchain technology. To have part of the solution in the shape of a technology framework and then to start looking for a problem is usually not the way to approach innovation. The innovation process should start with a certain need or problem, and then look for solutions. It was only later that the setup of the research was changed to more reflect this approach.

Infancy of blockchain

Blockchain technology is in its infancy and it is currently overhyped. This makes it hard to distinct fact from fiction, as even academic papers seemed biased. To a large extent this is the result of poor definitions and poor understanding. It is not unusual to find socio-economic papers on the potential of 'blockchain' and see the bitcoin protocol being explained. This leads to a trivialization of what blockchain technology is and what it can and more importantly cannot do.

Limited use of the prototype

The prototype could have been used better but this would have taken a different chronology. It is only at the final stage of the research that structural specifications have become clear, these could have served as input for prototype design. This exemplifies the time one should take for these kind of projects. On the other hand, the prototype mostly served to assess the blockchain technology developed by the Delft University of Technology. Mortgages being complex products this is not the most logical asset to test a technology.

Scope vs experience: limited depth in domains

The broad scope of the business model methodology makes that every aspect has only limited depth. This effect is

compounded by the fact that both mortgage funding and blockchain are specialist subjects. Identifying solutions in both domains takes a certain thoroughness that can't be assured with four interview rounds and lacking a computer science background.

Omission of legal aspects

The legal aspects of splitting a single mortgage have not been assessed. It would have added a completely new layer of complexity to the case. The researcher lacked the background to explore these aspects. For this reason the legal part was omitted. It is however a very central part of the case, transfer of ownership is half payment and half transferring the legal rights to something.

Only one pilot case financially assessed

Only the pilot case had a financial model. The cash flow model itself was limited in the extent to which costs were separately accounted for. Also legal and development costs and income stemming from providing the platform were omitted from the model. Though the evaluation respondents found it sufficient, they also indicated that these costs should be taken into account in later stages. Furthermore it is unclear what exactly the income is from purely providing the platform and how this compares to the operational costs, which is rather fundamental to the business case of the marketplace itself.

Recommendations

Recommendations for further research follow partly from the limitations and partly from the conclusions.

Proposition: Maturity matching

The most relevant proposition from the perspective of the bank is still to create efficient matchmaking between loans and funding with regard to their maturity. Because the bank wants continuity in their mortgage offering it issues mortgages with a fixed interest rate horizon of 20 years, even if funding with this maturity is limited. This creates refinancing risk. It is this the bank wants to see solved more than anything else. At the same time pension funds and insurers have a need for investments with a longer fixed interest rate horizon. The potential for a marketplace supporting the sale of mortgages with different fixed rate horizons between originators and investors is identified in almost all interviews and definitely worth researching.

Mortgage: Pricing and valuation on a micro level and on aftermarket

Indispensable for the idea above is valuation of running mortgages. Currently the appraisal methods of mortgages in securitization happens on a portfolio level, because the statistics only work when you apply them to 50 billion euros in mortgages. Single mortgages in that respect are rather binary, they prepay or they don't, they default or they don't. The truth is obviously way more complicated. But considering the enormous amount mortgage portfolio data and the progress in the field of self-learning algorithms might make it possible to better anticipate borrower behaviour, including contextual indicators on both macro (economic) and micro (personal) level to better predict and manage the mortgage and its value.

New cases

The difficulty of a public blockchain like Ethereum is that it is both fundamental infrastructure and a completely new paradigm. The point is that for the designed business model it doesn't really matter if you use 'blockchain' or not. Yes, it would make things more efficient, but it innovates within the current paradigm. So where it is definitely mortgage funding innovation, it isn't necessarily blockchain innovation. That would require a new concept of what we view as ownership. To comprehend the implications one should not start with homeownership, because of its size on one hand and the intrinsic duality homeownership on the other –it's both for use and investment-. With the volatility of cryptocurrencies, investment cases are difficult, stabilising instruments such as swaps are virtually non-

existent. Cases for ‘use’ will be much easier, as they can anticipate the exchange rate with fiat currencies.

Proposition: user requirements

Looking at the mortgage marketplace funding case it is recommended to further research the user requirements through interviews and the development of mock-ups, as this seems to work quite well.

Blockchain research: Privacy and confidentiality

The most friction came from financial sector user requirements in a blockchain environment. Especially the privacy and confidentiality aspects form the biggest question marks. Additional research should give better insights in the possibilities and limitations that certain blockchain(-inspired) technology frameworks offer.

Blockchain research: markets

One of the research papers indicated that blockchain transactions have much in common in traditional *over the counter markets* (OTC). It’s very well possible that the many of the regulatory framework related questions as well as other subjects are covered in this line of research. OTC implies direct interactions between peers, someone buying bread at a bakery for instance. With decentralised systems the transactions are also peer-to-peer. Much research have gone into the dynamics of these peer-to-peer interactions and a start has been made to relate them to blockchain cases with Malinova and Park (2016).

Business model outline: legal structures and the aftermarket

As indicated the legal part was omitted, so this would obviously be something to research. Especially with regard to selling on the shares in a mortgage and the transfer of ownership as well the corresponding obligations. An example of these obligations can be the borrower asking to increase the mortgage. Investors should then be obliged to provide the additional funding. This then changes the repayment scheme, the yield, the risk, so on and so forth. Also, the platform is digital, meaning that investors could come from all over the world, which raises questions on (inter)national jurisdiction.

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Appendices

Interview Protocols

- Focus Group
- User requirements
- Evaluation

Delft UT Blockchain Lab

- Trustchain
- Prototype
- Decentral Market

Private Blockchain Summary

Interview summaries

- User requirement Interviews
    - Debt Solutions
    - Residential Group
    - Asset Manager
- ALM – 4 January 2017
- Bouwsteen – 14 December 2016
- Jungo – 14 December 2016
- Balansmanagement – 21 December 2016
- Ministerie van Financien – 7 December 2016
- AAHG – 24 November 2016
- Crowdfunding platform – 24 November 2016

Summary Explorative Research

Initial prototype Bachelor Students

Business model quickscan 101

Interview Protocol – Focus Group

Start

- Interview objective
- Permission to record the conversation
- Interview structure
- Background of the respondents

Introduction

Short introduction of the thesis, ABN AMRO Innovation Centre and the goal of the experiment and research

Interview (in Dutch)

What proposition are we going to validate?	*Pains in the Investment process in the field of mortgages*	
Background	*Please describe yourself and your company*	Welke rol hebben jullie in het hypothekenproces
	What is your experience with the mortgage funding?	Hebben jullie transacties ondersteund, of zijn jullie andere manieren betrokken geweest bij hypotheek-funding? Krijgen jullie hier als consultants vragen over?
	What do you regard as the most striking in the mortgage funding domain?	Qua proces? Qua product?
Validation of drivers	*Regulation*	Welke wet en regelgeving heeft de meeste impact? - LTV, LTI - BASEL Wat is jullie visie op Basel? Heeft het effect op traditionele business modellen?
	Investment opportunities	Hoe kijken investeerders tegen huidige mogelijkheden aan, hoe past dit binnen hun risico-rendement eisen? Wat zijn over het algemeen de risico-rendement eisen (Hoe) wordt dit gestructureerd? Welke partijen houden zich hiermee bezig?
	Investment Process	Hoe maak je een investering in hypotheken? Is dit een gemakkelijk proces? Wat voor eisen liggen er aan het due dilligence proces?

	Is snelheid van enig belang?
After acquisition of positions	In hoeverre is het monitoren van investeringen van belang?
Secondary market	Worden hypotheek-investeringen doorverkocht? Waarom? Zou dit een meerwaarde hebben? Waarom?
Other developments?	In welke richting ontwikkelt de hypotheek(funding) markt zich op dit moment? Wat is daar het meest op van invloed - *Startups? Competitie?* - *Technologie?*

Finalisation

Thank the participant for the conversation.

Discuss future steps and collaborations

Notify the respondent that a summary will be sent as soon as possible for him/her to review.

Interview Protocol – User requirements

Start

- Interview objective
- Permission to record the conversation
- Interview structure
- Background of the respondent

Introduction of the proposition

The explanation was sent in advance but is repeated shortly in the shape of a pitch. A stakeholder journey and value network is showed to visualize the proposition. The pilot case (syndicated mortgage) is explained as well.

Introduction of the mock-up

The interactive mock-up is showed and explained. The initial reaction is recorded as well.

Interview (in Dutch)

We focussen ons op de vraag: hoe maakt een investor een goede investering. Wat heeft hij daar voor nodig. Wat wil hij zien. Wat moet hij doen.

Proces	**Procesflow**	wat voor stappen moet een investeerder maken wat pas je aan ten opzichte van de mock-ups
	Match	zet een originator de karakteristieken van nog uit te geven hypotheken online Match je op basis van voor opgegeven criteria automatisch ga je onderhandelen over de hoogte van de hyprente Is er tijdswinst te behalen? Of is er geen noodzaak?
	Payments	hoe betaal je de originator wat voor informatie is daarvoor nodig? Hoe hoog zijn de veiligheidseisen
	Integratie huidige systemen	met welke systemen moet dit platform in contact staan zie je een rol voor een digitaal platform? Is de huidige gang van zijn mens-intensief? Draait het nu op verouderde systemen?
	Communicatie contractpartij	wat voor communicatie is er nodig tussen loan originator en investor Is hier een tussenpartij voor nodig? Wat doet deze partij?
		Hoe maakt een investor een goede bieding?
	Benchmarking	waar haalt hij zijn referenties vandaan wat voor informatie wil je in beeld brengen
	rekentools/valuatie	zou je rekentools toevoegen aan het platform wat heb je dan nodig of laat je dit door een debt solutions doen wat voor tools hebben jullie
	Reporting	aan wie moet een investor laten weten dat hij een investering heeft gemaakt wat stuurt hij dan op

		waarheen
Due Dilligence	**Informatie over de assets**	welke informatie over de asset wil je zien
	transparantie	wil je performance zien
		wat wil je zien aan asset management/bijzonder beheer/service
Portfolio management	**portfolio**	wat zijn de belangrijkste indicatoren voor de performance van assets
		wil je in kunnen grijpen en hoe zou je dat doen
		welke additionele services wil je zien
	Mate van transparantie	wat wil je zien van andere deals
		Hoe hebben investeerders belang bij een hogere transparantie
		Moet je transactiedata delen met veel andere partijen
	tegenpartij	wat wil je weten van de tegenpartij
		wat wil je weten van voorgaande tegenpartijen
Security	**Veiligheid van data**	wat is de meest gevoelige data
		in welke datarisico categorie vallen die?
	Support van platform provider	wat voor support zou je nodig hebben
	Rechtszekerheid	*is er een standaard voor securitisatie*
		welke zekerheden zijn het belangrijkst
	Rol van de Regulator	wat moet een regulator zien en wat absoluut niet
		welke regulators heb je mee te maken
		welke partijen sluit je nog meer aan?
Looks	**Eisen aan de interface**	wat zou je aanpassen aan de huidige mock-ups
		wat wil je als eerste zien?
	Zichtbaarheid blockchain	wil je de blockchain zien? Of gewoon weten dat het werkt
Costs	**Kosten**	wat moet zoiets kosten
		ga je dit per aankoop betalen
		of betaal je een platform access fee
		abonnement vorm?
Anything else		zijn we nog iets vergeten

*red questions are blockchain usefulness indicators based on Seppälä (2016).

Finalisation

Thank the participant for the conversation.

