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Blockchain and the Movement of Value in Africa

Enforceable contracts, strong credit systems and robust property rights are often cited as critical factors required for any country or region to accelerate its development. While impressive development progress has already taken place in Africa, our research leads us to believe that obstacles (and opportunities) currently still exist around the movement of value.[a] In some cases, this is merely an efficiency argument: for example, "How can costs be minimized in transferring money from one person to another, and reduced to the level of simplicity of sending an email across the world?" However, in other situations the challenges are far more complicated, since they can include multiple stakeholders with widely varying incentives, substantial sums of money and contractual layers. These factors ultimately drive a lack of transparency and shortage of trust in many mechanisms that transfer value today.

Blockchain technology and the use of distributed ledgers that are cryptographically secured can potentially ameliorate some of these issues and lead to better outcomes for all of the principal parties. In the optimistic scenario, a well implemented blockchain technology solution underpinned by a strong incentive system can create a system of trust and transparency that completely removes the impact and influence of bad actors. In a pessimistic scenario, however, blockchain technology may also be an incremental solution that might solve some of the existing issues—but could also create additional problems. Notwithstanding that concern, given the attention to the technology and its promise, blockchain technology is worth considering further as a disruptor to alleviate some of the issues.

This note provides a basic introduction to blockchain technology and some of its core features such as smart contracts, describes some of the more pertinent problems around the movement of value in Africa, and postulates what (if any) solutions can be driven by blockchain technology.

[a] In this context "the movement of value" means anything that relates to the flow of money. Specific examples used in this context include remittances, foreign aid, SME financing. Satisfaction of contracts for delivery of goods and services could also be applicable.

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Blockchain Technology and its Features

Short Introduction to Blockchain Technology

Blockchain technology first appeared in the mainstream consciousness when a mysterious white paper surfaced titled "Bitcoin: A Peer-to-Peer Electronic Cash System,"[1] in the wake of the global financial crisis of 2008. The first use case for blockchain technology was Bitcoin, an electronic peer-to-peer method to send digital money between parties without the need for a financial intermediary like a bank. Bitcoin was able to disintermediate the need for trust amongst its participants, while providing the security and a source of truth in an open ledger that would prevent fraud within the network. However, while often confused with the underlying technology, Bitcoin is merely one of many potential use cases for the blockchain technology.

More broadly, blockchain technology[2,3] is a digital distributed ledger that provides an immutable record of transactions and information where the record is fraud proof. Transactions and information on a blockchain are cryptographically secure and are virtually impossible to change, due to its underlying architecture. The distributed element implies that rather than having a central actor that governs the network, a group of computers called nodes govern the network. It is important to note that more times than not, these nodes do not know each other in real life. Instead, through a system of incentives, they all follow the same rules to maintain the network. Most blockchain projects open source their code for download, and theoretically anyone operating the code on their computer can become a node. This level of decentralization works because all nodes are governed by the same lines of code or "protocol" on the blockchain. The protocol functions as the "rules" of a particular blockchain, and since all nodes run the same code, agreement on a specific transaction is reached when a majority of the nodes agree on the latest state of the transaction and ledger. This process to reach agreement is also known as achieving consensus.

Today, many blockchain projects have evolved beyond the initial use case of a digital currency. Second to Bitcoin in popularity, another critical blockchain project is Ethereum, a project that many consider to be the future of blockchain technology. Ethereum employs a similar architecture to Bitcoin; however, instead of a digital currency use case, it functions as a massive distributed and decentralized computer. Ethereum uses the concept of smart contracts, a protocol encoded by any user to digitally facilitate, verify, or enforce the performance of a contract.[4] While simple contracts enacted by two parties who know each other are straightforward and carry minimal / known risks, the advent of smart contracts allows users across the world (who may not know each other) to "do business" with each other (with confidence in the transaction record) by employing the underlying blockchain architecture. In theory users can trust the outcome of smart contracts without a third party governing the performance of the contract.

The blockchain architecture design delivers a few core value propositions regardless of the use case. Blockchain technology offers transparency, decentralization, and immutability which all lead to greater security and trust.[5] Transparency is ensured by universal access to the transaction data on a particular blockchain, and therefore data can be audited. Decentralization comes from the fact that blockchain technology is distributed, hence multiple computers or nodes have to agree and validate that the transactions being proposed to the system is indeed correct, because they progress to the latest and greatest state of the ledger. Achieving consensus largely depends on the specific blockchain's design, which is a function of both rules and the incentives behind its protocol.

The immutability aspect of blockchain technology potentially makes it appealing in industries and geographies where fraud and corruption are prevalent. In a traditional database structure managed by

a third party, users may be at a disadvantage if the third party changes details on their own ledger. In a blockchain scenario, to change any details, consensus must be reached (the majority of all the nodes must confirm). In this state of the world, a bad actor would either have to take over a majority of the nodes or convince a majority of individuals running the nodes to change the state of a specific blockchain—while it is theoretically possible, it is virtually impossible.[6] Further, security comes from using cryptography to secure the data and transactions within a particular blockchain. To change any transactions, a bad actor would have to get the majority to change the information and also hack the individual private keys (analogous to secured PINs and passwords) that only a user knows.

A Closer Look into Smart Contracts

While the term *smart contract* existed before blockchain technology, smart contracts governed on a blockchain represent a huge opportunity to drive efficiency and eliminate unnecessary participants and middlemen who drive leakage in transactions and systems. A smart contract is like any other contract in that terms and conditions are entered into by two or more parties; however, the facilitation, execution, verifiability and enforcement of the contract is done digitally without the need for a third party to track performance or execution.

A common analogy used for a smart contract is to compare it with how vending machines work. A vending machine's "smart contract" is programed to only execute on the instructions given to it.[7] This means, it can only accept a certain type of currency (coins, certain bills, etc.), and allows the user to only key in a limited selection. Once the first two conditions are satisfied and executed by the user, in return the user receives the item. In blockchain technology vernacular, assets and contract terms are coded and put into a particular blockchain. The contract is distributed across all the nodes on that specific blockchain platform. After the triggering event takes place (as stated in the contract) and the contract is performed in accordance with the terms, the code verifies the performance and executes the corresponding condition (i.e., once all conditions are met, party A gets their payout, etc.). In both the vending machine and the smart contract scenario, this is all executed without a third party administrator or facilitator.

One of the most common standards to code smart contracts is on the Ethereum Blockchain. Ethereum provides developers with tools to create smart contracts and to build decentralized applications. In practice, smart contracts are most effective when the inputs and outputs of the contract are electronic as it does not require real world engagement.[8] For example, if Alice and Bob wanted to enter into a contract[b] with the following conditions, they can use a smart contract.

Alice and Bob want to enter in a bet, for example: If the weather next Monday is 50 degrees or colder, then Bob will send Alice $100.

Alice and Bob specify which source of data their smart contract should pull from to determine whether the weather is 50 degrees or colder. Once they agree to this and post the contract, all nodes on the Ethereum platform will hold a copy of the contract with the corresponding code.

