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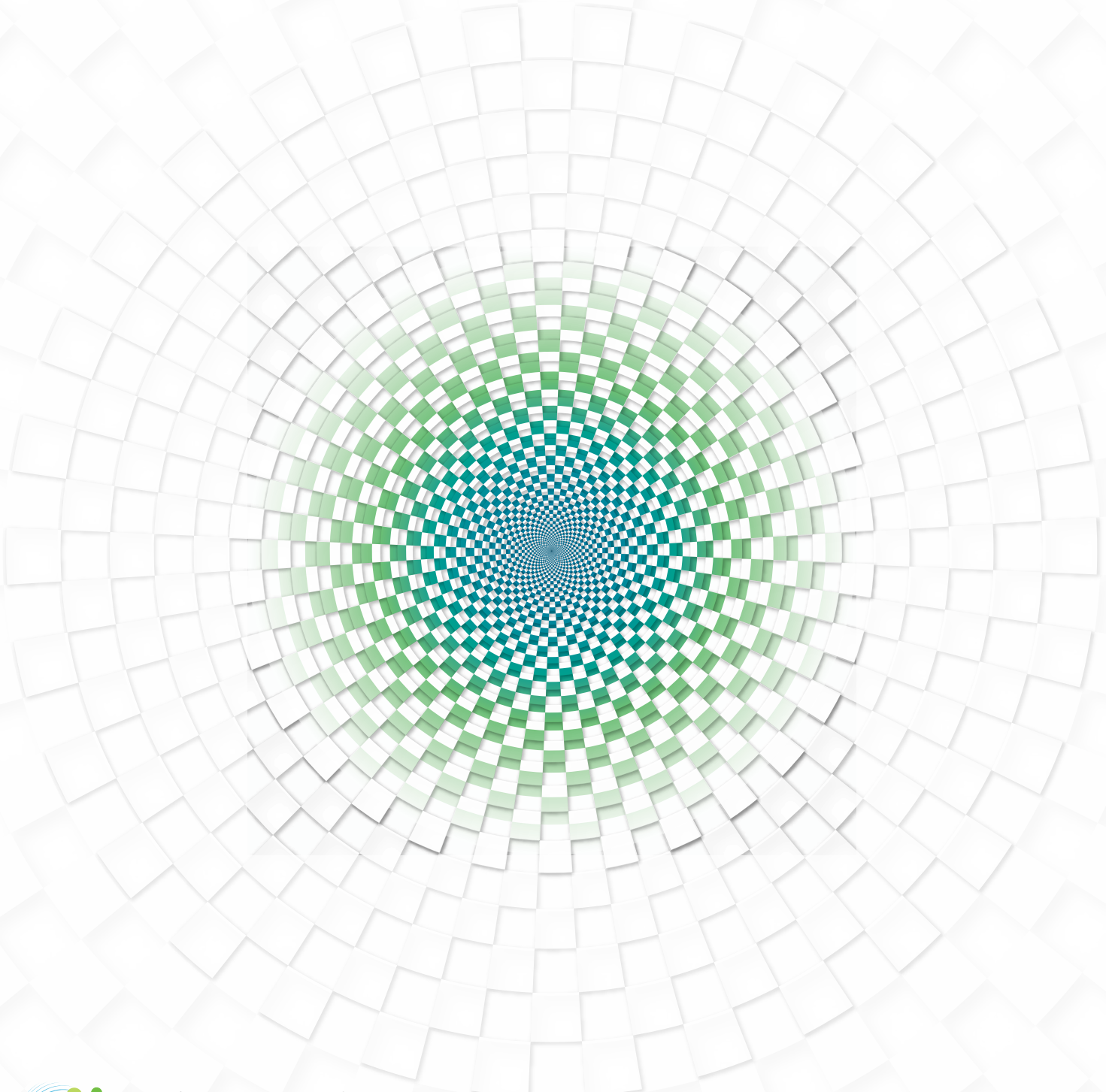
FINTECH AND SUSTAINABLE DEVELOPMENT

ASSESSING THE IMPLICATIONS



Inquiry: Design of a
Sustainable Financial System

December 2016

The UNEP Inquiry

The Inquiry into the Design of a Sustainable Financial System has been initiated by the United Nations Environment Programme (UNEP) to advance policy options to improve the financial system's effectiveness in mobilizing capital towards a green and inclusive economy—in other words, sustainable development. Established in January 2014, it published the first edition of *'The Financial System We Need'* in October 2015, with the second edition launched in October 2016. The Inquiry's mandate currently extends to the end of 2017, with work focused on deepening and taking forward its findings.

More information on the Inquiry is available at: *www.unepinquiry.org* and *www.unep.org/inquiry* or from: Ms. Mahenau Agha, Director of Outreach *mahenau.agha@unep.org.*

About this report

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EXECUTIVE SUMMARY

Finance is a system in constant flux. At present, the financial system is in both turmoil and transition. The financial crisis and its aftermath caused enormous turmoil and led to an extended period of low growth and instability across the international political economy. Transition of the financial system is in part driven by this turmoil, through policy and regulatory drivers, and heightened the influence of emerging nations in shaping global finance.

Transition is driven by broader historic developments, including sustainable development and financial technology innovations. The world is struggling to address growing inequality, the impacts of climate change and widespread deterioration in the natural wealth that sustains communities and underpins the global economy. The current turmoil is driven in part inadequate policy responses to these challenges. This imperative may seem distant from the financial system, but nothing is further from the truth. As the UNEP Inquiry has spelled out in both editions of its global report, "The Financial System We Need", realizing the Sustainable Development Goals (SDGs) and climate commitments agreed in 2015 depends in part on a reset of the global financial system to ensure that private capital is redeployed to finance the transition to an inclusive, green economy.

Financial technology ('fintech') is emerging as a core disruptor of every aspect of today's financial system. Fintech covers everything from mobile payment platforms to high-frequency trading (HFT), and from crowdfunding and virtual currencies to blockchain. In combination, such forceful innovations will threaten the viability of today's financial sector business models, and indeed the effectiveness of current policies, regulations and norms that have shaped modern finance.

The unit cost of intermediation of the last century has been estimated to about 1.5-2%, leading to suggestions that efficiency savings over time in one area of financial services have been largely offset by additional fees in another area. This has attracted new fintech start-ups and their disruptive business models, and with them significant opportunities and risks.

The use of technology in finance is of course not new – but a step change is now expected with the novel application of a number of technologies in combination, notably involving blockchain, the 'Internet of things' (IoT) and artificial intelligence (AI). This novel application of a number of technologies in combination makes the current wave of disruption unlike any we have seen before in finance. Fintech innovations promise a more efficient, accessible and less vulnerable financial system. At the same time, by creating new markets and blurring the boundaries between financial services and adjacent industries like retail and telecom industries, technology-enabled innovations bring a new set of risks to the financial system and may lead to significant unemployment in light of the increase in AI-led automation and the expanded use of robots under way. Minimizing the risks and maximizing opportunities of new innovations is essential to maintaining a healthy financial system that benefits society at large.

Regulatory response to the 2008-09 financial crisis created an opportunity for new start-ups, where they could provide financial services without the same (high) standard of regulation, and hence without the associated costs. With these new regulations, incumbent banks were forced to shift away from non-core assets and unprofitable customers, leaving this space wide open for new entrants.

In this context, the emergence of Bitcoin and its associated ecosystem of blockchains, sidechains and altchains have been described as a disruptive force in the financial sector in opposition to the centralized, trusted and guarded current state model of today's financial transactions. Blockchain may still be an immature technology, but just as earlier disruptive technologies like the World Wide Web and the rise of mobile phones, it holds the potential for a disruptive wave of innovations as it enables transparent interactions of parties through a trusted and secure network that distributes certified and auditable access to data. The blockchain may indeed solve for problems in trust, asymmetry of information and economics of small transactions without the costly and complex risk infrastructures and central intermediaries of today.

The technologies involved are not all new but the combination of them – the speed, the breadth and depth of their disruptive impact across the board – makes fintech unique in the way it may disrupt the system as a whole.

UN Environment commissioned an initial landscape review of the potential for fintech to advance sustainable development. This report is a more detailed companion to the high-level overview of fintech and sustainable development reviewed in the Inquiry's second edition of its report "The Financial System We Need".

Technological innovation is already offering sustainability solutions across the five core functions of the financial system: moving value; storing value; exchanging value; funding value creation; and managing value at risk. In this report, the overarching question is:

How can fintech innovations *help us and/or hinder us in* harnessing the financial system to align financing with sustainable development outcomes?

We focus on deconstructing further this question into the following 'how' questions:

1. How can we unlock much higher *financial inclusion* by significantly reducing the costs for payments and provide suitable access to capital domestically and internationally for the 'unbanked', the 'underbanked' and for small- and medium-sized enterprises (SMEs)?
2. How can we mobilize domestic savings at scale to enable long-term investment directed at long-term sustainability of the real economy through *investment in sustainable development innovations and in resilient and sustainable infrastructures?*
3. How can we disrupt the provision of *financial protection, risk management, risk transfer and risk diversification for vulnerable and exposed communities, real economy assets and infrastructures, and nature's ecosystems?*
4. How can we best *collect, analyse and distribute financial system and real economy information for better economic decision-making, better regulation and better risk management?*
5. How to better *provide effective and efficient financial markets with a level playing field and with market integrity for long term real economy investors* aligned with the sustainable development agenda?
6. How to best *remove barriers for scaling the resulting 'fintech for sustainable development' (FT4SD) innovation portfolio* given their significant impacts if deployed widely and deeply?
7. How to *mitigate the unintended consequences of fintech to obtain a net positive impact* for our FT4SD innovation portfolio?
8. How to *make sense of the complex FT4SD system change required to inform our journey* going forward?

Bank of England Governor Mark Carney recently articulated fintech's potential to deliver a great unbundling of banking's core functions, highlighting that the outcomes could be 'bucketed' in one of three potential scenarios – revolution, restoration and reformation. These scenarios could provide benefits to the financial sector including speed of transaction chains, greater capital efficiency and greater operational resilience. More broadly, he argued for leveraging advanced computer science to take a real-time and data-driven approach to monitoring and forecasting the real economy and of the financial system in ways similar to the fusion of advanced physics and computer science to model the earth's atmosphere in long-range climate and short-range meteorological prediction. In fact, he was beginning to connect the two worlds that are the focus of this report: articulating the connections between fintech and sustainable development in a new domain area we term 'fintech for sustainable development' (FT4SD).

Fintech offers the prospect of accelerating the integration of the financial and real economy, enhancing opportunities for shaping greater decentralization in the transition to sustainable development. Turmoil and transition guarantee that tomorrow's financial system will be very different from our current understanding and practices. Indeed, the very distinction between finance and the real economy will become blurred as fintech embeds

finance at the core of an increasingly automated global economy with seamless two-way communication. Change is clearly desirable given the current shortfalls in providing finance for sustainable development.

But what kind of changes can be expected through fintech disruption and how might they impact on sustainable development outcomes?

Just as most DNA molecules consist of two coiled strands that form a double helix – where two DNA strands are composed of simpler units called bases that combine in pre-set ways to generate the genes that code all lifeforms on earth – we will adopt the language of 'double helix of FT4SD' to understand the fundamental attributes (or DNA bases) of fintech and of sustainable development, as drivers of disruption and impact. These two concepts can also "connect" in pre-set ways to enable new sustainable business models. This will help highlight the changes under way and provide a common language to discuss the both positive and negative impacts of FT4SD – effectively providing a first attempt at a *meta-language* for translation across the finance, sustainable development and technology communities.

With this background, we posit some fundamental features, or "DNA" of fintech as including:

- *Increased access and decentralization of the financial system*: whereby advanced technologies are used to enable the inclusion of the unbanked and underbanked community of individuals and SMEs in two complementary roles as both producers and consumers (prosumers).
- *Increased transparency, accountability and collaboration across sectoral boundaries*: where advanced technologies can enable greater transparency, traceability, accountability and information sharing, to regulators, citizens and businesses to work together in the best interests of society.
- *Improved risk management and diversification*: better capture and analysis of citizen, business and financial institution data allow both the private sector and financial regulators to identify, characterize and manage more granular risks through the development of early-warning infrastructure and by better spreading risk across a range of actors in the financial system and in the real economy.
- *Lower costs through improved efficiency, speed and automation*: artificial intelligence (AI) platforms allow for end-to-end automation of processes, reducing costs, increasing reach, tailoring services and increasing the speed of execution of financial system front- and back-end services.
- *Increased competition*: disruption of the competitive landscape by the entry of fintech start-ups and the proliferation of alternative products and business models creates more accessible lower cost choices for all.
- *Redefining how we can better account for (sustainable) value*: by combining advanced technologies, we can create a system of accounting that brings us into the 21st century, migrating away from the reductionist double-entry bookkeeping invented by Pacioli in the 1300s – with an approach that looks beyond numbers in ledgers and utilizes machine learning, multiparty computation and algorithmic representation to redefine "value", particularly sustainable value.

Similarly, the connective fundamentals of sustainable development can be described as:

- *Increased inclusive prosperity for all*: this calls for reducing inequality and ensuring the provision of basic needs for all (water, energy, food, education, health, etc.).
- *Increased solidarity*: solidarity is needed within and across communities in a nation and internationally, particularly in times of disaster.
- *Improved natural resource productivity*: the use of water, energy, food, land and material resources can be improved by drastically reducing environmental externalities and enabling affordable access to all basic natural resources that sustain life and economies.
- *Increased social, economic and environmental resilience*: societies cannot exceed planetary boundaries if they wish to avoid catastrophic and irreversible change; instead they should strive to ensure stability and resilience of communities, of real economy assets and infrastructure, of the financial system and of natural infrastructure and their ecosystem functions.
- *Enhanced circularity:* disruption of whole industries and supply chains where effective flows of materials, energy, labour and information interact with each other and promote by design a restorative, regenerative and more productive economic system.
- *Improved intergenerational decision-making: adopting individual, business, government and collective decision-making to provide a safe and liveable planet for future generations.*

The DNA bases of fintech and of sustainable development connect and interact enabled by a "FT4SD Gearbox". We argue that blockchain coupled with machine learning and artificial intelligence (MLAI) and the Internet of Things (IoT) will lead to revolutionary innovations for building trust, immutability, transparency and traceability in transactions in both the financial system and in the real economy – through entirely new business models such as asset financing models based on real-time accumulated risk versus fixed terms.

Why do we believe that the combination of IoT, blockchain and AI ("FT4SD Gearbox") if deployed correctly, would enable the sustainable development agenda at scale?

Two drivers explain this:

- IoT and AI enable the 'animation of the physical world' – once we bring physical and natural assets, machines, and physical and natural infrastructures to life by interacting with each other and by sensing and responding to each other in real time.
- Blockchain's smart contracts on the immutable distributed ledger allows real economy assets, infrastructures and processes to interact with the financial system in predictable ways and with business models that were unheard of ten years ago. Providing this two-way real-time interoperability between the real economy and the financial system will be disruptive.

The challenge for financial systems is twofold: to mobilize finance for specific sustainable development priorities and to mainstream sustainable development factors across financial decision-making:

- Mobilizing finance**:** Capital needs to be mobilized for *financial inclusion* of underserved groups (e.g. low-income citizens and SMEs), raising *capital for sustainable and resilient infrastructure* (e.g. energy) and *financing critical areas of innovation* (e.g. off-grid energy solutions, smallholder agriculture, sustainable land use, and sustainable fisheries). Estimates suggest that US$5-7 trillion per year is needed to implement the SDGs globally. Developing countries face an annual investment gap of around US$2.5 trillion in areas such as infrastructure, clean energy, water and sanitation, and agriculture.
- Mainstreaming sustainability**:** Sustainability factors are increasingly relevant and material for financial institutions decision-making. This starts with ensuring *market integrity* (e.g. corruption, enabling new common-pool resource markets, efficient markets) and extends to integrating environmental and social factors into *risk management* (e.g. climate-related risk ratings of biological assets, risk transfer in smallholder agriculture and shared assets). Sustainability also needs to be incorporated into the *performance disclosure and reporting* (e.g. immutable registries of property rights and moveable assets) of market actors to guide their decision-making.

To understand how a *FT4SD innovation portfolio* (see summary table) could play a strategic role in addressing the financing challenges of the sustainable development agenda, we examine a representative sample of case studies from the portfolio to understand how they may provide breakthroughs to address the sustainable finance drivers of financial inclusion, capital for infrastructure, financing innovations, market integrity, risk and resilience and reporting and disclosure. The FT4SD innovation portfolio is characterized in terms of applicable geographical contexts, sustainable development goals, sustainable finance drivers, level of maturity and potential for scale. The FT4SD innovation portfolio is balanced across all key dimensions by design so that we can understand its potential systemic impact, the barriers for scaling and the unintended consequences.

Will the alignment of the financial system with sustainable development be a challenge? Global finance is arguably the most complex, dynamically adaptive system ever created. Hundreds of billions of transactions daily enacted by millions of financial institutions and billions of people impact nearly person on the planet. Attempts to simply track these transactions have proved hard to design, let alone implement, as have measures to effectively stabilize the system. Transition drivers like fintech will make policy guidance more difficult in some ways as 'technical code' requires a multidisciplinary approach involving computer scientists, lawyers, cryptographers, scientists, policymakers and domain experts. It will dramatically increase the system's complexity and dynamism, making many current policy instruments less effective or indeed redundant. On the other hand, the combination of blockchain, IoT and AI may offer a basis for new policy instruments and new business models, while others may provide citizens with improved access to, and control over, financial services and related opportunities.

Fintech for Sustainable Development Innovation Portfolio

PORTFOLIO OF FT4SD CASE STUDIES		GEOGRAPHY	FT4SD CASE STUDY CHARACTERISTICS		SCALING POTENTIAL	
		GEO SCOPE	SD GOALS	SUSTAINABLE FINANCE DRIVER	ADOPTION STAGE	SCALING POTENTIAL
1.1	SME collateral management registry	Global	Jobs and growth	Financial inclusion	Conceptual	++
1.2	Welfare conditional transfer	Developing	Poverty	Financial inclusion	Conceptual	+++
1.3	Remittances/accounts for unbanked	Developing	Poverty	Financial inclusion	Pragmatic followers	+++
1.4	Economic identities for refugees	Developing	Peace	Financial inclusion	Early adopters	+++
1.5	International aid smart contracts	Developing	Poverty	Financial inclusion	Early adopters	++
1.6	Smallholder identity and land registry	Developing	Hunger	Financial inclusion	Early adopters	+++
1.7	Participative democracy 2.0	Global	Jobs and growth	Financial inclusion	Conceptual	++
1.8	Enabling microfinance 2.0	Developing	Poverty	Financial inclusion	Conceptual	++
2.1	Pay as you go resource utilities	Developing	Energy	Capital for infrastructure	Pragmatic followers	+++
2.2	Flexible energy supply and demand	Developed	Energy	Capital for infrastructure	Early adopters	+++
2.3	Renewable energy P2P	Developed	Energy	Capital for infrastructure	Early adopters	++
3.1	Smallholder extension services	Developing	Hunger	Financing innovation	Conceptual	++
3.2	Community distributed generation	Developed	Energy	Financing innovation	Early adopters	+++
3.3	SME asset trade finance	Developed	Jobs and growth	Financing innovation	Conceptual	++
3.4	SME smart assets	Developed	Jobs and growth	Financing innovation	Conceptual	+
4.1	Financial markets early warning system	Global	Partnership	Market integrity	Early adopters	++
4.2	Sustainable fintech regulatory sandbox	Developed	Partnership	Market integrity	Early adopters	+
4.3	Biodiversity conservation exchange	Developing	Land-based	Market integrity	Early adopters	++
5.1	Shared asset insurance	Developed	Consumption	Risk and resilience	Early adopters	++
5.2	Smallholder index insurance 2.0	Developing	Food	Risk and resilience	Conceptual	+++
5.3	Basin water rights management	Global	Water	Risk and resilience	Conceptual	+++
5.4	Agricultural credit risk management	Developing	Land-based	Risk and resilience	Conceptual	++
6.1	Water asset registry and ratings	Global	Water	Performance and disclosure	Conceptual	+++
6.2	Fish supply chain traceability	Global	Ocean-based	Performance and disclosure	Early adopters	++
6.3	Climate monitoring reporting verification	Global	Climate	Performance and disclosure	Conceptual	+++

In this context, the path to adoption requires addressing six key dependencies and 11 key barriers.

Key dependencies for scaling:

- Need for industry-wide standards and network interoperability
- System and process integration challenge across institutional borders
- System-wide coordination barriers
- Migration away from IT infrastructure legacy
- Broadband connectivity requirements
- Enabling (pseudo)-anonymity

Key barriers for scaling:

- Regulatory barriers
- High energy bitcoin network consensus cost
- Requirement of a validation network
- Scalability of blockchain and technology robustness
- Operational transition risks
- Immutability barriers
- Incumbent business model risks
- Security, privacy and resilience against cyber-attacks
- Cost sharing across the network
- Governance of the network
- Legality of smart contracts

There is a range of both transitional and more structural unintended consequences, however, with potential downside risks for sustainable development. The rapid development of fintech has raised policy questions about proper regulation and supervision. But typically financial system regulators concentrate their efforts on financial stability and not around fintech's many unintended consequences spanning various areas, which are often the purview of other sectoral regulators in the telecom/IT and in the natural resources arenas.

In this report, we discuss 15 unintended consequences that can be grouped into eight structural and seven transitional types.

Structural consequences:

- Cryptocurrency outsized energy footprint
- Ownership and governance of use of data
- Cashless society provides backdoors to privacy and control
- Too high a granular risk may make high-risk communities uninsurable
- Provisioning cognitive layer of robo-advisers with unintended value system
- Fintech commoditization destroying relationships
- Know Your Customer (KYC)/Anti-Money Laundering (AML) compliance on the blockchain may aid state surveillance efforts
- Blockchain's immutability and the right to forget

Transitional consequences:

- Alternative sources of finance with unmanaged risks
- Increasing several fold the cyber security risks of going fully digital
- Fintech AI-driven automation will create significant unemployment
- Unintended killer apps for mobile money/bitcoin exchanges
- Accelerating regulatory knowledge gaps
- Capital markets level playing field
- Rapid obsolescence of mission-critical digital technology through ownership lifecycle

Shaping a financial system that can meet the needs of the 21st century requires a focus on its underlying purpose and resilience, not just on measures to cope with today's sources of turmoil. Dangers associated with the current turmoil encourage us to focus attention and policy measures on stabilizing a system that is fundamentally no longer fit for purpose. Continued misalignment with sustainable development will ferment further instability across economies, nations and ecologies. This will in turn undermine the stability of the financial system and its effectiveness in allocating capital for private gain. Key, then, is to place more focus on transition drivers such as fintech, which offer an opportunity by blending market, technology and policy innovation to align the financial system with sustainable development.

As part of the UNEP Inquiry report on the 'Financial System We Need', a number of scenario vectors were developed including one termed 'Technology Edges', which to a large extent is the lens of this report. In the "Technology Edges" scenario, our end-state vision considers that (to leverage advanced technologies) mainstreaming sustainable development in the financial system requires developing and understanding the levers of the 'real economy-financial systems graph'. This graph is analogous in nature to Facebook's "social graph" or LinkedIn's "economic graph". But in our case, we have an interest of mapping the interactions and the positive and negative feedback loops between the four (excluding the social network) foundational

networks linking the real economy with the financial system: natural resources and infrastructures, physical infrastructures, supply chains and the financial system networks. We believe that this "system of systems approach" will allow us in time to model the complex world we live in with advanced computer science disciplines in AI and network science. If we can do this in time, it will allow us to understand the overall system interactions, the positive and negative feedback loops, the vulnerabilities, the overall dynamics – and chart our future with more confidence. Becoming the "cartographers of FT4SD systems change" then becomes a high priority for ensuring net positive outcomes.

Broad technological change enabled by fintech can redefine the systems constraints and thus the location of the equilibrium points. Shocks of various origins (regulatory, novel technology ecosystems, standardization, risk instabilities, etc.) can force the equilibrium points to move over time. Thus we expect the dynamics of the system originating from a level of equilibrium, followed by a shock, followed by a new level of temporary equilibrium. Another important characteristic of this type of system fully complies with the first and second laws of thermodynamics. The nature of this system change is complex, in that sometimes it is in a stable pseudo-equilibrium state but it can also be subject to complex unpredictable exponential growth and collapse – where all economic activities and financial activities are firmly grounded in the real physical world of things, physical assets and infrastructures, natural resources and natural infrastructures. In another words, attaining sustainable development outcomes will to a large extent require complying with the fundamental laws of thermodynamics.

A case in point are the feedback loops between the financial system and the real economy, whereby accelerating climate change increases the amplitude and frequency of weather extremes, thereby impacting financial assets negatively either through a correction or elimination of the underlying financial value. These weather extremes can also disrupt the real underlying economic activities of assets and infrastructures through higher temperatures, changed patterns of precipitation, droughts, floods, landslides or public health disasters. Dietz et al.[1] estimate that under unabated climate change, there is a 1% chance that at least US$24 trillion will be lost.

Irrespective of the massive complexity involved as discussed in the prior section what can we say about the system change ahead? The first blockchain applications emerged out of eroded trust in traditional institutions, and yet eight years later, more than 60% of the global financial system has entered into a consortium to apply blockchain to remove cost and create efficiency in their businesses. In addition, the World Economic Forum Deep Shift research estimates that 10% of global gross domestic product (GDP) will be stored on blockchain technology by 2025. However, the notion that a novel fintech start-up can capture the bulk of the global financial market settlement and become the Google, Apple or Facebook of global finance, while transforming post-trade operations and earning massive profits is overly simplistic and probably just plain wrong.

Reality is distorted by the near daily announcements of new developments, new partnerships, new consortiums, new standard battles, new world-changing proofs of concept, new start-ups – all promising to change the world for the better, as well as a steady stream of news on technological improvements and their potential scalability. Ignoring the current media hype, we can safely say that all developments are nascent. Furthermore, there are no commonly accepted standards for a number of practical areas, and with multiple efforts being undertaken in the space, resolution will take time. While talk of the next big disruption and a blockchain revolution (or two) suggests that wide-scale adoption is imminent, the facts suggest otherwise. In reality, this may take longer than expected but the results will be more profound once the change is finally under way. As Bill Gates clearly articulated: "We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't let yourself be lulled into inaction."

