Sustainability of cryptocurrency in blockchain technology for business development in African Countries

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ABSTRACT

The aim of the paper is to analyze the sustainability of cryptocurrency in blockchain technology in African countries for securing financial business transactions. Following the subprime crisis that shook the world economy, a new perception of money has emerged. It is a fully digital currency whose transactions are made through a distributed network. This algorithm-encrypted currency, reputed to be tamper-proof, transparent and inclusive, relies on a distributed network called the Blockchain. By comparison with traditional registers in which operations are paginated and successively recorded, transactions in blockchain technology are aggregated within the chain of blocks. It is decentralized since it is replicated on several geographic sites around the world. It enables peer-to-peer transactions, automated in real-time, reliable, secure, without intermediaries and non-repudiable. To ensure maximum security during financial transactions, blockchain miners use cryptography. This distributed system is, therefore, a major technological innovation capable of securing the financial infrastructure and mitigating failures by reducing operational risks. According to our analysis based on the Merkle tree model and blockchain energy consumption, the sustainability of cryptocurrency is a major issue for developing countries. Especially in Africa, its practicality poses a number of constraints.

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Introduction

The effects of digitalization on the business ecosystem and business models are increasing day by day. Businesses and individuals intensely benefit from the services that FinTech platforms offer. As a result, there are significant changes in the structure of financial institutions and financial instruments. Blockchain technologies play an important role in the transformation of business ecosystems (Hacioglu & Sevgilioglu, 2019; Söylemez, 2019). Blockchain technologies are profoundly disrupting the business ecosystem. Blockchain is an innovation that enables cryptographic verification and registration through the use of private and public keys. These electronic signatures avoid reversing, modifying or repudiating any transaction, thus creating a history of verifiable, irreversible, irrevocable and verifiable data in a public and sometimes private manner. It does not require centralized storage or central control body. It allows digitalized, secure, reliable transactions without intermediaries between the parties (Hacioglu, et al., 2021).

In the 1970s, we saw the emergence of magnetic stripe card and ATMs. It was the beginning of a great adventure in the dematerialization of the financial system. The digitalization processes have led to major transformations, in particular in the economic models of financial institutions (Hacioglu, 2020). Today, there are many media for mobilizing and using money. For financial transactions, these advances have given rise to innovations such as bank cards, Swift transfers, monetary wallets and mobile banking.

There is some confusion about qualifying these media as electronic money. Indeed, they are different from fictitious money and that cryptocurrencies fit into this continuum of different forms of electronic currencies. This perception is misleading because electronic money is one of the modern forms that fiat money takes. Moreover, from a technical point of view, it is not about money, but about

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payment medium which makes it possible to mobilize and use bank money for various transactions. Let's note that holders of electronic money are not banked; their assets are jointly consolidated in the operator's bank account and their identity in the financial system is limited to their phone number. Given the invaluable contribution of such a system to financial inclusion, it is not surprising that it is arousing great enthusiasm, particularly in emerging countries with low banking rates.

However, from a transactional point of view, a mobile phone can be compared to a bank account because it must be funded to be usable. With the economic crisis of 2007/2008, we are witnessing a new perception of monetary design with cryptocurrency's advent and its underlying technology, the Blockchain. The latter is a transparent and secure system of storage and transmission of information, operating without central control body (Nakamoto, 2008). By extension, it constitutes a digital register which contains the history of all the exchanges carried out between its users since its implementation. This database is based on cryptographic technology which makes it possible to elaborate and develop techniques of distributed ledgers (Distributed Ledger technology - DLT) which offer a centralized management of transactions but also more security or even guarantees that could not be considered with paper supports. DLT is therefore a transparent, secure and decentralized database (without a central control body), distributed over all or part of the nodes of a network. The latter, called Blockchain, records and stores in virtual registers (or blocks), immutable, each transaction that occurs in the network (Bussac, 2018). In this database, the validated transactions are materialized by blocks with unique identifiers and a signature obtained by the hash fingerprint. Each block has the hash of the previous block in the chain, which ensures the integrity of all transactions recorded since the "Genesis" block. This mechanism thus clarified, seems a priori inviolable and should allow the developing country to nurture the hope of having a system capable of securing the financial infrastructure.

