

A REVIEW OF USE CASES FOR BLOCKCHAIN IN THE MORTGAGE AND REAL ESTATE INDUSTRIES

Field research on problems in mortgage and real estate transactions and a solution proposal for these issues

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Steven F. Schepman Schepman was born in Saint Louis, Missouri, on July 9th, 2000. Schepman went to MICDS in Saint Louis before moving to Jackson Hole, Wyoming to attend and graduate from Jackson Hole Community School. Schepman entered Washington University in Saint Louis for his first year of college before transferring to the University of Southern California. Schepman is currently an undergraduate business student pursuing a data science major and a business administration major at the University of Southern California in the United States. Schepman has followed blockchain's development in Wyoming, where he attended conferences regarding the regulation of blockchain and cryptocurrency. Schepman has worked with Gemini Consulting in Saint Louis, Missouri to integrate blockchain technology into financial institutions in Saint Louis. Schepman acquired his IBM Digital Badge after taking blockchain-related courses online. His research interests include data science, finance, and entrepreneurship, which is reflected in this paper as it is his first official research paper.

Abstract

This paper discusses several areas in the real estate and mortgage industries that a blockchain could be applied to and grow from. Blockchain is a distributed ledger technology that contains a ledger recording transactions hosted on the platform of tokenized assets, which smart contracts govern using transaction protocols. After interviewing many players in the mortgage industry, it is apparent the mortgage industry is centralized around institutions like Freddie Mac and Fannie Mae. However, the point of sale, home closing and ownership processes are somewhat disconnected from these behemoths. This paper discusses interviews and a customer survey that garner the efficiency and cost problems the mortgage industry is currently facing. These problems include manual processing of documents, time consuming information verification, lack of privacy, communication issues and lack of technological systemization in the recording process. This paper proposes solutions handling document and information verification for Loan Applicant Report creation and uploading to the LOS. It discusses simplifying real estate transactions themselves with the blockchain. It lastly discusses the idea of

forming a land registry on a blockchain because many countries do not have access to sufficient land records. This paper finds that all three are good use cases for a blockchain application, but blockchain technology could start and grow from one of these applications. A blockchain-based mortgage system should be made to connect credit information verifiers, banks and homebuyers, process their documents and make the mortgage process faster.

Keywords: Blockchain technology, distributed ledger, land registry, LOS, OCR, real estate, smart contract, optimization, efficiency

Introduction

The mortgage and real estate industries involve very complicated transactions requiring communication with many parties and documentation of a lot of dispersed information. The process of buying a home can be very burdensome to brokers and officers that have to form a pre-approval letter, help customers find a home, form a loan applicant report and collect and verify troves of homebuyer information. The high amount of information required for mortgages makes it difficult for borrowers to provide documents to several lenders if needed. The homebuying process takes about 30 days for a residential mortgage and even longer for commercial mortgages (Kejriwal & Mahajan, 2017). The purchase and ownership of a home are connected processes that are often disorganized, time-consuming and sometimes fraudulent. Land registries have to manage thousands of property records and deal with many middlemen. The homebuyer must fill out the deed, sign it, get it notarized and send the documents to the government for property transfer. While many U.S counties have digitized land records, technology can help streamline processes involved in ownership transfer, which may be connected to the homebuying process for more organization. Third-world countries with less

organized governments especially see issues with fraud and disorganization in homebuying. With the progress made in financial technology, what can blockchain technology offer to innovate and streamline processes in home finance?

Self-enforcing digital contracts, artificial intelligence, and ledgers that manage transactions on a shared online ecosystem could heal and perhaps cure the inefficiencies in real estate. A distributed database could give information access to permissioned parties, making processes quicker for parties needing homebuying information to complete transactions and transfer ownership. This system would get information directly from those that possess it as opposed to going through multiple parties because it would be a permissioned ecosystem of data. Sellers could transfer a title of ownership directly to the homebuyer without waiting on and paying fees to third parties because digital contracts could build a trustless ecosystem where only vetted transactions would execute. Furthermore, APIs like optical character recognition (OCR) could organize, label and process some documents to speed up sorting through all the documentation, a job description for many employees required to do this manually. These are just some of the roles blockchain technology could play in the homebuying process because it possesses the distributed ledgers, smart contracts and interacts with APIs to streamline processes.

The famed economist Kenneth Arrow once said, “it can be plausibly argued that much of economic backwardness in the world can be explained by the lack of mutual confidence”. The blockchain and its smart contracts create a trustless environment that allows unfamiliar parties to do business with confidence. Today, the vast majority of large financial transactions involve a trusted third party like escrow to ensure participants’ security, but blockchain’s capabilities enable transactions to be more direct without compromising security. People pay financial intermediaries fees because they identify parties, settle transfers and maintain a record of

transactions, but these functions can be performed by a blockchain's consensus system, distributed ledger, smart contracts and data structure. These intermediaries also create a single point of failure for transactions due to the centralization of their data, but blockchains distribute systematic functions to approved nodes in the system. This concept protects sensitive financial data better than traditional systems. Financial transactions involving real estate are full of intermediaries and inefficient processes that blockchain could fix.

Why Blockchain?

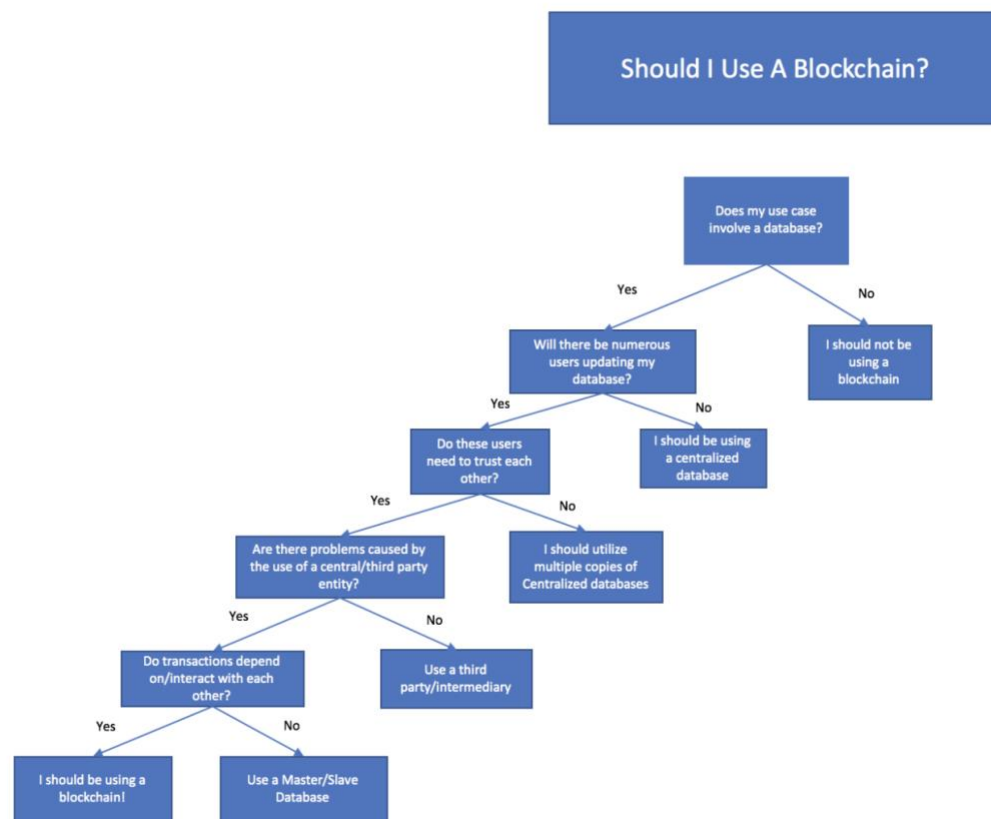


Figure 1 (Ett, 2018) - A flowchart from GreenTech Media describing when a blockchain is appropriate for a use case

The mortgage industry has lagged many other industries in technological progress until recently as loan origination systems, CRM systems and data consolidation in institutions such as

Freddie Mac and Fannie Mae have evolved the industry. However, there is still a lot of room for improvement because these technologies and systems serve mortgage brokers in very specific ways, tailored to very specific points in the mortgage's lifecycle. Freddie Mac and Fannie Mae have centralized the mortgage industry, but the flow of information and documents is very much decentralized in the initial stages of the mortgage process. A mortgage involves many participants that have to communicate and execute tasks that are time-consuming and inefficient in some cases. There's also a large amount of dispersed information that must be collected and verified by different parties that operate on different technological systems with different databases. Parties in a mortgage need to trust one another when they transact information because a real estate purchase is often the most important purchase in one's life. Mortgages move through one entity, a bank, so mortgages and the relevant parties all surround the bank in its handling of the mortgage. Bank employees are fully responsible for ensuring information is correctly collected and evaluated, which leads to many errors that employees pass down the mortgage value chain because current loan origination systems (LOSs) allow this event to occur (Shalev). Large institutions such as Freddie Mac and Fannie Mae also control housing data and touch virtually every mortgage transaction. The mortgage industry is centralized because banks value the large amount of data possessed by these large institutions. It is healthy for banks to access and use one credible source for their housing data, but data on housing is a small piece of the entire mortgage. Banks must collect and verify their customer's personal and other information, which is a task they often independently perform without much help from Freddie Mac and Fannie Mae. Loan origination software allows banks to collect documents from their customers. However, these LOSs do not help banks gain customers, collect customer information, verify it or efficiently coordinate communication between different parties

possessing their customer's credit information. Thus, errors and inefficiencies originate at the beginning of the mortgage due to the human responsibility of initiating the mortgage.

