Blockchain-Based Solutions to Improve Financing for the Ultra-Poor: Technological Potential and Practical Challenges

Abstract

Several blockchain-based financial technologies (fintechs) and cryptocurrencies have been launched to improve the access to and affordability of financial services for the poor. Blockchain has technical potential that can be captured to serve the needs of unbanked and underbanked population. A look at the startups that have launched fintechs and cryptocurrencies for the poor indicates that there is currently no clear evidence that most of them are achieving their stated goals of helping the targeted population. The startups' actions related to designs and other aspects are taken by keeping big companies' and investors' *needs and preferences in mind. The needs of poor consumers, on the other hand, often go ignored. Unfortunately, the benefits that are claimed that fintech products and cryptocurrencies can offer to the poor are far from guaranteed due to their lack of skills and unfavorable market and institutional environments. New users of such technologies lack skills and access to new opportunities that can be exploited with the technologies.*

Keywords: *Access to finance; blockchain; creditworthiness; cryptocurrency; Ethereum; identity; smart contract*

Introduction

According to the World Bank's Global Findex database, about 1.7 billion adults were unbanked in 2017, which means that they lacked an account with a formal financial institution or a mobile money provider (Demirguc-Kunt et al., 2017). A number of blockchain-based financial technologies (fintechs) and cryptocurrencies have been launched in order to improve the access to and affordability of financial services for the unbanked and underbanked population.

The lack of formal identity documents to prove who they are is among the main reason why many poor people lack access to financial services. According to the World Bank's ID4D database one billion people lack any form of identification to prove who they are. An additional 3.4 billion people have some types of identifications but lack the ability to use them in the digital world (White et al., 2019). Worse still, in many countries, banks demand a variety of other documents in addition to identification cards to open an account. According to a McKinsey study conducted in five developing countries and two developed countries, in 2030, with full

digital ID coverage counties could create economic value equivalent to 3% to 13% of GDP. Over half of this value is likely to go to individuals (White et al., 2019). In light of these observations, an encouraging development is that a key component of some blockchain startups' initiatives has been to build blockchain-based identity solutions for the poor.

Blockchain's key features can make fintechs based on this technology and cryptocurrencies superior to those offered by non-blockchain fintech and traditional financial institutions. Some fintechs and cryptocurrencies aim to capitalize on blockchain-led decentralization and disintermediation to directly connect borrowers with lenders thereby reducing the costs of financial services. Another notable feature of these solutions is to aggregate information from many sources to build economic history. This aspect is especially important for many developing countries, because they lack reliable credit information on most people and companies, which is needed to minimize banks' lending risks. In China, only 20% of the adult population has a credit score (Lohr, 2015). Theoretically borrowers can show blockchain-based credit information to lenders and receive loans more easily (Stanley, 2017).

Underdeveloped supporting technologies and infrastructures pose challenges to take advantage of new technologies such as blockchain. Developing economies face unfavorable institutional arrangements such as contract enforcement procedures, property rights and standards (North, 1990). Institutional environments in developing economies and the interaction of these environments with information flows, transaction costs and risks, and market access-related constraints hinder the implementation of new technologies (Dorward et al., 2003).

Put simply transaction costs consist of wo things: "(1) the costs of measuring the dimensions of whatever it is that is being produced or exchanged and (2) the costs of enforcement" (North, 1999). Regarding (1), most developing economies lack databases of

reliable credit information on most people and companies. Assessing a potential borrower's creditworthiness is thus a challenging task. In some developing countries, it costs up to US$1,000 to check for a person's detailed financial and other background information (Schwartz, 2005). Likewise, in many developing countries due to forgery and fraud in ID cards and fraudulent birth certificate, it is difficult to determine whether a person is who he says he is (IBRD/World Bank, 2017). As to (2), formal contracts cannot be easily enforced in developing countries. These factors increase the transaction costs (Williamson, 1991).

Regarding information flow, empirical studies conducted in the agriculture and food and beverage industry have indicated that farmers receive information from relatively restricted channels and that they learn about new technologies from very few sources. Moreover, information they receive is not perfect (Udry and Conley, 2001). All these lead to slow learning of new technologies within a village and use of new technologies is often limited to specific groups and networks (Vann den and Derco, 2001). Barriers such as lack of sufficient skills and opportunities to apply these solutions may prevent the poor from benefiting from blockchain-based fintechs and cryptocurrencies. It is thus important to consider whether these solutions can successfully overcome these barriers.

In light of the above discussion, the objective of this paper is to provide an overview of the benefits and limitations of blockchain-based fintechs and cryptocurrencies that are targeted to the poor. We look at the early evidence of blockchain startups that have launched fintechs and cryptocurrencies with a focus on poor people in developing countries.

The paper is structured as follows. We proceed by first explaining blockchain and some related concepts. Next, we discuss some key examples of blockchain-based fintech solutions and cryptocurrencies for the poor. Then, we look at some major benefits and potential opportunities

offered by blockchain-based fintechs and cryptocurrencies. It is followed by an analysis of challenges in using blockchain-based fintechs and cryptocurrencies. The final section provides concluding comments.

Blockchain: Some background, concepts and facts

In this section, we define and make some comments about blockchain and related concepts (Table 1). Blockchain can be viewed as a decentralized ledger that maintains digital records of a transaction simultaneously on multiple computers. After a block of records is entered into the ledger, the information in the block is mathematically connected to other blocks. In this way, a chain of immutable records is formed (Yaga et al., 2018). Due to this mathematical relationship, the information in a block cannot be changed without changing all blocks. Any change would create a discrepancy which is likely to be noticed by others (Kshetri, 2018). To ensure that only authorized users can access the information blockchains verify identities using cryptography-based digital signatures. Users sign transactions with a private key, which is a long and random alphanumeric code. Complicated algorithms create "public keys" from private keys to make it possible to share information.

Blockchains can be permissioned (e.g., Ripple) or permissionless (e.g., Bitcoin and public Ethereum). In a way, permissionless blockchains are like a shared database. Everyone can read everything. However, a user cannot control who can write.

Many different parties can read and write transactions in blockchains' databases. Blockchains' consensus mechanisms check transactions to ensure that they are valid. Transactions that are validated rules get hashed. That is, they are assigned digital fingerprints that identify the transactions. Validated transactions are grouped together to form a block. Each block is also assigned its own hash. This hash is linked together with the next block of transactions in the chain. The validators of a transaction are rewarded.

