Funds Routing System: an accountable fund allocation mechanism

Research Project

MSc in Fintech

Rodolfo José Monsberger
Student ID: x18175457

School of Computing
National College of Ireland

Supervisor: Victor del Rosal

National College of Ireland

MSc Project Submission Sheet

School of Computing

Student Name: Rodolfo José Monsberger

Student ID: X18175457

Programme: MSc. in Fintech **Year:** 2020

Module: MSc. Research Project

Supervisor: Victor del Rosal

Submission Due Date: 17th August 2020

Project Title: Funds Routing System: an accountable fund allocation mechanism

Word Count: 6058 words **Page Count:** 20 pages

I hereby certify that the information contained in this (my submission) is information pertaining to research I conducted for this project. All information other than my own contribution will be fully referenced and listed in the relevant bibliography section at the rear of the project.

ALL internet material must be referenced in the bibliography section. Students are required to use the Referencing Standard specified in the report template. To use other author's written or electronic work is illegal (plagiarism) and may result in disciplinary action.

Signature:

Date: 17th August 2020

PLEASE READ THE FOLLOWING INSTRUCTIONS AND CHECKLIST

Attach a completed copy of this sheet to each project (including multiple copies)	□
Attach a Moodle submission receipt of the online project submission, to each project (including multiple copies).	□
You must ensure that you retain a HARD COPY of the project, both for your own reference and in case a project is lost or mislaid. It is not sufficient to keep a copy on computer.	□

Assignments that are submitted to the Programme Coordinator Office must be placed into the assignment box located outside the office.

Office Use Only	
Signature:	
Date:	
Penalty Applied (if applicable):	

Funds Routing System: an accountable fund allocation mechanism

Rodolfo José Monsberger
X18175457

Abstract

Agency problems have been subject of analysis in recent decades and continue to represent a challenge from an academic and technological point of view when it comes to finding potential solutions able to decrease information asymmetries. Lack of transparency and information generates mistrust and alters risk perceptions. These are dissuasive factors for business which can also derive in resources misallocation and assets mispricing. On the other hand, blockchain technology eliminates intermediaries, verification procedures, and reconciliations. It also provides a single version of transactional history broadcasted in real-time to all interested stakeholders and thereby reducing information gaps. The current study aims at examining whether blockchain technology and smart contracts help reduce credit risk by providing greater accountability regarding funds allocation. To this end, a Funds Routing System (FRS) was designed based on an escrow mechanism which exploits main advantages of this new technology. The first prototype proves to ensure targeted funds allocation and simultaneous information sharing among stakeholders. Main findings show FRS is a particularly useful tool for donors, investors, lenders, or any entity transferring funds to a third party which has great discretionary power in terms of funds management. In addition, its flexible and simple architecture foresees a user-friendly interface able to operate with different platforms and applicable in different economic sectors. It represents a window of opportunity for complementary developments which can provide a more comprehensive approach for other dysfunctional factors and market failures explained in the agency theory, such as adverse selection.

1 Introduction

The principal-agent problem has been a field of study for the last few decades since Ross and Mitnick defined the agency theory in the 1970s (Mitnick, 2019). Credit business represents a typical agency problem where the lender immediately fulfils the transfer of an agreed amount of money to the borrower, who commits to deferred payments plus interest in one or several instalments. If the principal had some concerns or mistrust about the use of funds, a monitoring system that makes funds allocation accountable would be helpful to reduce the associated credit risk. The principal-agent problem is causally related to information asymmetries in terms of objectives and risk perceptions of each party (Eisenhardt, 1989). Lack of information undermines trust, and consequently, it may dissuade parties from closing a deal. If they do close it, different

objectives and risks tolerance may lead the principal to reduce the required amounts to be transferred or to overvalue the assets prices the agent must pay. In any case, it is not an optimal outcome.

Blockchain (BC) and Smart Contracts represent game-changer technologies that can help reduce information asymmetries and make processes more efficient and transparent. BC, once defined by The Economist as a "trust machine"[1], eliminates intermediaries, multiple data storage, and transaction reconciliation between different parties. A single and agreed version of records, encryption, transparent consensus mechanism and smart contract with coded business logic represent unique BC technology features.

This study aims at developing a Funds Routing System (FRS) based on smart contracts (SC) and distributed ledger technology (DLT) able to verify transactions and broadcast them in real-time to all counterparties, at a lower cost, with greater security and accountability. The research question (RQ) is the following:

RQ: *How can distributed ledger technology and smart contracts route funds, increase accountability, and reduce credit risk?*

Although the credit business is the primary research and application area of this study, the basic operational principles can be replicable to different sectors in which agency problems arise, even in everyday situations. From this angle, the current study lays the foundations of a system which can be adapted to different commercial and private scenarios (B2B and B2C) with multiple purposes.

Following this introduction, a literature survey encompasses descriptive and prescriptive research methodology (Gregor & Hevner, 2013). Descriptive research focuses on analysing BC technology and agency theory. Blockchain section explains the fundamentals of the distributed ledger technology. Agency theory section provides examples of different transactions and economic sectors that face information asymmetries to visualize its wide field of application. Besides, the prescriptive research presents a systematic review of existing studies or methodologies applying BC and SC in the credit business sector. The Design Science Research (DSR) is explained in the research methodology section, along with the main reasons for its selection. The design specification section shows the technical architecture based on SC and DLT together with the main components and interaction between stakeholders. The main outputs of the FRS developed in solidity language is displayed as a prototype with its critical features. The evaluation section compares and assesses FRS's main characteristics with similar artefacts and proof of concepts presented in Table 1 (prescriptive research). Finally, main conclusions and further research are presented.

[1] https://www.economist.com/leaders/2015/10/31/the-trust-machine

2 Related Work

2.1 Descriptive research

2.1.1 Distributed ledger Technology and Smart Contract

"*The network is robust in its unstructured simplicity. Nodes work all at once with little coordination*" (Nakamoto, 2008)

Satoshi Nakamoto's quote from his famous paper published in 2008, summarises most BC technology attributes which support Bitcoin and many developments implemented in recent years. BC is a ubiquitous and decentralised storage network which provides a unique and immutable transactions record with chronologically encrypted blocks replicated in real-time at each node. Smart contracts, on the other hand, contains the logical programming layer which enables processes automation with self-executing codes that are activated when certain conditions are met. Finally, tokens can be created to perform as transferable assets or rights such as currencies, loyalty points, voting rights, or any fungible or negotiable asset. All three elements combined provide a powerful tool able to bypass intermediaries or trusted third parties in charge of validating any transactions (Patel, et al., 2017).

The absence of intermediaries and the existence of a single ledger of records, which is shared among the different counterparties, eliminates duplication and reconciliation checks, reduces processing times and its associated costs, and consequently increases transparency. Although Blockchain and Distributed ledger Technology are used indistinctly, they are not the same. Blockchain is a public distributed ledger created specifically to coin tokens called Bitcoins in a decentralized manner using Proof of Work as consensus mechanisms. On the other hand, DLT scope of application is broader than BC. It can be public, federative, or private[2] and can use different consensus mechanisms such as Proof of Stake (PoS), Proof of Elapsed Time (PoET), Proof of Work (PoW), among others. For simplicity sake, only PoW or PoS will be explained with the concept of consensus mechanism:

- Consensus mechanism: it refers to the process of achieving an agreed decision among all network nodes to validate transactions of a block.
- Proof of Work: it is a consensus mechanism based on a competition among miners to solve a mathematical calculation or computational puzzle. Its solution is achieved by trial and

[2] Please check meaning at https://www.researchgate.net/figure/Differences-between-public-private-and-federated-blockchain_tbl1_329882609

error with computational brute force. The first miner able to solve it, is awarded tokens or cryptocurrencies.