Furthermore, relying on third parties to provide information takes time and risks accuracy.

Mortgage transactions also depend on and interact with one another because a mortgage affects one's ability to refinance, creditworthiness and ownership of the property. Refinancing among baby boomers could be a key operation performed by a blockchain because smart contracts can check the credit performance of a borrower and automatically offer refinancing if they meet certain criteria.

Real estate transactions are also appealing for a blockchain use case due to the need for a common database, multiple entities contributing and modifying information, lack of trust between entities, opportunities for disintermediation and transaction dependence. A shared database can unite parties throughout the homebuying process and ensure consensus on the information transacted, making verification of documents easier. Shared databases are important for all types of real estate transactions like leasing, rent, purchase, and sale. A blockchain listing platform could manage property information sourced from real estate agent databases. Real estate transactions rely on many parties such as owners, tenants, operators, lenders, title offices, and investors that provide and modify information. Parties in leasing, purchase and sale transactions are often unfamiliar with each other, so they are over-cautious in due diligence. In many third-world countries, property records are disorganized, which opens the door for fraud and conflict between people over ownership. Blockchain can reduce data integrity risks with private digital identities and real-time record systems of real estate titles, entitlement, tenancy, and financing. Intermediaries like title companies can be not only disintermediated but reformed by blockchain technology by integrating their systems with more transparent blockchain

technologies. Integrating blockchain into title management would increase security with automatic confirmation from government land registries. Real estate transactions are dependent on one another and stages in the process are conditional on certain information. Real estate transaction contracts often have conditional clauses that can be encoded into and executed by a blockchain's self-enforcing smart contracts. For instance, loan approval or title clearance could trigger the clearance of a transaction.



Figures 2&3 - McKinsey and Company's research into the impact and feasibility of applying blockchain to land registries and transaction monitoring

Problems Addressed

Extensive documentation and multi-channel communication between parties make real estate payments and ownership transfers time-consuming and expensive. This issue is “most pronounced when the buyer funds a purchase through a mortgage or when the transaction is cross-border” (Kejriwal & Mahajan, 2017). Deloitte notes commercial mortgages as more convoluted than residential mortgages, taking three months on average to complete (Kejriwal & Mahajan, 2017). Due diligence in pre-approval is a pain point in the mortgage process as it

involves extensive paperwork and verification of information. Lack of standardized data and common tech systems causes poor coordination, significant risks and inefficiencies for mortgage lenders. While LOSs have helped make up for these issues by providing a central place for parties to transact information, these technologies still lack coordination and documentation functionalities, making it hard for mortgage brokers to create the mortgage. While LOSs have been a consolidating force in the mortgage industry, many lenders still use different recording formats. These records are often simply scanned paper contracts and documents, which are stored in servers, data centers and government departments, spread across the U.S. Separation of data provides extra security, but also creates reconciliation and access difficulties, which causes inconsistencies in information between issuers, underwriters, regulators and rating agencies among others (Sindle & Santhana, 2017). Separate data compromises market efficiency for an added layer of data protection, both of which should not be mutually exclusive with today's technologies. Despite the discoordination among mortgage and real estate players, regulators are asking for increasingly more data checks to ensure creditworthiness in regulation ABII and Regulation Z¹, which increased loan disclosure requirements. Verifying information like asset, income, debt, credit history required by the ATR (Ability to Repay) can be problematic for commercial mortgages due to "heterogeneous qualities that usually keep originators from standardizing promissory notes, loan agreements, and deeds of trust, resulting in high due diligence needs and costs" (Sindle & Santhana, 2017). Not only are residential mortgages complicated but also commercial mortgages because a property's cash flow is used instead of borrower incomes. As a result, data on the income and expense side are essential in the approval and underwriting processes. Additionally, many commercial mortgage companies obtain rent

¹ Proposed updated rules in 2019

rolls, operating statements, lease updates, budgets and more without data systems to do so. Manual collection, reconciliation and updates of information are not sustainable in complicated business processes as they are prone to high costs and errors in documentation. Reading over and analyzing all the documentation related to mortgages is also very time-consuming, and many companies have hired individual employees just to read over 200-page PDF documents to upload them onto their LOS systems.

The entrance of many fintech companies into the mortgage space has hurt operating margins, pushing existing financial companies to innovate. Digital verification of information is one area in which banks are interested in innovating. Banks do not want to use paper-based processes and different platforms of communication like email and the phone for verification. Many want to use digital data for validation of employment, assets, income, etc. to refine the customer experience and to speed up the mortgage process. Digital information systems have crept into the mortgage industry through third-party companies, which sometimes make borrowers feel insecure. A system not directly controlled by any one party that manages borrower data through their bank's channels may make them feel more secure.

After the mortgage has been originated, the real estate transaction and ownership registration share some of the same issues and need optimization. Kairos Future points to blockchain as the “only solution” to the problems with these processes that finalize the homebuying process (Snäll & Kempe). The first issue in land registries that the United States shares with Sweden is the lack of involvement by land registries until the end of the real estate transaction, hindering transparency with stakeholders. The second issue is how time-consuming the closing process is for property transactions in the United States. In the digital age, no transaction should take three to four months even for something as important as a home, yet this

is the case in the U.S housing market. The title transfer and deed registration take about three weeks alone in the U.S. While there are many government-mandated waiting periods, especially in mortgages, that hinder the process, inefficiencies in the homebuying process also contribute to the time length. The financing process is arguably the most time-consuming process in the purchase of a home, but “the transaction can be marked with frustrations as it feels as if there’s either a flurry of activity (requesting of a ton of documents) or no activity at all (or so it seems)” (Sibiga, 2017). The last problem involving real estate transactions in the U.S is the large number of intermediaries that people have to go through to file deeds and documents with land registries. Even if these intermediaries are needed, the amount of communication and filing processes that the homebuyer goes through does not make it easy for them to register their property. There is no online platform that notarizes documents and uploads documents to the deeds office as revealed by the interviews below. The mortgage industry has not solved the problems revealed by the following interviews and survey because they have not connected parties involved in mortgages and organized their systems to optimize efficiency and minimize customer effort. The mortgage industry has yet to use a system with OCR, chatbots and blockchain to automatically complete tasks humans cannot perform and complete mundane human tasks faster.

Mortgage Customer Survey Approach and Results

A survey of 106 homeowners mortgage customers of 40 years and older was also conducted to identify problems in the mortgage process and determine whether certain technology solutions could help solve those problems. Over half of the people that took the survey were between the ages of 40 and 50. Some of the questions were formulated to confirm some of the problems found in the interviews existed in the customers’ eyes. The survey was done using built on Survey Monkey’s website and distributed to the target participants through a

top-rated surveyor on Fiverr. The survey's results revealed many issues in the mortgage process and the mortgage customers' value of online platforms and technology to solve some of those problems. The problems addressed in the survey included communication with mortgage agents, finding a bank, time-consumption, handling documents, refinancing confusion and general inefficiencies.