Table 1: Explanation of major terms used in the paper

Term	Explanation
Blockchain	A decentralized ledger that maintains digital records of a transaction simultaneously on multiple computers.
Cryptocurrency	A cryptocurrency functions like money, which means that it defines value, serves as a value transfer and can be used for making and receiving payments. Such currencies are on the blockchain and encrypted using cryptography**.**
Crypto token	A crypto token is a special kind of cryptocurrency that represents an asset or utility. For example, a crypto token may represent certain amount of customer loyalty points on a blockchain, streaming content on a video-sharing platform, other cryptocurrency (e.g., 5 bitcoins) on a blockchain. Crypto tokens are tradable and transferrable among various participants (Frankenfield, 2018).
Cryptocurrency mining	Cryptocurrency mining is a process to verify and validate transactions to add to the blockchain digital ledger. A cryptocurrency miner ensures the authenticity of information.
ERC-20 token	Ethereum -based ERC-20 token keeps track of token owners at a given point of time (Consensys Media, 2017). ERC-20 is a technical standard used for smart contracts. An ERC-20 token can be created with less than 100 lines of codes (Wolfson, 2017).
Ethereum	The Ethereum network is a public blockchain-based open software platform, in which each node can be discovered by and known to other nodes in the network. It has its own cryptocurrency known as Ether.
Ethereum Gas	A fraction of an Ethereum token used by a smart contract to pay for the miners' efforts to secure the transaction on the blockchain.
Hyperledger Fabric	It is an open-source blockchain platform from The Linux Foundation, which is provided by IBM as "Blockchain as a Service". It is targeted to businesses. Hyperledger facilitates smart contracts by connecting all relevant parties together. Fabric is type of private or permissioned blockchain. Some organizations or government agencies "own" the nodes, who permit the nodes to communicate with each other. Identities and roles of members are known to other members
Initial coin offering	A fundraising tool that allows a company to pre-sell future cryptocoins in exchange for cryptocurrencies of immediate and liquid value such as bitcoin and Ethereum. A start-up raising money through ICOs can create its own crypto-currency utilizing blockchain protocols. Roadmap goals and strategies are outlined in a whitepaper. ICO values are set up based on the amount of money required to achieve the stated objectives. The pre-sold tokens could serve as the medium of exchange in the future on a peer-to-peer platform (Li and William, 2018).
Permissioned blockchain	In a permissioned blockchain, nodes or users are not publicly discoverable. The permission to create smart contracts may also be restricted to approved actors.
Permissionless blockchain	A permissionless blockchain can allow anyone to join the network and participate in block verification to create consensus and create smart contracts. Some examples include the Bitcoin and Ethereum blockchains
Smart contracts	Smart contracts execute automatically when certain conditions are met. Computerized protocols and user interfaces are used to execute a contract's terms (Szabo, 1994) and to "formalize and secure relationships over public networks" (Szabo, 1997).

Bitcoin is a "write-uncontrolled, read-uncontrolled" database (Bauerle, 2019).This means anyone can write a new block or read a block as long as the rules are followed. Permissioned blockchains can be designed to be write-controlled and read-controlled. In such blockchains, protocols can be set up in such a way that only permissioned participants can write into or read

the database. Ripple, for instance, runs a permissioned blockchain. It determines the nodes that may act as transaction validator. The company has included Canadian global information technology consulting CGI, MIT and Microsoft as validators (Bauerle, 2019).

Implementing smart contracts is among blockchain's most transformative applications. Smart contracts execute automatically when certain conditions are met. A smart contract assures a party with certainty that the counterparty will fulfill the promises. For instance, when an individual A performs an outsourcing work for a firm B, it would automatically trigger a payment of the agreed amount in cryptocurrency to A from the account of B. In this way, smart contracts may overcome moral hazard problems.

The first blockchain to implement smart contracts was Ethereum. Smart contracts are "installed" in each node of the Ethereum network, which allows a user to interact with other nodes. While Bitcoin stores data related to transactions, Ethereum stores diverse types of data such as those related to finance, industry, legal, personal information, community, health, education and governance. These data can be accessed and used by computer programs known as decentralized applications (dApps) that run on the Ethereum blockchain. Software developers can choose their own 'rules' for ownership, transactions formats and other aspects that may underlie the interactions among various parties (https://www.stateofthedapps.com/whats-a-dapp). The Ethereum blockchain can thus be customized to offer unique solutions to special needs. It is mainly used to develop B2C applications. In Ethereum blockchain, computers connected in an open and distributed network provide the processing power needed to run a smart contract. The computers in the network also verify and record transactions in the blockchain.

The owners of the computers are awarded with Ether tokens for their contributions. Ethereum can be viewed as the first shared global computer. Bitcoin, on the other hand, is

considered to be the first accounting ledger that can be shared globally (MIT Technology Review, 2017). The Ethereum blockchain needs what is referred to as Ethereum Gas in order to execute transactions or smart contracts (Ethos Team, 2019). The Gas system gives a higher priority to important transactions. In order to do so, their computational costs and rewards are made publicly available to the miners.

The network does not require to validate reads. Anyone with an access to the blockchain ledger's local copy can read the contents locally. The security and immutability features of blockchain would ensure the trustworthiness of information in the ledger. Two factors determine a write's monetary costs in the Ethereum blockchain: a) the degree of complexity of the codes to be executed in the smart contract (simple transactions cost less); and b) the time lag that is acceptable to the parties involved in processing the transaction (the costs are lower if longer time lag is acceptable) (Reynoso, 2017).

Examples of blockchain-based fintech solutions and cryptocurrencies for the poor

Table 2 provides brief descriptions of some blockchain-based fintech solutions and cryptocurrencies that are targeted at poor people in developing countries.

Humaniq

Humaniq's Ethereum-based app creates user profiles based on biometric data such as facial and voice recognition algorithms. Potential users are not required to have a passport or an email account. A smartphone is used to take a selfie and record a video making facial gestures. The user also pronounces a randomly selected text shown on the screen to record voice. Humaniq says that users can complete the bio-identification process in 20 seconds using the cheapest smartphones.

A user's unique and secure identity is verified and stored on Humaniq's servers, which can be used for smart contract (Icoholder, 2019). For instance, a user that has Humaniq tokens (HMQ) can use token smart contract for sending and receiving money.

The company's initial target audience is emerging economies. It plans to have a network of local cashiers to exchange HMQ and other cryptocurrencies into local currencies (econotimes, 2017). Humaniq's initial offerings will focus on creating an account and core banking services such as remittance payments. Humaniq announced that it would release its app code on Github. Third party developers can adapt their services to plug into Humaniq's app.

Humaniq offers an initial deposit of HMQ once a consumer completes the bio-identification process. Users can transfer money instantly to another Humaniq account without fees. With Humaniq IDs, entrepreneurs can connect with investors using HMQ anywhere in the world. It thus aims to facilitate small entrepreneurs' access to low-cost loans. HMQ tokens can be used to buy and sell goods and services such as data security, small business loans and pensions with third-party services utilizing Humaniq. HMQ tokens can be used as store of value and a means of payment and a medium of exchange on the platform.