When Monday arrives, each node will execute its contract code at the pre-determined time and pull the data from the specified data source. Each node will confirm whether the condition "50 degrees or colder" is true or not, according to the agreed source. Once all the nodes arrive at consensus and confirm that the conditions are met, the code will execute and withdraw $100 from Bob's account and send it to Alice's account, if Alice's condition is true.

[b] Example is derived/adapted from article in Endnote viii with minor changes.

This entire process is recorded on the Ethereum Blockchain, creating a common digital history.

This is a simple illustration, but one can imagine the many use cases that can be implemented with smart contracts. In this example, there is no need for a third party bookkeeper or arbiter for market making as all the conditions in the contract are coded and agreed upon in advance. The code will just check the conditions in the contract and execute accordingly.

An important concept to understand is how the input data is gathered and verified by the smart contract. Smart contracts do this through a mechanism called oracles.[9] An oracle is an agent that finds and verifies real-world occurrences and submits this information to a specific blockchain to be used by smart contracts[10]. In the example above, Alice and Bob will only need a software oracle, and everything can be kept digitally.

In other use cases, for example smart contracts in the context of supply chains, hardware oracles are needed. Examples include IoT devices that provide monitoring data, and sensors in factories that can track the movement of goods. In other scenarios where software and hardware oracles do not exist or may not function perfectly as intended, Consensus Based Oracles need to be used. To confirm a particular outcome, multiple oracles may be used, where a majority or unanimous confirmation determines the outcome of an event. For example, Augur,[11] a blockchain based betting platform, used a consensus based oracle system, such that its oracles confirm the occurrence of events. To do this, its oracles hold Augur's native token, REP. Specifically, oracles will report[12] that an event either happened or it didn't and will stake a certain number of REP tokens. If an oracle reports the same outcome as the majority of other oracles, they get the REP tokens they staked back, plus a portion of the reporting fee. The goal of this protocol is to penalize bad actors who may lie on the outcome of an event, as only the majority reported outcome generates additional wealth via the reporting fee and in theory this incentive should drive oracles to report the "truth".

Current Criticisms of Blockchain Technology

There are conditions and environments where blockchain technology adoption can yield better results, but absent some of these supporting factors, blockchain technology may be nothing more than a few useless lines of code. For example, if the use case was Peer-to-Peer money transfer through blockchain technology, internet penetration and mobile adoption would be critical. For the verifications of a supply chain use case, the data from the "real world" still needs to be sourced into the system—without fault—and bad actors in this scenario can still lie.

Another issue with blockchain technology today is the idea of scalability. Critics often cite the practicality of the blockchain technology, often noting the tradeoff between transactions per second (TPS), or how much the network can process at once for robust security, with slower transaction processing efficiency. For example, the Bitcoin Blockchain can handle about 7 transactions per second, as compared to Visa which does about 24,000 transactions per second. Other blockchains with different protocols also have varying levels of TPS. (See **Exhibit 1**).

Critics of blockchain technology often argue that what the blockchain technology can do, we can simply use a database to do. However, this is only the situation if you believe that the third party managing the database is a good actor that everyone can trust. Furthermore, aside from the trust element, one would have to believe that the centralized third party is also secured and the database they operate cannot be hacked by another bad actor.

Blockchain technology is governed by a protocol and uses a combination of cryptography, computer science and incentive design without the need for a central party to manage the network. Given the

decentralized nature of blockchain technology, it generally does not need permission from institutions to execute. Adoption is largely dependent on users seeing value in the network, and enough individuals running nodes to ensure the health of the network. Some may argue this is a technology that is "by the people, for the people," akin to public commons. The downside of this characteristic is that it places a lot more responsibility on the individuals, as without a central third party and with irreversible transactions, users do not have any consumer protections.

Another criticism of blockchain technology is that oracles feeding in data to smart contracts may pose security risks and may not have the same level of cryptographically secured data as the core blockchain technology.[13] Simply stated, this means something like an IoT device feeding data into a smart contract can be hacked and manipulated by a bad actor. In a Consensus Based Oracle system, enough bad actors can theoretically also work together to collude and report false information that can benefit them. In the latter scenario, the idea of incentive design will be increasingly critical to encourage oracles to act as truth tellers and penalize those that do not tell the truth. However, existing projects (e.g., Augur) in practice are still nascent, and it's still too early to tell which incentive systems would work to address these issues.

Do You Even Need a Blockchain?

In deciding whether blockchain technology should be implemented, there are several criteria one should consider. [14,15] Furthermore, with these criteria in mind, the blockchain technology solution can manifest in a few different ways. The first question is whether the problem one is trying to solve requires a database structure at all. If not, then blockchain technology is not relevant. However, if a database is required, then an opportunity to use blockchain technology may also exist. Some questions one should ask to make this determination are:

Does the database require other editors to have "edit" access? To use an analogy, imagine you had a spreadsheet on your computer. Is it for something you will work on by yourself, or would you like to collaborate with others digitally? If the answer is no, then blockchain technology is not required; if yes, consider the next step.

Are the other editors known and trusted, with aligned incentives? If the answer is yes to both of these question, then blockchain technology is not required; if either answer is no, then consider the next step.

Do you want or need a single trusted third party to manage the database for other than technical reasons? If yes, then don't use blockchain technology; if no, consider the next step.

At this point, if an entity is still considering using blockchain technology and the previous conditions suggests that a blockchain technology solution is beneficial, then the question becomes the type of blockchain technology to implement (e.g., public, private or hybrid blockchains).

Public Blockchains like the Bitcoin Blockchain should be implemented if there is a rationale for *decentralization* and no need/desire for a single entity to control functionality, coupled with a need for transparency.

Private Blockchains should be implemented if there is a need for a *single entity* (could be multiple users and editors within the entity) to control the functionality of a specific blockchain, and consensus is determined within the specific entity. This could be a bank wanting to implement a better data architecture, where the nodes are employees in the bank but they are distributed across different offices in the world.

A *Hybrid Blockchain* is useful if there is a need for a group of entities to control the functionality, but consensus is determined by a specific group of entities. This could be a consortium of banks working together to create a better payment system on a particular Blockchain, and each bank is a node in the consensus process.

The Movement of Value in Africa: Select Examples

Foreign Aid in Africa

There is a strong correlation between the balances of foreign aid provided to Sub-Saharan African countries and the growth prospects of the country. In the paper "Do Corrupt Governments Receive Less Aid,"[16] the authors provide evidence that:

> . . . corrupt governments receive just as much aid as less corrupt ones. Furthermore, often financial assistance does not reach the really needy in the developing country, but, instead, is wasted in inefficient public consumption. [. . .] The evidence points to the negative consequences of corruption on growth. Thus, if our results on foreign aid stand, they suggest that foreign aid may increase, or, at best, has no effect on corruption. It follows that foreign aid does not improve growth by improving the quality of government.

The following question arises: if there were a system in place to properly track and audit the use of foreign aid (a feature currently missing given the aforementioned), what would be the effect on the growth of the countries receiving aid? What system could be used to maintain immutable transactions and how would we motivate the main stakeholders (i.e., foreign aid providers and governments) to implement such a system? The premise is that when foreign aid is provided and distributed efficiently, it can positively impact millions of lives and have a positive footprint on growth, but when implemented poorly, it can lead to bolstering existing inefficiencies and corruption rendering mixed growth and results.