Question 1

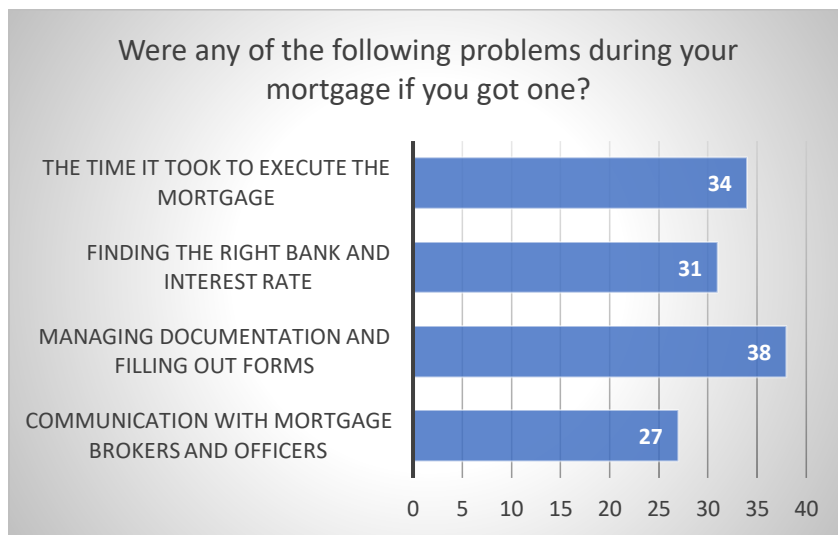


Figure A - A bar chart showing how many people indicated that they experienced each problem listed

The most problematic aspect of a mortgage for about forty percent of mortgage customers in the survey was document management. Typically, at minimum, a mortgage customer needs to provide ten documents to file a mortgage on top of personal information. This process is very burdensome for the mortgage customer to organize and complete in a timely manner. Filling out forms is also time-consuming for customers when current technology can simply populate these forms with information they may have already provided to the bank. To many customers, it seems unnecessary to get documents, especially when third parties like employers could theoretically provide these documents directly to banks. Another popular concern that is somewhat connected to documentation is the amount of time it takes to complete

a mortgage, especially in an age where people want everything quickly. This survey question was optional, yet 94 out of the 106 people taking the survey answered it, showing many participants experienced at least one if not more of these problems.

Question 2

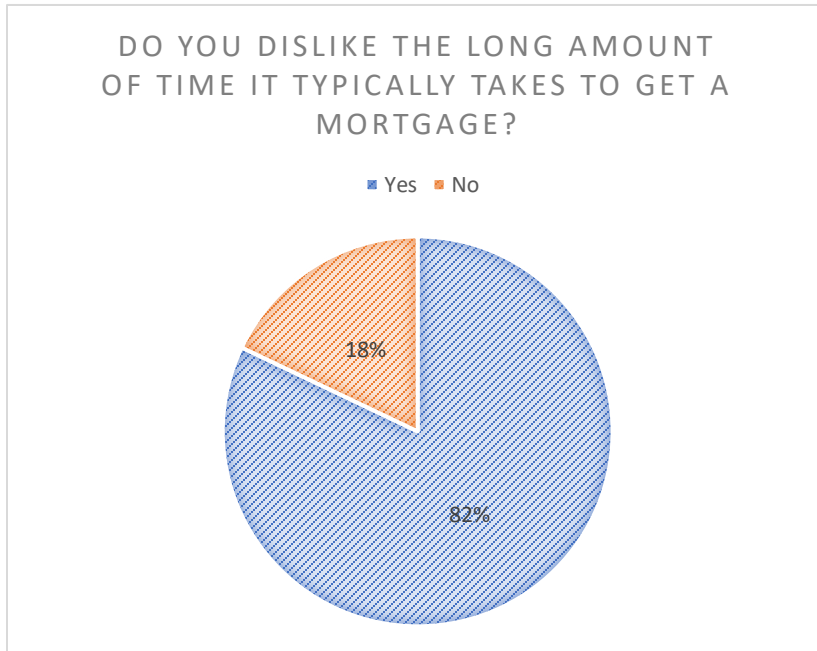


Figure B - A pie chart representing survey responses

This question was meant to gauge if people appreciated the time it takes to secure a mortgage to ensure it is accurate. Although only 36% of people thought time-consumption was a problem, 82% of survey participants disliked the amount of time it took for them to get a mortgage. While it was not viewed as a problem by many, it certainly was a negative customer experience for them.

Question 3

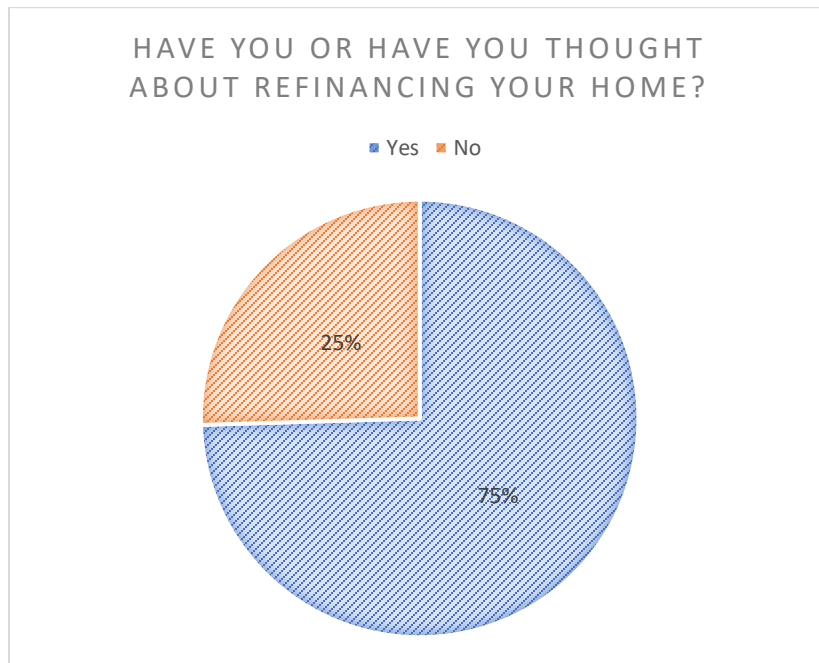


Figure C - A pie chart representing survey responses

Refinancing is becoming increasingly popular, especially among baby boomers, so this question aimed to find out how popular refinancing is among this demographic currently.

Seventy-five percent of respondents said they had considered refinancing, showing it has become a serious option for many baby boomers today. Many mortgage customers will likely have to ask themselves whether refinancing is a good option for them financially.

Question 4

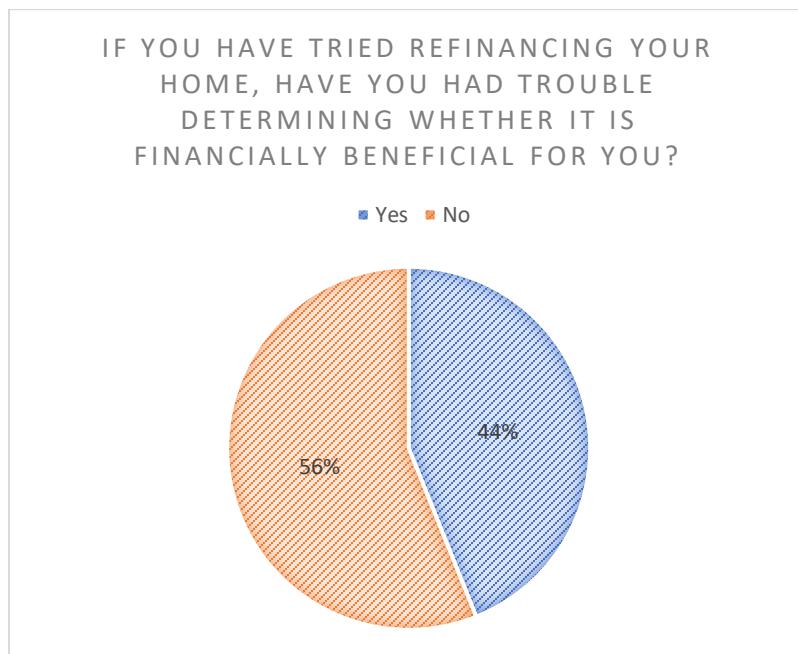


Figure D - A pie chart representing survey responses

Forty-four percent of respondents had difficulties figuring out whether refinancing would benefit them financially, which is fairly significant considering many people have access to financial advisors and accountants. This question is a precursor to a later question asking about a technology solution that would help them make that decision.

A third option, “not applicable”, was provided to participants to account for those that had not obtained refinance loans, who represented 37.75% of all participants, which means 62.25% of respondents refinanced their homes. In 2018, 377 billion dollars of refinancing was done (Rudden, 2020). Based on questions 3 and 4, 12.75% of respondents had thought about refinancing, yet did not follow through on refinancing their homes, meaning refinancing was not right for them or other problems arose (see questions 5 and 6). If this portion of Americans were

considering whether they wanted to refinance in 2018², mortgage companies could have increased their volume by 12.5%, meaning they missed out on 55 billion dollars of refinance loans in 2018. Whether the disconnect was on the customer or bank's end is uncertain, but the next two questions try to figure out what the banks could improve on to encourage refinancing.