Governments often play a key role as inventors and/or funders at the infrastructure-building stage of new transformational innovations like the Internet (US DARPA). The end-to-end open standards principle adopted for the Internet allows for innovation at the network's edges where the tinkerers, innovators and start-up disruptors reside. By unbundling the transportation of bits from the provision of applications, innovations can be developed without permission – this is precisely what we need to reinvent our future in terms of sustainable development. Let 'thousands of FT4SD flowers bloom' is without a doubt the best strategy possible.

Government's mission-oriented policies drawing on frontier knowledge for great impact leveraging "big science deployed to meet big problems" makes a huge difference. The market creation and support

mechanisms that governments deploy in the future will set the odds for good, bad or even ugly scenarios. This is a major challenge that will determine the probabilities of success or failure.

If we can engineer a similar outcome for the blockchain and associated technologies as per the Internet example, we have yet to imagine the limits of what is possible. If not, then positive innovations and disruptions will be stifled and history books may see the 'FT4SD Gearbox' as a failed innovation platform. To get this right, we need to seriously consider how to govern the public-private and citizen's interests to achieve the best possible outcome for all.

With this hindsight, we can envisage that the road ahead will involve one or multiple 'standards battles' that take us back to the famous operating system wars, the browser wars, the Betamax and VHS wars and so many other standard wars where the most common outcome is that the "winner takes all".

The FT4SD revolution calls for addressing these design principles in the next 3-5 years. The questions we need to address are how best to take advantage of this short window of opportunity and what are the policies required to enabling scaling and mitigate the impacts of the unintended consequences?

The net impact of the FT4SD revolution will also depend on a number of policy and regulatory innovations that enable scaling and minimize fintech's unintended consequences in the areas of:

- Enabling 'technical code'
- Enabling open data policies
- Policies Enabling Trust and Interoperability
- Enabling policies of embracing blockchain regulatory co-benefits
- Public sector taking a leadership role
- Enabling 'hands-off regulatory approach' to market creation and innovation

We envisage three implementation pathways: FT4SD start-up pathways; FT4SD multi-stakeholder partnership pathways; and top-down FT4SD policy-mandated innovation pathways.

Challengers (FT4SD start-ups)

FT4SD start-ups will need strong focus to increase market adoption, based on reducing customers' costs, risks, or capital consumption by at least a factor of 10-100. Anything less than this performance threshold will not overcome the main obstacle for start-ups: inertia and status quo. This is particularly challenging in a networked business such as the financial system, where the business case for any participant depends on adoption by several of its counterparties creating 'network effects'. Start-ups have a significant role to play in demonstrating the real possibilities of disruption, as they have no legacy or business model to defend or no revenues. Incumbents need to learn from their 'take no prisoners' approach at high speed, with a motto than can be characterized as iterations of *'do, fix, learn'* versus the more classical *'meet, discuss, plan and meet again to refine'* of incumbents.

Multi-stakeholder FT4SD Partnerships (including incumbents, FT4SD start-ups, regulators, policymakers, real economy and philanthropic players)

The multi-stakeholder approach relates to adoption by stakeholders from the public, private and public purpose sectors. Achieving consensus on the joint outcome is very time-consuming, given the different languages of the different communities (finance, technology, real economy, sustainable development, policy and philanthropy), their contribution and power in the value chain, and the benefits and costs that the partners experiment in technical, business, policy and regulatory model types.

Top-Down Mandated or Policy-driven FT4SD Innovation

In the blockchain-enabled FT4SD universe, top-down regulatory mandates are unlikely to achieve the positive impact we need. These, however, will be necessary to create the enabling environments for blockchain-enabled value propositions that can be prototyped and proven at scale. In the short term, innovative central bank innovators are planning to provide regulatory grade data to incubate RegTech start-up hubs for their own purpose. This is a good move from leading-edge regulators that prefer to co-develop innovations and explore the possibilities (both good and bad), rather than wait to see what evolves and then try to regulate the innovations.

Policy interventions can be active on both the fintech supply-side and on the manner in which financial system development is aligned to sustainable development. Some key steps in the FT4SD innovation journey could include:

1. Convening the multi-stakeholder platform to jointly develop the standards required
2. Co-developing the multiple FT4SD ecosystem-wide pathways for system-wide change
3. Envisioning and co-designing FT4SD innovations
4. Rapidly developing FT4SD prototypes and embracing agile "do, fix, learn" cycles
5. Bringing VC performance management rigour to FT4SD start-ups and multi-stakeholder initiatives alike

In this context, there are at least three potentially complementary "how to" models to accelerate the development of FT4SD innovations:

- Step 1 : **Creating a FT4SD challenge fund** – this challenge fund would be similar in nature to the Longitude and X-Prizes that seek a select number of jurisdictions or initiatives that are either piloting pioneering initiatives or are ready to embark on the FT4SD journey. The fund would provide them with the design, technical support and funding to develop implementable pilot plans. It would also create a global community of purpose that can pilot and create investment-grade, replicable partnerships and solutions. This is an area where a visionary philanthropic foundation can shape a catalytic system change.
- Step 2: **Setting up regional FT4SD innovation incubators for multi-stakeholder partnerships** – these would use design-centric rapid prototyping methodologies developed in social innovation labs and in technology start-ups around the world. Governments, international development partners, NGOs, scientific organizations, private sector companies, central bank regulators, FT4SD start-ups, philanthropic organizations and incumbent financial institutions can convene place-specific and time-bound "co-creation labs" with the objective of designing the specific FT4SD capabilities needed on the ground across different regional realities.
- Step 3: **Raising FT4SD VC and social impact funds** – FT4SD VC and social impact funds can bring on board the high impact multi-stakeholder partnerships incubated in Step 2 above to fund the scaling of FT4SD innovations by selecting jurisdictions for deploying their resources. They would then recover the initial investments through participation in successful FT4SD start-ups and/or initiatives. A VC-type model of performance based funding will be at the core of the design to insure impact and scalability.

Chapter 1

1.1 FINANCE IN NEED OF A REVOLUTION

> *"... Finance, particularly banking, does need a revolution ... It is because finance is so important that a revolution is needed. But for that very reason the revolution also requires careful watching."*[2]
>
> **Martin Wolf, Financial Times, 2016.**

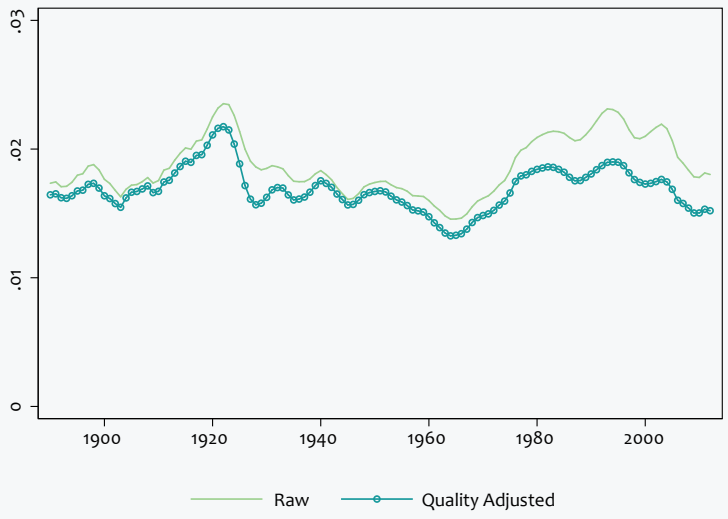
Andrew Haldane[3] of the Bank of England noted on a recent speech that "astonishingly, the unit cost of US financial intermediation seems to be unchanged over a century", suggesting a huge inefficiency (see Figure 1). Thomas Philippon[4] estimates that the unit cost of intermediation of the last century has been roughly equal to 1.5-2% leading to suggestions that efficiency savings over time in one area of financial services has been to a large extent offset by additional fees in another area.

Financial Institution numbers are always very large. Worldwide, their after-tax profit reached US$1 trillion in 2014. The global payments industry revenues are even larger at US$1.7 trillion in 2014. China's banking profit is estimated to have grown by 500% since 2006.

At the same time, banks have taken on US$165 billion in fines from 2010 to 2014 and in the 'machine age', a settlement can take days. Still, 10 million US households and 1.5 million UK adults have no bank accounts, not to mention the two billion 'unbanked' in the developing world.

It is clear that the sector has potential to attract new fintech start-ups and their disruptive business models and with them significant opportunities and risks.

FIGURE 1: US COST OF FINANCIAL INTERMEDIATION



Source: Philippon, T. (2012)

In 2015, Goldman Sachs CEO Lloyd Blankfein declared that "we are a tech company"[5] and mentioned that computer engineers and programmers accounted for around a third of its 33,000 employees. Financial services firms are by far the largest buyer of IT products and services as a percentage of their revenues. Celent[6] estimates that the IT expenses for the financial services industry are US$200 billion and expects them to grow by around 5% per year.

Incumbent banks are often unsuccessful in delivering IT project outcomes and typically spend over 70% of their IT expenses on maintenance-related activities and on adaptation to regulatory reporting, rather than on the deployment of innovative new services and capabilities.

Fintech start-ups without a legacy and staffed with young, entrepreneurial computer scientists with no fear of failing are far more agile in developing new products, new platforms and new business models adopting a modus operandi that can be described as going through repeated 'do, fix, learn' cycles.

1.2 POTENTIAL DISRUPTION OF FINANCE

Silently over the last few years, the world economy has been undergoing a massive transformation at high speed, driven by the fusion of advanced digital, material and biological innovations and leading to the concept of the Fourth Industrial Revolution.[7] The accelerating confluence of emerging technology breakthroughs – covering wide-ranging fields such as AI, robotics, the IoT, autonomous vehicles, 3D printing, nanotechnology, synthetic biology, DNA editing, biomimicry, advanced materials science, energy storage and distributed computing[8] – will create massive opportunities and risks.

Many of the Fourth Industrial Revolution innovations are already reaching an inflection point in their development, as they build on and amplify each other across the physical, digital and biological worlds. 3D printing will be combined with gene editing technologies to produce living tissues to generate skin, bone, heart and vascular tissue. Blockchain immutable distributed ledgers in combination with AI and IoT technologies will soon revolutionize the way biophysical assets are registered and traced along end-to-end supply chains from source to use to reuse in a global system of record.[9]

Although all technologies at the core of the Fourth Industrial Revolution are not new, they are getting more sophisticated and integrated across the physical, biological and digital domains and their impact into various segments of the economy is becoming pervasive and highly impactful.

Use of technology in finance is not new, but rather the novel application of a number of technologies[10] in combination makes the current wave of disruption unlike any we have seen before in finance.

From blockchains and cryptographic currencies to marketplace lending and AI solutions, new technologies come with great promise for a more efficient, accessible and less vulnerable financial system. At the same time, by creating new markets and blurring the boundaries between financial services and the adjacent retail and telecom industries, technology-enabled innovations bring a new set of risks to the financial system and may cause significant unemployment in light of increased AI-led automation and the expanded use of robots. Minimizing the risks and maximizing the opportunities of new innovations is essential for maintaining a healthy financial system that benefits society at large.

In this context, two important definitions of money and communities by Professor Mainelli remind us of the core challenges and opportunities (in a personal communication with one of the authors[11]):

WHAT IS MONEY?
"TECHNOLOGIES COMMUNITIES USE TO TRADE DEBTS"
WHAT ARE COMMUNITIES?
"A GROUP OF PEOPLE PREPARED TO BE INDEBTED TO ONE ANOTHER ACROSS SPACE AND TIME"

Or consider what the UK Government Science Office[12] clearly articulated: handing a dollar bill to someone instantly transfers a dollar of value, without requiring a third party to verify the transaction. To transfer that dollar more widely, we need to trust one or more intermediaries, with the possibilities of the transaction not being fully completed if connected to illegal activities for example.

In this context, only physical notes are a 'bearer instrument' or 'censorship resistant'. This is where our story begins, as it presents the current state that will be transformed radically over the next few years.

Some technological disruption fundamentally erodes value across a whole industry. It happened recently in many industries such as music sales, video rentals, travel booking, newspapers, taxis and hotels. According to Citi,[13] these industries resulted on average in a 44% loss of share from physical to digital business models over a 10-year period.

Disruptive forces have already begun to impact the financial service industry. In a series of three reports released in 2015 called "The Future of Finance", Goldman Sachs[14] estimates that US$11 billion of annual profit are at risk in the banking system. In the six key US lending segments (personal, small business, student, mortgage, commercial real estate, and leverage lending) 41% of the market is held by non-banks, or the new 'shadow banking' sector, as they call it.

Regulatory responses to the 2008-09 financial crisis created an opportunity for new start-ups, where they could provide financial services without the same high standard of regulation, and without the associated costs. With these new regulations, incumbent banks were forced to shift away from non-core assets and unprofitable customers, leaving this space wide open for new entrants. In China, a country with more hands-off regulation for innovation, disruption is past the tipping point, as China's top fintech players already have as many clients as the largest Chinese banks. As these start-ups have strong parents in the large e-commerce space they can sustain a larger balance sheet than typical VC-funded businesses.

Undoubtedly, the emergence of Bitcoin and its associated ecosystem of blockchains, sidechains and altchains have been a disruptive force in the financial sector, as opposed to the centralized, trusted and guarded current state model of today's financial transactions. Leading clearing houses and trusted central authorities, like the Depository Trust & Clearing Corporation (DTCC), have already started to study the distributed ledger model to understand the risks and opportunities it presents. In a 2015 report, the DTCC argues that distributed ledgers have significant potential to "address certain limitations of the current post-trade process … with a shared fabric of common information". They also see several key gaps and risks with the technology before any significant widespread adoption can take place. They envision leading the blockchain-enabled revolution in their market, embracing the parts of disruption that further contribute to their current role.

Blockchain may still be an immature technology, but just as earlier disruptive technologies like the World Wide Web and mobile phones, it holds the potential for a disruptive wave of innovations as it enables transparent interactions of parties through a trusted and secure network that distributes certified and auditable access to data. The blockchain may indeed solve problems in trust, asymmetry of information and economics of small transactions without the costly and complex risk infrastructures and central intermediaries of today.

If we examine the evolution of networked innovation in time, the 1970s and 1980s saw the development of the Internet by Sir Tim Berners-Lee's World Wide Web invention. In the early 2000s, the description of Byzantine Fault Tolerance,[15] and the launch of P2P-distributed computing projects like Weather@home[16] led us finally to Satoshi Nakamoto's October 2008 paper launching Bitcoin and the associated blockchain platform.

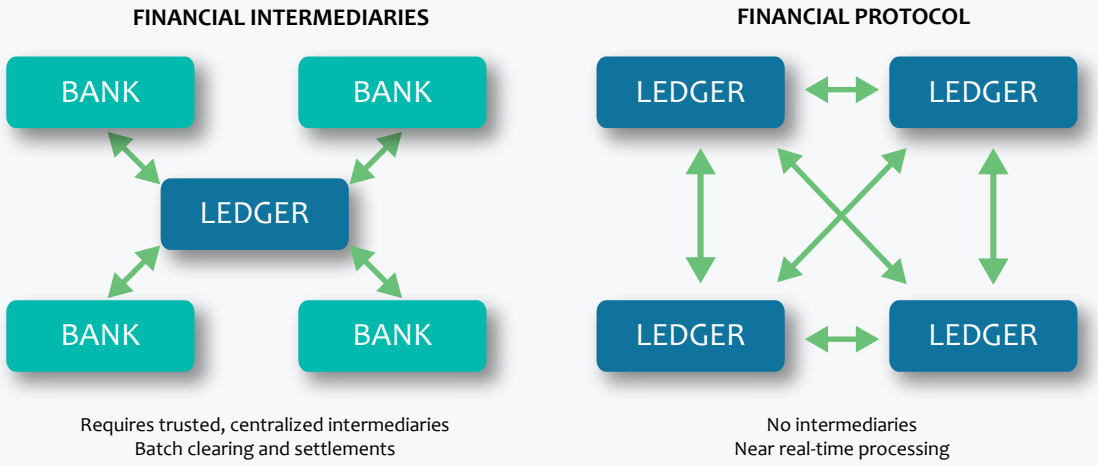
The blockchain as a disruptive platform in finance facilitates the exchange of value without the need for intermediaries (Figure 2).[17]

Summarizing, blockchain can disrupt finance through:

- Decentralization: enabling direct transfer of digital assets allowing counterparties to transact without the need of intermediaries reducing their related costs.
- Programmability: enabling pre-programmed smart contracts to be executed once agreed conditions are met.
- Immutability: maintaining an immutable audit trail and enabling irrevocable transactions that would clear and settle near instantaneously and, in the process, creating a historical record of all transactions, significantly reducing the cost of compliance to complex regulations.
- Cost/capital efficiency: enabling a major simplification of existing processes lowering the costs and increasing the capital efficiency.

As a series of MIT papers[18] have argued, we are in the early stages of experimentation of the adoption of blockchain. As we will discuss in this report there is no doubt that blockchain coupled with MLAI and the IoT will lead to revolutionary innovations to building trust, immutability, transparency and traceability in transactions in both the financial system and in the real economy – through entirely new business models such as asset financing models based on real-time activity versus fixed terms.

FIGURE 2: IMPACTS OF DISTRIBUTED LEDGERS



Source: Citi GPS (2016)

1.3 THE LANDSCAPE OF FINTECH ACROSS KEY FINANCIAL SYSTEM FUNCTIONS

In 2015, fintech start-ups raised a total of US$19 billion.[19] These ventures have concentrated in areas with the greatest customer friction points and highest potential profitability: payments, capital markets, bank credit and personal financial management, among others. Some of the fintech capabilities are incremental in nature and some potentially disruptive. Figure 3 below from McKinsey lays out the Fintech investment landscape in quantitative terms. below from McKinsey lays out the Fintech investment landscape in quantitative terms.

Fintech firms have so far 'stolen' some incumbent bank business, mostly in commercial banks: in mobile and Internet payments, unsecured P2P lending, invoice finance, among others. The big prize though is still up for grabs as the centrepiece of customer's financial lives: the current account.

A large entry barrier[20] for fintech start-ups will continue to be regulation, even after the 2008-2009 financial crisis changed attitudes toward banks. The millennial generation is especially prone to trust their finances to brand new web-only/smartphone-only companies and to transact with a unique customer experience at a fraction of the cost base of traditional retail banks[21] – always on, and on the move.

The developing world, with its large unbanked population and high penetration of mobile phones, has been a natural market for fintech start-ups originating in the telecom industry. M-PESA, the iconic P2P mobile money service that was launched in Kenya almost a decade ago currently has about 25 million customers in 11 countries.[22] Other countries with a large unbanked population, like India and the Philippines, are also turning to mobile fintech. They are doing this mostly with a 'hands-off approach' to banking and telecom regulation to address financial inclusion at scale.

To define the scope of fintech is a challenge. The technologies involved are not all new but the combination of them, the speed, the breadth and depth of their

FIGURE 3: CUSTOMER SEGMENTS AND PRODUCTS OF LEADING FINTECHS

PRODUCT/CAPABILITIES CUSTOMER SEGMENTS	ACCOUNT MANAGEMENT	LENDING AND FINANCING	PAYMENTS	FINANCIAL ASSETS AND CAPITAL MARKETS
Retail	10%	14%	25%	13%
Commercial	3%	9%	12%	4%
Large Corporate	2%	1%	6%	2%

Source: McKinsey (2015)

disruptive impact across the board makes fintech unique in the way it may disrupt the system as a whole.

In order to define the functional scope, we look into the financial system's core functions (Figure 4) that will be disrupted to a greater or lesser extent by a combination of one or several financial technologies and most notably by the IoT-AI-Blockchain Gearbox:

- Moving value
- Storing value and lending value
- Exchanging value
- Funding and investing in value creation
- Insuring value and managing risk

1.3.1 MOVING VALUE

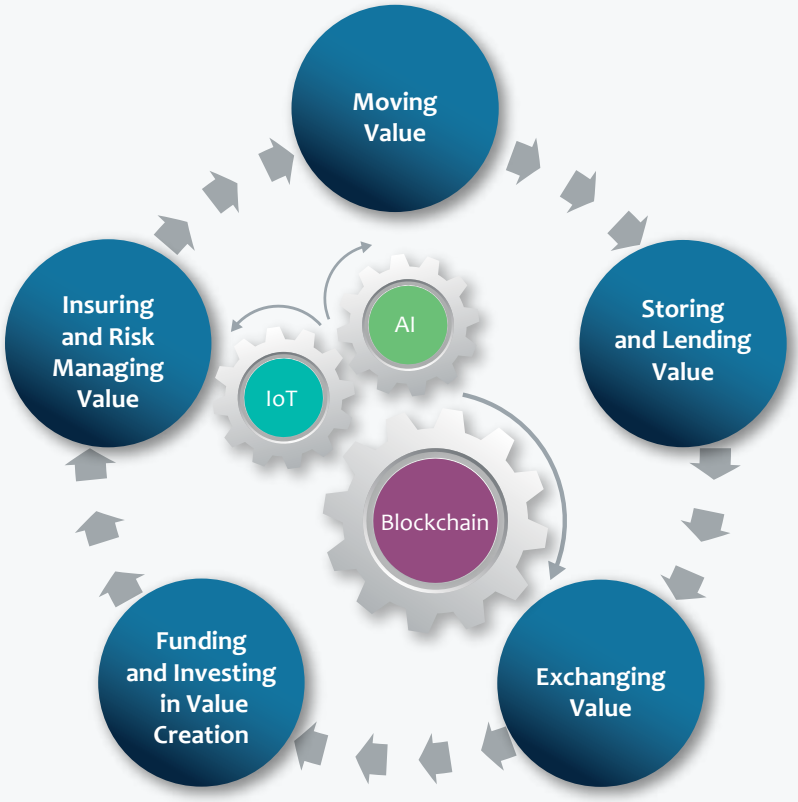
"The payment systems have moved from the backroom to the boardroom of all financial institutions" argued a World Bank in a report in 2010,[23] not only because of the importance of payments to any economy accounting for 40% of total bank revenue, but also because the payment space is the easiest for new entrants to make headway.

The path of digital payments growth has been almost unique to each country, especially in the developing countries, as a function of smartphone and bank penetration. In Kenya, the success of M-Pesa was driven by a 'hands-off' regulation mode, as discussed in the previous section. In China, due to its large e-commerce ecosystem, high penetration of mobile and Internet penetration and relatively unsophisticated incumbents, growth has been exponential: China's Alipay already has as many clients as traditional banks. In India, the national biometric identity programme has been a gigantic market enabler with over 200 million new banks accounts opened since the programme started.[24,25]

There are two billion unbanked, mainly in developing countries (Figure 5). In addition, the World Bank estimates that over US$580 billion were sent as remittances in 2015. As retail banks there focus primarily on the wealthy part of the population, fintech start-ups play a critical role to help accelerate financial inclusion across the board.

The best known success story is Kenya's M-Pesa where 45% of the population is still unbanked even though 88%

FIGURE 4: FINTECH DISRUPTIONS ACROSS CORE FUNCTIONS OF THE FINANCIAL SYSTEM



Source: UNEP Inquiry (2016)

have mobile phones. In Mexico, where regulation was put in place in 2009 and reviewed in 2012, mobile bank accounts – a regimen of simplified accounts – is growing fast from about 250,000 accounts in 2011 to more than 5 million accounts in 2014.[26] In the Philippines, a country where remittances represent 9.6% of its GDP, GCash, one of the main mobile banking start-ups recently partnered with Amdocs to deliver payments for salaries and government disbursements.

Around the world, cash still accounts for the majority of SME transactions: 75% of receivables and disbursement transactions according to IFC Mobile Money (2011). The existing legacy payment infrastructure is still the backbone of the system. In the future a blockchain-enabled payment rail can be disruptive, especially for foreign exchange and cross-border payments and remittances. We will discuss this further in future chapters.

1.3.2 STORING AND LENDING VALUE

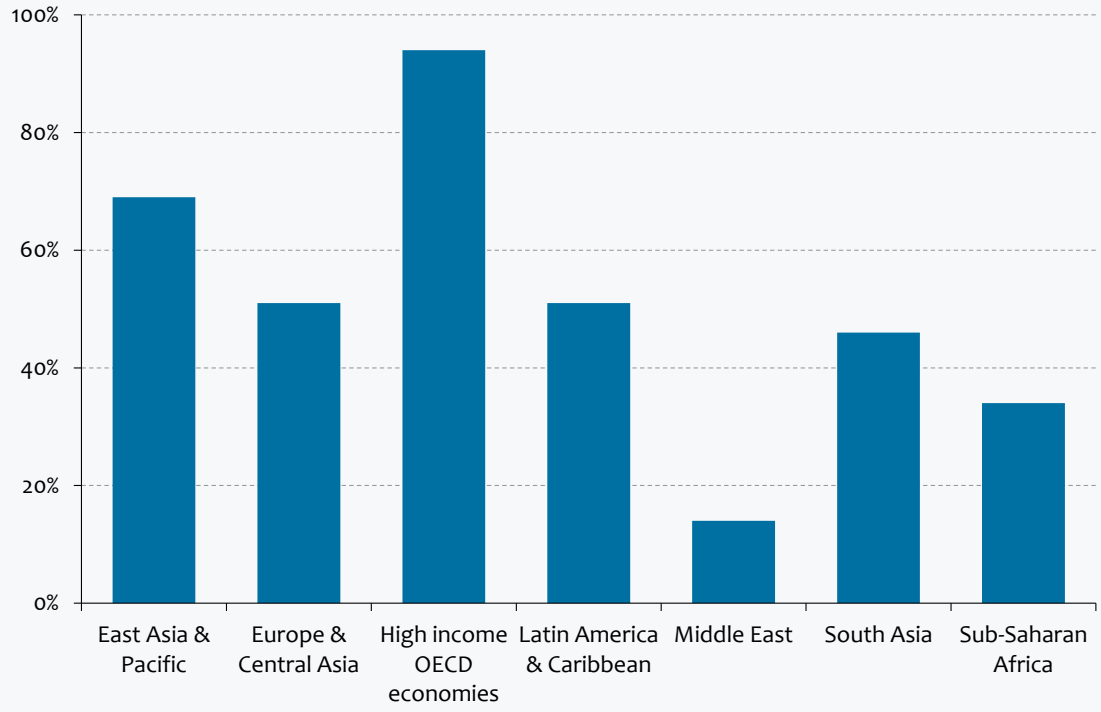
Throughout the 1800s and 1900s, P2P became the most common form of lending in Europe. Fast forwarding, Zoppa, the first world's P2P lending platform, was founded in London in 2005.