Blockchain constitutes a secure database for the processes of all the users. The main aim of this technology is to remove the need for mediators and perform processes over a distributed network (Zehir & Zehir, 2020; Hacıoglu, 2020). However, blockchain's applicability comes up against certain constraints specific to developing countries where there is an energy deficit and insufficient internet penetration. Hence the question of whether blockchain is accessible to African countries. In order to allow good understanding of the article, we have structured it in two parts, the first of which deals with the importance of blockchain in securing financial infrastructure, and the second, with its applicability in African countries.

This paper aims to analyze the sustainability of cryptocurrency in blockchain technology in African countries for securing financial business transactions. This study will provide a conceptual basis on blockchain technologies from a theoretical perspective.

Blockchain Ecosystem and Cryptocurrencies

Cryptocurrency in Blockchain Technology

Crypto-asset transfers are based on blockchain technology, which a priori makes it possible to do without intermediaries and carry out peer-to-peer transactions. In this system, we have finance without a bank and without a trusted third party. This paradigm shift was made possible by digital currency's advent. Alternative money systems based on Blockchain are called cryptocurrencies because of the heavy usage of hashes (Cagliyangil et al., 2020). This type of currency is virtual, dematerialized, unregulated, created and generally controlled by computer scientists (developers). It is not legal tender, only exists on the internet and is only accepted in a virtual community that adheres to the protocol that governs its implementation. In reality, no one has an obligation to accept it for transactions. They use cryptography to be traded securely over the Internet. These are virtual currencies without a bank that are digital forms of fiat values. They are designed using a cryptographic process and adapted to transmit value on the Internet in a public environment, totally decentralized, and in complete security. For the most part, they operate in a distributed system, where information is fully and simultaneously available to all participants. Transactions are decided and validated by "consensus". In the current financial system, cryptocurrency is starting to position itself.

Figure 1: Place of cryptocurrency in the universe of monetary instruments; *Source:* Légifrance (2017).

For the moment, they are marginal on the global financial scene, but they continue their breakthrough, even going so far as to replace fiat currency. Moreover, with bitcoin, El Salvador intends to improve the standard of living of poor families in a context where 30% of its population don't have a bank account. Moreover, the country relies mainly on international transfers of cryptocurrencies from expatriates to achieve this with the advantages of the absence of withdrawals by intermediaries and a stratospheric bitcoin value. These virtual tokens which, in general, are convertible into tangible currencies, are based on a principle of issuance and decentralized management in blockchain's network. For all these reasons, they are called cryptocurrencies, sometimes even cybermoney (Légifrance, 2017). In reality, the blockchain was created to solve the problem of decentralization and securing digital currency. The first cryptographic hash function whose goal is to secure its issuance, the transactions to which it is the subject but also the respect of the privacy of users was created by Chaum (1983). However, the Chaum ecash (1983), although revolutionary, suffered from a strong correlation with the classical financial system. Therefore, the challenge was to move away from this interdependence, especially concerning trusted third party such as a central bank. Blockchain is applied to increase the transparency of transactions and to increase the security of platform operations and applications (Ku, 2020). Nakamoto (2008) enabled this paradigm shift by proposing a decentralized protocol, guaranteeing the full functionality of a currency and ensuring its transparent creation and management of transactions. The financial sector is the forerunner of the decentralized network among other sectors. This is not only due to the fact that the most well-known application of this technology is cryptocurrency, but it is also due to significant process inefficiencies and a massive cost base problem specifically in this financial industry (Gürnlü, 2019).