Question 5

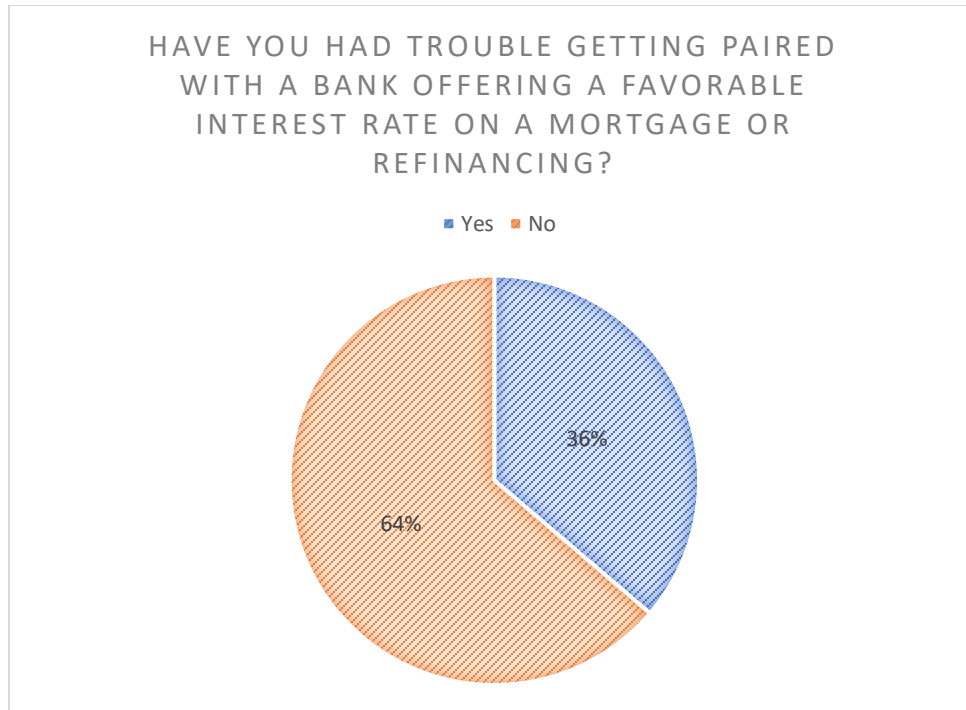


Figure E - A pie chart representing survey responses

Many online platforms such as Lending Tree have been adopted by customers to get paired with banks, so it is not surprising that the majority of people did not have a problem with finding a bank and securing a good interest rate. However, 36% of answers indicated that this first step in getting a mortgage was still a problem for customers.

² This is an unlikely scenario, but this hypothetical situation puts the missed opportunity for banks into perspective if this survey sample is truly representative of the United States, which is difficult to determine

Question 6

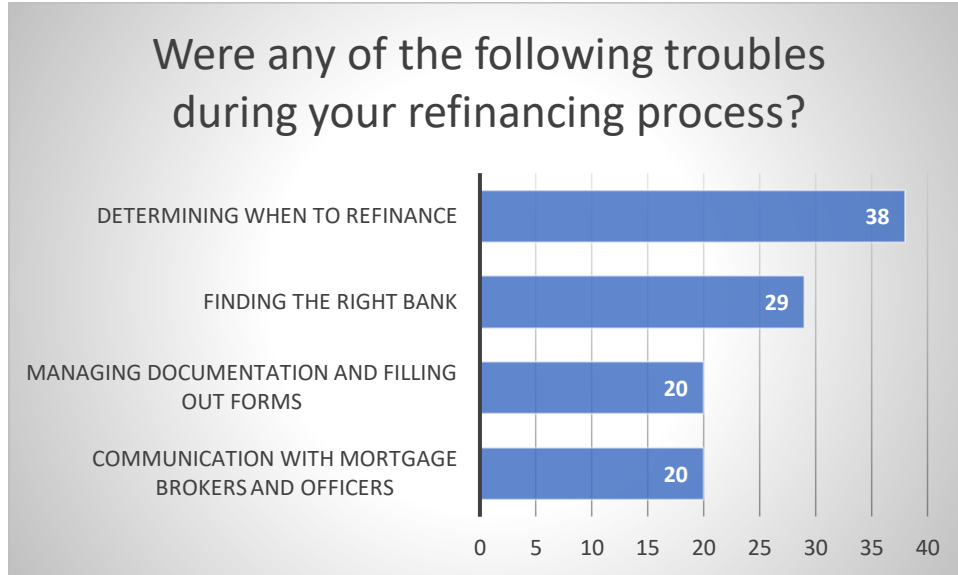


Figure F - A bar chart showing how many people indicated that they experience each problem listed

These issues may have been why approximately 12% of survey participants did not refinance their homes. 40% of this question's respondents had trouble determining when to refinance, which is statistically significant given the standard deviation of the sample is 8.6 and this option was selected 9 more times than the next highest selected option. The timing of refinancing is a big question because it depends on the interest rate environment and how long the homebuyer wishes to occupy their home. Finding the right bank for refinancing seems to be about as problematic as a mortgage loan given 30% of respondents selected this as an issue for refinancing and 36% as an issue for mortgages in a previous question. Managing documentation and communication was still a problem for 21% of respondents despite most likely working with the same bank they got a mortgage from.

Question 7

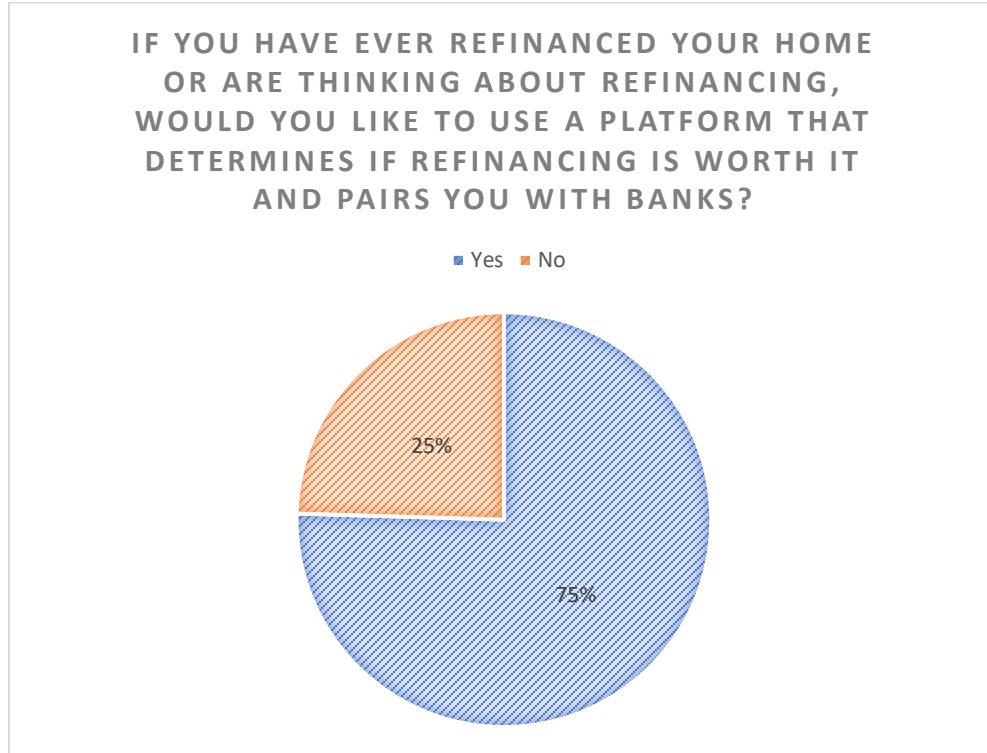


Figure G - A pie chart representing survey responses

This question garnered customer interest for a platform that would determine if refinancing is worth it for them at a specific time. The preceding questions may have led respondents to realize the value of such a platform as many indicated they had problems determining the right time to refinance and finding a bank. 75% of survey participants believed they would use a platform that would guide them through the refinancing process and objectively determine how advantageous refinancing would be to them. A blockchain-based online network could connect lenders and customers after using smart contracts to determine refinancing prospects.

