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THE ROLE OF FINTECH IN UNLOCKING GREEN FINANCE: POLICY INSIGHTS FOR DEVELOPING COUNTRIES

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Abstract

The achievement of the Sustainable Development Goals (SDGs) and implementation of the Paris Agreement will require significant new investment. New financial technologies ("fintech") offer the potential to unlock green finance technologies, such as blockchain, the Internet of Things and big data, developed over the same timeframe as the Paris Agreement and the SDGs. This paper outlines three broad areas for the possible application of fintech to green finance: blockchain applications for sustainable development; blockchain use-cases for renewable energy, decentralized electricity market, carbon credits and climate finance; and innovation in financial instruments, including green bonds. The paper focuses on blockchain use-cases pertaining to sustainable development and renewable energy and highlights examples from Europe, which has been a leader in blockchain technology. The paper explores the implications for developing economies in Asia and draws preliminary recommendations for policy makers interested in harnessing fintech and blockchain for low-carbon, climate-resilient investment and the achievement of the SDGs.

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INTRODUCTION

Implementation of the Paris Agreement and achievement of the Sustainable Development Goals (SDGs) will require significant new investment (World Economic Forum 2013; Global Commission on the Economy and Climate 2014; Organisation for Economic Co-operation and Development 2017; Bhattacharya et al. 2016; Bielenberg et al. 2016). Indeed, the latter will require additional investment of $2 trillion–$3 trillion per year and $1.4 trillion per year in developing countries, including $343 billion–$360 billion for low-income countries and $900 billion–$944 billion for lower-middle-income countries (Schmidt-Traub 2015; Schmidt-Traub and Sachs 2015).

Trillions of dollars in new investment, including incremental investments to ensure that long-term investments such as infrastructure are low-carbon and climate-resilient, will be required to meet the Paris Agreement's key objective of ensuring that global average temperature increase remains "well below" 2°C and achieves the SDGs. The United Nations Conference on Trade and Development (UNCTAD 2014) estimates total global annual investment needs as equating to $5 trillion–$7 trillion, including $3.3 trillion–$4.5 trillion in developing countries in key SDG sectors (comprising infrastructure, food security, climate change mitigation and adaptation, health and education). The OECD (2017) estimates current levels of investment as approximately $1 trillion per year, i.e., less than a third of the amount required. Developing countries in Asia will need to invest an estimated $26 trillion by 2030 (or $1.7 trillion per year) in infrastructure, including $4.7 trillion for power and $8.4 trillion for transportation, in order to maintain growth, eliminate poverty and address climate change (ADB 2017).

Owing to limited public budgets, private capital must constitute a large proportion of this new investment. The Paris Agreement includes a commitment to "[making] finance flows consistent with a pathway toward low greenhouse gas emissions and climate-resilient development" (United Nations Framework Convention on Climate Change (UNFCCC) 2015, p. 2, Article 2.1 (c)). Ensuring that capital flows to sustainable investment has therefore become an important focus for policy makers. The United Nations Environment Program explored the potential for alignment of the financial system to meet sustainability objectives (Zadek and Robins 2018). Innovations in green finance offer the potential to contribute to global goals and reshape the economy in favor of access to services such as energy, poverty reduction and economic activity, as well as lowering aggregate investment and operating costs and therefore helping to improve our capacity to achieve agreed sustainability outcomes.[1]

Technology innovation and new financial instruments will be required to lower costs and raise capital at the appropriate scale and speed. Green finance and fintech are relevant to policy makers, particularly in emerging and developing countries, as they pursue the implementation of the Paris Agreement and achievement of the SDGs. Fintech broadly refers to "companies or representatives of companies that combine financial services with modern, innovative technologies" (Dorfleitner et al. 2016, 2017, p. 5). Green finance can be said to constitute "financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy" (Lindeberg 2014,

[1] The Sustainable Development Goals encompass 17 global goals, including SDG 1 – No Poverty, SDG 2 – Zero Hunger, SDG 7 – Affordable and Clean Energy, SDG 8 – Decent Work and Economic Growth, SDG 9 – Industry, Innovation and Infrastructure, SDG 10 – Reducing inequalities, SDG 11 – Sustainable Cities and Communities, SDG 12 – Responsible Production and Consumption, and SDG 13 – Climate Action.

p. 1). Innovations in new technologies such as blockchain that have the potential to accelerate the flow of capital to a more sustainable economy technology, as well as financial instruments such as green bonds that meet the risk-return requirements of investors for sustainable investments, will help meet global policy objectives.

The aim of this paper is to survey the potential applications of fintech and blockchain for green finance, with an emphasis on renewable energy as a key element of implementing the Paris Agreement and achieving the SDGs. Moreover, the paper will suggest areas for future policy consideration. Where applicable, it highlights examples from Europe, which has emerged as a leader in blockchain innovation, and therefore potentially relevant for developing countries in Asia, especially in the energy sector.