This blockchain-driven innovation marks the advent and phenomenal breakthrough of so-called virtual currency or cryptocurrency. This name differentiates them from electronic currencies which are only dematerialized versions of traditional assets and which are supported by digital wallets. Blockchains, receptacles of cryptocurrency, are either public and therefore open to all, or private, access and use of which are limited to a number of designated actors. The public blockchain can be assimilated, in traditional finance, to an anonymous and forgery-proof accounting ledger. According to Delahaye (2018), this is a very large notebook in which anyone can write and read freely without being able to destroy it or erase the scriptures. Blockchain is in a form of succession of blocks.

Figure 2: Structuring of blocks; *Source:* Delahaye (2018),

Any public blockchain necessarily works with a token whose characteristics are predefined by a computer protocol. Transactions between network users are gathered in the blocks validated by "miners", according to techniques specific to each Blockchain. This validation is done by proof of work (PoW). According to Karagoz & Demirel (2020), in the PoW method, a problem is defined as the summary value generated by the SHA-256 Hash function for a computer solution in a certain range. After validation, the block is time stamped and added to the chain. At this moment the transaction is visible to the receiver as well as to all network players. To be identified, each block has a digital signature called a cryptographic hash. In the model of Nakamoto's Bitcoin (2008), it is obtained by hashing the block header twice with the SHA256 algorithm.

Proof of work refers to a system for validating the blocks of the blockchain using the computing power provided by a computer. It eliminates the necessity to trust a regulatory authority or rely on a trusted third party when processing transactions. It is therefore an original consensus of algorithm use to confirm transactions and create new blocks in the chain. This cryptographic process creates money by solving a complex mathematical calculation which sometimes requires a particularly energy-intensive mining farm and is endowed with a very large computer computing power.

The complexity of the problem to be solved varies in real time, so that blocks can be created at regular intervals (10 minutes for bitcoin). To claim to mine digital currency, you will need proof of stake which requires the user to prove possession of a certain quantity of cryptocurrency before participating in the validation of blocks in the chain, and to be able to receive the reward after validation.

Figure 3: Validation of a transaction in the blockchain; *Source:* Légifrance (2017)

Validation of a transaction in the blockchain relies on following steps. Step 1: A performs a transaction to B; Step 2: Several transactions are grouped in a block; Step 3: The block is validated by the miners using cryptographic techniques; Step 4: The block is time stamp and integrated to the blockchain to which all users have access; Step 5: B receives the transaction from A.

Each transaction carried out is open to the public and recorded on a regular and ad hoc basis, and added at the end of the chain as a block. According to Dayi (2019). This system prevents the repetition of previous transactions and serves to protect them against tampering. Each transaction is, independently of each other, stored in a blockchain that contains approved blocks. The confirmation rules followed in the blockchain in order to reach a consensus are called consensus rules. When the blockchain structure is examined, it is seen that each of the blocks consists of a Hashed and coded stack. Each block contains the cryptologically encrypted hash function of the previous block. These blocks are encoded as Merkle Tree (Karagoz & Demirel, 2020).

All the transactions are therefore arranged in Merkle's tree (1978) where the transactions are taken in pairs and then hashed between them. The operation is repeated until a single hash is obtained. In bitcoin's case for example, the hash algorithm used is SHA256.

To illustrate the Merkle's tree (1978), let's take the example of a block containing 16 transactions and use letters to identify them. Let from A to P. The hash algorithm will first give a hash for each of these transactions.

Then, we will combine the hash of A and B to have the hash of AB. Subsequently, we combine the hash of AB and CD to obtain the hash of ABCD and so on until we obtain a hash for ABCDEFGHIJKLMNOP. This last hash is none other than the Merkle's root which will be stored in the header of each block present in the network. This is how the transactions within a block are ordered. Regardless of the number of transactions present in the block, they will always be expressed in hash of 64 characters of the type:

e320b6c2fffc8d750423db8b1eb942ae710e951ed797f7affc8892b0f1fc122b.