New services such as peer-to-peer (P2P) lending and insurance services has been added as planned (Bruntinx, 2017). Humaniq has partnered with Tanzania-based micro-health insurance provider Jamii Africa, which targets low income individuals and the informal sector. Jamii Africa has been integrated with the Humaniq platform. Humaniq and Jamii Africa have signed a Memorandum of Understanding to expand the latter's services to the 22 nations where Humaniq operated.

As of July 2018, Humaniq app was downloaded by over 500,000 users in 50 countries (Hurst, 2018). They sent more than 60 million messages and made over 1.4 million transactions.

A large proportion of the transactions were made on a peer-to-peer (P2P) basis. Humaniq's app mainly focuses on the B2B business model. The transaction costs were zero in the beginning.

Humaniq's regional ambassadors educate users in order to encourage the adoption of the network. Local ambassadors have been appointed in some African countries to help increase the adoption blockchain-based ID and use the apps (Church, 2018).

Table 2: Blockchain-based fintechs and cryptocurrencies targeted to the poor

Platform	Brief description	Geographic areas of deployment
Humaniq's Ethereum-based user profiles and HMQ Tokens	Profiles are based on biometric data. HMQ tokens can be used to buy and sell goods and services with the third-party services utilizing the token and get access to small business loans.	September 2018: operated in about 50 countries including 21 in Africa
Kiva's digital identification system	Provides blockchain-based IDs. People get secure and complete ownership of personal information: all credit-related events are captured in a ledger connected to an individual's ID.	August 2019, Sierra Leone launched a blockchain-based National Digital Identity Platform (NDIP) developed by Kiva. Sierra Leone's government wants all banks and MFIs to use the system by the end of 2019. Worked with the UNCDF and the UNDP.
BanQu's "economic passport"	Establishes economic identities and proofs of record for people in extreme poverty zones. Also working to verify the authenticity of academic certificates and credentials	2018: served over 15,000 farmers, displaced people and refugees in eight countries. April 2019: The platform was used in 12 countries.
Moeda's microfinance platform	Banking-as-a-service cooperative financial network by linking investors with cooperative businesses. Users can get micro-loans to start or expand businesses. They can use Moeda's app to pay for the things they need for businesses.	The project was initially launched in rural Brazil. Also incorporated in Uruguay.
WFP's Ethereum-based cryptocurrency for refugees	Uses cryptocurrencies to pay refugees. The receivers can spend in participating stores. Parity Ethereum is used.	Mainly Pakistan and Jordan (for Syrian refugees) Early 2019: 1.1 million cryptocurrency transactions transferred more than US$ 23.5 million

Kiva

Kiva's blockchain protocol aims to address two major barriers that hinders poor people's access to financial services: formal identification and verifiable credit history (Cheney, 2019). Kiva worked with the U.N. Capital Development Fund (UNCDF) and the U.N. Development Program (UNDP) to develop a blockchain-based ID system in Sierra Leone. In August 2019, the

government of Sierra Leone launched a blockchain-based National Digital Identity Platform (NDIP), which was developed by Kiva. Sierra Leone's government wants all banks and microfinance institutions (MFIs) to use the system by the end of 2019 (Inveen, 2019).

Transactions are recorded in blockchain. A borrower will be assigned with a digital wallet, which will be accessible through an app. Individuals can access their wallets on cellphones. They can also work with an MFI or other agents that are already working in their community. The agents can also use the application offline (Kiva, 2019). Lenders can view borrower's credit histories in the NDIP platform (tokenpost.com, 2019).

When a lender provides a loan, the borrower gets a verifiable claim with all details. The borrower accepts the claim. The loan is then posted to the borrower's private credit ledger in the Kiva wallet. The same process is repeated when the borrower makes a loan repayment. The borrower approves a verifiable claim sent by the lender, which is then posted to the ledger. All credit-related events are thus captured in a single ledger connected to the wallet controlled by an individual. Financial institutions, government agencies and third-party agencies can access the information only with the owner's consent.

If a potential borrower's credit history has been verified by a local lender or Kiva Field Partner, the information can be accessed by other lenders. For instance, the borrower can apply for a loan from a national bank using the verified information. The new lender can get one-time access to the credit history of the borrower. The cost to operate the Kiva system is low. It eliminates fees that might prevent poor people or institutions from using other credit reports.

Kiva Protocol is built on open-source blockchain platform Hyperledger Fabric, which is a permissioned blockchain. A member organization (e.g., Kiva) is responsible for setting up its peers to participate in the network. Kiva administers access to the nodes. Partners such as banks

and government agencies act as peers. The users can share information that only the members can see. Once entered into the blockchain, the information cannot be altered. With this system people get secure and complete ownership of their personal information.

In June 2019, Kiva became one of the founding partners of Facebook's Libra Association, which is an independent not-for-profit organization (Kiva, 2019). One of the stated goals of Libra Association is to advance financial inclusion.

BanQu

BanQu utilizes Ethereum blockchain to establish economic identities and proofs of record (economic passport) for unbanked persons that live in extreme poverty zones (Stanley, 2017). It defines economic identity as "the marriage of identity and commerce, resulting in a global, vetted, and manageable asset" (Ramirez, 2017). A blockchain-based verifiable digital identity can help disadvantaged groups establish ownership, business assets, and production values. Such an identity would thus help them to engage in economic transactions and participate in the global economy.

It aggregates information from a number of sources such as those related to financial history, land records, trust networks documenting trust-relationships with others and business registrations, vaccination records and remittance income. ID-related information sources include selfies, biometrics, and key physical attributes. Blockchain's decentralized, secure ledger also provides Know Your Customer (KYC) and other information to the partners that can potentially offer products and services to these disadvantaged individuals (White, 2018).

Individuals and organizations who potentially engage in transaction with unbanked persons such as financial institutions and supply chain partners also join BanQu's platform. In this way, unbanked individuals are connected with parties that might be banked or

unbanked in order to build a "mini financial network" (Krishnakumar, 2017). This allows the creation of history of transactions on the platform and the formation of economic identity.

Theoretically potential borrowers with blockchain-based economic ID can thus more easily receive loans by showing such information to lenders (Stanley, 2017). For instance, farmers can access their records using a mobile phone to present proof of identity. A potential borrower can also ask the bank to do so. BanQu users maintains ownership of their personal information and decide what information to share with whom (Bangu, 2018).

Among the first projects, BanQu created a secure identity for displaced people in Kenya's Dadaab refugee camp. By 2018, it connected 25,000 farmers, displaced people and refugees to the platform across eight countries.

