

Scaling Up Sustainable Investment through Blockchain-based Project Bonds*

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FIRST DRAFT – COMMENTS ARE WELCOME!

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Abstract

This paper explores options for mobilising domestic savings through fintech solutions to scale up sustainable investment. Most developing and emerging economies face an urgent need to scale up sustainable finance for low-carbon and climate-resilient infrastructure. Yet domestic resource mobilisation for infrastructure investment tends to be inhibited by underdeveloped capital markets. At the same time, domestic savers are confronted with a scarcity of “safe” assets in local currency, resulting in an export of capital to financial centres of advanced economies. The paper discusses how fintech can help to complement conventional capital markets and help to mobilise financial resources for sustainable infrastructure investments. It puts forward a proposal for blockchain-based project bonds to raise finance through a digital crowdfunding platform, which is also able to transparently record and certify the use of proceeds, sustainability impact and revenue streams of the project by combining timestamp, public and private key mechanism, and smart contract technologies. This approach would not only provide investors of different sizes the opportunity to purchase local-currency assets and issuers such as municipalities to raise funds for sustainable infrastructure investment. It would also facilitate project management once the project is operational, e.g. through metering and billing, and create full transparency across the life cycle of the investment, reducing problems with mis-use of funds.

Keywords: Sustainable investment, fintech, blockchain.

JEL Classification: G23, O16, O18, Q01

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1. Introduction

Countries all over the world face an urgent need to scale up sustainable infrastructure investments, including in renewable energy infrastructure, to foster a low-carbon transition and to align their economies with the Paris Agreement and the 2030 Agenda. Recent estimates by the International Monetary Fund (IMF) put the additional annual public investment needs in infrastructure, low-carbon technologies and other areas needed to achieve the Sustainable Development Goals (SDGs) at more than US\$ 20 trillion over the next two decades (IMF 2020). Especially in developing and emerging economies, finance has been identified as a key challenge for making these investments happen. Although the international discourse on financing for development – led under the catchy slogan “from billions to trillions” – has highlighted the need for unlocking domestic resources, much of the discussion has centred around incentivising private capital from advanced countries to finance investment in developing and emerging economies. While foreign aid and foreign private capital can play an important role in financing development, it is important to acknowledge the limits to the role of foreign investment in financing infrastructure and the financial vulnerability risks associated with foreign finance. It is also important to make better use of domestic savings in developing and emerging economies, many of which invest significant amounts of their savings in low-yielding assets in the financial centres of advanced economies. Strengthening domestic resource mobilisation is therefore crucial, and concerted efforts to this effect are needed. Besides the mobilisation of finance, a central problem around infrastructure investment is corruption. The IMF (2020: 1) estimates that “one-third of funds for public infrastructure is lost worldwide to inefficiencies.” It is hence crucial to identify ways how this slack can be reduced if not eliminated.

Against this backdrop, this paper will discuss how financial technologies – or fintech – and blockchain-based solutions can facilitate domestic resource mobilisation for sustainable investments and at the same time improve the implementation of infrastructure projects throughout the entire life cycle by facilitating processes and enhancing transparency. In particular, this paper explores how fintech can help to complement conventional capital markets and help to mobilise financial resources for sustainable infrastructure investments. It puts forward a proposal for blockchain-based project bonds to raise finance through a digital crowdfunding platform, which is also able to transparently record and certify the use of proceeds, sustainability impact and revenue streams of the project by combining timestamp, public and private key mechanism, and smart contract technologies. This approach would not only provide investors of different sizes the opportunity to purchase local-currency assets and issuers such as municipalities to raise funds for sustainable infrastructure investment. It would also facilitate project management once the project is operational, e.g. through metering and billing, and create full transparency across the life cycle of the investment, reducing problems with mis-use of funds.