- Proof of Stakes: it is a consensus mechanism based on stake or participation in the total number of tokens released. A miner holding 3% of tokens issued will have the right to mine only 3% of the transactions. By eliminating competition to solve the same computational puzzle among many miners distributed in the network, resources can be spared, especially electric power.

However, the virtues and benefits of DLT and SC have been exaggerated and not all that is said is entirely accurate. DLT and SC do also have limitations and cannot magically solve everything. Some of these myths are the following (Hileman & Rauchs., 2017):

- "DLT and SC do not require any trusted third party to validate transactions": This is only true for permissionless DLT. However, permissioned DLT requires an operator or validator. The right configuration can minimize mistrust.
- "DLT and SC are a truth machine": like all coding and programming, if incorrect data is entered, the output is also incorrect.
- "DLT and SC provide an immutable record of transactions": There is a possibility of reversing transactions if 51% of the nodes collude. In well-atomized networks it is improbable, but doubts arise in permissioned DLT. Contracts and rules among stakeholders are fundamental in permissioned DLT to discourage misbehaviour and potential collusions.
- "DLT and SC enable fiat currency payments": a SC cannot make any payment in fiat currency. This will only be possible if some representation of fiat currency is put onto a DLT[3].

2.1.2 Agency theory and information asymmetries

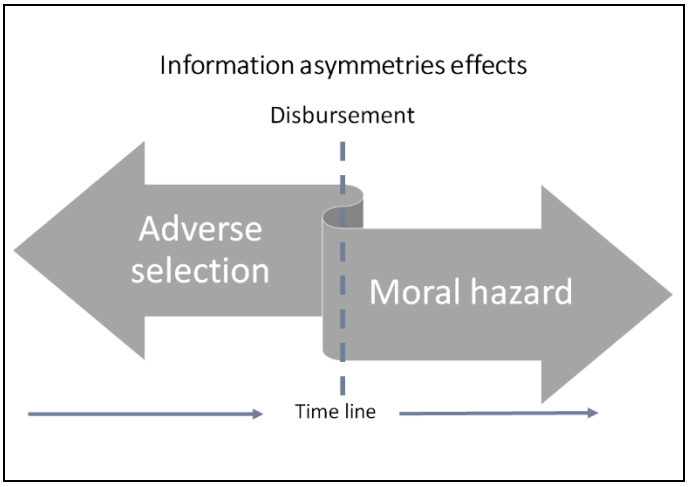
The principal-agent model is critical to understanding the type of risks and information gaps FRS can help reduce. The moment the principal grants the agent an asset or right it represents a threshold, which marks an ex-ante and ex-post scenario according to the agency theory. This scenario applies to multiple real-life situations. In order to clarify how FRS's applications might work, the lender-borrower agency problem is addressed.

A loan disbursement represents a dividing point or threshold (see figure 1), with two different effects in terms of information asymmetries: i) *the adverse selection effect* (before disbursement) and ii) *the moral hazard effect* (after disbursement) (Claus & Grimes, 2003). Adverse selection refers to the fact that bad borrowers or those with riskier projects act more decisively or aggressively to get a loan and therefore, are ready to pay higher interest rates. In that way, the

[3] https://bitsonblocks.net/; Three common misconceptions about smart contracts.

interest rate serves lenders as a screening device to classify good borrowers from bad ones. Borrowers' real intentions and risk tolerance are exposed, and consequently, those who accept higher interest rates should not be the top candidates in lenders' shortlist. Yet, once the loan is disbursed "moral hazard" arises. Debtors could engage in riskier businesses or make decisions that may affect their capacity to repay the loan; for example, by deviating funds to purposes not considered in the original investment plan.

Figure 1



Own source

Hence, adverse selection and moral hazard undermine the trust that should prevail in business relationships, with two possible negative outcomes: i) lenders or financial institutions get discouraged from continuing with the transaction, or ii) they continue but charging a premium that compensates for the higher risk or lack of information, plus extra expenses for monitoring borrowers' actions after disbursement.

These extra charges will ultimately increase interest rates. In the later, if some borrowers are still willing to take the loan and lenders approve it, the higher interest rate will decrease borrowers' payment capacity. Therefore, financial intermediaries will prefer to reduce loan amount to avoid moral hazard caused by higher interest rates (Stiglitz & Weiss, 1998) (Jeffee & Russell, 1976).

Yet, objectives and risk alignment can be achieved through two approaches according to agency theory. First, *incentive systems* can positively influence agents' objectives and risk perception. This approach is appropriate for the adverse selection effect. Second, moral hazard can be better controlled by implementing appropriate *information systems* able to monitor the agents' actions and their potential misbehaviour. Both systems have a cost. In certain contexts, it is advisable and cheaper to apply an information system, while in other situations incentive systems are more appropriate (Eisenhardt, 1989). Incentive systems can be implemented by improving the product or service attributes. Another form of incentive is to offer access to new lines of financing on better terms when the previous debt has been timely cancelled. In other words, credit history works as an incentive system to keep financing lines open. Finally, information system improvement refers to monitoring systems as the one FRS proposes, a system able to track and route loans while broadcasting transaction status in real-time to the different stakeholders. The following three sections show some of the sectors or types of transactions where the FRS could be implemented in.

2.1.2.1 Microcredit

An extreme and very representative case of the agency theory occurs in the microcredit sector where borrowers have no stable income, no accounting information, no credit records, and no significant assets to serve as collateral. The great financial vulnerability of the microentrepreneur, along with little information they can provide, expose microfinance institutions (MFIs) to greater risk than other financial institutions. Therefore, the microcredit sector is challenging in terms of information asymmetries which hamper financial inclusion.

Microloans are intended to finance productive activities, i.e. working capital or fixed assets, to self-employed people or microentrepreneurs (up to 5 employees) that belong to the informal economy, with no collateral (to seize) or regular cashflows. However, criticism surrounding microcredit addresses the fact that most of the funds are spent on consumption rather than invested in their microenterprises. (McGough, 2010) (Nghiem, et al., 2012) (Awaworyi, 2014). In contrast, other studies stress the benefits of microloans as consumption smoothing mechanism and as valuable support to finance a variety of purposes such as education, healthcare and as risk-coping tool for all kinds of contingencies microentrepreneurs and their families face (Rosenberg, 2010) (Karlan, et al., 2016).

Yet, regardless of the controversies surrounding the real impact of microloans, the objective of this paper is to provide a new tool for organizations, practitioners, donors and funders which can cope with the sector challenges regarding accountability and transparency of funds allocation. Indeed, without accountability in terms of funds allocation, it will be difficult to measure the true impact of billions of dollars flowing to the sector. Additionally, if funders' objective is to enforce the loan allocation to specific activities or purposes, FRS can also prevent both MFIs and borrowers from diverting the use of funds to non-agreed destinations according to investors wish and policies; and consequently ensuring social investors' missions. Finally, accountability and targeted loan allocation will assuage many of the criticisms microcredit sector has faced for years.

2.1.2.2 Crowdfunding

The collective financing of new ideas and business, art, music, and charity projects is a successful model which has positioned itself in financial markets in the last 15 years. Crowdfunding has evolved since its inception and today it encompasses new financing alternatives such as lending-based, equity-based, donation-based, and reward-based crowdfunding. Nevertheless, crowdfunding platforms have little to offer to investors, donors, and lenders in terms of accountability and certainty of funds allocation.