Discuss future steps and collaborations

Notify the respondent that a summary will be sent as soon as possible for him/her to review.

Interview Protocol – Evaluation

Start

- Interview objective
- Permission to record the conversation
- Interview structure
- Background of the respondent
- Make sure the respondent reviewed the business model in advance
- If not, introduce the proposition

Introduction of the proposition

The business model outline as well as the criteria are sent in advance to make the best of the available time.

The proposition is repeated shortly in the shape of a pitch. A stakeholder journey and value network is showed to visualize the proposition. The pilot case (syndicated mortgage) is explained as well.

Introduction of the mock-up

The interactive mock-up is showed and explained. The initial reaction is recorded as well.

Interview (in Dutch)

General. Sufficient detail.	*Missed opportunities*	Zijn er zaken onvoldoende aangestipt in het huidige business model
Scalability	*Increased demand*	Wat gebeurd er met het technologische en organisatie domein als de vraag naar de service verhonderdvoudigd?
	Consequences	Wat zijn de consequenties voor de overige domeinen bij die situatie?
	Modularity	Is het ontwerp van de technologische infrastructuur modulair of op een andere manier makkelijk schaalbaar genoeg?
Adaptability	*Multifunctionality*	Wat gebeurd er met het 'service design' (de waardepropositie) wanneer blijkt dat het een heel andere doelgroep aanspreekt dan van tevoren bedacht? (zeg individuen in plaats van institutionele beleggers)
	Competition	Is de technologische infrastructuur in staat om op te kunnen tegen nieuwere en goedkopere technologie mocht deze beschikbaar worden? En wat zijn de consequenties voor de overige domeinen?
Robustness in Scenarios	*Scenarios*	Hoeveel kan het business model hebben qua contextuele veranderingen?
	Contextual drivers..	Wat als Basel IV niet zo heftig is voor banken als verwacht?
		Wat als de hypotheekrentes gaan stijgen?
		Wat als de huizenprijzen stijgen?
		Wat als de inflatie stijgt?

		Wat als de LTV voor consumenten naar 90% gaat?
Viability	*Compelling value proposition*	Is de waardepropositie voldoende aantrekkelijk voor alle stakeholders? Maken aanvullende services het platform aantrekkelijker voor eindgebruikers? Maakt een grotere groep hypotheekverstrekkers het platform meer aantrekkelijk voor investeerders en/of vice versa?
	Clearly defined target group	Zijn de doelgroepen voor het platform voldoende duidelijk? Weten we genoeg over elke gebruikersgroep met betrekking tot hun eisen, wensen, capaciteiten, resources en gevoeligheden? Is de strategie om het platform op te starten duidelijk? Hoe je de vraag en aanbod dynamiek initialiseert?
	Unobtrusive customer retention	Is het duidelijk hoe gebruikers blijvend aan het platform gebonden worden? Zijn er strategieën bedacht om binding te genereren (subsidie, lock-in, etc.). Is het duidelijk voor wie deze strategieën nodig zijn? Is het duidelijk wie voor deze strategieën betaalt?
	Acceptable profitability	Gaan alle stakeholders akkoord met de financiele propositie zoals hij er ligt? Past het binnen de risico-rendement eisen? Vallen de service fees (voor gebruik van het platform) binnen redelijke kaders?
	Sustainable network strategy	Is er een gezamenlijk doel wat alle stakeholders -op en aan het platform- nastreven?
	Acceptable division of roles	Is er een centrale actor bereid en capabel om de organisatie te leiden en op te zetten?

Finalisation

Thank the participant for the conversation.

Discuss future steps and collaborations

Notify the respondent that a summary will be sent as soon as possible for him/her to review.

Prototype Technology: Trustchain

Aim.

Trustchain is a Sybil resistant scalable blockchain specifically designed to create trust and aimed to be a generic method that can be reused in a variety of cases (Otte, de Vos and Pouwelse, 2017). A reputation mechanism is part of the Trustchain architecture and addresses the conflict created by the need to present a trusted identity and the need of permissionless open access. This is the groundwork of the ideology; the current 'sharing economy' is not completely peer-to-peer, since platforms such as Uber and Airbnb have created a platform monopoly by being first to be the biggest and can therefor scoop profit of the top of both the ask and bid side. A common solution for trust through reputation is likely to reduce this effect and increase competition (Otte et. al., 2017).

Functionality

Trustchain can best be seen as a ledger of interactions, rather than a cryptocurrency or a smart contract platform. The work on this chain is performed by an academic institution, this has the consequence that everything is open-source and that it focusses on the development of new concepts rather than commercial production level applications. With Trustchain every participant in the network has its own genesis block and blockchain. These are interweaved when interactions with other participants take place. When initiating new transactions, each participant includes the hash of their last interaction, creating a chain of temporally ordered transactions. Trustchain records are tamper-proof and irrefutable since modification of specific records can be detected by verification of the cryptographic signature (Otte et.al, 2017). Each participant that initiates a transaction will request the chain of their counterparty and compute its trustworthiness level based on the counterparty's earlier interactions, the initiating party validates the counterparty's interactions by also requesting the chains of the party he or she had interactions with. The figure below shows the entanglement of the different chains.

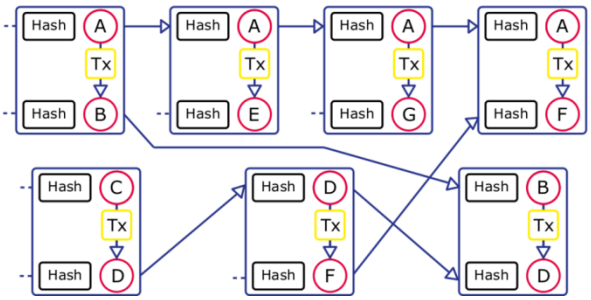


Figure 37 Trustchain Data structure (Otte et.al., 2017)

The consensus mechanism is a method of authenticating and validating a value or transaction on a blockchain or a distributed ledger without the need to trust or rely on a central authority. Trustchain works with bottom-up consensus, a form that is less wasteful than proof-of-work (bitcoin) and more scalable than other (classical Byzantine Fault Tolerant) mechanisms *(Bottom-up consensus, 2016).* So there is no network-wide consensus mechanism used in Trustchain, the safety comes from "proof-of-lying" where faults are punished by being banished from the network. You will have to conclude this as an individual participant by crawling the network and requesting the chains as described above.

Compared to other blockchain platforms

Bitcoin keeps track of who owns every bitcoin today, it also contains a record of who has owned every bitcoin since its inception in 2009, this chain has grown to above 100GB which make it unusable on non-dedicated machines and therefor limits its scalability. Apart from size, the Trustchain protocol has a higher throughput because it doesn't validate every transaction. The system avoids hard-forking as modifications can be made without changing the core system (Ren et.al., 2017, p14).

R3 Corda is similar in its approach to tamper-proof transaction recording in that it avoids proof-of-work, global consensus and fork mechanisms (Otte et.al., 2017). However R3 Corda only records on the servers of the involved parties, so there is no replication. They have chosen a focus on legally binding contracts that can be translated into running code and still be compliant, which is something Trustchain lacks.

Applications - Decentralised market

The Blockchain Lab is currently developing a use-case incorporating Trustchain, called the decentralised market. A decentralised market is aimed at facilitating direct trade between peers on a marketplace platform without the need for (trusted) intermediaries. A description can be found in appendix XX.

Known issues and barriers to implementation

Currently the adoption of Trustchain is limited to alpha testing within the Blockchain Lab. The plan is to release a bug-finding contest with bitcoin as a reward.

Purpose. The current implementation was developed to regulate leeching in a Bittorrent-like environment, for down- and uploading. While an accounting system, this doesn't make it directly suitable for financial applications. For regulators to get a view of the transactions they will either have to crawl the entire network, or every transaction will also need to pass a notary node. It is also noted that not every malicious transaction can be falsified (Ren et.al, 2017, p13). This is obviously a problem for financial institutions.

Every participant has its own genesis block and therefore full control of his own data, and this ownership is unambiguous. Privacy remains an unsolved problem since the whole chain needs to be provided to validate a transaction with a peer. The use of notaries or validator nodes is suggested, making it similar to most private and consortium blockchains. *Essentially the Trustchain system is permissioned. However, unlike other permissioned blockchains, new nodes can actually join the network without making any change to the existing system* (Ren et.al., 2017, p14).

Reliability. Currently the biggest threat to Trustchain is the fact that a reputation can be synthesized through the creation of fake accounts, sybils. These can interact to create reputation, even though they're not real individual participants. In theory the solution has been found by Otte (2017), who developed a Sybil resistant trust mechanism. Additionally nodes are required to behave consistently, this means that nodes cannot go offline. A node going offline would mean that consensus is not obtained by this node and the data from this node's chain is not available for validation of new transactions (Ren et.al., 2017). Although this effect is limited when the network's usage grow, since more nodes will have validated proof of a certain transaction, it still affects reliability at the beginning.

Proof-of-lying. Currently the harshness of the protocol is quite extreme. Once there is proof-of-lying you will forever be banned from the network. A proof-of-lying mechanism to some extent works as an alternative for consensus, since malice is evidenced rather than prohibited.

Still a consensus mechanism was proposed, called checkpoint consensus. It is a form of implicit consensus which doesn't happen on individual transaction level but on check points that validate those transactions every once in a while, for this any BFT algorithm can be used.

Conclusion Trustchain

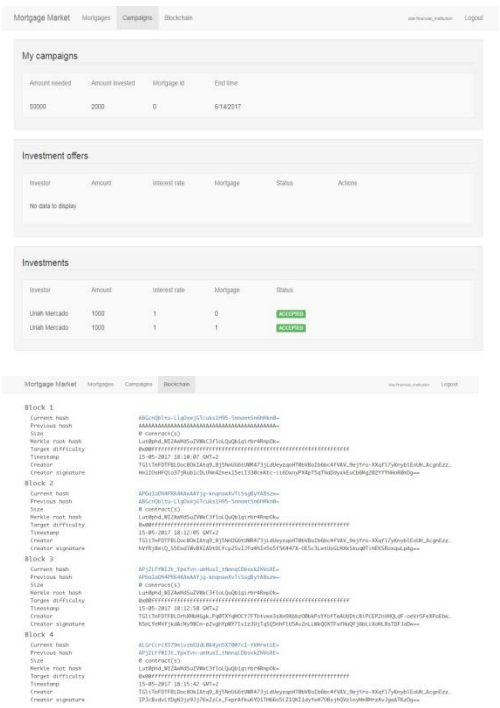
To a large extent the Trustchain proposes solutions for first generation blockchains in that it is more efficient, and better scalable. Also, some limitations in a business requirement setting have been identified, the main one being that in some cases malicious transactions cannot be falsified. In an enterprise environment the worry of offline nodes is less pressing, as financial datacentres run 24/7/365. It still has to prove its functionality for running contracts though. Many questions remain, which is only natural for a technology under development.

Appendix: Prototype

Parallel to writing this thesis a prototype of the mortgage funding market was developed. This was first and foremost a joint venture of the Delft University of Technology Blockchain Lab and ABN AMRO. The goal of the venture was two-sided, to explore the viability of the DUT blockchain solution with a relevant business case and additionally blockchain education will be offered. The researchers role within the project was to shape the offered value proposition and to provide the specific requirements from a business perspective, i.e. this thesis. It soon became clear that this role also included a project management task, being the communication channel between ABN AMRO in Amsterdam and the Lab in Delft. Working on this prototype yielded valuable insights of both the product (the application, blockchain technology and its current limitations) and the process (building an application in a joint venture). This paragraph provides an overview of the learnings.

