Estará África pronta para aderir à revolução blockchain? Um estudo de viabilidade

Is Africa ready to join the blockchain revolution? A feasibility study

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Resumo—Este estudo avalia a disponibilidade dos governos africanos para adoptarem a tecnologia de blockchain, que ganhou reconhecimento mundial desde o aparecimento da bitcoin em 2008. O documento analisa se os governos africanos, tendo em conta os seus desafios políticos, económicos e sociais, estão preparados para abraçar a revolução blockchain. A investigação centra-se num estudo de viabilidade de vários países africanos, incluindo a Nigéria, a África do Sul e a República Centro-Africana, utilizando uma abordagem de métodos mistos que combina métodos de análise de dados quantitativos e qualitativos. O autor baseia-se nos quatro elementos interdependentes de um estudo de viabilidade de Jennifer Bridges, que incluem a viabilidade política, a viabilidade económica, as capacidades técnicas e a conformidade legal e regulamentar.

O estudo analisa a forma como a tecnologia de blockchain pode fornecer sistemas transparentes e fiáveis para combater a corrupção e a má gestão nas estruturas governamentais, que contribuem para a má prestação de serviços na região. Além disso, a investigação avalia os potenciais resultados positivos e negativos da implementação de blockchain no desenvolvimento africano, tais como um aumento do investimento direto estrangeiro e da produtividade e uma redução das despesas supérfluas.

Palavras-Chave — 4IR; Tecnologia de blockchain; Governação eletrónica em África; Viabilidade da adoção blockchain; Prestação de serviços públicos.

Abstract—This study assesses the readiness of African governments to adopt blockchain technology, which has gained global recognition since the emergence of bitcoin in 2008. The paper examines whether African governments, given their political, economic, and social challenges, are prepared to embrace the blockchain revolution. The research focuses on a feasibility study of several African countries, including Nigeria, South Africa, and the Central African Republic, using a mixed-methods approach that combines quantitative and qualitative data analysis methods. The author draws on Jennifer Bridges' four interdependent elements of a feasibility study, which include political feasibility, economic feasibility, technical capacities, and legal and regulatory compliance.

The study examines how blockchain technology can provide transparent and reliable systems to combat corruption and mismanagement in government structures, which contribute to poor service delivery in the region. Furthermore, the research evaluates the potential positive and negative outcomes of blockchain implementation on African development, such as an increase in foreign direct investment and productivity, and a reduction in wasteful expenditure.

Keywords — 4IR; Blockchain technology; E-governance in Africa; Feasibility of blockchain adoption in Africa; Public service delivery.

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1 Introduction

Since Satoshi Nakamoto's white paper popularized the digital currency *bitcoin* in 2008, blockchain technology has gained considerable notoriety worldwide. Nakamoto was inspired by Stuart Haber and W. Scott's idea to create a system where document timestamps could not be tampered with (Hayes 2022). Although Nakamoto's blockchain technology gained popularity through its digital currency applications (that is, with cryptocurrency like Bitcoin), the technology has branched into various other usages-including that which forms the subject of this paper. Owing to its secure, cost-effective, and agile digital structures, members of both the private and public sectors have sought to explore how governments could adopt this technology to ameliorate their systems. In the public sphere, many countries, such as Estonia and the United Kingdom, have successfully begun implementing the technology into their systems.

However, for some states, this adoption remains out of scope-even though pressure from local and international actors is *forcing* governments' hand. To this effect, the paper aims to analyse whether African governmentsconsidering their political, economic, and social challenges-could be ready to join the rising blockchain revolution. To do this, the paper employs four, interdependent elements of a feasibility study as outlined by Jennifer Bridges in an article on Project Management (2021).

The first element studies the political (operations) feasibility of implementation. This includes capacity, resources such as human capital, and the governments' goals and objectives; it also includes the users of the technology: the people. Is there a market for the product? How have citizens responded to blockchain technology, whether domestically or globally? The second element is an analysis of states' financial ability to support the technology-that is, the economic feasibility. Provided that the state meets the above two prerequisites, the third analysis looks at the country's technical capacities: materials, skills, necessary support infrastructure. The fourth analysis explores the domestic and foreign legal and regulatory compliance of blockchain technology and its requirements.

In order to support this investigation, the paper studies how several African countries fare on this possibility 'scale'. The study includes the continent's largest economies, Nigeria and South Africa, as well as the weakest Central African Republic. The research borrows from the Information Technology, Governance, and Developmental Economics schools. This is because the paper will be looking at the economic, social, and political impact that this digital infrastructure has had on development-and, on governments-in the region. This development can be measured in terms of an increase or decrease in statistics: an increase in foreign direct investment and productivity, and a decrease in wasteful expenditure, for example. The research will employ mixed research methods: a quantitative approach, performing statistical analyses to study the extent of development-where there has been; as well as study existing literature on the possible positive or negative consequences of blockchain implementation on African development.

1.1 *How ready is Africa for the blockchain revolution?*

Before studying the region's readiness for this change, it is important to first explore what a blockchain is. That is, among others, what it aims to do, and how it aims to do it. Simply put, a blockchain is a digital database of information that is distributed among network users. In a typical database, information is stored in a table that could easily be edited. In blockchain technology, on the other hand, this information is stored as a series of 'blocks' that, when full, are linked together chronologically, forming a chain-hence the name 'blockchain' (Hayes 2022). The chronological nature of this linkage guarantees that the information could not be altered; and, the distribution of data creates decentralization, which heightens the authenticity, security, and transparency of information on the chain (Hayes 2022). There are a number of ways to build this chain network. For example, open to public participation; privately governed by an organization

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that controls who has access to the network; permissioned networks in which individuals or groups grant access to the network via invitation; or, where multiple structures maintain a blockchain in consortium, sharing responsibility for activity and access (IBM 2021). It is owing to this structure that different applications of the technology are being explored, like how it could improve government systems.