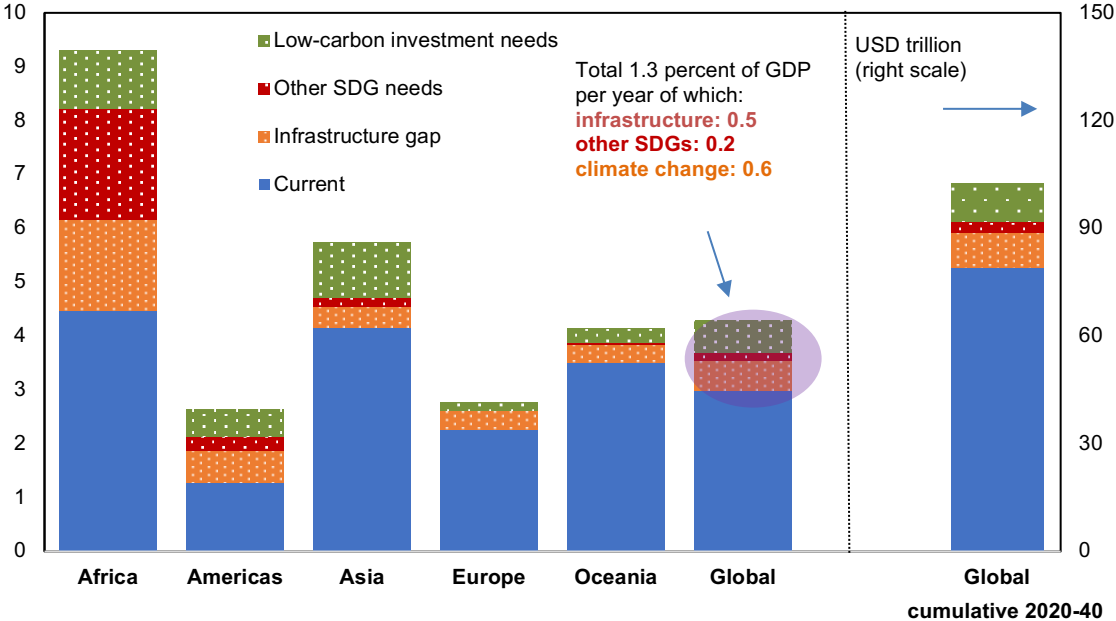
The remainder of the paper is structured as follows. Section 2 discusses the need for scaling up domestic resources for much-needed investment in low-carbon, sustainable infrastructure and other sustainable investment needs. It will also discuss the problems facing developing and emerging economies in mobilising these resources locally for domestic investment. Section 3 will then review the solutions for raising local savings and enhancing sustainable investment made possible through fintech applications, paying particular attention to blockchain solutions.

Subsequently, Section 4 will put forward a proposal for an integrated blockchain-based fintech solution. Section 5 concludes.

2. Domestic Resource Mobilisation for Sustainable Investment

The IMF (2020) estimates the additional annual public investment needs in infrastructure, low-carbon technologies and other areas needed to achieve the SDGs at 1.3% of world GDP (Figure 1). Cumulated over the period 2020-2040, the estimated additional investment needs would exceed US\$ 20 trillion in current US dollar. To scale up finance for the SDGs, multilateral development banks (MDBs) have advanced the “billions to trillions” agenda to “unlock, leverage, and catalyze private flows and domestic resources” (African Development Bank et al. 2015: 2). The idea is to use official development assistance, or “blended finance”, to mobilise private capital for investment in sustainable development.

Figure 1: Global investment needs for infrastructure, climate change, and other SDGs (% of annual regional GDP; trillions of US dollars, right scale)



Sources: IMF (2020), drawing on data from Global Infrastructure Hub; Oxford Economics; and IMF staff estimates.

Note: The blue bars show the current investment levels across regions as of the end of 2017. Additional global investment needs are estimated, on average, at 1.3% of global GDP per year during 2020–40 (exceeding US\$ 20 trillion in current US dollars), and comprise infrastructure (0.5% of GDP), other SDGs (0.2% of GDP), and low-carbon investment (0.6% of GDP). The right panel shows the cumulative investment needs in trillions of US dollars (constant 2019 prices and exchange rates) over the next two decades. SDGs = Sustainable Development Goals.

Critics of blended finance have voiced concerns about financial stability risks associated with “the escorting of international capital by multilateral development agencies into frontier and emerging market settings” (Carroll and Jarvis 2014: 540). A fundamental problem of initiatives aimed at leveraging private investment by “de-risking” is that the risk itself does not disappear, but that it is merely shifted to public balance sheets (Mazzucato et al. 2018). In particular, concerns have been raised that issues around “complexity, accountability and transparency” of blended finance (Mawdsley 2018: 194) and growing risks of related financial innovation and an over-financialisation in developing economies (Akyuz 2017) may contribute to debt crises. Financial stability risks may also arise from the fact that both development finance institutions and private financiers usually provide finance only in international currency, which leaves borrowers with foreigners exchange risk.¹ UNCTAD (2019: viii) criticises that “the focus of the development finance agenda on complex – and mostly non-transparent – new financial instruments and on securitized finance, does not bode well for its ability to deliver reliable financing at the required scale to where it is most needed.”

Instead of trying to lure international capital for blended finance solutions – which has not been very successful to date, as reflected by small volumes and low leverage ratios (Attridge and Eigen 2019) –, efforts should concentrate more on mobilising domestic resources, without creating complex financial structures. While foreign capital in the form of direct investment or foreign aid has played a role in the economic development of many countries, historically no economy has developed its infrastructure and financed its development primarily through foreign finance. Mobilising domestic savings for local investments is hence a crucial part of economic development. The good news is that for many countries, especially middle-income countries, domestic savings are not the main bottleneck.