Each "leaf" (transaction) in the tree depends on another "leaf", so it is impossible to manipulate one "leaf" without the others being modified. If you try to edit a single transaction, the global hash will be changed, as it was built by grouping two or two different transactions. For this reason, in the case of an attempted fraud, the hash at the top of Merkle's tree (1978) - the root will change.

Figure 4: Merkle's Root; *Source:* Merkle (1978)

If you look at the face upside down, you can see that it looks like a tree. Transactions constitute the leaves of this tree and the result is its root. As a principle of calculation, transactions (TX) are hashed twice by the hash function SHA256, which brings us to the first

branch height. For example, the first hash (H1) is calculated by taking the double SHA256 from transaction 1: $H1 = \text{SHA256}(\text{SHA256}(\text{TX1}))$. The prints obtained are concatenated two by two before being chopped again. For example, the fingerprints from the different transactions 1 and 2 are combined to give the fingerprint H1, 2: $H1, 2 = \text{SHA256}(\text{SHA256}(H1 + H2))$.

This is then repeated for each level until only one footprint remains. If we come across an odd number in the process, we must combine the last fingerprint with itself, as is the case here for the H5, 6 fingerprint: $H5, 6, 5, 6 = \text{SHA256}(\text{SHA256}(H5, 6 + H5.6))$.

The final imprint is the tree's root called "Merkle's Root".

This organization of transactions is particularly useful for the operation of the SPV (Simplified Payment Verification) nodes. These just download the block headers instead of the entire chain. The header set (which is also a string) currently weighs around 40 megabytes, which allows wallets to exist on smartphones. To verify a transaction, the SPV nodes therefore cannot refer to the blockchain and must request the desired information from the network.

The tree organization of Merkle (1978) has the advantage of considerably reducing the load. For example, to verify transaction 2 in the previous tree, it suffices to obtain from the network the fingerprints H1, H3, 4 and H5, 6, 5.6; to proceed with the different hashes and to compare the result with the Merkle root. This process makes the blockchain a secure ledger, which can be shared simultaneously and in a synchronized manner by a multitude of designated or anonymous participants.

The blockchain is therefore a special form of distributed ledger in which all of the information relating to the transactions carried out is stored in blocks sequentially linked to each other, time-stamped and numbered. It is therefore in retrospect impossible to make changes, even infinitesimal, to a block in the chain without all the previous ones being completely upset in an immediately visible way. This is the great interest of the blockchain: it is immutable because we cannot go back on what has been entered. In addition, there are consensus procedures that allow network participants to collectively validate transactions.

The blockchain includes many characteristics, the main ones being as follows:

- i. All participants in the system have a shared and constant view of the information;
- ii. Information is verified by all stakeholders and be accepted by consensus;
- iii. Each item of value or digital asset is recorded and identified separately;
- iv. Transactions are verified for their legitimacy, and secured against manipulation and modification;
- v. Transactions are automated and programmed to autonomously execute a predefined set of rules;
- vi. The blockchain, although popularized by its financial applications, lends itself to several applications in different fields.

In most cases, the blockchain works on the cryptographic principle of public key and private key. This pair of keys are generated together and are linked for all transactions. The public key is usually generated by the elliptic curve digital signature algorithm (ECDSA). After several hashes with the SHA256 & RIPEMD160 function, we finally arrive at an address in the form of a character string and on which a person can send bitcoins.

The reason for the multiple hashes is to decrease the size of the address while preventing certain types of attacks. This address is public and can be displayed on a website or in a financial or commercial structure without any fear. It is comparable to a post office box. The private key is generated by means of ECDSA and allows the bitcoins of the corresponding public key to be spent: this is the "secret code". It is very important not to divulge it and to keep it safe because anyone holding it can trade as they please.