Public service delivery (or lack thereof) has increasingly been the nexus of citizen dissatisfaction across numerous African countries, as seen through the rampant protests of the last five years (IIAG 2020 in White 2021). In an article on South Africa, Rebone Tau highlights how, in addition to corruption, mismanagement in government structures-stemming from the lack of skills and the proper infrastructure-contributes to poor service delivery (Tau 2021). Luz (2019) adds to this sentiment, positing that corruption from resource revenues (natural or otherwise) and "shady financial dealings" contribute to Africa's stymied economy. Further, the COVID-19 pandemic increased corruption[1] risks in Africa-reflected in the low average Corruption Perceptions Index (CPI) score of 32/100 (Seychelles: 70/100, Somalia: 12/100)[2], with the majority of countries scoring below 50 (Transparency International 2023). This shows stagnant or worsening corruption levels, posing significant threats to global peace and security.

Public and private actors believe that to combat phenomena such as the above-described, African governments need to implement transparent, reliable systems. This is where blockchain technology comes into play. As will be shown in the paper, blockchain's transparency and immutability can help mitigate corrupt practices in various sectors, including land registry and resource management. By doing so, African governments can potentially experience the political and economic benefits discussed herein, fostering development, stability, and prosperity for their nations.

1. For the purposes of this research, corruption is studies through Transparency International's 2022 Corruption Perceptions Index (CPI).

2. The numbers on the CPI represent a country's perceived corruption level, ranging from 0 (highly corrupt) to 100 (very clean).

The next four sections analyse the feasibility of implementing blockchain technology in the region, looking through operational (political and social), economic, technical, and legal prisms. Each is discussed, in turn, below.

2 Africa and the blockchain revolution

2.1 *Politics, government, and the operational feasibility of blockchain technology*

Contrary to contemporary belief, the big push for the adoption of blockchain technology in the public sector has not been 'forced onto' developing countries by the Global North-it actually comes from the South (Capici and Kim 2019). In fact, it has been countries of the South that have since set a precedent for blockchain adoption in the sector. To illustrate, in 2017 China became the first country in the world to test a national cryptocurrency: the digital yuan (e-CNY). In 2022, the government ramped up its testing to more Chinese cities; and, its growing success sets it up to challenge the dollar's position as the global currency-especially, considering that China is gearing up to be the world's largest trading partner (Huang 2022).

Since around 2018, African governments have expressed interest in creating government-regulated blockchain-based services-like central bank digital currencies (CBDCs) (Simons 2022). In March 2018, Sierra Leone became the first country in the world to employ blockchain technology to verify votes in their March elections (Perper 2018). Nearly four years later, another African state set a record in the blockchain sphere, with the Central African Republic becoming the first in the region to accept Bitcoin (and other cryptocurrencies) as an official legal tender (Al Jazeera 2022). The Central African Republic is the second country to have made Bitcoin a legal tender: El Salvador, which is also a developing country, made the announcement last year, but rollout has since been hampered by global and local scepticism (Al Jazeera 2022). Regardless, the sentiment remains.

In addition, of the nine countries in the world that have fully launched CBDCs, Nigeria-with its eNairahas become the first and only country in the region to have built one (Rathburn 2022) as at May 2022. Unfortunately, the

planning, implementation, and reception of these projects has been less than ideal. Simons (2022) identifies the issue behind the slow adoption of blockchain-based or digital financial projects as the overreliance on government to be "the bank of the masses". He supports this position by stating that African governments are better at connecting their citizens-that is, creating national infrastructure-than serving them (Simons 2022). This view is paradoxical, considering the service-provision protests alluded to earlier, which highlight governments' inability to do either of these things-i.e., connecting and serving.

Furthermore, to this previous thought, Osei et al. (2021) highlight how Ghana's e-Zwich showed immense promise as Africa's first biometric (digital) payment system, but failed to live up to its potential due to government's poor customer relations. The problem came from having not educated the citizens (the market) on the system, and how it works-even failing to properly market the existence of the product. To elaborate, Ghana's 2018 financial report showed an 8.85% drop in e-Zwich usage from the previous fiscal year due to citizens finding the system to not be user-friendly (Ministry of Finance - Ghana 2018).

Nigeria's eNaira has faced a similar fate. The digital currency has received mixed reception since its launch in October 2021: the Central Bank of Nigeria (CBN) neglected to properly communicate what the eNaira was, and what it could-and was meant to-do (Benson 2021). This maladministration has resulted in backlash from the public, as well as international actors (an event which will be discussed further in the technical feasibility section). Local and international private actors have stepped forward to aid governments in bridging this service provision gap. Withal, this only raised concerns over control and stewardship (among others)-even though, as Simons (2022) modifies, the notion that government has to be the only actor to advance national policies has become increasingly outdated.

The right to own land is party to UN SDGs 1 2, 8, and 12. Even so, land is central to conflict in many African countries because of corruption surrounding land and property ownership. To exemplify, every second African citizen in 2013 had been affected somehow by land corruption by government officials (Transparency International 2013). With this, private actors have offered to help governments bridge these service delivery gaps-with mixed results.