In fact, many developing and emerging market economies, especially in Asia, are net capital exporters, as is reflected in their current account surpluses. And even countries that do not record current account surpluses tend to invest parts of their savings at low or negative returns in the financial centres of advanced countries, only for them to be reinvested in their home countries, typically at higher returns which then benefit foreign investors. This phenomenon is known as round-tripping of capital. There are different reasons why domestic savings are invested abroad, including macroeconomic instability at home, international portfolio diversification, and tax evasion. Two important reasons to invest savings abroad (which motivate this paper) are better financial services abroad and a lack of safe financial assets in the domestic economy due to underdeveloped capital markets.

The reliance on foreign currency borrowing to finance domestic investment has been associated with two major problems: currency mismatches and maturity mismatches (Goldstein and Turner 2004). Financing long-term projects that yield returns in domestic currency with short-term foreign-currency credit creates financial vulnerabilities that can contribute to financial crises. The currency crisis literature has highlighted the importance of developing local currency bond markets to overcome problems of “original sin” – the problem that most emerging markets in the past were unable to borrow in domestic currency, even domestically (Eichengreen et al. 2003) –

¹ For a discussion of the shortcomings of blended finance in leveraging private capital see Attridge and Engen (2019).

and avoid financial vulnerabilities associated with currency mismatches (Burger and Warnock 2006, 2007; Burger et al. 2012).

Since the emerging market crises of the late 1990s and early 2000s, progress has been made in developing local currency bond markets (Burger et al. 2012, Berensmann et al. 2015, Dafe et al. 2018). Yet, these are in part still very dependent on foreign investors. The large-scale withdrawal of international capital from emerging economies' bond markets in March 2020 has once again highlighted the vulnerabilities associated with a shallow domestic investor base and a heavy reliance on international portfolio investors (Hofmann et al. 2020; Beirne et al. 2020). There clearly is a need to further develop local currency capital markets with a strong domestic investor base. An important question in this context is: can fintech help by mobilising domestic savings and channelling these into sustainable investments?

3. Fintech Solutions to Enhance Sustainable Investment

3.1 Current state of discussion

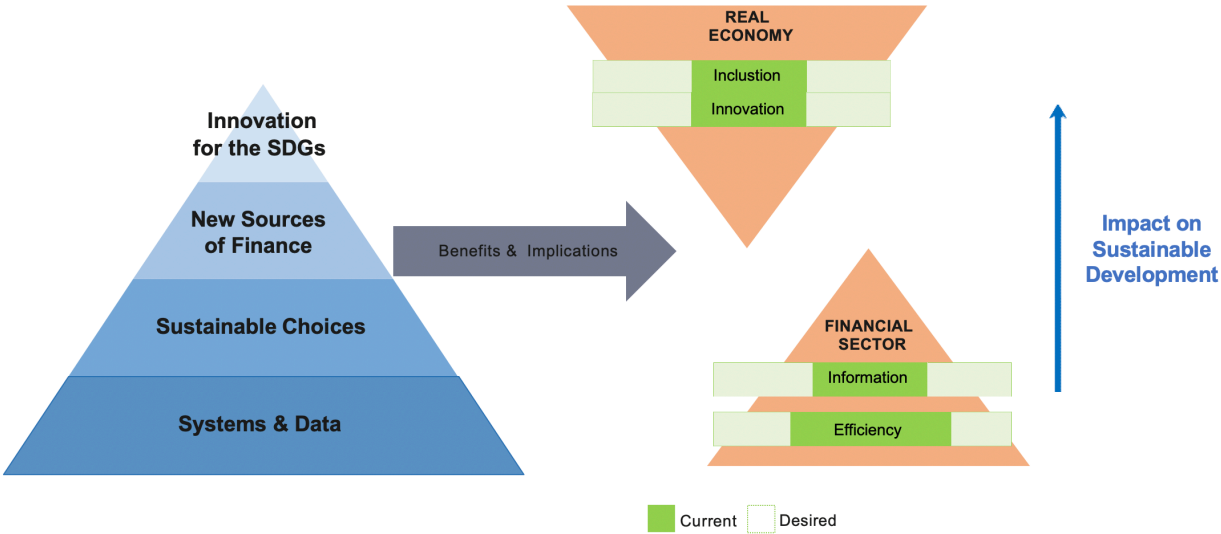
The financial system has experienced continuous development due to the sustainable finance agenda and emerging financial technology (Chishti and Barberis 2016, Jeucken 2010). The G20 Sustainable Finance Study Group highlighted the emerging practice of applying digital technologies to sustainable finance (G20 SFSG 2018). As shown in Figure 2, the Sustainable Digital Finance Alliance identifies several challenges for connecting the financial sector with the real economy and highlights the potential of digital finance for improving information and efficiency in the financial sector through better systems and data, and for fostering inclusion and innovation in the real economy by broadening sustainability choices and providing new sources of finance. Digital finance can be developed to leverage the full potential of sustainable finance, by facilitating a better use of sustainability-related data for financial decision-making, and by supporting nascent business models by enabling better access to funding. Digital finance can help to address barriers that limit the scalability of sustainable finance, such as lack of local community power and asymmetrical information between investors and other stakeholders. By doing so, digital finance can help to promote goals such as financial inclusion and energy justice, both of which are key issues in the sustainable transition (Aboushady and Gowaid 2019; Demircuc-Kunt et al. 2018; Arner et al. 2020).

