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BLOCKCHAIN AND TOKENIZED SECURITIES: THE POTENTIAL FOR GREEN FINANCE

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Abstract

Green investment vehicles are limited by multiple market failures, such as high transaction costs for certification and monitoring, and high minimum investment sizes. In this exploratory study, we apply an inductive approach based on qualitative evidence from expert feedback to assess the potential of blockchain-based security tokens to address these market failures. The tokenization of real assets or debt/equity instruments reduces transaction costs through disintermediation and automation, enhances transparency, and reduces size and liquidity requirements due to lower transaction costs. The main constraints to the adoption of tokenized securities are software risk, regulatory uncertainty, and immature investment infrastructure. These constraints can be addressed by decision- and policy makers in Asia. Through developing pilot use cases and establishing regulatory sandboxes for tokenized securities, valuable experiences and stakeholder feedback can be merged into coherent regulatory and investment frameworks. Even though tokenized securities are a nascent technology and currently limited by immaturities, it is important to consider and develop this financing mechanism in a proactive manner, given its high potential to democratize green finance.

Keywords: green finance, blockchain, tokenized securities, security token offering, Asia, green bonds, policy implications, climate change, sustainable development, climate finance, Paris Agreement, sustainability finance

JEL Classification: E40, E42, F34, F35, G00, G12, O3

Contents

1. INTRODUCTION

The Paris Agreement emphasizes the importance of '[making] finance flows consistent with a pathway toward low greenhouse gas emissions and climate-resilient development' (UNFCCC 2015, p. 2) to achieve the contributions of each of the nearly 200 signatories. For this, the World Bank IFC (2016) estimates investments of $23 trillion for climate-smart investments in emerging markets, while further stating that '[t]here has never been a better time to invest in climate solutions.' Asia alone is estimated, in another study (Sachs et al. 2019), to require climate change investment of $22.6 trillion between 2016 and 2030. Thus far, only about 35% of the estimated $4 trillion needed annually is available, leaving a $2.5 trillion investment gap (Merrill, Schillebeeckx, and Blakstad 2019). Due to limited public budgets, innovative financial instruments are needed to accelerate private financing to close this gap (Pham 2016; Nassiry 2019). Blockchain technology has recently emerged as such an innovative financing mechanism that lowers the transaction costs of financing activities, the so-called tokenized securities or security token offerings (STOs).

1.1 Green Investment Barriers

With a volume of over $100 trillion in 2017 (SIFMA 2018), the bond market could provide the finance required to close the finance gap. However, green bonds only amounted to 1.5% of the bond market ($1.45 trillion) of climate-aligned bonds and $0.4 trillion of labelled green bonds in 2018 (CBI 2018). This was due to multiple market failures limiting the adoption of green investment vehicles such as green bonds.

Banga (2019) identifies high transaction costs and minimum investment size as key barriers to green bonds in developing countries. Transaction costs refer to the cost of obtaining a green label certification, which is an important barrier to green bond creation in developing countries (Banga 2019). These transaction costs are significantly higher for green bonds compared to regular or vanilla bonds (Ma et al. 2016; EY 2018; Hachenberg and Schiereck 2018; Flammer 2019; Tang and Zhang 2019; Weber and Saravade 2019), and are particularly inhibiting for small to medium-sized companies (SMEs) in developing countries (Ma et al. 2016). In addition, many developing countries lack personnel with the technical skills to satisfy the green reporting requirements (Banga 2019). Certification and monitoring are important hygiene factors for credibility of green offerings (Wardle and Mills 2018) and are crucial for mitigating the risk of greenwashing (Shishlov, Morel, and Cochran 2016; Park 2018; Flammer 2019).

The minimum investment size is an important factor and refers to the required minimum value of the green bond (Duru and Nyong 2016; EY 2018; Banga 2019; Weber and Saravade 2019). Investors require a minimum size due to liquidity concerns—i.e., being able to sell the bonds later on (Franklin 2016). Ma et al. (2016) state a minimum size of $100 million, Franklin (2016) proposes $200 million, and Chiang (2016) states minimum sizes ranging from $250 to $500 million to offer acceptable liquidity. These minimum size requirements pose a critical barrier to creating green bonds, particularly in developing country settings with many fragmented SME projects. There are only a few environmentally focused companies that can issue green projects on a sufficient scale (Chiang 2016; Duru and Nyong 2016; Franklin 2016).