Although crowdfunding platforms have disrupted traditional financial intermediation with lower costs and regulation requirements, information asymmetry problems inherent to any financial transaction persist. In this regard, crowdfunding does not offer any disruption at all and can be considered one more intermediary in the financial sector (Cai, 2018). According to Lukkarinen (Lukkarinen, et al., 2016), it increases information asymmetries because individual investors and donors are less prepared than banks and venture funders to assess creditworthiness. As reward-based crowdfunding is the least risky of the four formats (it is just an online purchase for a small amount of money with reciprocal and immediate compensation), FRS would not be suitable for this crowdfunding version. In contrast, equity, lending, and donation-based crowdfunding face greater information asymmetries with unilateral and immediate fulfilment of funders' obligations and postponed compliance of the beneficiaries' obligations. Donors, lenders, and investors require assurance that funds are used for the purposes stated during the original fundraising campaign. Furthermore, FRS will force beneficiaries to better prepare their investments plans, and by doing so, to increase their projects' success probabilities.

2.1.2.3 ICOs

ICOs (Initial Coin Offers) also seem to suffer from lack of transparency and accountability. ICOs use DLT technology to coin tokens, a kind of security which represents a variety of rights such as a licence to use a software, a membership to a community, financial assets in a start-up and the proportional participation in cash flows these assets and projects could generate, among others (Zetzsche, et al., 2017). From this viewpoint, ICOs represent a new paradigm that competes with traditional stock markets IPOs (Initial Public Offers). However, the sector has faced some concern and criticism after frauds and cyber-attacks made many projects vanish as well as funds collected.

Two problems undermine the ICO market. On the one hand, security issues (insecure data transfer or storage, fake back-ends, etc.) has been exploited to sabotage the systems or subtract the funds provided in cryptocurrencies (Divyashree, 2019). On the other hand, information asymmetries are overwhelming. An ICO is usually promoted with a white paper publication where in principle all technical, operational, and financial aspects should be explained. A study carried out by Zetzsche (Zetzsche, et al., 2017) shows almost 25% of the promotional white papers did not mention the purpose and destination of the funds collected. Additionally, the same ICOs were scrutinized after the collection process finished, and nearly 45% of them did not report how much money was collected and, thus, neither gave any information about the investment made.

Since ICOs success depends on quantitative and qualitative information white papers inform, such as detail budgets, bonding systems, and a clear explanation of the project goal (Howell, et al., 2019), FRS could ensure predictability of funds allocation and accountability about management decisions.

2.2 Prescriptive research

In line with the previous literature review, this section complements the analysis of related papers and developments that have contributed to clarifying how DLT's and SC's applications can improve loan processes. To this end, Table 1 evaluates the most relevant DLT application in the credit business sector from a technical point of view. Each paper and prototype will be analysed in more detail in the "Evaluation" section comparing and assessing their main contributions in relation to FRS main attributes.

Table 1

Alternative devises: Papers, proof of concepts, and similar developments using distributed ledger technologies and smart contracts to improve loan management processes and systems

Paper	Main objective	Evaluation	Permission / Permissionless Distributed ledger	Smart contract platform	Token	Consensus mechanism	Other technologies used
LoC: Poverty Alleviation Loan Management System based on Smart Contracts (Guo, et al., 2018)	To improve the Chinese government's poverty alleviation programme by increasing transparency and efficiency of the credit management system. Shared information among stakeholders should reduce delays and frauds as well as improve regulator compliance	Ex ante evaluation, Code development: YES	Permissioned DL	Hyperledger Fabric		Proof of stake	Digital signature and Oracle are used to ensure data privacy and loan assets security.
Re-inventing PTPTN Study Loan With Blockchain (Gazali, et al., 2017)	Reengineering of the current student loans management system in Malaysia. The proposal provides accountability about student progress and a distributed ledger with future employers to discount loan instalments from roll payments	Ex ante evaluation: proof of concept Code development: NO		Ethereum Virtual Machine			
Blockchain and business model innovation: Designing a P2P mortgage lending system *(Henriquez, et al., 2019)*	To create a prototype of a mortgage lending system able to work in P2P crowdlending platforms. The new business model addresses problems related to mortgage ownership as well as information and financial flows between lenders and borrowers	Ex ante evaluation: proof of concept Code development: NO	Permissioned DL	Ethereum Virtual Machine	Combination of fiat and cryptocurrency fixed at a specific exchange rate	Not mentioned. PoS is a possible consensus mechanism since it is based on a permissioned DL	Artificial Intelligence (AI) and Artificial Neuronal Networks (ANN) for credit risk assessment. InterPlanetary File System (IPFS) for paper documents storage. Special purpose vehicles (SPV) should hold the mortgage-slices
Improving the Process of Lending, Monitoring and Evaluating through Blockchain Technologies *(Arantes, et al., 2018)*	To improve lending procedures by implementing a loan tracking system in Brazilian Development Bank (BNDES) that ensures the appropriate use of public funds, reduce funds misuse and audit costs	Ex ante evaluation: proof of concept Code development: NO	Permissionless DL	Ethereum Virtual Machine	BNDES token, a digital representation of the official fiat currency - the Real	Not mentioned, however Proof of Work (PoW) is implicitly defined as a permissionless Ethereum blockchain is used as infrastructure	
Blockchain for Microlending: Towards a Solution for Poverty Reduction and Financial Inclusion of the Underprivileged Through Transparency and Auditability *(Turkiewics & Marinescu, 2019)*	To increase transparency, security and auditability in the microfinance sector, with the main focus on information sharing related to funds destination between investors and MFIs. DLT and SC reduce information asymmetries and improve financial inclusion	Ex ante evaluation: proof of concept Code development: NO	Permissioned DL	Agnostic framework approach, however Ethereum is mentioned as one plausible solution	Creation of an own security token that represents a fiat currency	Proof of Authority (PoA) or Proof of Publication (PoP)	Crypto ATM also called BTM where borrowers can retrieve fiat currency
Blockchain-driven supply chain finance: Toward a conceptual framework from a buyer perspective *(Omrana, et al., 2017)*	To optimise working capital by means of reverse factoring. Reverse factoring is similar to FRS from process but not from objective and initiator perspective. The buyer (borrower) is the initiator (not the financial institution) who asks a bank to advance payment to their suppliers but postpone own payments. The bank closes the financing gap between buyer and seller (supplier)	Ex ante evaluation: proof of concept Code development: NO		Agnostic framework approach			

Own source

3 Research Methodology

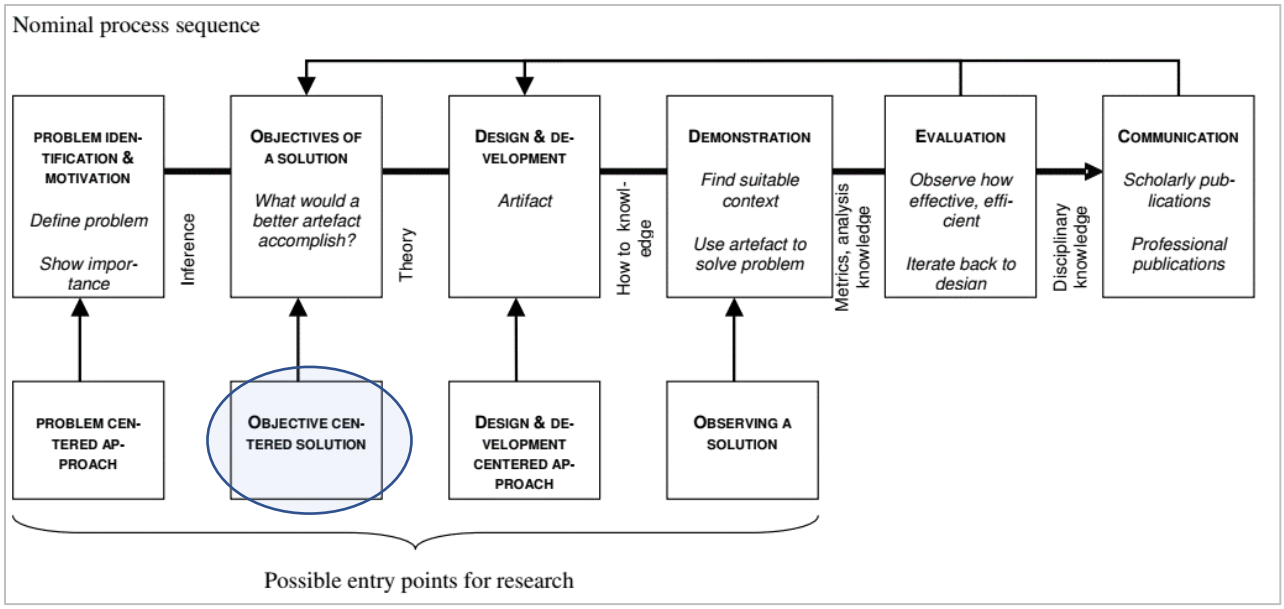
Every research process follows the next logical sequence: definition of the problem, hypothesis, analysis, and argumentation based on results. This process should fulfil specific requirements.