The paper is organized as follows:

Section 1 provides an introductory overview of fintech, focusing on blockchain and with reference to the complementary role of the Internet of Things (IoT) and big data.

Section 2 highlights the potential application of fintech (with emphasis on blockchain) for a range of sustainable development goals.

Section 3 outlines potential use-cases of blockchain technology for carbon credits, renewable energy and distributed electrical power systems.

Section 4 describes the application of fintech and green finance, specifically on green bonds as a financing tool for sustainability investments.

Where applicable, the paper highlights examples from Europe, which has assumed a leadership role in sustainable finance and fintech innovation, including blockchain start-ups.

The paper also draws linkages from these innovations to the People's Republic of China (PRC), as a leader in both green bonds issuance as well as in fintech and blockchain technology.

Section 5 proffers recommendations for developing country policy makers seeking to tap the potential of these new technologies to advance climate and sustainability goals.

1. FINTECH AND BLOCKCHAIN

Fintech in its initial applications involves "technologies used and applied in the financial services sector, chiefly used by financial institutions themselves on the back end of their businesses" but its applications have enlarged "to represent technologies that are disrupting traditional financial services, including mobile payments, money transfers, loans, fundraising, and asset management" (Marr 2017).

Prominent among fintech applications are blockchain or distributed ledger technologies. The concept of a blockchain protocol and its application for bitcoin was first proposed in a white paper published in 2008 by an unknown person or persons named Satoshi Nakamoto (Nakamoto 2008). Blockchain, which is a type of distributed ledger technology, enables the creation of a distributed database that removes the need for trusted intermediaries, such as banks or other institutions, to facilitate transactions. A blockchain is "a type of database that takes records and puts them in a block (akin to, say, a sheet in your Excel file). Each block is then 'chained' to the previous block, using a cryptographic signature. This allows blockchains to be used like

a ledger, which can be shared and corroborated by anyone with permission" (DiCaprio and Beck 2017). Blockchain thereby ensures "the integrity of the data exchanged among billions of devices without going through a trusted third party" (Tapscott and Tapscott, 2017, p. 5; also see Tapscott and Tapscott 2016). As Crosby et al. (2015, p. 3) explain:

> A blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by consensus of a majority of the participants in the system. And, once entered, information can never be erased. The blockchain contains a certain and verifiable record of every single transaction ever made.

Blockchains can be public (open access) or private (controlled access). Vitalik Buterin (2015, who created Ethereum, a decentralized platform that runs self-executing 'smart contracts,' describes public blockchains as ones "that anyone in the world can read, anyone in the world can send transactions to and expect to see them included if they are valid, and anyone in the world can participate in the consensus process" that determines the blocks to be added to the chain. By dis-intermediating institutions that were previously required to establish trust, blockchain offers the potential of "a world without middlemen" (Gupta, 2017a, 2017b).

Public distributed ledgers combine economic incentives with cryptography, peer-to-peer protocols and data storage to create a transparent, immutable and decentralized record of transactions that is visible to all parties on the blockchain (Gupta and Knight 2017; Meunier 2018). As the Blockchain Trust Accelerator (2018) explains:

> The innovation of the Blockchain begins with the fact that no central entity owns or controls it. Data is stored across a global network of computers. When we put an asset of value onto the Blockchain, these transactions are cryptographically linked in data blocks, providing a complete history for every piece of data in the system. Each transaction on the record is digitally signed so we know who submitted it to the network. Avery asset can also be directly transferred in a secure, fast, and transparent way.
>
> The Blockchain provides unprecedented data security. The Blockchain system self-guarantees the authenticity of all the data within it, eliminating the need for trust in other parties. This prevents double spending, falsified asset ownership, and other forms of data tampering. ... The Blockchain is highly transparent; a record of all transactions is permanently available. All users on the system can see in real time as new transactions are added to the database. ... The Blockchain is also entirely auditable. Every time a new transaction is added to the record, it is also cryptographically linked to every previous transaction. Therefore, the Blockchain ledger cannot be altered once it is verified.

As a result, blockchain technology has been described as a "trust machine" because it produces the efficiencies of trust between parties without a central intermediary (*The Economist*, 2015). Blockchain proponents note the far-reaching, transformative potential of the technology in financial services and across the global economy, even as blockchain applications remain at an early stage of development. Indeed, Tapscott (2016) describes blockchain as "the biggest innovation in computer science—the idea of a distributed database where trust is established through mass collaboration and clever code rather than through a powerful institution that does the authentication and the settlement."