Question 8

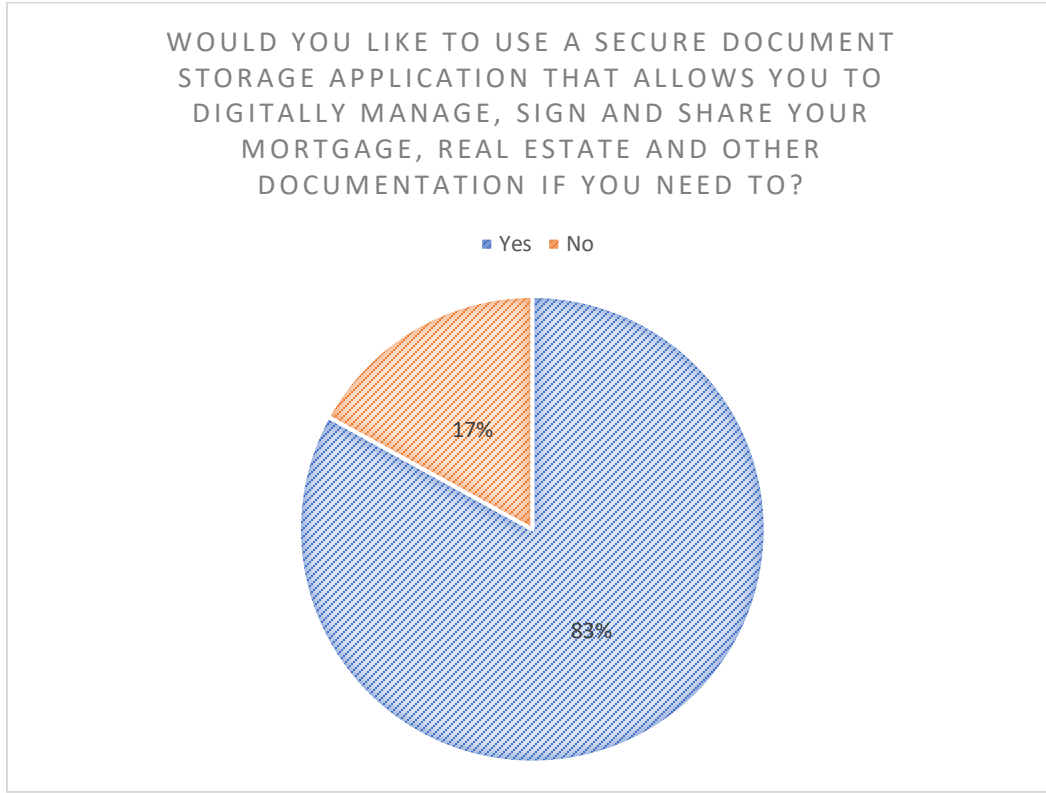


Figure H - A pie chart representing survey responses

This question tested the attractiveness of the minimal viable product proposed in this paper. 83% of survey participants wanted to use an online system to manage their documentation, which was the largest problem indicated in question 1. This blockchain-based system would allow them to securely store their documentation, sign e-files and give access to parties to upload and view e-files to their profile. Given that 8% more respondents wanted to use this type of system than the system described in the last question, this product would be more popular among customers of this survey's demographic. Other documents such as homeownership documents could also be managed and transacted on this platform because many recording offices like the Saint Louis Land Management Department do not have an online system to directly submit homeownership documents to them. Banks currently use a third-party

system called Laredo that charges them for access to property records, which they could instead obtain on a distributed ledger technology that connects them with land registries on the same document system.

Question 9

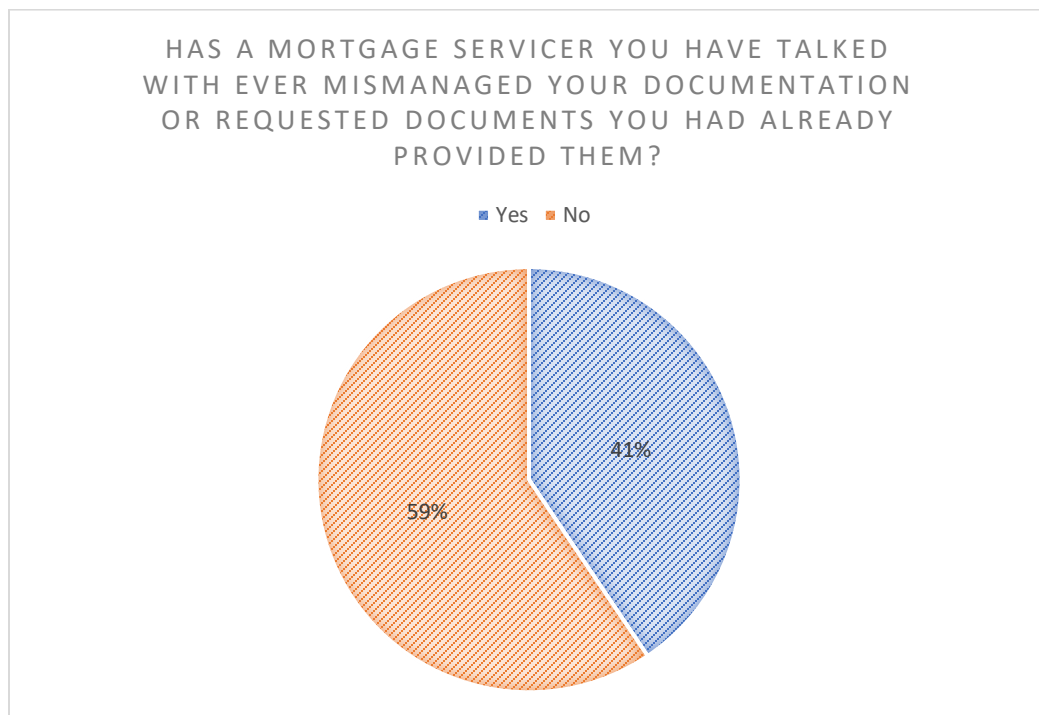


Figure 1 - A pie chart representing survey responses

This last question targeted human error in the mortgage process by asking respondents whether mortgage agents had ever mismanaged their documentation or repeated processes like asking for documentation already provided. This problem would be directly solved by the minimal viable product described in the next section. This system would use smart contracts to manage documentation according to set rules and reference its ledger to determine what documents have already been provided. Forty-one percent of mortgage customers in this survey had experienced mismanagement of or repeated asking for documentation, which is high

considering how fundamental this task is to the job of a mortgage agent. While the majority did not experience this issue, a good portion was affected by human error in the mortgage process, which could be aided by a blockchain system utilizing a distributed ledger and smart contracts.

Discussion of Survey and Interview Results Framed within 3 Use Cases

Case 1: A Real Estate Transaction Platform

A blockchain managing the valuation and sale of a property would work as a starting point for a property management blockchain because it would focus on the homebuyer, tailoring the process to them as opposed to a public entity or financial company. Computerized real estate appraisals are on the rise in the United States. According to the Wall Street Journal, “federal regulators are moving to allow a majority of U.S homes to be bought and sold without the involvement of licensed appraisers, by increasing from 250,000 to 400,000 dollars the value of homes exempt from human evaluation” (Dezember, 2019). The blockchain’s ledger could be very useful in tracking real estate data trends and the sale history of a particular home, which could value an individual’s home or building. The real estate owner could log onto the blockchain, and an API could use the ledger’s history of the home and similar homes to appraise the real estate, provided that the value of the real estate permits a digital appraisal. The system would be independent of human biases and use raw data to generate a home value. This value can help the owner to decide whether they want to sell. If the owner decides to sell, they can list their property on this blockchain and match the property with buyers that have entered particular preferences, processed by smart contracts potentially. An iteration of this technology could also evaluate the homebuyer for financing and give the homebuyer multiple mortgage vendors to choose from and compare. The smart contracts would check that all required processes such as

inspection, interest rate locking, loan agreement and bidding have occurred in an acceptable order before triggering the sale of the property and transfer of ownership (title). Processes involved in closing such as escrow will become unnecessary because smart contracts will manage settlements as seen in the diagram below.