The UN Secretary General's Task Force on Digital Financing of the SDGs recently emphasised the development of financial inclusion into citizen-centric finance as one of the transformational opportunities brought about by digitalization (DFTF 2020). Citizen-centric finance is not only about the financial return but also represent an aggregation of influence through different channels and organisations (DFTF 2020).

Fintech or digital finance is a business approach dedicated to making financial services more efficient through internet-related technologies. Normally, fintech companies play two roles in the financial sector. One is as a challenger to traditional financial institutions, in which these fintech companies rely on algorithms or machine-based logic to replicate the back-office processes of traditional financial institutions and generate new technology-based business models. The other is as a pioneer in providing services in places where there is no traditional financial infrastructure,

e.g. through mobile banking and other internet-based automated information platforms. Fintech comprises different applications, including lending, blockchain/crypto, regtech, personal finance, payment service/billing, insurance, capital market solutions, wealth management, money transfer/remittances and mortgage/real estate financing (Table 1).

Figure 2: Implications of Digital Finance for Sustainable Development



Source: Compiled by authors based on SDFA (2018).

Table 1: Overview of fintech solutions

Fintech category	Examples
Lending solutions	Online marketplace lending and alternative underwriting platforms such as peer-to-peer lending platforms and digital crowdfunding platforms
Blockchain/crypto	Companies leveraging blockchain technologies for financial services
Regtech	Audit, risk, and regulatory compliance software
Personal finance	Tools to manage bills and track personal and/or credit accounts
Payment service/billing	Payments processing, payments transferring, card developers, and subscription billing software tools (a major function of mobile banking)
Insurance solutions	Online insurance services or data analytics and software for (re)insurers
Capital market solutions	Sales and trading, analysis, and infrastructure tools for financial institutions
Wealth management	Investment and wealth management platforms and analytics tools
Money transfer/remittances	International money transfer and tracking software
Mortgage/real estate financing	Mortgage lending and financing platforms

Source: Compiled by authors drawing from CB Insights (2019).

Mobile banking has been developed further to provide investment opportunities in capital markets for people who would traditionally have neither the means nor the expertise and access to invest in securities. For instance, the M-Akiba project is a mobile-based fintech solution developed by the Government of Kenya. The scheme focuses on the local, small-scale individual investors and engages them to raise funds for national building (Central Bank of Kenya 2020a). In a similar project in Kenya called Treasury Mobile Direct (TMD), the Central Bank of Kenya enabled users to buy treasury bills and bonds on their phone (Central Bank of Kenya 2020b). However, the value of these bonds and bills is questionable due to the abuse of government power in adjusting interest rates and potentially associated multiple transaction cost (Suri et al. 2018). Neither M-AKIBA nor TMD are based on blockchain, which allows to record each party's digital property rights and curb corruption (Kshetri and Voas 2018).

Digital crowdfunding platforms can offer new solutions to personal finance and wealth management. For instance, digital crowdfunding platforms can be used to mobilise financial power and accumulate the local resources (Larralde and Schwiendbacher 2012). Belleflamme et al. (2015) classify crowdfunding into two groups: investment-based crowdfunding (financial-based crowdfunding), and reward- and donation-based crowdfunding (nonfinancial-based crowdfunding). The first category includes equity-based, royalties-based and loan-based crowdfunding, where the funders are investors in the campaign and may receive monetary gains through the growth of the company or based on the interest rate. In the second category, funders cannot expect to receive monetary compensation. They fund the campaign because they obtained the product, or because they supported the purpose (or a combination of both).

3.2 Blockchain

Technical features and value-added of blockchain

Blockchain is an emerging technology that has attracted great attention from financial institutions, energy companies, technical developers, national governments and academia (Hughes et al. 2019). Blockchain technology, which is based on distributed ledger technology (DLT), provides an encrypted, tamper-proof and transparent system that can implement innovative business solutions by integrating or disrupting different business models. Zheng et al. (2018) summarise blockchain in four key characteristics, namely decentralisation, network persistency, anonymity, and audibility. They also highlight three challenges: scalability, privacy leakage, and selfish mining. Several reports, including Galen et al. (2018), Herweijer et al. (2018) and OECD (2019), maintain that blockchain has the potential to bring significant innovation that can support the low-carbon transition.

DLT is usually based on a peer-to-peer (P2P) architecture with broadcast capabilities, where transactions are simultaneously recorded in multiple locations. Generally, DLT systems allow computers to exchange information directly without going through a central server or an authorized institution (Lawrenz et al. 2019). The best-known DLT technology is blockchain, which usually uses a specific structure composed of a chain of data blocks. "Blockchain" and "DLT" are often used interchangeably.

