CGAP

BRIEF

Exploring Blockchain Applications to Agricultural Finance

The rapid pace of technological transformation across the developing world has important implications for the financial inclusion of the world's poor. Amid this change, new technologies that enable inclusive agricultural finance have garnered heightened interest. From mobile phones to drones, digital tools may one day overcome longstanding barriers to reaching the world's 500 million smallholder farming households (Christen and Anderson 2013).

Identifying use cases for emerging technologies to reach financially excluded smallholders means looking beyond the hype to develop a clear understanding of these technologies' unique features, costs, and benefits. And because few innovations have generated as much hype as distributed ledger technologies (DLT), more commonly referred to as blockchain,[1] CGAP set out to understand how this emerging technology could enable broader and more inclusive markets for agricultural finance. This Brief summarizes CGAP's approach and offers insights into the applicability of DLT to agricultural finance in a developing country context. Importantly, this Brief does not attempt to provide comprehensive background on the technology itself—additional resources are provided for readers who would like a deeper understanding of this evolving space.

Understanding DLT

Before analyzing how DLT can be applied to agricultural finance, it is important to understand the nature of the technology itself. First, as the name suggests, DLT is built around the concept of a ledger, or shared record of transactions. However, unlike traditional ledgers that are maintained by a trusted third party (e.g., government land registries, credit bureaus), DLT theoretically provides a mechanism for creating a shared record of transactions among several institutions or individuals in the absence of a trusted arbiter.

What makes DLT unique?[2]

- It is **distributed**. Peer-to-peer communications are used to record, share, and synchronize ledger data among multiple devices referred to as "nodes."
- It includes a mechanism for achieving **consensus**. Information can be added to the shared ledger only when the participating nodes reach a consensus that the transaction is valid. There are several ways to achieve this consensus, but the aim is to avoid the need for a central authority.[3]
- It is **programmable**. Software applications (often referred to as "smart contracts") can be embedded into the ledger and programmed to execute a specific task when certain conditions are met—for example, initiating a payment from buyer to supplier upon delivery of a good or service.[4]

DLT can take many forms, with key differentiators, including whether participation in the ledger is open to the public or restricted to certain parties. Additionally, both public and private ledgers can include permissions, which provide participants with specific privileges and capabilities as they pertain to key functions, such as reading and writing data to the ledger or contributing to consensus.

The best known DLT, the Bitcoin Blockchain,[5] is an example of a public, "unpermissioned" ledger, in which anyone can view data on the ledger, write new transactions, and participate in building consensus around the validity of a given transaction. On the other hand, many emerging DLT implementations in the financial services industry are private, permissioned ledgers.

Of course, assigning permissions and limiting participation to a select group raise important questions about the core advantages of DLT, which was originally intended to be a mechanism for overcoming a lack of cooperation and trust. Private or consortium ledgers still require participants to cooperate in the management of the DLT and to agree on a set of governance rules. At the same time, permitting only select participants to read, write, or validate data on the ledger potentially reintroduces some of the same trust issues that exist in a conventional ledger—namely, that one or more parties must be trusted to maintain the ledger's integrity. While the sensitive nature of data written to distributed ledgers in some use cases (e.g., financial records) limit the viability of public, unpermissioned ledgers, the decision to add restrictions involves trade-offs that have important implications for the use of DLTs where there is a lack of trust and weak institutional capacity.[6]

Applicability of DLT

DLT pilots and proofs of concept are underway across a range of applications, including financial services and supply-chain management. But despite the hype surrounding DLT, a thorough understanding of its limitations and careful evaluation of its applicability are important to any successful implementation.

Where there is a strong, trusted, third party that has the capacity to manage a centralized ledger, the anticipated benefits of a DLT-based solution over a more conventional approach should be weighed against the costs and risks of implementing this still nascent technology.[7] Furthermore, lack of trust in and of itself may be a barrier to effective DLT implementations. For example, some applications will require several organizations—which may be in the public and private sectors, direct competitors, or from different industries—to work together to establish and maintain systems and governance structures. Trust in

1 The terms "blockchain" and "distributed ledger technology" are often used interchangeably. But blockchain is only one type of DLT (see R3 2017).
2 For an overview of the technology and its potential development applications, see Nelson (2018) and Natarajan et al. (2017). For a glossary of key terms, see Reuters (2017).
3 For more on distributed consensus, see Seibold and Samman (2016).
4 For more on the use of smart contracts in DLT, see SWIFT (2016).
5 For a history of the Bitcoin Blockchain and DLTs, see Iansiti and Lakhani (2017).
6 For more on the debate over the use of private, permissioned ledgers in financial services, see Irrera (2015).
7 For a perspective on the limitations and costs of using DLT for development applications, see Pisa (2018).