Recent market activity involving bitcoin and other crypto-currencies has drawn attention to blockchain and the related digital ledger technologies that underpin them as having broader and deeper long-term societal and economic implications than the volatile market prices of cryptocurrencies such as bitcoin.[2] As Johnson (2018) writes:

> The true believers behind blockchain platforms such as Ethereum argue that a network of distributed trust is one of those advances in software architecture that will prove, in the long run, to have historic significance. That promise has helped fuel the huge jump in cryptocurrency valuations. But in a way, the Bitcoin bubble may ultimately turn out to be a distraction from the true significance of the blockchain. The real promise of these new technologies, many of their evangelists believe, lies not in displacing our currencies but in replacing much of what we now think of as the internet, while at the same time returning the online world to a more decentralized and egalitarian system.

Technologies such as the Internet of Things (IoT) and big data can be deemed as complementing blockchain as a platform for the exchange of value, where data is the core underlying element. IoT refers to connecting any object or electronic device with a sensor and that is connected to the Internet, while big data refers to the large-scale collection, analysis and application of data, which may generated by the IoT. IoT and big data provide a base layer of information that can then be managed, automated and acted upon by either human or automated decision processes.

This interrelationship between technologies will enable a future in which these complementary technologies are integrated. As Outlier Ventures (2016, p. 40) state: "Blockchains, artificial intelligence, the Internet of Things, autonomous robotics, 3D printing, and virtual and augmented reality are all converging to significantly disrupt existing industries and create whole new markets and economic models." In this future economy, the big data collected by the IoT are "authenticated, validated and secured using distributed ledgers, consensus and other decentralised technologies" (Outlier Ventures 2018, p. 13). As IoT, big data and blockchain continue to evolve, their gradual convergence will create new possibilities for the fulfillment of sustainability goals where these digital technologies are developed with such objectives in mind.

2. FINTECH AND SUSTAINABLE DEVELOPMENT APPLICATIONS

Fintech – and blockchain in particular – have important potential implications for the implementation of a range of sustainable development applications, owing to the potential impact of fintech on the economy and the fact that these new technologies will continue to develop over the same timeframe as the implementation of the Paris Agreement and SDGs.

Fintech and blockchain have already been related to sustainability applications and use-cases. The United Nations Environment Programme (UNEP 2016) has identified over two dozen distinct applications of fintech for sustainable development and in varying levels of implementation, including four applications in energy described in greater detail below: pay-as-you-go resource utilities; flexible energy supply and demand, peer-to-peer renewable energy, and community distributed generation. Chapron (2017, p. 403) has compared blockchain technology "to the invention of double-entry book-keeping...which enabled the modern economy" and has highlighted

[2] Citations from *The New York Times*, *Wall Street Journal,* and the *Financial Times.*

the potential for blockchain applications that blend cryptography and sustainability. Gupta and Knight (2017) have highlighted innovations in mobile money services such as M-Pesa as an example of how developing countries can leap ahead: "[Imagine] what full-scale transformation build on blockchain might do. It could create hyperefficient government with provably trustworthy infrastructure; new markets and opportunities for citizens to access the formal economy on equal terms; efficiencies of operations that lower prices and improve the quality of goods for all consumers; and a kickstart to high-tech innovation around the world."

The World Bank (2017) has catalogued a wide range of blockchain applications in the financial sector, including money and payments, financial services infrastructure, agriculture, governance, healthcare records, and humanitarian and aid applications, such as tracking and delivery of aid.

Examples of potential use-cases that are relevant to sustainable development include supply chain transparency, identity and financial inclusion, and property rights, as described below.

2.1 Supply Chain Transparency

A major set of use-cases with implications for sustainable development involves supply chain transparency. Blockchain's application in tracking assets is expanding into natural resources and offers the potential to transform the ways in which natural resources are recorded and traced across several subsectors, including forestry and fisheries to carbon accounting and energy. DeCaprio and Beck (2017) have cited the example of a pilot blockchain project to establish a sustainable supply chain in Indonesia to track the provenance of skipjack and yellow fin tuna caught by local fishermen, which enables compliance at origin and could replace the current system of hard-to-verify paper records, which are subject to corruption. In 2018, Maersk, the world's largest shipping company, based in Denmark, and IBM, announced plans to form a joint venture "to provide more efficient and secure methods for conducting global trade using blockchain technology" with the aim of reducing costs and inefficiencies (White 2018).

Golden and Price (2018, p. 2) have noted the number of pilot projects that have been launched by major supply chain companies – including agriculture traceability tied farmers' digital identity, shipping and logistics software to reduce inefficiencies in container shipping, mapping to create transparency in supply chains for consumer goods to improve ethical sourcing, and efforts to build solutions for the sustainability of seafood supply chains – and predict that if "blockchain-based supply chain solutions reach scale over the next five years, they could deliver a transformation in global supply chain management." Indeed:

> Blockchain solutions constitute the rare innovation that could provide both profits and social purpose. Regulators, social enterprises, and civil society organizations are poised to harness the transparency and accountability available through blockchain-based tools to help solve supply chain problems including dangerous labor conditions and environmentally destructive practices. (Golden and Price 2018, p. 3)

Blakstad and Allen (2018, passim), from the fintech start-up Hiveonline based in Denmark, have highlighted the potential of fintech solutions across a number of intervention areas tied to sustainability, as well as diverse ways in which blockchain can improve supply chain integrity, including: the traceability of transactions, allowing consumers to "be confident where their money is going"; provenance across the

lifecycle of an asset or commodity such as location of origin; disintermediation using self-executing contracts that "can be encoded so that the need for administration and central intermediaries is significantly reduced or removed, taking much of the challenge and cost out of running circular economies"; and transparency in "removing the need for third party auditing" and facilitating identification of value through a supply chain.