Blockchain applications in financial markets

The World Bank launched a new type of bond called *Bond-i* in 2018, which is a blockchain operated new debt instrument. The bond raised US\$ 100 million with a two-year maturity and a triple-A rating (Klopfer 2018). In 2019, the World Bank raised an additional AUD 50 million and expanded market participation with the *Bond-i* platform (World Bank 2019). The purpose of this bond is to exploit the potential of disruptive technology for faster, more efficient, and more secure transactions. Leveraging blockchain for bond development is not only being pioneered in advanced countries; emerging market players also are exploring this niche market. BMT Bina Ummah, one of Indonesian Islamic microfinance cooperative, has raised IDR 710 million (US\$ 50,000) through the world's first issuance of Islamic bonds on a public blockchain (Gonçalves 2019). In Thailand, the Public Debt Management Office plans to sell THB 200 million saving bonds through Krungthai Bank's blockchain-based e-wallet system to engage retail investors to invest in the market (Chantanusli 2020).

Blockchain can play an important role in the green bond market. In the conventional bond market, it is hard for multiple stakeholders to monitor the flow of money, get or provide updates on the development status in a real-time manner, or demonstrate the impacts of green bonds (Banga 2019). The use of blockchain in the green bond market could help to enhance system transparency and capital traceability. SDFA and HSBC (2019) indicate three directions for combining blockchain technology and the green bond market:

- 1) Building a blockchain supported bond issuance platform, which could digitalise the whole bond issuing process. This includes utilising stablecoins – a digital form of money (or cryptocurrency) which is typically pegged to fiat money – for automatic settlement and payment to investors and setting transparent nodes for supervision.²
- 2) Converting the manual reporting to data tokens, which enables investors to communicate in a real-time manner and establish a shared asset history on the ledger for the project aggregation.
- 3) Providing a “bond-as-a-service” platform to enlarge the local community bond market. It means people can create their green bonds at low cost based on the blockchain system and provide them in certain markets through security tokens. This will allow smaller entities (such as medium-sized companies or communities) to issue green bonds directly without the need for banks to provide expensive full-services.

Apart from the traditional bond market, DLT can be applied as a new format of crowdfunding. Several papers argue that blockchain has the potential to bring significant innovation in the crowdfunding sector and enhance financial inclusion (Zhu and Zhou 2016, Muneeza et al. 2018). Blockchain technology provides a distributed, tamper-proof and encrypted system that can disrupt the traditional model of crowdfunding (Hartmann et al. 2019). For example, renewable energy assets could be backed as cryptocurrencies.

Blockchain-based crowdfunding activities have similarities with conventional crowdfunding models but conceptualise the monetary value into a token manner such as Initial Cryptoasset Offerings (ICOs) and Security Token Offerings (STOs) (Ackermann et al. 2020). There are three types of blockchain-based crowdfunding models: utility token, payment token and investment token (Howell et al. 2018). Utility tokens are the inherent carriers of value on the platform, protocol

² A stablecoin could be a digital currency issued by central bank.

or network, that network participants need to hold to engage or access the products or services provided by the platform, protocol or network (Hartmann et al. 2019). Utility token sales are similar to traditional reward-based crowdfunding models. Investment tokens such as security tokens have more similarities to conventional equity-based crowdfunding. Payment tokens are similar to fiat money, especially in terms of stablecoin, which typically pegged with fiat money. For example, Bitcoins are designed as a payment token to execute peer-to-peer transactions (Nakamoto 2019).

Blockchain utilises smart contracts to automate transactions and enhance reliability and efficiency (Peters and Panayi 2016). The legal elements can be embedded into the code, which aims to list and add conditions on every possible transaction (Clack et al. 2016). Transactions will happen automatically when all the network participants have agreed with the set terms. It has been argued that a large portion of the population can benefit from blockchain technologies, especially in developing countries (Kshetri and Voas 2018). With the increasing affordability and usability of smartphones, blockchain can offer a better value proposition because of typically weak rules, laws, regulations and enforcement in developing countries and regions (Kshetri and Voas 2018).

In an interesting case study from the Yale Open Innovation Lab, blockchain is utilised to initiate the financing of a decentralised energy resources (DERs) platform called OpenSolar (Wainstein 2019). OpenSolar is a security-based (lending and equity) crowdfunding platform. Unlike a traditional public-private-partnership project (which locks users or “off-takers” into a long-term payment agreement without final ownership), the project allows people to own the DERs in a real-time manner. Thus, they can participate in the local energy economy as co-owners of community-based microgrids. However, the scalability of such projects is still an issue. Other channels are needed to scale up such projects, such as offering user-friendly applications to mobilise finance for infrastructure projects. For instance, mobile phone applications – such as those used for M-AKIBA or TMD – could help to provide an investment opportunity for people to buy these assets, and provide a platform to people to invest in rights to benefit from local energy infrastructure.