1.2 STOs for Green Assets

Multiple studies recognize blockchain technologies' potential to address the present barriers to green finance (Blakstad and Allen 2018; CLI 2018; Marke and Sylvester 2018; Nassiry 2018; Neves and Prata 2018; Thomason et al. 2018). By automating the data collection, blockchain technology, in combination with Internet of Things (IoT) sensors, can reduce transaction costs and enhance transparency and the availability of credible data (Sanderson 2018; Merrill, Schillebeeckx, and Blakstad 2019). As transaction costs for issuing green assets are significantly higher compared to traditional assets, green assets benefit disproportionately from blockchain application.

While acknowledging the potential of blockchain technology for a green bond application for reducing transaction costs, this paper focuses specifically on tokenized securities, as this innovative financing mechanism decentralizes and democratizes the interaction of private (retail) investors with SME project issuers. An STO is the process of issuing a tokenized security, which is the digital representation of a security asset in the form of a digital token on a blockchain platform. There are three categories of tokenized securities: (i) asset-based tokens, representing ownership of an asset like real estate, commodities, or works of art; (ii) debt tokens, representing a debt instrument like green bonds or real estate mortgages; and (iii) equity tokens, representing the value of shares issued by companies and entitling the investor to company profits and voting rights, like stocks. Tokenized securities have to comply with legal regulations like conventional securities law. Regulatory oversight combined with blockchain provides enhanced transparency and greater issuer and investor protection (Perlebach and Collins 2019). In the remainder of this paper, we use tokenized securities and STOs interchangeably.

STOs can increase both the demand and supply side of green investments. On the demand side, the enhanced transparency features of blockchain can further increase investor and donor confidence in oversea investment and aid projects, while simultaneously reducing corruption risks and transaction costs (Blakstad and Allen 2018). On the supply side, STOs allow for significantly smaller investment sizes and thus enable access to finance for SMEs that are currently excluded due to the size threshold of green bonds and other financing mechanisms. Presently, the investment sizes for STOs generally start at $3 million–$5 million (STOScope 2019), while green bonds, in contrast, start with sizes of $100 million (Ma et al. 2016). By providing funding for SMEs, the number of bankable projects increases significantly (Merrill, Schillebeeckx, and Blakstad 2019). These projects can be aggregated into a project portfolio, which reduces investor risk due to diversification and can be scaled to sufficient size to allow investors with liquidity constraints to participate. In addition, STOs offer investor ticket sizes of a few hundred US dollars only, which increases financial inclusion by enabling retail investors and communities to participate and create a diversified portfolio.

Despite these advantages, however, there is only limited academic literature available that investigates the present potential of STOs. This paper reviews the existing research, assesses STOs' advantages and disadvantages, and outlines policy recommendations to address present adoption barriers. Beyond this analytical contribution, the paper seeks to extend the literature on STOs for green finance and raise awareness. This paper focuses on three main questions: (a) How can STOs be used as a vehicle to accelerate (green) finance?; (b) What are the strengths, weaknesses, opportunities, and threats related to STOs for green investments?; and (c) What are the policy implications to resolve the existing constraints?

2. METHODOLOGY

To answer these questions, the paper follows an inductive approach, due to the present lack of use cases and empirical data. Firstly, we conducted a comprehensive literature review and summarized the findings in a preliminary note. We then shared this note with a focus group of subject matter experts and specialist practitioners for feedback, with follow-up interviews to verify the literature review findings. Based on this feedback, we conducted a strengths-weaknesses-opportunities-threats (SWOT) analysis of the present state of STOs. There already exist a number of SWOT analysis studies on blockchain, which were considered for inspiration (Gatteschi et al. 2018; Niranjanamurthy, Nithya, and Jagannatha 2018; Duchenne 2018). However, these studies only consider the application of blockchain technology to an existing financing mechanism, like a green bond. This is the first academic study to conduct an analysis of STOs as an innovative financing mechanism specifically.

The article is divided into three parts. The first part introduces general concepts regarding blockchain and blockchain-based financing concepts that are relevant for this paper. The second part introduces STOs specifically, conducts a SWOT analysis, presents selected STO case examples, and introduces the idea of tokenized green bonds. The third part concludes the paper with an evaluation of the technology's potential in the light of present constraints, and derives policy recommendations based on the identified technological constraints.