Foreign aid is usually initiated in developed countries by using taxpayer money. According to Bill and Melinda Gates' Annual Letter in 2014,[17] it accounts for ~1% of the US federal budget. The goal is simple—to assist emerging countries in the development of their infrastructure, support disaster relief, alleviate chronic poverty, eliminate famine, and fight pervasive diseases.

The issue is that there are various filters that the funds pass through in order to reach the end user. For example, the Global Fund, which gathers funds from donor governments as well as some private donors, deploys the funds as financing for projects targeting three diseases: HIV, TB and Malaria. The funds are not deployed directly to service providers; instead the Global Fund finances organizations called implementing partners, which are on-the-ground operators who apply for grants for the projects that they consider most relevant/applicable. Once the implementing partners receive funding, they usually collaborate with governments on the national and local level to execute selected projects.[18] There are costs associated with each stage of the projects (funded by the aid organizations): initiation, implementation and monitoring, and evaluation, ranging from training, admin and personnel costs, incentive costs for local operators to perform monitoring and evaluation programs, etc. Observers note that these costs eventually add up and ultimately diminish the balance that reaches the end users.[19]

Given these overhead costs associated with funding and implementation, in the above example, healthcare organizations would receive only a part of the original balance. As a result of this potential leakage, donors can lose faith in the efficacy and impact of the funds invested, implementing partners

can lose incentive and motivation to improve upon their programs, and governments may continue to depend on foreign aid for a longer period of time than intended if leakage remains high. This ultimately may hinder a government's ability to solve internal problems and the end user ends up with only a share of the initial aid.

Though the common goal of all constituents should be to help communities, the current system lacks three main features: transparency, efficiency and accountability—which leads to a current misalignment of incentives. There is a lack of transparency as current systems do not provide a clear map or record regarding how funds are used.[20] The lack of a clear transaction map further reinforces the lack of accountability of the stakeholders involved and leads to further inefficiencies in the way funds are allocated and ultimately provided. There is currently no system to track these initiatives in an optimal manner and this leads to excess requirements of metrics, data that is held in silos, lack of trust between constituents and ultimately failure to deliver funds to those who need them the most.

Remittances for Individuals

Immigrants from Africa today number approximately 20 to 30 million adults, who send around $40 billion USD annually back home to their families and local communities. For the region, this represents 50 percent more than net official development assistance (ODA) from all sources, and, for most countries, the amount also exceeds foreign direct investment (FDI). In several countries, remittances are estimated to exceed 50 percent of GDP. Remittances are mostly used for food, education, payment of basic services (utilities), homebuilding, land purchases and farm improvements. Individuals still prefer the transfer of physical cash, despite the advent of various digital platforms.[21]

According to the IMF[22]:

> Although remittances can facilitate the entry of households into formal financial markets, only a fraction of them find their way into the formal system. The high fees formal providers charge deter poor migrants, who want to send small sums of money home. Even if a migrant has access to banks, the recipient may not. As a result, many migrants rely more on import-export operators, retail shops, and currency dealers, which do not keep records of their transactions. [. . .] Informal providers offer such client-friendly features as anonymity, minimal paperwork, and speed. But the lack of supervision of these markets makes it a risky proposition for the recipients of small remittances to continue to rely on these channels. The cost of formally transferring funds to SSA (Sub-Saharan Africa), especially small sums, is high. [. . .]The market in money transfers between SSA countries is especially underserved by formal institutions, and the prohibitive fees they charge severely depress their use.

These cash remittances accounted for 90% of all the transfers from the UK to Africa, which was estimated at £4.1 billion ($6.5 billion) in 2015.[23] If users had opted for alternative digital services, they could easily have saved over a £100 million a year in total fees to agents.[24] Since these remittances are sent out by and to the most in-need population, these high transfer costs have an especially large impact on the senders and their families. The population's lack of digital literacy and trust in online financial services, the lack of bank interoperability or the receiver's access (rural population receiving approximately 40% of the balance) to the pay-out location are main causes for the prevalence of cash transfers. This makes Africa the most expensive region to send money to, averaging 9.8% of the amount sent.[25] (See **Exhibit 2** and **Exhibit 3** for additional information on remittances).

Funding Gap for SMEs: Kenya as a Specific Case Study

Small and Medium Enterprises (SMEs) play a key role in both job creation and the development of the economy in Kenya. In 2014, 80% of jobs created were largely driven by the SME sector.[26] While Kenya does not have a comprehensive record of SMEs, a 2014 CNBC news report puts SME contribution to Kenya's GDP at about 45%.[27] According to the Kenyan government's "2017 Doing Business in Kenya Report," the ease with which businesses can be registered has a bearing on the number of entrepreneurs who start businesses in the formal sector. On average, starting a business involves seven procedures, takes 22 days and costs 21.1% income per capita.[28] The Deloitte "Kenya Economic Outlook 2016"[29] notes that Kenyan SMEs are hindered by inadequate capital, limited market access, poor infrastructure, inadequate knowledge and skills and rapid changes in technology.

Given the critical role that Kenyan SMEs play in the country, Kenya's FSD (Financial Sector Deepening) program seeks to expand access to financial services among lower-income households and small enterprises. The FSD is currently funded by the Kenyan government, the UK department for International Development, the Swedish International Development Agency, and the Bill and Melinda Gates Foundation. The FSD carries out research projects to better understand the SME finance market, and its research has largely confirmed that banks were not serving SMEs effectively.[30]

Under this circumstance, between 71.9% to 80.6% of SMEs in Kenya cite that their main source of capital for business was from family and own funds, while those who cite bank financing as their main source of capital make up only between 0.8% to 5.6%[31] (See **Exhibit 4**). If we consider the challenges of starting any entrepreneurial venture, capital is a key catalyst that allows an entrepreneur to get their business off the ground. Unless an aspiring entrepreneur has saved adequate funds, outside capital is likely a big part of the equation to an entrepreneur's success. Related to this, because SMEs seek financing mainly for working capital needs, speed of execution is also critical, as an SME who is struggling to fund their working capital cannot wait too long for the financial institutions to carry out their lending process.

The barrier to capital access is due to a number of factors, including the limited use and sharing of positive information about borrowers, lack of trust in the SME's repayment abilities, data and collateral provided (most collateral is land and the current rights registration system is unreliable[32]), the cost of the judicial process, and high overhead costs. These factors also affect the risk assessment and underwriting processes which render the financing process extremely inefficient and expensive, ultimately passing on costs to the end users. Given that the main reasons of businesses for taking loans are related to working capital requirements (as depicted in **Exhibit 4**), their prospects of developing, employing people, and contributing to the GDP are limited by the lack of deployable capital (See **Exhibits 4** through **7** for additional details).

Blockchain Technology as a Potential Solution

Blockchain technology can be one of many solutions to address some of the problems outlined in this paper. However, while many authors have written about blockchain technology as an all-encompassing solution, it's important to understand its limitations, and what needs to exist in the surrounding ecosystem for the solution to work.