Borrowers and lenders have been 'matched' through online P2P platforms for around a decade already. The total amount lent remains small (less than 1% of total loans) according to the CITI GPS.[27] According to China MSME Finance Report[28] 2014 by Mintai Institute of Finance and Banking, almost 80% of SMEs accounting for around 60% of China's GDP were not served by banks. The Chinese Internet companies and P2P lending ones are entering the world of online finance to fill this gap and the growing needs of the unserved and underserved.

The aim of these P2P lending platforms is to lower the cost for the borrower while increasing the return for the lender. These lending platforms typically target the unserved and underserved by the banking system. The risks lie in that some of these P2P platforms have potentially less stringent standards on KYC/AML regulations and, with softer lending standards, can suffer on the downside of the credit cycle, as recent news on the Lending Club has attested.

Contemporary forms of local credit creation that innovate in the use of transferable liabilities as mediums of exchange – in contrast to commercial bank deposits that make up the majority[29] of the broad monetary supply may be growth vector for sustainable credit. This is important, as credit is associated with funding either sustainable or unsustainable practices, assets and infrastructures. A case in point is Banco Palmas in Brazil, that since 1998 provides microloans, micro-insurance

FIGURE 5: ACCOUNT PENETRATION – ADULTS WITH AN ACCOUNT (2014)



Source: Demirgüç-Kunt, A., Klapper, L., Singer, D. and Van Oudheusden, P. (2015)

and correspondent banking services in a local currency to citizens excluded from the formal banking system. Thanks to the recognition of its pioneering model by Brazil's Central Bank in 2014, there are now over 100 local replicas of the original bank.

1.3.3 EXCHANGING VALUE

Banks' current exchanging value systems include different platforms for trading, settlement, and order management. Back offices, at a very high cost, resolve any transaction exceptions, which can be complex and inefficient. Settlement times are long due to manual processes. Shorter settlement times have the potential to reduce liquidity risk which could reduce the risk capital parked in balance sheets.

Blockchain-enablement[30] for core market infrastructures and exchanging value could take a long time to reach industrial scale. The power of blockchain comes from capturing network effects which depend on its wide adoption by market participants.

Blockchain would improve the cost and capital efficiency for financial institutions in the long run. This would arise from removing intermediaries in the trading process and from faster settlement times, which could shrink the size of the balance sheet with a reduction of risk capital required.

We will discuss HFT and dark pools in later sections of the report.

1.3.4 FUNDING AND INVESTING IN VALUE CREATION

The global asset management industry is estimated to manage about US$69 trillion across different asset classes, such as equities, fixed income, commodities, forex and others.

Investment advice is a costly function and many investors and the mass-market in general cannot afford it. Robo-advisers can be a solution for younger and less affluent customers. According to the CITI GPS Digital Disruptions 2016 report, robo-advisers are already managing US$2.6 trillion of the total US$30.4 trillion of the ETF and mutual fund market.

Robo-advisers are MLAI-powered solutions that are used to offer customized investment portfolios for individual investors online. They provide advice for a much lower cost than traditional portfolio managers and financial advisers and offer choice to the customer that looks for investments advice at the time and place of their choosing.

Investors typically fill out an online questionnaire and the algorithmic engines provide advice on the optimal investments as a function of risk tolerance and expected return drivers. The platform also rebalances the investment portfolio as needed to be in line with the initial settings. For the service provided, the platform earns a management fee and fund-related expenses.

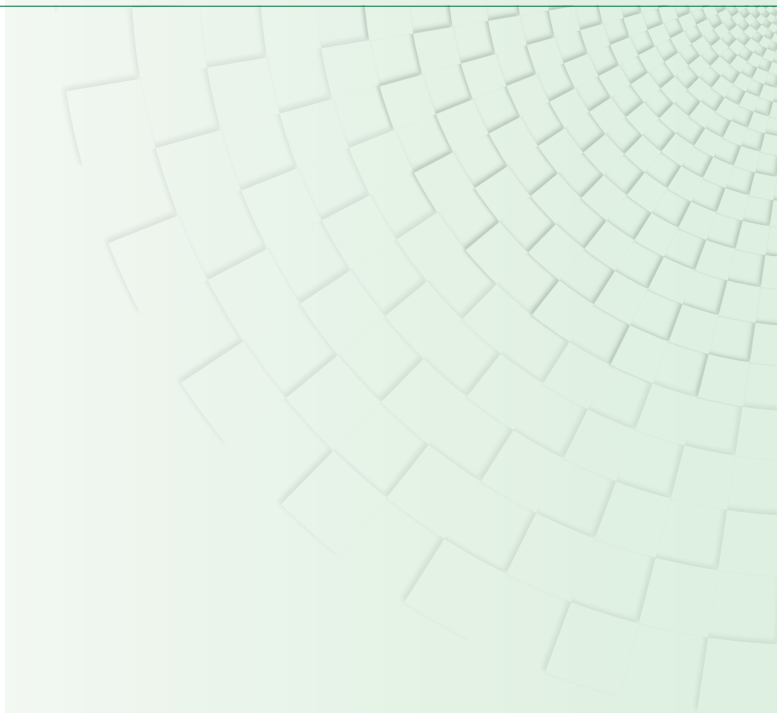
Although higher-net-worth or more sophisticated investors may still prefer face-to-face adviser, the robo-adviser provides a value proposition to less experienced and/or more conservative investors to keep their investments balanced and diversify in-line with their expectations. In the US, while robo-advisers remain small, their growing prominence among the younger generation will probably continue to drive the market.

1.3.5 INSURING VALUE AND MANAGING RISK

The rise of autonomous vehicles powered by advanced IoT sensors and MLAI and the growing number of shared assets as part of the sharing economy will, without a doubt, bring new challenges for the insurance sector. Autonomous vehicles are now a question more of *when* than *if*. A recent survey by IEEE[31] found that they ranked the roadblocks to mass adoption of autonomous cars as legal liability, consumer acceptance, and protection as more material than technological and cost-related issues.

Also the introduction of sensors measuring risky behaviour in real time (e.g. telematics applications for variable-pricing insurance in the US by Progressive Insurance[32]) can also present the sector with new opportunities like the possibility to proactively risk-manage throughout the insurance policy term hour by hour and price for actual risk incurred, instead of only predicting the risk up-front when issuing the policy, with all simplification errors that this entails.

With the rise of the "connected citizen" in various ways (through P2P lending), coupled with the rise of the sharing economy with millions of people interacting with each other on a global scale (Airbnb), it may be just a matter of time before new InsureTech platforms dis-intermediate insurers' risk transfer and risk management functions.



Chapter 2

2.1 THE CHALLENGE OF FINANCING THE SUSTAINABLE DEVELOPMENT AGENDA

Momentum is building around the world to align financial systems with the financing needs of an inclusive, sustainable economy. This is complementary to real economy actions such as environmental regulations, reform of perverse subsidies and changes to resource pricing. However, while these are critical, it is also increasingly recognized that changes are also needed in the financial system to ensure that it is both more stable and more connected to the real economy.

A financial system consists of institutional units and markets that interact to mobilize funds for investment and provide facilities, including payment systems, for the financing of commercial activity. The role of financial institutions within the system is primarily to intermediate between those that provide funds and those that need funds, and typically involves transforming and managing risk.

Banks play a key role in assessing risk, originating loans and underwriting the issuance of equities and debt. However, as short-term deposit, they are not well suited to hold long-term assets on their balance sheet. Therefore, capital markets provide a critical channel to enable long-term debts or equity-backed securities to be sold to institutional investors such as pension funds, insurers and sovereign wealth funds that have long-term liabilities and need to match these with long-term assets. Thus for the financial system to work as a source of long-term investment and a means of transmission of monetary policy into the real economy, it depends on the effective operation of banks, capital markets and institutional investment as a system for capital allocation.

Insurance also plays a key role as a risk manager, risk carrier and investor. Insurers help communities understand, prevent and reduce risk through research and analytics, catastrophe risk models and loss prevention. Insurers also advocate proper land-use planning, zoning and building codes and promote disaster preparedness. As risk carriers, insurers protect households and businesses by absorbing financial shocks due to cyclones, floods, droughts and earthquakes. Insurance pricing also provides risk signals and rewards risk reduction efforts. Insurers are also major investors with US$29 trillion in global assets under management.

Financial systems are critical both in enabling large-scale projects and corporate ventures to mobilize capital and transfer risk, but also for small, medium-sized and micro-enterprises and households to plan and invest for the longer term.

The challenge for financial systems is two-fold: to *mobilize* finance for specific sustainable development priorities; and to *mainstream* sustainable development factors across financial decision-making:

- **Mobilizing Finance:** Capital needs to be mobilized for ***financial inclusion*** of under-served groups (e.g. low income citizens and SMEs), raising ***capital for sustainable and resilient infrastructure*** (e.g. energy) and ***financing critical areas of innovation*** (e.g. off-grid energy solutions, smallholder agriculture, sustainable land use and sustainable fisheries). Estimates suggest that US$5-7 trillion per year is needed to implement the SDGs globally. Developing countries face an annual investment gap of around

US$2.5 trillion in areas such as infrastructure, clean energy, water and sanitation, and agriculture.

- **Mainstreaming Sustainability:** Sustainability factors are increasingly relevant and material for financial institutions' decision-making. This starts with ensuring ***market integrity*** (e.g. corruption, enabling new common-pool resource markets, efficient markets) and extends to integrating environmental and social factors into **risk management** (e.g. climate-related risk ratings of biological assets, risk transfer in smallholder agriculture and shared assets). Sustainability also needs to be incorporated into the **disclosure responsibilities and reporting** (e.g. immutable registries of property rights and moveable assets) of market actors to guide their decision-making.

Figure 6 below maps the relevance of the key sustainable finance factors discussed above to meeting the 17 SGD goals.

FIGURE 6: FINANCE AND THE SDGS

The two themes of mobilizing finance and mainstreaming sustainability can be broken down into financial inclusion, capital for infrastructure and financing innovation on one hand and market integrity, risk and resilience and responsibility and reporting on the other. Using the 17 SDGs as the reference point, the table below tracks the relevance of these themes against each Goal.

SDGs	**MOBILISING** FINANCE FOR SUSTAINABLE DEVELOPMENT			**MAINSTREAMING** SUSTAINABLE FINANCIAL PRACTICES		
	Financial Inclusion	Capital for Infrastructure	Financing Innovation	Market Integrity	Risk & Resilience	Responsibility
1 NO POVERTY	✓	✓	✓		✓	
2 ZERO HUNGER	✓	✓	✓	✓	✓	✓
3 GOOD HEALTH AND WELL-BEING	✓	✓	✓		✓	✓
4 QUALITY EDUCATION	✓	✓				✓
5 GENDER EQUALITY	✓		✓	✓	✓	✓
6 CLEAN WATER AND SANITATION	✓	✓	✓		✓	✓
7 AFFORDABLE AND CLEAN ENERGY	✓	✓	✓		✓	✓
8 DECENT WORK AND ECONOMIC GROWTH	✓	✓	✓	✓		✓
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	✓	✓	✓	✓		✓
10 REDUCED INEQUALITIES	✓	✓		✓		
11 SUSTAINABLE CITIES AND COMMUNITIES	✓	✓	✓		✓	✓
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	✓	✓	✓		✓	✓
13 CLIMATE ACTION	✓	✓	✓		✓	✓
14 LIFE BELOW WATER			✓		✓	✓
15 LIFE ON LAND			✓	✓	✓	✓
16 PEACE, JUSTICE AND STRONG INSTITUTIONS				✓	✓	✓
17 PARTNERSHIPS FOR THE GOALS	✓	✓	✓	✓	✓	✓

In this report we attempt to answer the following overarching question:

How can fintech innovations *help us and/or hinder us in* harnessing the financial system to mobilize the finance required to improve sustainable development outcomes at scale?

This question can be analysed further by the following 'how' questions:

1. How can we unlock much higher **financial inclusion** by significantly reducing the costs for payments and provide suitable access to capital domestically and internationally for the 'unbanked', the 'underbanked' and for SMEs?
2. How can we mobilize domestic savings at scale to enable long-term investment directed at long-term sustainability of the real economy through **investment in sustainable development innovations and in resilient and sustainable infrastructures?**
3. How can we disrupt the provisioning of **financial protection, risk management, risk transfer and risk diversification for vulnerable and exposed communities, real economy assets and infrastructures and nature's ecosystems?**
4. How can we best **collect, analyse and distribute financial system and real economy information for better economic decision-making, better regulation and better risk management?**
5. How to better **provide effective and efficient financial markets with a level playing field and with market integrity for long term real economy investors** aligned with the sustainable development agenda?
6. How to best **remove barriers for scaling an innovation portfolio** given their significant impacts if deployed widely and deeply?
7. How to **mitigate the unintended consequences of fintech to obtain a net positive impact** for an innovation portfolio?
8. How to **make sense of the complex FT4SD system change required to inform our journey** going forward?

Bank of England Governor Mark Carney[33] recently articulated fintech's potential to deliver a great unbundling of banking's core functions, highlighting that the outcomes could be 'bucketed' in one of three potential future scenarios – revolution, restoration and reformation. These scenarios could provide benefits to the financial sector including speed of transaction chains, greater capital efficiency and greater operational resilience. More broadly, he argued for leveraging advanced computer science to take a real-time and data-driven approach to monitoring and forecasting the real economy and of the financial system in ways similar to the fusion of advanced physics and computer science to model the earth's atmosphere in long-range climate and short-range meteorological prediction. In fact, he was beginning to connect the two worlds that are the focus of this report: articulating the connections between fintech and sustainable development in a new domain area we term '**fintech for sustainable development' (FT4SD)**.

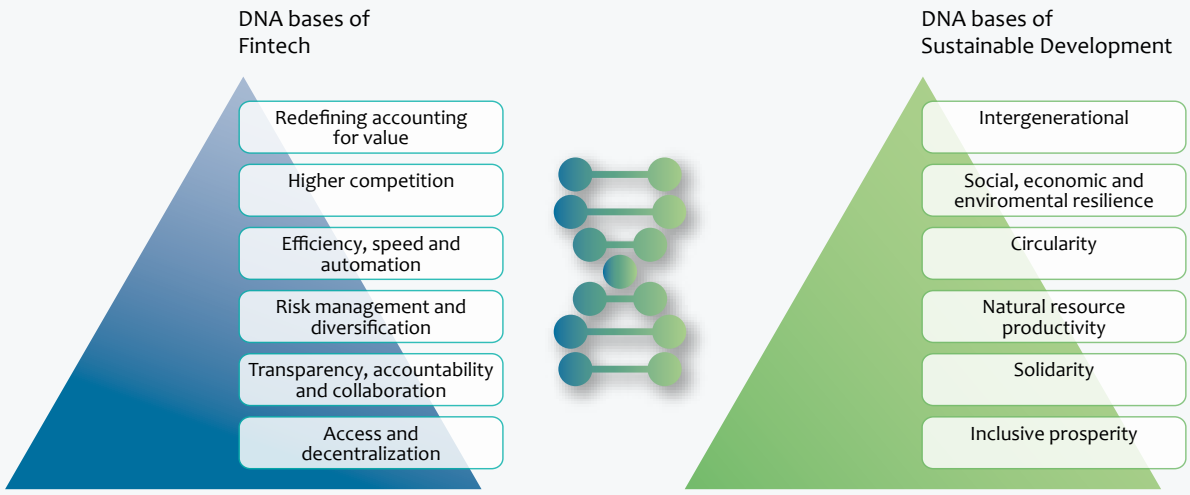
2.2 UNDERSTANDING THE CONNECTIONS BETWEEN FINTECH AND SUSTAINABLE DEVELOPMENT

In his 1937 paper "The Nature of the Firm",[34] Coase identified three types of costs in the economy: the costs of search, coordination and contracting, proposing that a firm would expand until the cost of performing a transaction inside the firm exceeded the cost of performing the transaction outside the firm. Fundamentally his thesis is about information-related costs. Fintech promises to disrupt multiple functions of the financial system and the real economy by massively reducing Coase's information search, coordination and contracting costs.

In a paper published in Nature in January 2013,[35] scientists demonstrated DNA's ability to code information as a means of digital data storage. It is then appropriate to use the DNA double helix analogy to describe the fundamental attributes of FT4SD, as we are fundamentally dealing with information coding, processing and storage. In his ground-breaking book *Why Information Grows*,[36,37] Cesar Hidalgo makes the case for how information and knowledge is developed, disseminated, used and embedded and this determines the complexity of economies worldwide and thus their ability to develop over time.

Most DNA molecules consist of two coiled strands that form a double helix. The two DNA strands are composed of simpler units called bases that combine in pre-set ways to generate the genes that code all lifeforms on earth. In this report, we will adopt the language of 'double helix of FT4SD' (Figure 7) to understand the fundamental attributes (or DNA bases) of fintech and sustainable development, as drivers of disruption

FIGURE 7: THE DOUBLE HELIX DNA OF FT4SD



Using the DNA double helix analogy is appropriate to describe the fundamental attributes of fintech sustainable development, as we are fundamentally dealing with how information is coded, processed, interpreted and stored in the two-way interactions between the real economy and the financial system.

and impact. These two concepts can also "connect" in pre-set ways to enable new sustainable business models. This will help highlight the changes under way and provide a common language to discuss the both positive and negative impacts of FT4SD – effectively providing a first attempt at a *meta-language* for translation across the finance, sustainable development and technology communities.

The **"DNA bases of Fintech"** can be described as:

Increased access and decentralization of the financial system: whereby advanced technologies are used to enable the inclusion of the unbanked and underbanked community of individuals and SMEs in two complementary roles as both producers and consumers (prosumers).

Increased transparency, accountability and collaboration across sectoral boundaries: where advanced technologies can enable greater transparency, traceability, accountability and information sharing, to regulators, citizens and businesses to work together in the best interests of society

Improved risk management and diversification: better capture and analysis of citizen, business and financial institution data allows the private sector and financial regulators to identify, characterize and manage more granular risks through development of early-warning infrastructure and through helping to better spread risk across a range of actors in the financial system and in the real economy.

Lower costs through improved efficiency, speed and automation: AI platforms allow for end-to-end automating of processes, reducing costs, increasing reach, tailoring services and increasing the speed of execution of financial system front and back-end services.

Increased competition: disruption of the competitive landscape through entry of fintech start-ups and the proliferation of alternative products and business models creates more accessible lower cost choices for all.

Redefining how we can better account for (sustainable) value: by combining advanced technologies, we can create a system of accounting that brings us into the 21st century, migrating away from the reductionist double-entry bookkeeping invented by Pacioli in the 1300s – with an approach that looks beyond numbers in ledgers and utilizes machine learning, multiparty computation and algorithmic representation to redefine 'value', particularly sustainable value. A transformation in the metric system underlying finance, business, governments, and managing resources at scale has the potential to address sustainable development at

its core. Joi Ito[38] argues there is no reason that every entry in ledgers needs to be a single number, as each entry can and should be an algorithmic and probabilistic representation of the obligations and dependencies that it represents in the context of space, time and who is asking the question.

The **"DNA bases of sustainable development"** can be described as:

Increased inclusive prosperity for all: this calls for reducing inequality and ensuring the provision of basic needs for all (water, energy, food, education, health, etc.).

Increased solidarity: solidarity is needed within and across communities in a nation and internationally, particularly in times of disaster.

Improved natural resource productivity: the use of water, energy, food, land and material resources can be improved by drastically reducing environmental externalities and enabling affordable access to all basic natural resources that sustain life and economies.

Increased social, economic and environmental resilience: societies cannot exceed planetary boundaries if they wish to avoid catastrophic and irreversible change; instead they should strive to ensure stability and resilience of communities, of real economy assets and infrastructure, of the financial system and of natural infrastructure and their ecosystem functions.

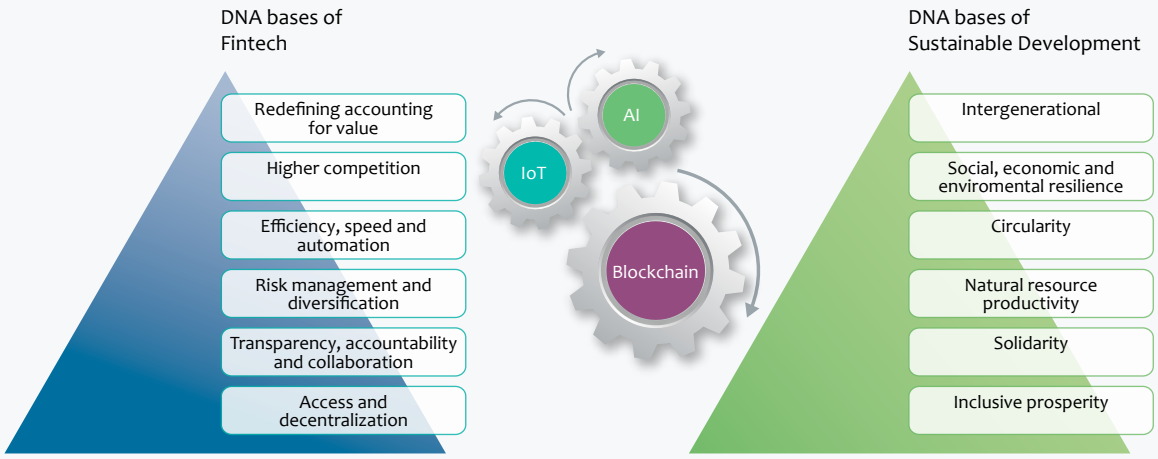
Enhanced circularity: disruption of whole industries and supply chains where effective flows of materials, energy, labour and information interact with each other and promote by design a restorative, regenerative and more productive economic system.

Promote intergenerational decision-making: adopting individual, business, government and collective decision-making to provide a safe and liveable planet for future generations.

The DNA bases of fintech and of sustainable development connect via **'DNA connectors' enabled by a "FT4SD Gearbox"**

FIGURE 8: FT4SD DNA CONNECTORS ENABLED BY "FT4SD GEARBOX"

IoT and AI: will enable the 'animation of the physical world' bringing the physical and natural assets, machines, physical and natural infrastructures to life interacting with each other by sensing and responding to each other in real time.



Blockchain's smart contracts on the immutable distributed ledger will allow real economy assets and processes to interact with the financinal system in predictable ways and with disruptive business models that were unheard of ten years ago.

Why do we believe that the combination of IoT, blockchain and AI ("FT4SD Gearbox") if deployed correctly, would enable the Sustainable Development agenda at scale?

Two drivers explain this:

- IoT and AI enable the 'animation of the physical world' – once we bring physical and natural assets, machines, and physical and natural infrastructures to life by interacting with each other and by sensing and responding to each other in real time.
- Blockchain's smart contracts on the immutable distributed ledger allows real economy assets, infra-structures and processes to interact with the financial system in predictable ways and with business models that were unheard of ten years ago. Providing this two-way real-time interoperability between the real economy and the financial system will be disruptive.

The FT4SD Gearbox connects the fintech drivers with the sustainable development drivers seamlessly. In the next section we will explore a non-exhaustive but representative set of case studies that bring the FT4SD framework to life. These range from early concept ideas, to prototypes underway to full implementations at scale.

2.3 HOW THE FT4SD INNOVATION PORTFOLIO MIGHT ADDRESS THE FINANCING CHALLENGE

The FT4SD portfolio as per Figure 9 and Figure 10 (detailed in Appendix 3) presents a non-exhaustive but representative set of case studies across the five key functions of the financial system.