3. BLOCKCHAIN AND DECENTRALIZED FINANCING CONCEPTS

Blockchain technology has reinvented data storage by synchronizing the data across a network of participants in compliance with the agreed-upon codified rules so that each individual participant holds a copy of the record chain (Andoni et al. 2019). This creates data immutability and digital scarcity, and offers a solution to the double spend problem (or duplication of digital data) (Duchenne 2018). In a blockchain, all new data transactions are collected in a new 'block' that is cryptographically linked to the existing chain of transaction blocks (Howson 2019). Due to timestamping and the cryptographic linkage of the blocks, the transaction history of this blockchain is immutable (Peters and Panayi 2016).

Swan (2015) divides blockchain evolution into three phases. Blockchain 1.0 refers to cryptocurrency and its application for digital payment systems. Bitcoin was the first cryptocurrency and introduced blockchain technology as a means to create digital scarcity that enables a decentralized digital currency system (Yli-Huumo et al. 2016). Bitcoin is still the most widely used blockchain application amongst almost 2,500 other cryptocurrencies.[1] Blockchain 2.0 represents blockchain and smart contract enabled digital asset ownership of financial products (like stocks, bonds, derivatives, and loans). Smart contracts are computer applications that automatically verify, enforce, and execute the terms and conditions as specified in the codified contract (Kiviat 2015; Dai and Vasarhelyi 2017; Duchenne 2018). An important feature of the blockchain architecture is disintermediation, meaning that multiple parties can directly and transparently interact without need of a trusted intermediary or central authority (Bano et al. 2017). This disintermediation leads to reduced monitoring or enforcement costs (Kiviat 2015). Blockchain 3.0 refers to blockchain applications in areas such as

[1] CoinMarketCap. Top 100 Cryptocurrencies by Market Capitalization. https://coinmarketcap.com/ (accessed 27 August 2019).

government, voting, and identity. For the remainder of this paper, we focus on Blockchain 2.0 applications, the digital asset ownership of financial products.

Taking advantage of blockchain features like smart contracts, the decentralized finance (DeFi) or open finance movement provides an alternative to the existing monetary and banking system. The DeFi movement seeks to disrupt the present financial system by offering individuals access to all financial services via a blockchain, often Ethereum (Curran 2019). The blockchain community is experimenting with ideas to tokenize social values and resources, leading to new business models and potentially new means to raise green investments in the future (Thomason et al. 2018; Duchenne 2018).

The first application of blockchain as a funding vehicle was the so-called initial coin offerings (ICO), which have raised over $25 billion for blockchain-related projects since mid-2015 (CoinDesk 2019; ICObench 2019). In an ICO, a startup raises funds for a blockchain-related project; in return, it offers a specific utility token to the investor that gives later access to a good or service of the project. Utility tokens are currently unregulated and are thus used by ICO projects to avoid regulatory requirements. However, regulatory institutions like the US Securities and Exchange Commission (SEC) are increasingly taking action against these utility tokens as unregistered securities, as in the case against Kik Interactive Inc. (SEC 2019). As ICOs remain largely unregulated, there is little investor protection, with the result that an estimated 81% of all ICOs are categorized as scams (Seth 2018) and many tokens have lost over 90% of value since their inception (Kharif 2019). Thus, ICOs succeeded as a popular funding vehicle with rapidly increasing volumes over time, but only approximately 1.9% of all projects turned out to be successful overall (Seth 2018). Notwithstanding these shortcomings, initial exchange offerings (IEOs), which are similar to ICOs except that they are underwritten by an exchange, have seen growing demand, with 23 offerings raising $180 million in the first quarter of 2019 (Kharif 2019). STOs represent the next step in the evolution of blockchain-based financing and will be assessed in detail in the next section.

4. STO SWOT ANALYSIS

This section provides an assessment of the advantages and disadvantages of tokenized securities by conducting a SWOT analysis (Table 1). This is the first SWOT analysis of tokenized securities and is based on a number of other studies that used SWOT analysis to analyze blockchains in general (Gatteschi et al. 2018; Niranjanamurthy, Nithya, and Jagannatha 2018; Duchenne 2018).