Foreign Aid and Blockchain Technology

As outlined above, the fundamental issue with the movement of foreign aid today is the potential for leakage arising from a lack of transparency in the process. One can argue that a centralized database

managed by an independent third party can solve some of the transparency issues. This third party can work with each of the stakeholders within the value chain to collect information to create an audit trail to ensure that funds are properly allocated, and that bad actors are not "gaming the system." However, this solution still concentrates information at one single source, with a single point of failure. In this state of the world, if a bad actor wanted to fabricate information, they would need to concentrate their attention on taking down the central database—not an immaterial risk. Furthermore, the independent third party can be open to things such as bribery and corruption depending on the incentives presented to them, and they themselves can also become a bad actor, further hurting the ecosystem.

With blockchain technology in general and smart contracts specifically, one can code in what the flow of money should look like and map out where the funds originate from and where they should end up. The benefit of having this in a smart contract is that the code can self-execute if certain conditions are met. Foreign-aid-stipulated requirements for funds to be distributed can be coded directly onto a smart contract. This allows for the donor to clarify specific conditions, and the recipient to receive aid directly. However, it's important to note that smart contracts in their current form can only be coded with deterministic outcomes,[33] and while this may drive efficiencies in some processes, they may not be as effective in areas within contracts that are subjective. For example, if a donor wanted to stipulate that one of the many conditions to send aid to a particular organization is that the organization must have the correct registration paperwork with the right authorities—this condition can be coded, since the answer to this particular question is deterministic.

Given that information stored on a particular blockchain is publicly accessible, for future foreign aid donors, they can understand how historical flows of money have moved, providing a level of accountability that is missing today. Furthermore, over time we can expect a robust data set to develop to provide a stronger understanding on the impact of foreign aid sources, and which initiatives drives the highest level of impact per unit of foreign aid. Lastly, a blockchain based solution for foreign aid can also disrupt some of the players in the existing value chains, such as implementing partners by limiting their scope of work and removing inefficiencies that can drive leakage today. By removing some unnecessary costs and processes from the system, good implementing partners can also stand to benefit since removing unnecessary leakage would allow implementing partners to maximize the amount of aid that ultimately reaches the end user.

Taking a closer look to a potential application of blockchain technology in foreign aid, consider a grant provided by the AFSA (Agricultural Aid to Africa) reaching directly to the farming community (bypassing any intermediary organization). Currently, there would be a non-profit (one of the implementing partners in the region) applying for a grant from USAID and AFSA, deploying the funds to farmers and monitoring their use. Blockchain technology would facilitate the integrity and confirmation of the payment-receipt process, and its decentralized process would enable farmers to report on the use of funds (using various monitoring and evaluation metrics decided upfront) and have other nodes confirm said use of funds.

Let's say the farmer would like to report the purchase of the seeds: blockchain technology would allow for the input of the supplier confirming the purchase, bank account (if the farmer has one) information to verify the cash withdrawal, and nodes that might have access to information to confirm the transaction for currency rewards. Over time, a database is created that will help speed up the process of verification and recording of transactions. Given the need for a majority of nodes to agree, the farmer (who may also operate as a node) is dis-incentivized to lie on the actions taken because if identified as lying, his or her credibility and access to additional funds would be restricted. Further, given the anonymity of nodes (a node could be the farmer's neighbor or someone on another continent

who operates a drone that captures images of the seeds purchased), it would be close to impossible to collude and lie. It's important to note for this type of system to work, the incentives and dis-incentives must be aligned—whether financial, reputation, etc.—to drive the desired outcomes.

That being said, translating the "physical world" (i.e., evidence that the seeds were purchased) in a digital world, remains an area to be further explored since it is relatively easy to verify digital/electronic transactions and yet challenging to verify verbal agreements, cash purchases of physical equipment, actual yields on the farm, and similar judgment-intense validations in the "physical world."

Remittances and Blockchain Technology

High costs in remittances[34] are primarily due to inefficient paper-based processes, large concentrated players that can charge high prices, multiple tiers of banks and money transfer operators involved in an international payment (who each take a cut from the transaction), and extensive regulation. For remittances, there is both a cost problem and an efficiency problem with existing solutions. As noted above, a remittance to Africa averages about ~10% in transaction costs with varying times from a few days to weeks depending on the situation.

While digital solutions exist and may offer a cheaper alternative than some other non-digital solutions, the fact that remittances have to go through many conversions and transfer approvals in the process before the money gets to the end customer does not change. These conversions create leakage as fees are levied throughout the transaction lifecycle. With a blockchain based solution, using cryptocurrencies can eliminate the need for the money to "travel through" different payment rails where at each "stop" a transaction fee is charged. In this implementation, a user's currency can be converted to the cryptocurrency for the payment solution, and the user looking to send money back home can send the cryptocurrency through blockchain technology instead. This solution would yield the fastest speed and the lowest transaction fees.

Many see remittances as a clear blockchain technology use case, and companies like BitPesa have some notable traction operating in Africa, having raised around $10M[35] in venture financing and serving multiple countries within the region. As described on their website, BitPesa[36]:

> . . . is an online payment platform [and digital exchange] that leverages Blockchain technology settlement to significantly lower the cost and increase the speed of business payments to, from and within sub-Saharan Africa. BitPesa's clients range from African businesses and multinational companies paying suppliers as far as China and Dubai to international remittance companies using our API services for white-label payments to dozens of bank networks and mobile money operators across Nigeria, Kenya, Uganda, Tanzania, Senegal, and the DRC. Customers can also buy and sell bitcoins in these countries.

BitPesa touts its two biggest value propositions as (1) faster payments and (2) more cost-efficient payments since they allow their customers to purchase and sell Bitcoin, effectively allowing all parties to transact through a common payment channel with negligible transaction fees. It's also important to note that BitPesa itself is a consumer facing application building on top of the Bitcoin Blockchain.[37] This is a clear example of how a third party may be able to leverage open sourced blockchain technology while still keeping costs low for their consumers. Furthermore, multiple initiatives and companies are working on the so called "plumbing" of the financial system such as the Interledger Protocol,[38] a protocol looking to connect multiple blockchain platforms to drive interoperability

between them. If these initiatives are successful, more payment rails and channels will open up to provide consumers with even more options for moving money from point A to point B.

When thinking about remittance solutions through a blockchain technology lens, it's important to realize that a healthy system—whether it's fully decentralized or partially decentralized—will have to consider the context in which it operates. For payments and the movement of value, strong Know Your Customer (KYC) and Anti-Money Laundering (AML) processes are still critical to prevent fraud and funding of potentially illegal activities. In a centralized world where the flow of capital moves through the banking system, banks take on the responsibility for KYC/AML. If remittances move to a more decentralized world, KYC and AML will remain an important implementation consideration, and multiple actors may have to take on the responsibility to ensure KYC/AML processes exists.

From an adoption perspective, certain conditions should be met. For example, users need to be tech savvy and connected enough, whether via internet penetration or mobile penetration, to use digital applications for remittances. In a decentralized world, if cryptocurrencies are not regulated, users need to change their fundamental "relationship with money" as they will enjoy some of the benefits mentioned in this paper but also have to take on greater responsibility to keep their information safe and protect themselves from bad actors. There will be fewer protections, as there is no bank or central entity to complain to and mediate disputes and potentially offer compensation if something goes wrong.