FIGURE 9: FT4SD INNOVATION PORTFOLIO AROUND KEY FINANCIAL FUNCTIONS

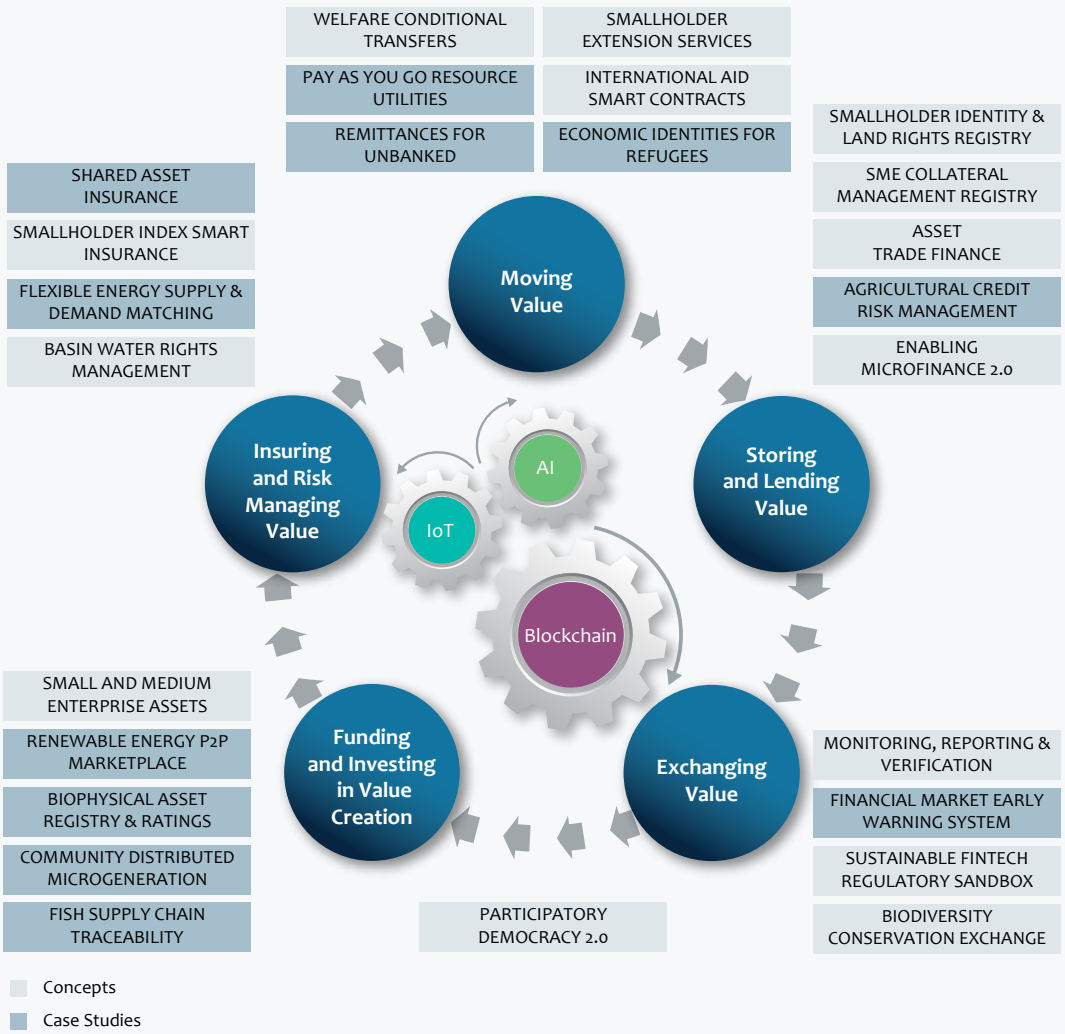
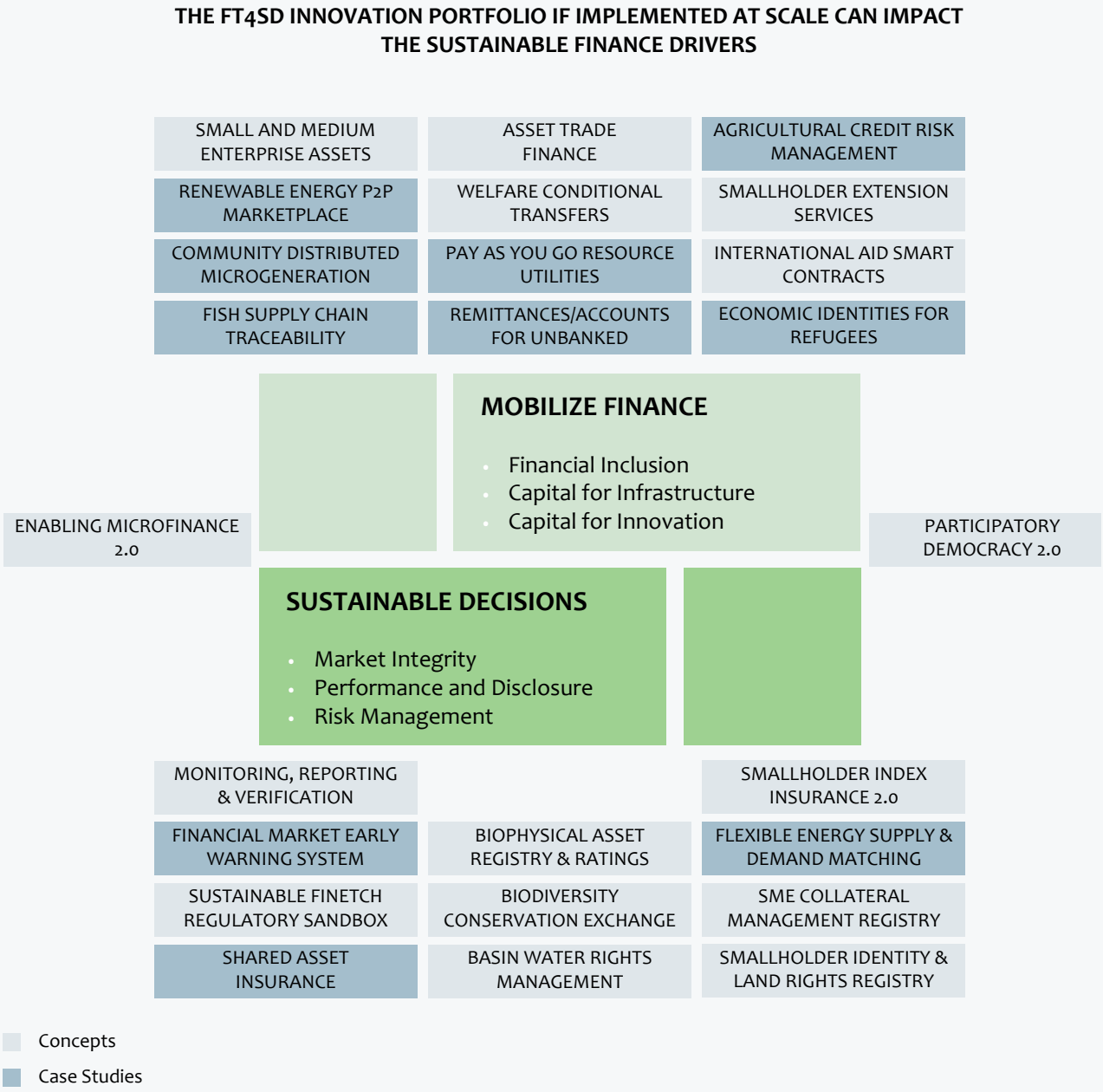


FIGURE 10: FT4SD INNOVATION PORTFOLIO IMPACTING SUSTAINABLE FINANCE



In Figure 11, the FT4SD innovation portfolio is characterized in terms of applicable geographical contexts, sustainable development goals, sustainable finance drivers, level of maturity and potential for scale.

The FT4SD innovation portfolio is balanced across all key dimensions by design so that we can understand its potential systemic impact, the barriers for scaling and the unintended consequences.

FIGURE 11: CHARACTERIZING THE FT4SD INNOVATION PORTFOLIO

PORTFOLIO OF FT4SD CASE STUDIES		GEOGRAPHY	FT4SD CASE STUDY CHARACTERISTICS		SCALING POTENTIAL	
		GEO SCOPE	SD GOALS	SUSTAINABLE FINANCE DRIVER	ADOPTION STAGE	SCALING POTENTIAL
1.1	SME collateral management registry	Global	Jobs and growth	Financial inclusion	Conceptual	++
1.2	Welfare conditional transfer	Developing	Poverty	Financial inclusion	Conceptual	+++
1.3	Remittances/accounts for unbanked	Developing	Poverty	Financial inclusion	Pragmatic followers	+++
1.4	Economic identities for refugees	Developing	Peace	Financial inclusion	Early adopters	+++
1.5	International aid smart contracts	Developing	Poverty	Financial inclusion	Early adopters	++
1.6	Smallholder identity and land registry	Developing	Hunger	Financial inclusion	Early adopters	+++
1.7	Participative democracy 2.0	Global	Jobs and growth	Financial inclusion	Conceptual	++
1.8	Enabling microfinance 2.0	Developing	Poverty	Financial inclusion	Conceptual	++
2.1	Pay as you go resource utilities	Developing	Energy	Capital for infrastructure	Pragmatic followers	+++
2.2	Flexible energy supply and demand	Developed	Energy	Capital for infrastructure	Early adopters	+++
2.3	Renewable energy P2P	Developed	Energy	Capital for infrastructure	Early adopters	++
3.1	Smallholder extension services	Developing	Hunger	Financing innovation	Conceptual	++
3.2	Community distributed generation	Developed	Energy	Financing innovation	Early adopters	+++
3.3	SME asset trade finance	Developed	Jobs and growth	Financing innovation	Conceptual	++
3.4	SME smart assets	Developed	Jobs and growth	Financing innovation	Conceptual	+
4.1	Financial markets early warning system	Global	Partnership	Market integrity	Early adopters	++
4.2	Sustainable fintech regulatory sandbox	Developed	Partnership	Market integrity	Early adopters	+
4.3	Biodiversity conservation exchange	Developing	Land-based	Market integrity	Early adopters	++
5.1	Shared asset insurance	Developed	Consumption	Risk and resilience	Early adopters	++
5.2	Smallholder index insurance 2.0	Developing	Food	Risk and resilience	Conceptual	+++
5.3	Basin water rights management	Global	Water	Risk and resilience	Conceptual	+++
5.4	Agricultural credit risk management	Developing	Land-based	Risk and resilience	Conceptual	++
6.1	Water asset registry and ratings	Global	Water	Performance and disclosure	Conceptual	+++
6.2	Fish supply chain traceability	Global	Ocean-based	Performance and disclosure	Early adopters	++
6.3	Climate monitoring reporting verification	Global	Climate	Performance and disclosure	Conceptual	+++

To understand how the FT4SD innovation portfolio could play a strategic role in addressing the financing challenges of the sustainable development agenda, we examine a representative sample of case studies from the portfolio to understand how they may provide breakthroughs to address the sustainable finance drivers of financial inclusion, capital for infrastructure, financing innovations, market integrity, risk and resilience, and reporting and disclosure.

2.3.1 FINANCIAL INCLUSION

How can we leverage fintech innovations to unlock much higher **financial inclusion** by significantly reducing the costs for payments and provide suitable access to capital domestically and internationally for the unbanked, the underbanked and for SMEs?

Financial inclusion is a key priority for developing country financial regulators.[39] While the number of people who lack access to financial services is falling, still two billion adults, or nearly 40% of the adult population, lack a basic bank account, and many more are not well served by markets for savings products, credit and insurance. Greater financial inclusion promises more inclusive growth and development. Enabling access to finance for SMEs is a particular priority. 70% of SMEs cite lack of access to finance as an impediment to growth and another 15% report they are underfinanced.

CASE STUDY: INTERNATIONAL AID

The overarching goal is to allow international donors to issue 'international aid coins' taking advantage of the distributed ledger's ability to offer reliable and irreversible transfers of aid funding to the right recipients at the right time and for the right reasons. Conditionality of funds use can be coded into the aid coins in the form of smart contracts, which could prevent them from being spent on items not deemed appropriate within the international aid context. It would also provide for transparency, accountability and end-to-end traceability of funds, ensuring money is well spent. By providing an immutable ledger of the flow of funds, it compels large institutions, from aid groups to governments, to act with integrity and fulfil their commitments. For example, the funds for major social rehabilitation projects could simply go into escrow and be released only after the successful completion of key milestones, resulting in radically improved transparency and accountability in the delivery of foreign aid, drastically reducing corruption and improving the intended outcomes of foreign aid flows.

In Appendix 3, we discuss the innovation continuum in the Financial Inclusion cluster. Here we highlight two complementary breakthrough innovations that on the one hand create economic entities for refugees and on the other provide the end-to-end transparency of more effective and efficient international aid delivery on the ground.

CASE STUDY: ECONOMIC IDENTITIES FOR REFUGEES

The first ever blockchain economic identity technology platform and network enables a secure and immutable platform for creating economic opportunities for refugees and people living in extreme poverty. The BanQu network uses a proprietary method to create a mashup of 'selfie' and other key human characteristics for people with no access to technology or banking. This economic identity then can be augmented by critical pieces of information such as land rights, voter registration, relationship based credit profiles, education records and health records, etc. The BanQu network thus enables a true credit/bankable profile for the refugees/unbanked and extreme poverty populations who are otherwise left out every day. While the uses are infinite, BanQu is focused on solutions in the three areas of:

1. Refugee crisis (Sub-Saharan Africa and Middle East)
2. Food/medical/payroll distribution in conflict and poverty zones globally
3. Increasing revenue streams for social enterprises via diaspora capital participation and compliance-based remittance

2.3.2 CAPITAL FOR INFRASTUCTURE

How to leverage fintech innovations to mobilize domestic savings at scale to enable **long-term investment directed at long term sustainability of the real economy through investment in resilient and sustainable infrastructures?**

According to the New Climate Economy report (NCE),[40] investment demand for sustainable infrastructure is estimated to be around US$6 trillion annually over the next 15 years, up from some US-3 trillion invested in all types of infrastructure today. The scale of this investment is so large that it will have to rely on blended capital mechanisms and vehicles: where public finance 'jump starts' the necessary capital, but transformational change requires the shifting of private capital flows to meet the green infrastructure demand. Traditional financing for green and resilient infrastructures has faced significant financial, regulatory and structural constraints, such as heightened risk perceptions and transaction costs since the 2008-09 global financial crisis.

In Appendix 3, we discuss the innovation continuum in the Capital for Infrastructure cluster. Here, we highlight two complementary breakthrough innovations that on the one hand enable off-grid distributed generation at scale and on the other provide the flexible energy demand matching to enable the growth of renewable energy generation with reliability and better economics, thus effectively providing the incentives for migration away from fossil fuel-enabled infrastructures.

CASE STUDY: FLEXIBLE ENERGY DEMAND MATCHING

A flexible energy system that embraces and enables renewables to be managed cost effectively while delivering security of supply is critically required to transition to a 2°C world. This requires a level playing field that accepts and manages the price risk inherent in renewables through leverage of financial technologies. The growth of zero marginal cost renewable generation has created conditions of oversupply and will eventually create undersupply when enough loss-making fossil fuel generation plants are retired. This over- and under-supply creates the pricing dynamic that enables renewable energy innovation to flourish. Energy-only markets are able to function because high prices have created the investment case for fast-response, gas-fired generation. Price risk during high demand/low supply events is mitigated by running fast-response, gas-fired generation. The same market conditions will create the investment case for a flexible demand-side and battery storage. Electricity has both a physical and financial flow, by connecting physically to consumption sources and managing time of energy use using financial signals, it is now possible to operate in a more commercially favourable way for electricity users. Using a real time IoT and AI platform that connects through software links into buildings via their building management system or directly to assets such as air conditioning, refrigeration, electric storage heating and battery storage, this optimization is achieved. Tempus Energy is a pioneer in this field.

CASE STUDY: PAY AS YOU GO UTILITIES

'Pay-as-you-go' energy services for off-grid customers that are leveraging the mobile infrastructure provide a leapfrog opportunity for delivering sustainable energy for all in the developing world. As a pioneering example of pay-as-you-go utilities, M-Kopa provides affordable solar power to low-income households on a pay-per-use instalment plan. In partnership with mobile money systems such as M-PESA in Kenya and IoT sensors in each solar system, M-Kopa monitors real-time performance and payment status. M-Kopa aims for 1 million homes in Kenya by 2018, having already achieved same scale as Solar City in the US. Off-grid technologies leveraging M-Pesa P2P payment capabilities requires taking an ecosystem approach that orchestrates the technical and distribution capabilities of multiple parties. To further scale M-Kopa Africa-wide and other developing countries a 'hands-off' regulatory approach in the financial system, energy and telecom industries is required.

2.3.3 FINANCING INNOVATION

How to leverage fintech innovations to mobilize domestic savings at scale to enable **long-term investment directed at long-term sustainability of the real economy through investment in the critical sustainable innovations?**

One of the most important classes of sustainable innovations available is capturing the total resource productivity opportunity of US$2.9 trillion a year in 2030.[41] According to McKinsey, 70% of the opportunities have an internal rate of return of more than 10%, and 80% if the externalities of resource use and subsidies were included in prices. Given the financial complexity involved and the political economy barriers around the resource provisioning, this calls out for breakthroughs in the business, technology, regulatory and funding/financing models that must be put in place for scaling the impact.

CASE STUDY: RENEWABLE ENERGY P2P MARKETPLACE

Historically, the key barriers for financing renewable energy projects at a local level have been local authorities being overly cautious investors.

A renewable energy investment project marketplace (P2P) such as the one pioneered by Abundance Investment in the UK has the benefit of highlighting popular projects within a local area and encouraging greater transparency and participation from residents in the decision and implementation process as well as sharing the financial benefits of the development more widely and evenly.

This requires:

- Building an investment-grade programme of individual projects led by local government authorities to realize local renewable energy plans/targets by turning renewable energy projects into financially and socially productive assets for local authorities.
- Generating a mix of revenues to the local authorities and direct to the communities (either via democratic finance models or community dividends).
- Connecting those projects to a base of investors who want to back local projects within the local authority boundaries.
- Encouraging engagement with renewable energy benefits, sustainable energy usage and efficiency behaviours.
- Designing a blended finance architecture with public debentures generating long-term (tax) revenues for the local authority and risk sharing with local authorities to de-risk investments to small investor via P2P marketplace.

The broader 'scale up' question is really about how the UK model of P2P and crowdfunding can be applied in different jurisdictions in a way that ensures investor protection with proportionate regulation of businesses and investment risks. The global picture is patchy in that respect, with the US taking its own view on P2P and crowdfunding (JOBS act) and attempts at European harmonization with the MiFID legislation/rulebook.

CASE STUDY: COMMUNITY DISTRIBUTED GENERATION

Micro-generation allows consumers to produce energy in-house or in a local community. Trading this micro-generated energy then becomes possible among consumers and 'prosumers'. Blockchain, combined with IoT metering systems and next-generation batteries, has the potential to open the energy market to prosumer via an 'energy-coin' system. Creating blockchain-enabled markets for micro-generated energy would further expand solar PV adoption on rooftops. Distributed community generation at scale creates significant resiliency to the electrical grid in the case of climatic disasters as a local Brooklyn-distributed generation implementation clearly demonstrated when hurricane Sandy hit New York in 2012. LO3 Energy start-up, in partnership with Consensys (Ethereum co-founders), is working with local utilities, community leaders and technology partners to create a market where neighbours can buy and sell the local environmental value of their energy generated, which simplifies messaging complexity and ensures that the parties cooperate over their data.

In Appendix 3, we discuss the innovation continuum in the Financing Innovations cluster. Here, we highlight two complementary breakthrough innovations that on the one hand can enable community-driven distributed generation at scale and on the other enable a renewable energy P2P investment marketplace, which together can mobilize the savings, the behaviours and the long-term investments that are necessary.

2.3.4 MARKET INTEGRITY

How to leverage fintech innovations to provide **effective and efficient financial markets with a level playing field and market integrity for long-term real economy investors** aligned with the sustainable development agenda?

On the one hand HFT, algorithmic trading, electronic front-running continue to be areas of concern for many regulators. According to Healthy Markets,[42] HFT is generally considered a valuable service in the market that is simply being driven along in a latency race by poor regulation and structural inefficiencies and incentives. The exponential increase in complexity of markets, and the resulting difficulty for investors and regulators to understand what is happening in real time compounds this problem further especially in light of the extreme volatility in financial markets from the dot-com boom and bust to the financial crisis of 2008-09, to the Euro-crisis, to Brexit. The resulting extreme short-termism of investors naturally goes against the long-term investment needs of sustainable innovations and green and resilient infrastructures outlined above. In addition, the financial instruments that are traded to conserve fragile ecosystems need a transparency and accountability breakthrough to preserve market integrity.

In Appendix 3 we discuss the innovation continuum in the Market Integrity cluster. Here we highlight two complementary breakthrough innovations that on the one hand can enable a technology-centric regulatory sandbox and on the other enables a biodiversity asset marketplace providing end-to-end transparency and accountability for conservation of fragile ecosystems. Together, they can provide a step change in the market integrity that is critical for sustainable development at scale.

CASE STUDY: TECHNOLOGY-CENTRIC REGULATORY SANDBOX

Academics, regulators and financial system practitioners have difficulty gaining access to both market data and proprietary trading data in order to study the effectiveness and efficiency markets – in particular to understand how best long-term investors can channel investment dollars towards the sustainable development agenda. As markets become electronic and more complex, they present an unprecedented opportunity for study and understanding. The Healthy Markets Research Institute is being set up to drive a far more data-driven and technology-centric approach to regulation, leading to smarter, more effective regulations by providing regulators a sandbox for sustainable fintech regulation innovations, among others. Regulators and market participants are making decisions based on incomplete data in the context of rapid technological change brought about by fintech technologies and business models. Participants can only study their own proprietary data, academics cannot share proprietary data with each other and regulators often lack the tools and resources for comprehensive and increasingly complex data analysis. Healthy Markets seeks to address these problems by building an open data repository in which non-direct access to proprietary and public data is provided to academics. This should lead to dramatically better understanding of market structure, more effective and informed market structure reforms, and more sophisticated approaches by market participants – especially long-term investors associated to the agenda of sustainable development.

CASE STUDY: BIODIVERSITY CONSERVATION EXCHANGE

Biodiversity is earth's most precious resource, a living library reflecting of billions of years of evolutionary learning. A cause of our escalating global ecological crisis is the failure to assign a monetary value to natural capital. The UN-REDD+ carbon credit scheme is well intended, but taking root slowly and needs an open, competitive market boost, if we are to prevent the rapid degradation and destruction of natural capital. The Natural Capital Alliance (NCA) has been established to protect biodiversity platforms by democratizing and increasing investment in natural capital. NCA will apply bitcoin technology to democratize investment in natural capital and to protect critical biodiversity assets such as rainforests, mangroves and coral reefs. Blockchain-enabled coloured coins that represent biodiversity assets empower issuers to digitize and monetize natural capital, by first raising capital with through an Initial Coin Offering (ICO). An issuer would first issue coloured coins and associate them with a formal or informal promise that they will redeem the coins according to terms they have defined. Coloured coins can then be stored or transferred using transactions that preserve the quantity of every asset. REDD+ coloured coin issuance incentivizes the protection of rainforest ecosystems, while mitigating atmospheric CO_2. Infinite Earth will be the pioneering issuer with its Rimba Raya Biodiversity Reserve REDD+ credits. The democratization of REDD+ investment disrupts institutional carbon brokers, who benefit from market opacity and illiquidity (with OTC bid/ask spreads as high as 400%). Furthermore, the entrance of retail investors into biodiversity markets has the potential to transform present stagnant market dynamics.

2.3.5 RISK AND RESILIENCE

How to disrupt the provision of **financial protection, risk management, risk transfer and risk diversification for the vulnerable and exposed communities, real economy assets and infrastructures and nature's ecosystems** by leveraging fintech innovations?

Technology is also changing how the industry understands risk using an explosion of data sets from space – nanosat constellations imaging the planet every two hours at 1 m resolution with multi-spectral sensors will be revolutionary for agriculture and natural resource-intensive industries – and machine/asset embedded sensors. In addition, the industry and multiple start-ups are revisiting how best to use MLAI models to better understand hazard, exposure and vulnerability analytics versus the conventional actuarial analysis using long time series alone. With increasing climate variability and accelerating climate change, continued use of traditional historical datasets and return curves is unreliable and risky. On the other hand, the rise of autonomous vehicles powered by advanced IoT sensors and MLAI, and the growing number of shared assets as part of the sharing economy will bring new challenges for the insurance sector.

In Appendix 3 we discuss the innovation continuum in the Risk and Resilience cluster. Here we highlight two complementary breakthrough innovations that on the one hand can enable an insurance innovation for the shared economy and, on the other one, that enables scaling and end-to-end transparency of smallholder farmer weather index insurance, which together can provide a step change in addressing risk and resilience considerations for sustainable development at scale.

CASE STUDY: SHARED ASSETS INSURANCE

The 'sharing economy' is an economic model where individuals are able to borrow or rent assets owned by someone else in a marketplace. The sharing economy model is most likely to be followed when assets are not fully used and their cost is high. The sharing economy has great potential to increase asset utilization and lower environmental impact in multiple sectors of the economy in both developed and developing markets. However, current insurance for automobiles or homes most often excludes shared use, even invalidating policies. For start-up founders who wish to purchase a 'gap policy' when they rent their temporary workspace, SafeShare provides temporary cover. Delivering this cover requires five parties to collaborate – the person renting the workspace, the person hiring the workspace, an orchestrator making the market, SafeShare broking the insurance, a Lloyd's underwriter underwriting the gap policy – and Z/Yen provides a blockchain solution to the broking system that simplifies messaging complexity and ensures that the parties cooperate over their data.

CASE STUDY: SCALING WEATHER INDEX INSURANCE

Smallholdings contribute 70% of global food production. However, they are severely uninsured. Cumulatively, by 2015, over 800,000 farmers in Kenya, Tanzania and Rwanda were insured by ACRE and similar vehicles (US$646 million) against a variety of weather risks. Scaling this technology would protect an estimated 1.5 billion smallholder farmers in the developing world from increasing weather volatility impact to agriculture. Climate change will impact smallholder farmers' crop yields by as much as 17% globally by 2050 relatively to a scenario of unchanged climate. Weather Index insurance (input or otherwise) has been tested and scaled in the developing world with mixed success. The combination of IoT, blockchain and AI will enable the next wave of growth of this critically important risk management capability in the developing world. Using AI to process the radio signals from mobile radio towers (IoT) to generate high-resolution weather surfaces will provide the necessary weather triggers to deploy index insurance contracts at low cost, given the widespread availability of mobile infrastructure in the developing world, in contrast to the low density of conventional weather stations available. Furthermore, index insurance contracts can be fully automated in the distributed ledger in the form of smart contracts that are visible to all, providing end-to-end transparency and accountability.

2.3.6 PERFORMANCE REPORTING AND DISCLOSURE

How best to leverage fintech innovations to **collect, analyse and distribute financial system and real economy information for better economic decision-making, better regulation and better risk management?**

As per the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) in its first report,[43] many users and providers of financial capital increasingly recognize the risks and opportunities inherent in a rapidly changing climate that fuels a high demand for science-based, contextually relevant information that can be trusted for financial decision-making. Nevertheless, users of climate-related financial disclosures commonly identify inconsistencies in disclosure practices, a lack of context for information, lack of science-based methods in the measurements and incomparable reporting as major obstacles to incorporating climate-related risks as a consideration in their investment, credit and underwriting decisions. "Enhanced quality disclosures on climate-related risks that are used by investors, creditors, and underwriters can improve market pricing and transparency and thereby reduce the potential of large, abrupt corrections in asset values that can destabilize financial markets." – TCFD April 2016 report.

In Appendix 3 we discuss the innovation continuum in the Performance Reporting and Disclosure cluster. Here we highlight three complementary breakthrough innovations that on the one hand can enable true 'measure to manage risk' capabilities of water assets and of the fishing supply chain on the other one that enables whole system early warning capabilities. Together they can provide a step change in addressing performance reporting and disclosure considerations for sustainable development at scale.