A case study provided by one of the founders of BanQu is that of a poor Rwandan female farmer near the border of Tanzania. She lacks any identity but owns a piece of land. She can produce about 100 kilo grams of corn in the land. She needs to feed a family of eight to ten. When she harvests her crops, she is often forced to sell them to a broker at a low price. If she can show information that she owns the land that produces 100 kilo grams of corn annually, she can sell her crops at higher prices to contract buyers that may also be willing to enter into long-term agreements with her.

Rapid post-harvest deterioration reduces the tradability of some crops (Dorward et al., 2004). For instance, if the Rwandan farmer in the above example is able to dry her corn to 13% moisture content, the corn's price may increase by 100%. With her economic identity that includes the land she owns, a forecast for production and a buyer, she can purchase a dryer. This purchase also becomes a part of her economic history for future transactions. If her BanQu

identity has gone through a few farming cycles, the lender would charge her lower interest rates for future loans.

High transaction costs associated with ensuring timely delivery of products that are quality assured often prevents small producers' participation in the market economy (Kydd and Poulton, 2000). In this regard, tracking supply chains is another key mechanism for building economic history for the population living at the poverty level. The importance of this process may be seen most clearly by considering the proportion of poor people that act as suppliers to big companies. According to BanQu, out of the 2.7 billion unbanked and underbanked people, about one billion are some forms of suppliers to 5,000 global brands (Paynter, 2019). To serve this market, in June 2018, BanQu teamed up with the multinational drink and brewing holdings company Anheuser-Busch InBev to promote supply chain transparency and traceability in Zambia. The BanQu system is also referred to as Chembe cassava online buying project in Zambia. The partnership started with the cassava crop value chain with an aim to provide economic empowerment to small-scale farmers. Using BanQu solutions, Anheuser-Busch's local business, Zambian Breweries can track its products throughout the supply chain: from the farmer to local businesses to aggregated buyers and retailers (Paynter, 2019).

A farmer supplying to Anheuser-Busch receives a digital payment through BanQu's platform. The crypto tokens can be redeemed for cash or applied for payment to other transactions such as paying energy bills (Paynter, 2019).

Farmers may benefit from the immutable records of economic activities that are linked with their digital profiles. For instance, with this record, farmers can connect with NGOs, local cooperatives, MFIs and banks to receive loans, grants and trainings. The program started with 2,000 farmers. The system is projected to track 2,000 tons of cassava, used to produce a high-

quality starch used in beer. Zambian Breweries is expected to add 2,500 additional cassava farmers by the end of 2019 (Paynter, 2019).

Since 2018, BanQu had a presence in Uganda. The goal is to reach 7,000 barley farmers by the end of 2019 (Paynter, 2019). As of June 2019, Nile Breweries, which operates as a subsidiary of Anheuser-Busch, implemented this system to track over 5000 barley farmers in Sebei region of Eastern Uganda. A farmer receives an SMS, which shows the quality, quantity and price of the crop sold to Nile Breweries. This record is with farmer and Nile breweries. The farmer can access the payment by presenting the code received in the SMS to the partner bank or mobile telecom (Equator News, 2019).

In 2018, BanQu joined AB InBev's Accelerator program to scale the idea in other locations. The company announced a plan to start a new program with 1,000 Indian barley farmers in April 2019.

BanQu is also working to verify the authenticity of academic certificates and credentials. A pilot program in Costa Rica seeks to improve young people's employment opportunities. The idea is to use blockchain systems to document their accomplishments and experience. Blockchains would help to create secure and immutable records of certificates and other documents that are related to educational achievements, internships, and employments from schools, universities and organizations. These documents play a key role in most employers' hiring decisions. However, most students lack accurate and reliable documents. Employers thus often contact educational institutions and organizations to validate the accuracy and authenticity of job candidates' CVs.

Moeda

Moeda describes itself as a blockchain-based microfinance platform that links investors with cooperative businesses (Schiller, 2018). Moeda aims to create a banking-as-a-service cooperative

financial network and provide P2P loans to disadvantaged entrepreneurs. In 2018Q2, Moeda moved its transactions to IBM's Hyperledger fabric composer (Table 1).

The company's stated goal is to provide opportunities for under-banked individuals to establish digital identities and credit profiles, prove creditworthiness and build reputation. Moeda has offices in the U.S. The projects were initially launched in rural Brazil. It is also incorporated in Uruguay.

Moeda app can be used without any knowledge of cryptocurrency. Users can get micro-loans to start or expand businesses. It aims to works with cooperatives and banks to provide micro-loans to underserved populations (Radocchia, 2018). Borrowers can use Moeda's P2P payment app to pay for goods and services. The borrowers are issued pre-paid debit cards, which allow monitoring of spending (Schiller, 2018). Entrepreneurs who receive loans pay interest rates of 15% with Moeda compared to 120% from other lenders.

Moeda's cooperative agriculture model allows it to capitalize on a community of local entrepreneurs. Moeda partnered with Unicafes, which has 100,000 members mostly small farmers in rural areas. The organization has stated that its aim has been to develop systems that allow investors to track project's progress and accountability in a transparent manner (Field, 2018). Theoretically if lenders want to invest in projects that have social impacts, they can do so (Isa, 2017).

In August 2017, Moeda raised US$20 million by an initial coin offering (ICO). There were about 2,000 token investors. US$10 million of that amount was allocated to funding projects. The ROI was expected in the 5%-10% range (Schiller, 2018). Most of the investors for the ICO were from China. Foreign investors can thus use blockchain tokenization to invest in Brazil.

MDA is on the Ethereum blockchain. MDA tokens are the standard ERC-20 token (Table 1). They can be stored in various wallets that are compatible with Ethereum (Anwaar, 2018).

Investors can buy Moeda's cryptocurrency MDA tokens and allocate to businesses through an app. Brazil's cooperative banks exchange the tokens for local currency. This model helps to minimize costs associated with currency change, regulations, and other obstacles (Schiller, 2018). Moeda can cut middlemen and increase operational efficiency.

A borrower was Hope Valley, a cooperative pumpkin and yucca farm and food processor in located in Formosa, Brazil. Moeda reported that Hope Valley received a six-month US$55,000 loan to pay for an irrigation system and food processing equipment, which increased its production by fivefold (Field, 2018).

WFP's Building Blocks

The World Food Program's (WFP) Innovation Accelerator started "Building Blocks" pilot in early 2017. In the first stage, food and cash assistance was provided to needy families in Pakistan's Sindh province. Starting May 2017, the WFP started distributing food vouchers in Jordan's refugee camps by delivering cryptographically unique coupons to participating supermarkets. Supermarket cashiers are equipped with iris scanners to identify the beneficiaries and settle payments. UN databases verify biometric data about refugees. Building Blocks' ledger records the transactions on a private version of the Ethereum blockchain: the Parity Ethereum. No banks are involved and beneficiaries thus receive goods directly from the merchants.