On one hand, private real estate firms such as the Land LayBy Group in Kenya have lobbied for widely-accessible blockchain-based land registry records to curb corruption (Mwanza and Wilkins 2018). It is important to note that Kenya, as at 2021, was home to Africa's largest informal settlement of Kibera, with over 250,000 dwellers (Bloxham 2020). Still, as Mwanza and Wilkins (2018) add, the Kenyan government had proven hesitant to allow this adoption. Ghana, on the other hand, succeeded in this regard. To solve Ghana's historically unenforceable and cumbersome land tenure system, the government is working with private blockchain innovator Benben to revolutionize their land-registration system (BigchainDB 2020; Bridges 2021). Ultimately, reducing corruption has significant political impacts, including enhanced public trust in government and institutions, improved political stability, strengthened democratic governance, and more effective governance. Economically, it fosters economic growth by redirecting resources to productive activities and attracting foreign investment. It improves the investment climate, reduces poverty by equitable resource allocation, ensures proper resource management, and enhances infrastructure development by reducing costs and improving quality.

Syed Omer Husain from Input Output Global (IOG) identifies one reason (of many) why African governments have been hesitant to explore the technology. Per Hussain (2020), since blockchain-based projects allow citizens to be in charge of their agency, they would facilitate a shift of power from government back to the people. As an interviewee in Hussain (2020) conveys: "[T]here's no way government is going to let this [blockchain] be disruptive...ceding power requires someone to cede power to, and it's not going to be [to] an algorithm". This tendency to refuse to cede power is particularly true for Africa, where power has often driven state leaders to extreme measures to getand keepit for extended periods of time. Equatorial Guinea's President Teodoro Obiang Nguema Mbasogo is one such case: by 2022, still, President Mbasogo remains in power in the coun-

try, following his coup d'état in 1979. This makes him the longest serving national leader in the world. Unfortunately, his tenure has been far from stellar: corruption and maladministration in the central African state has come at the expense of his citizens, as shown by a 67% poverty rate as per 2022 (African Development Bank 2023; BTI Transformation Index 2022).

Another reason for governments' hesitation towards blockchain adoption, according to Rao (2018), is that governments could not control nor regulate cryptocurrency owing, in part, to the lack of local and international legislation to that effect. This event is explored deeper in the legal *feasibility* section. Notwithstanding, Hussain (2020) suggests that governments should embrace blockchain technology to reinvigorate trust between governments and their citizens-leaving their fears of the "depoliticization" of services behind.

One way that blockchain technology ensures trust in systems is through a feature called *Smart contracts*. Smart contracts are automated contracts in which the terms between the buyer and seller (or, in this case, citizen and public service provider) are directly written into the blockchain code, which is then distributed along the chain (Frankenfield 2022). This process ensures traceability, authenticity, and security of transactions-factors whose absence from current systems has contributed to the waning trust Africans have in their governments.

Here is one possible use case: in South Africa, only one body-i.e., the parliament-appointed Auditor-Generalhas the power to 'check' government's financial activities. Through blockchain technology, as Dinham (2018) shows, every South African citizen could assume this role, instead of having one body for this oversight function. Cryptocurrencies are transparent because transactions are distributed to new computers (called nodes) every time a new transaction is made, and anybody could track and trace said transactions-and their balances-through specialized platforms such as Maltego (Maltego Technologies 2021). The process is similar to how a customer could track the delivery of their packages through an app or a website. This ability would, in turn, help curb events of wasteful expenditure in the public sector.

An example of such an event is the R480 million (about US$30.4million) worth of marked Rustenburg Local Municipality vehicles that were bought in 2018, but remain unused (Masungwini 2022). This, Masungwini (2022) continues, despite Rustenburg having one of the worst service delivery records in the country. To further reflect the importance of Africa joining the digital revolution, a 2019 African Development Bank report on the project's potential on the region supports Dinham, Hussain, and Faleg's sentiments. The report also stresses the need for governments to become agile, working with the private sector and development partners to create sustainable development strategies-such as the adoption of blockchain technology-for public service provision (African Development Bank 2019).

There is clearly still a long way to go before African governments could join the blockchain revolution. In some cases, such as with Ghana and Nigeria above, governments have proven keen to explore and adopt the technology. However, unfortunately, even though the will might be there, the means becomes a substantial obstacle. This event is explored below.

2.2 *Economic/financial feasibility*

As reflected in the previous sections, numerous scholars highlight the benefits of introducing blockchain technology into African economies. However, as a region composed of developing and least developed countries, the economic feasibly of this adoption warrants concern.

Although Africa had one of the least shares of global debt in 2019 (i.e., 1.9%), most countries on the continent owed more than their GDP-worth in national debt in the same period (Gold 2021). In 2021, three of Africa's largest economies: Nigeria, Egypt, and South Africa, had GDP-to-debt ratios of 35.7%, 83.2%, and 70%, (FDFA 2021; O'Neill 2021; Kamer 2022; SA Treasury 2022) respectively. The COVID-19 global pandemic-coupled with Russia's invasion of Ukraine and the interest-rate hike by the US Federal Reserve, have further worsened the region's debt crisis. Despite efforts to suspend debt in the region, the figures remain alarmingly high[3], thus putting more countries at

3. R9.9 trillion (US$625 billion) in 2020

risk of defaulting (Gold 2021). More is the operative word in this statement, pointing to the fact that in 2021, Zambia became the first country in Africa to default on its debt during the pandemic era.

From the above statistics, it is clear why the economic feasibility of studying and implementing such revolutionary technology would be subject to analysis. To draw a comparative picture, the table below provides an estimated cost of implementing blockchain technology for a single government project.