SMEs, Financing and Blockchain Technology

As noted above, financial institutions operating in Kenya do not have a robust way to assess the risks of borrowers due to lack of information. Coupled with a lack of verifiable collateral, SMEs have a tough time accessing the financial system. Under this context, blockchain based solutions can manifest themselves in several ways.

To solve the access to financing problem in the short term, a Peer-to-Peer (P2P) business lending solution or a crowd funding solution could provide liquidity, as these platforms may require less traditional loan evaluation processes compared to traditional banks. In Africa, crowdfunding and P2P lending are popular forms of alternative financing, ranking second and third respectively, only lagging microfinance by volume.[39] P2P lending has exhibited the most growth, where the volume in 2014 was ~$2M, but grew almost 7x to $14M in 2015.[40] Additionally, many startups are building alternative finance platforms and are finding creative ways to assess the risk of potential borrowers. Branch, a company based out of San Francisco, is using data on a borrower's mobile phone to create a credit score.[41] Similarly, KiaKia, a startup based in Nigeria, is utilizing machine learning, big-data, predictive analytics, digital forensics, and social collateral as part of its proprietary algorithm for risk assessment.[42]

Given that a significant level of market validation exists for non-blockchain solutions, a blockchain based solution is not necessarily required—but such a solution can help drive additional efficiency in the short term while in the long-term helping to bolster the overall financial system. In the short term, an opportunity using a blockchain based solution to create a P2P lending marketplace can work. A prospective borrower can design a specific loan they are seeking, and post the proposal onto that specific blockchain platform. A lender somewhere else in the world may choose to accept the contract, and the blockchain technology can then create a smart contract to govern the terms and execution of the loan. In this scenario, everything is self-executing as long as the conditions are met.

Similar to the remittance case, this model places increased responsibility on both parties in the transaction. The lender is responsible for evaluating its options in this marketplace to determine the

level of risk they are willing to take. This is akin to how someone may back a crowdfunding project rather than invest in a more stable financial instrument. On the borrower side, the borrower is responsible for proposing terms that they believe are fair and reasonable as compared to other loan opportunities available in the market. An open question also exists around consumer protections (on both sides) and what governance looks like for this type of blockchain technology network, as bad actors can potentially game the system by posting loans and simply not paying them back.

However, if we take this model and think of it at scale, in the long term there can be an open-sourced reputational record of loan history coupled with other factors such as success of loan repayment, time to repay, etc. Those who are responsible for the health of this particular blockchain technology network can also build in capabilities to create a credit score for each of the SMEs who borrowed through this platform. This system of record can be akin to one's financial profile that any bank, financial institution, or other prospective lender can use in their risk assessment process. The interoperability of this profile can help SMEs in the long run access alternative sources of capital and get more fair pricing in borrowing. In implementing a credit score and a financial profile, the reputation of the SME is available for others to see, and as a result, this can be a disincentive to bad behavior since SMEs are incentivized to build their financial profiles over time (i.e., for a SME looking to build a strong business and one who will likely need multiple loans over the course of their business' lifecycle, they should optimize for their reputation over fraudulent behavior in the short term).

A similar application could be used for land ownership registration. As mentioned above, SME's restriction to financing is bolstered by the lack of evidence of existing collateral. As land is the main asset used as collateral, having a ledger of ownership rights would help alleviate the "access to capital" problem. Though challenging in the short term to incentivize governments to participate in an initial registration process, having a decentralized system to verify such ownership is especially important given the frequent cases of double ownership of land, where cartels collude with officials to create parallel titles for parcels of land they want to acquire illegally. Blockchain technology would reduce cases of fraud because each property would be uniquely coded and linked to a unique digital key that each owner will have and know. Land ownership projects has also been cited as a key use case for blockchain technology. For example, in Rwanda, the Government blockchain project has partnered with WISeKey, a cybersecurity and IoT solutions firm to delimitate land ownership, to enable secure transactions, digital authentication and legally binding signatures.[43]

More so than the other examples laid out in this paper, there are numerous open questions before a system like this can work. KYC and AML considerations are still critical following similar logic above. It is still unclear if something like reputation will be strong enough to dis-incentivize bad behavior, and if not, solving the problem of having bad actors in the network is still critical. It's unclear which party (if any) is responsible for consumer protections when transactions and loan agreements inevitably create disputes. Lastly, one can argue that in this scenario, a hybrid blockchain architecture may work better where the blockchain network is managed by a consortium of relevant players and they drive some level of governance or best practices to ensure the intended outcomes of such a P2P lending platform addresses potential perverse incentives.

Conclusion, Caveats, and Opportunities

The motivation for this paper is to start a conversation about how some of the key problems that exist today in Africa could be addressed by frontier technologies like blockchain technology. However, with any new technology, there are significant execution risks to consider. Some issues identified are: short term implementation hurdles, reliability of input data, incentives for the parties involved to provide truthful input and avoid collusion, cost comparison of existing alternatives, processing power

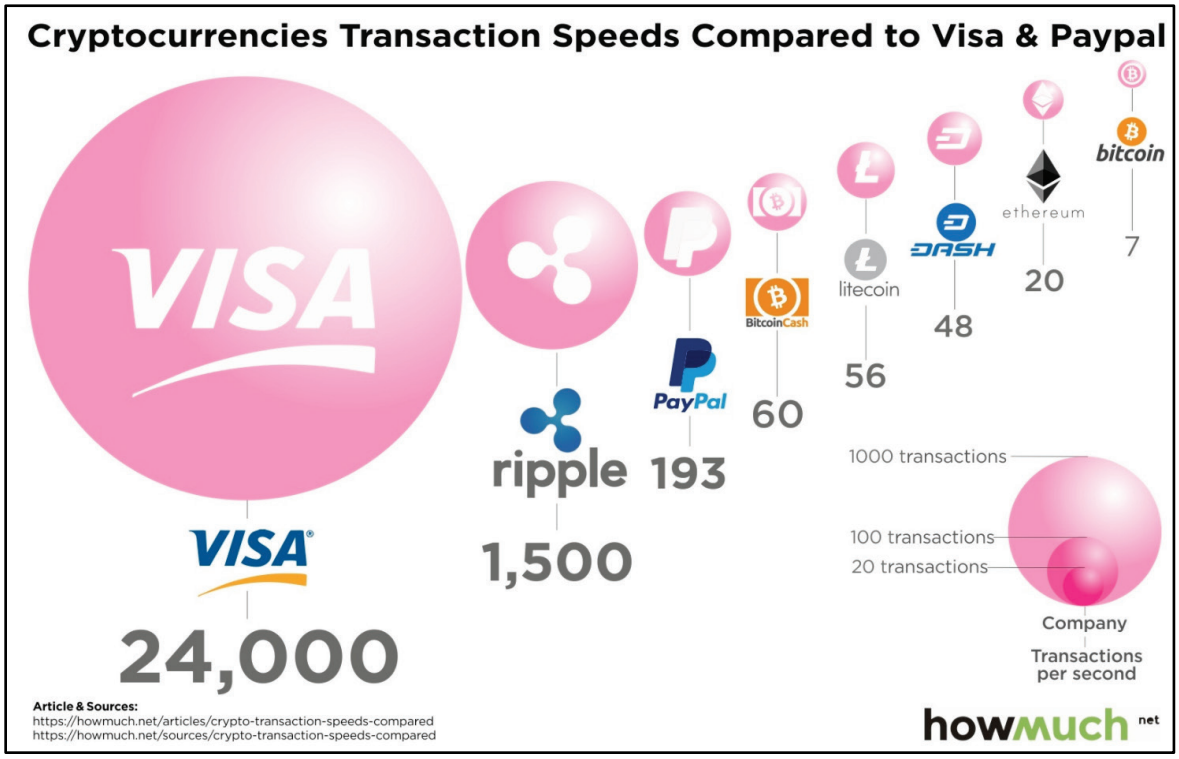
of blockchain technology, trust and user ability to interact with the technology, and KYC and AML considerations. We have tried not to propose vaporous solutions that oversimplify the context and implementation challenges that may exist in Africa as a region, and of the initial challenges that impede broad adoption of any new technology. Rather, in highlighting some of the issues that blockchain technology can solve, the hope is that these solutions enter the realm of possibility in a more meaningful way.