CASE STUDY: GLOBAL WATER ASSET REGISTRY AND RISK RATINGS

Leveraging petabytes of nano-satellite data with AI technologies to characterize the intra- and extra-annual variability of demand and supply drivers of the planet's water resource assets would create the water basin baselines necessary to understand fundamental biophysical risk associated to water scarcity. This breakthrough capability would then enable managing water resources sustainably for multiple uses in energy generation, agriculture, industry and critically for human consumption and for allowing for minimum ecosystem flow requirements. These baselines can then be modelled stochastically with scenarios of possible climate and resource futures to inform more realistic economic asset risk ratings of specialized rating agencies. Providing an immutable global registry of all water assets (and their risk profile) in the planet whose ecosystem services are directly related to underlying economic assets and activity would provide the transparency, auditability and end-to-end visibility required to steward these scarce natural resources in the context of ongoing urbanization processes. Start-up Space Time Analytics has been pioneering this. This would provide the basis for more sophisticated predictive risk scoring of assets and infrastructures at risk (and values at risk) in the sub-basins identified as water risk hotspots.

CASE STUDY: FINANCIAL MARKET EARLY WARNING SYSTEM

To what extent can we prevent the next financial system crises? Rather than having to deal with unpredictable black swans according to Sornette's Dragon theory, the premise is that the majority of crises are endogenous in origin and predictable. Endogenous crises arise when structural fragility builds up from, for example, accumulating risk of accelerating climate change, and a tremor grows into an avalanche. The idea is to pre-diagnose structural fragility arising from fundamental unsustainable practices of different sectors of the economy, and quickly identify emerging risks before irreversible tipping points are crossed. Dynamic sustainable finance risk maps powered by AI and network science provide the financial system cartography about systemic fault lines, and allow us to mitigate emerging risks while there is still control. Shared risk maps are mass collaboration platforms that amplify social intelligence: many eyes detect emerging risks better, and make better collective risk decisions. By democratizing access to dynamic risk maps, the hope is to build a global culture about systemic risk and enable us to more effectively protect our global commons. The democratization of risk maps would broadly benefit the financial ecosystem and its stability. It is a potential disruptor to internally developed early warning signals by major hedge funds and asset managers, who may currently derive some advantage with proprietary early risk detection. Shared maps could give rise to a diverse research ecosystem around analysing emerging signals, and improve market efficiency. Start-up Financial Network Analytics is a pioneer in this field.

CASE STUDY: FISH SUPPLY CHAIN TRACEABILITY AND TRACKING

An end-to-end fish catch documentation system enables local fishermen to provide end-to-end traceability to their customers. Accurate recording of where the fish are caught, when and by whom provides the basics of any traceability system. By combining blockchain with the IoT, individual fish can be tagged electronically. The 'smart fish' would then record any transaction where ownership changed hands or alert parties that terms of a contract may not be satisfied. Fish supply chain traceability and tracking on the blockchain would provide the fishermen with an immutable record of their catch provenance and sales revenues to enable them to obtain loans contingent on their sustainable certifications and be paid electronically and empower them to take control of their own destiny. The local communities and fishermen benefit by having permanent auditable catch records that enables them to obtain credit and reduce their reliability on third party intermediaries at much higher costs. The assessment of local fish stocks can be strictly controlled reducing the effects of overfishing.

2.4 THE KEY DEPENDENCIES AND BARRIERS TO SCALE

Figure 12 presents the FT4SD portfolio mapping the initiatives across the different levels of maturity in terms of preparedness for implementation at scale and a qualitative assessment of the remaining barriers to scaling. Note that the light blue initiatives are more mature than the conceptual ones marked in grey.

As an example of barriers for scaling, Mainelli[44] argues that in real world distributed ledgers, we typically cannot remove the need for central third parties, as these are needed to confirm identity, asset existence and legal dispute resolution. This simple but profound example is one of many barriers in real world contexts that need to be addressed to scale the FT4SD innovations we have discussed in this Chapter. For system-wide change, basic dependencies need to be met before scaling can proceed.

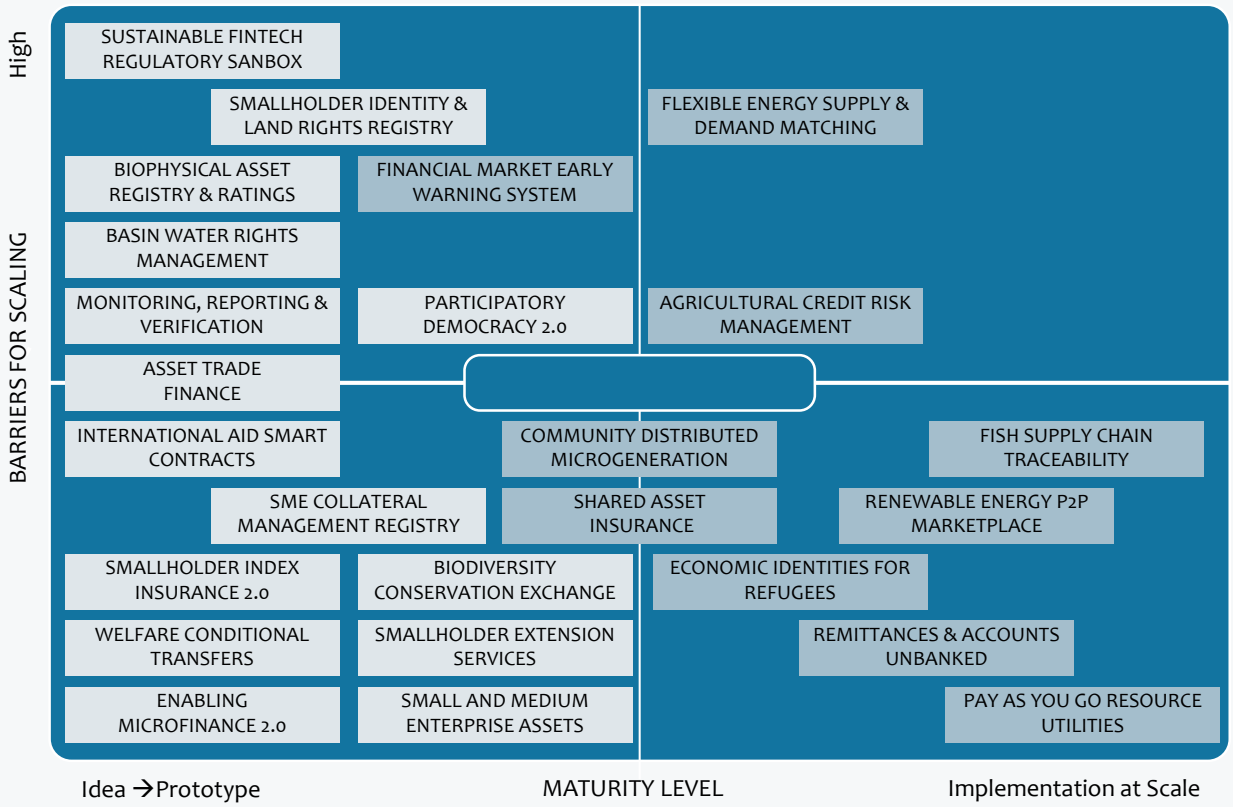
The path to adoption requires addressing six key dependencies and 11 key barriers (Figure 13). We discuss them in turn.

2.4.1 KEY DEPENDENCIES

Need for Industry-wide Standards and Network Interoperability

The absence of widely adopted standards is a key dependency. Industry-wide collaboration will be required for both open platforms (as with Bitcoin blockchain network) and for use in closed, permission-based networks that the financial industry prefers. Issues of how the standards of interoperability between different

FIGURE 12: FT4SD INNOVATION PORTFOLIO BARRIERS VS. MATURITY LEVEL



networks run different consensus protocols and deal with smart contracts will also need common agreement and governance from a diverse set of players. This takes a significant number of iterations. We should not underestimate the time and complexity represented by process, regulatory, data and technology (IoT, telecom) interoperability standards. Battles are won or lost with standards battles – remember the VHS and Betamax standard war?

System and Process Integration Challenge across Institutional Borders

Given that the Bitcoin blockchain was originally developed to support a simple data relationship (i.e. ownership of virtual currency), it cannot easily integrate with the thousands or hundreds of thousands of data relationships of ordinary business databases and processes embedded in the world's ERPs. Blockchain does not integrate with existent business workflows. Integration with existing non-blockchain systems (such as risk management platforms in financial institutions and ERPs in industrial organizations) will continue to be a significant dependency for the foreseeable future. Figure 14 highlights the complexity involved from the point of view of both level technology and process change required in the exchanging value function.

System-wide Coordination Barriers

Significant effort is needed to coordinate the right sequence to adopt new system-wide protocols, regulations, technology and process change across a network of institutions and practices. Multiparty coordination master planning is needed to define how different innovation components will be applied, by whom, in what sequence, with what contingency plans and with what success metrics – this a major system-wide coordination challenge that can dramatically slow down adoption. Technological innovation adopted in isolation does not provide institutions with a competitive advantage, since the value of the innovation is a function of the number of institutions in the network. Instead, a coordinated and agreed adoption of a major standard is required.

Migration Away from IT Infrastructure Legacy

Given the existence of current complex IT infrastructure within any medium-sized and large financial or non-financial organization, the costs of replacing existing

FIGURE 13: FT4SD KEY DEPENDENCIES AND BARRIERS TO SCALING

technology with new blockchain investment will be high and not necessarily cost-effective.

Broadband Connectivity Requirements

Adoption of pervasive broadband connectivity depends on many factors, particularly in the developing world. This can cause incomplete data collection of IoT sensor networks that enable low-cost weather index insurance for example – creating difficulties for thorough spatial analysis of crop damage and render an insurance policy useless. A number of significant communication satellites, high altitude drone (Facebook) and high-altitude balloon (Google) innovations are currently being tested. Figure 15 presents the nature of the challenge quantitatively.

Enabling (Pseudo)-Anonymity

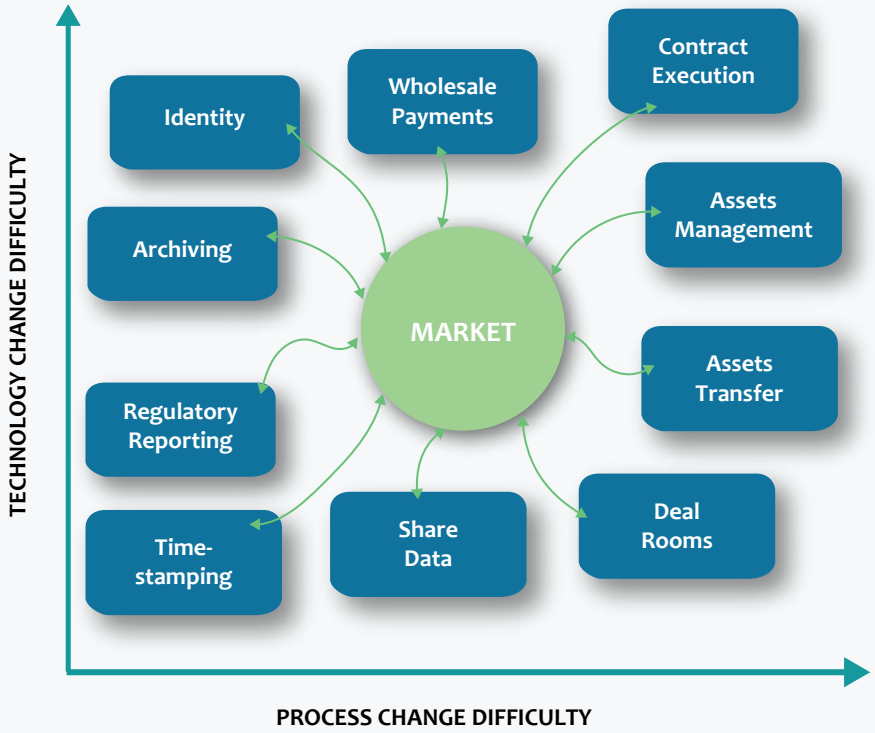
Anonymity or pseudo-anonymity is a critical requirement for many processes in the financial system. Advanced cryptographic techniques could go a long way towards protecting anonymity in a blockchain. But above all these considerations is the question of how to link cryptographic identities to real world identities for KYC and AML regulations. In addition, regulators are likely to require more granular views of data in the blockchain in order to perform real-time market surveillance and predictive early warning activities.

2.4.2 KEY BARRIERS

Regulatory Barriers

Disrupters in other industries have adopted an 'act first, seek forgiveness later' approach to regulation. Innovations in financial markets typically require the explicit blessing of regulators ex ante in most countries. New regulatory principles may be needed where blockchain technologies become an integral part of both the financial system and the real economy, and where consensus protocols are run through an international network

FIGURE 14: TECHNOLOGY CHANGE VS. PROCESS CHANGE DIFFICULTY IN EXCHANGING VALUE



Source: Mainelli, P. (2016)

of nodes. This is a form of market failure and new policies may be required to promote technological innovation. In addition, 'hands-off' cross-regulatory regimes in telecom/IT industries, natural resources and accounting may need to be revisited to implement an innovation (e.g. enabling M-Kopa in Africa). Regulatory sandboxes will be a must-have to deal with this complex barrier.[45]

In addition, numerous policy issues crop up when scaling: digital identity, cross border standards and integrity of systems are nearly always atop the lists. A single digital identity passport authorizer for KML and AML will be key. How these initiatives work across borders is equally a large issue to resolve. Solving for provisioning economic identities for refugees and the extreme poor will need to be at the top of the agenda.

High Energy Bitcoin Network Consensus Cost

High and escalating costs of reaching consensus in bitcoin-like networks will be a barrier for adoption, in particular given the large energy footprint[46,47,48] of bitcoin mining operations, which are currently estimated to be as large as Ireland's total yearly consumption. One study suggests that to encrypt all permutations for the citizens in Germany and the spectrum of bank products used in that country would cost more energy annually than that produced by the country as a whole. This is worrisome, as the bitcoin network is small relative to the size of the financial system and the real economy globally.

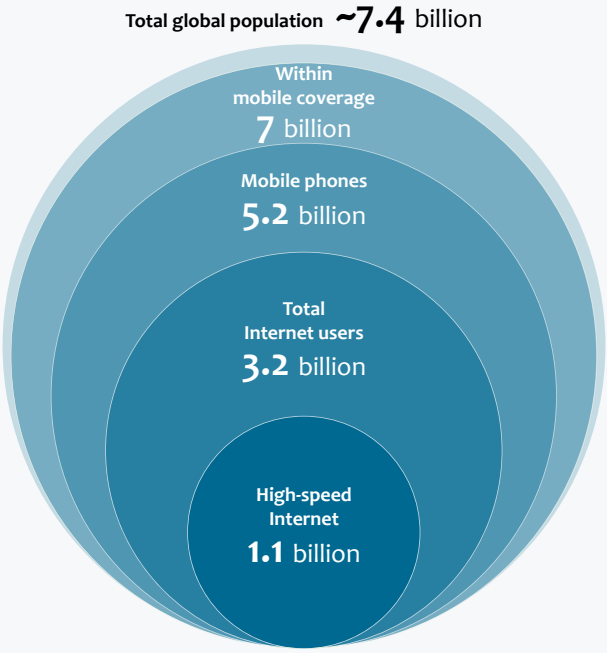
Requirement of a Validation Network

The distributed ledger innovations discussed in Chapter 1 can only be expected realistically to replace two of the three key functions of the trusted third party: safeguarding against fraudulent transactions and preserving an immutable public record of transactions. Distributed ledgers do not fully substitute for confirming the existence of the asset to be exchanged, and the rights of those participating in the transaction. A 'validation or trusted notary function' is in the main always still required. In other words: the Internet of Trust still requires a degree of conventional and trusted validation.

Scalability of Blockchain and Technology Robustness

In terms of scalability, the bitcoin network's original block size limit of 1MB is limiting for financial system scale applications. Current processing time of bitcoin transactions takes 10 minutes on average – this is fine for many applications but not for others. Questions over the scalability and throughput capacity for blockchains

FIGURE 15: GLOBAL BROADBAND PENETRATION CHALLENGE



Source: The World Bank (2016)

– which will need to be orders of magnitude larger – must be addressed (10 transactions per second versus Visa's 40,000 transactions per second). Moreover, for blockchains to become mainstream in industrial and financial system scale applications, very high standards set for scalability, security, robustness and performance must be set by policymakers and public/private institutions alike. Scalability has limits across network bandwidth, storage and even processing power. In the limit, for blockchain-enabled infrastructure to move forward, it needs to offer a more efficient and scalable solutions over the current infrastructure.

Operational Transition Risks

Operational risks come into play through the adoption of new technologies, especially from large single event migrations (e.g. Y2K systems migration in 2000). A significant amount of work will need to go into ensuring that these operational risks are minimized and contingency plans are in place. The risk of technical failure during implementation will require participants to be able to recover quickly, or be able to revert to the traditional ecosystem of market infrastructures, technologies and processes, as a risk mitigation fallback.

Immutability Barriers

Blockchain transactions are considered immutable. The ability to cancel or correct a transaction is not supported in today's blockchain platforms. This not only applies to financial institutions but to real asset registries that are being rolled out: if a fraudulent land right gets duly registered in the blockchain, then it cannot be reversed. Also, EU regulations have imposed the 'right to be forgotten' under special circumstances.[49]

Incumbent Business Model Risks

The business models of numerous institutions (of the financial system and the real economy) are potentially threatened by the introduction of shared and immutable records of ownership and transactions. The industry may need to completely rethink its industry-wide market infrastructures in order for more participants to distribute more products to more people including the unbanked and underbanked, shifting from limited participation with relatively high margins to more competitive, much higher scale and very low margin. In this context 'open data' is not typically a priority for both incumbent financial institutions and real economy players, even though improving the efficiency of intermediation in financial markets should benefit all in the long run.[50]

Security, Privacy and Resilience to Cyber Attack

Bitcoin 'wallets' have proven vulnerable to theft, but in contrast the bitcoin network itself has remained secure, though in theory it could become vulnerable if over 51% of 'bitcoin mining' fell into the hands of a single malevolent

organization. The opportunity for blockchain to provide greater security is indeed possible, particularly in the context of the exponential increase in cybersecurity risks the world over (e.g. the recent SWIFT breach of the central bank of Bangladesh). The risks will be particularly acute if you consider the exponential increase of the 20-100 billion connected devices expected by 2020 and therefore highly hackable, not to mention the frightening scenarios of autonomous planes, ships, submarines, cars and trucks being hacked while in motion.

Cost Sharing across Network

Banks will need to share infrastructure build-out costs equitably if new systems are to be truly inter-operable industry utilities. This is potentially subject to organizational disputes, which can result in free riders or never-ending battles of equitable allocation of costs among participants by revenues or market share. The alternative is clubs to build-out the industry-wide market infrastructures via industry consortiums such as R3.

Governance of the Network

Dealing with network governance issues will be key to answer such questions as: 1) who will pay for what when and how; 2) who admits new participants to the blockchain with KYC/AML approvals in a permissioned system; 3) who validates any given transaction; and 4) who determines who sees which transactions and with what granularity, etc.

Legality of Smart Contracts

For smart contracts to be useful at scale, 'technical code' and legal code need interoperability, which in many jurisdictions is a not straightforward as it requires a multi-disciplinary approach to design, formulation and legal validity of smart contract deployments at scale. Furthermore, 'technical code' itself could enable significant fraud as the recent DAO hard fork recently illustrates.[51]

2.5 THE UNINTENDED CONSEQUENCES

Our ability to foresee the unintended consequences is not always on par with our ability to foresee the positive impacts of system change innovations.

We posit that fintech has multiple unintended consequences in many areas. Its rapid development has raised policy questions about proper regulation and supervision. But typically financial system regulators concentrate their efforts on financial stability and not around fintech's many unintended consequences spanning various areas, which are often the purview of other sectoral regulators in the telecom/IT and in the natural resources arenas.

One well-known example of the failure to deliver of a promising "revolutionary technology" is the electronic medical record (EMR) in the US that was once hailed as a revolution in medicine. A recent MIT study[52] explains this failure as a direct consequence of the end-buyer of the technology being the CFO and therefore EMRs were optimized for financial reporting instead of the original intent and revolutionary promise of significantly improving health outcomes.

We will next discuss 15 unintended consequences that can be grouped into eight structural and seven transitional types (Figure 16).

2.5.1 STRUCTURAL CONSEQUENCES

Cryptocurrency Outsized Energy Footprint

Malmo[53] highlighted a widely circulated but difficult to verify figure that the Bitcoin network consumes around 250 MW to 500 MW around the clock. From this he worked out that each bitcoin transaction uses about the same amount of electricity for validation as is required to power the average American home for 1.5 days. Previously, a study[54] concluded that the entire bitcoin mining network is on a par with Ireland for electricity consumption. If confirmed, these figures pose significant questions about long-term sustainability in environmental terms, particularly if you consider applying bitcoin-like networks at financial system scale versus their total market value today at about US$7 billion (a drop in the financial system ocean).

Ownership and Governance of Use of Data

The ownership of digital data has been a problem for almost two decades now. The US Digital Millennium Copyright Act has important consequences, as one of the key implications is that you may not have access to content that you created on devices you own.[55] Uncertainty also exists around ownership of customer data and what is considered appropriate use of this information. For example, the line between enhanced risk analysis and use of data to deny service to a particular customer must be defined. In contrast to paper

cash, electronic transfers leave a trail that can aid law enforcement positively but also create unintended uses for malicious purposes.

Cashless Society Provides Backdoors to Privacy and Control

Unmonitored resources like cash create privacy opportunities for criminals. But in a cashless virtual currency society it would be possible for intrusive government authorities to decide what you can buy, rent or whom you can pay. WikiLeaks was founded through credit card donations until a financial blockade against the organization was mounted through traditional payments rails like Visa and MasterCard. As paper money disappears, financial censorship could become pervasive, via payments systems, back doors to the smartphones and other devices or even through new surveillance innovations.

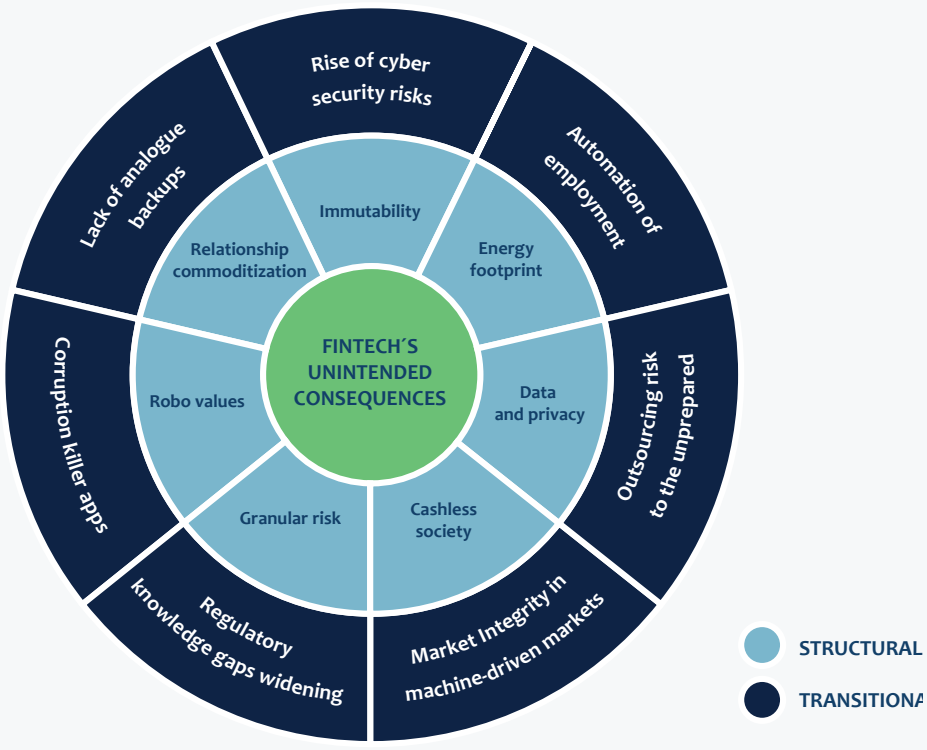
Too High a Granular Risk May Make High Risk Communities Uninsurable

Because of the lack of granular risk information historically, insurers have created a risk-sharing environment where pools of risk are the norm. But with big data, MLAI and IoT, insurers will gain a more granular risk assessment of micro-segments of risk transfer in their markets. When insurers can buy data from medical and health device providers about activities and exposure of their individual clients, the risk of a person or a population becoming uninsurable becomes real. Someone with a genetic marker for a specific cancer may find themselves in a situation where they will not be able to find an insurance policy to cover their most expensive costs. This scenario also applies to biophysical risks of climate change impacts in cities, energy and water resource provisioning and in agriculture.

Provisioning Cognitive Layer of Robo-advisers with an 'Unsustainable Investment Value System'

As Brett Scott put it: "When you talk to the robots you are actually talking to their bosses as they need to be programmed."[56] With the rise of robo-advisers, you effectively outsource your decision-making to robo-advisers as they deal with your information, risk aversion level and the available markets opportunities. As they become ubiquitous and a primary interface, clients may forget that they have embedded a 'value system' that may not correspond to their own (e.g. not investing in fossil fuel assets versus renewable energy portfolios). With human financial advisers, if the bank wanted to direct the investments to a specific fund, it would have to disclose the strategy. With robo-advisers, the strategy only needs to be coded into the algorithm and all the clients would be directed to the bank's strategy

FIGURE 16: FINTECH'S UNINTENDED CONSEQUENCES



without even realizing it. This may cause an unintended consequence of coding to invest in sectors of the economy that are not sustainable and may contribute to the increasing climatic risk, thereby ignoring long-term investment decisions in the new energy system or other innovations that require a long-term investor mindset consistent with the sustainable development agenda.

Fintech Commoditization Destroying Relationships

When a customer cannot or will not understand the difference between similar competing professional services, then price becomes the only deciding factor. And when price is the only deciding factor, competitive bidding destroys long-established relationships. The commoditization of finance, the rupture of trust between clients and the financial system and the race for the cheapest price, the fastest transaction, and the shortest process may have the impact to destroy long-established relationships. If money can be framed in the context of social relationships, what are the impacts of a digital finance system that does not rely on any kind of durable social relationships?

KYC/AML Compliance on the Blockchain May Aid State Surveillance Efforts

The Know Your Customer (KYC) and Anti-Money Laundering (AML) laws require banks to collect and store data from their clients. But most times, you only need metadata[57] to track people using MLAI and pattern recognition techniques. Because the permission-less blockchain is potentially visible to the whole network, it is even easier to collect data and harder to maintain privacy. The KYC and AML implementations will need to undergo significant changes if the financial sector heads towards open blockchain-enabled models.