The Parity Ethereum used in the system employs four nodes to validate transactions (Stanley, 2018). This means that transactions cannot be seen by actors that are not a part of the authorized peer nodes. An additional benefit is that cryptocurrency mining process is not needed to validate the transactions. This feature removes a key bottleneck to the processing speed and transaction capacity (Wong, 2017). The system is designed to scale.

The WFP reported that by October 2017, it had distributed US$1.4 million in food vouchers to 10,500 Syrian refugees in Jordan (Kshetri and Voas, 2018). As of early 2019, 106,000 refugees in Jordan's Azraq and Za'atari camps received cash transfers in cryptocurrencies. By that time, 1.1 million cryptocurrency transactions transferred more than US$ 23.5 million to refugees (https://tinyurl.com/yy7neuo6).

When the applications reach at a more advanced development stage in the future, more benefits can be realized. For instance, the WFP expects that refugees may be able to access their funds by controlling their own cryptographic keys. This would also allow them to incorporate and integrate personal data from diverse sources. For instance, their medical records could be with the World Health Organization (WHO), academic credentials with the United Nations Children's Fund (UNICEF), and nutritional data with the WFP (Wong, 2017). In this way, they can build their economic identity.

Benefits and potential opportunities offered by blockchain-based fintechs and cryptocurrencies

Blockchain-based fintechs and cryptocurrencies can bring several benefits for the poor and disadvantaged groups.

Speed and efficiency

Processing speed and efficiency can be increased with cryptocurrencies. For instance, once refugees are registered, the WFP's blockchain system encrypts their data and vouchers are transferred almost instantaneously. In this regard, a key attractiveness of blockchain-based fintechs and cryptocurrencies is the ability to intervene in a fast and efficient way in societies that face the most difficult environments. For example, when vulnerable places that lack financial infrastructures such as ATM machines and banks face disasters such as earthquakes or storms, blockchain can help humanitarian organizations provide life-saving cash assistance faster

than other available means (wfp.org, 2017). Cryptocash (crypto tokens) can represent local currencies such as Pakistani Rupees and Jordanian Dinar that can be traded outside of the banking realm. The recipients can use the cryptocash to buy goods and services in participating shops. Cryptocurrencies can even replace scarce local cash, allowing aid organizations, residents, and merchants to exchange money quickly and electronically (Kshetri and Voas, 2018).

Hyperledger Fabric, which is used by Kiva and Moeda, also performs better than well-known cryptocurrencies in terms the speed at which transactions are completed. For instance, as of the early 2018, Hyperledger Fabric deployed in a single cloud data center had a throughput of over 3,500 transactions per second (TPS) with latency rate of less than one second (IBM Research, 2018). This compares favorably with the public Ethereum network's peak throughput 16 TPS (Hanada et al., 2018) and bitcoin's is 7 TPS (Yli-Huumo et al., 2016).

Creation of secure and authentic identity

According to the World Bank's ID4D database one billion people lack any form of identification to prove who they are. An additional 3.4 billion people have some types of identifications but lack the ability to use them in the digital world (White et al., 2019).

Existing ID systems are biased towards men. For instance, in Uganda, a 2014 study showed that only 63% of women had any form of ID compared to 83% of men (https://www.equaltimes.org/africa-s-invisible-millions#.XWnnZy5KjIU). A key advantage of blockchain-based IDs is that it can reduce the existing gender disparities in the access to IDs.

Blockchain- increases the ability to get a secure and authentic identity at a low cost (Table 3). Since ID cards in many countries are paper-based, which can be easily forged, blockchain solutions have significant potential to reduce fraudulent activities**.** In the WFP program, iris scan is used to verify refugee's identities (themerkle.com, 2019**)**. Each user's

account is linked to her/his iris. It is extremely difficult if not impossible for nefarious actors to falsify information or make up fake profiles to disburse the funds.

Table 3: Advantages of blockchain-based IDs

Dimension	Non-blockchain world	Blockchain's advantage
Availability and ability to get	Due to under-funded identification agencies, many governments are unable to implement identification programs in countries such as, DRC, Tanzania and Zambia. Zambia's Department of National Registration, Passport and Citizenship (DNRPC) has suffered from a severe lack of funds to run civil registration operations (IBRD/World Bank, 2017).	No need to rely on government agencies. Startups such as Humaniq's blockchain-based apps allow users with smartphone to create their own IDs.
Cost	Average cost of enrollment and registration for a national ID system per person: US$ 3-6, additional 15-25% per year for maintenance, software, and data updating. Card production and distribution: US$1-5 per person (Atick, 2015) Nigeria: conservative estimates US$ 5 per person for the identity lifecycle (IBRD/World Bank, 2017).	2018: the average cost of transaction in Ethereum network was US$0.03 (Yalovoy, 2018). To register a customer's identity, companies such as BanQu may need to execute few blockchain transactions.
Security and authenticity	Susceptibility to forgery and fraud: ID cards in many countries (e.g., the Madagascar, Sierra Leone, and Zambia) are paper-based, which can be forged. Zambia: National Registration Cards (NRCs) can be forged by substituting photos and altering texts. Sierra Leone: fraudulent birth certificate can be obtained easily (IBRD/World Bank, 2017).	Blockchain allows for a higher degree of security and authenticity

The availability and utilization of more relevant information to assess creditworthiness

Developing economies lack information about the creditworthiness of most of the population. For instance, Sierra Leone has one credit bureau that has information only on the country's 2,000 people (Crawley, 2019). Over 75% of Sierra Leone's population lacks access to formal banking services. People rely on informal institutions such as community banks and MFIs for their financial needs, which charge extremely high interest rates. They also do not share credit information (Inveen, 2019).