Product

A group of four bachelor students started in November with the first version of the prototype. The aim then was to build a blockchain based platform for crowdfunding your mortgage. Their final product in January facilitated the journey of a consumer securing funding on the platform, first at the bank for say 60-70% of the LTV and then securing the final 30-40% through a campaign on an investor marketplace. All agreements were recorded on a blockchain. From a business perspective the final product evidenced the hassle a consumer goes through to secure a mortgage as well as the dysfunctionality of investor all determining their own terms and agreements with regard to interest rate and payment schemes. In the second phase a PhD candidate took over and streamlined the code, made it work better and more secure, but kept the role of the consumer and his campaign in place. The pivot to exclude the consumer from the platform was already made on the business side but not communicated well enough to the development side of the project. This caused some dissatisfaction, but it brought the project back on track with its initial goals (to test the technology in a sensible business case). The project is currently scoped to achieve transfer of ownership with an integrated payment solution and a monitoring element.



Learnings

Contract: NDA's + Open Source.

Advantage in business often comes from an information advantage like patents or faster newsfeeds. It is a defensive strategy which uses contracts like non-disclosure agreements. Blockchain is a network technology, which means that it benefits from widespread adoption because more use will improve it more quickly. This is an open source strategy, anyone can view, work and comment on your code. A traditional business working with open source technology creates friction because if you are able to download the code and install the application, it is not very hard to decipher business logic behind it.

Communication: business vs technological language

While many non-technology companies are now adopting the agile and scrum methods first introduced in the world of software, this doesn't mean that workflows, meetings, frameworks or communication methods align. What seem minor details to a software developer are major indications of progress for a business official. The strange occurrence with the dawn of blockchain technology is that business people are suddenly much more interested in the exact workings of the software, where they would first just take things like the internet for granted. Possibly this is to do with the fact that you transfer value, instead of information. Yet, the danger is that project members lose sight on the important factors like: does it or does it not deliver the value proposition.

Business and technology starting with 2 unfinished ideas and iterations

This project started in November. At that point there was little more than a sketch of the business case and the value proposition. Also there wasn't a finished blockchain or infrastructure layer. Apart from logical consequences like time increasingly constraining the scope, this created two problems. The first was the misconception to "do something with blockchain". Blockchain is a means. It is logical in some situations, not in others. It is very hard to develop a business model from a technology, and even harder if that technology is not finished yet. This created the second problem, the large impact iterations have. Working with an unfinished product resulted in highly customised solutions, so when the business case pivoted, it had a harsh impact on the developed demo prototype.

Decentral market

Decentral Markets from an Ideological perspective

Any asset, any scale, no middle men

Decentral markets and transparency

Dealers exploit the fact that the competition has to assess their position instead of a centralized and known price level. Biais (1993) specifically states that decentralised (fragmented) markets are less transparent, however the bid-ask spread is comparable with that of a centralised market –one with market makers- because the costs of market making and the expected monopolistic surplus are balanced.

The studies that followed upon Biais's work, namely that of Frutos and Manzano (2002) and Yin (2005) have disproven this expected bid-ask similarity between centralised and decentralised markets. Frutos argued that decentralised markets are actually more preferable because the bid-spread ask is smaller and market players prefer this. Yin argues that Frutos has underestimated the cost of searching. This refers back to the transparency argument posed by Biais. From this we can conclude that transparency is a key variable for the success of decentralised markets, specifically the ability for traders to compare prices of all dealers.

Increased transparency allows the trader to find a better counterparty (with a liquidity need), but it exposes the trader to the risk of predatory pricing in the bargaining phase so apart from transparency in holdnigs an observation of the behaviour of counterparties is important (Malinova and Park, 2016).

Decentral market TU Delft

Aim. The decentral market by the TU Delft was developed with the aim to be fully immune to shutdown by governments, lawyer-based attacks, or other real world threats (Olsthoorn and Winter, 2016). Through decentralisation the platform avoids platform monopolies that are common to two-sided markets like Uber, AirBnB, etc.

Functionality. The original function was to trade Multichain credits (TU Delft reputation-based blockchain) for bitcoin. Multichain credit represents the amount of data a peer has uploaded to a torrent network. The marketplace therefor aimed to create an incentive for good behaviour (to upload files) and punish bad behaviour (only downloading).

Infrastructure. The market is based upon Dispersy, which is a platform to simplify the design of distributed communities. It is a message handling system, where every user and community is uniquely identified. Because it is completely distributed you can't find users in a centralised database, but you have to connect to them through other users.

Message Protocol. The Market Protocol consists of three stages: ticks, trades and transactions. Ticks are used to distribute asks and bids across the network. Trades are used to find a peer to trade with and come to an agreement. Transactions are used regulate the payments and are divided in multiple payments to increase security.

Matching Protocol. The orderbook is used to store data about supply and demand and is divided in a buyer and seller side, in particular a price-time strategy is used. The matching engine follows three steps:

(1) Retrieve the price level with the highest bid price;

(2) Go through all the bids in the price level

(a) reserve as much quantity of the ask on the current bid

(b) if the quantity still left to be traded is zero then return, otherwise continue;

(3) If the quantity still left to be traded is zero then return, otherwise continue with 2 and with a lower price level.

Incremental payments.

Main issues.

- Designed to incentivize good behaviour in up- and downloading… not for financial transactions.
- Distribution of ticks is limited because it puts pressure on the network
- When there is no cryptocurrency used in the market, there is no recording of transactions and a notary node is needed.
- Only relevant for global scale, when participants are known decentralisation makes no sense.
- Splitting transactions in multiple payments makes limited sense in real life situations and slow the system down.

Conclusion. The decentral market allows traders to directly trade with each other, this circumvents centralised parties to create monopoly positions and exploit a surplus. It is important for traders to find each other, this requires transparency in holdings and behaviour and can be reached through an efficient search/matchmaking protocol. The TU Delft Decentral market facilitates these aspects to a great extent but currently hasn't the functionality to trade securities for real euros. This means that it can be used as a matchmaker for agreements, which implies a legal layer for contracts needs to be implemented and we are still bounded by the clearing and settlement processes of the SWIFT network. It is unclear if the decentral market should also be used to monitor principal and interest payments. It is important to remember that the decentral market is an application that falls within the realm of peer2peer trade but that it doesn't necessarily requires blockchain to be able to run. In the end one does only need to facilitate finding counterparties for transactions.

TECHNOLOGY STACK
GUI
API
Mortgage Market Business Logic • Stakeholder communication • Matching Engine • Trustchain
Dispersy

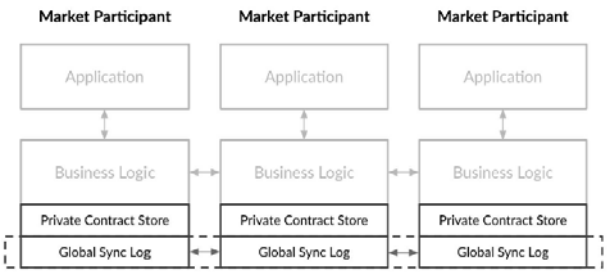
APPENDIX: Solution providers in the enterprise blockchains (permissioned)

Chain. Provides permissioned and private blockchain services for enterprise businesses. Chain has a confidential asset scheme that hides the transaction amount and account identity on multi-asset ledgers. Utilizes a *zero-knowledge proof* system to verify transaction amounts and ID's. Additional *noise* hides the transaction information, a private key is used to delete the noise and extract the data.

- Collaboration with Visa to create an international B2B payment Solution built on Chain
- Launch of an open source development platform
- Key figures from the financial sector (Goldman Sachs executives) have joined the company.

Digital Asset Holdings. A blockchain software provider focused on distributed asset settlement.

Has a global synchronization log: The GSL is a log of commitments and notifications that guarantees the integrity and auditability of the distributed data stores to contract stakeholders. The GSL establishes a common and complete set of valid transactions that, when combined with the corresponding private contract data in the PCS, comprises the Distributed Ledger. The GSL is a communication layer designed to deliver network-wide integrity guarantees of transaction commitments and notifications (DAH, 2016).



- DAH is working with the Australian stock exchange
- DAH is focused on financial sector feasibility alignment, working with ex-JP Morgan and CitiBank execs
- DAML is a program language explicitly for writing smart contracts

Hyperledger. An open source cooperative managed by the linux foundation creating permissioned distributed ledger platforms to help financial institutions mitigate settlement risk and lower reconciliation costs. Fabric and Sawtooth are frameworks that fall under the Hyperledger label.

- Hyperledger members participate in the first pan-atlantic transaction on the Fabric platform.
- Has over 100 consortium partners

Intel/Sawtooth Lake. Is a platform for developing and maintaining distributed ledgers by Intel. In sawtooth lake the data model and transaction language are implemented in a transaction family. Users are expected to build their own specialised transaction family. The families provided by sawtooth are sufficient for building, testing and deploying a marketplace for digital assets.

- Uses Proof of elapsed time and quorum voting (like ripple)
- Has created a public proof of concept for a bond trading platform

IBM/Fabric. Is an implementation of blockchain technology proposed by Tamas Blummer (DAH) and Christopher Ferris (IBM) that allows components like consensus and membership services to be plug-and-play. Fabric allows two or more parties to automate contractual agreements in a trusted way. Use cases include trade finance, asset depository. It is available on IBM's cloud platform for applications called Bluemix.

R3CEV/Corda. Has officialy announced not to be a blockchain platform anymore. Yet it is blockchain inspired. It is a global consortium of banks, insurers and technology providers with the aim of digitizing financial contracts. It is a Digital Ledger Platform

for managing and executing financial agreements. The program code has recently gone open source. Corda is not designed to be an all-purpose solution.

Ripple. Allows banks to offer real-time cross-border payments to their customers. Ripple currently has 19 partners. Ripple uses its native currency XRP as a bridge asset for global interbank payments, dramatically reducing cost of cross-border payments, through limiting liquidity costs. XRP as a native currency is still rather volatile so where the trials shown 42% cost reduction, it could have been 60%. Ripple provides an 'interledger' protocol for secure payments using ledger provided escrow. This means that as long as your ledger supports interledger you can participate in a payment and someone will be able to provide liquidity. It can be paypal, bitcoin, bank ledgers etc.

http://hackaday.com/2017/02/23/shattered-sha-1-is-broken/

http://www.coindesk.com/mt-gox-the-history-of-a-failed-bitcoin-exchange/

http://cs.stanford.edu/people/eroberts/cs181/projects/2010-11/DigitalCurrencies/advantages/

http://www.coindesk.com/making-sense-smart-contracts/

https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains/

User Requirement Interview Summaries

Debt Solutions

Theme	Functionality
Asset creation. Mortgage investments work with two dimensions 1. LTV (including NHG) 2. Fixed rate period And the loan originator is scrutinized on 4 categories V. Underwriting criteria (LTI, collateral appraisal criteria, job security) VI. Product terms (interest rate averaging, relocation options, prepayment fine percentage, quotation period) VII. Quality of regular or special management VIII. Origination and servicing fees	Always show these dimensions Have information available in drill down menus
Primary (origination) The risk is that the consumer demand doesn't align with the interests of investors. The loan originator must have continuity in his offerings and certainty of interest rate offerings. *Or a more pragmatic loan offering, RyanAir-style*	Show nominal value Show quotation risk indicators (interest rate changes) Show either pre-determined buckets Or secure funding first for every bucket…
Secondary (aftermarket) *The originator needs compensation for his ALM risk, because he attracted expensive funding that needs to be broken down?*	Show underwriting criteria and product terms See **pricing**
Price creation. There should be a calculator tool that incorporates probability of default and prepayment, servicing costs, as well as the exact portfolio. This tool then gives an indication of the price range. On the long term, when there is sufficient volume to create meaningful price points, benchmarking can be done based on completed transactions. The difficulty is because of the various LTV height and Fixed Rate combinations.	Appraisal tool that imports characteristics of the (bucket of) mortgage(s) Analysis function. Structure data AI deep learning ready.
Ways of investing. Spread in large portfolio – *large pool macro risk limiter* Portfolio per investor – *easier tradable*	You need information on the entire portfolio
Portfolio creation. One wants to look up opportunities that fit the portfolio strategy.	Search function
Bidding. There should be a way for loan originator and investors to negotiate a price.	Live communication function Simple bid/ask function
Transfer of ownership. There is either a role for a notary to validate a payment has been made and transfer of ownership is due. Or you work with securities, which is an economic participation. These are tradable without the use of a notary, but then a SPV holds the depositories and the rights to the mortgages.	Possibly a notary node
Payments. Capital calls, clearing,	

Reporting. Only internal internal reporting is necessary. No regulator is involved in these transactions. This consists of the sales price. The theoretical value of the portfolio. The break funding costs. The results (in comparison to the benchmark of theoretical value).	Internal reporting, data dump function.
Costs. Platform fee per trade. Unclear what price exactly, or where to base it upon. Service costs	Show fee in quotation Show fee and service actions?