With all these implementation considerations in mind, for any individual or organization thinking of leveraging blockchain technology to solve some of these problems, it is important to understand that while blockchain technology looks and feels like an innovation almost as powerful as the internet, fundamentally changing *human behavior* in a specific context is what drives outcomes. If we look at something like Bitcoin, that project works on paper because the incentives for all the stakeholders are largely aligned—but the adoption is nowhere near at large scale, which raises the question: For whom does Bitcoin (as a system) work, and for whom does it not work? In designing any blockchain based network and system, understanding how incentives motivate stakeholders is crucial—and understanding how incentives structures can break down is equally as critical.

At the end of the day, if everything progresses as intended, we believe blockchain technology can create substantial value and allow businesses, lenders, and *people* in developing countries to participate more effectively in a variety of economic activities where (unnecessary) barriers, frictions, and leakage exist today. While the long-term can look promising, one should take into account the operating context both (1) in implementing a new technology, and (2) from doing so in an emerging market environment. There could be significant unintended negative consequences.

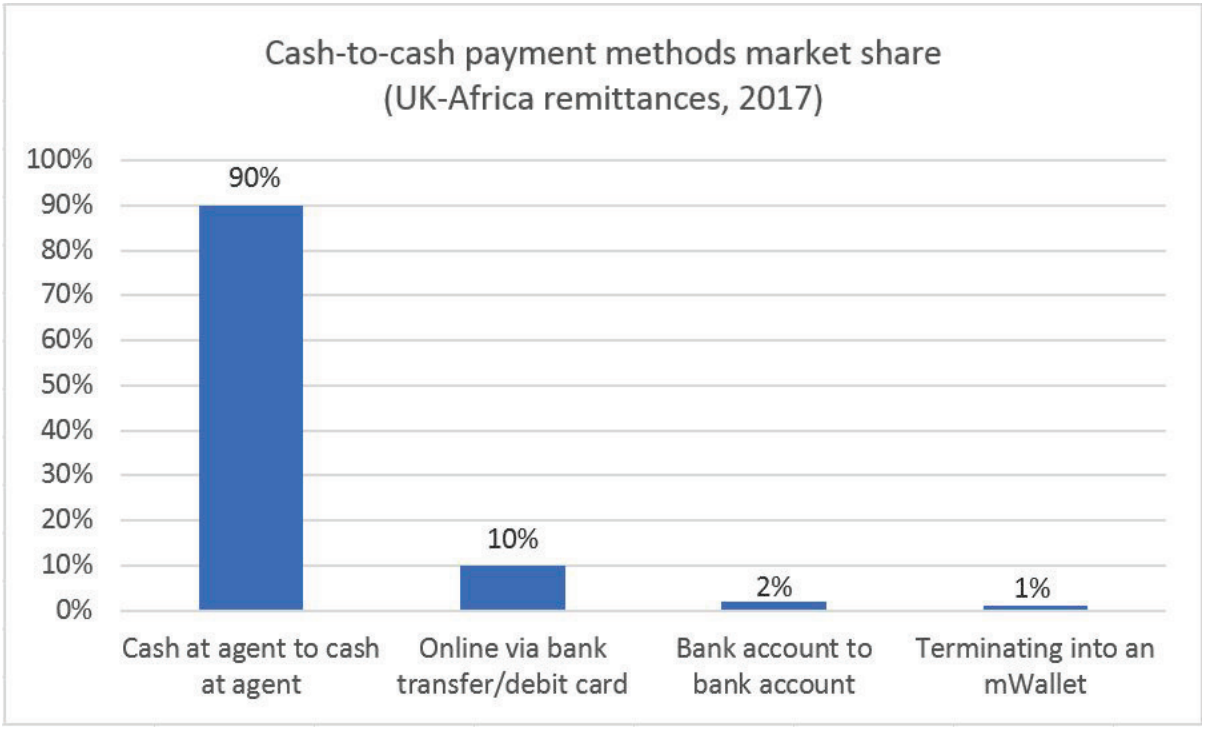
The core of this discussion is about creating systems that allow people to participate in broader and greater economic and social activities *without* the need to delegate trust to actors that may or may not have our best interests in mind. The technology is still young, and while blockchain technology is not the be-all and end-all solution, it certainly is worth considering for those looking to solve the big problems of the world using the tools of capital, finance, and commerce. We hope this paper serves as a wide ranging and realistic starting point for considering how to do this.

Exhibit 1 Transaction Speeds



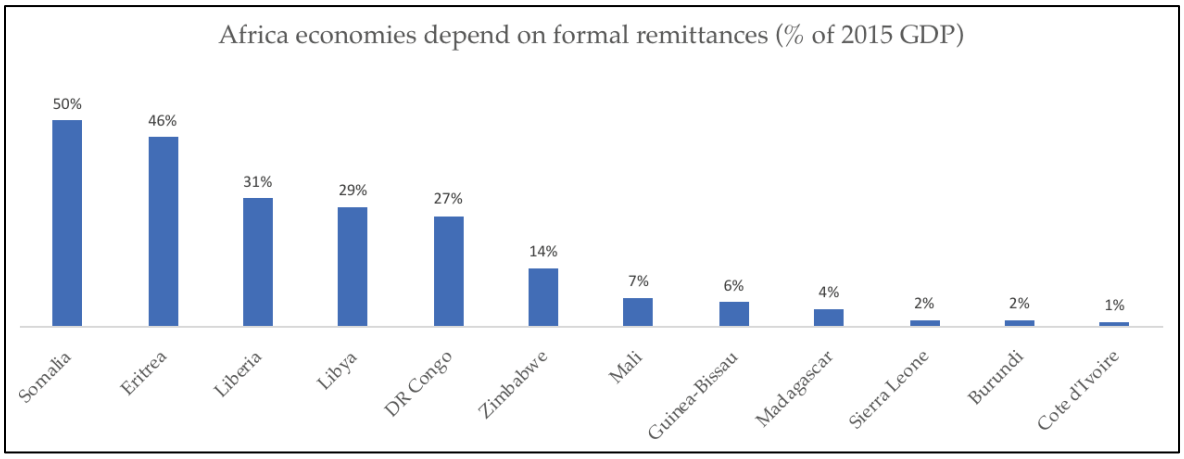
Source: https://howmuch.net/articles/crypto-transaction-speeds-compared, January 2018. Accessed in February 2018. How Much is a cost information website.