Table 1: Estimated cost of one blockchain project per month (Banerjee 2021)

Factor	**Freelancer / hour (US$)**	**Outsourcing / hour (US$)**
Front-end developers	80,00	70,00
User-interface (UI) Developers	40,00	40,00
Blockchain developers	200,00	200,00
Miscellaneous	2 000,00	1 500,00
Turnaround time (hrs)	50	30
Tools (minimum cost, per month)	1 500,00	1000[4]
Hosting	1 000,00	200[5]
Native blockchain (Ethereum – ETH[6]) Price for 1 ETH as at June 13th 2023	1735.20	1735.20
Maintenance (as required)	7 000,00	Varies by contractor
Total[7] (US$)	**24,735.20**	**7,035.20** + Varies

4. Minimum cost

5. Ibid

6. Smart contracts run on Ethereum's native token ether (ETH).

7. Total = factors per hour x turnaround time. Costs per month, as well as that of 1 ETH and maintenance, have been excluded.

From Table 1 above, it is evident that outsourcing a project would be the most economic option. However, the cost above is for just one project. According to Banerjee (2021), government tasks like record-keeping require Opportunistic Solutions software, which is custom-built to solve very precise problems. This means that each identifiable problem would require its own blockchain project.

Now, considering that record-keeping is a crucial part of every service provider's work, and taking the South African government as an example;

With 128 State-Owned Enterprises (SOEs) working across 9 provinces in South Africa (Gov.za 2020), each SOE would require its own record-keeping project in each province. That is:

$128 \times$ R156 426,00 (US$ 9 300,00 $\times$ 16.82[8]) = R 20 022 528,00 for the first month in one province;

Assuming all 128 SOEs operate in all 9 provinces, it would be

R 20 022 528,00 $\times$ 9 = about R180.2 million for the first month

Looking at the R480 million wastage by the Rustenburg Local Municipality mentioned earlier, that would be enough to install new record-keeping software in every SOE in every province twice over (R480 million ÷ R180.2 million). That means that the South African government could very well afford blockchain technology-they just have not come around to implementing it. Moreover, the Government had allocated R2.4 billion in February 2022 to "modernize" the country's Information and Communication Technology, so as to accelerate the road to universal connectivity that would accommodate digital technology like blockchain (Odendaal 2022).

Nevertheless, it is important to remember that the data applies to one of Africa's biggest economies. With 10 of the poorest countries in the world hailing from the continent (Ventura 2022), it would be prudent to perform the same study on the opposite end of the GDP spectrum. Cen-

8. USD - ZAR exchange rate as at July 9th 2022

tral African Republic, which-as discussed earlier-recently announced that it will be recognizing cryptocurrency as a national legal tender, is also the fourth-poorest country in the region (Ventura 2022). The Republic's GDP was US$1.9 billion in 2021less than 1% of South Africa's US$276.1 billion (African Development Bank 2022a; African Development Bank 2022b).

Using the same formula employed in South Africa's case: the Central African Republic has about 32 ministries (Anadolu Agency 2021) operating in 16 prefectures.

This means that if we were to assume that every ministry operates in each prefecture; and, assuming that it would cost an upwards of R156 426,00 per blockchain-backed project, government would require, hypothetically;

R156 426,00 × 32 ministries = R5 005 632,00 for the first month in one prefecture; and,

R5 million × 16 prefectures = about R80 million for the first month.

That would be approximately 4% of the annual GDP spent in just one month. For a country that is already struggling economically-like the Central African Republic-a blockchain project would not be financially feasible; unless, of course, it is implemented gradually over a very long time. Economic improvement, positively, is the reason the government opted to legalize cryptocurrency. According to the CAR's Presidents chief of staff, Reuters (2022) reports, the President supports the Draft Law Governing Cryptocurrency bill because, he believes, it will open up new opportunities for the country, ultimately improving the citizens condition.

Notwithstanding, proponents of blockchain technology in the public sector continue to advocate for the positive impact that its adoption would have on these economies. First, blockchain technology improves access to financial services by allowing access to funds from anywhere in the world-with the added benefit of significantly reduced cross-border transaction costs (Reiff 2021). To illustrate, according to the World Bank (2019, in Gogo 2019), traditional banks charge as much as 10.2% on international transfers, 7% more than the SDG goal of 3%. Cryptocurrency, on the other hand, presents a less expensive alternative. A Kenya-based exchange called BitPesa, for example, claims to only charge between 1-3% (depending on the cryptocurrency and amount) for international transactions (Gogo 2019).

Domestically, Central Bank Digital Currencies-or CBDCS, as discussed earlier in the paper-would substantially cut financial costs by cutting out middlemen (banks), and the reduced risk that comes from more transparent and secure transactions. This point leads to financial inclusion. Second, with smart contracts, issues with land titling and registration could be solved, as the information is stored in temper-proof blocks. This is important because land is a resource from which all natural resources come, which makes it a crucial element for development (Encyclopædia Britannica 2019).

Third, the global push for blockchain adoption has exposed Africa's limited access to digital technologies. To that effect, citizens have resorted to building their own Internet infrastructure in their communities. In war torn northern Uganda, Harrisberg (2021) introduces, a local businessman has created an Internet and phone network to ensure that villagers in the area maintain access to work and studies online.

The blockchain movement could be the key to helping underdeveloped countries bypass traditional, ineffective systems, so as to close developmental gaps (GetSmarter 2022). To elaborate: PwC (2021) predicts a R29,7 trillion (US$1.86) trillion global economic recovery hike by 2030, as people's trust in the financial system returns. In the same vein, the World Bank (2019, in Gopaldas 2021) estimates a GDP growth of up to 3% for every 10% advancement in technology.