Blockchain applications in industries

In the context of energy, climate and environment, blockchain applications in the energy industry mainly include: 1) cryptocurrencies for funding renewable energy projects; 2) metering, billing and security; 3) decentralised energy trading; 4) green certificates and carbon trading; 5) grid management; 6) internet of things (IoT), smart devices, automation and asset management; 7) electric e-mobility; and 8) general-purpose initiatives developing underpinning technology (Andoni et al. 2019).

In the context of decentralised energy trading schemes, there are several applications in early stages of development: wholesale energy trading, energy trading support for small generators and end-consumers, energy trading for utilities and energy system stakeholders, and P2P trading in community projects and microgrids (Andoni et al. 2019). Although the scale of their adoption is limited at this stage, these applications have the potential to create radical changes to disrupt the incumbent business model, such as energy suppliers or grid operators who have the monopoly power or own the physical infrastructure. There is a gap for analysing the emerging localised or community-based energy system in contrast with the mainstream energy system and the role of blockchain in this transition. It needs further investigation in how the blockchain interacts with regulation, policy and markets to deliver certain promises for end users.

Blockchain is able to connect the energy and financial systems. For example, blockchain could be used for financing local energy projects, and in the subsequent operational phase of the utility work with IoT to collect metering and billing data, ensuring the certification of origin. In the following, we will develop a proposal that combines different fintech- and blockchain-based approaches that could be employed to mobilise domestic savings to finance and operate local energy projects based.

4. A Proposal for a Blockchain-based Bond for Sustainable Investments

We propose a comprehensive blockchain-based approach that integrates multiple fintech applications to mobilise domestic financing for sustainable infrastructure investment. The approach should account for the interests of the various stakeholders involved, including local residents, public policy, multiple investors, and possibly international development agencies. Table 2 provides an overview of the likely interests of these stakeholders.

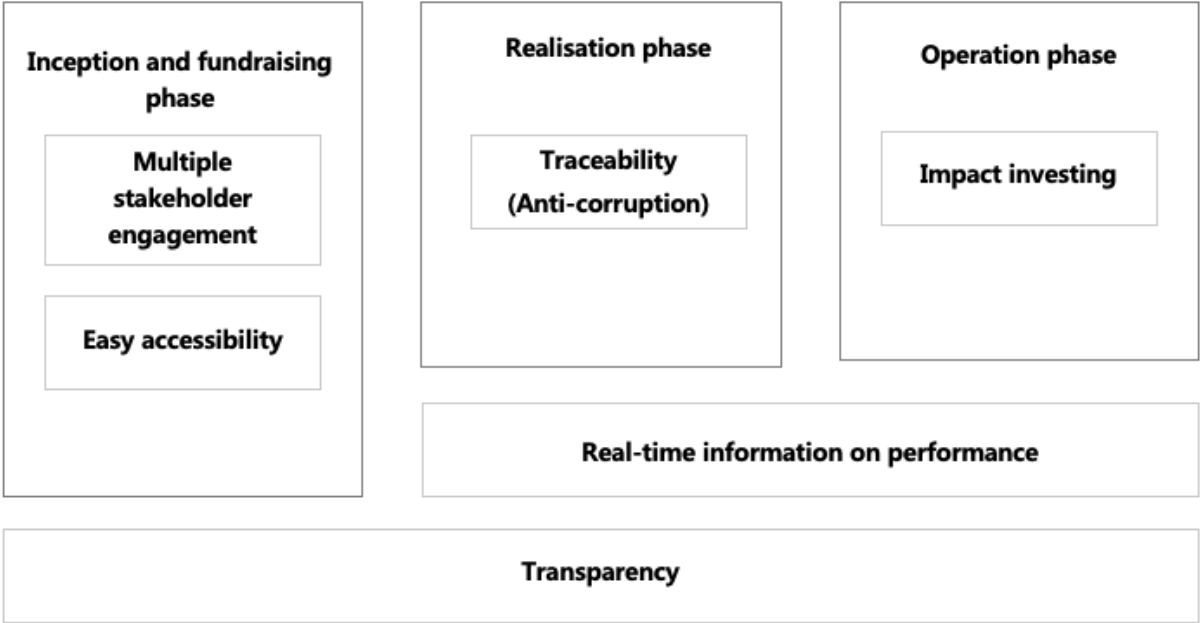
Table 2: Main interests of stakeholders

<p>From a public policy perspective Investment in sustainable infrastructure to support local development</p> <ul style="list-style-type: none"> • Deliver and operate infrastructure utility at low cost, with reliable revenue stream <p>Favourable financing conditions</p> <ul style="list-style-type: none"> • Raise long-term project finance in domestic currency and avoid currency and maturity mismatches • Low interest rates <p>Financial sector development and reduction of financial instability risk</p> <ul style="list-style-type: none"> • Strengthening domestic local currency bond markets • Strengthen local investor base • Broaden opportunities for domestic savings to be invested in safe assets <p>Strengthen accountability and “good governance”</p> <ul style="list-style-type: none"> • Strengthen transparency of use of proceeds and reduce corruption problems
<p>From an investor perspective Investment opportunity into “safe assets” (i.e. low risk of default) User-friendly investment process Easy access, even for small amounts for retail investors Aggregation small sized projects for institutional investor Sustainability driven projects, capable for impact investors</p>
<p>From a local resident perspective Investment in sustainable infrastructure to support local development Access to quality infrastructure services at low cost No negative environmental externalities Positive local employment effects</p>
<p>From a development agency perspective (if applicable) Support sustainable infrastructure development Promote access to affordable energy, water etc. Promote “good governance”/anti-corruption efforts Support domestic financial market development</p>

Source: Compiled by authors.