Blockchain's Immutability and the 'Right to Forget'

The combination of cheap storage and fast processors meant that remembering Internet transactions became simple and the norm. And blockchain technology, by its immutability, amplifies the good and the ugly sides of this characteristic. A business deal with a company that is later at the centre of a corruption scandal, holding to an "X-Coin" that previously belonged to a corrupt ex-business partner, would be immutable in the open ledger with significant unintended consequences. Mayer[58] argues that all data collected should be tagged with metadata defining when it should expire and be forgotten. In 2014, the European Court of Justice ruled that Internet search engines have to remove web pages when certain criteria are met. It is still early to understand the impact that the EU ruling will have.

2.5.2 TRANSITIONAL CONSEQUENCES

Alternative Sources of Finance with Unmanaged Risks

Even if alternative sources of credit are monitored appropriately, many value propositions actually shift the risk to the end consumer – where there is potential for sizeable losses to be directly incurred by average investors who may not understand the product or its associated risks. The need for consumer protection from this unintended consequence could be very significant.

Increasing Several Fold the Cyber Security Risks of Going Fully Digital

Because of KYC rules, information about clients is organized into systems that allow it to be collected and shared, becoming highly vulnerable to hackers. Adopting fintech innovations at scale enabled with 20 billion devices connected to the IoT by 2020 will increase the potential cyber risks many fold. The more financial data that is put into digital form, the more cybersecurity risks are exposed. A recent example of cyber-attacks in the financial sector involved Asian institutions through the SWIFT network. SWIFT handles more than US$6 trillion of transfers every day and has suffered at least three attempts of malicious hacking during the first five months of 2016. Fintech start-ups and non-financial institutions (e.g. Telcos) participating in finance may have a higher risk than incumbents.

Fintech AI-driven Automation Will Create Significant Unemployment

In a study published in 2013, Frey and Osborne argued that the 'machine age' may place 47% of the US work force at risk of unemployment over a decade or two. They also point to a job polarization, where employment would grow in high-income cognitive and creative jobs and low-income manual occupations, but it would greatly diminish for middle-income routine and repetitive jobs. In a recent paper[59] from the OECD, the authors revisit the methodology defined by Frey and Osborne, and recalculated the "risk of automation" to only 9% for richer OECD countries. To put this in context in the financial industry, some have argued[60] that banks may face an

"Uber moment" given increasing pressure from fintech competitors to automate their higher cost infrastructures like bank branches and back offices. Citi research estimates a 30% reduction in staff between 2015 and 2025 from automation programmes in progress.

Unintended Killer Apps for Mobile Money, Bitcoin Exchanges and Distributed Autonomous Organizations

Corruption cases using M-Pesa have already surfaced in Kenya, as customers often need little in the way of identification, which makes it almost impossible for authorities to monitor. Silk Road was hidden in the so-called 'dark web' where special cryptographic tools are needed for access, allowing drug dealers and their customers to find each other. Bitcoin's Mt. Gox Bitcoin exchange was also subject to fraudulent transactions. Recently the DAO – a prominent but risky vehicle for crowdfunding blockchain applications – was hacked due to technical issues in the code.

Accelerating Regulatory Knowledge Gaps in a Techno-centric World

One widely held concern is that traditional financial regulation does not always cover fintech start-ups or, if they do, they are held to different standards, such as reduced oversight, even though they can scale up quickly and create significant unintended consequences. The counter-argument is that lighter regulation fosters innovation. M-Pesa could not have grown as quickly if Kenya's Central Bank had erected strict regulatory hurdles. In addition, because fintech regulatory models will have to involve 'technical code' that may have significant overlaps with the IT/telecom regulator mandates, there will be a growing knowledge asymmetry between the regulators and the start-ups leveraging technologies that cross boundaries in financial, technology and even real economy regulatory portfolios. This may create regulatory uncertainty and unintended consequences in ways that cannot be totally foreseen and planned for. The massive complexity of understanding and managing financial markets is a case in point.

Financial Markets Un-level Playing Fields

HFT, dark pools and the use of alternative trading platforms have garnered much media attention recently, prompting public debate around the appropriate use of trading algorithms and the actual versus perceived level of liquidity in global capital markets. Despite regulatory action taken to ensure that capital markets incorporate factors of safety and testing, this remains an area of intense scrutiny. HFT and proprietary dark pools were in fact the products of regulatory intervention. The transformation of equity trading would not have taken place without Reg-NMS in the US and MiFID in Europe creating the possibility of competition between trading venues. Recently the SEC authorized IEX with its innovative 'speed bump' as a full exchange.

Rapid Obsolescence of Mission-critical Digital Technology through the Ownership Lifecycle

Banking and their legacy systems are running the risk of obsolescence with the growth of fintech solutions, but what is going to happen when a whole sector of digital finance becomes obsolete without an analogue backup? On May 2016, Google's Nest IoT home device business discontinued the service of one of their acquired products, an automation hub called Revolv. Although some clients were still using the product, Nest decided to turn off the service. Although it only automates devices inside one's home, it uses the software hosted outside one's home. When Nest decided to stop the service they actually (unintentionally) "bricked" a device. In the era of IoT, what does it mean to actually own something? With devices where software and hardware are inextricably linked, and finance is all digital, can the software owner keep you out by ending a product life extension without an analogue backup? What if your digital wallet is no longer supported, or any device you rely on for your financial digital transactions?

Chapter 3

3.1 MAPPING THE SYSTEM CHANGE DYNAMICS

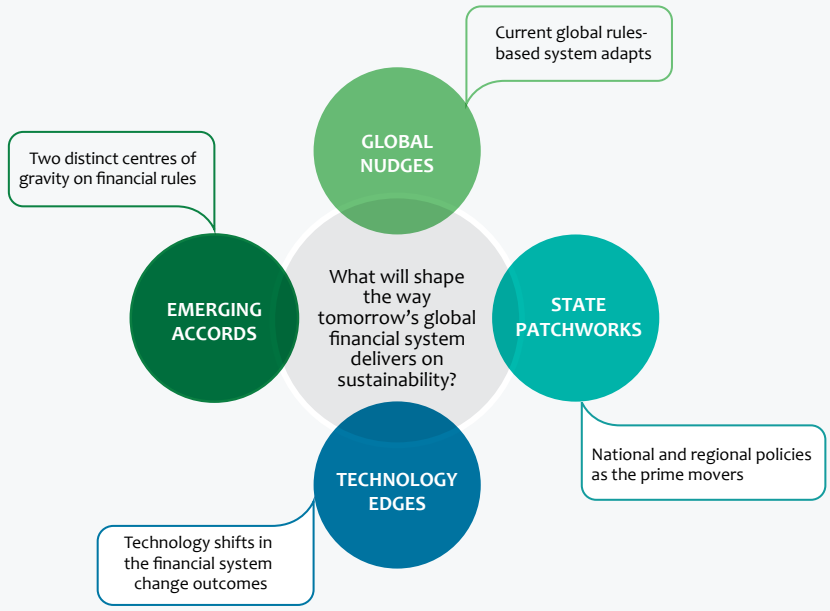
"In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it".

Jose Luis Borges On Exactitude in Science[61]

As part of the Inquiry report on the 'Financial System We Need', a number of scenario vectors were developed including one termed 'Technology Edges' (see Figure 17), which to a large extent is the lens of this report.

In the 'Technology Edges' scenario, our end-state vision considers that (to leverage advanced technologies) to mainstream sustainable development in the financial system requires developing and understanding the levers of the 'the real economy-financial systems graph' presented in Figure 18. This graph is analogous in nature to Facebook's "Social Graph" or LinkedIn's "Economic Graph", but in our case, we have an interest of mapping the interactions, and the positive and negative feedback loops between the four (excluding the social network) foundational networks linking the real economy with the financial system: natural resources and infrastructures, physical infrastructures, supply chains and the financial system networks (Figure 18). We believe that this "system of systems approach" will allow us to

FIGURE 17: UNEP INQUIRY'S "THE FINANCIAL SYSTEM WE NEED" SCENARIOS

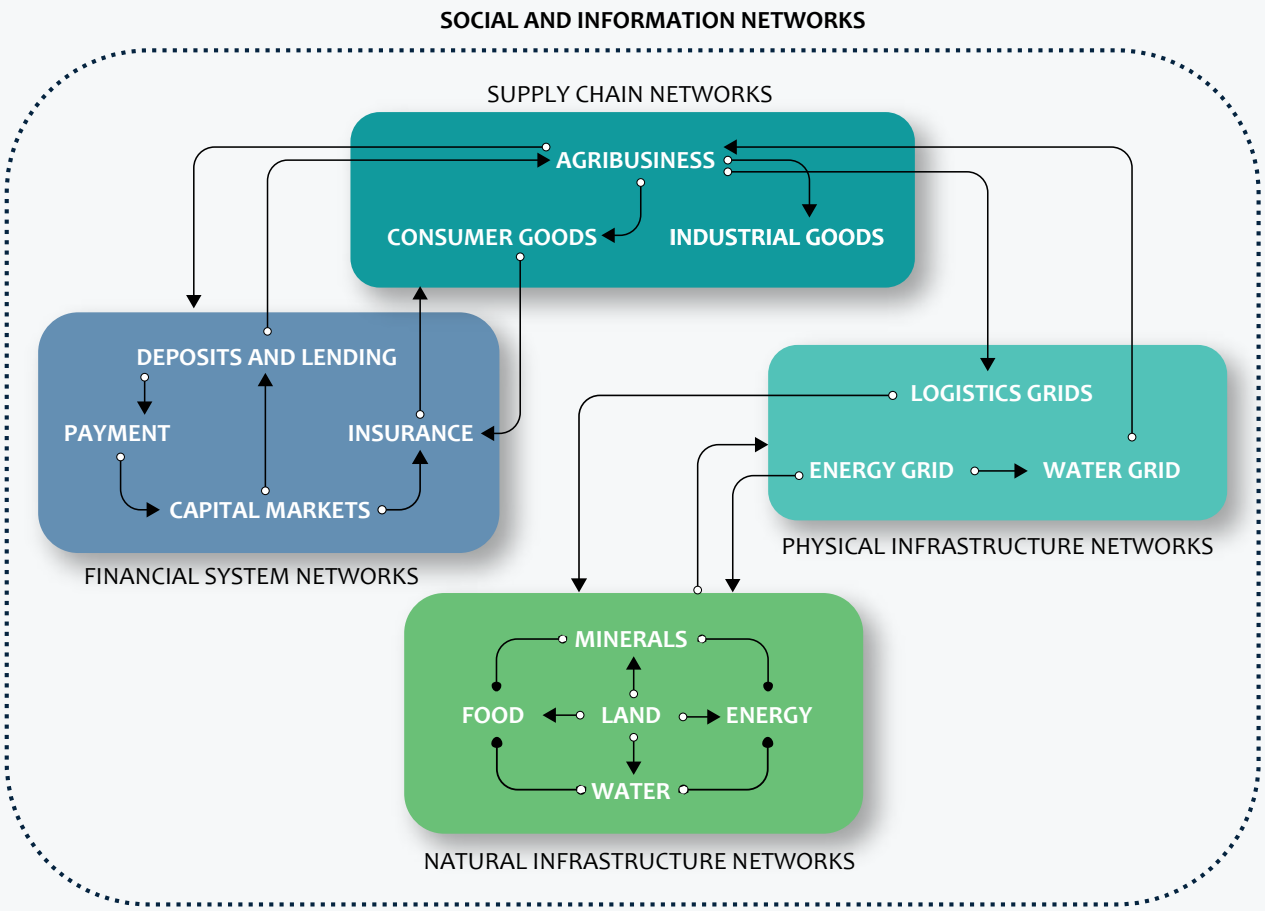


model the complex world we live in with advanced computer science disciplines in AI and network science.[62,63] If we are able to do this in time, it will allow us to understand the overall system interactions, the positive and negative feedback loops, its vulnerabilities, the overall dynamics and therefore chart our journey with more confidence. Becoming the "cartographers of FT4SD systems change" then becomes a high priority to ensure that we generate net positive outcomes.

Broad technological change enabled by fintech can in effect redefine the systems constraints and thus the location of the equilibrium points. Shocks of various origins (regulatory, novel technology ecosystems, standardization, risk instabilities, etc.) can force the equilibrium points to move over time. Thus we expect the dynamics of the system originating from a level of equilibrium, followed by a shock, followed by a new level of temporary equilibrium. Another important characteristic of this type of system fully complies with the first and second laws of thermodynamics.[64] The nature of this system change is complex, in that sometimes it is in a stable pseudo-equilibrium state but it can also be subject to complex unpredictable exponential growth and collapse – where all economic activities and financial activities are firmly grounded in the real physical world of things, physical assets and infrastructures, natural resources and natural infrastructures. In another words, attaining sustainable development outcomes will to a large extent require complying with the fundamental laws of thermodynamics.

It is beyond the scope of this report to actually model the system change that we are after – in fact we strongly recommend that a research and development initiative be carried out in this important domain as a follow-on phase to this report. The basic ingredients of such modelling effort would need to include definitions for the: a) open dynamic non-linear systems at work; b) the key real economy and financial system agents to be studied; c) explicit capture of the complex interconnected sub-networks at play with agents and their relationships; d) understanding the macro patterns that emerge from micro-behaviours and patterns; and e) the evolutionary process at work providing the novelty and the growth in order and complexity.

FIGURE 18: THE REAL ECONOMY – FINANCIAL SYSTEMS GRAPH



Source: Space Time Ventures

A case in point are the feedback loops between the financial system and the real economy whereby accelerating climate change increases the amplitude and frequency of weather extremes and in turn impacts financial assets negatively. This can occur either through a correction or elimination of the underlying financial value or by disrupting the real underlying economic activities of assets and infrastructures through higher temperatures, changed patterns of precipitation, droughts, floods, landslides or public health disasters. Dietz et al.[65] estimate that, under unabated climate change, there is a 1% chance that at least US$24 trillion will be lost. A practical example of this trend is a consequence of other synergistic negative trends, most notably the increase of climate extremes driving resource constraints and volatility coupled with stagnating productivity and real wages in an environment with massive demographic change and undesirable debt levels – creating a perfect storm for long-term saving vehicles such as funded pension schemes.

3.2 SCALE OF SYSTEM CHANGE AND POTENTIAL OUTCOMES

Irrespective of the massive complexity involved as discussed in the prior section, what can we say about the system change ahead?

The first blockchain applications emerged out of eroded trust in traditional institutions, and yet eight years later, more than 60% of the global financial system has entered into a consortium to apply blockchain to remove cost and create efficiency in their businesses. In addition, the World Economic Forum[66] Deep Shift research estimates that 10% of global gross domestic product (GDP) will be stored on blockchain technology by 2025. However, the notion that a novel fintech start-up can capture the bulk of the global financial market settlement and become the Google, Apple or Facebook of global finance, while transforming post-trade operations and earning massive profits is overly simplistic and probably just plain wrong.

Reality is distorted by the near daily announcements of new developments, new partnerships, new consortiums, new standard battles, new world-changing proofs of concept, new start-ups – all promising to change the world for the better, as well as a steady stream of news on technological improvements and their potential scalability. Ignoring the current media hype, we can safely say that all developments are nascent. Furthermore, there are no commonly accepted standards for a number of practical areas, and with multiple efforts being undertaken in the space, resolution will take time. While talk of the next big disruption and a blockchain revolution (or two) suggests that wide-scale adoption is imminent, the facts suggest otherwise. In reality, this may take longer than expected but the results will be more profound once the change is finally under way.

As Adam Ludwig argued recently to international central bankers in a joint convening by the World Bank/IMF,[67] the key blockchain innovation is that, for the first time, the "digital bearer instruments" can be created, whereby we can achieve a payment and settlement in a single step over distance, eliminating all other intermediary steps of today's market infrastructure. This is better than paper money as a bearer instrument, where control of an asset equates to owning that asset. In other words, it transforms today's complex and costly messaging infrastructure that triggers a series of steps across multiple institutions: recording, clearing, settling, reconciling, etc. into a digital bearing instrument in a single step network. Thus the concept of "money over IP" that closely mimics the convergence of multiple data, voice and video networks using the Internet Protocol (IP) that occurred in the late 1990s and early 2000s.

Governments often play a key role as inventors and/or funders at the infrastructure-building stage of new transformational innovations like the Internet (US DARPA). The end-to-end open standards principle adopted for the Internet allows for innovation at the network's edges where the tinkerers, innovators and start-up disruptors reside. By unbundling the transportation of bits from the provision of applications, innovations can be developed without permission – this is precisely what we need to reinvent our future in terms of what we need to achieve in sustainable development. Let 'thousands of FT4SD flowers bloom' is without a doubt the best strategy possible.

Government's mission-oriented policies drawing on frontier knowledge for great impact leveraging "big science deployed to meet big problems"[68] makes a huge difference. The market creation and support mechanisms that governments deploy in the future will set the odds for good, bad or even ugly scenarios. This is a major challenge that will determine the probabilities of success or failure.

If we can engineer a similar outcome for the blockchain and associated technologies as per the Internet example, we have yet to imagine the limits of what is possible. If not, then positive innovations and disruptions will be stifled and history books may see the 'FT4SD Gearbox' as a failed innovation platform. To get this right, we need to seriously consider how to govern the public-private and citizen's interests to achieve the best possible outcome for all.

We can envisage that the road ahead will involve one or multiple 'standards battles' that take us back to the famous operating system wars, the browser wars, the Betamax and VHS wars and so many other standard wars where the most common outcome is that the "winner takes all".

The FT4SD revolution we have painted in this report rests on addressing these design principles in the next 3-5 years. The questions we need to address are how best to take advantage of this short window of opportunity and what are the policies required to enabling scaling and mitigate the impacts of the unintended consequences?

3.3 POLICY RECOMMENDATIONS FOR SCALING AND MINIMIZING THE UNINTENDED CONSEQUENCES

The net impact of the FT4SD revolution will also depend on a number of policy and regulatory innovations that enable scaling and minimize fintech's unintended consequences. We will discuss them in turn (Figure 19).

Enabling 'Technical Code'

The UK Government Science Adviser[69] argues that two sets of rules or codes are involved in fintech applications. The first is the traditional code of law. The second set is broadly termed as 'technical code' and includes the set of rules that regulate how software behaves in mission-critical applications in information-intensive industries. Enabling much needed information-intensive innovations in both the financial system and in the real economy, and determining the optimum balance between legal and technical codes are going to require unusual mixes of skills, including the need for lawyers, mathematicians, cryptographers, computer scientists and a number of real economy domain experts to work together to resolve many of the key regulatory issues.

Bitcoin networks have shown that they can function without government rules. Instead, the rules that each participant follows are enforced by the open source technical code. Each participant in the network runs the same code that defines what kinds of transactions are permissible and under what circumstances. Regulators would be wise to focus more energy, investments and highly specialized human resources to be proactive and highly knowledgeable about an enabling *technical code*. 'Learning by doing' through regulatory sandboxes for technical code experimentation will be foundational in the future.

Enabling Open Data Policies

Open data platforms with a large ecosystem of developers have been shown time and time again as engines of innovation – this applies to almost any sector that is information- and content-intensive.[70] They can enable both challengers and incumbents alike to offer new products and services, pursue new business models at radical new price points and cost bases to deliver performance improvements of ten times current baselines.

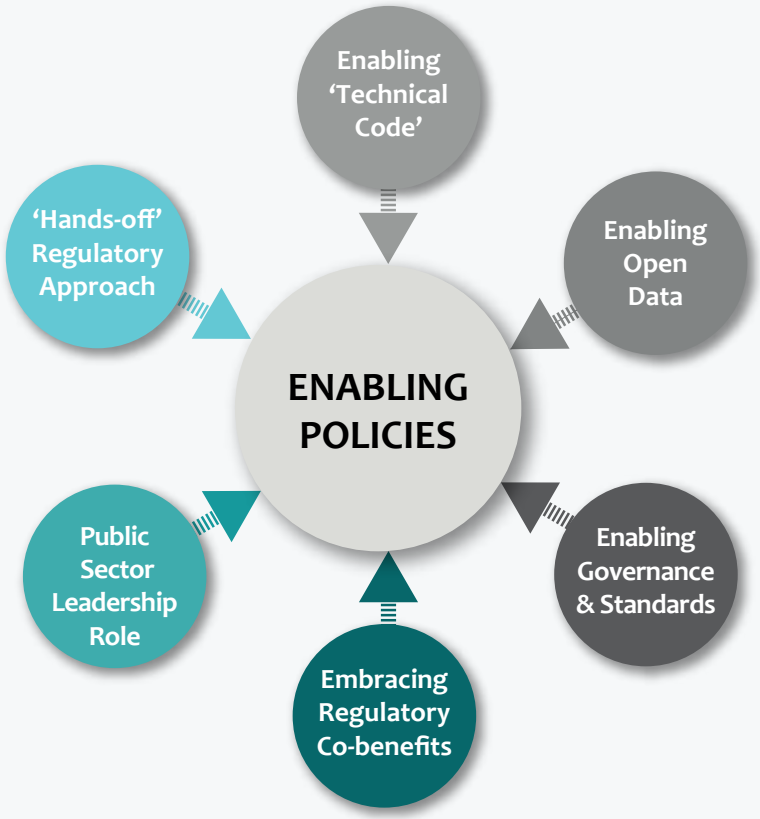
Policies Enabling Network Trust and Interoperability

In order to maximize the power of distributed ledgers, authentication and identification need to be interoperable with other systems and other blockchains. Other policies enabling agreements about data and standards interoperability will be foundational for scaling. The IoT leveraging the distributed ledger provides a case in point:[71] interoperability between different sensors and actuators of different manufacturers that in turn interoperate with a plethora of communication standards can be a nightmare if not well thought and agreed well in advance.

Enabling Policies of Embracing Blockchain Regulatory Co-benefits

The principal concern for regulators when confronted with cryptocurrencies and blockchains has been ensuring that these innovations do not undermine either prudential considerations or customer protection. Regulators are naturally cautious given the role played by lightly regulated 'shadow banking' in the global financial crisis of 2008-09. Adoption of new common data standards that are implied in enabling

FIGURE 19: FT4SD ENABLING POLICY FRAMEWORK



blockchain applications can significantly improve the cost-effectiveness of regulation as a whole. In particular, Mainelli[72] argues that persistence and pervasiveness of blockchain applications make them ideal for providing a regulator with a full and immutable transaction record for both oversight and recovery in the case of a systemically important financial institution failing, and also for promoting account portability and competition. Mandating regulatory reporting requirements on industry-wide permissioned blockchains can also lead to potentially large reductions in the compliance costs of regulatory reporting of financial institutions.

Public Sector Taking a Leadership Role

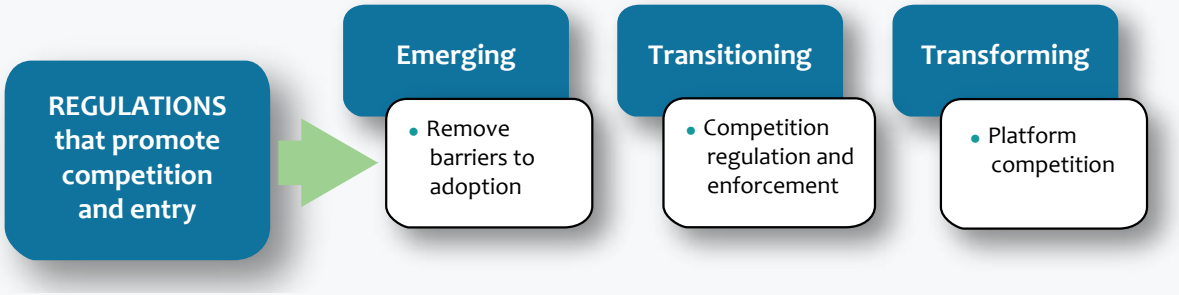
As in the past, integrating public sector demand for preferential procurement of SME products and services created significant impact, iconic blockchain pilots in the public administration that lead to aggregation of demand for blockchain for public service applications would lead the public sector exercising leadership and becoming a role model in the field.[73] Learning from Broadband Universalization Fund best practices, given the number of similar barriers may be a very fruitful.

Enabling 'Hands-off Regulatory Approach' to Market Creation and Innovation

Safaricom's M-Pesa is a well-known success story and deservingly so. It was able to grow quickly because Kenya's banking and telecom regulators initially decided to take a hands-off approach. According to the World Bank Digital Dividends[74] report, for seven years Safaricom maintained a dominant position through exclusivity agreements locking agents into the system. When maturity was reached in 2014, Kenya's Competition Authority changed the rules and opened the system to alternative mobile operators.

Where banks are strongly regulated, there are more barriers to entry and less completion leading to lower quality service, the underserved and the unserved. The World Bank proposes a framework for choosing the right approach of regulation according to the level of digital transformation of each country/sector. Their framework segments the level of digital transformation into three types: "emerging", "transitioning" and "transforming" (see Figure 20). In countries with low access to technology, the goal is to facilitate connectivity so that the focus of regulation prioritizes the removal

FIGURE 20: POLICY PRIORITIES FOR COUNTRIES THAT ARE EMERGING, TRANSITIONING OR TRANSFORMING



Source: The World Bank

of the right barriers to prepare for a competitive regulation (a clear example being abolishment of an import tax on ITC capital goods). When a country is already transitioning to a digital economy, the focus must be on increasing competition regulation and enforcement as the aforementioned M-Pesa case. With a transforming economy, there are new challenges as regulators typically struggle with transnational and dominant players like Uber and Google. How to regulate these players without hurting consumers is the main challenge for the developed economies?

3.4 IMPLEMENTATION PATHWAYS

Oliver Wyman and Euroclear[75] argue that the potential adoption paths of fintech innovations fall into three distinct categories: challengers, industry partnerships and top-down policy mandates. We concur with their analysis and that a similar approach applies for FT4SD, but modify the second category with the notion of multi-stakeholder partnerships.

Challengers (FT4SD start-ups)

FT4SD start-ups will need strong focus to increase market adoption, based on reducing customers' costs, risks, or capital consumption by at least a factor of 10-100. Anything less than this performance threshold will not overcome the main obstacle for start-ups: inertia and status quo. This is particularly challenging in a networked business such as the financial system, where the business case for any participant depends on adoption by several of its counterparties creating 'network effects'. In the experience of one of the authors, we expect to see a number of start-ups drop out of the market with failure rates that are likely to be over 95%.