In essence, African states are in evident need of transparent financial systems to revitalize their development. As reflected earlier, corruption is one of the leading causes of the region's stifled economic growth, as wasteful and irregular spending in the public sector that has diminished public trust in the system. Fortunately, blockchain technology offers a solution to this malaise, through its open and secure systems. Alas, though, even if governments have interest in adopting the technology, the means to either study or implement it

are lacking. So, to whether it is financially feasible for Africa to explore blockchain technology in its sectors, it varies between domestic economies.

The sad reality is that a majority of African governments would not be able to afford this exploration. The few that can, are either hesitant or wholly against it: because the existing inefficient system works for them; lack sufficient understanding of the technology; or, are afraid of what it would mean for their hold on power. There are, of course, those who posses both the means and the willingness to explore blockchain technology for public systems. The challenge, as alluded to above, comes from a lack in the technical resources to carry out the technology. This is discussed next.

2.3 *Technical feasibility*

Having analysed the political and economic feasibility of blockchain technology in Africa, this section aims to study its technical feasibility. That is, do African countries have the necessary infrastructure, as well as the necessary skills, to support the technology. According to Faria (2022), four people out of ten in Africa had access to the Internet in December 2021. This is an alarming figure, considering how important the Internet, and digital connectivity in general, has become-especially in the wake of the COVID-19 pandemic, when many aspects of life had to 'go digital' to limit transmission.

Mobile connectivity is also required for blockchain technology. That considered, one of the primary goals for the proposed African Continental Free Trade Area (AfCFTA) is to work towards inclusive digitalization and subsequent connectivity for Africans (Faleg 2021). In order to meet this goal by 2030, the World Bank (2017, in Faleg 2021) estimates that African governments will require an investment of about R1,5 trillion.

Although slower than the rest of the world, Africa's telecommunications infrastructure has made substantial strides: Jackson (2021) points to a doubling of Internet speeds in the region, coupled with data costs that have nearly halved between 2015 and 2019. Onyango (2021) supports this position, adding that Africa's most technologically advanced countries charge less for 1 GB of data than the global average of US$4.07 (about R65): South Africa, Kenya, and Nigeria charge R45, R36, and R14 respectively. To this previous point, it is important to note, Gopaldas (2021) adds, that Africa's telecommunications sector was able to leap-frog tech development as soon as digital technology became cost-effective. This means that countries were able to move from fixed-line to mobile connectivityall while on near non-existent infrastructure (Gopaldas 2021). Unfortunately, these achievements are still not enough to meet the increasingly growing demand for connectivity in the region. This means that they also fall short of adequately supporting the current technology wave.

To illustrate: the Bank of Ghana introduced the world's first ever biometric money (the e-Zwich) in 2008-through its subsidiary, the Ghana Interbank Payment and Settlement System (GhIPSS). The aim of this innovation was to usher the country into the era of cashless economies, therefore working towards socio-economic development and inclusion (Albrecht-Heider 2020). The project has, however, met considerable technical (and operational) challenges. Osei et al. (2021) highlight, among others, "...connection failure, frequent breakdown of equipment, sluggish service delivery process and long queues..." as challenges to the successful adoption of the technology. As a result, their study found, a drop in e-Zwich usage due, in part, to finding the system inconvenient (Osei et al. 2021). This led to citizens reverting to cash.

It is because of these difficulties that private actors have stepped forward to help governments better roll out their digital projects. German tech organization KfW has partnered with the GhIPSS to improve Ghana's e-Zwich. As a result, other initiatives like the Ghana Social Opportunities Project (GSOP) are starting to use the e-Zwich system (Albrecht-Heider 2020), which also works towards poverty-reduction.

Nigeria's CBDC, the e-Naira, met similar technological challenges. According to Adepetun and Oji (2021), "...the level of digital infrastructure, network reliability, low Internet penetration...", among others, jeopardize the e-Naira's sustainability. On October 26th 2021, several news outlets in and around Nigeria reported a 'sudden' disappearance of the e-Naira's digital wallet

from Google's Play Store. This removal followed immense negative reviews and poor application ratings which, regrettably, the CBN blamed on Nigerians, instead of taking responsibility for the glitches that the users experienced (Abiola 2021).

Evidently, the private sector plays a crucial and continued role in Africa's digital transformation. An estimated 3 300 "tech start-ups" hailed from Nigeria alone in 2020, with South Africa following with 660, and Kenya with 600 (Saleh 2022). In the blockchain space, the South Africa-based cryptocurrency exchange Luno is the largest in Africa, with an estimated 1.5million users across 40 countries (Ogunjuyigbe 2022). Luno is also the first exchange to have a presence in two of Africa's largest economies, Nigeria and South Africa (Ogunjuyigbe 2022). Crypto exchanges work like conventional bureau de changes in that they allow users to buy different currencies. The difference, here, is that one could exchange fiat for cryptocurrency, as well as cryptocurrencies for others.

Although native platforms like Luno exist, Africans can-and do-still use some international exchanges. Binance is the most popular international exchange, and is also the largest exchange in the world as of May 2022, with over 28.5 million users in October 2021 (McGovern 2022). Per Larnyoh (2021) African users on the platform increased by 2000% despite numerous national restrictions-notably, Ghana's Securities and Exchange Commission (SEC), and, ironically, the Central Bank of Nigeria. In fact, Binance recorded a 114.3% increase in African users in just the period between January and April 2021 (Larnyoh 2021). This shows that Africans are warming up to blockchain technology, that the market exists.

However, there is concern that the skills to self-develop infrastructure is lacking. Pawczuk, Massey and Holdowsky (2019) support this position. They present that a quarter of respondents to their 2018 and 2019 survey on blockchain felt that the lack of in-house skills and understanding on the subject had been a barrier to adoption of the technology (Pawczuk, Massey and Holdowsky 2019). Sawahel (2018), IITPSA (2020), and Kaaru (2020) further highlight the still-inadequate supply of blockchain skills, shifting the lens towards the education sector.