Residential – loan originator

Theme	Functionality
Consumer Product characteristics. These are the terms and conditions of a mortgage, consumer behavior is influenced by these characteristics. Prepayment fine, ability to transfer the mortgage to a new house, annuity/linear/interest-only, length of interest offer.	
Consumer price dependencies. LTV, LTI, funding costs, liquidity premium, profit margin and consumer data	Based on this a credit rating is made.
Pricing strategy. Weekly meeting. Mostly dependent on the competition, the funding costs and the balance sheet position of the bank.	
Consumer data. Standard: ID, income statement, employment statement Non-standard (private contractors, etc.) 3 year transaction and income record Additional : appraisal report, mortgage advisory report.	Says something about documents
Consumer data sharing. Only necessary data should be shared, or anonymized.	Anonymization of data requires the originator to place risk reports or credit ratings.
Data security. Mortgage information has one the highest security demands of the bank. The risks are operational, legal and reputational and are quantified in a CIA rating. Yet it depends on aggregation level. One mortgage is less of a problem than the entire portfolio	
System integration Asset and Liability management system for funding Risk analysis to appraise the value of the portfolio Stater mortgage management system (SHS) – records repayments, prepayments, delays. But also sends notifications to issuers and servicers, who can act on it.	**Monitoring.** The platform needs a link with the Stater system, it shouldn't want to be an administration system.
Limitations to systems. The SHS system works only in predefined LTV and fixed rate horizon buckets. This limits the flexibility, yet keeps options clear.	
Asset creation. The level of anonimisation. What information is needed for an investor to make a decision. Level of privacy, laws on personal data sharing	
Risk analysis. Do you leave it to the underwriting process of the issuer or to make your own analysis.	Definition of the data categories to be available
Payments. Everybody's mortgage payments for ABN AMRO flow to three bank accounts. You can't have 4 (investor) bank accounts requesting payment from one consumer. *The consumer has made a deal with the issuer, not the investors.*	
Mortgage management. Service, support and special management are important functionalities to keep the portfolio healthy.	Service, support and special management functions should be available. The investor should be able to give these parties a mandate to act.
Regulators. Have the authority to see everything. Tax authority: interest payments, height of debt, advisory costs are shared. Financial markets authority (AFM): check for "duty of care" for consumers	The authorities should run a node, this way they can monitor activity and

Dutch Central Bank (DNB): structural bank wide assessments of the balance sheet positions European Central Bank (ECB): both structural assessments as “duty of care” checks	perform assessments at any logical time
Originator Ecosystem. As a consumer you want to be able to choose from different originators.	Platform should be open to many originators.
Platform transparency. Mortgage strategy is not high paced. Therefor transparency in funding requests can illuminate your strategy and make you lose your competitive advantage. Also you don’t want to open up your entire portfolio.	This proposition will probably not be suitable for a bank’s entire portfolio. A new label should be created.
Interest rate. There are two options 1. A fixed interest rate towards the consumer. Then the profit margin varies as a result of differentiating funding costs. There should then be clear profit distribution formula for all investors. 2. The interest rate is dependent on the funding costs. Then the profit margin is fixed. This creates difficulties for marketing a clear story towards the consumer, but could give him a more competitive rate.	The system should be able to show the interest rate offered by the originator and calculate the profit distribution.
Funding process. There are two options. The prerequisite is 1. Place the funding stream next to the internal ALM funding. It would create a competition element. Based on funding offers by investors. 2. Instant securitization process. Based on funding requests by the originator.	The system should facilitate both directions. Which means that investors should be able to place offers and originators should be able to place requests.

DMFCO

One of the investors indicated that it should be possible to ‘post’ the criteria that he is interested in, so loan originators can anticipate on the funding that is available in the market.
Investor: makes an investment decision based on credit risk and duration.
Investor: only when you care about market share or there is high demand on the funding side you should price competitively, otherwise it doesn’t really matter.
Investor A bidding tool was suggested, to get the most competitive pricing out of the market. Your interest has a max, but could get lower. This also increases the amount you can borrow.
Investor: in the end it will be mostly asset managers doing the investment work on behalf of investors
Investor: AAA (0-90) 30-40bps; AA (90-92) 80-120 bps; A (92-94) 250-300bps; BBB (94-96) 450-600bps; BB (96-100) Junior tranch. Go for around 3.5% minimum. The market makes the price, let the market decide.
Note: Top20% could also be interesting for retail investors, because of the short duration (depends on the payment scheme).
Investors want to see a transparent personal credit rating system. And then you’d adjust the interest rate according to creditworthiness.
Investor: The quotation risk also decreases the closer you get to issuance, this influences the investment price.
Investor: sooner or later the consumer will enter this platform. The added value can be found there. In connecting investors with borrowers.
Investor: want to see projected cash flow, return on equity, received cash flow.
Investor: you still need special management, communication and contract should be with loan originator. This has no notarial effect.
Investor: payment per trade is fair. You want to pay for something you use.
Investor: calculate based on state bonds plus the risk premiums seen fit
Investor: start with a standard, limited terms and conditions, stripped mortgage to gain volume and scale on the platform. Yet added value might be found in specialties.
Loan originator: the investors should agree on additional funding when borrowers want to increase their mortgage, for instance in case of renovation. This debtor risk needs to be transparent for secondary buyers.
There should be a guideline for interest rate reset, does the investor keep the mortgage or is it posted to marketplace once again
Loan originator 1: there should be a guarantee for continuity

Loan originator: underwriting takes time. It can take multiple months from first indication to issuance. Influences the moment when you post your funding request. Too late and you risk not arranging the funding, so this is only an option for originators who can take mortgages on their balance sheet. A standard underwriting document verified by an accountant would make this process faster. But is out of scope for this project.

Evaluation Interviews

Asset and Liability Management – 4 January 2017

Data

"Even een filtering van alle leningen die aan bepaalde voorwaarden doen, dat is een hele exercitie"

"Als de data kwaliteit goed is, dan heeft de Blockchain geen toegevoegde waarde"

ALM activiteiten

"Zolang wij op onze eigen methodiek geld kunnen verdienen, dan kijken we naar hoe we ons geld op een andere manier kunnen investeren zodat we er meer uit kunnen halen"
"Spaargeld is duurder dan geld uit de markt halen, daar hebben we dus meer uitgehaald. "
"We monitoren bv spaargeld, als er meer uitloopt dan schroeven we de rente wat om hoog zodat er weer meer inkomt"

“Hypotheken worden überhaupt weinig verkocht“ (in de vorm van bonds of securitisaties)

Tweederde van de winst komt uit hypotheken

Het is omvat de helft van het kredietboek van de bank

Matchen van lang geld en lange leningen wordt al gedaan, vorig jaar 1.5 miljard 15 jaar geld opgehaald tegen 1% (om daar hypotheken mee uit te geven.)

“LTV ratio wordt op portfolio niveau bekeken, dan is het maar 75%..”

Rating

"Dat we nog Moodys nodig hebben om bedrijven te raten. Wie gelooft nog de rating van Moodys?" “Blijkbaar de halve wereld”

Idee

Wat is interessant :

- Private banking klanten de top 20% laten financieren en 2% rente geven, of iets van voordeel, er is geld genoeg (spaargeld klotst tegen de plinten)
- Personal credit rating

LTV zal sowieso omlaag worden gestuurd.

Meerdere leningdelen, wordt nu al gedaan ook.

Interessant als je andere financiers kan aansluiten, zoals pensioenfondsen

MATCHING VAN PRIVATE BANKING KLANTEN SPAARGELD MET RETAIL KLANTEN BEHOEFTEN ("Marktplaats"). Private banking klanten klagen over 0 rente maar willen niet beleggen, en zijn hierdoor ontevreden.

AANTREKKEN VAN SPAARGELD OM TE INVESTEREN, disintermediatie, de spaarders zelf laten investeren, de bank doet de risicorapportage. Risk as a Service. En verdienen aan de fee.

Eens per kwartaal maken we een funding rapport / voorstel voor de bank

Samenvatting Bouwsteen – 14 December

Conceptproduct nieuwe manier financieren

Gek dat er maar 1 volwaardig product is

In een markt die sterker segmenteert

Aan de aanbodkant die steeds meer standaardiseert

Hoe kan je de betalingsdruk af doen nemen

Maatschappelijke context

Producten doorrekenen

Begonnen als stimuleringsproduct, later volwaardig hypotheekproduct van te maken

Team is gegroeid,

Product concept ontwikkelaar maar is nu ook hypotheekverstrekker en regiehouder

Concept regiepartij

Productinnovatie, doelgroep ondersteuning

2 funders, stoppen geld in een fonds. Maakt ons fondsbeheerder en productinnovator

Sneller geld uit dan weer terugkomt

Revolving fund is een optie, maar kan ook een maximale allocatie zijn

100/500/miljard

Wij managen de keten, die je inhuurt,

Mid office zorgt voor de communicatie met de frontoffice en de servicer?

Acceptatievoorwaardes zijn vooraf gedefinieerd, liggen bij de servicers

Explain gaat door naar de fundmanager

Alles staat opgelijnd, druk bezig met funding, als die rond

80/20 maakt voor fonds niet veel uit.

20 wordt vooruit geschoven

Vergelijkbaar met koopgarant. Beperkt bereik, kopende en verkopende partij hetzelfde dus intransparantie. Is geslonken aan de aanbod kant door corporatie

20% + vergoeding wordt. Vergoeding is rente alle jaren van hypotheek

BD AFM, concept was makkelijk erdoorheen te krijgen, de juridische uitvoering was het lastigst.

Belangrijke reden dat het lastig te betreden markt

Appetitie for funding bij de normale hypotheek is intentieovereenkomst getekend, nu door voor de funding van de andere twee concepten.