Table 1: STO SWOT Analysis

Strengths	Weaknesses
• Transparency, traceability, immutability and auditability • Efficiency through smart contracts and reduced transaction costs • Programmability and regulatory compliance	• Nascent technology, understanding, and awareness • STO platforms and disintermediation • User experience and interfaces • Fiat gateways and custody • 'Garbage-in, garbage-out' problem • Regulatory uncertainty
Opportunities	**Threats**
• Increasing investment flow through new investors • Integration of other emerging technologies • Liquidity through global investor base and fractional ownership • Alternative financial infrastructure • Greater flexibility for small to medium-sized projects to raise funds	• Stalling progress on addressing the weaknesses • Regulatory uncertainty and potential prohibition

4.1 Strengths

By creating an end-to-end audit trail of all transactions, blockchain offers full traceability of the execution of all agreements (Blakstad and Allen 2018; Varma 2019). In order to alter the blockchain state, a malicious actor needs to change the data of the distributed participant records simultaneously, which is very challenging, making the transaction data relatively immutable and tamper-proof (Thomason et al. 2018). The application of smart contracts increases efficiency through removing intermediaries (like banks, lawyers, or accountants), and reduces complexities and paperwork related to managing securities (Perlebach 2019). This disintermediation could provide $12 billion annually in cost savings for investment banks alone, and boost project development through lower administrative costs (Duchenne 2018). Dividend payments of assets can be automated and transaction costs reduced, enabling frequent micro- and cross-border payments of dividends to investors (e.g., for generated electricity) on a regular basis (WEF 2016; Varma 2019). In contrast to the low blockchain transaction costs, regional remittance transaction costs in Africa and Asia currently range between 15% and over 20% (Diar 2019).

Blockchain technology and smart contracts allow the automatic and consistent enforcement of predefined token and network rules across the network. This assures compliance with regulatory frameworks, while the audit trail provides regulatory entities with the data needed for compliance checks. As an example, a token can be programmed to be transferable only to the address of an authorized investor that is located within a compliant regulatory jurisdiction.

4.2 Weaknesses

Tokenized securities are a nascent financing mechanism with limited use cases, causing a number of problems and misconceptions. At the time of writing, nine out of 81 STOs received funding for a total of $241 million (STOScope 2019). Roughly half of all STOs are hosted by a specialized STO platform provider[2] that offers a range of services to the issuer, including legal and technical support. The promised disintermediation is therefore currently often only a substitution of banks, accountants, and lawyers with STO platforms, KYC and AML providers, fiat gateway providers and exchanges, and trusted custodians. The different STO platform providers and other STO stakeholders are adopting different protocols, as there are not yet any uniformly agreed ones. The trustworthiness of the STO infrastructure itself is important to attract institutional investors, who will wait for a mature STO infrastructure with uniform and proven frameworks and protocols.

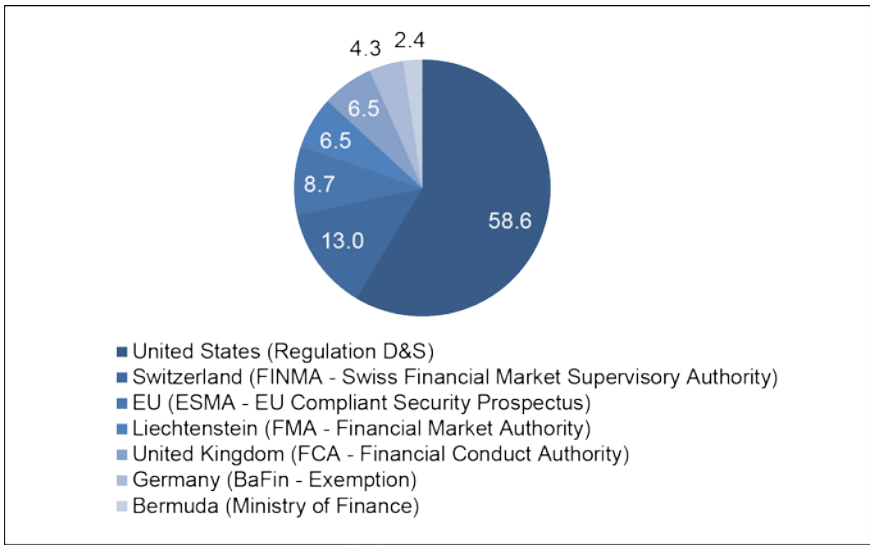
Despite transparency and data immutability being key features of blockchain technology, the data quality is dependent on correct data entering the blockchain. If the entering data is of poor quality, the data on the blockchain will be poor—i.e., the 'garbage-in, garbage-out' problem (CLI 2018; Duchenne 2018). Presently, most data are captured and inserted manually through a trusted third party, causing increased costs, dependence, and delays. One of the most developed applications of sensors is energy smart meters that can be integrated with blockchain technology to distribute return payments based on energy supplied (Fu, Shu, and Liu 2018; Thomason et al. 2018). These smart meters can, however, be a weak link for manipulation and need to be protected from tampering (Zhumabekuly Aitzhan and Svetinovic 2016). For many