In 2018, there was already a great call for African universities to offer blockchain-related courses and training, as almost half of the global top 50 universities were already providing such (Sawahel 2018). University of Johannesburg (UJ) in South Africa is one of the few learning institutions that offer courses related to blockchain technology (incorporated into their financial engineering course), and cybersecurity (Hawkes 2018). In 2022, the public institution also revealed that it would start offering certificates and degrees secured with blockchain technology to combat results fraud and provide hassle-free credential verification (BusinessTech 2022). This initiative shows that private actors have partnered with public education institutions to bridge the skills and knowledge gap. For example, the partnership between Liquid Intelligent Technologies (or Liquid Tech) with the University of Johannesburg (Hawkes 2018).

Private learning institutions have also championed the blockchain-education movement. For example, Blockchain African Ladies (BAL) is a non-profit educative forum that brings African women together through blockchain education (BAL 2022). The organization has members from Nigeria, South Africa, Egypt, Kenya, Ghana, and Uganda, among others (BAL 2022). Other private institutions include South Africa's Vega, and the Red and Yellow Creative School of Business (Terenzi 2018 in Sawahel 2018). The former school offers blockchain courses at tertiary level, while the latter allows students to pay their tuition fees in cryptocurrency (Terenzi 2018). The above paragraphs reveal that there is a skill shortage for the study and adoption of blockchain technology.

Now, the question is: what exactly are these missing skills? Hiremotely, a platform for remote-working recruitment, identifies six of the most essential of these skills. First, a proficient understanding of blockchain technology. That includes what it is, how it works, and what it aims to do. Second, proficiency in at least one programming language-be it C Suite JavaScript, or Python. Some languages are specific to the blockchain project or application for which they are used. For example, Solidarity is specific for Ethereum, and Bitcoin was initially built on C++ (Hiremotely 2022). In addition to these languages, a blockchain

developer must understand how algorithms work, and for what purpose. Fourth, one must have a firm understanding of cryptography (extensive data protection) and other cybersecurity principles. Fifth, experience with distributed, decentralized systems like the blockchain's, as well as in peer-to-peer networking: all blocks are "peers", and this lack of hierarchy rids of central control of information. Lastly, a knowledge of smart contracts is also essential, considering that a lot of projects rely on this automated verification protocol (Hiremotely 2022).

It is, then, in light of this skills gap that researchers like Kaaru highlight the importance of getting the education sector on board. With public and private institutions providing access to relevant learning resources, states can bridge the human capital gap, and, ultimately, lead to the development of appropriate technical infrastructure for blockchain technology in Africa. On the plus side, it should not be difficult for Africa's estimated 716 000 software developers (AfricaNews 2022) to build their blockchain development skills. Notwithstanding, there is considerable potential to use the existing technological skills and mobile infrastructure to develop applications based on blockchain, which make services such as eGovernance, eCommerce, eHealth, and digital finance more secure and reliable.

In a nutshell, although Africa is considerably behind in terms of technological advancement, it shows incredible promise. Technological advancements such as Ghana's e-Zwichwhich is the world's first biometric money, and Nigeria's eNaira, support this position. Albeit met with a series of obstacles, these projects have set a precedent for what is possible.

The public sector has proven more than willing to provide both the technology and the technical expertise to support these public projects-especially, considering the strides that actors in this sector have achieved. Case in point, the Luno cryptocurrency exchange, which is the largest in the region; as well as other providers of blockchain-based solutions, who are partnering with the public sector to improve service delivery. A gap in knowledge has inspired the need for such partnerships: a gap that has been attributed to the slowed exploration and adoption of blockchain technology in the region. Fortunately, learning institutions are beginning to heed the call for formal technical training-a movement that will positively impact Africa's development.

2.4 *Legal/regulatory feasibility*

In Africa, as with the rest of the world, the blockchain revolution has faced considerable backlash-particularly, concerning the technology's ethical and legal ramifications. To this effect, this section seeks to identify whether Africa is ready to embrace this technological advancement by studying the region's regulatory environment. Owing to its decentralized, transparent, and open properties, one of the main concerns over the adoption of this technology is if-and how-it contravenes with existing domestic and international legislation (GIZ 2019). The financial application of blockchain, in particular, has borne the brunt of legal scrutiny.

Even though blockchain-based systems are neither compatible nor incompatible with regulation (Gakwaya et al. 2020), governments across the globe have been hesitant to accept cryptocurrency because its decentralized nature means that they cannot control it (CEO Today 2022). Therefore, instead of regulating the technology itself, governments have resorted to regulating its applications. This is because certain elements of blockchain technology-notably the requirement of access to personal information and the non-reporting of financial activity-have potentially illegal and unethical uses. Citing these characteristics, as a result, governments have sought means to oversee the technology. These events and (attempts at) regulation follow.