Exhibit 2 Cash to Cash Payments Market Share



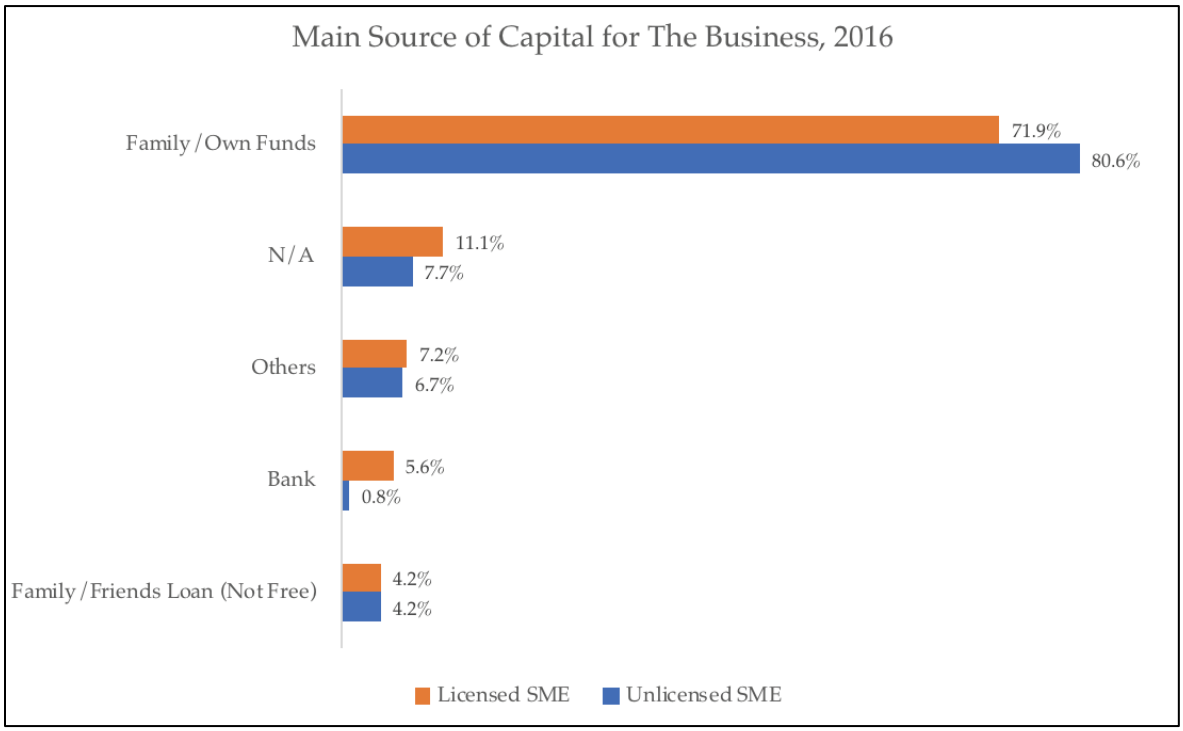
Source: Adapted by casewriter from "Cash-to-cash payments top UK-Africa remittances," https://www.theatlas.com/charts/SJiz-Gem-, accessed February 2018.

Exhibit 3 Percent of GDP that Depend on Formal Remittances: Selected African Economies



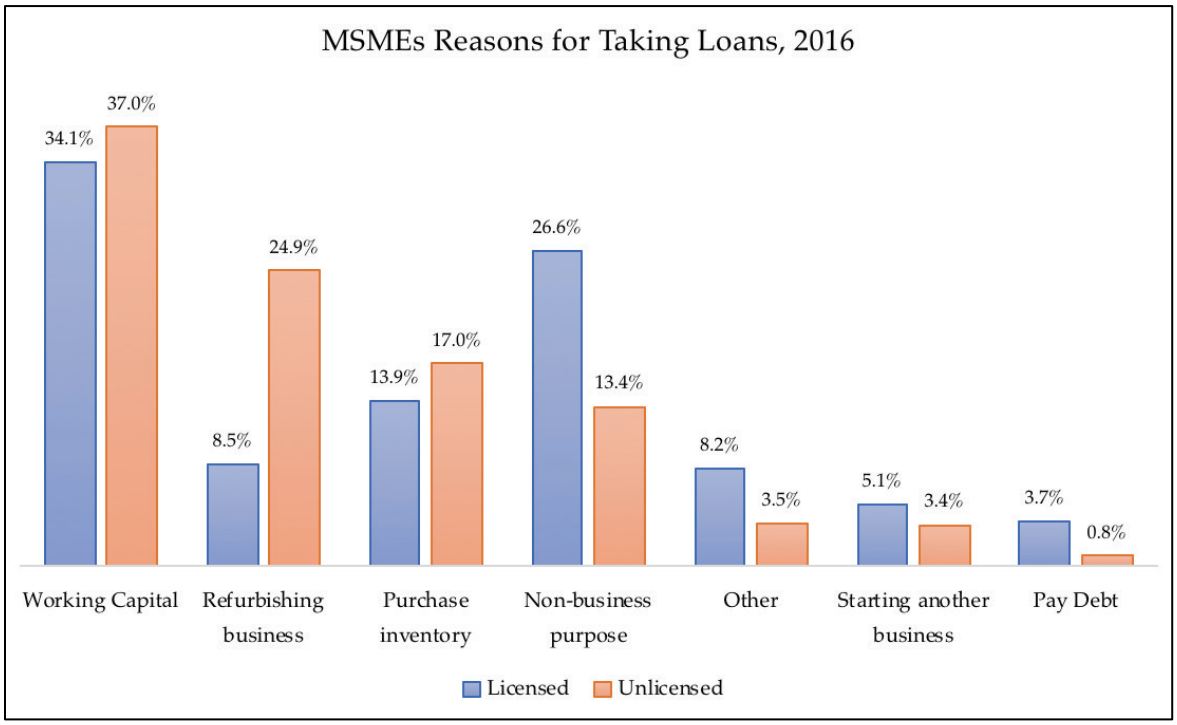
Source: Adapted by casewriter from "African economies depend on formal remittances," https://www.theatlas.com/charts/BJIPtWgQW, accessed February 2018.