Start-ups have a significant role to play in demonstrating the real possibilities of disruption, as they have no legacy or business model to defend or no revenues. Incumbents need to learn from their 'take no prisoners' approach at high speed, with a motto than can be characterized as iterations of '*do, fix, learn*' versus the more classical '*meet, discuss, plan and meet again to refine*' of incumbents.

Multi-stakeholder FT4SD Partnerships (including incumbents, FT4SD start-ups, regulators, policymakers, real economy and philanthropic players)

The multi-stakeholder approach relates to adoption by stakeholders from the public, private and public purpose sectors. Achieving consensus on the joint outcome is very time-consuming, given the different languages of the different communities (finance, technology, real economy, sustainable development, policy and philanthropy), their contribution and power in the value chain, and the benefits and costs that the partners experiment in technical, business, policy and regulatory model types.

Existing financial system incumbents are already working on using advanced fintech technologies, both for internal purposes and for working in consortiums with other participants. These consortiums are working on issues such as standards, technical protocol choices, and legal and regulatory questions. Two are notable: R3 and Hyperledger.[76] R3 offers a community or club of the world's largest financial institutions, with 50 institutions actively involved and growing every month. Hyperledger is managed under the auspices of the world-renowned Linux Foundation, which successfully stewarded the open software movement around the world with huge success. Engaging with both R3 and Hyperledger in the future will be key for the scaling of our FT4SD innovation portfolio going forward.

Top-Down Mandated or Policy-driven FT4SD Innovation

In the blockchain-enabled FT4SD universe, top-down regulatory mandates are unlikely to achieve the positive impact we need. These, however, will be necessary to create the enabling environments for blockchain-enabled value propositions that can be prototyped and proven at scale. In the short term, innovative central bank innovators are planning to provide regulatory grade data to incubate RegTech start-up hubs for their own purpose.[77] This is a good move from leading-edge regulators that prefer to co-develop innovations and explore the possibilities (both good and bad), rather than wait to see what evolves and then try to regulate the innovations.

3.5 MAKING IT HAPPEN: FT4SD INNOVATION ENABLERS

Notwithstanding these reflections and irrespective of adoption pathways, we can envision that the key steps in the FT4SD innovation journey (Figure 21) will be:

1. Convening the multi-stakeholder platform to jointly develop the standards required
2. Co-developing the multiple FT4SD ecosystem-wide pathways for system-wide change
3. Envisioning and co-designing FT4SD innovations
4. Rapidly developing FT4SD prototypes and embracing agile "do, fix, learn" cycles
5. Bring VC performance management rigour to FT4SD start-ups and multi-stakeholder initiatives alike

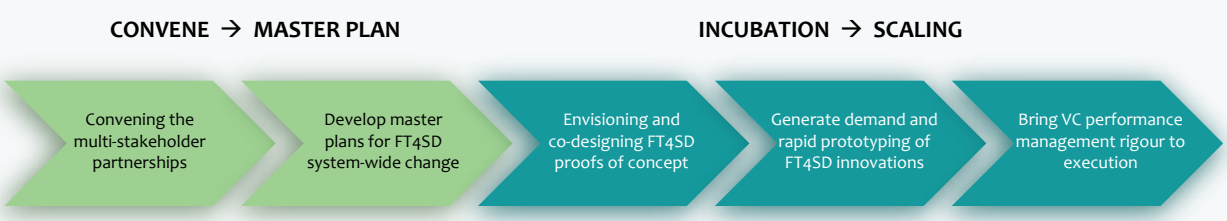
There are at least three potentially complementary "how to" models to accelerate the development of FT4SD innovations learning from one of the authors' recent experience with similar system-change:[78]

Step 1: Creating a FT4SD challenge fund – this challenge fund would be similar in nature to the Longitude and X-Prizes that seek a select number of jurisdictions or initiatives that are either piloting pioneering initiatives or are ready to embark on the FT4SD journey. The fund would provide them with the design, technical support and funding to develop implementable pilot plans. It would also create a global community of purpose that can pilot and create investment-grade, replicable partnerships and solutions. This is an area where a visionary philanthropic foundation can shape a catalytic system change.

Step 2: Setting up regional FT4SD innovation incubators for multi-stakeholder partnerships – these would use design-centric rapid prototyping methodologies developed in social innovation labs and in technology start-ups around the world. Governments, international development partners, NGOs, scientific organizations, private sector companies, central bank regulators, FT4SD start-ups, philanthropic organizations and incumbent financial institutions can convene place-specific and time-bound "co-creation labs" with the objective of designing the specific FT4SD capabilities needed on the ground across different regional realities.

Step 3: Raising FT4SD VC and social impact funds – FT4SD VC and social impact funds can bring on board the high impact multi-stakeholder partnerships incubated in Step 2 above to fund the scaling of FT4SD innovations by selecting jurisdictions for deploying their resources. They would then recover the initial investments through participation in successful FT4SD start-ups and/or initiatives. A VC-type model of performance based funding will be at the core of the design to insure impact and scalability.

FIGURE 21: THE FT4SD JOURNEY AHEAD



APPENDIX 1: DEFINITIONS

FUNDAMENTAL DEFINITIONS IN THE BLOCKCHAIN WORLD

As the UK Government Science Office[79] argues, formal definitions are unlikely to satisfy all parties. Here we present their definitions of key terms which we believe provide good descriptors:

"A **block chain** is a type of database that takes a number of records and puts them in a block (rather like collating them on to a single sheet of paper). Each block is then 'chained' to the next block, using a cryptographic signature. This allows block chains to be used like a **ledger**, which can be shared and corroborated by anyone with the appropriate permissions.

There are many ways to corroborate the accuracy of a ledger, but they are broadly known as **consensus** (the term 'mining' is used for a variant of this process in the cryptocurrency Bitcoin). If participants in that process are preselected, the ledger is **permissioned**. If the process is open to everyone, the ledger is **unpermissioned**.

Unpermissioned ledgers such as Bitcoin have no single owner — indeed, they cannot be owned. The purpose of an unpermissioned ledger is to allow anyone to contribute data to the ledger and for everyone in possession of the ledger to have identical copies.

Permissioned ledgers may have one or many owners. When a new record is added, the ledger's integrity is checked by a limited consensus process. This is carried out by trusted actors — government departments or banks, for example — which makes maintaining a shared record much simpler that the consensus process used by unpermissioned ledgers.

Distributed ledgers are a type of database that is spread across multiple sites, countries or institutions, and is typically public. Records are stored one after the other in a continuous ledger, rather than sorted into blocks, but they can only be added when the participants reach a quorum.

A **shared ledger** typically refers to any database and application that is shared by an industry or private consortium, or that is open to the public. A shared ledger may use a distributed ledger or block chain as its underlying database, but will often layer on permissions for different types of users. As such, 'shared ledger' represents a spectrum of possible ledger or database designs that are permissioned at some level. An industry's shared ledger may have a limited number of fixed validators who are trusted to maintain the ledger, which can offer significant benefits.

Smart contracts are contracts whose terms are recorded in a computer language instead of legal language. Smart contracts can be automatically executed by a computing system, such as a suitable distributed ledger system. The potential benefits of smart contracts include low contracting, enforcement, and compliance costs; consequently it becomes economically viable to form contracts over numerous low-value transactions. The potential risks include a reliance on the computing system that executes the contract."

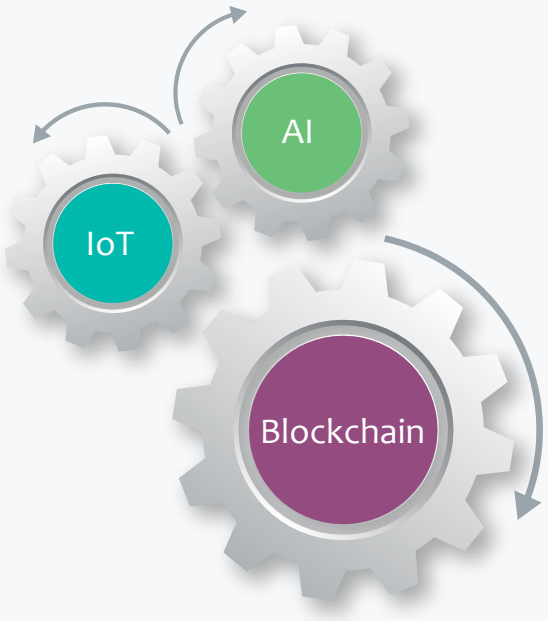
ALTERNATIVE USEFUL DEFINITION OF 'BLOCKCHAIN'

Another useful perspective from Mainelli[80] goes as follows: "A **ledger** is a record of transactions; **distributed** means divided among several or many, in multiple locations; **mutual** is shared in common, or owned by a community; a **mutual distributed ledger** (MDL) is a record of transactions shared in common and stored in multiple locations; and a mutual distributed ledger technology is a technology that provides an immutable record of transactions shared in common and stored in multiple locations".

APPENDIX 2: ADVANCED FT4SD GEARBOX

Among the innovations associated with FT4SD are a more ubiquitous and mobile Internet, cloud and social technologies. However the major jump of potential impact is driven by a "FT4SD gearbox or platform" (Figure 22) combining MLAI, the IoT and blockchain (Internet of Trust) technologies. We describe each of these fundamental 'gears' and note that in the main report we make the case of the 'what' and the 'how' of this highly valuable combination.

FIGURE 22: THE FT4SD GEARBOX



BLOCKCHAIN AND CRYPTOGRAPHIC CURRENCIES (BCC)

The history of bitcoin and the blockchain led by the Cypherpunk movement, culminating in Satoshi Nakamoto's paper in 2008,[81] provides an impetus for that type of radical innovation that is needed to address the sustainable development agenda head-on and at scale:

"The traditional banking model achieves a level of privacy by limiting access to information to the parties involved and the trusted third party. The necessity to announce all transactions publicly precludes this method, but privacy can still be maintained by breaking the flow of information in another place: by keeping public keys anonymous. The public can see that someone is sending an amount to someone else, but without information linking the transaction to anyone. This is similar to the level of information released by stock exchanges, where the time and size of individual trades, the 'tape', is made public, but without telling who the parties were." Satoshi Nakamoto, 2008

The blockchain innovation disruptions that stand in front of us[82] are in a large part due to these highly creative and skilled libertarian technologists in the wake of the financial crisis of 2008-09, when trust in the financial system was severely eroded.

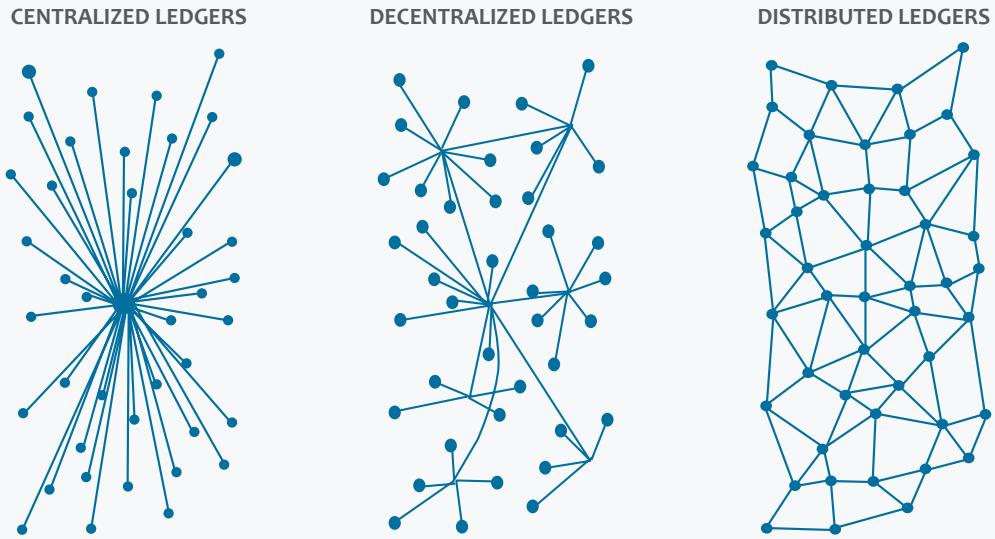
In his 2008 revolutionary paper, the elusive Satoshi Nakamoto claimed that Bitcoin, and its associated protocols, was a system of "purely peer-to-peer electronic cash", which could be sent to anybody without needing a bank's permission. A recent RAND paper[83] argued that this could provide non-state actors looking to disrupt sovereignty by

displacing state-based currencies. Also from a risk management perspective, Lloyd's[84] argued that virtual currencies need focused attention of the insurance industry for understanding and characterizing the multiple unintended.

Bitcoin's real breakthrough was to combine existing techniques in computer science consensus protocols, cryptography and game theory in revolutionary ways and to do so at a time when the idea of open source software was reaching maturity, thanks in no small measure to the Linux open source movement, and when people were in reflection mode post-financial crisis of 2008-09.

Blockchain is the underlying platform technology of the peer-to-peer digital cash Bitcoin. A decentralized network of computers following a set of protocols controls the issuance of digital cash. Given that these networks rely heavily on cryptography, Bitcoin is sometimes known as a cryptocurrency. Every participant has a copy of every transaction arranged in 'blocks', with each block being cryptographically linked to the previous block, forming a block chain. Once a transaction is sufficiently confirmed by about 7,000 'bitcoin miners' on last count, it becomes immutable and censorship resistant. The mining analogy is apt because the process of bitcoin mining is very energy intensive, as it requires large computing power to solve increasingly difficult cryptographic puzzles to reach consensus. It has been estimated that the energy requirements to run the bitcoin network in 2014 was comparable to the electricity usage of Ireland.[85]

FIGURE 23: THE ADVANTAGES/DISADVANTAGES OF LEDGER TYPES



The bitcoin network is completely 'unpermissioned', meaning 7 billion people on the planet are 'permissioned' to participate at any time if they have an Internet connection on a mobile phone. This is in contrast to conventional 'permissioned' arrangements where financial institutions make final exchange, settling bank payments with detailed checks of identity under KYC, AML and require a central ledger and central trust authorities to function.

Ledgers have been at the heart of commerce since ancient times and are used to record assets such as money, farm area, textiles, cows and beans using wood, stone or paper. Any changes to an electronic distributed ledger are reflected in all copies in minutes. The security and accuracy of these assets are maintained cryptographically.

Figure 23 maps the advantages and disadvantages of the various ledger typologies.

MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE (MLAI)

Simply put, MLAI is the use of advanced computer science to recognize patterns in data and turning that data into knowledge. AI involves multiple fields of computer science including an extension of ML where computers can make decisions or provide specific recommendations. The scope of AI that we refer to is sometimes called 'narrow AI' in that it does not include fast developments of artificial general intelligence (AGI) of deep concern to a number of policymakers of widely discussed catastrophic scenarios in the general media.

What is innovative and disruptive about MLAI is the variety of problems across all sectors of the economy it can address, including finance. Each day that passes MLAI can handle increasing complexity with larger and larger datasets with cheaper and cheaper computing resources on the cloud, and develop more generalizable AI algorithms, mostly all openly available in the Internet. The intersection of improved accessibility, rapidly expanding computing capacity as a service and the marked explosion in the availability of petabytes of data from a plethora of sensor network sources (e.g. from space based constellations of nanosats to drones to submarine ROVs) make this possible.

In complex businesses with large amounts of data, machine learning can provide insight that humans cannot usually deal with efficiently and in a timely fashion. Machines can produce insights in real time against datasets of staggering size and complexity that would take an army of people with specialized software to assist them and years or decades to perform. MLAI is already at a level where it is difficult for people to compete against a highly customized algorithm in financial markets, consumer retail, energy, agribusiness or other industries where timely of decision making are critical.

MLAI will continue to improve at breakneck speed, and it is becoming increasingly disruptive through direct impact and as an enabling building block for other innovative technologies. These disruptions occur through multiple effects, but primarily through the ability of MLAI to learn from data and make good decisions. For the first time, machines are replacing cognitive-intensive work rather than just manual labour. The result is a direct impact on the economy and in the employment of the future, and those effects are here and accelerating – these will result in very positive outcomes and others will be major risks we will need to deal with.

MLAI applications are diverse and growing by the day: from autonomous drones that require autonomous object recognition to path optimization and in-flight decision-making on the fly (literally), to financial institutions using machine learning to determine credit worthiness by learning from social and mobile 'data crumbs', to quant-based hedge funds using machine learning to assist or automate their investment analytics to ML being used in retail to analyse consumer behaviour, to optimize everything from inventory management to shelf layout, to automatically reconstructing planting lines and detecting planting failures in agriculture improving land use productivity many fold.

With enough training using large data samples, objective and quantifiable measures can be used to train the algorithms to reach and even surpass human performance and traditional technologies and methods. This was recently demonstrated with the highest complexity game that humans play: go. A few months ago the Deepmind Go[86] challenge was won by a machine against the world's top go player. This was only predicted to occur a decade from now.

INTERNET OF THINGS (IOT)

The fusion of low-cost connected sensors (Internet of Things) and AI is resulting in machine learning that automates discoveries and enables 'intelligent' computers capable of non-routine tasks.

Maybe the best example of this 'brave new world' is autonomous vehicles. Levy and Murnane (2005) argued that for years truck driving was considered a task too complex to be automated, given that a truck driver is processing a constant stream of complex sensory information from their environment. Only five years after publishing this, Google in October 2010 announced that its fleet of autonomous cars had already driven 1,000 miles on America's roads without any input from humans. Another five years from the milestone, in October 2015, the European Truck

Platooning Challenge was complete. Although all trucks had drivers as a plan B, the trucks were equipped with multiple sensors and technology that enabled them to move without the drivers. This is particularly eye-opening given that more than 50% of all transported agribusiness and manufactured goods are transported by road in Brazil.

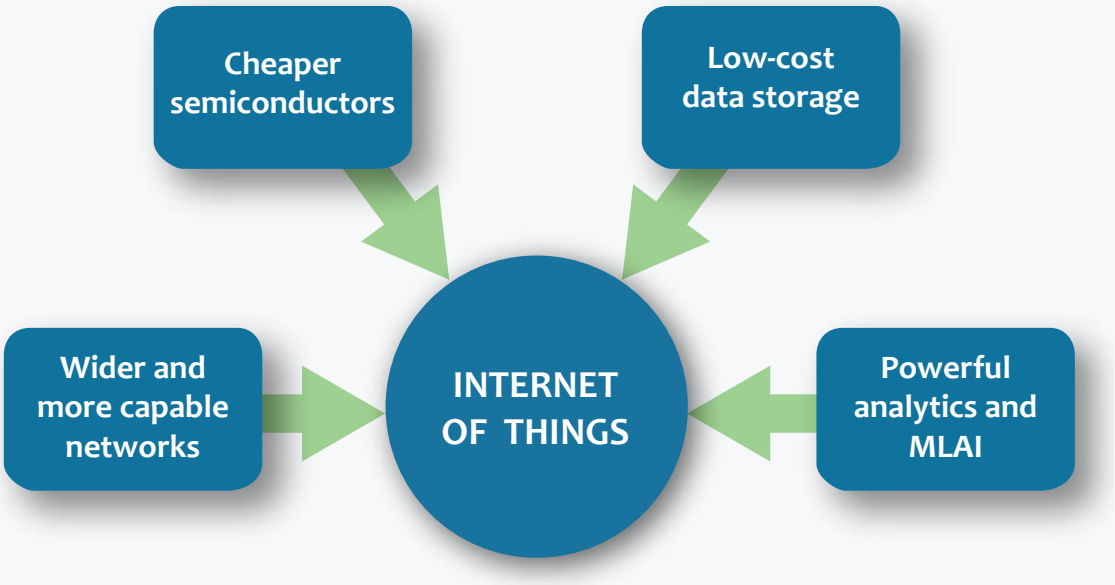
The IoT concept was coined almost 30 years ago and many of the essential components have existed for decades. The hardware part is composed of the connected devices such as sensors (on the ground, in rivers, oceans, on earth, in space), simple actuators, wearable devices and even smartphones and the networks that connect them in real time. There are a number of underlying trends driving the new IoT ecosystem that Figure 24depicts.

Many applications already exist in multiple industries. In insurance for example, preferentially pricing premiums for safer drivers has a long expertise of Progressive Insurance in the US.[87] We are reaching a tipping point where new innovative models combining blockchain and IoT are used in tandem.[88]

IoT is expected to have a large impact in areas of the real economy like transport, energy, agriculture, water, infrastructure and others – all of which are foundational to the sustainable development agenda. Already an iPhone has more processing power than NASA's Apollo 11 landing module. IoT can enable end-to-end information on supply chains in real time, providing data on the location and state of goods and supporting system-wide applications of the circular economy paradigm whereby businesses and consumers shift away from the linear take-make-dispose model of natural resource use, which relies on large quantities of easily accessible resources, and towards a "new industrial model where effective flows of materials, energy, labour and now information interact with each other and promote by design a restorative, regenerative and more productive economic system".[89]

Taken together, the McKinsey Global Institute[90] estimates that the economic value of the IoT could be as much as US$11.1 trillion per year in 2025. That is a 10% increase to the current global GDP of well over US$100 trillion.

FIGURE 24: IOT ECOSYSTEM DRIVERS



APPENDIX 3: FT4SD INNOVATION PORTFOLIO

A.1 FINANCIAL INCLUSION

A.1.1 SME Collateral Management Registry
A.1.2 Welfare Conditional Transfers
A.1.3 Remittances/Accounts for Unbanked
A.1.4 Economic Identities for Refugees
A.1.5 International Aid Smart Contracts
A.1.6 Smallholder Identity and Land Registry
A.1.7 Participative Democracy 2.0
A.1.8 Enabling Microfinance 2.0

A.2 CAPITAL FOR INFRAESTRUCTURE

A.2.1 Pay as You Go Resource Utilities
A.2.2 Flexible Energy Supply and Demand
A.2.3 Renewable Energy P2P

A.3 FINANCING INNOVATION

A.3.1 Smallholder Extension Services
A.3.2 Community Distributed Generation
A.3.3 SME Asset Trade Finance
A.3.4 SME Smart Assets

A.4 MARKET INTEGRITY

A.4.1 Financial Market Early Warning System
A.4.2 Sustainable Fintech Regulatory Sandbox
A.4.3 Biodiversity Conservation Exchange

A.5 RISK and RESILIENCE

A.5.1 Shared Asset Insurance
A.5.2 Smallholder Index Insurance 2.0
A.5.3 Basin Water Rights Management
A.5.4 Agricultural Credit Risk Management

A.6 PERFORMANCE and DISCLOUSURE

A.6.1 Water Asset Registry and Ratings
A.6.2 Fish Supply Chain Traceability
A.6.3 Climate Monitoring Reporting Verification

The FT4SD case studies are structured below using a common template for a better understanding:

- **Problem/Solution:** what are the problems and solution features?
- **Impact:** who benefits and how?
- **Leadership/Ecosystem:** change agents and partners leveraged?
- **Level of maturity and barriers for scaling:** progress-to-date and actions for scale up?

A.1 FINANCIAL INCLUSION CLUSTER

A.1.1 SME COLLATERAL MANAGEMENT REGISTRY

Problem/Solution

- 95% of the world's businesses are SMEs and their credit gap is estimated at over US$2 trillion across over 200 million businesses.
- Similar to low-income citizens, a lack of sufficient collateral serves as a limiting factor on the ability of SMEs to secure a loan, particularly in developing countries.
- According to a World Bank[91] study, 80% of all enterprise loans require collateral, which on average needs to be valued at 200% of the loan amount.
- While on the one hand, fixed property assets such as small factory buildings are usually acceptable as a form of collateral, assets in movement such as receivables or inventory frequently are not. Yet they comprise the majority of SME value that could be treated as collateral.
- A blockchain-enabled[92] collateral movable asset registry for SMEs would enable closing this significant gap for inclusive prosperity.

Impacts

- In a 2013 study of over a 100 countries by IFC,[93] those that implemented collateral registry reform saw an 8% increase in access to credit for SMEs, followed by lower costs of credit.

Leadership/Ecosystem

- Wider use of movable assets as collateral is limited by a lack of trusted, central collateral registries that currently require government support, SME organizations and funding.
- Using best practices already established by international agencies such as the IMF, SMEs could register their assets and grant access to potential lenders offering better information to make credit decisions.

Level of Maturity and Barriers for Scaling

- Early stage of development.
- Despite overwhelmingly positive benefits many countries have yet to implement collateral registries and resolve inconsistent standards exist globally.

Inputs kindly provided by David Schrier, MIT Connection Science

A.1.2. WELFARE CONDITIONAL TRANSFERS

Problem/Solution

- Novel conditional welfare transfer payment models would enable distribution of welfare support more efficiently and more effectively, improving intended poverty alleviation policy outcomes.
- Distributed ledgers can improve effectiveness and efficiency of the end-to-end processing of conditional transfers to the poor, given that a large number of welfare claimants are unbanked or underbanked.
- Through blockchain-enabled smart contracts, it would be possible to set conditionality/eligibility rules at both the recipient and originator institution ends of welfare transactions.

Impacts

- Principal impact levers are demonstrated through fraud reduction, providing an effective safety net to vulnerable citizens and improving overall effectiveness and efficiency of welfare transfers.

Leadership/Ecosystem

- Engaging the whole welfare system in a country is daunting given the multiple players, processes, legacy systems, regulations involved. Instead a priority welfare transfer service should be the focus of development, testing and rollout.

Level of Maturity and Barriers for Scaling

- Early stage of conceptual design.
- Requires education of welfare recipients.
- Requires significant process change and technology integration efforts with current legacy welfare systems and processes.