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Table 1. Framework for evaluating the relevance of DLT to a given use case

Benefits of DLT	Does this use case require. . .
Transparency	Shared data among several parties?
Shared Control	Collaboration across sectors, industries, or with competitors for common benefits?
Disintermediation	Two or more parties to make an exchange without the intermediation of a third party?
Immutability	An immutable record of transactions that can be used for financial audit, provenance, or any other compliance with regulation?
Reduced Transaction Costs	Low transaction costs?
Resilience	A high degree of resilience with no single point of failure?
Interoperability	The ability for participants on different networks and using different systems (one of which is based on DLT) to transact directly with one another?

data written to the ledger is another potential roadblock, because participants need to trust that the data were entered correctly and completely. Additionally, in cases where the data represent a physical asset (e.g., land, crops, livestock), DLT alone does not prevent the asset from being altered or transferred without corresponding changes being made to the ledger. This raises another concern: What legal or regulatory framework would be required to enforce transactions or other agreements that are recorded on a DLT?

Adding to the issues surrounding the viability of DLT in developing countries is the sheer complexity of these new technologies. Poor connectivity, a lack of computing power required to run a node, low penetration of devices that can interact with DLT (e.g., smartphones), and limited technological skills are all potential obstacles. Also, because DLTs are nascent and rapidly evolving, their interoperability with one another and their ability to integrate with existing systems represent additional challenges.

Table 1 offers some guidance for those seeking to evaluate the applicability of DLT. The evaluation criteria consist of seven key questions related to the features of DLT. This framework is qualitative and there is no set number of criteria that a use case must meet to warrant further consideration. For certain use cases, it may be important to answer yes to each of the questions in Table 1, while in other cases, the potential for DLT to meet one or more of these criteria may be sufficient. The weight assigned to any one criterium depends on the importance of its related benefit to enabling a given use case.

Opportunities in agricultural finance

Lack of formal identification, collateral, and credit histories; difficulties in contract enforcement; and the high cost of serving geographically dispersed customers are just a few of the myriad obstacles standing between smallholders and formal financial inclusion. The inability to access formal financial services affects the efficient functioning of agricultural value chains because producers may be unable to maximize their yields and buyers may struggle to ensure an adequate supply of agricultural commodities. Financial services not only allow smallholders to invest in their farms, they can help to relieve liquidity constraints that make it difficult for buyers to pay farmers on delivery and force cash-strapped smallholders to sell their crops at lower prices in exchange for faster payment.[8]

When evaluating the applicability of DLT to agricultural finance using the proposed framework, several features of the technology emerge as particularly relevant. The need to share information across several parties—including between the public and private sector, among competitors, and across industries—means that both transparency and shared control are important benefits of DLT. Disintermediation can also help to overcome barriers to agricultural finance, because business agreements can be enforced when there is no third-party intermediation. Last, but not least, the use of DLT to verify the identity of smallholders is fundamental to each of the identified use cases (see Box 1).

Box 1. The role of digital identity in DLT solutions

One of the benefits of DLT lies in its potential use of cryptography to verify ownership of data stored on the ledger and used to fulfill know-your-customer requirements. For example, identifying data such as a birth certificate could be written to the ledger and signed using a customer's cryptographic "key pair" (consisting of a public and private key).[a] This helps to prove that the data belong to the individual holding the corresponding private key. In turn, this key pair can be used to prove the customer's identity when opening a financial account or performing a transaction. Such applications also open the door to creating "self-sovereign" identities, in which individuals choose when and what data they want to share with other parties.[b, c]

However, while DLT can assist in authentication, identity management, and user control, it is not sufficient as a standalone solution for proving identity. Indeed, a DLT-based digital identity still depends on a "real world" ID to which it is linked when it is created (e.g., birth certificate, national ID, passport, etc.) (Yaga et al. 2018). Therefore, lack of formal identification may remain an obstacle in certain contexts.

a. Vryanis (2013) offers a concise, clear explanation of public key cryptography.
b. For more on digital identities, see Singh (2017).
c. For more on self-sovereign identities, see Tobin and Reed (2017).

8 For more information on how technology and financial services can improve the efficient functioning of agricultural value chains, see Mattern and Ramirez (2017).

Based on the proposed framework for evaluating the potential of DLT use cases, there may be several use cases for DLT in agricultural finance.

Collateralization. The collateralization of assets such as land, livestock, machinery, warehoused crops, or even payments owed to smallholders for produce pledged or delivered could enable smallholders to access financing for inputs, working capital, and post-harvest liquidity. By creating digital records of these assets on a distributed ledger (e.g., land registries, moveable asset registries, warehouse receipts, invoices), financial services providers (FSPs) may be amenable to lending that is based on this collateral. Relevant features of DLT include transparency (ability of several parties to view assets on the ledger), shared control (ability of competing financial institutions to use the ledger), and disintermediation (ability to use smart contracts to automate the transfer of ownership of assets in the event of default without the intervention of a third-party).

Supply Chain Management. Data on smallholder agricultural production could be stored on a distributed ledger and used to track the provenance of agricultural commodities. This may allow for certifications such as fair trade and single origin, which in turn, increase the value of commodities for stakeholders along the value chain. Storing production records on a distributed ledger may also unlock new opportunities for smallholders to obtain credit from FSPs. Relevant features of DLT include transparency (ability of value-chain stakeholders to view the movement of goods through the value chain) and immutability (ability to determine provenance of goods).