According to Wilson (Wilson, 2002) research needs to answer three important questions: i) is it interesting? ii) is it true? iii) is it new? The first question is the most critical since an uninteresting topic automatically disregards the second and third questions. Finally, the foremost criterion and essence of the research process is knowledge generation which serves as a theoretical framework for the benefit of the scientific community and practitioners (D. Straub & Evaristo, 1994).

Information System is an applied discipline whose utmost goal is to facilitate and make more efficient how people solve problems in organizational environments (Nunamaker, et al., 1990). Hence, different stakeholders' views, mainly from practitioners and end-users, should be considered in a dynamic testing process based on trial and error. Agile Methodology (Highsmith & M. Fowler, 2001), and Action Design Research (ADR) (Sein, et al., 2011) are in line with this dynamic approach, whose primary goal is to optimize time and avoid the development of an obsolete product from its genesis. Unfortunately, although Agile or ADR seems to be the most appropriate methodologies, they were disregarded in view of the current project scope and time restriction.

Under these constraints, DSR (Design Science Research) is one of the information system methodologies which best suits needs of this study. DSR follows next steps: i) Problem identification and motivation, ii) Objective of a solution, iii) Design and development, iv) Demonstration, v) Evaluation, vi) Communication (Gregor & Hevner, 2013). It is a nominal order which does not necessarily need to be strictly followed. Research can start at any step irrespective of the numbering (Peffers, et al., 2006). Given the fact, practitioners usually have valuable field experience and practical solutions, this flexible approach is very convenient since the development of an artefact could trigger different entry points as figure 2 shows.

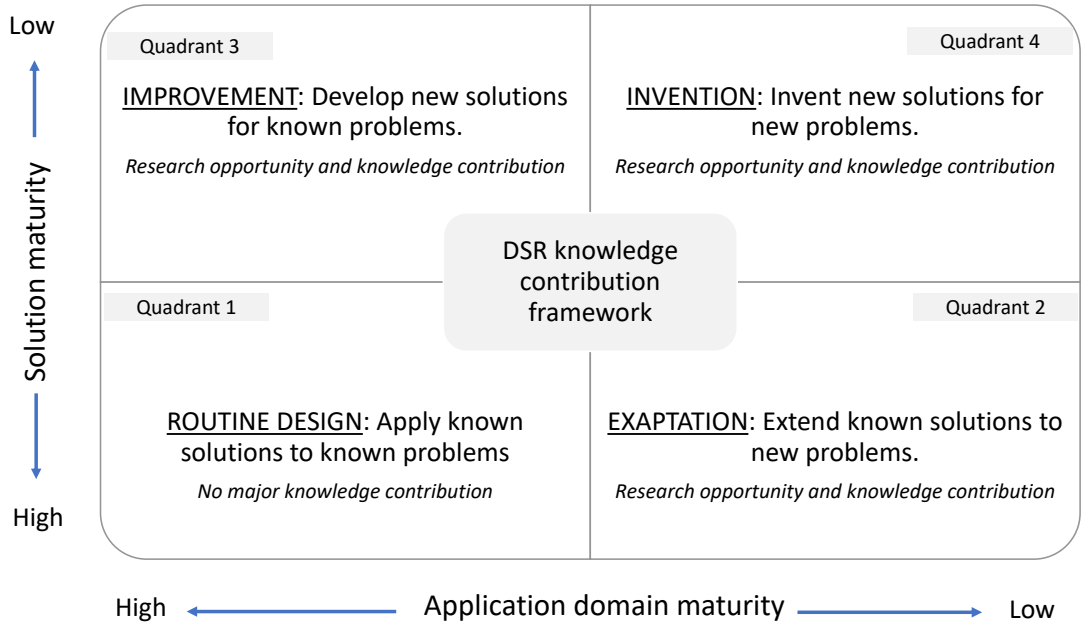
Figure 2 – DSR Research Methodology



Source: adapted from (Peffers, et al., 2006)

Thus, practitioners know-how and field experience, called *justificatory knowledge*, is a central component of the DSR (Gregor & Hevner, 2013). It represents a cornerstone to this paper's writer, who has a long record in the microfinance sector. Most of his experience in dealing with misallocation of microloans funds has provided insight to different sections of this paper. This research entry point is marked in the second step of DSR (see figure 2), because the problem is well-known, and the solution emerged after exploring BC technology benefits. Subsequently, a field of study transition took place during the research process. The original objective, with a special focus on microloans, was gradually broadened after conducting a comprehensive literature review which covered descriptive and prescriptive research (Gregor & Hevner, 2013). Descriptive research comprehends justificatory theories and related research domains. Prescriptive research refers to identifying artefacts, proof of concepts and design theories previously used to solve similar problems, as shown in Table 1.The agency theory provides theoretical framework on which FRS's applicability in other sectors and transactions types is based on, such as crowdfunding, and ICOs. Thus, Wilson's first question (is it interesting?) is answered by showing information asymmetry is a widespread problem in different sectors, and the proposed device could optimise resource allocation and asset pricing in different domains. Next, the underlying system architecture is presented in the "Design Specification" section. Wilson's second question (is it true?) is answered with the prototype results in "Implementation" section, which represents the core processes of the entire architecture. The "Evaluation" section shows Table 2 listing FRS attributes which serve as a benchmark to be compared with other devices. Finally, FRS's contributions in terms of solution and domain maturity are analysed using "DSR knowledge contribution framework" illustrated in Figure 3, which answered Wilson's third question (is it new?). FRS can be located in quadrant 3 - improvement - as will be explained hereafter.

Figure 3 - DSR knowledge contribution framework



Source: adapted from (Gregor & Hevner, 2013)

The DSR knowledge contribution framework consists of a graphical representation of solution and domain maturity. Exaptation (quadrant 2) represents an artefact used in one specific field which is adapted and implemented in another field. New solutions applied to well-known problems is an improvement (quadrant 3). New solutions for new problems represent the biggest challenge (quadrant 4); generally, they derive in an invention, a radical breakthrough or game-changer, for instance, 2008 S. Nakamoto's paper which introduced bitcoin and blockchain technology. Conversely, known solutions for known problems (quadrant 1) leave no scope for knowledge development since there are no contributions at all.

4 Design Specification

The main DLT's advantage is information sharing among multiple counterparts involved or interested in a transaction. This is executed in real-time with a single ledger, avoiding record duplications and reconciliations. FRS's design should consider a business scenario where its potential is shown and at least the following parts intervene.