2.2 Digital Identity and Financial Inclusion

For many people in developing countries, participation in the financial economy (including capital formation through savings, opening a bank account or borrowing money from a financial institution, or financial leverage to support investment and growth) remains impossible due to a lack of sufficient identity and credit history, which are elements of identity that are often taken for granted in developed economies. Economic identity can be defined as "the marriage of identity and commerce, resulting in a global, vetted, and manageable asset. This identity consists of the digital or electronic credentials that define a person's history of economic interactions in the world economy" (BanQu 2018).

As the United States Agency for International Development (USAID 2017, pp. 1, 72) has observed:

> There may be no single factor that affects a person's ability to share in the gains of global development as much as having an official identity. Identity unlocks formal services as diverse as voting, financial account ownership, loan applications, business registration, land titling, social protection payments, and school enrollment.
>
> A functioning digital economy hinges on the critical infrastructure of digital identity. Emerging trends in digital identity have the potential to offer more inclusive biometrics, leveraging digital footprints to identify those who lack official ID, and potentially providing individuals with more convenient, secure, and portable identification options.

Examples of relevant blockchain-based use-cases include economic identification, in which identification is "built up over time through a series of transactions stored on a blockchain and verified by others," humanitarian cash transfers where the potential for fraudulent claims is reduced or eliminated, and land titling, described in further detail below (USAID 2017, p. 57).

2.3 Property Rights

Closely tied to the application of fintech and blockchain for economic identity and financial inclusion are property rights and land titles. In nearly every country, the way in which people know that they own property is dependent on a well-established and often complex set of documents certifying that the title holder has a legal claim on the property. In some countries, title insurance is required in the event of a dispute between the parties about the validity of the transfer of the property.

A wide range of countries, including Estonia, Georgia, Ghana, Honduras and Rwanda, have started to test the potential of putting land titles on a blockchain platform, thus simplifying the process of transferring title and rendering future disputes less likely. Sweden, where land records are already recorded in digital form, may represent the country that is furthest ahead in this pilot testing process. A recent report on the second phase of Sweden's test for the feasibility of putting property titles on a blockchain

highlighted the significance of this application for developed as well as developing economies:

> For countries without a trustworthy real estate ownership record and land registry, a similar project may be the easiest, most cost efficient and fastest way to increase GDP in the medium term. It will serve as a foundation for better investments in land, enable the development of a mortgage market and a credit market in general, and become an institution for trust in one of the most fundamental parts of an economy: land and real estate (Kairos Future 2017, p. 5).

Moreover, as Pisa and Juden (2017, p. 28) note:

> [Sharing] a land registry across a distributed network greatly enhances its security by eliminating 'single point of failure' risk and making it more difficult to tamper with records.... A blockchain cannot, however, address problems related to the reliability of records. ... This suggests that using the technology to store land records works best in places where the existing system for recording land titles is already strong.

3. BLOCKCHAIN TECHNOLOGY FOR RENEWABLE ENERGY AND DISTRIBUTED ELECTRICITY SYSTEMS

In addition to the potential applications of fintech and blockchain for SDGs, blockchain and related technologies have important early use-cases in the energy sector, including peer-to-peer energy trading, climate finance and carbon credit trading. Applications have drawn attention from the financial sector, where the potential for blockchain to improve the efficiency of settlement and other intermediary functions has represented a key attraction.

Energy has been the second major sector where blockchain has attracted interest due to its potential role in disrupting current business models. According to the World Energy Council (2017, p. 3), blockchain was identified as "one of the most critical uncertainties" and "is perceived by energy leaders globally to be an issue of both relatively high impact and uncertainty," with IoT blockchain scoring highest in terms of impact and uncertainty among issues facing the energy sector. In the energy sector, blockchain's potential implications include dis-intermediation of utility business models of centralized generation and grid distribution, with significant implications for distributed energy systems and decentralized grids:

Blockchain is in an early stage of the innovation process ... [but] is expected to lead to much more direct relationships between energy producers and consumers, and to strengthen the market participation opportunities for small energy providers and prosumers. In a decentralised energy system, blockchain could enable energy supply contracts to be made directly between energy producers and energy consumers, and for them to be carried out automatically (World Energy Council 2017, p. 4).