Exhibit 4 Main Source of Capital for Business



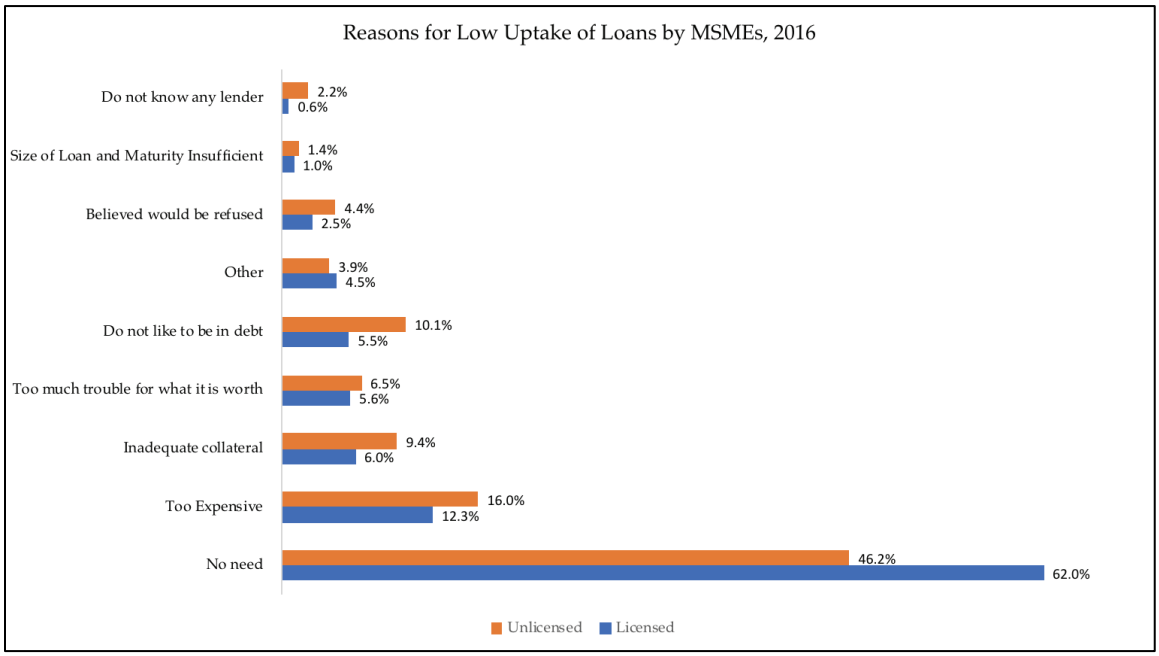
Source: Adapted by casewriter from Kenya National Bureau of Statistics Report: "Economic Survey 2017, Figure 18.6" https://www.knbs.or.ke/download/economic-survey-2017/?wpdmdl=4006&ind=Jik8Qq4cE9_7WtLov8cwQO4yvJHlT3lv_ptzssQmH3MD4I0OPtaBnWv0AlDl5mRF, accessed February 2018.

Exhibit 5 MSMEs Reasons for Taking Loans



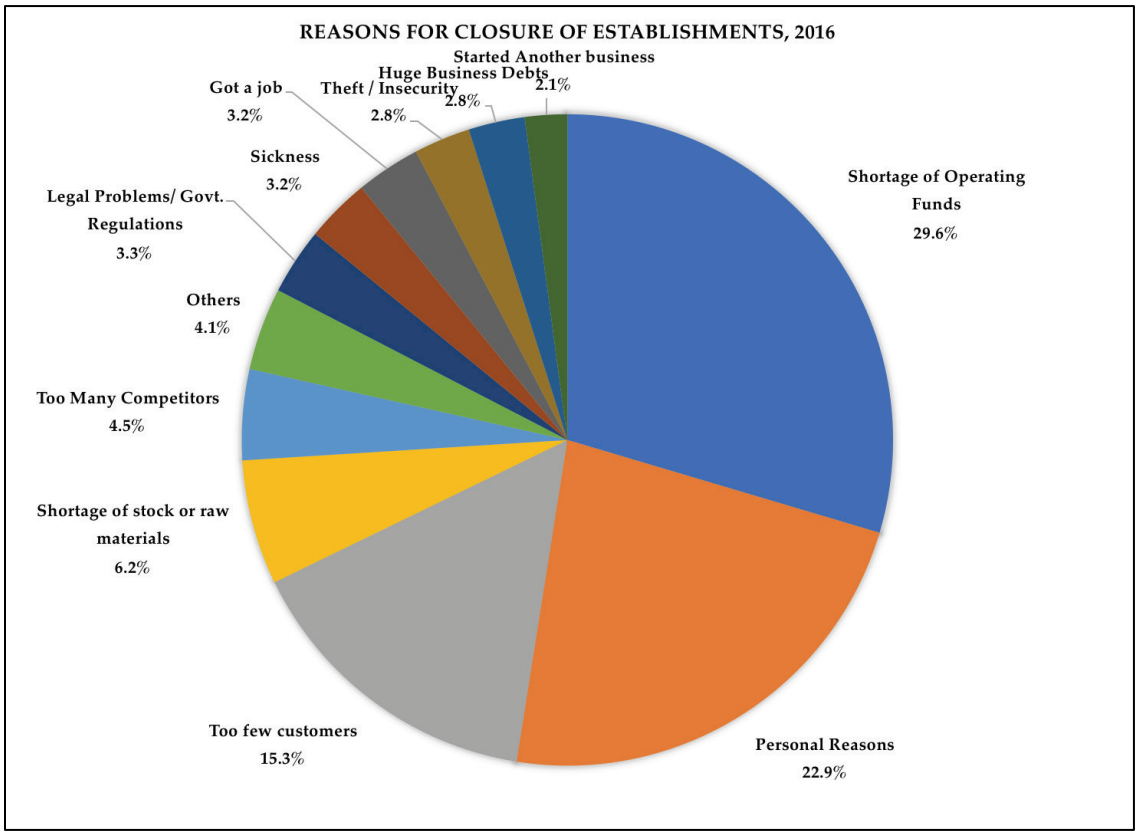
Source: Adapted by casewriter from Kenya National Bureau of Statistics Report: "Economic Survey 2017, Figure 18.16" https://www.knbs.or.ke/download/economic-survey-2017/?wpdmdl=4006&ind=Jik8Qq4cE9_7WtLov8cwQO4yvJHlT3lv_ptzssQmH3MD4I0OPtaBnWv0AlDl5mRF, accessed February 2018.

Exhibit 6 Reasons for Low Uptake of Loans by MSMEs



Source: Adapted by casewriter from Kenya National Bureau of Statistics Report: "Economic Survey 2017, Figure 18.15" https://www.knbs.or.ke/download/economic-survey-2017/?wpdmdl=4006&ind=Jik8Qq4cE9_7WtLov8cwQO4yvJHlT3lv_ptzssQmH3MD4I0OPtaBnWv0AlDl5mRF, accessed February 2018.

Exhibit 7 Reasons for Closure of Establishments, 2016



Source: Adapted by casewriter from Kenya National Bureau of Statistics Report: "Economic Survey 2017, Figure 18.13" https://www.knbs.or.ke/download/economic-survey-2017/?wpdmdl=4006&ind=Jik8Qq4cE9_7WtLov8cwQO4yvJHlT3lv_ptzssQmH3MD4I0OPtaBnWv0AlDl5mRF, accessed February 2018.

Endnotes

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