[2] STOSCOPE. Issuance Platforms. https://stoscope.com/platforms?country=all&service=6 (accessed 8 August 2019).

countries and use cases, the application of IoT devices and sensors is costly and often limited by a lack of skilled people and limited internet access in rural areas (CLI 2019).

In addition to these technological challenges, regulatory uncertainty also remains. As tokenized securities are an investment contract that represents a legal claim against the asset issuer and/or voting rights, these tokens have to comply with securities regulations. Almost every country has securities regulations, but only a few have adopted specific STO regulations. By not committing to a regulatory framework for STOs, these jurisdictions impose the risk of an altered regulatory environment for issuers and investors at a later stage. Thus far, STOs have only been conducted in jurisdictions with clear STO regulations in place (Figure 1). According to Zhang et al. (2018, p. 299), '[r]egulations governing Blockchain technologies worldwide can be described as excitement, suspicion, or indifference. They are highly dependent on the attitude of a particular government toward this disruptive technology.' At present, the United States is the biggest issuing jurisdiction of tokenized securities, hosting more than half of all STOs. In the United States, tokenized securities are subject to federal security regulations (Regulation D, A+, or S), but with state governments being able to introduce their own rules and regulations.

Figure 1: Current Regulation Applied to STOs (STOcheck 2019)
(%)



4.3 Opportunities

An STO can become a vehicle for investing directly into green projects across borders. With wind and solar-generated electricity becoming increasingly cost competitive in Asian countries (IEA 2018), tokenizing these assets can be an appealing investment and accelerate the transition of the global economy.

Asia could strongly benefit from STOs, which can offer more convenient and affordable financial products and services to address the enormous investment potential (Cognizant 2017; Nassiry 2019). The possibility of offering a tokenized security to a global investor base increases the potential liquidity pool, while fractional asset ownership enables small investments and constant micropayments of dividends. Most STOs offer minimum investment amounts of below $500, significantly reducing the investment barrier for retail investors and local communities. Millennials are currently

showing an interest in innovative and blockchain-based investments: 25% of millennials in the United States hold cryptocurrency, 31% are interested in using cryptocurrency, and 74% state that blockchain makes the financial system more secure (Edelman 2018). The total disposable income of millennials is expected to exceed the income of all other generations by around 2029 (Adamant Capital 2019).

At present, almost $1 billion is invested into the STO infrastructure through mature fiat gateways, tokenized security exchanges, custodian services, and bank integration (see, for example, Andra Capital, tZero, Neluns, VRBEx, SPiCE VC, and Vaultbank). Once the infrastructure is mature, with established protocols and players, STOs offer conservative investors like pension funds enhanced transparency, lower project and transaction costs, and reduced risks through diversification.

At the moment, emerging technologies such as IoT devices and big data are often not feasible for the collection and verification of data. Due to the nascent stage of these technologies, future developments are difficult to predict. However, these technologies combined with blockchain can create a base layer of reliable information. Smart contracts could be combined with IoT devices and automate bookkeeping processes based on data submitted from these devices, reducing data collection costs and execution delays (Dai and Vasarhelyi 2017). Big data can be used to assure data quality and spot fraudulent behavior. This offers the potential to create entirely new approaches toward economic management of the environment (Thomason et al. 2018), the creation of new sustainable digital finance products (Merrill, Schillebeeckx, and Blakstad 2019), and, ultimately, systemic transformation (Nassiry 2019).

4.4 Threats

Despite the very high expectations of blockchain technology in general, and the great potential, STOs are presently not better than conventional financing mechanisms. Consequently, the biggest threats to STOs are stagnation and persisting uncertainty. With significant investments flowing into the space and general excitement for this innovative financing approach, STOs have to prove their utility in the real world. STOs have to address their weaknesses (outlined in Table 1) to satisfy the high expectations; the longer there are no successful cases, the more the value of this vehicle will be questioned.