Europe has been pioneering innovation and financing for blockchain firms involved in energy and the clean technology sector. According to data from the Cleantech Group, which tracks firms spanning energy, logistics and supply chains, blockchain and IoT, mobility, agriculture and other applications, the number of companies or consortia involved in the broader blockchain ecosystem has grown over the past year from about 35 to over 150. European companies had raised some $723 million as of May 2018,

compared to $251 million in Asia and $140 million in North America (Besnainou 2018). An analysis of companies and pilot projects working with blockchain and energy found that over half were based in Europe, followed by North America and Asia, and nearly three quarters had been founded in either 2016 or 2017, reflecting their early stage of development (SolarPlaza 2018).

Livingston et al. (2018) have described a range of potential applications of blockchain technology to electric power systems, including peer-to-peer and grid transactions, energy financing, sustainability attribution, electrical vehicles, as well as other applications such as smart appliances. Examples of applications for renewable energy and distributed energy systems described below include peer-to-peer energy transactions, carbon credits and climate finance.

3.1 Peer-to-peer Energy Transactions

A prominent set of use-cases of blockchain technology for sustainability applications involves peer-to-peer energy exchange, including from distributed energy systems using renewable energy (Tapscott 2018). As PwC (2017, p. 16) explains: "so called 'prosumers' not only consume energy but also dispose of generation in the form of solar systems, small-scale wind turbines or CHP plants; moreover, blockchain technology could enable them to sell the energy they generate directly to neighbors." As a result, "[b]lockchain based energy processes would no longer require energy companies, traders or banks (for payments). "Instead, a decentralized energy-transaction and supply system would emerge, under which blockchain-based smart contract applications empower consumers to manage their own electricity supply contracts and consumption data" (PwC 2018, p. 18).

As of 2017, over 90 companies and pilot projects were working with blockchain and energy, including the United States (US) start-up L03 Energy, which has a pilot peer-to-peer energy exchange called the Brooklyn Microgrid; PowerLedger, an Australian blockchain-based trading platform that enables the decentralized selling and buying of renewable energy; and Energy Web Foundation, a consortium of major global energy and blockchain companies aiming to develop an energy sector blockchain (Solarplaza 2018). In Norway, the state-owned energy company Statkraft has demonstrated the feasibility of energy exchange on a blockchain platform and has predicted that within five years "[b]lockchain will be able to provide many rapid, low-cost transactions in an electricity market with a growing share of renewable energy" (Statkraft 2018).

According to Livingston et al. (2018, pp. 9–10), "[even] if blockchain does not replace the grid, it could enable more participants to trade electricity. For example, Vattenfall, the largest Nordic utility, is running trials in which it uses a private blockchain network to record electricity transactions in which department stores or even individual homes can sell electricity generated by distributed batteries or solar panels; previously, such transactions would have been prohibitively expensive or time-consuming to process." In his design principles for the power markets of the future, Liebriech (2017, pp. 7–8) views blockchain technology applied to payments for transmission and distribution as well as the attribution of carbon content of imported power as being part of a broader "digital convergence of energy, infrastructure and services."

In Europe, over 40 energy-trading firms have joined forces under the project name Enerchain, a blockchain project to conduct peer-to-peer trading in the wholesale energy market:

> The main goal of Energy is to deploy a technical infrastructure allowing participants in the energy wholesale markets to trade power and gas in a decentralised way, thus avoiding intermediaries and central market platforms. ... Operating costs for a decentralized system are different from operating a 'classical' central platform, i.e., dramatically reduced (Merz 2018, pp. 7, 10).

Enerchain is at the proof of concept stage and is designed to determine whether a decentralized blockchain-based model can support the trading volumes and transaction speeds required for trade execution in the gas and electricity markets (World Energy Council 2017). Other early-stage initiatives include Alliander in the Netherlands, which is piloting a blockchain-based energy tool to enable consumers to manage and share their renewable energy, and Conjoule, a start-up launched by Innogy in Germany, which is developing blockchain-enabled peer-to-peer energy markets (World Energy Council 2017).

The International Energy Agency (IEA) (2018, p. 98) has stated: "Although still early-stage and small-scale, projects of this kind suggest that decentralized energy, flexibility from transactive energy and blockchain could develop together to positive effect." Indeed, these use-cases remain at an early stage, and the technologies and regulatory frameworks for these approaches must develop further for these use-cases to reach their potential scale or disruptive impact (Medium 2018; Metlelitsa 2018). Similarly, as Basden and Cottrell (2017) argue:

> To be sure, as with any new technology, blockchain remains largely unproven, and significant barriers remain. ... Nevertheless, if it proves reliable and scalable, blockchain technology may ultimately accelerate the transition to what the energy industry calls a "distributed world" made up of both large and smaller power-generation systems for homes, businesses, and communities.