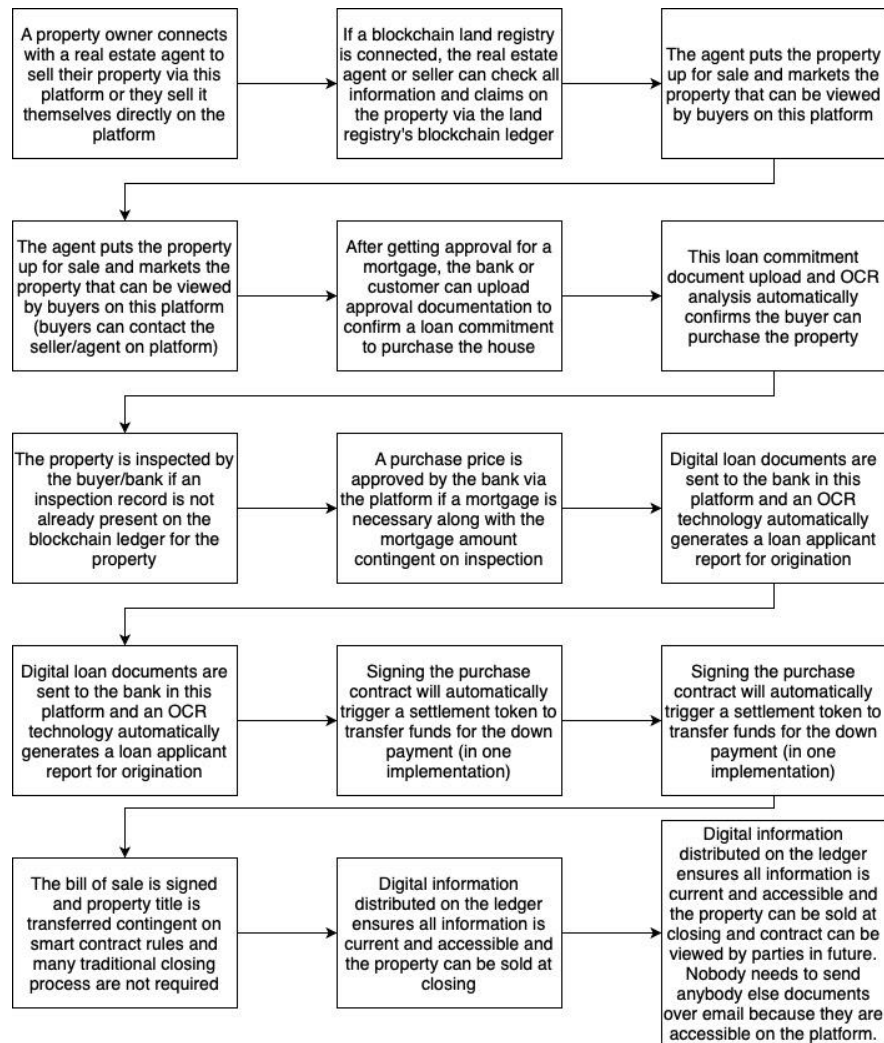


Figure 4 - A flowchart of a real estate transaction platform (inspired by Sweden's blockchain-based real estate sales system) hosted on the blockchain meant to make the transaction more efficient

Case 2: A Mortgage Document Platform

Blockchain could be highly beneficial for early stages of mortgage financing by streamlining documentation and due diligence and forming an accurate loan application report. A

blockchain-based property identity, associated with a buyer, could be connected to documentation flow and information verification after making a loan agreement, sanctioned by a smart contract³. The transaction taking place on the blockchain would create an audit trail on its distributed ledger⁴ of know your customer (KYC) and mortgage information. If the property would be purchased through a mortgage, a smart contract could ask the buyer permission to access information from relevant parties such as credit agencies, employers, financial companies, appraisers, ect. to pull information relevant to forming a Loan Applicant Report. Alternatively, these parties could access the blockchain and verify that the information they provided is correct. An OCR API could be implemented into the blockchain to label and process long documents that current employees have to currently break down, organize and label manually. Using the OCR technology to break down the long documents, this API⁵ could populate the loan applicant report with relevant information once the smart contract triggers the API to do so. Once information collection and verification trigger the smart contract to upload the loan applicant report (LAR) onto the LOS, the digital property identity would be updated with the LOS's progress on the mortgage (i.e approval and closing) to add to property history. For instance, once closing occurs, a smart contract could automatically transfer title and update deed documents in conjunction with land registry offices. The buyer and mortgage company employees could monitor mortgage progress in real time through the ledger.

This blockchain would manage the flow of information and documentation in the early stages of the mortgage process. Each borrower would have their financial profile for banks to evaluate mortgage information from. Appropriate information needed for servicing would be

³ A smart contract is a computer program that automatically executes, controls or documents legally relevant events based on the contract or agreement terms

⁴ Accessible to relevant parties to protect privacy of the homeowner and other parties

⁵ Connecting to technologies like Laserfiche

collected in the first steps of the process to ensure all documentation is accurate as it moves down the value chain. The financial profile of the borrower would include the borrower's FICO score, credit rating, debt to income ratio, W-2s, bank statements, tax records (or balance sheets) among other relevant information. People could upload other documents to store on their digital identity, protected by the blockchain platform. Instead of a mortgage agent requesting documents and managing their information, this online system would control the documentation and know not to ask for documentation repeatedly. Thus, the 41% of mortgage customers that indicated their mortgage agents mismanaged their documentation in the survey would avoid that experience. Using blockchain technologies such as Corda, only certain nodes relevant to the mortgage on the blockchain would be able to access this personal information because transaction data is private. Corda's coding language, Kotlin, uses File I/O that would be able to secure documents and attachments throughout the blockchain as well as process them. The LOS could feed loan payment receipts to this platform, posting them to its distributed ledger, which would make payment reconciliation frictionless with an audit trail. If payment receipts stop feeding into the chain, a smart contract could notify the borrower, lender and credit agencies. The smart contract could engage a default servicer if default becomes a possibility after a certain number of missed payments. If repossession of property is required, the blockchain could transfer the title to the appropriate lender automatically. Immutability of the blockchain's record would allow for easier and less costly downstream due diligence. An extra benefit of this system would arise if mortgage underwriters and servicers use the blockchain's ledger instead of tapping into external data silos. A hack on the cryptographically sealed distributed ledger would require almost impossible amounts of computing power to break and alter data in the chain⁶. Investors

⁶ Denial of state (DoSt) attacks are still possible but can be prevented using state signatures, wet signatures and TEE technologies to regulate the transfer of state ownership on Corda

could make use of the blockchain's distributed ledger for their own due diligence and servicing needs. This platform would serve as a digital assistant to the mortgage officer or broker by using smart contracts and APIs to perform easy but time-consuming tasks.

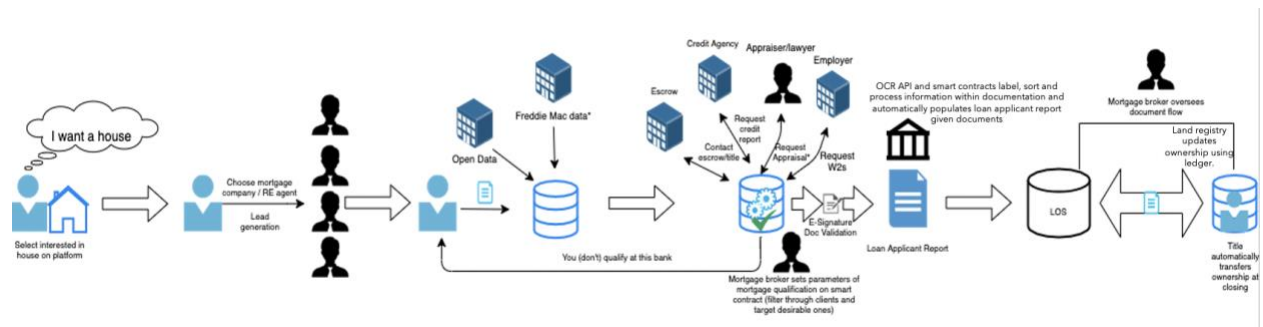


Figure 5 - A flowchart depicting the flow of a mortgage transaction on a blockchain that manages credit information verification directly, processes documents and automatically generates a loan applicant report, tailored to the bank's needs using an OCR API

Utility tokens would be useful in a blockchain application managing mortgage documentation because they could be used to grant banks and mortgage companies access to this system. These utility tokens would be an effective way to monetize a blockchain with APIs that perform mortgage information management for banks. Utility tokens are similar to tradable gift cards and pre-sold software licenses. However, the issuing of utility tokens has been under scrutiny due to the many ICO scams that have hurt investors. Many premature technologies had not been scrutinized and adopted before the ICOs, which caused many failures in the ICO market. However, if executed at the right time, a utility token ICO could help fundraise for expansion and further scrutiny of this system.

Case 3: A Land Registry: Management of uploading documents and transferring ownership

Buyers and sellers would register on a blockchain-based ownership platform by creating a profile with their name, government ID and other information. A hash, or node, with identity

information would be held in the blockchain. Sellers would upload property images and related documents onto the blockchain and mark the location of the property on a map. The property listing would then be displayed on the blockchain and available to view by all buyers on the platform. A buyer interested in the home would request access to view details on the home, which the seller can accept or deny once notified. Buyers can view the ownership history of the property, review property specifications and request to purchase the property on the blockchain. Requests, reviews, and inspections are recorded as having occurred on the blockchain to ensure traceability and security.