Institutionele partijen, risicoprofiel passend

Niet private equity, die gaan eerder voor sale lease back, heel agressief vooral zichtbaar senioren

Rentepercentage is competitief

Past allemaal binnen nHG

Hoe het fonds werkt. Er is een paritj die zowel het 20 als 80 gedeelte op zich neemt. Zijn 2 financieringstukjes, maar vallen onder hetzelfde contract. Geen co-funding dus. Maakt het simpeler voor de klant.

Klant klopt aan bij de hypotheekadviseur bij issues.

Bouwsteen mag geen klantgegevens opslaan.

BS draait op de management fee van het fonds.

Het is van belang dat je zo snel mogelijk hypotheken verkoopt. Anders heb je ook geen management fee

Frontier strategy, 10 starters, kwalitatief onderzoek, uitgenodigd, bouwsteen propositie uitgelegd. Best confronterend, heel leerzaam. Restschuld, is bijvoorbeeld zegt een beginnend huiseigenaar niets.

Wat drijft doelgroep en wat niet.

Zelfde soort sessie met financieel intermediair. Of het te verkopen is.

Eindrapport, prof advies.

Branding. Propositie getest. Maar fin adv staan nog niet in expliciet in lijn, maar kennen het product.

Marketing bedrijf voor het bedrijven van jonge doelgroep.

Heeft ook invloed op strategische partners. Voor senioren zouden we graag met Amro samenwerken

Het lastige is. Een hypotheekproduct kost veel trial en error. Maar het moet er in een keer staan. Nieuwe proposities af moeten hebben voordat je het in de markt kan plaatsen.

Zolang de voortgang er blijft houd iedereen geloof.

Rentes waren misschien te hoog. Zijn nu laag. Stijgen op

Kapitaalmarkt is competitiever gekomen

De vraag naar woningen blijft wel

Maar een kwart van de nederlandse lenen maar maximaal

Mensen worden gepusht, maar er zijn nog steeds maandlasten die daar blijven

Renteaftrek, is

Het systeem is erop ge-ent dat iedereen max wil lenen, maar niet iedereen wil dat.

Kunnen starters nu onverantwoord gaan maxen met bouwsteen. Door meer te lenen dan ze kunnen, door het vooruitschuiven?

Niet bij bouwsteen, max LTI voor 100 is ook max LTI voor 80. Moet ook, anders valse belofte, risico vergroten. Lagere uitgaven.

Interne switch is zonder boete. Naar normale en dan verzilver. Levensbestendige ondersteuning.

Hoe 20%. Is een rekensom. Die 20 los je niet af. Maar je moet wel headroom creeren, overwaarde, om potentiele waardedaling van het vastgoed te counteren.

Samenvatting Jungo – 14 december

Topicus: Softwarebedrijf bouwt hypotheekstraat en beleggingsysteem Ze bouwen het niet, het zijn al producten die Topicus zelf heeft ontwikkeld.

Collaborative economy

Campagne probleem, hypotheek moet vantevoren klaar staan

Vervolgens de crowd mobiliseren. Hoe voordeliger je hypotheek wordt

Jungo is een hypotheekverstrekker, vergelijkbaar met munt Of een willekeurige andere hypotheekverstrekker. Het unieke is dat de crowd mee kan doen.

Institutionele funder erachter

80.20 Op gevalideerde aannames deels vanwege Basel

Crowd gaat er Maximaal voor 7.5 jaar in, 3%

Scheelt je tot wel 10k op 250k

Aflossingschema speciaal voor jungo Jungo heeft een eigen aflossingsschema ontwikkeld, dat de eigenschappen van lineaire en annuïtaire aflossing combineert. De klant ziet uiteindelijk gewoon 1 lening.

Begint iets duurder, je betaalt minder rente dan bij bank, daarmee los je het hoogste risico als eerste af, daarna (na zo'n 4 jaar bij 100% ltv) is het de rest van de looptijd goedkoper

Starters, tweeverdieners, verstandige mensen, kinderen, minder werken

Belastingdienst, AFM om uit te leggen wat je doet

Idee is nog steeds hetzelfde als begin

Weinig input toezichthouders, soms dogmatisch met de regels

Uiteindelijk gaat het veelal om juridische termen, die voor de leek inwisselbaar lijken. Voldoet aan alle regels, het is spannend, maar nu akkoord erop

Aflossingschema heeft subregels

Wanneer live, bijna, bijna

Bekendheid product

Via adviseurs, voorinschrijvingen

Investeerders gaan via online jungo platform

Financieel adviseurs zijn meest geschikt

Ze hebben klanten die geld hebben liggen en klanten die hypotheek willen afsluiten

Meest interessante partners, vinden het product ook het meest interessant

Geen fees meer van jungo naar adviseurs, is verboden Dat is het provisieverbod

Natuurlijk moeten klanten wel betalen voor advies

Interessant voor adviseurs omdat ze een product hebben wat voor klanten interessant is

Normale 30 jaar 100% hypotheek annuitair schema

Jungo 80% LTV door institutionele investeerder, 20% door crowd. De eerste 8 jaar los je de bovenste 20% af.

Jungo zorgt aan de achterkant dat het klopt, hebben ze een algoritme voor om het te laten kloppen. Dat de crowd in 8 jaar afbetaald is, en daarna de bank.

Jij kiest als investeerder in wie je investeert. Volledig peer2peer. Later kan je ook een groep kiezen. Kans op in toekomst risico/rendement reactie

De huidige groep vooringeschreven investeerders zijn onbekenden.

Concept is vergelijkbaar met kickstarter.

Equity variant overwogen? Wel over nagedacht. Meer bij collaborative gebleven. Waardegroei meenemen? Regio amsterdam. Maar minder persoonlijk. SamenInGeld, = meer vastgoedbeleggen.

Vertrouwen opbouwen van investeerders, getest, maar een proces omdat het nog niet voor het 'echie' is gegaan. Afwachten hoe het daadwerkelijk gaat zijn. Pas als de eerste hypotheek er is kan er daadwerkelijk geïnvesteerd worden.

Wat vinden mensen spannend; krijg ik m'n geld terug. Een screening, vergelijkbaar met banken. Een garantievermogen bij defaultsituaties. Een model waarbij je het risico minimaliseert. Allemaal failsafes ingebouwd. Onzekerheid over meedoen. Belangrijke rol voor financieel adviseur bij inleggen bedragen

Hypotheek met NHG aanbieden voor jungo is niet interessant want er blijft geen rendement meer over.

Balansmanagement – 21 december

Balans management is niet hetzelfde als ALM

BM koopt geld van ALM

Koen. ***BASEL:*** de vloer waarover gesproken wordt is een factor tov standaardmodel en eigen model

Aan standaardmodel wordt ook gesleuteld

De RWA (kapitaalreserve richtlijn van 35%) wordt nu al gestaffeld en gefaseerd meegerekend in de kostprijs.Kapitaalreserve Is nu officieel 12%.

De marge zit safe voor ABN, terwijl rabo en ing hoger lijken te zitten

Verzekeraars/pensioenfondsen hebben andere richtlijn (solvency) en hebben minder noodzaak vanwege diversificatie. Voor de bank zijn hypotheken een cashcow.

Maximum van 5 mrd ingesteld voor hypothekenuitgifte langer dan 10 jaar. Om de risico's van herfinanciering voor de bank in te perken.

De renterisico kan grotendeels afgedekt worden door derivaten

Liquiditeitsrisico (ie het vertrouwen van investeerders in ABN) welke afhankelijk is van markt is slechter af te dekken. Nu is dat bvb 75 basispunten, was 150 5 jaar terug.

RISK gaat over wat moeten we inprijzen.

ABN Portfolio strategie: In stand houden, betekent een vrij hoge productie (inflow). *Robert Köller? Weet meer over het marktaandeel.*

Risicoweging al vrij prudent: er zit een hardcore topslice in de indexatie van de verkoopwaarde, 75% stijging, 100% daling

Laatste jaren veel meer covered bonds uitgezet, want secs hebben een slechte naam,

CB's hebben langere looptijden. Hebben double recourse, bij bank en op hypotheek.

TLTRO = opkoopprogramma

Liquiditeit spreads zijn te klein voor securitizaties

CB's, 1 bak hypotheken. Secs komen (ook) in tranches

Nieuwe ideeen: Topgedeelte verzekeren, premie is dan goedkoper dan de kapitaalreserve voor 100

Deens model; investeerder direct aan de aanvrager linken – maar was mislukt (?)

LTV en rente flexibel laten muteren in plaats van SHS bakken (<65, 66-80, etc)

Een gedeelte van de secs staat ook op de balans van de bank voor liquiditeits ratio management

! ALM fund hypotheken niet 1 op 1 en ze zijn ook niet individueel terug te zien in de resultaten ALM

! "abn krap in lang geld"

! “abn verdient goed aan spaargeld”

! AFM: boetedossier wordt wellicht groter dan derivatendrama

Ministerie van Financiën, Christian Schouten – 7 December 2016

Pilot traject overhead x25 (Marloes, Koen)

PoC in januari met ING over onderwijsgebouwen financiering potjes schatkist

Zie case omschrijving in mail Christian

Ambitie om echt geld via blockchain te laten lopen

Wet en regelgeving kader

Eerst intern – duurt zeker 3 jaar

Vooralsnog geen samenwerking DNB, ECB

Tot die tijd geen aanspreekpunt voor bedrijven

Applicaties voor burgers en extern – duurt zeker 5 jaar. Wachten is op een standaard.

Niet zelf bouwen.

Wel gedachten over een schatkistcoin?

Rol christian

Interne awareness, en eerste pilot voor legitimiteit

Rijksbrede functie, teamformatie over verschillende afdelingen

Mensen meetrekken in traject, daar kennis genereren

! Blockchain is een middel, hoeft uiteindelijk geen eigen afdeling te hebben

- Wel voor de overgangsfase

Visie

Earmarked – crypto begroting en exploitatie

Misc.

Bitcoin kan je wel opgeven bij belasting

Welke rechtspersoon heeft DNB

ING beheert rijksrekeningen

Kost tijd; want politieke inweekspelletjes

Belangen van de big4 bij legacy systemen en verslaggeving

Abn Amro Hypotheken Groep – 24 November 2016

Front Office	Mid Office	Back Office
MoneYou Portfolio 0.1% Nieuw 1% *Site* Werkgeververklaring per post	**Acceptanten:** Maken Adviesrapport Doen rentebod Maken offerte Geven goedkeuring	**STATER:** Administratie (&management?) Abn is 100% aandeelhouder Maar staat volledig los vanwege andere klanten verzekerings maatschappijen etc. Notaris krijgt het geld van Stater Het geld staat op een ABN rekening beheerd door Stater
Florius Portfolio 50% Nieuw 33% *Intermediair* Veel oude Fortisproducten		
ABN Bankkantoor Portfolio 50% Nieuw 66% *Site* *Intermediair* *Bank*		

Opmerkingen

- Online tools zijn hetzelfde programma als het orientatieadvies (HAVIK)
- Orientatieadvies is gratis
- Advies is betaald. Vaste prijs. Regelgevingprovisiewetgeving gaat hierover
- Daarom nu eerst rentebod ("concept" adviesrapport) dan pas adviesrapport en offerte

[1]Abn verkoopt alleen abn hypotheekproducten

Eerste indruk
(1) Orientatie (-advies)

Advies
(2) Adviseur doet een eerste goede (documenten) check om advies te creeren

(3) Acceptanten checken aanvraag.
€950,- (Starter)
No solution no pay[1]
Voordat je je rapport krijgt 50% betalen

Offerte
(4) Doen een rentebod

Afname

TIME

Crowdfunding platform – 24 November 2016

Douw en Koren – crowdfunding consultants:

info/tool: Fundepal ←ook checken voor hypotheken

Symbid – aandelen crowdfunding

Lender & Spender

Topicus – Jungo

Inzichten

Wel bij aanvrager beginnen.