3.2 Trade and Exchange of Carbon Credits

According to the World Bank (2018), current markets for climate assets have created a 'patchwork' of climate actions with different units, governance structures, registries and rules, resulting in a system that does not encourage economic efficiency, scale or complexity. At the same time, the rapidly developing technological landscape is creating new opportunities for the harmonization of climate assets among different systems, instruments and assets. According to a recent World Bank study, "Blockchain, Big Data, the Internet of Things (IoT), smart contracts and other disruptive technologies hold out the promise of addressing the needs of new generation climate markets post-2020" (World Bank 2018, p. 4).

For different physical commodities, a digital asset can be created to represent and provide title to the commodity asset, as well as multiple outputs (e.g., energy content) and outcomes (e.g., greenhouse gas emissions, energy access enhancement and poverty reduction impact) associated with its production and/or lifecycle. Blockchain technology can provide a digital mechanism for recording and tracking these separate streams of information associated with units. This delineation and tracking of separate value elements in the unit is the central idea behind this new architecture (World Bank 2018).

Marke (2018) has explored the ways in which blockchain may increase the efficiency of emissions trading schemes, including by suggesting more efficient systems to transfer or trade carbon credits and proposing the networking of carbon markets using blockchain technology, as well as boosting peer-to-peer renewable energy trading and accelerating international climate finance transfers.

3.3 Climate Finance

A broad group of over 40 organizations, including the International Emissions Trading Association (IETA), formerly the Carbon Disclosure Project (CDP), the Energy Web Foundation, and Power Ledger, recently launched the Climate Chain Coalition (CCC) "to cooperatively support the application of distributed ledger technology ('DLT', including 'the blockchain') and related digital solutions to addressing climate change" (Climate Chain Coalition 2018). The UNFCCC has expressed support for the CCC initiative and "the potential of blockchain technology to contribute to enhanced climate action and sustainability" (UN Climate Change News 2018).

Blockchain offers significant promise for creating new flows of finance for climate investments. As Thomason et al. (2018, p. 148) note, "[b]lockchain enables new forms of finance to address global climate finance problems, including crowdfunding and dynamic funding mechanisms from private finance markets." More broadly, Marke and Silvester (2018, p. 58) state:

> Climate finance and green investment provide the best ground on which to apply Blockchain as a 'fintech' to combine technology and finance. ... As a loop, the energy sector provides valuable production data very useful for the research and development of financial products, whereas new financial products benefit the energy sector reciprocally. Among the fintechs including big data, cloud computing, machine learning, distributed computing technology, Blockchain is the most impactful and revolutionary to the bottom- level (green) finance architecture, especially in lowering regulatory costs and expanding regulatory boundaries.

4. FINANCIAL INNOVATION AND GREEN BONDS

Financial instruments with the ability to mobilize public and private capital toward low-carbon, climate-resilient investment are therefore key to success. One of the most dynamic instruments in the area of sustainable finance comprises green bonds, which are fixed-income instruments whose proceeds are used by the issuer for environmental projects. Over the past decade, investor demand for these instruments has been growing in response to shifts in policy and capital allocation due to growing concerns about climate change and sustainability. Moody's (2018) projects that the global issuance of green bonds will grow to between $175 billion and $200 billion in 2018, up from $155 billion of green bonds issued in 2017.

In Europe, Nordic countries have pioneered the use of green bonds to mobilize capital for investment in sustainable infrastructure and related sectors. Beginning in the 1970s, Sweden, Norway, Denmark and Finland have demonstrated leadership in environmental policy, regulation and changes in behavior consistent with a sustainable economy (McCormick et al. 2015). Nordic countries have also pioneered the use of green bonds to mobilize capital for sustainability goals.

4.1 Subnational Pooled Financing Mechanisms

One of the key financial innovations at the institutional level for green finance has been the use of a structure known as subnational pooled financing mechanisms (SPFMs) as means of raising sustainability-oriented capital from financial markets. An SPFM aggregates the financial needs of members into a pooled financing agency (PFA), which then issues debt and distributes the proceeds from the bond offering to its members. As International Institute for Sustainable Development (IISD) (2018) explains:

> Most SPFMs require the set-up of a Special Purpose Vehicle (SPV) that have transparent governance structure and processes. These SPVs, whose structure depends on national laws, are responsible for contracting debt and making debt service payments on this debt. They are usually owned by governments, though owners can also include the private sector, development partners, NGOs, etc.
>
> SPFMs must be structured in such a way as to have a high-level of creditworthiness. This can be achieved by using several levels of credit enhancements, which would be cost-prohibitive if applied to individual projects. These enhancements include reserve accounts, cash flow over-collateralization, intergovernmental financial transfers and intercepts, partial credit guarantees, first loss-facilities and subsidies (IISD 2018).