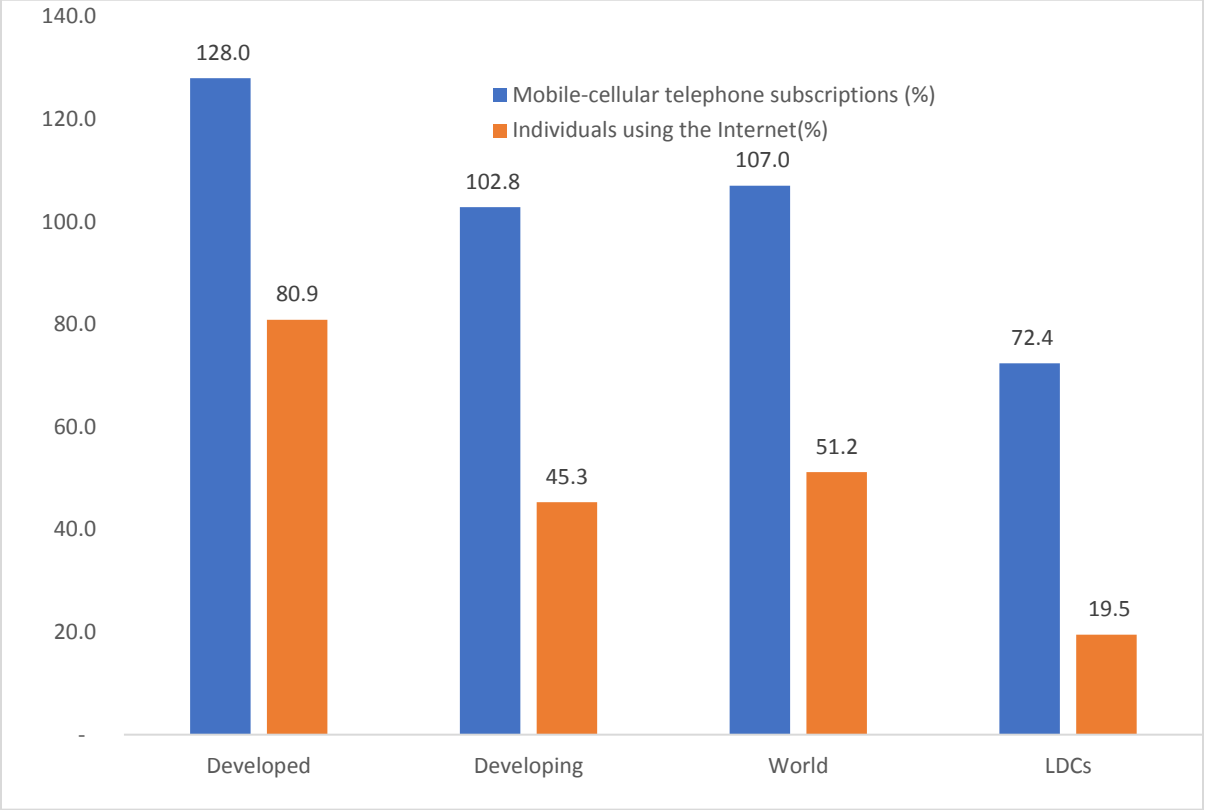
Large non-financial firms, especially from technology sectors--also referred to as TechFins--are leveraging their data asset aggressively in order to provide financial services (Zetsche et al. 2018). In many cases, however, TechFins' datasets originate from sources such as social media that are unrelated to financial services. Big data analytics used to predict potential borrowers' creditworthiness rely on correlations rather than causations. It is not easy to determine which correlations shown by big data tools are random and which ones may reflect responsible financial and consumption decisions (Zetsche et al., 2018).

A key benefit of blockchain-based application concerns the availability and utilization of more relevant information to assess creditworthiness**.** For instance, many women, small-scale farmers, migrant workers, refugees and displaced people receive foreign aid and humanitarian assistance from the United Nations or international non-governmental organizations. Some of them receive microfinance loans. Others participate in various training programs. The different categories of information are often stored in independent disjoint databases such as those of microfinancing institutions, the UN and relevant INGOs (Ramirez, 2017). Such data are unlikely to be captured by TechFins' algorithms.

Blockchain systems discussed above aim to capture and organize more relevant information compared to those used by TechFins. For instance, Kiva's blockchain system captures all credit-related events in a single ledger connected to a borrower's wallet. Likewise, BanQu's "economic passport" aggregates financial history and other information from a number of sources (Stanley, 2017). These blockchain systems use more fundamental rather than proxy attributes to characterize a potential borrower's ability and willingness to pay. Likewise future plans for the WFP's Building Blocks is to allow refugees and displaced people to control their

own cryptographic keys and integrate personal data sources such as the WHO, the UNICEF, and the WFP (Wong, 2017) in order to build their economic identity and creditworthiness.

Figure 1: Penetration rates of cellphones and the Internet in economies with various levels of development



Data source: International Telecommunications Union (ITU)

Even more importantly, financial and other forms of exclusions are more likely to affect non-users of certain services such as social media (Zetsche et al. 2018). Compared to wealthy individuals, larger proportions of poor people are non-users of cellphones, the Internet and social media, which are used by TechFins and fintech companies to analyze creditworthiness. For instance, in least developed countries (LDCs), which are low-income countries (Figure 1) that perform poorly in human assets and face high economic vulnerability (https://www.un.org/development/desa/dpad/least-developed-country-category/ldc-criteria.html), more than 27% of the population does not have cellphones and more than 80% lacks Internet

access. For the population that lacks any digital footprint, the initiatives such as those implemented by Kiva and BanQu might be the only way to make the information available to potential lenders.

Higher privacy protection and safer from misuse and abuse of data

Before proceeding further, it is important to stress that TechFins are emerging as an important source of lending activities for the poor. While banks store large amounts of consumer data on spending habits, strict regulations prohibit them from exploiting the data. Banks' lending decisions largely rely on standard industry scores. On the other hand, TechFins often exhibit a tendency to think they can store and analyze any data. Tech companies are subject to less strict regulations than banks and thus are more likely to engage in the abuse of personal information (Gapper, 2018). TechFins in the developing world have poor data handling practices due to political, regulatory and cultural conditions that are indifferent to privacy (Kshetri, 2016).

An additional point that deserves emphasis is that many tend to think that data privacy is something that only rich people need. For instance, 90% of the discussion at the 2013 Internet Governance Forum (IGF) held in Indonesia referred to big data as a surveillance tool. The debate focusing on developing countries, however, treated big data as a means to 'observe' people to fight poverty. The argument was that data can help provide key necessities such as drinking water and healthcare. Indeed, a contrary case could be made. In some developing countries, there are inter-ethnic, tribal tensions and violence. Some people are living in the aftermath of civil wars. In such countries, privacy breaches may lead to a physical risk (Letouzé, 2012).

A key advantage that blockchain-based models have over TechFins is that borrowers have controls over their information. For instance, in Kiva's digital identification system and BanQu's "economic passport" people get secure and complete ownership of personal information.

Lower cost solutions compared with other alternatives

The above solutions also have lower installation and operating costs compared to alternative technologies. For instance, in order to register a customer's identity, BanQu may need to execute multiple write blockchain transactions. In 2018, the average cost of transaction was US$0.03 (Yalovoy, 2018). According to Eth Gas Station, which provides a tool to calculate the GAS required for an Ethereum transaction, the cost to process a simple contract with a less than two minute lag was estimated at one fifth of a cent (Reynoso, 2017). With this rate, a million customers can be registered for a few thousand dollars. This is significantly less than Amazon's AWS's operating costs of thousands of dollars every month. Once the data is written, ongoing costs are insignificant because the costs to read data are very low (Reynoso, 2017).