Credit Bureaus. FSPs often lack information about smallholders' creditworthiness. Recording smallholders' borrowing and repayment histories in a decentralized credit bureau could open new opportunities for financing. Importantly, DLT could be used to record loans extended by value-chain actors such as off-takers and agridealers, which typically are not visible to the financial sector. Relevant features of DLT include transparency (ability of multiple financial institutions and value-chain actors to view individual credit histories), shared control (ability of competing lenders to collaborate in maintaining the credit bureau), and disintermediation (ability to create a trusted record of lending transactions in the absence of a central authority).

Contracts. A lack of formal, enforceable contracts between smallholders and the buyers to whom they have pledged their crops can lead to situations in which these smallholders choose to sell to a third-party (side-sell). This means that such agreements are often of limited utility when seeking to access financing from a financial institution. Posting contractual agreements on a distributed ledger in which all major buyers in a value chain are participants could help mitigate side-selling and allow smallholders to use the agreements as a guarantee of repayment when applying for credit from formal financial institutions. Relevant features of DLT include transparency (ability of financial institutions and buyers to view pledged crops), shared control (ability of multiple, competing buyers and financial institutions to cooperate in maintaining the ledger), and disintermediation (smart contracts allow for enforcement of agreements in the absence of a trusted third party).

Design considerations

Given the unique characteristics of agricultural contexts, a DLT solution would need to be designed accordingly. The following factors determine what design features would be most appropriate:

- **Capability of the smallholder**. Smallholders may not have the capacity or devices such as smartphones that are required to interact directly with a distributed ledger.[9] Therefore, it is expected that transactions involving smallholders would be, at least initially, largely "on behalf of" or "over the counter." The DLT will need to support an access control layer to manage different roles and permissions.
- **Privacy of sensitive financial and personal data**. Information about smallholder financial and agricultural transactions that will be recorded by the DLT is likely to be sensitive. Therefore, data on the ledger should be encrypted and available only to users with the appropriate permissions.
- **Overall governance and control**. Clear rules for participation in and maintenance of the DLT (including system upgrades and protection against attacks) will be important to ensure that the actors involved have confidence in and trust the DLT-based infrastructure. Appropriate governance will be necessary to set the rules by which the system will operate.

Based on these considerations, it is likely that permissioned public ledgers or permissioned consortium ledgers would work best in the context of smallholder agriculture.

From theory to implementation

DLT is more than just a new technology. It represents a change of mindset and a shift in how individuals and institutions interact. It provides a means to build a distributed system of records with a high degree of transparency and robustness, without the need to rely on a central authority or trusted third party. Theoretically, DLT is most applicable to systems in which several actors wish to cooperate, but do not have a high degree of trust in the other participants. Agricultural finance, which encompasses a diverse set of actors and suffers from information asymmetries that undermine efficiency, offers several potential applications.

However, as with any new technology, several obstacles will need to be overcome before DLT can be deployed at scale to unlock financing along agricultural value chains. Access to a reliable electricity supply, sufficiently powerful computers, and 3G coverage are essential for DLT to function properly—and this can be a challenge in some remote rural areas. Additionally, technological literacy will pose a significant hurdle as participants interact with a technology that remains poorly understood even in the developed world.

Trusted actors that ensure the smooth functioning of DLT is paramount—even in a system designed to operate without third-party intermediation. Setting up the DLT, recruiting participants, and developing the rules on which the system runs calls for cooperation between participating institutions and would likely require technical and financial

9 CGAP found that an average of just 5.5 percent of smallholders across six markets surveyed owned a smart phone(Anderson 2015, 2016).

support from outside actors such as donors. One or more actors would need to be trusted to manage the cryptographic keys tied to customer identities (including their issuance and mechanisms for dealing with lost or compromised keys).

Smallholders who lack internet-connected devices like smartphones would need to rely on a third party to read and write data on their behalf, while participants such as financial institutions would need to trust that data entered by others are accurate (e.g., did the warehouse properly record the quantity of grains stored by a farmer seeking to borrow against its value?). Governments would also need to put in place appropriate legal and regulatory frameworks that recognize the use of digital ID to meet know-your-customer requirements, recognize records of asset ownership stored on the ledger, and provide enforcement mechanisms for DLT-based contractual agreements.

Any DLT solution for agricultural finance should be as simple and straightforward as possible and should not pretend to have eliminated the need for some degree of shared trust among participants. In some cases, industry and the public sector may choose to test certain principles of DLT, such as cooperation around maintaining a shared ledger, in a controlled context where strong third-party enforcement would not require a full DLT implementation. Otherwise, initial attempts at implementing DLT solutions for agricultural finance should focus on a robust minimum viable product—for example, a distributed ledger that allows a small number of banks to record formal loans to their existing customers. Over time, as the technology is proven and early issues are ironed out, more participants and types of data can be added, thereby facilitating a greater number of use cases and increasing the overall contribution of DLT to smallholder financial inclusion and the efficient functioning of agricultural value chains.

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