According to the Global Fund for Cities Development (FMDV) or Fonds Mondial pour le Développement des Villes), SPFMs "have been successfully used since 1898 in securing finance for both large and small local projects, securing over $1 trillion in finance in the US and Europe, and over $2.6 billion in developing countries" (FMDV 2017, p. 6).

In Europe, Nordic countries in particular have applied the SPFM model to meet subnational financing needs. Examples of Nordic PFAs include Kommuninvest (Sweden), an organization jointly owned by local government authorities and that acts as an aggregator and conduit issuer to Swedish local governments and uses proceeds from its green bond capital-raising for lending to Swedish municipalities in the form of green loans, which members then use to invest in environmental projects; Kommunalbanken, Norway's largest lender to local governments, which has an active green bond and green loan program; KommuneKredit (Denmark), which serves as a municipal credit aggregation agency and is similar in function to Kommuninvest and Kommunalbanken; and MuniFin (Finland), which is the main financial services provider to Finland's local governments and offers a discount margin to its borrowers to provide an incentive to propose projects depending on how 'green' the project is in terms of its environmental sustainability (Climate Bonds Initiative 2018).

In addition, an important blockchain use-case has begun to take shape in monitoring green bonds proceeds in the form of the Green Asset Wallet initiative (Repinski 2017). The project, led by Stockholm Green Digital Finance and backed by Norway's Center for International Climate Research (CICERO), applies the concept of sustainability attribution to green financial investments. As CICERO (2018) explains:

> The project ... is designed to equip green investors with the technology to better deliver on the goals of the Paris Climate Agreement and the SDGs. ... The wallet is based on open-source technology tailored for capital market actors. The technology will offer a platform for validation of, as well as impact reporting on, green investments. The Green Assets Wallet will help to effectively channel private institutional capital to green projects globally, specifically supporting green emerging markets investments.

In spite of the rapid growth in the green bond market, transparency remains a concern among investors. Continued momentum in the growth of the green bonds market and more broadly in the expansion of green finance will be contingent on transparency in the use of proceeds (Santibanez et al. 2015; Kyriakou 2017; Linsell 2017). In order to raise capital for the implementation of the Paris Agreement and the SDGs, developing countries in Asia and other regions may expand the use of green bonds, adopt financing models such as SPFMs, and further develop and implement innovative fintech and blockchain approaches to enhance and promote the growth and transparency of their growing green bonds markets.

Adoption of innovative approaches, such as the Green Asset Wallet initiative described above, could provide additional means to boost investor confidence in the underlying quality of green financial instruments.

4.2 Implications for Asia

Major developing countries in Asia have recently begun to adopt and extend innovative approaches to promote green finance. The People's Republic of China (PRC) has identified the establishment of a green financial system as a goal in its Thirteenth Five-Year Plan (Central Committee of the Communist Party of China (CPC) 2016) and has taken the lead in creating new institutional frameworks and incentives for green finance and green bonds. The Guidelines for Establishing the Green Financial System, released in 2016 by the People's Bank of China (PBOC), the Ministries of Finance and Environmental Protection, the National Development and Reform Commission (NDRC), and the banking, insurance, and securities commissions, all emphasize the importance of establishing a green financial system, including "financial instruments such as green credit, green bonds, green stock indices and related products, green development funds, green insurance, and carbon finance, as well as relevant policy incentives to support the green transformation of the economy" (People's Bank of China 2016). The PRC's growth in activity in the green bonds market has propelled the country into a leadership position, and green bond issuance from this country represents one of the largest sources of issuance in the global green bond market (Climate Bonds Initiative 2017).

4.3 Green Fintech in the People's Republic of China

In the PRC, the ANT Financial Services Group, formerly known as Alipay and a leading fintech company, launched a large-scale pilot to engage with consumers in shaping their behavior in ways aligned with green finance at scale. Chen et al. (2017, pp. vi-vii) have explained the design of the pilot and have highlighted its immediate impact and long-term potential:

> The 'Ant Forest' encourages Ant's users to reduce their carbon footprint through a three-part approach: (a) providing individualized carbon savings data to peoples' smartphone, (b) connecting their virtual identity and status to their earnings of 'green energy' for reduced carbon missions, and (c) providing carbon offset rewards through a physical tree planting program.
>
> The Ant Forest pilot has far exceeded expectations in attracting large numbers of users in a short period of time, and elicited significant behavioral change. Over the first six months from August 2016 to January 2017, 200 million people across the PRC have voluntarily joined the program, about 44% of Ant's user base in the PRC, or about 20% of the PRC's adult population or 3% of the world's total population. Behavioral change over the period has resulted in an

> estimated 150,000 tons of cumulative avoided carbon emissions and over 1 million trees planted by January 2017. ... The Ant Forest pilot could be extended in collaboration with other digital financial companies to encourage billions of people to reduce their carbon footprint.