The biggest threat is the regulatory uncertainty, and the possible hostile attitude of legislators. In a recent report from Greenwich Associates (Johnson 2019), 63% of interviewed executives stated lack of regulatory clarity as the biggest challenge for security tokens. The report was based on interviews with 114 blockchain and financial technology space executives, 70% being involved in security token initiatives, and active across all of North America, Europe, Asia and the Pacific, and the Middle East and Africa. Currently, regulatory uncertainties impose significant issuance costs on the development of the legal prospectus while restricting international investor access, and thus liquidity. If this regulatory uncertainty prevails, or worsens, current and planned infrastructure developments could be halted and STO projects and investors could lose interest.

4.5 STO Case Examples

This section presents a range of case examples that are relevant for the STO and green asset ecosystem.

BnkToTheFuture[3] is an online platform founded in 2010 that allows investors to invest in companies, funds, or alternative financial products in an innovative way. The platform has raised $789 million today from over 85,000 investors and over 110 countries. Although the platform was established before blockchain and STOs gained traction, BnkToTheFuture (BFT) recently acquired the security token exchange Altcoin.io.

> ‘Capital markets are long overdue for an upgrade,’ said Gazdecki. ‘Much of it still relies on paper and outdated tech, so they’re slow and inefficient. Blockchain technology now presents an opportunity to fractionalize traditionally illiquid assets to democratize the market and remove barriers to entry’ (BFT 2019).
>
> 'Security tokens are digital assets issued on the blockchain. Given their approved regulatory status, they can represent virtually any tradeable asset. At BnkToTheFuture, we intend to utilize Altcoin.io’s technical advancements to capture this growing market' (BFT 2019).

This example shows that the potential of STOs is recognized by established players and that there is an international investor base with an interest in investing small amounts of money for fractional ownership in international projects. However, regulatory uncertainties are raised as an issue:

> ‘To fulfil its promise, however, security token trading must operate within the bounds of a watertight legal framework, something upon which both Andrew Gazdecki, Altcoin.io CEO and Simon Dixon, CEO of BnkToTheFuture, agree’ (BFT 2019).

Liquid Token[4] is an investment platform offering investments into tokenized sustainable development and impact projects, promising an annual return of 7%–12%. This platform offers an innovative financing approach to protect the oceans, restore nature, and empower communities. Presently, there is a proposed joint venture with the United States’s largest non-bank securities broker dealer, which raises billions of dollars annually into assets and funds.

HiveOnline[5] is a platform that matches small businesses in developing countries with green investors. The platform is blockchain-based, which increases investor confidence by producing an immutable audit trail. Administrative overheads are reduced to near zero costs through the application of smart contracts. The digital assets offered have proven provenance and clear milestones and evidence structures that ensure agreement and accountability between delivery partners and comply with green bond standards.

5. POLICY IMPLICATIONS

Blockchain and STOs particularly are novel concepts to decision- and policy makers, requiring awareness raising and education. To unleash blockchain’s potential for mobilizing and leveraging green finance, appropriate regulatory frameworks are needed (Zhang et al. 2018). Regulatory uncertainty is the biggest weakness and threat to successful adoption of the technology. Regulators are in a difficult situation: overregulation at this early stage would constrain adoption and exclude the jurisdiction from participating in this economic opportunity, while a lack of regulation imposes

[3] BNK to the Future.com. https://bnktothefuture.com/ (accessed 28 August 2019).

[4] Liquid Token Market. https://liquidtoken.net (accessed 28 August 2019).

[5] Hiveonline. https://www.hivenetwork.online/ (accessed 28 August 2019).

uncertainties on honest actors and presents opportunities for exploitation by fraudulent actors (Neves and Prata 2018). The development of coherent regulation requires industry-wide collaboration among all stakeholder groups, such as project issuers, investors, STO platform providers and exchanges, as well as blockchain developers.

Asia shows promising policy approaches towards blockchain technology:

> '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' (Cognizant 2017).