Our proposal would address these stakeholder interests. Moreover, it would help to address key concerns in the three key phases of an infrastructure project’s life cycle: the inception and fundraising phase, the realisation phase, and the operation phase (Figure 2). First, in the inception and fundraising phase, blockchain applies the crowdfunding logic to mobilise domestic savings for investment in the domestic local currency bond currency market. The ownership structure can be recorded in the ledger to ensure customer’s user rights. As the above cases show, fintech applications, such as M-Akiba and TMD, could be used to mobilise local savings for the domestic bond or bill market, allowing for small-size investments through easy-to-use online applications. However, transparency concerns and inflexible investment manner create barriers to deliver the promise. The characteristics of blockchain could potentially solve the bottleneck problem in the market. By applying smart contracts, the return will be automated to correlate with interest rates. Customers won’t bear with asymmetric information risk. By applying blockchain-technologies such as timestamp³ as well as public and private key mechanism,⁴ the bond issuing entity can record the bond issuance, registration and certification information in the blockchain network, which enlarges the credibility of projects. By integrating crowdfunding and the local currency bond market, blockchain can enhance the efficiency of the fundraising phase by engaging with multiple stakeholders and promoting accessibility.

Figure 3: Key phases of the infrastructure project life cycle and advantages of a blockchain-based finance approach



³ A timestamp is coded information used to identify when a specific event occurs, usually providing the date and time.

⁴ The public and private key mechanism is an encryption system that uses a pair of keys: a public key that can be widely spread and a private key that only the owner knows.

Source: Compiled by authors.

Second, in the realisation phase, all stakeholders can trace the use of proceeds and obtain information on the construction status in a transparent way. By ensuring investors' ownership, companies or the government can collect more money from domestic customers and generate more sustainable projects. As mentioned above, one reason to track finances with blockchain is that digitisation can have a dampening effect on corruption. Investors face the risk that the issuing entities may misuse the funds and that they never get paid back. By recording information on the flow of money the construction on the blockchain, investors can better understand the status of the project and decide whether they will continue to devote money in the project. If the money raised through the issuance is mis-used or the project realisation stalls, investors can take decisions on real-time information. The interest rate and return should be formatted and automated by smart contracts.

Third, blockchain not only helps to finance infrastructure projects transparently, but it could also help to manage the project when it is operational, e.g. through metering and billing. Downes and Reed (2020) illustrate that transparency should comprise three parts: evidence, disclosure and access. 'Evidence' refers to a record of relevant information, such as green certification for renewable energy or carbon credits. 'Disclosure' means the project operator should provide information for multiple stakeholders so they can monitor and verify the operation process. 'Access' means stakeholders should have the right to access information for them to evaluate the operating status and decide whether they will keep the investment. By recording operating data on the blockchain, stakeholders can receive transparent information on project revenue streams and reduce the risk that investors would get no returns because some corrupt manager ran off with the money. The whole data life cycle management enables a new way to raise funds for sustainable investment. An example would be a community-based renewable energy project, where investors can play the role of consumers. The community ownership model would allow for a "pay-as-you-go" approach, where developers are the utility companies willing to sell, e.g. electricity services, through a pre-paid model. By recording the investor profile in the blockchain network, consumers can leverage their ownership of the project to use electricity and even trade with each other, that is, become a "prosumer" – a producer and a consumer at the same time. This is a suitable solution for adopting a net metering policy for microgrid or other renewable projects by enabling an investor to become a prosumer (Stoutenborough and Beverlin 2008; Hwang et al. 2017).