Each private key is linked to a public key; however, in rare cases, it is possible that a single private key is used for a number of public keys; vice versa, in the case of a multiple signature it is possible to associate private keys with a single public key. A public address is in the form of a random alphanumeric identifier of 26 to 35 characters starting with the characters "1" or "3". It is generated at no cost by any economic agent and looks like this: 1ErMy5qaJgWUSzySYt1VWDmW3VchfvC1.

The "1" added after the hash indicates that we have an address with a single signature while the "3" indicates an address with a multiple signature.

In contrast, a private key is generally a 256-bit number. For some, they vary between 128 and 512 bits. 256 bits in hexadecimal correspond to 32 bytes; representing 2256 different combinations. To put this number in perspective, this represents 1 followed by 77 zeros of possibilities. For example, on the assumption that one trillion private keys are generated per second; we would be past the age of the universe before we had enumerated all the possible combinations. The private key looks like 5J6DUP2N3mBctcVjHN4tbPE2hA2PJ8YBS9D4jY2E4wKhdcSQY4K.

All these addresses are generated and managed by wallet-type software. When creating a monetary wallet, an address and a private key are set up. A good practice in cryptocurrency is to use an address only once; it is not mandatory but strongly recommended to increase the level of anonymity and security. Indeed, if the acquisition of a good or a service with cryptocurrency requires the last name, first name and address of the person concerned, anonymity would no longer exist. Note, however, that a wallet is quite capable of tracing or regenerating an address. In order to simplify the task for users, the addresses are transformed into QR Code for quick and efficient sharing. This also avoids transcription errors although the probability of an address with an error being accepted into the blockchain network is extremely low, on the order of one in 4.29 billion chances.

Practicability of Cryptography and Blockchain in African Countries

Blockchain remains closely linked to the financial sphere. In Africa, the inaccessibility to financial services, the lack of financial literacy, the lack of confidence in the traditional banking system, the low level of income of the populations, the strong inflation observed in some African countries, the difficulties linked to the conditions for opening a bank account, are all factors that illustrate the fact that blockchain, based on a principle of decentralization and the absence of trusted third parties, offers an alternative to the disastrous regulatory policies of the banking system (Vedie, 2019). It is a disruptive innovation rich in potential which has not reached its maturity (Bussac, 2018), and the pitfalls in its path are not lacking, even if the enthusiasm it arouses around the world suggests that obstacles will one day be lifted. For African countries, despite the enthusiasm, several energies, technical and regulatory challenges arise. From a technical point of view, it would be legitimate to wonder whether the current Blockchain protocols, which, for the moment, allow to manage relatively weak data, would support the change of scale in the event of widespread and massive use. Probably, the process of validating transactions in the blockchain, with several nodes and cryptographic techniques, should be lightened. Since the technical solutions go through validation mechanisms that require the prior processing of the electronic identity of goods or people (since the blockchain is supposed to be a secure register of transactions), the fragility of the interfacing between the web and the "real" world is therefore the major technical issue of blockchain (Erdem & Altun, 2019).

On the other hand, digital currency issuance and blockchain transactions rely on proof of work; which implies a strong rivalry between miners and a worldwide competition for computing powers. The goal is to perform as many hashes as possible, especially as the gain per miner is proportional to the proof of work. This competition results in an exponential increase in the number of hashes made, which is assessed by the hashrate curve. Faced with the explosion of prices and strong speculation, the halving provided by computer protocols is very limited to play the role of arbiter and standardizer of the digital financial system. This computing power required for mining translates directly and proportionally into electricity consumption. Crypto-currency issuance is therefore only possible if energy is available in abundance. For example, El Salvador, which has just legalized cryptocurrency as a state currency, intends to mine it with the energy of its volcanoes. Given their very high energy needs based on proof of work and their energy consuming nature, digital finance raises the crucial question of its ecological and environmental impacts.

The method of calculating this consumption is the subject of several studies and reviews especially for the sake of competition, minors never communicate with each other and their number and identity are not known. As a result, power consumption can only be estimated, using different methods. However, a minimal evaluation is achievable thanks to the so-called economic calculation technique of Delahaye (2018).