There is enormous investment potential for green assets in Asia, while the present market mechanisms fail to provide sufficient funding. Given a mature investment infrastructure and regulatory frameworks, STOs can enable international investors to invest in SMEs that were previously only available to large-scale investors. In terms of regulation, there are positive signals from Singaporean and Thai legislators, and currently mixed signals from the People's Republic of China (PRC). The Monetary Authority of Singapore recently updated its Guide to Digital Token Offerings,[6] and Thailand's National Legislative Assembly has legalized the issuance of tokenized securities.[7] The PRC is sending conflicting signals—banning ICOs and prohibiting cryptocurrency trading in September 2017, yet investing heavily and including blockchain in the PRC's 13th Five-Year Plan for the development of information technology,[8] with President Xi Jinping calling blockchain a 'breakthrough' technology.[9] In addition, the PRC has made great efforts to establish a green financial system through new policies, regulations, standards, and market instruments (Zhang et al. 2018). Many major financial institutions in the PRC are researching blockchain-based use cases, developing proofs of concept and pilots to reduce the compliance costs of international financial regulation (Zhang et al. 2018). Following these examples, Asia could create an appealing environment for testing innovative business models (Cognizant 2017).

To test and learn about the technology, some jurisdictions have established regulatory sandboxes that allow for a more flexible approach in consultation with the regulator (World Bank 2017; CLI 2018). These regulatory sandboxes 'create a safe space in which businesses can test innovative products, services, business models and delivery mechanisms in a live environment without immediately incurring all the normal regulatory consequences' (World Bank 2017, p. 35). Several regulators in OECD countries, as well as regulators in Australia; Bahrain; Canada; Malaysia; Singapore; Switzerland; Thailand; the United Kingdom; and Hong Kong, China, have announced or implemented such sandboxes (Cognizant 2017; World Bank 2017). These sandboxes are established for blockchain projects in general and are not STO-specific. Additionally, multiple countries are already operating STO regulation (Figure 1) that can serve as an inspiration for other jurisdictions. In the future, harmonization of all STO regulations from suitable jurisdictions can reduce complexity and facilitate cross-border investment flows.

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[6] Monetary Authority of Singapore. https://www.mas.gov.sg/publications/monographs-or-information-paper/2019/a-guide-to-digital-token-offerings (accessed 28 July 2019).

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[9] Cheng, E. 2018. Chinese President Xi Jinping Calls Blockchain a 'Breakthrough' Technology. CNBC. https://www.cnbc.com/2018/05/30/chinese-president-xi-jinping-calls-blockchain-a-breakthrough-technology.html (accessed 28 July 2019).

Based on the findings presented in this article, we propose the following policy recommendations.

(1) There is a need for the development of pilots and regulatory sandboxes for promising use cases to gain practical insights and test the advantages and constraints in a real-world setting.

(2) This innovative financing approach necessitates the education (capacity building) of decision- and policy makers to facilitate the development of regulatory frameworks. Successful use cases will facilitate the education of decision- and policy makers.

(3) For mainstream adoption through a global user base, STO regulation of the different jurisdictions needs to be harmonized.

6. CONCLUSION

Closing the climate finance gap and transitioning our global economy toward sustainability requires innovative financing approaches: 'The financial system is instrumental in achieving the transition to a sustainable economy' (Schoenmaker and Schramade 2019, p. 19). The paper takes a new angle on climate finance, presenting an alternative approach by assessing the status of STOs. This assessment has shown that tokenized securities are currently limited by immature infrastructure and regulatory uncertainty, while promising significant potential benefits compared to conventional financing mechanisms. The STO investment infrastructure is maturing, with current investments of almost $1 billion.

Taken together, the findings of this paper outline the potential of STOs to democratizing green finance for both private (retail) investors and SME issuers, resulting in more efficient allocations of capital in developing economies and ultimately accelerating global climate finance. Tokenized securities can address both supply- and demand-side issues: a global investor base can increase the demand for green finance projects, safeguarded through enhanced transparency and auditability. Reduced minimum investment sizes and reduced transaction costs make SMEs bankable, which is particularly relevant for developing countries.

Finally, a number of limitations need to be noted regarding this paper. A limitation of the study is the lack of empirical data for this novel approach. There is very little academic literature available on tokenized securities, or on blockchain as a vehicle for green investments. Additionally, there are very few use cases with more than a theoretical proposition at this time, causing a lack of empirical data. Given the novelty of this field, there is only a small number of experts, who are at the same time very active in the STO space, potentially limiting diversity and leading to a positive bias in the feedback received for this study. Use case studies are needed to improve understanding, provide empirical data, and educate the relevant stakeholders. Only the practical application of tokenized securities in a real-world setting will reveal the true potential of this innovative mechanism.

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