The protection of personal data has become an increasingly important function of governments, and Africa-albeit slowly-is no different. In January 2001, Cape Verde, through the landmark General Legal Framework for the Protection of Personal Data of Natural Persons, became the first country in Africa to have legislated the protection of personal information (Hogan Lovells 2022). To date, Hogan Lovells (2022) continues, 33 countries have followed in these footsteps-with Zambia having enacted legislation to regulate the digital economy in 2021. In the context of Africa's adoption of

blockchain technology, it is crucial to consider how these advancements align with data protection regulations. The continent's model instrument on the protection of personal data and privacy is the 2014 African Union Convention on Cybersecurity and Personal Data Protection, which only 14 countries, regrettably, had ratified by April 2023 (African Union 2023). Other regional data protection regulations include the 2008 East African Community Framework for Cyberlaws; the 2010 Supplementary Act on Personal Data Protection of the Economic Community of West African States; and, the 2013 Southern African Development Community model law for unified ICT Market policies in sub-Saharan Africa (Gakwaya et al. 2020). However, the challenge lies in harmonising blockchain technology with international data privacy regulations like the General Data Protection Regulation (GDPR). According to Baker McKenzie (2022), many data protection laws in Africa draw inspiration from GDPR, sharing key principles like data subject rights and processing principles. While not identical, these laws align with GDPR to a significant extent[9], acting as a framework for international data protection. Further, without the proper supporting legislation and frameworks, the adoption of blockchain technology-and any digital infrastructure for that matter-is stalled; and, creates space for illegal and unethical practices. To this effect, Whitehouse (2020) proposes a structured and coordinated Pan-African approach to blockchain regulation, through which the technology's full potential can be realized, and the protection and verification of personal data can be achieved.

Withal, concerns remain-notably, in the apparent impossibility to delete information from a blockchain, which appears to conflict with the right to erasure. The right to erasure, also known as the right to be forgotten, gives an individual the right to request the erasure of their data from databases once the information is no longer required. For example, an applicant can request a company delete their CV from file should their application be unsuccessful. There are very few laws that explicitly recognize the right to erasure on the continent; some existing legislation just allude to it. In South Africa, for instance, the Protection of Personal Information Act of 2020 only calls for deletion of information if it is "...inaccurate, irrelevant, excessive, out-of-date, incomplete, misleading or obtained unlawfully" (Weeks 2013). Kenya's Data Protection Act of 2019, conversely, terms it the right to erasure, and allows for this deletion of information "without delay" (Atamba 2021). It is now possible to see-even if just on the surface-why blockchain technology might be a major area of concern for legislators.

Another regulatory concern for blockchain technology is the non-reporting of financial activity, which legislators feel helps mask financial crimes. To combat financial crimes such as money laundering, fraud, and cyber crime, traditional banks follow KYC (Know Your Customer) processes and Financial Action Task Force (FATF) frameworks (N26 2020). Through these, they identify suspicious accounts and transactions, and then report them to regulatory bodies-usually formed by the government and central bank. Cryptocurrency, on the other hand, is borderless and decentralized, making it difficult for governments to apply local monetary policies to financial transactions-even if they originate from within their borders (CEO Today 2022). Regardless, as mentioned earlier, governments are still exploring ways to regulate aspects of the technology.

One way that governments are doing this, is the establishment of Central Bank Digital Currencies (CBDCs), through which they can issue their own cryptocurrencies (which they can regulate and monitor), and (hopefully) limit other digital currencies (CEO Today 2022). Another way, is through the regulation of blockchain and cryptocurrency applications. A common event in Africa is the move towards the taxation of crypto assets like digital currencies, utility coins, and security tokens. The South African Revenue Service (SARS) for example, regulates these assets in terms of the Income Tax Act 58 of 1962, and the Value-Added Tax Act 89 of 1991 (Ukwueze 2021). This means that interest earned on these assets is treated as income, and transactions made using cryptocurrency are subject to VAT rules. The

9. Ghana, Kenya, Rwanda, and Uganda have data protection laws aligned with GDPR, though with variations. South Africa's POPIA provides broader protection covering natural and juristic persons, unlike GDPR. Mauritius' Data Privacy Act aligns with GDPR, with differing provisions.

same case is true for Nigeria, wherein cryptocurrency is regulated by the Personal Income Tax, companies Income Tax, and Value Added Tax Acts. Essentially, blockchain regulation puzzles regulators from developed and developing countries alike. Nevertheless, governments still need more straightforward regulatory strategies.

Proponents of blockchain technology oppose regulation, claiming that the act itself contradicts what the technology stands for. However, advocates of regulation believe that it has more advantages than considered. For one, regulation allows for public protection by decreasing the risk of blockchain investment, and increasing investment by institutions (Wu 2022). For Gailey (2022), regulation provides stability in "a notoriously volatile market", could protect long-term investors, prevent fraudulent activity within the crypto space, and "...provide clear guidance to allow companies to innovate in the crypto economy". As Ukwueze (2021) adds, having an effective and efficient crypto regulation would make it easy to detect the negative criminal applications of blockchain, and provides a source of revenue for governments.

Nevertheless, African governments lack the adequate regulatory structures for these applications. Prinsloo and Henderson (2021) posit that this stalled approach to blockchain regulation has resulted in businesses moving offshore: Luno, for example, is registered in London, with a 'presence' in Singapore. For governments that have shown more positive attitudes toward the technology, strides have been made to reach this regulatory ideal.

One such notable step, is the establishment of sandboxes. Sandboxes are environments in which innovators can test technologies in real-time, while leapfrogging the legal requirements for full adoption (GIZ 2019). The publishing of Kenya's Stakeholders' Consultative Paper on Policy Framework for Implementation of a Regulatory Sandbox to Support Fintech Innovation in the Capital Markets is one such case. Through this initiative, the Capital Markets Authority (CMA) recognizes cryptocurrencies as a capital market-based Fintech innovations (Pavia e Ansaldo 2019). Even though cryptocurrencies remain unregulated in the country, these efforts show that this position might change in the future. Other African countries with regulatory sandboxes are Nigeria, South Africa, Sierra Leone, Rwanda, Mauritius, Ghana, and Mozambique (Ngari 2021; IFWG 2022).