This involves calculating the annual energy consumption in (Terra watt hour) TWh with the following formula: $((B * 12.5 * 6 * 24 * 365) + RC) * RDG * PE * CA / (EL * 109) = \text{Annual consumption}$. Based on the following assumptions:

- i. "B" The value of the cryptocurrency at the time of estimation;
- ii. "12.5" Represents the remuneration in bitcoin by proof of work, defined by the protocol;
- iii. "6" Represents the number of transaction validation per hour defined by the protocol;
- iv. "24" Represents a working day;
- v. "365" Represents one year of work;
- vi. "RDG" represents the expense / gain ratio deemed acceptable by a minor;
- vii. "PE" represents the percentage of the expenditure devoted to the purchase of energy;
- viii. "EL" represents the price of electricity;
- ix. "RC" represents the annual income due to transaction fees. Here it will be considered negligible;
- x. "CA" represents the attenuation coefficient, which is used to protect against any variation in the price of the crypto currency; knowing that the adjustment is not done simultaneously with the power of the network. This coefficient is conventionally between 0.5 and 0.75 in the event of an upward trend in the value of the cryptocurrency. On the other hand, if it is stable or has a downward trend, the adjustment coefficient is maintained at "1".

The production of digital currency as carried out in the current blockchain is pipe dream for the often-immature emerging economies. For example, the energy consumption of Bitcoin in 2020 is 143 Twh compared to that of Norway (124Twh), Belgium (82 Twh), Switzerland (58 Twh), Google (12Twh) and that of Facebook (5Twh). Such consumption, which far exceeds that of the eight WAEMU countries combined, is not bearable by any African economy. Which, moreover, proves that the production of cryptocurrency as carried out in the current blockchain is inaccessible to African countries in terms of energy consumption. Such a financial practice risks are destroying all the development efforts already made on the African continent.

Conclusion

Using of cryptography and Blockchain is a disruptive technology that allows major innovations and profound changes in the financial system. It is decentralized, tamper-proof and public, thus reducing transaction intermediation costs and ensuring the integrity of the financial infrastructure. In this register, the fully transparent system allows permanent consultation of the history of entries by all members of the network. It ensures full traceability of transactions while guaranteeing the anonymity of economic agents.

Once saved in the blocks, the information can no longer be modified or deleted; they become tamper-proof and inviolable. For developing countries marked by unfinished economies, blockchain technology promotes supreme autonomy without a regulatory authority, and a form of infallible transparency, without recourse to a third party. Transactions are carried out by computer programs with smart contracts or smart contracts which are self-executing.

All the advantages of blockchain combine to promise optimal economic efficiency to African countries, in terms of time savings through automation, cost reduction by removing middlemen, reducing the error rate and litigation by hashing. From the point of view of the violability of the network, the still experimental blockchain is the object of numerous attacks, hacks, thefts, falsifications of private keys, introduction of malicious software, which question the hope of inviolability and infallibility of the system.

As for crime, anonymity (or rather pseudonymity) appears to be a prime location for covering criminal activities such as money laundering, terrorist financing, and arms and drug trafficking. However, the fight is possible thanks to the traceability enabled by the blockchain.

From the above, we can state that using cryptography in blockchain technology is an innovation that offers great hope to African countries for securing financial system. However, its applicability comes up against a multitude of difficulties linked to the availability of the internet, the volatility of digital currency, the regulation of the system, but also and above all to energy limits and ecological impacts. Despite these undeniable advantages, blockchain also has a lot of limitations for sustainability.

In African countries and from a societal perspective, integrating this technology into our lives and workplaces can lead to the potential loss of jobs. In Africa, cryptography associated with financial business infrastructure could complement the current system but their implementation should be gradual, in accordance with adequate supranational regulation and the energy policies of member countries.

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