Directly connecting lenders and borrowers and aid-givers and aid-receivers

Blockchain-based solutions make peer to peer lending possible by directly connecting lenders and borrowers thereby eliminating the need for intermediaries. As an example, consider Kiva. The company does not make direct loans. While some investors mistakenly think that Kiva offers direct person-to-person connections, it actually works with local MFIs as middlemen (Strom, 2009). Kiva says that it conducts audits of its Field Partners to ensure that poor people are not exploited (Barry, 2012). However, due to high overhead costs and other sources of inefficiency, Kiva Field Partners charge exorbitantly high interest rates. For instance, a Kiva Field Partner in Senegal was reported to charge an interest rate of 40% (femalefounderstories.com, 2019).

Such loans could be made more affordable by eliminating the middlemen such as Kiva Field Partners. In this regard, programs such as Kiva's blockchain-based IDs are a first step towards improving access to finance for the poor. True decentralization will be complete

when impact investors and philanthropic funders can directly reach the poor with cryptocurrencies.

Similar benefits can be achieved in the systems used to distribute donations and aids. For instance, the WFP expects that blockchain-based solutions would reduce its overhead costs from 3.5% to less than 1% (Kshetri and Voas, 2018). What is even more important is that an estimated 30% of development funds do not reach the intended recipients due to problems such as third-party theft and mismanagement (Paynter, 2017). Blockchain holds a great potential and promise to reduce such practices.

Challenges in using blockchain-based fintechs and cryptocurrencies

There are many challenges and obstacles that need to be overcome for a widespread adoption of blockchain-based fintechs and cryptocurrencies.

Limited resources and capability of startups

A commonplace observation is that most ICO projects such as those of Humaniq and Moeda are initiated by small groups of engineers that have little or no experience and understanding of real-world business practices (Wagner, 2017). Moreover, startups that have launched fintechs and cryptocurrencies for the poor have limited resources and capability to design products that poor can benefit. The relative lack of success of the startups can also be explained by a difficulty that they face in competing for the market against more established companies. For instance, the fintechs and cryptocurrencies discussed above may find it difficult to compete with Facebook's Libra cryptocurrency, which is planned to be launched in 2020. Facebook's WhatsApp has already been testing a new feature called WhatsApp Pay, which lets users send money directly to each other's bank accounts. It is only available in India, where there were 1 million users in early 2019 (https://www.pymnts.com/facebook/2019/libra-wallet-markets/). Fintech firms such as Coinbase and PayPal, which are Libra Association's founding

partners, may include Libra in their wallets. The plan is to run Calibra inside WhatsApp and Messenger.

WhatsApp is available in up to 60 languages on Android (whatsapp.com, 2019). In India, alone WhatsApp provides messaging in 13 languages (Kshetri, 2019). Humaniq app is offered in English, French and Swahili (https://bitcointalk.org/index.php?topic=1711764.4065;wap).

Some startups have planned training and development to bridge skill gaps. Prior researchers have found the chance of adopting a technology increases if a farmer's network has someone who has already adopted it (Van den and Dercon, 2011). Humaniq's regional ambassadors aim to educate users in order to encourage the adoption of its apps. Ambassadors in some African countries are already doing this (Church, 2018). However, there are too few ambassadors to facilitate the information flow and adoption of Humaniq apps. For instance, by June 2019, Humaniq listed a total of 15 ambassadors on its website (Humania, 2019). Seven of them were from Tanzania. Most countries in which Humaniq was operating that time did not have any ambassadors.

Complexity of technology making it difficult to grasp

Poor people in developing countries lack necessary skills to utilize and benefit from technologies such as blockchain. For instance, some estimates suggest that half of the populations of developing countries cannot speak an official language of their own country (Kenny, 2003). The challenges related to poor information flow are even more daunting for blockchain applications due their high degree of complexity. Blockchain-based fintechs and cryptocurrencies are more complex and more difficult to understand compared to traditional financial solutions. This is even more so for the poor people in the developing world, who lack technological skills. Practitioners in the field have observed that individuals in Africa handwrite

their debit card PIN numbers on the card itself in order to make sure that they would not forget them (Stanley, 2017).

More user-friendly apps can facilitate information flows and communications to increase the adoption of the above apps. However, efforts have not been undertaken to develop poor-friendly apps. A related mechanism that can facilitate information flow would be to make sure that there is someone who can educate users regarding the benefits of blockchain-based fintechs and cryptocurrencies and how to use the apps. In this regard, while Humaniq's plan to appoint regional ambassadors is a good idea. As noted above, the implementation, however, has not been successful.

Lack of connectivity

Poor people's ability to benefit from blockchain-based fintech and cryptocurrencies is hindered by the lack of connectivity. According to the International Telecommunication Union (ITU), Least Developed Countries (LDCs) had a cellphone penetration of 72.4% and the Internet penetration of in 19.5% in 2018 (https://www.itu.int/en/ITU-D/Statistics/Pages/default.aspx) (Figure 1). Only 15% of Sierra Leone's population has Internet access. Kiva's partners such as banks are expected to set up Internet hotspots for borrowers to access their private keys (Ledger Insights, 2019). However, it is yet to see whether this action would be taken by Kiva's local partners.

Lack of supporting technologies and infrastructures

Developing economies are characterized by low quality physical capital such as the infrastructures, plant, equipment and information technology (Dorward et al., 2003). Blockchain startups find it difficult to build well-developed ecosystem around their products. These conditions do not allow the maximum utilization of fintech products and cryptocurrencies. For instance, Moeda White Paper claimed that it will combine Ethereum

with machine learning (ML), artificial intelligence (AI) and the Internet of Things (IoT) (Reis et al., 2017). However, the company does not seem to utilize any of these technologies. To build and maintain an IoT system would typically require a large investment in software infrastructure and local skill development. Even if such systems are set up with outside helps, small farmers cannot perform technical tasks such as troubleshooting and maintenance.

Unfavorable market and institutions

Unfavorable markets and institutional arrangements act as major impediments that prevent poor people from maximizing the potential of blockchain-based fintech and cryptocurrencies. Developing economies lack contract enforcement procedures, property rights and standards (Dorward et al., 2003).

These unfavorable conditions make it difficult for the poor to benefit from blockchain-based fintech and cryptocurrencies. For instance, Humaniq claimed that new users can buy phones for as little as US$10 and start earning money immediately within a few weeks by performing tasks for outsourcing firms (NewsBTC, 2017). Humaniq app's Business Chats allow users to access a marketplace and buy and sell goods and services using HMQ. The company also wants to connect companies with the financial services sector and local enterprises.