In sum, the legal feasibility of African countries joining the blockchain movement rests firmly on the domestic and regional regulatory environment. One of the main issues with the technology, for regulators, is whether the technology infringes on existing legislation-and if so, how.

Although blockchain technology is not entirely compatible or incompatible with formal regulation, governments that are open to the technology have been exploring ways to regulate the technology's applications-particularly cryptocurrency. For other regulators and legislators, concerns over access and protection of personal information, as well as the non-reporting of financial transaction synonymous with crypto transactions, has influenced the stalled approach to the adoption of the technology. Still, legislation to regulate blockchain technology itself does not exist yet-with governments and regional bodies relying on existing legislation to regulate the technology and its applications.

To meet the global technological advancements halfway, some African governments have developed sandboxes for the controlled testing of technological innovations within their borders. Others are looking to develop CBDCs, so as to create digital currencies they can monitor and regulate against financial crimes. Regulation, according to its advocates, has many advantages, including the protection of citizens against the aforementioned crimes, providing stability of assets, and creating revenue streams for governments that could be used to better their countries. Regardless, proponents of blockchain technology are against regulation. This conflict of positions creates an uncertain environment for blockchain adoption in the region; and, therefore, leaves analysis truly wondering whether Africa is ready to join this technological movement.

3 Conclusion

The fourth industrial revolution has opened up possibilities for the public and private sectors

alike to transform their processes. Digital advancements like Artificial Intelligence (AI) and blockchain technology, in particular, promise avenues to completely revolutionize said processes. Blockchain technology, which is essentially the chronological storage of data in a series of 'blocks'-that in turn secures this data-has provided an alternative to traditional data storage.

In the public sector, blockchain technology has an array of applications that could tackle some of the struggles that African governments face: the decline in the quality of service delivery. Public service delivery (or lack thereof) has increasingly been the nexus of citizen dissatisfaction across numerous African countries. In fact, the big push for the adoption of blockchain technology in the public sector has come from actors in the developing world, who see the potential that the technology has on national socio-economic development, as well as on political processes. To exemplify, some of the biggest strides in the adoption of blockchain technology (and other digital movements) have been made by the developing world: Ghana with the first biometric money (eZwich); Nigeria with one of nine Central Bank Digital Currencies (CBDCs) in the world; Kenya with its accommodating regulatory environment; as well as the Central African Republic-joining Ecuador, another developing state-in allowing the use of cryptocurrencies as national legal tenders.

Although the reception of the technology varies across countries on the continent, the above shows that governments are aware of a gap, and are therefore exploring ways to bridge it. However, that is easier said than done. The purpose of this study, then, was to study how possible (that is, how feasible) it is for Africa to join the global technological movement.

The four facets that are explored: political/operational, economic, technical, and legal feasibilities, seek to determine this readiness in studying, first, whether (and how) African states-and their people-react to blockchain technology. Second, studies whether these African states can afford to implement-or even study-the technology. Even though Africa had one of the least shares of global debt, most countries in the region still owe more than their GDP-worth in national debt. Zambia, for example, made headlines during the global COVID-19 pandemic era, as the first country in the region to default on its debts. A lot more countries are still facing this grim future. It is, therefore, prudent to see whether the implementation of such expensive technology would be possible, or even advantageous, for these states.

For those who can afford the technology, the issue that arises becomes whether the will for this adoption exists, which also speaks to the political feasibility discussed herein. Where means and the willingness exist, a possible roadblock is the lack of the technical expertise required for adoption. That is, whether African countries possess the technical know-how, as well as the infrastructure necessary to support the technology. This third aspect also revealed worrisome information, including that, amongst others, that only almost a quarter of the African population had access to the internet in December 2021. At least some structures exist to attempt to remedy this problem: the proposed African Continental Free Trade Area (AfCFTA), for example, which is to work towards the region's inclusive connectivity and digitalization. Nevertheless, some scholars believe that the continent's current technology infrastructure most likely will not be able to support the blockchain movementnot yet, anyway.

The fourth facet, legal feasibility, presents an analysis of whether the African regulatory environment is conducive for technological advancements like blockchain. This area is important owing to the backlash that the technology has faced-particularly, concerning the ethical and legal ramifications that come with some applications of the technology. Although the technology itself is neither compatible nor incompatible with local and international legislation, its financial application of blockchain, in particular, has borne the brunt of legal scrutiny. Notably, the requirement of access to personal information, and the non-reporting of financial activity, which have apparent potentially illegal and unethical applications. The former, because of the protection of personal information that forms part of many domestic and international regulations. The latter's issue arises from the international efforts towards the prevention of financial crimes.

Regulations exist to protect the citizen: since blockchain is decentralized, no one body fully

owns (and, therefore, can control) it. In light of these, some governments, like South Africa, have resorted to taxation of digital assets, for example, in an attempt to watch over this financial blockchain application. The lack of explicit regulation in Africa has, unfortunately, resulted in the off-shoring of crypto assets and organizations to countries where such legislation and regulation exists. South Africa's Luno, for example, in registered in London. This negatively affects the South African government, since corporate taxes that would otherwise be paid into the country, are being paid elsewhere.

That said, whether African countries are indeed ready to join the blockchain revolution requires further study. The countries explored in this analysis represent the so-called "best" and "worst" of Africa. In order to perform a more informed study, the research requires looking at the "middle"-which was beyond the scope of this paper. Furthermore, since the technology is still relatively new, its impact on development in the region is yet to be seen, and studied.

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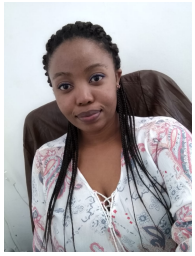

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