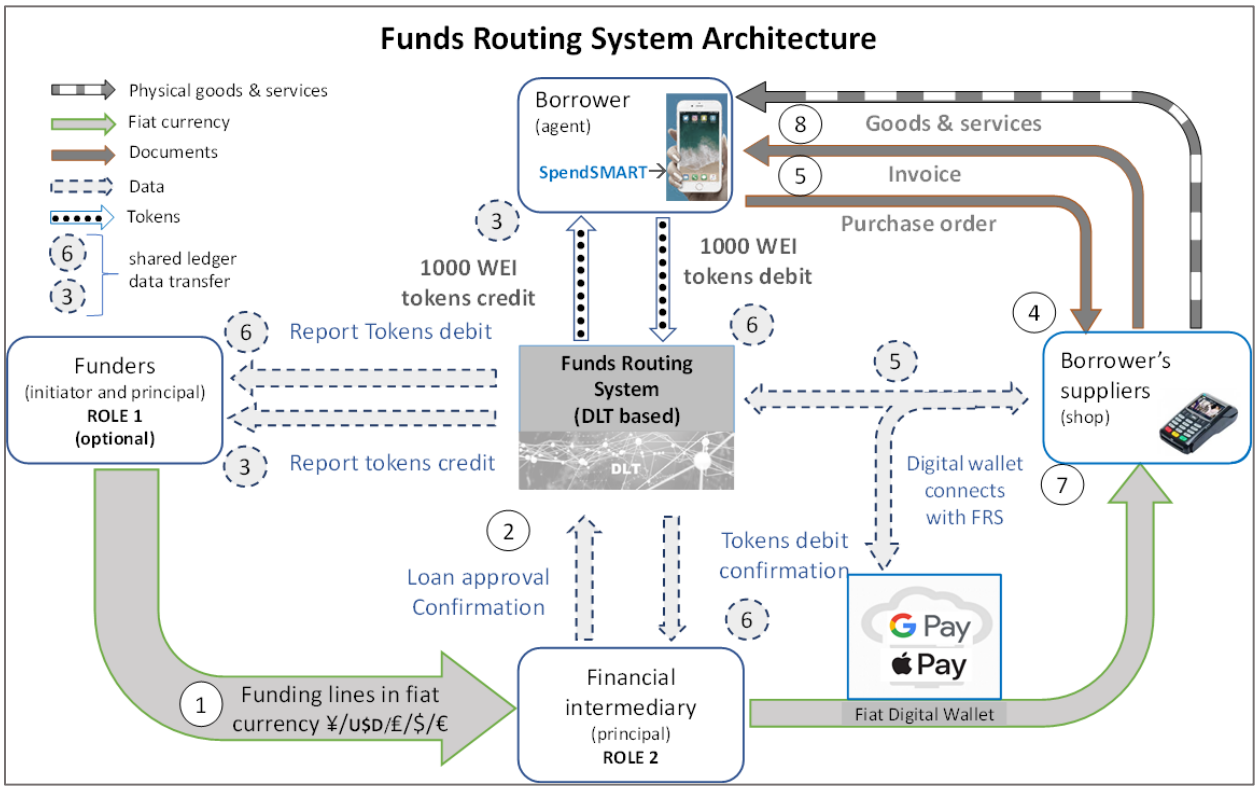
1. The principal or sender of the funds.
2. The agent or borrower.
3. The provider or creditor of the agent to whom the funds are transferred.
4. A stakeholder interested or involved in the operation to whom accountability for the transaction success is due. The stakeholder's interest can be quite diverse, such as financial (refinancing lines), taxation, audit, environmental, social issues, etc. In other words, it is a counterparty that requires to be informed based on an agreement or regulation.

For explanatory purposes, a lender-borrower transaction is used as case study in light of its evident and explicit information asymmetries. The following assumptions are applied.

- There are no technological or infrastructure constraints that would prevent the application of state-of-the-art technology.
- The information or transactional systems of the principal and agent, as well as the cell phone APPs, are integrated among them and with the FRS using Application Programming Interfaces (APIs).
- There are no cultural or knowledge barriers between participants to manage and interact with systems and applications described.

Under this context, it is set up a challenging scenario with cutting-edge technology in line with the Fintech sector. Nonetheless, it is assumed this advanced development will have to be adapted to the reality of each sector, organization, and individuals. Figure 4 illustrates FRS architecture with all components and interactions.

Figure 4



Own source

Design and process explanation:

1. Funders or initiator (Role 1) transfers funding lines in any currency to a financial intermediary who provides loans to a specific target group. The initiator is assumed to be interested on the fact that these loans need to comply with specific policies agreed with the financial intermediary, for instance, productive purposes, compliance with green, licit or gender policies, among others.
2. The financial intermediary (the principal hereafter) disburses a loan for productive purposes according to the borrower's statement. Loan is approved along with a specific investment plan based on the information the borrower (the agent) has provided. The investment plan must contain a list of items to buy, estimated prices and potential suppliers from where the purchase will be carried out. This action takes place in the principal's transactional system, which automatically sends an investment plan confirmation to the FRS.
3. The FRS credits 1000 WEI tokens[4] equivalent to the total loan amount, which automatically generates a specific conversion rate (CR = loan amount $ / 1000 WEI tokens). This feature makes the system flexible to be implemented in any currency. The transaction is automatically

[4] An Ether cannot be fractioned, but 1 Ether is equivalent to 1 Eth = 1e18 WEI. The possibility of the borrower making more than one purchase requires working with fractions of an Ether or token.

shared with the funder's information system confirming borrower's name, the amount approved, and other attributes required by lenders.

4. The borrower downloads an APP (SpendSMART hereafter) which connects with the FRS when introducing borrower's data (ID, loan number, Financial institution) and receives 1000 WEI credit. SpendSMART is uploaded and registered as one more payment source of digital wallets such as Google Pay, Apple Pay, Alipay, or Wechat Pay. These payment systems accept and connect with multiple credit and debit cards, and other payment sources. The user can select which source of payment to use in different shops. The borrower orders the suppliers good or services authorized in the investment plan.
5. The borrower proceeds to pay with the chosen digital wallet (i.e. Google Pay, Apple Pay, Ali Pay etc.) to which SpendSMART was integrated. The purchase will only take place if it is done in one of the shops authorized and verified in the investment plan. QR code, NFC[5], or MST[6] are used in the payment terminal to recognize the shop and purchase amount.
6. The FRS converts the invoice amount into tokens according to the CR and debits the equivalent number of tokens. Next, the outstanding balance in tokens is checked to keep the operation open until new purchases are registered to complete the 1000 tokens equivalent to 100% of the loan amount. This transaction information, together with the scanned invoice, is automatically reported to the initiator's information system and the principal's transactional system on a daily, weekly, or monthly base.
7. The principal's transactional system issues a payment transfer in fiat currency to the bank account of the borrower's suppliers via the payment system (digital wallet) used for that specific purchase.
8. The supplier delivers the goods and services together with the final invoice to the borrower, which can be scanned with SpendSMART to support the investment plan compliance, one of the funder's requirements.

The same configuration can be applied to a simplified version, without the first stakeholder intervention (role 1). Financial intermediaries or the principal (role 2) could be replaced by investors, lenders, donors, promotors as well as contracting, represented or instructing parties depending on the type of contract and whether they are written or verbal. Especially for verbal contracts, FRS could represent a powerful tool in terms of higher accountability and target allocation of funds when there is no other written evidence of the agreement. Agents, on the other hand, could be any recipient of funds, for instance, a beneficiary, a business partner (entrepreneur), a borrower, employee, contractor, consignee, among others, who has been entrusted with the fulfilment of a specific task, namely to spend or invest funds in determined items or shops during a defined time.