In welke situaties zal iemand extra financiering zoeken?

Restschuld

Verbouwing

De volgorde van LTI en LTV, er zal ook een groep zijn die hoger kunnen wat betreft LTI maar niet hoger kunnen door LTV van 100%.

1 partij neemt top20% en securitiseerd voor de achterliggende beleggers

Equity financiering zonder dividend wel een optie

Je kan geen ***verplichting*** aan gaan boven de wettelijke normen

Alles wat je doet met de bovenste x% beïnvloedt het voorstel van de bank

Spelregels

Exits voor beleggers

Aftermarket

Oude projecten

Marketplace finance ← check abn.com

Gestapelde financiering

Decentral Market Expert Interview Summary – 9 December 2016

Decentralisation = Geen centrale autoriteit

Central: zoals bank, afhankelijk van single point of failure

Oude skype, kazaa, bitcoin = decentraal

Peer discovery: hoe vind ik mensen

Message dissemination: hoe kan ik op een efficiente manier mensen berichten sturen

Market is gebouwd op dispersy (=messaging system)

Dispersy is ook distributed database, waarmee je kunt zeggen jij hebt info, ik heb info, als we dat synchroniseren weten we samen alles

Voor de decentral market gebruiken we alleen het messaging systeem.

Niet de synchronisatie want dat systeem is vrij traag. Ook omdat de hoeveelheid bids/ask volatiel is

Protocol in drie stappen

Ask bid dissemination

Markt is bedoeld om multichain tegen bitcoin te verhandelen. Betekent dat deze markt een connectie heeft met de multichain.

Bitcoin wordt bereikt via een API. Electro wallet api. Die met command lines aan te spreken is.

Ask = ik heb multichain, ik wil btc. Bid = ik heb btc, wil mc

Protocol. Q plaatst ask. Dit maakt hij bekent door te verspreiden naar andere peers. In dispersy gaat dit door gossiping

Gossiping: iemand anders vragen of hij iemand kent die ik nodig heb. Gebeurd iedere 5 seconden, kan ook dynamisch. Er worden ongeveer 10 andere mensen opengehoudne

Is iets te gelimiteerd, daarom TTL (time to live) mechanisme geintroduceerd. Is een getal dat je toevoegt aan het datapakketje. Elke keer dat iemand hem doorstuurt snoept hij een nr van het getal af, tot 0. Stel met 10 directe peers is ttl 2, kom je tot 100

TTL heeft invloed op de bandbreedte. Kan snel het netwerk flooden.

P weet nu ook van de ask en stopt hem in zijn orderbook. Ieder heeft zijn eigen orderbook.

Stel ze hebben dezelfde prijs en zelfde kwantiteit, dan proposed trade.

Als Q accepteert, dan stuurt Q een accept trade.

Op het moment dat pim bid verstuurt reserveert hij al een hoeveelheid

Vanwege het reserveringsysteem kan het zo zijn dat een gedeelte van de ask al fulfilled is

Op dat moment stuurt Q een countertrade. En die wordt altijd geaccepteerd.

Decline wordt gestuurd als er helemaal niets over is.

Start transaction (ST) als er een ST naar bid wordt gestuurd, komt er altijd een continue transaction naar ask. Dit is gedaan zodat degene met multichain altijd als eerst komt. Het verlies is minder groot als multichain verloren gaat omdat het nog een conceptuele currency is.

Het versturen van multichain gaat door multichain te registreren

De transactie gaat in stukjes, om het risico te minimaliseren.

Als laatste wordt er een end-transaction gestuurd.

De code is vrij aardig. Je moet kennis hebben van: Hoe werkt dispersy, hoe werkt messaging, hoe maak je een payload aan,

Er is geen integration test gedaan, wel een hoop unit tests.

Scenario testing, er zit nog een probleem in het PT protocol waardoor nog maar 4 van de 5 trades.

Op dit moment is er geen gegeven prijs. Je moet zelf kijken wat andere bieden. Het laagste aantal bitcoin voor het hoogste aantal multichain.

Het is eigenlijk heel dom om te asken.

Omdat er ask en bids door het netwerk versturen kunnen we wel matchen, want **er zit een matchmaker in het systeem.**

Het grote probleem is dat multichain credits helemaal geen ding zijn. Het hangt af van de persoon.

Het systeem is tamelijk onveilig

Je hoort in dit systeem geen bids te kunnen doen, alleen asks. Want dan is het offer gekoppeld aan de entiteit die de multichain geeft. Op dat moment heeft mc een bepaalde waarde, dan heb je geen netwerkbrede exchange rate, omdat je moet bepalen of de transactie met die bepaalde persoon de moeite waard is.

Als je temporal page rank mechanisme gebruikt, als je in 10 delen overdraagt, verandert dat de score.

Op het moment dat we een andere currency gebruiken kan je wel bid/ask doen

Multichain kan je fabriceren. Door middel van sybils kan je zeggen dat je 60TB heb uitgewisseld. Mits het correct gesigned hebt, heb je in een keer 60TB aan multichain credits.

De check is om het transactieverleden te bekijken.

Wat erop gebouwd moet worden is dat je als gevolg van een hoge reputatie (veel multichain credits) voorrang krijgt bij downloaden. Want dan heeft een gevolg, dan heeft het waarde en heb je een incentive.

Dus het reputatiesysteem kan niet zijn we tellen het allemaal bij elkaar op want dat maakt je ontzettend gevoelig voor sybil attacks. Je hebt dus iets nodig als temporal page rank of netflow –zie thesis Pim-

Implementatie wordt nu bekeken door Pim Veldthuys

Pim heeft implementaties met network X, is geen engineering level code.

Nu worden tests gedraaid door Martijn

Hoe beinvloed de connectivity van een peer de market efficiency. Op het moment dat die connectivity lager is kan het zijn dat een peer aan de ene kant van het netwerk nooit te weten komt van een ask aan de andere kant van het netwerk

Als we kiezen voor een walker op basis van reputatie, connect je met peers met een hoge reputatie en wordt van daar uit je ask verspreid.

Op het moment dat je dus eerder joined, zal je altijd een voorkeurspositie houden. Dat is een feature, geen bug.

Je hebt een tweede soort reputatiemaker nodig; kan op basis van hoeveel geld je hebt uitgegeven. **Kan ook op basis van risico**

Ook in de hypothekenmarkt wil je dat hypotheken uitgezet worden als een ask. Maar dat je geen bid kan stellen van ik wil zoveel investeren in een hypotheek..

En je wilt niet beginnen voordat je hypotheek gevuld hebt.

Het terugbetalen via de markt: op het moment dat je reputatie op basis van geld stromen doet dan wil je het wel doen, want iemand die dan steady terugbetaalt is heel reputabel.

Je wilt van de markt eigenlijk een contractmaker maken. En dan laat je het geld door de bank regelen.

Als je een bank hebt die ook nog signed, dan worden sybil attacks lastiger.

De aanvrager komt met een ask. Krijgt een kredietscore.

Misschien wil je het eerste stuk niet decentraal doen.

Driestaps: hypotheekaanvrager stelt een vraag, als eerste de banken die een superbid doen en dan de general population

De banken zijn supernodes, altijd online, met de juiste informatie

In een ideaal systeem heeft een peer een renterisico op basis van reputatie.

Q: de reputatie is afhankelijk van meer dan je betaalgeschiedenis in het systeem.

Je kan het renteaanbod niet definitief kunnen maken.

Je kan ook het proces herhalen

Je kan een max rente geven

Competitie element komt voort uit je latency.

Andere flaw: je kan de asks van andere aanpassen. Omdat het niet ge-encrypt is.

Voor het principe heb je bitcoin niet per se nodig.

De audit trail wordt gevormd in de multichain.

Een probleem is; dat er nu nog geen signatures in de markt zetten.

Beaver van MIT is een theoretisch concept.

Bitmarket. Is ook related.

Bootstrap servers zijn nog wel centraal. Die laten je toe in het netwerk. Geven je eerste peer.

Hij kan volledig decentraal. Zei elric. Via DHT mainline?

Kan je verwijzen naar documenten die zijn opgeslagen op dispersy: ja. Maar die zijn wel publiek. Je kan wel om authentication vragen door andere peer. Dan kan je het native signen.

SUMMARY Explorative Research

During the first months of the research, the focus has been on finding a relevant business case for innovation in the mortgage domain. Several options have been reviewed through exploratory interviews. The options fell into three categories: mortgage products, mortgage processes and funding with mortgages. The options are described below together with their origination of the idea, the main aspects driving the idea, the research methods used to develop and evaluate the idea, the most important learnings, and potential next steps.

The most important realization for the business case was that the financing of mortgages (the issuance) is not 1-to-1 related to the funding, this is because of the capital creating abilities of a bank. This creates a lot of flexibility for the crowdfunded mortgage case as the issuance of mortgages can happen without delay because of funding rounds.

Crowdfunded Mortgages

A borrower will be able to lower his interest rate when external investors provide a secondary loan to reduce the loan-to-value ratio, in return, the investor will get principal and interest. The bank benefits through lower required capital and might even provide it as an option to its private banking clients. Having clear risk assessment of the borrower is important. It should be possible to invest a little amount in many appliers as well as the total requested amount. This case shows the changing role and business model of the bank as well as an innovation in the mortgage domain.

Origination
- TU Delft (original idea)

Drivers
- Lower LTV: reduces interest rate – relieves payment pressure for consumer
- Securing access to the housing market for starters and private contractors
- Reduces capital requirements for the bank
- Attractive return proposition for the external investor

Research
- Interview Jungo
- Interview Crowdfunding Platform Seeds
- Interview ALM
- Interview Balance Management ABN Mortgage group
- Research BASEL requirements
- Research LTV/LTI policies

Learnings
- There is a market for new mortgage products
- There is standardization in supply, yet segmentation in demand for mortgage products
- Launching new products takes time because of regulators, but it is possible to do crowdfunding partially and still have an annuity mortgage with mortgage interest relief.
- With regard to new BASEL policies, external source of funding for lowering LTV is attractive
- Can be attractive for serving private banking clients, unwilling to venture into stock markets, but currently losing money on their savings

Next Steps
- Interview potential investors (private banking clients, institutionals)
- Interview Financial Advisors
- Development of technical requirements for the platform
- Development of quick scan for the business model
- Development of product

Affordable Housing Solutions (AHS)

Housing corporations have provided products for affordable housing for many years, but are now limiting their supply due to restrictions in their operations. The facilities offered allowed homeownership at a reduced cost, either through equity or debt solutions. Commercial parties like Bouwsteen have seen the opportunity of addressing this particular target group of starters and offer a forwarded loan, allowing a discount of 20% to be repaid when the owners are moving home in the future. It causes less payment pressure monthly but does lead to an equity lag in the future.