If the seller accepts the homebuyer's request to purchase, the smart contract releases property documentation access to the property inspector, who begins the property transfer process. A property inspection event with the buyer, seller and inspector would be recorded on the blockchain's ledger. After the land inspector verifies all documents, the blockchain would add the validated records and tie them to the property on the blockchain. The seller and buyer would use their private keys and e-signatures to sign the property transfer documents on the blockchain platform. The blockchain's ledger would display the transfer documents attached to the property transfer for relevant and trusted parties to view. Smart contracts would automatically transfer funds to the seller from their bank account using a settlement token, and the title would transfer to the buyer with a signature and click of a button. The distributed land ledger could serve as the electronic registry of deeds for the office of records for certain cities as deed documents could automatically be created and populated with information using these transactions. Of course, not all transactions will be hosted on this blockchain as already existing technologies handle real estate transactions, so APIs could be implemented to connect with these systems and communicate with data conveyors like appraisers to generate record information.

Payment integration could be established with the option to avail loans from banks, which could serve as a growing point for the technology into other realms of real estate like financing.

Currently, homebuyers in Saint Louis have no way to upload and validate documents from home to the City of Saint Louis Recorder of Deeds, which could easily be done with a blockchain through e-signatures and smart contract scrutiny of documentation that will utilize the many parties that must verify and notarize these documents. This platform would connect all conveyance players such as buyers, sellers, appraisers, attorneys, and lenders to the deeds office to allow people to send in and vet documents online. A private blockchain would be most useful for this use case because court orders may rule a reversal of a transaction, which is possible under certain circumstances in a private blockchain. It would also ensure that only permissioned parties would be able to access this ecosystem. Utility tokens should be issued to counties wanting to access the land registry platform.

Minimal Viable Product Proposal: Mortgage Assistant Platform

A Mortgage Information Processing Platform that Simplifies and Streamlines the Process for Both the Homebuyer and the Mortgage Customer

The minimal viable product should generate leads for companies while helping companies handle their customers and their information to speed up transactions. The platform would use a chatbot to engage customers and enhance customer service, asking them questions about what they want in a mortgage and answering their questions. The chatbot will feed conversational data directly into the mortgage company's customer relationship management system (CRM), allowing the mortgage agent to avoid redundancy and service the customer better. The chatbot will also save mortgage customers time by automating processes and tapping into data servers to

give quick and specific answers to customers. The chatbot will also generate more leads for customers through multiple channels like Facebook, Messenger, Slack, Skype and E-Mail on top of phone conversations. The chatbot will also operate during non-business hours to generate more leads. The chatbot can also search through MLS databases to pull up listings the buyer is interested in financing with a mortgage. Once the chatbot has acquired and serviced the customer, the platform will automatically obtain credit information from the customer and use entities like financial companies, the IRS, employers and more to verify their credit information using its distributed ledger. Then, this system will collect documents from the customer and credit information verifiers and distribute them to the bank after processing them into one loan applicant report (LAR) document using OCR, which will label and process long documents and their contents. The customer's documents and information would be cryptographically encrypted on the blockchain, which would improve banks' data protection. After this LAR is generated, the mortgage broker can use the blockchain platform to engage the customer and prepare for the origination of the mortgage on a loan origination system (LOS). Once the mortgage agent uploads the LAR onto their company's loan origination system, the mortgage process will be set in motion with complete and accurate information. The blockchain mortgage platform will eventually connect to title companies and the Saint Louis Deeds and Records' Office, where the title of the property can be transferred between the seller, buyer and bank, and ownership of the property can be recorded by the homebuyer online. This feature will resemble the third use case described in the previous section. Older customers looking to refinance their mortgage could also benefit from a platform feature that notifies them of refinancing opportunities at a bank based on their credit performance and determines whether refinancing is worth it for them. All transactions can be viewed on the blockchain's permissioned distributed ledger, which

customers can use to access real-time mortgage status, and regulators and investors can use to vet investment-grade mortgages. The documents and information that the customer uploads will be stored on this blockchain platform, allowing them to easily access and share their credit information for future loans.

Smart Contract Structure

Document transaction monitoring will be done by the first layer of smart contracts, which will ensure sensitive personal and financial information is protected. These smart contracts will check that the customer approves document transfer from the companies to the mortgage company for processing/verification. These parties can sign off on the information provided by the customer using the ledger platform, which will trigger the smart contract to add the verified information onto the customer's financial profile and scan through the documents using OCR APIs to form a LAR. The smart contract will also check that the information is necessary for the LAR, given the mortgage broker's input into the system. This platform will only need to ask the borrower for their documents once because they will be cryptographically stored on the blockchain's ledger, eliminating a problem frequently experienced by borrowers. According to the Consumer Financial Protection Bureau, "consumers complained of prolonged loss mitigation review processes in which the same documentation was repeatedly requested by their servicer" (CFPB, 2016). Smart contracts will check whether a document has already been obtained before allowing the mortgage officer or broker to request further documentation.

The second layer of smart contracts will determine if the user is interested in a mortgage, connect them to a mortgage company, and link mortgage companies to real estate they are targeting in certain communities. By linking mortgage brokers to these homes, nodes in the platform, the mortgage brokers can access this database of interested homebuyers to generate

leads. This platform will attract homebuyers because they will find desirable mortgage options, and it will be an easy way to consolidate all their documents electronically. These customers could use their documents for other uses, including healthcare and education. This platform could be a Facebook for your personal information and documents, which somebody could share securely with certain parties that need to see, sign and verify your documents. These parties can silo that data for themselves if they need to construct customer or even patient databases. While use cases in other industries would take time to adopt and expand into, this technology could grow into these spaces, using the underlying technology. People fear their information and documents sent over email being compromised if their email gets hacked or misused. Smart contracts and cryptography can check more than what you know to verify you are who you are.

The third layer of the smart contracts will check to see that all information verifiers such as employers, credit agencies, financial companies, regulators, ect. have verified that the information provided by the mortgage customer is true. The National Bureau of Economic Research published a paper explaining that blockchain technology has “the ability to cheaply verify state with economic incentives targeted at rewarding state transitions that are particularly valuable from a network perspective” (Catalini, 2016). This verification process will ensure that the information in the loan application report is accurate before it gets uploaded onto the LOS and passed down to different employees that pre-approve, underwrite, service and close the loan. The mortgage brokers can program the smart contracts to approve their customers for a mortgage if they want to write algorithmic checks into the system, but this may be a redundancy with the bank’s LOS, depending on the bank. This layer of smart contracts will also check that the relevant parties have signed off and approved documents before they are uploaded to land registries for a deed and title filing after the transaction has been completed. The smart contracts

will also check that sufficient information has been provided and whether the information meets the requirements to file for ownership of a home and record the deed online. This layer of smart contracts will ensure all previous steps needed to be completed have been completed before new stages of the transaction are accessible. The notarization of the transactions will handle this step pretty well using platforms like Corda's built in transaction verification system through notaries.

Conclusion

Cryptocurrencies are growing significantly in many parts of the world such as China where their digital currency was released in 2020 (Yeung, 2020). Cryptocurrency platforms for real estate purchases and crypto-lending could be developed to create a commercial infrastructure surrounding the digital Yuan and future blockchain-based central bank currencies. However, the adoption of the digital Yuan and cryptocurrency in other areas of the world is still in its early stages. Until cryptocurrency sees more widespread adoption and acceptance by central banks, especially the United States', a crypto-based blockchain platform for real estate will not be suitable as a business venture and is outside the scope of this paper. Blockchain can serve as a settlement system for funds supported by real currency until the day arrives when currency is digital, if that day ever comes. Traditional banks should work diligently to ensure they are prepared for a time when currency is digital and commercial processes can be partially managed by technologies like blockchain, or they may risk becoming obsolete.

Blockchain and related technologies have lots of potential to innovate real estate transactions and real estate financing because they can streamline and consolidate workflows, automate time-consuming tasks and create a more transparent and efficient economic system. While there are regulatory and systematic hurdles to go through before adoption, the progress that R3 Corda has made in integrating the blockchain into financial systems stands as a testament

to the integrability of blockchain into payment and lending technologies. The fact that the technology is based on Java-based coding language Kotlin as opposed to Go, makes it much more fitting and interoperable with current banking technology (R3). There has been lots of talk and hype around blockchain, but more work by people like R3 needs to be done to fully realize the potential of new technologies like blockchain in the banking system. For the use cases described in this paper, handling mortgage documents seems the most pressing issue needed to be solved in the real estate ecosystem. A Corda application hosted on Amazon Web Services should be created to service the issues in the mortgage industry then grow down the real estate transaction timeline to service other aspects of real estate transactions like ownership recording and the transaction itself. This application can also grow into other industries by hosting other documents needed in customer-company relationships. Interoperability with loan origination systems will be key for this technology to ensure smooth implementation into banking systems. To achieve the goal of growing the parties involved and realizing the network externality advantages, this blockchain should be as easy to implement as possible. Banks simply should be able to login and connect their LOSs through APIs to the blockchain platform. Knowledgeable computer engineers and developers will be needed to develop this real estate ecosystem, and partnerships will need to be formed with other technology companies to ensure stability. Further research should be conducted on how feasible each of these use cases is by authors with more industry background. This research is limited to consumer and mortgage company willingness to adopt blockchain technology systems and impact of this technology on the mortgage and real estate industries.