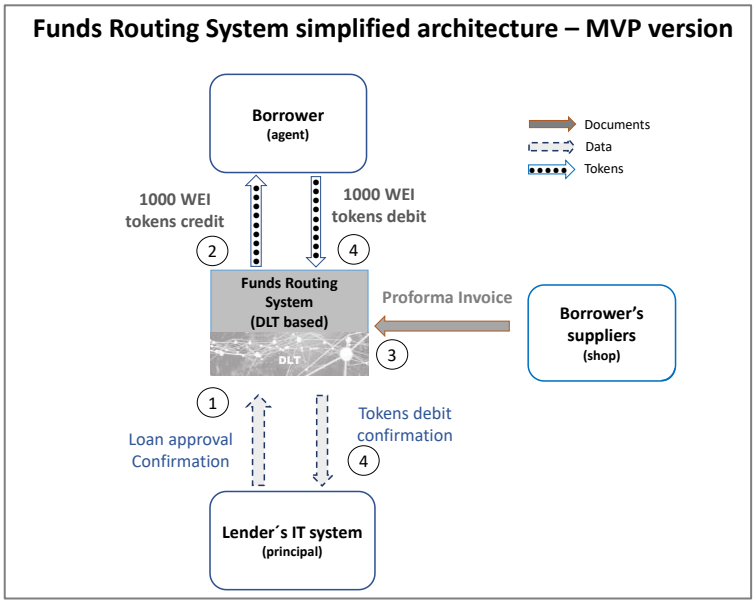
[5] Near Field Communication
[6] Magnetic Secure Transmission

To recap, FRS design exploits distributed ledger technology main advantages in terms of simultaneous information sharing with different counterparts. It incorporates an escrow mechanism to condition token accreditation, which triggers fiat currency transfers from principal via digital wallets to agents' suppliers or creditors and thereby avoiding agent discretion.

5 Implementation

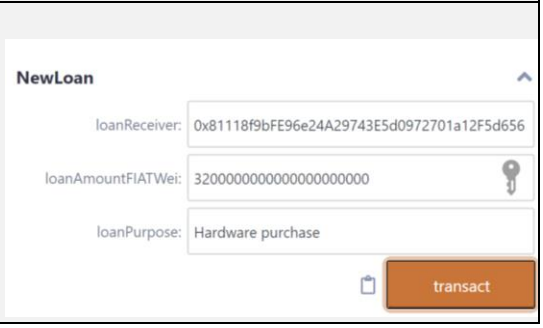
The core process of the FRS system can be represented in a prototype, which is a simplified version of the comprehensive design explained in the previous section.

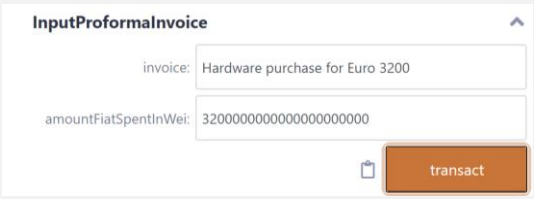
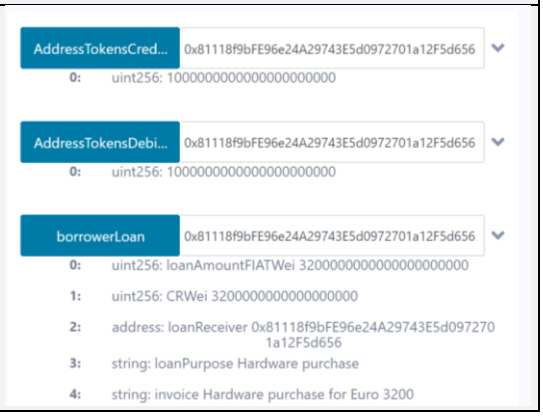
Figure 5



Own source

This prototype has been coded in solidity language in Remix IDE (integrated development environment). A simplified architecture representing FRS's core processes is illustrated in Figure 4. This first stage has only considered the development of the back end in order to verify its basic functions. The sequence of essential instances and outputs of a first coded prototype follows.

A) <u>Deploy</u>: Assignment of Financial Intermediary's address. Creation of the contract (deployment)	
B) <u>NewLoan</u>: 1. Loan Approval. Borrower's address and loan purpose are specified along with the loan amount of 3200 Euros. 2. Conversion of 3200 Euros (fiat currency) in WEI (3200 e18) that fulfils the token function. Credit of the loan amount in WEI.	

C) <u>InputProformaInvoice:</u> 3. Registration of proforma invoice data: • Invoice specifying loan purpose • Input fiat currency amount converted into WEI (3200 e18) 4. Perform transaction. Debit of the loan amount from the borrower's account.	
D) <u>Output</u>: • Token credited to borrower → 1000 e18 • Token debited to borrower → 1000 e18 • Borrower loan debited for hardware purchase for Euro 3200	

6 Evaluation

In view of FRS's objective and research question, a series of attributes and evaluation criteria were identified to be used as a benchmark. These features are compared and assessed with the closest studies, research projects and prototypes already analysed in Table 1. Although most of them have different objectives, they represent the closest reference to the current research project. The evaluation criteria defined in table 2 are presented below together with their respective weights:

- <u>Validation stage</u>: it refers to the high/low fidelity of the prototype; in other words, the prototype development level and which validation instances have been carried out. (5%)
- <u>Interoperability</u>: it is the flexibility to interact with other systems, other platforms, other counterparties, and different currencies. (15%)
- <u>Funds routing and tracking system:</u> it relates to front-end processes that ensure loan destination, as well as user-friendly, dynamic, and interactive interfaces. (20%)
- <u>Financial Intermediaries accountability</u>: it refers to whether the system makes funds allocation more transparent when there is a funder, external regulator, or any other stakeholder playing the role of principal and a financial intermediary playing the role of agent. (20%)
- <u>Borrowers accountability</u>: it refers to whether the system makes funds allocation more transparent when there is a financial intermediary playing the role of principal and a borrower or final beneficiary playing the role of agent. (20%)
- <u>Credit risk reduction</u>: it relates to specific features and procedures which enable the principal to reduce information asymmetries:

- Adverse selection: before disbursement (10%)
- Moral hazard: after disbursement (10%)

A scale with a range of 0 to 5 is used for assessing each criterium, where 0 (cero) is a minimum, which can be interpreted that no specific solution is envisaged for this challenge. On the other hand, 5 is the maximum score for a prototype attribute addressing a particular problem.

The "Total Score" column shows a top-down ranking where FRS achieved the best total score. This result is not a surprise given the fact that the selected criteria represent its main virtues, which are not necessarily the same from the other alternative devices. From this perspective, FRS's competitive advantages can be considered as a benchmark. It does not represent the best proposal but a better one in terms of its objectives and research question.

The column "Comments" sets out the main reasons for each scoring. Special focus should be placed on the second and third-ranked papers. Arantes et al. present a study with quite similar objectives to those of the FRS. Fundamental differences lie in the validation stage, the token system, and the user interface. In third place is Omrana's et al. proposal, which refers to reverse factoring system based on DLT. Reverse factoring mirrors FRS's processes. However, its objective is to optimize big corporation working capital. Consequently, they are not comparable devices. Reverse factoring has become a common solution among multinational companies engaged in foreign trade, but they are not based on DLT infrastructure yet.

In terms of novelty, it can be concluded FRS meets quadrant 3 requirements of "DSR knowledge contribution framework" (see figure 3). It is an "Improvement" based on *new solutions* (a tailor-made device to make funds allocation accountable) for *known problems* (the existence of information asymmetries and more specifically mora hazard between principal and agent). The first FRS prototype fulfils the basic functions in terms of ensuring the loan destination and sharing information among stakeholders. The defined architecture (figure 4), not developed yet in this first prototype, could amplify FRS's impacts. APIs, user interfaces and user-friendly approaches could provide an integrated ecosystem flexible to interact with different platforms, currencies, and stakeholders.