This approach, however, necessitates the highly unrealistic assumption that sufficiently high number of companies will be engaged in business activities with poor people as long as they have Humaniq IDs. This assumption is highly questionable in general. For instance, companies are reluctant to outsource to countries that lack privacy protection and have poor data integrity and cybersecurity practices (Jandhyala, 2013). There have been many instances of data breach in outsourcing destinations that have affected Western firms. To take an example, in 2003, a Pakistani medical transcriber working for a U.S. based medical center

threatened to post confidential voice files and patient records on the Internet if her pay was not increased (Kshetri, 2005).

Stockholder centric bias in the actions of blockchain start-ups

There has been an increased pressure to meet stockholder expectations (Porter and Kramer, 2002). Unsurprisingly the actions of blockchain startups that have launched fintech products and cryptocurrencies seem to be more investor-centric and less consumer-centric. A technology start up writer noted that "many of the highly publicized ICOs have yet to carry out much beyond upgrading the lifestyles of their founders and promoters" (Wagner, 2017).

The startups discussed above have adopted strategies to increase profitability for investors. For instance, Humaniq tokens have been listed on many exchanges to facilitate their buying and selling (coinidol.com, 2018). Likewise, while Moeda claims that it combines microfinance, crowdfunding and blockchain to help the poor (Reis, 2018), it has focused on larger loans to increase profitability for investors. Indeed, Moeda's loans, are too big to be considered to be micro-loans. Small size micro-loans lead to high administration costs for lenders (Murray, 2019). As of January 2018, it had invested in 18 projects. Loans ranged from US$50,000 to US$300,000 (Field, 2018). From a comparative perspective, Kiva's average loan outside the U.S. is US$400. In the U.S., the average request is US$7,000 (Ravindranath, 2013). Likewise, the network of microfinance institutions VisionFund's average loan size worldwide was US$495 (Vision Fund, 2019). The average loan sizes for Asia and Africa were US$313 and US$323. According to Brazil's central bank, microfinance loans are those that are smaller than BRL 15,000 (US$4,700) (iupana.com, 2018).

Big companies such as Anheuser-Busch can benefit tremendously from blockchain's use to promote supply chain transparency and traceability. Blockchain can help to guarantee the quality of products with relevant data. Making digital payments to farmers may lower the costs

associated with payments. Blockchain is being used by some firms to enhance reputational value by demonstrating their ability to innovate and increasing consumers' perception of food safety (Higginson, Nadeau, and Rajgopal, 2019).

Poor people's limited power and financial/social capital

Poor people have limited power or financial and social capital (Dorward et al., 2003). Social capital is defined as "features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating coordinated actions" (Putnam, 1993). Poor people's networks often just consist of other poor people**.** This means that powerful social and political actors, such as policy-makers and NGOs are less likely to pay attention to indicators related to whether the projects are achieving their stated goals of helping the poorest people. This is likely to be the case even when these actors notice poor performance indicators of the projects in terms of helping the poor and know what they mean. They may also know what they are supposed to do under these circumstances.

A Medium article by the Editor of Moeda Seeds claimed that the "investors know all the details of how their money is spent in each Seed Project, directly from Moeda's website" (João, 2019). However, the link provided--https://moedaseeds.mybluemix.net/7a1e1a65-7d0f-446d-801f-edbf7e77407e--listed two projects--Cooperval Craft Beer and Sustainable Coffee Seed Project—each with few details. Key pieces of information including the investment amount is missing in the Cooperval Craft Beer project. For the Sustainable Coffee Seed Project, it is stated that Moeda "is going to invest US$ 13,000". After more than two years of launching a US$20 million ICO, Moeda provided limited details regarding how investors' money has been invested. This defeats the primary purposes behind using blockchain, which is described as a trust machine.

An upshot of increased pressures to meet stockholder expectations is that philanthropy activities have been declining (Porter and Kramer, 2002). In many cases, the stated benefits for the poor are conditional rather than guaranteed. For instance, small holder farmers that supply crops to Anheuser-Busch may theoretically enjoy additional benefits (e.g., getting low-cost loans from financial institutions) using their identity and transaction information put on BanQu's blockchain. However, constraints related to information flows, transaction costs and market access would prevent them from realizing such benefits. For instance, the farmers may not be able to present the information in a way that meets the requirement of banks. They may also lack persons in their social network who possess capability to understand the various available loan services. Due to the lack of education, many potential borrowers cannot fill out loan applications. Poor people often need loans in small amounts. It is costly for financial institutions to deal with small transactions. In some cases, poor people may face prejudice and stereotypes. Some banks refuse their admission to bank branch offices (Thorsten, Demirgüç-Kunt, and Honohan, 2009).

Concluding comments

Fintechs and cryptocurrencies for the poor are among the most intriguing applications of blockchain. For instance, transparency and accountability can be improved by giving cryptocurrency vouchers to refugees instead of cash. Blockchain-based economic history can address problems associated with poor record keeping technologies and authentication models in developing countries.

However, it is not clear whether the startups focusing on fintechs and cryptocurrencies are achieving their stated goals of helping the poorest people. In some cases, their user base is considerably lower than their stated expectations. Humaniq's goal was to attract 1 million App users in 2018 (decentral.news, 2018). This target was not met even by June 2019 (https://play.google.com/store/apps/details?id=com.humaniq.lite&hl=en_US).

The startups lack resources or technical expertise to develop solutions that are useful for poor people. An ecosystem has not been developed around blockchain-based fintechs and cryptocurrencies because of a number of fundamental impediments. Highly unfavorable economic and infrastructural contexts make it unprofitable to serve the poor. Unsurprisingly the results in most cases have not been far from promising.

The startups' claims are also based on unrealistic assumption that partners in value chains (e.g., buyers of agricultural commodities) and those in economic networks (e.g., banks and MFIs) also adopt the fintechs and cryptocurrencies and engage in economic transactions with poor people. This is a convenient assumption, but it has been contradicted by the fundamental reality on the ground. This is due in part to the fact that most ICOs are initiated by individuals with little or no experience and understanding of real-world business practices. Network effects do not exist due to the lack of sufficient users. In the absence of network effects and a thick market to ensure poor people's access to broader economic system, the expected benefits cannot be captured.

The best explanation for the relatively little success of blockchain-based solutions to expand financial inclusion has less to do with the technologies than with the lack of users' skills and availability of opportunities. More user-friendly app can facilitate information flows and communication among different parties. Cryptocurrencies such as Libra may encourage better information flow and thus facilitate effective response from poor people.

Big companies' needs are often the key determinant when blockchain solutions are developed to connect the poor. They have skills, resources and financial capacity to benefit from these technologies. However, those benefits are conditional on poor people having skills to utilize the technologies and the existence of opportunities for them. The lack of well-developed

ecosystem around blockchain-based fintechs and cryptocurrencies hinders their ability to take full advantage of these technologies.

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