Origination
- Researching comparable solutions for securing access to the housing market

Drivers
- Relieving payment pressure for consumer
- Securing access to the housing market for starters and private contractors
- Housing corporations unable to continue AHS because of restrictions in their activities opens up an opportunity

Research
- Interview Bouwsteen
- Interview Marja Elsinga
- Research Affordable Housing Solutions

Learnings
- Equity solutions lower the payment pressure but create an equity lag for the future
- Debt solutions offer leeway for acquiring homes above the regular LTI assuming income growth but will increase payment pressure
- People experience the products as complex
- Products need be clear and straightforward on the consumer side; the cleverness needs to happen on the financing side (obscured for consumers).
- There is investor appetite for these products
- Financial advisors are key actors in the process
- 80/20 allows sufficient headroom in case of default
- Involves too little stakeholders to make a blockchain case interesting

Next Steps
- None in particular, product design might take inspiration from these solutions

Optimizing Mortgage Process for the bank

The bank has been issuing mortgages for many years and in many shapes and sizes. This, together with mergers, has led to a spaghetti of legacy systems that function slow and yield unclean datasets, which make management and packaging into asset-based securities a time-consuming and costly process.

Origination
- ABN AMRO Mortgage Group

Drivers
- Current process is a running on old legacy systems
- With clean data, monitoring and management could be improved

Research
- Interviews ABN AMRO Mortgage group
- Presentation Balance management
- Interview ALM

Learnings
- Legacy systems of the bank are inefficient
- This makes funding time consuming and costly
- MoneYou (new challenger bank of ABN) still runs on the same systems
- No urgency, yet a mammoth task
- No clear blockchain related case
- Not an innovation of the business model

Next Steps
- None in particular, the platform will be new, so clean data is guaranteed.

Optimizing Mortgage Request Process for the consumer

The mortgage application process for the borrower is a slow and often unclear process creating a lot of uncertainty. Even when the mortgage is finalized, an appraisal report can cause the mortgage not to be issued. Building a facility where the consumer can track the process could also yield benefits for the bank such as increased management and monitoring capabilities and increased customer satisfaction.

Origination
- ABN AMRO Mortgage Group

Drivers
- What do borrowers want from the mortgage appliance process

Research
- Interviews ABN AMRO Mortgage group

Learnings
- Uncertainty is the most influential factor for consumers during the process
- Supplying the correct documents can be a nuisance
- Clear view on the application process through flow charts
- No clear blockchain related case
- Not an innovation of the business model

Next Steps
- None in particular, platform will be new, so an efficient process will be part of the design

Flexible Funding

40% of the banks funding of mortgages is done with capital from the international capital markets through selling asset based securities. These are programs of multiple billions of euros worth of packaged loans (mostly mortgages) usually with a maturity of 7 years thereby creating a refinancing risk. The loans in the package vary in maturity, height, rating and interest rate to create a low-risk investment. By changing the mortgages into blockchain based smart contracts, packaging could become more flexible and efficient, selling mortgages exactly when they are no longer profitable for the bank but still exciting for institutional investors like pension funds. Increased cooperation with pension funds would match ‘long' Dutch savings with ‘long' loans but would require increased transparency for all stakeholders, a thing blockchain technology is suitable for.

Origination
- Development of crowdfunding idea towards funding side

Drivers
- Mortgages are not always the most profitable on a bank’s balance, without balancing there is a refinancing risk due to frequent funding cycles.
- Clean data and smart contracts could provide more flexibility in funding with bonds and securitizations
- Balance principle (Danish model) lowers system risks
- Relief of the bank's balance concerning BASEL capital requirements
- An adequate funding reduces interest rates for consumers?

Research
- Interviews Asset and Liability Management
- Presentation Balance Management
- Research Mortgage Funding

Learnings
- Funding and financing are not the same. Mortgages are financed by the bank independently from specific funding. Mortgages can be used as collateral to attract capital on international capital markets.
- Mortgage interest rates mostly depend on strategy in relation to competition
- Mortgages make up 50% of the credit book. They also provide two-thirds of the profit.
- Securitization programs are limited because mortgages are preferred on the balance

sheet of the bank. The associated cashflow is precious for the bank.

- Funding and financing is already balanced sufficiently.
- Data is clean enough, although steps need be made there is not any innovation potential there.
- BASEL LTV requirements are viewed on a portfolio level, which is around 75%.
- BASEL is already priced into the margin.
- BASEL can make it attractive to find ways for lower LTV mortgages.
- The innovation of the bank's mortgage business model can be sought in disintermediation, matchmaking of private capital and loan demand and providing the risk framework. Making money off fees for risk reports and personal credit rating.

Next Steps

- None in particular, although data input requirements for covered bonds/securitizations should be taken into account for the data input requirements of the final product to improve the efficiency of packaging.
- The new product guarantees clean data packages.

Conclusion

After consideration of all sides of the mortgage process, the most suitable business case has been chosen. Keeping in mind criteria such as business model innovation potential, an attractive value proposition for all involved stakeholders, applicability and usefulness of blockchain technology and its hallmark aspects as creating an immutable audit trail for multiple non-trusting stakeholders and the matchmaking capabilities of the TU Delft decentral market. Since product innovation will automatically create a new process and create clean data packages, the advantages of the process optimization on the bank, consumer and funding options are incorporated into a product innovation case. The crowdfunded mortgage is, therefore, the most attractive option as it could potentially also serve private banking clients as external investors as well as the earlier mentioned institutional investors. This idea will be further developed in the second part of the research. Multiple variations of crowdfunded mortgages are described and will be tested through expert and client interviews facilitated at ABN AMRO.

Initial Prototype Bsc Students.

Screenshots. Created by Asmoredjo, Hovanesyan, To and Wong Loi Sing, 2017

A team of bachelor end project students at the computer sciences faculty developed the first working demo of the platform. This is the initial application that will be adjusted and developed further by a team of Phd candidates and graduate students. The product changes will be influenced by the business model design described in this thesis.

It has to be noted that the business case and stakeholder journeys do not match. This is because the students started their project when the business case research was not fully done. The students therefor made assumptions.

With a couple of weeks to go they have now developed a working platform that communicates with a market, logs agreements on the multichain and processes requests through a system API. Their end product will answer to the set of requirement below. Screenshots of the application can be found in the appendix.

Table 12 Platform requirements (Asmoredjo, Hovanesyan, To and Wong Loi Sing, 2017)

Must Have These are the core functionalities and without these, the product cannot be delivered. These requirements have the highest priority. • Borrower can place loan requests. • Borrower can upload documents needed to apply for a mortgage. • Borrower can see offers they get from investors and financial institutions. • Borrower can accept offers they get from investors and financial institutions. • Investor can see which campaigns are available. • Investor can place an offer on a campaign. • Financial institution can create a quote for a mortgage. • Financial institution can see their pending loan requests. • Financial institution can review pending loan requests. • Financial institution can accept pending loan requests. • Python 2 to be able to interface with Tribler and Dispersy. • PyQT for the GUI. • Tests and coverage. • Full transparency. Everything open-source.	**Should Have** The Should Have requirements are important but not vital. The product is still viable without these functionalities. It has the highest priority after the Must Have requirements. • Borrower can reject offers they get from investors and financial institutions. • Investor can see which campaign they have currently invested in. • Financial institution can see which mortgages they currently have provided. • Financial institution can reject pending loan requests. • Scalable. • Blockchain technology
Could Have The Could Have requirements are wanted or desirable, but less important than the Should Have requirements. • Investor can resell their investment. • Investor can invest passively. • Financial institution can determine the maximum interest rate that a borrower is allowed to pay an investor for the loan. • Financial institution can recommend an interest rate that the borrower can pay to an investor for the loan. • Secure storage and transfer of information. • Encrypt and decrypt user documents.	**Won't Have** The Won't Have requirements will not be implemented in the final solution, because they are out of scope for this project. • Borrower can see how much has already been paid off. • Investor can see how much has already been paid off. • Financial institution can see how much has already been paid off. • Regulator can see the total financial health of all the active loans. • Transactions can be done through the system. • Smart contracts to ensure binding agreements between stakeholders. • The system can do a risk assessment.

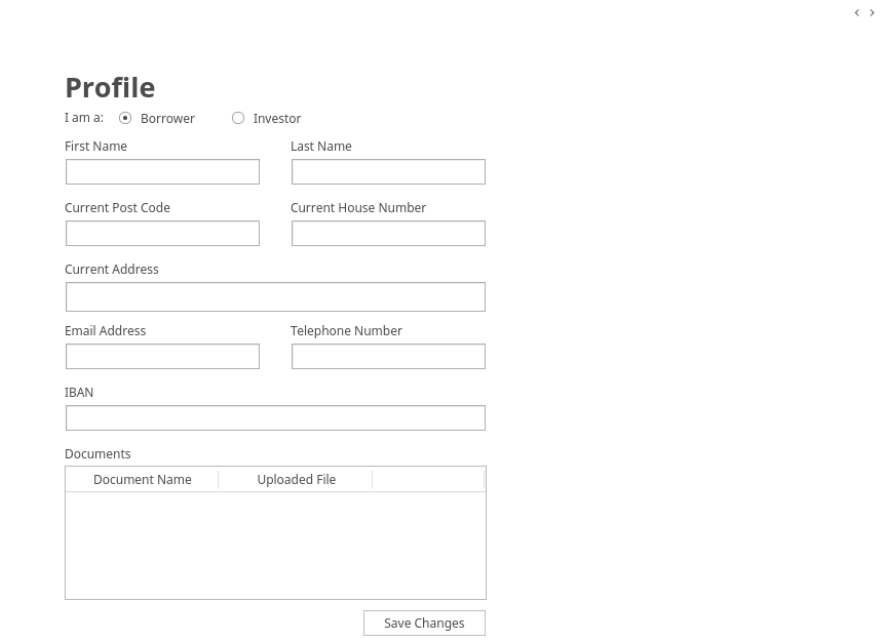


Figure 38 Create Profile screen

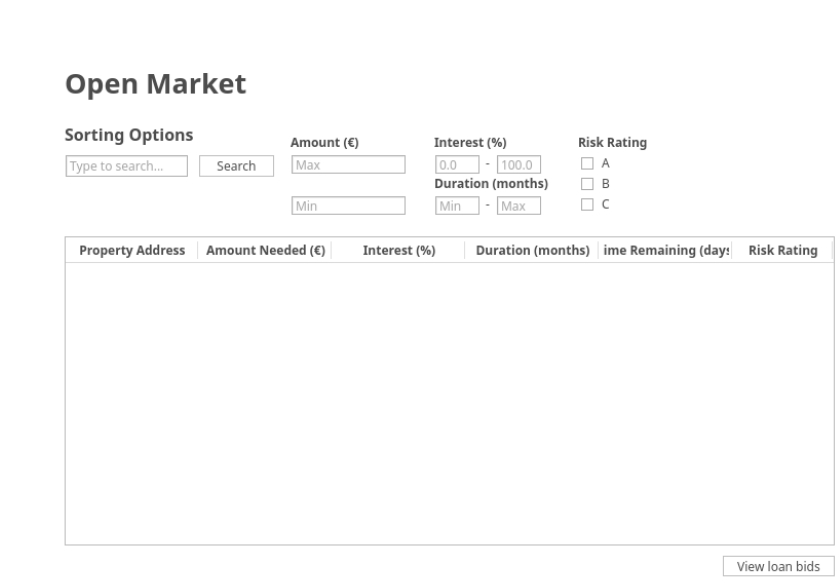


Figure 39 Open Market screen

Business Model Quickscan 101

Methodology

In line with Hevner et. al. (2004) the business model design is done in two complementary and repeating phases, a develop/build phase which addresses research question three and four and a justify/evaluate phase of which question five is the representation. To guide the process of developing and evaluating the STOF method design method by Bouwman et. al (2008) is used to fill out the business model design according to the STOF framework. The flowchart below shows the four design steps.