Finally, FRS main advantages are summarized next:

- Lower credit risk for lenders
- Lower capital requirements for financial institutions to cope with defaulted loans
- Lower principal monitoring cost
- Less recovery cost for delinquent loans
- Elimination of trusted third parties and other intermediaries
- Less paperwork and manual work, thus elimination of error-prone activities
- Transparent and tamper-proof
- Real-time and ubiquitous information
- Flexible multicurrency approach
- Scalability and interoperability

Table 2

Assessment of FRS's main features compared to alternative prototypes and proof of concepts with focus on loan process improvement

Scale from 0 (minimum) to 5 (maximum)

Ranking	Paper	Objective	Validation stage	Interope-rability	Funds routing and tracking	Financial Interme-diaries' accounta-bility	Borrowers' accounta-bility	Credit risk reduction		Total score	Comments
								Adverse selection	Moral hazard		
		Criteria weighted average	**5%**	**15%**	**20%**	**20%**	**20%**	**10%**	**10%**		
1	**Fund Routing System: an accountable fund allocation mechanism** (*current paper*)	**Score**	**3**	**5**	**5**	**4**	**4**	**0**	**4**	**25**	The first prototype is developed in solidity language in Remix IDE. One of the main advantages is its versatility and interoperability to adapt to retail finance (small transactions) or more complex operations involving several and larger stakeholders. The user interface can be integrated with other payment systems improving user experience. FRS has a multicurrency approach. Tokens are only intended for internal credit and debit procedures without exposing users to cumbersome operations with tokens or cryptocurrencies. The system is user friendly and exploit DLT advantages in terms of safe and efficient information sharing. FRS does not address adverse selection issues.
		FRS' objective: To trace and route funds transferred from principals to agents by means of a single and shared ledger of records with the aim of increasing transactions accountability and predictability. Research Question: how can DLT and smart contracts route funds, increase accountability and reduce credit risk?	**0.15**	**0.75**	**1**	**0.8**	**0.8**	**0**	**0.4**	**3.9**	
2	**Improving the Process of Lending, Monitoring and Evaluating through Blockchain Technologies** (*Arantes, et al., 2018)*	**Score**	**1**	**2**	**3**	**4**	**4**	**0**	**4**	**18**	It aims to make funds allocation more transparent by channelling payments to contractors and bypassing borrowers, similar to FRS. However, it is a device specifically designed for BNDES. Inflexible: it needs contractors verification, which is not a precondition of FRS. Not user-friendly: user interface not specified. Tokens are credited and debited among different counterparts that are not used to deal with cryptocurrencies. It does not consider a multicurrency approach. The paper is a proof of concept without coding of a prototype.
		To improve lending procedures by implementing a loans tracking system in Brazilian Development Bank (BNDES) that ensures the appropriate use of public funds, reduces funds misuse and audits costs	**0.05**	**0.3**	**0.6**	**0.8**	**0.8**	**0**	**0.4**	**2.95**	
3	**Blockchain-driven supply chain finance: Toward a conceptual framework from a buyer perspective** *(Omrana, et al., 2017)*	**Score**	**0**	**2**	**3**	**0**	**3**	**3**	**3**	**14**	It is a modality increasingly used by large companies mainly involved in foreign trade. It is intended to optimise working capital of reputable and creditworthy buyers who apply for financing of their accounts payable. Therefore, while the mechanism is similar to the FRS, it is not comparable because of the borrower low credit risk and the reduced information asymmetries. Processes do not match exactly FRS's requirements. It is a proof of concept with a basic design that shows how reverse factoring could work with DLT.
		To optimise working capital by means of reverse factoring. Reverse factoring is similar to FRS from process but not from objective and initiator perspective. The buyer (borrower) is the initiator (not the financial institution) who asks a bank to advance payment to their suppliers but postpones his own payments. The bank closes the financing gap between buyer and seller (supplier)	**0**	**0.3**	**0.6**	**0**	**0.6**	**0.3**	**0.3**	**2.1**	
4	**Re-inventing PTPTN Study Loan With Blockchain -** (Gazali, et al., 2017)	**Score**	**1**	**2**	**1**	**0**	**4**	**0**	**3**	**11**	It foresees a student marks accountability system, a distributed settlement ledger and a repayment mechanism once the student starts working. It is a general proof of concept with no specific artefact or explanation of the main components. Loan tracking systems is not envisaged. The repayment mechanism can provide cash flow certainty and reduce credit risk.
		Reengineering of the current student loans management system in Malaysia. The proposal provides accountability about student progress and a distributed ledger with future employers to discount loan instalments from roll payments	**0.05**	**0.3**	**0.2**	**0**	**0.8**	**0**	**0.3**	**1.65**	
5	**LoC: Poverty Alleviation Loan Management System based on Smart Contracts** (Guo, et al., 2018)	**Score**	**3**	**2**	**0**	**3**	**2**	**0**	**0**	**10**	The objective is to improve pre-disbursement processes and reconciliations but does not consider any mechanism aimed at reducing credit risk or loan misdirection. Its main focus is on achieving transparency and efficiency among government agencies.
		To improve the Chinese government's poverty alleviation programme by increasing transparency and efficiency of the credit management system. Shared information among stakeholders should reduce delays and frauds as well as improve regulator compliance	**0.15**	**0.3**	**0**	**0.6**	**0.4**	**0**	**0**	**1.45**	
6	**Blockchain for Microlending: Towards a Solution for Poverty Reduction and Financial Inclusion of the Underprivileged Through Transparency and Auditability** (*Turkiewics & Marinescu, 2019)*	**Score**	**3**	**1**	**0**	**4**	**0**	**0**	**0**	**8**	Proof of concept with an agnostic framework approach which does not foresee any solution for information asymmetries between loan borrowers and MFIs. There is no specific procedure to reduce credit risk. Its greater contribution is accountability improvement between funders and financial intermediaries. It counts with a detail devise architecture.
		To increase transparency, security and auditability in the microfinance sector, with the main focus on information sharing related to funds destination between investors and MFIs. DLT and SC reduce information asymmetries and improve financial inclusion	**0.15**	**0.15**	**0**	**0.8**	**0**	**0**	**0**	**1.1**	
7	**Blockchain and business model innovation: Designing a P2P mortgage lending system** *(Henriquez, et al., 2019)*	**Score**	**1**	**2**	**0**	**0**	**0**	**3**	**0**	**6**	It does not foresee any loan tracking system. An underwriting procedure with AI and ANN performs as credit risk screening mechanism. Its main contribution is the procedure defined to solve mortgage ownership among several lenders by means of Special Purpose Vehicle (SPV). It is a proof of concept.
		To create a prototype of a mortgage lending system able to work in P2P crowdlending platforms. The new business model addresses problems related to mortgage ownership as well as information and financial flows between lenders and borrowers	**0.05**	**0.3**	**0**	**0**	**0**	**0.3**	**0**	**0.65**	

Own source

7 Conclusions and Future Work

IT system's main goal is to develop artefacts and devices which solve people and organizations' concrete problems. This goal can be achieved in three different ways according to Gregor & Hevner (Gregor & Hevner, 2013): adapting existing solutions to new fields of application, creating new products or services to address emerging problems, or developing new devices for existing problems. FRS can be perfectly framed in this last alternative. Information asymmetries in financial transactions are a research field which has been studied in detail during the last decades. The agency theory provides the underlying principles for understanding the scope and impact of information asymmetries. These aspects were analysed as part of the descriptive research where moral hazard was identified as a specific information asymmetry arising after assets have been transferred to the agent. Key research findings suggest moral hazard requires monitoring and follow-up actions with the aim of reducing the great discretion agents have when dealing with transferred resources. In this context, ICOs, microfinance and crowdfunding sectors were explored as some of the application fields where moral hazard emerged.

On the other hand, DLT and SC technology are meant and designed to deal with information asymmetries. Monitoring and follow-up actions are usually costly and complicated to implement. One of the main factors that make their implementation particularly difficult is reconciliations and duplication of records. DLT and SC can provide a single version of records which are transmitted in real time to all interested parties. As part of the prescriptive research, different papers and prototypes addressing loan processes improvement were studied in terms of DLT and SC features (table 1).