Many countries like Sweden are pursuing blockchain applications backed by governments to enhance their economy's productivity; India implemented blockchain technology

into its national land registry six months ago (Ledger Insights, 2019). The United States is a force in the integration of blockchain into commercial processes with IBM's highly popular Hyperledger platform used around the world. While the United States has been instrumental in developing the blockchain technology itself, it has lagged many other countries in adoption and realization of the technology's benefits. In a ranking of blockchain development and adoption by The Blockchain Council, the United States ranked seventh in the world (Sharma, 2019). The United States is arguably the epicenter of technology in the world and possesses some of the most popular enterprise blockchain systems in the world, yet it is behind a lot of countries in this area. In industries like financial services, companies say they are developing blockchain systems and integrating them, but many of these systems are proofs of concept to generate publicity (Floyd, 2020). There has been lots of discussion about blockchain that has generated hype around the technology, but pilot projects and academic papers are just the start of this new technology in the U.S because eventually a handful of banks will be brave enough to implement this technology as it improves.

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Appendix (Interviews with Players in the Mortgage and Real Estate Industries):

Guild Mortgage

We interviewed a mortgage broker at Cornerstone Mortgage in Saint Louis, who now works for Guild Mortgage, a large mortgage lender, after its acquisition of Cornerstone.

The stresses in the mortgage process seemed to be most prevalent in the beginning stages of the mortgage during document collection and uploading onto their LOS. According to him, property inspection, document collection, verification and pre-approval were among the longest and most difficult tasks within his bank's mortgage workflow. He said that they have to verify lots of credit information from disconnected parties. The problem with the property inspection rests in getting the inspection done as early as possible and pushing the inspector to be efficient. Their company has hired someone to physically read through, label, organize and process all the documentation onto their loan origination system after they call and email to verify the credit information provided. He felt that this process could be much improved using technology. The loan applicant report that gets produced from this process by an employee is uploaded to the LOS controlled by Freddie Mac and Mae, which determines mortgage eligibility regardless of accuracy of the information. One topic of discussion in our conversation was how non-banks have gained so much traction in the lending space. He claimed that younger people want things quicker, which new banking technologies like Quicken Loans provide. However, efficiency can sometimes compromise accuracy and quality of lending processes. Based on his input, Quicken

Loans does little to verify the borrower information in order to give them the fastest pre-approval, which is why many brokers and agents do not trust Quicken Loans and will not accept their pre-approval.

Questions

What do you do to get leads on potential mortgage customers? Is it the company's responsibility or do you actively seek out customers?

Answer: A good loan officer will develop a network of good referral sources (real estate agents, financial advisors, insurance agents, lawyers) and a database. I farm my database on a weekly basis and help realtors with theirs. It's a crm system through Salesforce. Tracks everything that has to do with each specific client and their deal. It ties into the market and rates and lets us know when people could refinance, lets us know their bdays and anniversaries.

What does the process of uploading documents to the LOS look like (are there forms you must fill out and do customers submit documents electronically)?

Answer: You click a button that says upload and attach a picture or pdf

How do you gain access to Freddie Mac and Fannie Mae's data and is this data available to the industry (or individual companies)?

Answer: Companies have to be granted access to use their automated underwriting systems.

How involved in pre-approval are the LOS systems?

Answer: Very involved. You have to input the application into the los system and then submit it to Fannie and Freddie*.

Golden Oak Lending

We interviewed an IT manager at Golden Oak Lending on how blockchain can improve mortgage lending. Golden Oak Lending is a large Midwestern mortgage company that spends

lots of time on technology and advertising. He believed that many processes were time consuming in the mortgage processes due to inefficiencies but also government mandated waiting periods. He also mentioned that refinancing calls could be a task completed by automation through smart contracts. He mentioned that current companies use technologies like Work Number and Blend to verify credit information, but these technologies are pricey and create privacy concerns. He said customers often feel uneasy about a technology directly tapping into their personal and financial information. These technologies pull the information from credit verifiers instead of allowing these credit verifiers to simply check that the information given by the borrowers is accurate. He also mentioned the inefficient process of having to Google companies that their borrowers work for to check that they actually do work for them. A blockchain technology that employers and mortgage companies are connected on could easily check this information automatically because employers could see that the borrower claimed to work for them on the distributed ledger.

Towards the end of the interview, he said that Golden Oak and many mortgage companies were looking for a service or technology that would organize, label and process the extensive PDF documents of credit and personal information. Currently, he said that some companies send these long documents to people in other countries that read through the documents, organize them and pull relevant information for the loan applicant report. This practice is a privacy concern for borrowers whose personal and financial information is accessible to random people working at these foreign document processing companies. An OCR API could easily parse through, organize and pull information from these documents for easy upload onto the loan applicant report that the loan origination system handles. He mentioned this very technology in the interview and said this would be a very lucrative way to help the mortgage industry improve

its efficiency. He said that many mortgage companies need a way to identify documents based on OCR and break it down. This theme is consistent with our interview with Guild Mortgage that claimed they had to hire individuals to finger through these documents, organize them and upload their information onto a loan applicant report.

Saint Louis Recorder and Deeds Office

We met with the IT director of the Saint Louis Recorder's Office, who gave valuable insight on how property ownership is recorded in Saint Louis. One clear distinction he made was that the assessor's office handles the actual transfer of ownership of real estate in Saint Louis and most cities, not the recorder's office, so they will be a party that will be important to bring into this real estate ecosystem. The records office has all real estate records since the mid 1970s digitized, meeting a key prerequisite for blockchain adoption. Homebuyers can currently log on and view documents online, but, according to him, people have no way of uploading and filing documents online, a real problem especially during the COVID-19 pandemic. People have to go to a submitting company office and file the documents in person due to lack of technology infrastructure. Banks and offices have to send documents through a recording company often to file their deeds. In explaining how the current system worked, he said that the recorder office works with everyone on the conveyance side of real estate transactions such as buyers, sellers, attorneys, appraisers and lenders in recording property ownership. Their office currently has to communicate with all these parties via email and transact documents in person before uploading the documents onto a recording system. Putting all these parties on one system where they can electronically share documents and automate the document checking process would be highly beneficial. He said his office would like a technology that allows parties to file deeds for real estate from home because it would be easier, quicker and safer during epidemics. Linking the

assessor's office with the recorder's office for them to approve and check property transactions would allow smart contracts to automatically file these deeds after title transfer.

Saint Louis Real Estate Society

We interviewed a co-owner and real estate broker from Saint Louis Real Estate Society, which is a boutique real estate brokerage with 25 years of industry experience. The questions asked targeted their technology, transactions and interaction with other entities involved in real estate transactions. This interview tried to pinpoint inefficiencies in real estate transactions that blockchain was suitable to solve. The responses indicated the real estate industry is very digitized, but communication and interaction between parties is often difficult and automation is present but has not realized its full potential, perhaps due to transaction complexity.

Questions

Where do you see the most inefficiency in the home-buying process?

Answer: There are lots of different people involved in the home-buying process... buyer, seller, real estate agents, lender, title companies, inspectors, etc... Often times the communication among these parties is lacking so I would say that is the biggest inefficiency which is closely followed by poor training.

On a scale of 1-10 how automated is the home buying process by technology?

Answer: I would say that we are at an 8. That number has increased dramatically over the last 10 years. Our office (even as tiny as we are) was one of the first brokerages in St. Louis to adopt the electronic signature technology for our contract paperwork. This was back in early 2011. Those first few years were tough as many offices didn't want to accept digital signatures on paperwork even though the federal government had passed legislation saying that they were acceptable (I think this happened in 2006 but I'm not sure on that). We were constantly having to educate our

fellow Realtors and it was an uphill battle. Fast forward to today and you hardly see wet signatures anymore. It's almost all digital. Our office was also an early adopter of being fully digital in our record keeping. We had to go through a lot with the MREC in order to make sure we were in compliance and based on that, I'd say that we were also only among a small group of offices that were doing that in the State at that time. This was in 2014.

How do you transact documents and information with other intermediaries? Do you use email and phone? Or is there a technological platform where this information is exchanged?

Answer: I don't think real estate is much different than any other offices doing business nowadays. We use all sorts of technology and software. Certainly, email and phone are still a large part of what we do. As far as a technological platform where information is exchanged, there can be but there are so many different products out there that many agents/ offices use different ones.