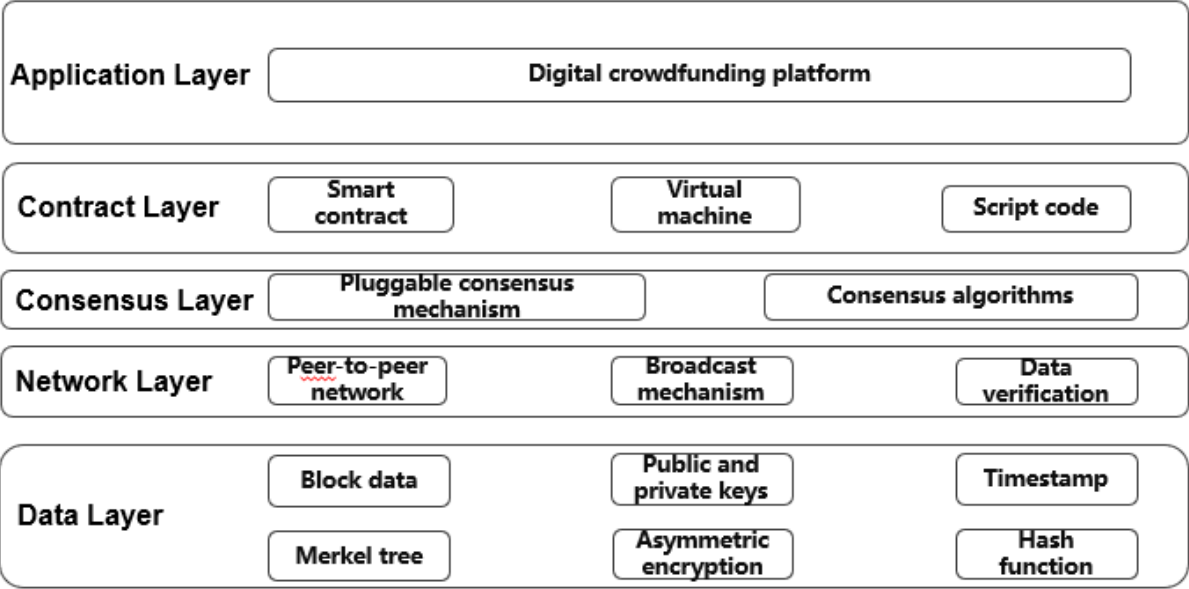
It also provides the option of documenting environmental or carbon impact which can be used for receiving carbon credits through carbon emission trading schemes. The issuing entity can leverage the blockchain to build an impact investing information platform, which incentives asset managers and customer in the space by quantifying the carbon certification or emission reductions, or any other positive impacts – be they ecological or social – the project may have.

Our proposal could be configured in multiple ways to suit different situations. The main goal of this proposal is to leverage the strength of a decentralised governance model backed by blockchain to achieve project-level financial inclusion. Through the blockchain-based project development platform, the issuing entity can engage with retail investors who would like to own

parts of the project by equity crowdfunding, such as micro-grid projects. Retail investors may receive deductions on their utility bill as part of their bond interests. Furthermore, by replicating this approach, multiple projects could be aggregated to create a larger portfolio that would be attractive to institutional investors, including impact investors.

Figure 4 illustrates the different layers and elements of the technical side of our proposal. This figure includes a digital crowdfunding platform for the funding as the main application in our proposal; technological features such as timestamp, public and private key mechanisms, smart contract and other technologies which were mentioned in the text are part of blockchain network. These technological features enable the process of registration and certification in the blockchain network and the data life cycle management for using blockchain to mobilise information on (i) use of proceeds, (ii) construction/realisation of the project, (iii) operation of the project and its environmental/social impact, (iv) metering/billing, and (v) revenue streams.

Figure 4: Technical structure of the proposal



Source: Compiled by authors.

5. Conclusion

In this paper, we explore how fintech can complement conventional capital markets and help to mobilise finance for sustainable infrastructure investments. Based on an analysis of the interests of relevant stakeholders, it puts forward a proposal for blockchain-based project bonds aimed at financing sustainable investments. A digital crowdfunding platform is used to raise finance, while the blockchain is able to transparently record and certify the use of proceeds, sustainability impact and revenue streams of the project. The suggested approach would not only provide investors of different sizes the opportunity to purchase local-currency assets and issuers such as

municipalities to raise funds for sustainable infrastructure investment. It would also facilitate project management once the project is operational by offering easy technical solutions for metering and billing. Last but not least, this approach would create full transparency across the life cycle of the investment, reducing problems with a misappropriation of funds. This in turn should increase the attractiveness of the underlying project.

The proposed blockchain-based project bonds could be issued, for instance, by municipalities to finance local infrastructure such as energy utilities that would generate returns that could be used for payments of coupon and principal. Multiple applications to suit different situations would be possible, including community ownership structures, using the strength of a decentralised governance model backed by blockchain.

To our knowledge, such an approach has not been explored in practice yet. With support from UNDP and UNCDF, the UN Secretary General's Task Force on Digital Financing of the SDGs has recently launched a Pathfinder Initiative with the government of Bangladesh to explore how to use digital technology to mobilise small amounts of domestic savings for sustainable infrastructure investment (LightCastle Partners 2020). Very much in line with our proposal, this initiative envisages to transform micro savers to micro investors and reduce the need for international borrowing, using blockchain as a technical backbone to improve the accountability of the funds, and returning the dividends from infrastructure investment to Bangladeshi citizens (LightCastle Partners 2020). Going forward, it would be desirable to extend this pilot and integrate some features of our proposal to gain operational experience, with a view to scaling this up in order to mobilise much-needed investment into sustainable infrastructure.

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