As a recent study on the future of blockchain technology in the Asia and the Pacific region has noted: "Asia could become a dynamic testing ground for the new business models promised by blockchain, as the region has high demand for financial inclusion and the need for more efficient, convenient and affordable products and services" (Cognizant 2017, p. 8).

> For the Asia-Pacific region, blockchain represents the most significant technological opportunity of the next decade, and is likely to be a wellspring of innovative ideas for leaders across the globe. Thoughtful observers of the blockchain phenomenon already recognize that they cannot ignore the cost efficiency and business effectiveness promises of distributed ledger technology. ... Blockchain offers a once-in-a-lifetime opportunity for firms and leaders in the Asia-Pacific region to provide an example to the rest of the world of how the blockchain revolution will unfold (Cognizant 2017, p. 22).

According to recent statistics, the PRC was the most active filer of patent applications related to blockchain technology, with 56% (226) of the 406 blockchain related patent applications filed in 2017 (Desouza et al. 2018; Noonan 2018; Thomson Reuters 2018). As Desouza et al. (2018) argue:

> Despite a spate of enthusiasm for blockchain business, many companies are keeping low profiles for their involvements in blockchain-related products owing to policy uncertainty. The central government's policy toward cryptocurrency is very explicit, as it banned initial coin offerings (ICOs) in September 2017 and later prohibited all cryptocurrency exchanges from operating in the PRC. Yet the regulation on blockchain, the technology behind cryptocurrencies, remains unclear. Business operators must be cautious, given the difficulty of determining if blockchain products are fully compliant with government rules, even when no cryptocurrencies are involved. ... Sorting out the regulatory uncertainty with blockchain is key to the future innovation trajectory.

5. CONCLUSIONS AND PRELIMINARY RECOMMENDATIONS

The future development and adoption of blockchain, IoT, big data and other related technologies offers the promise of systemic transformation: a radically different financial and capital allocation system geared toward inclusive and sustainable development. These new technologies are at an early stage of development and their future trajectories are difficult to predict with confidence. However, the net effect of applications of fintech and blockchain technology to the wide range of potential use-cases above will be to substantially improve reliability (such as identity and financial inclusion), increase access to services (such as energy, banking and property ownership) and importantly, lower overall system costs. The aggregate impact of lower costs in each individual organization or service-provider, and given sufficient competition and market dynamics, may have the positive effect of lowering the costs of achieving the goals connected to these services.

Of course, there will be growing pains, particularly as the system takes shape. According to Tapscott (2016), "[t]he biggest problems...have to do with governance. Any controversy that you read about today is going to revolve around these governance issues. This new community is in its infancy. Unlike the Internet, which has a sophisticated governance ecosystem, the whole world of blockchain and digital currencies is the Wild West." The significant energy use of blockchain consensus algorithms relying on proof-of-work, as compared to the more efficient proof-of-stake approach, will also need to be resolved.

However, even critics such as Roubini and Byrne (2018) who labeled blockchain "one of the most overhyped technologies ever" due to its inefficiency compared to existing databases and its superior demand for storage space and computing power, among other limitations, have conceded that blockchain could have "potentially far-reaching implications" if combined with "secure, remote automation of financial and machine processes" and in "specific, well-defined, and complex applications" such as in interaction with self-driving cars or drones.

5.1 Preliminary Recommendations for Policy Makers

Policy makers responsible for finance for climate change and sustainable development should pay attention to developments in fintech and blockchain. The sector is rapidly evolving with a proliferation of different initiatives that have either direct or indirect relevance to green finance and sustainable development. Many initiatives are at an early stage and, if supported by appropriate policy and regulation, have the potential to develop into business models that can both reduce the cost and improve the prospects of achieving the objectives of the Paris Agreement and the SDGs, particularly with respect to the areas described in this paper, including supply chain transparency, identity and financial inclusion, property rights, expansion of renewable energy, decentralization of electrical power systems, carbon credit trading and improved access to climate finance.

Policy makers can draw inspiration from a wide range of current and ongoing initiatives led by committed, dynamic fintech entrepreneurs who are focused on developing and implementing their particular technologies with a view to an application or set of applications that often have material direct or indirect bearing on our ability to fulfill the SDGs and the Paris Agreement. However, it is often the case that the deeper opportunity set rather than the agreements themselves are at the forefront of people's thinking and business models.

Finally, policy makers should engage more closely with the fintech and blockchain sector, in part because it is developing quickly, in parallel with and to some extent separately from the 'real' economy. For policy makers who can keep up with the pace of change, engagement with the fintech and blockchain sector will create new opportunities for countries that wish to reach the next stage of development in terms of financial, economic and technological performance in a global economy that is increasingly dependent on complex, decentralized networks. Recognition of this potential will create opportunities for approaches that provide significant long-term advantages in strengthening green finance for low-carbon, climate-resilient investment and achieving the sustainable development goals.

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