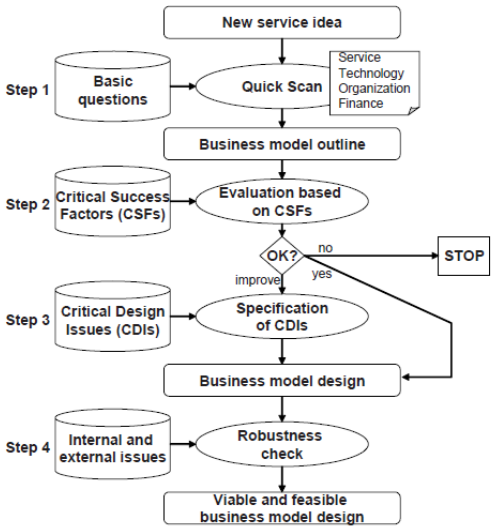


Figure 40 Steps in the STOF method (Bouwman et. al., 2008)

Quick scan

In the quick scan phase, a rudimentary business model is developed which includes the four domains of the STOF method.

Service Design

Intended value
Customer
End-user
Context
Tariff
Effort

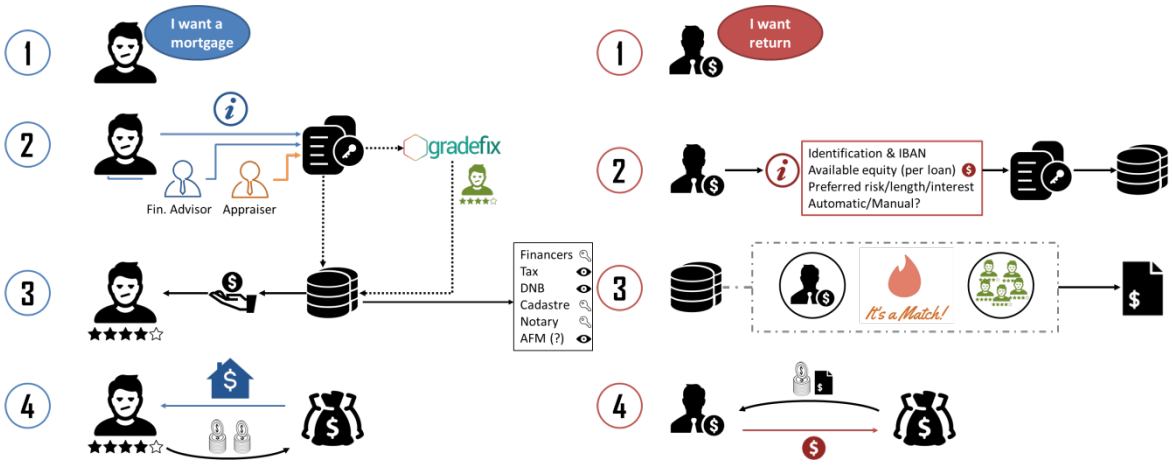


Figure 41 Borrower and Investor Journey (Own ill.)

Borrower Journey

The journey starts with the potential borrower finding a house and needing a mortgage. To do so he logs into the system and uploads all his required information. The aim is to minimize the number of documents and automate as much as possible. Verification of the borrower is necessary, by differentiating sources chances of fraud can be kept to a minimum, think of DigID, bank record, and external source. The bank account feeds into the Gradefix API to produce a personal credit rating.

This information is fed into the matchmaking protocol and provides an interest rate offer. The offer is an automatic combination of investor capital and bank financing. However, if particular investors known to the borrower want to chip in, the borrower will need to be able to select them.

If the offer is competitive, the borrower will accept. The smart contract will be finalized and logged to the distributed ledger. The contract monitors and distributes monthly payments dynamically and automatically according to the predetermined ratios. It will be possible to prepay for the borrower it depends on the value network structure described below in what form this will happen. The case of default will be described below.

Investor Journey

The investor journey starts with the investor identifying himself through a similar verification process as the borrowers. He then fills out the thresholds for his investment, meaning: the amount of equity available (per loan), preferred risk profile, length, and interest rate range.

It is important to note that the investor will almost always invest in multiple mortgages with the same characteristics to minimize default risk. The exemption is when the investor personally knows the borrower and wants to aid the borrower's chances on an attractive interest rate. These two options can be described as passive and active investment. Passive investment makes use of the automatic matchmaking capabilities of *the Decentral Market.* Active investment follows the protocols of the *Crowdsourced Real Estate Market* mentioned in the infrastructure chapter 5.

After the matchmaking, the confirmation follows, and the investment becomes visible on the investor's dashboard, since his investment gives him the right to a share of the principal and interest which has a certain Net Present Value. This makes it possible to resell the stock to other investors on an aftermarket. The smart contract updates the ownership of the share automatically.

Value Network

Bouwman et al. (2009) find that when organizational design issues relating to partner selection, openness, the orchestration of activities and the way collaboration between partners is managed are more clearly addressed, the division of roles between partners will be perceived as more acceptable. The division of roles needs to be addressed as clear as possible because "the bank" is not one entity and has therefore different multiple aims. The value network can, therefore, take different shapes. The other influential factor is the role of the technological infrastructure. Various options are described below.

A The mortgage issuance (financing) is separated from the fund management. This is possible because of the capital creating capability of the bank, when issuing a mortgage the bank doesn't need to have that exact amount in an account, the asset just needs to be balanced with a liability at the end of the day. In other words, funding and financing is separated. The advantage is that the technological infrastructure does not have to issue the mortgage.

- The bank issues a mortgage to a borrower that received a personal risk rating from Gradefix
- The SPV gets a loan to buy mortgages of the bank's balance sheet. (this could be from any bank).
- The borrower repays interest and principal to a SPV in which investors have invested.
- The investors receive interest and principal according to their share.
- The fund management department of ABN manages this SPV and receives a management fee.
- And all transactions are logged on the distributed ledger.

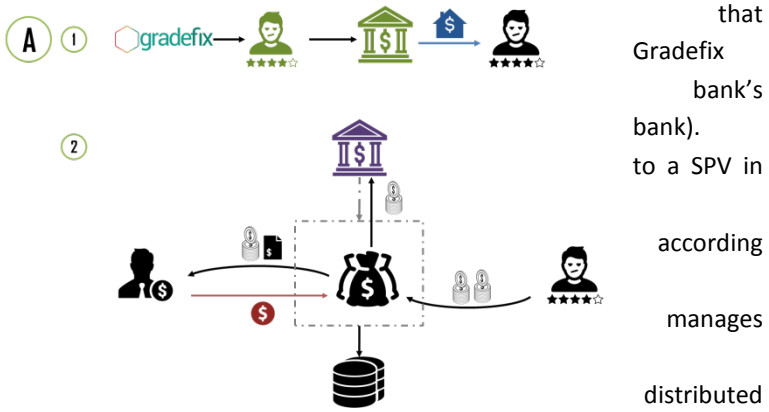


Figure 42 Option A (own ill.)

Pros/Cons

The bank would receive a fund management fee. The bank could also receive fees for risk reporting and the personal rating service.

In this case, you give away a large share of the cashflow to the SPV. The bank can, however, hold an amount of shares in the SPV. The question remains if the costs of creating an SPV aren't outweighing the advantages of investor involvement.

The role of the technological infrastructure is limited here as it only logs transactions on the distributed ledger.

B Option B is technologically most demanding. It involves the creation of a digital SPV governed by matchmaker protocol that matches investors and mortgages. The SPV is completely separated from the bank's balance sheet.

- The digital SPV gets a loan from the bank to be able to issue mortgages to appliers that fit the risk profile indicated by the current investor pool.
- The matchmaker matches the investors and borrowers.
- The mortgage is issued by the DSPV, partly financed by investors. (But it could also buy existing mortgages from any mortgage issuer.)
- The smart contract between DSPV, the investor and the borrower is logged on the distributed ledger and includes the ratios.

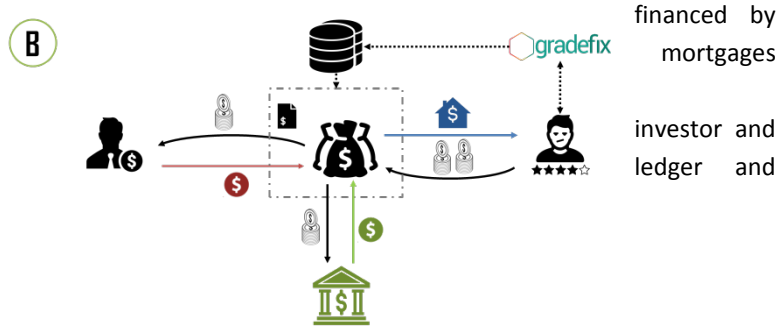


Figure 43 Option B (own ill.)

- The DSPV processes the (p)repayment which splits it to the investors. (p)repayment has an effect on the reputation of the borrower.

Pros/Cons

In this case, the mortgage is partly financed by investors, which means the LTV drops and so does the interest rate because the capital requirements aren't as stringent on lower LTV loans.

In this option, the smart contract would be a data package consisting of detailed and continuously updated information about the borrower. The flexibility increase this yields for further structuring is radical.

This option demands the most from the infrastructure as it has to do issuance of mortgages, matchmaking, monitoring of transactions and adjust the stakeholder's reputation as a result.

The question is if the capital requirements on a loan to an SPV is less demanding than a portfolio of high LTV loans.

C Option C is comparable to a classic covered bond situation, where the mortgage serves as collateral for the bond the investor buys. The advantage here is that the bonds and mortgages can be (automatically) balanced according to their characteristics, similar to the (old) Danish model. Both the mortgage and bond are on the bank's balance sheet, but they are separated, the bond holder receives from the bank, not from the borrower.

- The bank issues the mortgage and the borrower repays interest and principal
- A representation of the mortgage with similar height, interest, maturity is cut up in an amount of bonds which are bought by investors.
- The bonds are logged on a distributed ledger as a smart contract. The borrower can buy the bonds back and in that way (p)repay his mortgage faster when this is advantageous.
- All transactions are logged on the distributed ledger and therefore transparent for all stakeholders.

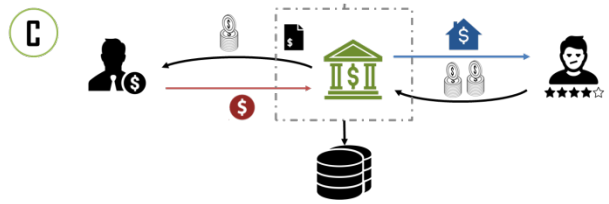


Figure 44 Option C (own ill.)

Pros/Cons

Most simple option. Allows for (p)repayment monitoring, thus creating valuable data packages for further structuring.

There is limited disintermediation because the transactions flow through the bank's balance sheet. This means that the investors not really invest in mortgages, but in the bank. It undermines the decentralized nature when there is a trusted party in the middle.

Organization Design

Financial Design

Technology Design

Technological Architecture

Protocol: must allow for

- Role-based security (i.e. privacy)

- Balance principle: a matchmaker function
- Issuance and Repurchase of shares
- Thresholds for purchase of financiers
- Data recovery from different servers

Applications

- Investment management dashboards
- Document access
- Audit trail reports

Devices

Web-based.

Service platforms (Billing and Customer Data Management)

Access Networks

Technical Functionality

Register:

- Capital allocation by financiers
- Share acquired by financiers and therefore the distribution of returns
- Approval, credit score of the borrower
- Mortgage issuance
- Borrower payments of principal and interest

Matchmaking:

- Based on thresholds determined by financiers
- Long term capital with long term loans

Data streams