FRS's architecture was defined with all system components (Figure 4) along with a description of the main interactions. A prototype (Figure 5) was developed in solidity language of Remix IDE. The proposed solution demonstrated its potential to solve all challenging aspects of the comprehensive architecture defined in figure 4. Finally, the main FRS's attributes were assessed in relation to similar studies and devices presented in the descriptive research section. Table 2 results show FRS provides new insights to deal with moral hazard issues. Its versatility, interoperability and simplicity stand out as its main attributes.

Interoperability is precisely what gives rise to further research and development of more advance prototypes. Progress must be made in interconnecting FRS with digital wallets and other potential stakeholder platforms. If the FRS cannot communicate with other platforms, mainly with digital wallets, its potential development will be limited to the less sophisticated market segments of the financial system. Furthermore, the possibility of complementing FRS attributes with databases able to store track record of agents operating with the system would

allow to make more accurate assessments of borrower's profile in the future and to address "adverse selection", the first information asymmetry effect. Adverse selection demands an incentive system to align agent's behaviour. To this end, immutable and ubiquitous credit history or any agents' track record taken from FRS's data base could provide further and better information to reduce lenders risk aversion when borrowers ask for new funds in the future. As a result, FRS tool can be expanded with functionalities able to deal not only with moral hazard but also adverse selection effects.

FRS prototype has proven to answer the research question by confirming there is great potential to move forward with a complete tool development. It represents a new technological solution to cope with information asymmetries and funds misallocation, an unsolved issue in the financial domain. When decisions no longer depend on people discretion but on self-executing codes and timely shared information, trust arises, and businesses thrive.

References

Arantes, G., D'Almeida, J. N. & Onodera, M., 2018. *Improving the Process of Lending, Monitoring and Evaluating through Blockchain Technology,* s.l.: IEEE Confs on Internet of Things, Green Computing and Communications, Cyber, Physical and Social Computing,Smart Data, Blockchain, Computer and Information Technology, Congress on Cybermatics.

Awaworyi, S., 2014. *Impact of Microfinance Interventions: A Meta-analysis,* s.l.: Monash University, Department of economics, ISSN 1441-5429.

Cai, C. W., 2018. *Disruption of financial intermediation by FinTech: a review on crowdfunding and blockchain. ,* s.l.: Accounting and Finance 58 - 565-992.

Claus, I. & Grimes, A., 2003. *Asymmetric information, Financial Intermediation and the Monetary Transmission Mechanism: A critical Review,* s.l.: New Zealand Treasury Working Paper, No. 03/19, New Zealand Government, The Treasury, Wellington.

D. Straub, S. A. & Evaristo, 1994. *Normative Standards for MIS Research,* s.l.: The Data Base for Advance Information System (25.1), pp 21-34.

Divyashree, K. S., 2019. *Initial Coin Offering (ICO) - A new Paradigm,* s.l.: E ISSN 2348 –1269, PRINT ISSN 2349-5138.

Eisenhardt, K. M., 1989. *Agency Theory: an assessment and Review,* s.l.: The Academy of Management Review, Vol 14, No 1, 57-74.

Gazali, H., Nor, R. & Rahman, H., 2017. *Re-inventing PTPTN Study Loan With Blockchain and Smart Contracts,* s.l.: 8th International Conference on Information Technology (ICIT).

Gregor, S. & Hevner, A., 2013. *Positioning and Presenting Design Science Research for Maximum Impact,* s.l.: MIS Quarterly Vol. 37 No. 2, pp. 337-355.

Guo, C., Mao, H., Cheng, S. & Wang, T., 2018. *LoC: Proverty Alleviation Loan Management System based on Smart Contracts,* s.l.: IEEE Confs on Internet of Things, Green Computing and Communications, Cyber, Physical and Social Computing, Smart Data, Blockchain, Comp. and Information Technology, Congr of Cybernetics .

Henriquez, R., Cohen, I., Brittan, N. & Tulbassiyev, K., 2019. *Blockchain and Business Model Innovation: Designing a P2P Mortgage Lending System,* s.l.: SSRN.

Highsmith, J. & M. Fowler, 2001. *The Agile Manifesto,* s.l.: Software Development Magazine, vol. 9, no.8.

Hileman, G. & Rauchs., M., 2017. *Global Blockchain and Benchmarking Study,* s.l.: University of Cambridge; Judge Business School.

Howell, S., Niessner, M. & Yermack, D., 2019. *Initiail Coin Offering: Financing Growth with Cryptocurrency Token Sales,* s.l.: Naional Bureau of Econocmic Research .

Jeffee, D. M. & Russell, T., 1976. *Imperfect Information, uncertainty, and credit rationing,* s.l.: Quarterly Journal of Economics 90, 651-666.

Karlan, D. et al., 2016. *Making Microfinance more Efficient,* s.l.: Economics & Society.

Lukkarinen, A., Wallenius, H. & Wallenius, J. T., 2016. *Success drivers of online equity crowdfunding campaigns,* s.l.: Decision Support Systems, 2016.

McGough, P. E. B., 2010. *Are microloans Bad for Growth?,* s.l.: IZA Discussion Papers, No. 5249, Institute for the Study of Labor (IZA), Bonn.

Mitnick, B., 2019. *Origin of the Theory of Agency: An Account By One of the Theory's Originators,* s.l.: SSRN.
Nakamoto, S., 2008. *Bitcoin: A Peer-to-Peer Electronic Cash System,* s.l.: www.bitcoin.org.

Nghiem, S., Coelli, T. & Rao, P., 2012. *Assessing the Welfare Effects of Microfinance in Vietnam: Empirical Results from a Quasi-experimental Survey,* s.l.: Journal of Development Sudies, 48, 619-632.

Nunamaker, J., Chen, M. & Purdin, T., 1990. *System Development in Information Systems Research,* s.l.: Journal of Management Information System, Vol 7, No 3, pp 89-106.

Omrana, Y., Henkeb, M., Heinesc, R. & Hofmannd, E., 2017. *Blockchain-driven supply chain finance: Towards a conceptual framework from a buyer perspective.* [En línea]
Available at: https://www.alexandria.unisg.ch/publications/251095

Patel, D., Bothra, J. & Patel, V., 2017. *Blockchain exhumed,* s.l.: ISEA Asia Security and Privacy (ISEASP).

Peffers, K. et al., 2006. *The Design Science Research Process: A Model for Producing and Presenting Information System Research,* s.l.: Journal of Management Information Systems, Volume 24 Issue 3, Winter 2007-8, pp. 45-78.

Rosenberg, R., 2010. *Does Microcredit Really help Poor People?,* s.l.: CGAP, Nr. 59.

Sein, M. et al., 2011. *Action Design Research,* s.l.: Mis Quarterly 35(1):37–56,.

Stiglitz, J. E. & Weiss, A., 1998. *Stiglitz, J. E. and Weiss, A. (1998), "Credit rationing in markets with imperfect information",* s.l.: The American Economic Review 71, 393-410.

Turkiewics, A. & Marinescu, S., 2019. *Blockchain for Microlending: Towards a Solution for Poverty Reduction and Financial Inclusion of the Underprivileged Through Transparency and Auditability,* s.l.: Copenhagen Business School.

Wilson, J., 2002. *Responsible Authorship and Peer Review,* s.l.: Science and Engineering Ethics (8:2), pp. 155-174.

Zetzsche, D., Buckley, R., Arner, D. W. & Föhr, L., 2017. *The ICO Gold Rush: It´s a Scam, It's a Buble, It's a Super Challenge for Regulators,* s.l.: SSRN Electronic Journal .