Inputs kindly provided UK Government Office for Science

A.1.3 REMITTANCE AND BANK ACCOUNTS FOR THE UNBANKED

Problem/Solution

- Remittances represent one of the largest flows of capital to developing countries. As an example, the Philippines receive US$24 billion every year in remittances, or 10% of GDP.
- Bitcoin has the potential to be used as an *intermediary* currency for *remittances*. In order to make this work, there needs to be a liquid market for both local currency-to-bitcoins, and bitcoins-to-local currency.[94] With bitcoin-enabled two-way wallets, citizens around the world can obtain a public key that represents their account in their community and internationally.
- With poor banking infrastructures pervasive in the developing world, there is a leapfrogging opportunity where Bitcoin would be the de facto infrastructure for everyday local payments with or without a bank account.
- Abra is a start-up developing a global digital asset management system on the bitcoin network, turning any smartphone into an ATM that can dispense physical cash to any other member of the peer-to-peer network or alternatively if the citizen is banked that can be accommodated as well – thus creating a payment mechanism and store of value, that may displace conventional banking system's two most essential roles: payments (and remittances) and value storage.

Impacts

- The end-to-end Abra process from the funds leaving one country to their arriving in another starting with one local currency to another local currency without FX risk at the transaction level – takes an hour rather than a week and costs 2% versus 7% or more for a typical international remittance.

Leadership/Ecosystem

- Bitcoin-enabled Abra has potential to complement, or compete with robust mobile banking applications like M-Pesa.
- Abra's goal is to turn every one of its users into a teller. Abra wants its payment network to outnumber all physical ATMs in the world. It took Western Union 150 years to get to 500,000 agents worldwide, Abra's target over the next few years.

Level of Maturity and Barriers for Scaling

- Early stage of conceptual design.
- As per the M-Pesa experience the scaling of this type of innovation will depend on primarily a 'hands-off' regulatory approach from regulators in finance and IT/Telecom. BitPesa follows a similar path in Kenya.

Inputs kindly provided by Brett Scott

A.1.4 ECONOMIC IDENTITIES FOR REFUGEES

Problem/Solution

- BanQu provides a practical, low-cost solution to a severe global crisis – extreme poverty and burgeoning refugee population. While the estimates may vary, the world has over 2 billion people living in poverty and over 65 million refugees. The majority of these global citizens are without a basic identity that legitimizes their existence in society. This lack of identity directly prevents them from breaking the cycle of poverty. Many of them die needlessly. For the millions of refugees, the problem is worse as they move across cities and across borders.
- BanQu is the first ever blockchain Economic Identity technology platform and network that enables a secure and immutable platform for creating economic opportunities for people around the world who are refugees and/or living in extreme poverty:
  - Immutable human-characteristics based (selfie) ID owned by the user who creates it.
  - Access to this identity without any need for physical documentation.
  - Ability to "tag/attach" assets or artefacts to build upon the identity. (These could be things like land rights, health records, birth registration, livestock owned, and other forms of identity such as mobile number, education records and health records).
  - Given the universal nature of the BanQu ID, global aid and NGO agencies can accept it and

legitimize the refugees (or populations they are serving) when delivering aid and services.
- The portability of the BanQu ID (since it exists on a public blockchain) enables a systematic build-up of transaction history for the refugee (and extreme poverty) populations, thereby creating a reliable profile for a path out of hardship situations.
- The blockchain technology by definition is a trust-based public ledger. BanQu has leveraged this and created a trust-network that allows BanQu users (individuals, social enterprises, aid agencies, NGOs, etc.) to connect with each other based on immutable and transparent transaction history and identities, thereby creating bankable customers.

Impacts

- The high refugee and IDP population worldwide puts enormous pressure on INGOs, the government and aid agencies to provide emergency assistance in the short term, as well as create long-term solutions to dramatically reduce this number. Moreover, a significant number "'fall through the cracks' while others receive duplicate services.

1. *Formalize trust-networks:* BanQu technology will be used in partnership with in-country NGOs, INGOs, social enterprises and local businesses to leverage philanthropy and diaspora capital for a true 'investment' path into fragile economies.
2. *Connect citizens:* BanQu allows for the connection of any citizen, anywhere in the world to the economic ecosystem allowing trade, growth, and long-term viability in interacting with the entire world. This is extremely relevant with regards to refugee populations that are trying to connect with their loved ones while on the move.
3. *Aid delivery/rapid deployment/provide emergency identities:* We avoid redundancy and derive big data insights measuring the results of investment effort by delivering, tracking and managing aid through the same ecosystem. Additionally, this allows states to more easily identify/track refugees and know who they are, what they own and their position in the global marketplace in crisis situations.

Level of Maturity and Barriers for Scaling

- Goal is adoption of 500,000 refugees by end of 2016 and 2 million by end of 2017.

Inputs kindly provided by BanQu Founder and CEO Ashish Gadnis

A.1.5 INTERNATIONAL AID SMART CONTRACTS

Problem/Solution

- Goal is to allow international donors to issue 'international aid coins'[95] by solving the double-spend problem.
- International donors could take advantage of the distributed ledger's ability to offer reliable and irreversible transfers of aid funding.
- Conditionality coded into the aid coins in the form of smart contracts could prevent them from being spent on items not deemed appropriate within the international aid context.

Impacts

- Providing transparency, accountability and traceability of funds ensures money is bein well spent.
- The immutable ledger of the flow of funds compels large institutions, from aid groups to governments, to act with integrity and fulfil their commitments.
- The funds for major projects could go into escrow and be released only after the successful completion of key milestones, resulting in radically improved transparency and accountability in the delivery of foreign aid.

Leadership/Ecosystem

- International donors need to maintain a relationship and agreed practices/protocols with the host governments.

Level of Maturity and Barriers for Scaling

- Early concept testing.
- Converting distributed ledgers into usable services of this nature requires the creation of a whole range of complementary capabilities.

Inputs kindly provided by UK Government Office for Science and by Vinay Gupta, Ethereum

A.1.6 SMALLHOLDER IDENTITY AND LAND REGISTRY

Problem/Solution

- Formalizing the informal economy in the developing world needs hard work of surveying and confirming citizen's property and identity. The information, when processed, resides in either paper records or in outdated proprietary databases which makes it very difficult to keep track of changes. These methods are prone to abuse and pervasive corruption in property registry, land sales and dispute resolution.
- A land rights registry on the blockchain would provide an immutable distributed ledger.
- It is no panacea, however, if the registration is fraudulent; that fraud will also be immutable and impossible to reverse.

Impacts

- According to Hernando de Soto of Peru's Instituto Libertad y Democracia (ILD),[96] the absence of formal title to property creates US$10 trillion in "dead capital" in the world economy – this is made up of all the houses, small business assets and other property for which low-income citizens are owners, but lack formal documentation.
- Immutable registers of property rights would dramatically free up the potential for transactions, which then would drive economic activity leading to a global growth of 8%, according to ILD estimates.

Leadership/Ecosystem

- In countries where corruption is rampant, blockchain-enabled registries offer a reliable alternative to current registries. However, the notary function of validation is still required and must be provided by a trusted authority.
- The Government of Honduras has the vision to record the government's land titles on a blockchain ledger in partnership with fintech start-up Factom.[97] The actual implementation is extremely hard as it involves much more than technology: enabling regulations, changing processes, entrenched power networks, to mention just a few. Multiple other pilots are under way.

Level of Maturity and Barriers for Scaling

- Early stage of development.
- Strong leadership at various levels of government is required to push ahead with the major cultural, process and regulatory change that is involved in trustworthy registry programmes like this.

Inputs kindly provided by Peter Kirby, Factom

A.1.7 PARTICIPATIVE DEMOCRACY 2.0

Problem/Solution

- Over time, effective and efficient resource allocation by governments across citizen programmes to address their pains and unmet needs has suffered, leading to disengagement from democratic processes and an explosion of popular movements demanding change.
- Blockchain applications generate next incarnation of e-governance platforms enabling better voting (Neutral Voting Bloc), participative budgeting (Major's Chain) and other central and local government services (BitNation).[98]

Impacts

- Reduction of error and fraud in government-mediated services to citizens and businesses.
- Reduction of widespread political contribution corruption around the world – if political contributions enabled on the blockchain.
- May provide an improvement to prior efforts of democratic governance online where uptake and greater citizen engagement did not materialize as planned for.

Leadership/Ecosystem

- Central and local government blockchain czars have been discussed as a way to signal top leadership requirements for organizations to undergo massive technology-, process- and people-related transformations implied.

Level of Maturity and Barriers for Scaling

- Early stage of conceptual design.

A.1.8 ENABLING MICROFINANCE 2.0

Problem/Solution

- The goal of traditional microfinance institutions[99] is to empower individuals to save, invest and build small businesses. When implemented and managed properly, microfinance institutions can deliver a real benefit to struggling communities increasing savings and investment with a special focus on empowering women.
- Provides an opportunity to increase oversight of some MFI institutions to avoid predatory loan practices that strain communities and ensure that the funds end up fulfilling the mandate of the MFI and their social impact investors.
- A Microfinance 2.0 programme would record the microloans in the permissionless blockchain with MFI customers accessing them through mobile phones. Via smart contracts, funds can be donated into escrow accounts, accessible only by women, say, for accessing children's education, food and health care.

Impacts

- Improve regulatory oversight of MFI potential predatory practices to ensure quality growth of these important institutions.
- Enable policy-directed financing to target segments (e.g. mothers) with conditional arrangements coded on smart contracts.
- By significantly reducing search, transaction and coordination costs MFI 2.0 borrowers should be able to pay back loans, withdraw funds, and save in tiny amounts of money in bitcoin-like networks, which is not feasible using today's costly payment rails.

Leadership/Ecosystem

MFI associations and leading MFIs should explore these models in partnership with government regulators.

Level of Maturity and Barriers for Scaling

- Early stage of conceptual design.
- Massive process, technology and regulatory change are barriers for scaling.

Inputs kindly provided by Tapscott and Tapscott

A.2 CAPITAL FOR INFRASTRUCTURE

A.2.1 PAY AS YOU GO RESOURCE UTILITY

Problem/Solution

- 'Pay-as-you-go' energy services for off-grid customers leveraging the mobile infrastructure provides a leapfrog opportunity for sustainable energy for all in the developing world.
- As a pioneering example of pay as you go utilities, M-Kopa provides affordable solar power to low-income households on a pay-per-use instalment plan.
- In partnership with mobile money systems[100] such as M-Pesa in Kenya and IoT sensors in each solar system, M-Kopa monitors real-time performance and payment status.

Impacts

- Goal set on 1 million homes in Kenya by 2018, having achieved same scale as Solar City in the US.
- 37.5 million hours per month of kerosene free lightening as of February 2016.

Leadership/Ecosystem

- Off-grid technologies leveraging M-Pesa P2P payment disruption requires taking an ecosystem approach that orchestrates the technical and distribution capabilities of multiple parties.

Level of Maturity and Barriers for Scaling

- M-Kopa has reached economies of scale after only a few years after launch.
- To further scale M-Kopa Africa-wide and other developing countries, a 'hands-off regulatory' approach in the financial system, energy and telecom industries is required.

A.2.2 FLEXIBLE ENERGY SUPPLY AND DEMAND

Problem/Solution

- A flexible energy system that enables renewables to be managed cost effectively while delivering security of supply is critically required to transition to a 2°C world.

- This requires a level playing field that accepts and manages the price risk inherent in renewables through technology innovation. The growth of zero marginal cost renewable generation has created conditions of oversupply and will eventually create undersupply when enough loss-making fossil fuel generation plants are retired. This over- and under-supply creates the pricing dynamic that enables innovation to flourish.
- Energy-only markets are able to function because high prices have created the investment case for fast-response, gas-fired generation. Price risk during high demand/low supply events is mitigated by running fast-response, gas-fired generation. The same market conditions will create the investment case for a flexible demand-side and battery storage.
- Electricity has both a physical and financial flow, by connecting physically to consumption sources and managing time of energy use using financial signals, it is now possible to operate in a more commercially favourable way for electricity users. Using a real time IoT and AI platform that connects through software links into buildings via their building management system or directly to assets such as air conditioning, refrigeration, electric storage heating and battery storage, this optimization is achieved.

Impacts

- Climate change caused by burning fossil fuels to create electricity will only be resolved when we accept and embrace the price risks caused by variable zero carbon generation and use innovation to manage this price risk.
- Electricity customers benefit through lower bills.
- The economy of the country embracing this approach through greater competitiveness in existing industries will enjoy a lower energy cost and economic development through growing new technologies and solutions and building a "smart energy" sector.

Leadership/Ecosystem

- Leveraging digital innovation to connect energy customers to sources of power that deliver value to customers, technology providers and asset owners in the energy system. This holistic approach will place customers at the heart of the system while still delivering a reasonable return on investment for energy asset owners.
- Currently, many governments view price spikes as purely a signal of scarcity instead of understanding that price spikes create the investment case for solutions to scarcity and drive efficient use of resources. Owners of fossil fuel generation plants, who are witnessing a decline in their profitability, actively exploit this misunderstanding.

Level of Maturity and Barriers for Scaling

- Disruption – Disaggregation of fossil fuel assets leading to a reduction in their asset value, reduction in value of fossil fuel stocks, greater volatility in electricity prices.
- Resistance – owners of fossil fuel stocks and generation assets using tactics around 'security of supply' concerns are currently successful at greatly reducing the speed of transition.
- In response to the risk of undersupply, the UK government created a capacity mechanism to build the investment case for gas-fired generation outside energy markets.

Inputs kindly provided by Sara Bell, Tempus Energy

A.2.3 RENEWABLE ENERGY P2P MARKET

Problem/Solution

A renewable energy investment project marketplace (P2P) such as the one pioneered by Abundance Investment[101] in the UK, has the benefit of highlighting popular projects within a local area and encouraging greater transparency and participation from residents in the decision and implementation process as well as sharing the financial benefits of the development more widely and evenly. This requires:

- An investment-grade programme of individual projects led by local government authorities to realize local renewable energy plans/targets by turning renewable energy projects into financially and socially productive assets for local authorities.
- Generating a mix of revenues to the local authorities and direct to the communities (either via democratic finance models or community dividends).
- Connecting those projects to a base of investors who want to back local projects within the local authority boundaries.

Impacts

- Encouraging engagement with renewable energy benefits and sustainable energy usage and efficiency behaviours.
- Impacts of blended finance across public debentures, generating long-term (tax) revenues for the local authority and risk sharing with local authorities to de-risk investments to small investor via P2P marketplace.

Leadership/Ecosystem

- A company wholly owned by local government authority manages the process from inception to tender and development, which includes Abundance Investment as regulated P2P investment platform, project developers, council officials (for legal process and due diligence) and a Community Interest Company PLC to provide an 'asset lock' to ensure that community assets remain in the purview and control of the community as a whole.

Level of Maturity and Barriers for Scaling

- Historically, the key barriers have been:
  - Local authorities have been overly cautious investors.
  - Local Authorities have lacked clear direction on how they can provide clear market signals and development framework to encourage entrepreneurial local investment projects.
  - No sharing of best practices between local authorities to encourage common templates and approaches to investment structuring (ultimately enabling a more liquid and deeper secondary market for the investments themselves).
- The broader 'scale up' question is really about how the UK model of P2P and crowdfunding can be applied in different jurisdictions in a way that ensures investor protection with proportionate regulation of businesses and investment risks. The global picture is patchy in that respect with the US taking its own view on P2P and crowdfunding (JOBS act) and attempts at European harmonization with the MiFID legislation/rulebook.

A.3 FINANCING INNOVATION

A.3.1 SMALLHOLDER EXTENSION SERVICES

Problem/Solution

- Agricultural productivity growth is decreasing.[102]
- With agriculture being location-specific, new production technologies, such as improved seed varieties, nutrient management, pest control methods and new weather prediction service[103] that are localized, are not reaching farmers to the extent needed.
- Providing this contextual information at farm level through pay for performance extension services enabled by smart contracts on the blockchain would be beneficial.

Impacts

- Public extension programmes can have more impact with higher visibility of delivery performance signals to optimize service delivery effectiveness and efficiency.

Leadership/Ecosystem

- In cooperation with agricultural research and extension services, telecom providers, technology start-ups and NGOs, this service performance play can be orchestrated at scale.

Level of Maturity and Barriers for Scaling

- Early stage of conceptual design.
- Dealing with the knowledge barriers and the integration of knowledge bottlenecks will be key to address barriers to scale-up once proofs of concept are deployed in the field.

Inputs kindly provided by Sara Boettiger, Bill and Melinda Gates Foundation

A.3.2 COMMUNITY DISTRIBUTED GENERATION

Problem/Solution

- Micro-generation[104] allows consumers to produce energy in-house or in a local community. Trading this micro-generated energy becomes possible among consumers and 'prosumers'.

- Blockchain, combined with IoT metering systems and next-generation batteries, has the potential to open the energy-market to prosumer via an 'energy-coin' system.

Impacts

- Creating blockchain-enabled markets for micro-generated energy would further expand solar PV adoption on rooftops.
- Distributed community generation at scale creates significant resiliency to the electrical grid in the case of climatic disasters as a local Brooklyn-distributed generation implementation clearly demonstrated when hurricane Sandy hit New York in 2012.

Leadership/Ecosystem

- LO3 Energy start-up in partnership with Consensys (Ethereum co-founders) is working with local utilities, community leaders and technology partners to create a market where neighbours can buy and sell the local environmental value of their energy generated.

Level of Maturity and Barriers for Scaling

- Early concept prototypes in progress to test different business, technology and regulatory models.
- Barriers to scaling including high security and stability of such applications.

Inputs kindly provided by UK Government Office for Science and John Lilic, Consensys

A.3.3 SME ASSET TRADE FINANCE

Problem/Solution

- International trade finance revenues growing to US$70 billion by 2020.
- Smart Asset Trade Finance (SATF) will combine IoT with blockchain's smart contracts to provide smart trade finance services leveraging IoT to tag their claims on physical assets, making them trackable and traceable. All documentation relating to a particular asset to be traded can be digitized and carried on the blockchain[105] including ownership, warranties, inspection certification, provenance, insurance, replacement dates, approvals, significantly increasing data availability and integrity, reducing paperwork handling, storage and loss, and other process improvements related to that documentation.
- Access to real-time trade details would enable smart contracts to issue a letter of credit to be verified instantaneously, assuming pre-defined conditions are met.

Impacts

- This represents a massive opportunity to streamline trade finance processes, cut operating costs and reduce losses by better underwriting the trade finance risk through improved data analysis of exposures to serve the current latent demand, particularly in developing countries.

Leadership/Ecosystem

- Segments of trade finance involving multiple players across the physical and financial supply chains need to be orchestrated given the massive technology, process and trade standards change implied.

Level of Maturity and Barriers for Scaling

- Early concept design and testing.
- Supply chain trade process and technology interoperability standards will be key for scaling.

Inputs kindly provided by Santander Innoventures

A.3.4 SME SMART ASSETS

Problem/Solution

- Providing a robust and trustworthy proof of record for a broad variety of assets and services that currently cost SMEs time and money would be beneficial for financial inclusion purposes.
- Distributed ledgers would provide an automated solution at scale to handle micropayments, decentralized exchange and transfers.

Impacts

- Reducing transaction costs for SMEs in dealing with bureaucracies would increase efficiency and effectiveness in their core businesses.

- Distributed ledgers can provide a boost to older generation e-government initiatives focusing on business licensing, registration, tax management, dealing with employees, etc.

Leadership/Ecosystem

- Empowered standard-setting bodies around all key processes to deal with assets will be foundational.

Level of Maturity and Barriers for Scaling

- Early stage of development.
- Requires local and national authorities to adopt distributed ledgers enabling standards, processes and technology protocol.

A.4 MARKET INTEGRITY

A.4.1 FINANCIAL MARKET EARLY WARNING SYSTEM

Problem/Solution

- To what extent can we prevent the next financial system crises? Rather than having to deal with unpredictable black swans according to Sornette's Dragon theory[106] the premise is that the majority of crises are endogenous in origin and predictable. Endogenous crises arise when structural fragility builds up, and a precipitating tremor amplifies into an avalanche.
- Fintech start-up FNA[107] has proposed a *Sustainable Finance Early Warning System*[108] as an online service accessible by anyone. The idea is to pre-diagnose structural fragility arising from fundamental unsustainable practices of different sectors of the economy, and quickly identify emerging risks before irreversible tipping points are crossed.
- Dynamic sustainable finance risk maps powered by AI and network science provide the financial system cartography about systemic fault lines, and allow us to mitigate emerging risks while there is still control.
- Shared risk maps as mass collaboration platforms amplify social intelligence to better detect emerging risks and make better collective risk decisions.

Impacts

- Risk management should be treated as a common public good. Democratizing access to risk maps can help build a global culture about systemic risk, and enable us to more effectively protect our global commons.
- The democratization of risk maps would broadly benefit the financial ecosystem and its stability.
- It is a potential disruptor to internally developed early warning signals by major hedge funds and asset managers, who may currently derive some advantage with proprietary early risk detection.
- Shared maps could give rise to a diverse research ecosystem around analysing emerging signals, and improve market efficiency.

Leadership/Ecosystem

- Sharing of timely systemic risk information (e.g. BIS data) in the form of user friendly risk maps would enable community members to discuss emerging risks, and to propose relevant stress scenarios.

Level of Maturity and Barriers for Scaling

- Early concept stage before prototypes.
- Partnership with the FSB could greatly accelerate the scaling and impact of this initiative.
- The Bank of England fintech incubator concept in development phase is a perfect home for the concept outlined here.[109]

Inputs kindly provided by Kimmo Soramäki, Financial Network Analytics

A.4.2 SUSTAINABLE FINTECH REGULATORY SANDBOX

Problem/Solution

- Academics, regulators and financial system practitioners have difficulty getting access to both market data and proprietary trading data in order to study the effectiveness and efficiency markets[110] – in particular to understand how best long-term investors can channel investment dollars towards the sustainable development agenda.
- As markets become electronic and more complex, they present an unprecedented opportunity for study and understanding.[111]
- The Healthy Markets Research Institute is being set up to drive a far more data-driven

and technology-centric approach to regulation, leading to smarter, more effective regulations by regulators by providing them a sandbox for sustainable fintech regulation innovations, among others.

Impacts

- Regulators and market participants are making decisions based on incomplete data in the context of rapid technological change brought about by fintech technologies and business models. Participants can only study their own proprietary data, academics cannot share proprietary data with each other and regulators often lack the tools and resources for comprehensive and increasingly complex data analysis.
- Healthy Markets seeks to address these problems by building an open data repository in which non-direct access to proprietary and public data is provided to academics. This should lead to dramatically better understanding of market structure, more effective and informed market structure reforms, and more sophisticated approaches by market participants – especially long-term investors associated to the agenda of sustainable development.

Leadership/Ecosystem

- The Healthy Markets Research Institute, a non-profit corporation, brings together public and proprietary data, advanced technology infrastructure and academics in a neutral research platform to promote better study and understanding of market structure. Expanding the partnership ecosystem to include all relevant public and private institutions would be beneficial.
- Level of Maturity and Barriers for Scaling
- Technology-enabled regulation models could conceivably be resisted by existing regulators, who may be resistant to exploring change.
- Incentives for data contributions from all actors would enable contribution of proprietary data, even from those firms who may stand to lose out from being studied using advanced AI platforms.
- The most significant barrier is getting access to the right proprietary data from buy side firms, market makers and broker/dealers. While this means that the Research Institute will be extremely attractive to academics, and able to fulfil its initial mission, it is only a fraction of what is required. In the best scenario, Healthy Markets partners with regulators (such as US FINRA or exchanges) to receive regulator-level data. This will ensure a complete dataset is available to researchers, and there is no selection bias in the data.

Inputs kindly provided by Dave Lauer, Healthy Markets

A.4.3 BIODIVERSITY CONSERVATION EXCHANGE

Problem/Solution

- Biodiversity is earth's most precious resource, a living library reflecting of billions of years of evolutionary learning.
- A root cause of our escalating global ecological crisis is the failure to assign a monetary value to natural capital. The UN-REDD+ carbon credit scheme is well intended, but taking root slowly and needs a competitive, more open market boost if we are to prevent the rapid degradation and destruction of the majority of earth's natural areas.
- The Natural Capital Alliance (NCA) is being established to protect biodiversity platforms by democratizing and increasing investment in natural capital. NCA will apply Bitcoin technology to democratize investment in natural capital, and to protect critical biodiversity assets such as rainforests, mangroves, and coral reefs. Blockchain-enabled coloured coins empower issuers to digitize and monetize natural capital, by first raising capital with through an Initial Coin Offering (ICO).
- Biodiversity assets are represented by tokens called coloured coins. An issuer would first issue colored coins and associate them with a formal or informal promise that they will redeem the coins according to terms they have defined. Coloured coins can then be stored or transferred using transactions that preserve the quantity of every asset.

Impacts

- REDD+ coloured coin issuance incentivizes the protection of precious rainforest ecosystems, while mitigating atmospheric CO_2. Economists broadly agree that a global price for carbon is the most effective policy response to climate change. With voluntary carbon credits trading around

US$5/ton, investors in REDD+ carbon credits will benefit as broader market participation increases prices from current low levels, with the potential for a portfolio insurance payoff if global carbon prices are introduced.

Leadership/Ecosystem

- Natural capital coloured coins can be stored on a digital wallet, and traded on Likke's coloured coins exchange that will provide liquidity and enable near frictionless exchange of coloured coins with other digital assets and major currencies. Infinite Earth will be the pioneering issuer with its Rimba Raya Biodiversity Reserve REDD+ credits. InfiniteEARTH will seed NCA with 10,000 tons of Rimba Raya credits.

Level of Maturity and Barriers for Scaling

- The democratization of REDD+ investment disrupts institutional carbon brokers, who benefit from market opacity and illiquidity (with OTC bid/ask spreads as high as 400%). Furthermore, the entrance of retail investors into biodiversity markets has the potential to transform present stagnant market dynamics.
- In addition to existing *government-to-government* programmes, policymakers should also encourage the flow of private capital. Peer-to-peer mobile technology can be extended to monitor ecosystems, report crimes, and provide law enforcement to protect our global commons.

Inputs kindly provided by Alan Bausch, Likke

A.5 RISK AND RESILIENCE

A.5.1 SHARE ASSET INSURANCE

Problem/Solution

- The 'sharing economy'[112] is an economic model where individuals are able to borrow or rent assets owned by someone else in a marketplace. The sharing economy model is most likely to be used when assets are not fully used and their cost is high. The sharing economy has great potential to increase asset utilization and lower environmental impact in multiple sectors of the economy in both developed and developing markets.
- However, current insurance for automobiles or homes most often excludes shared use, even invalidating policies. "Unlocking the Sharing Economy: An Independent Review" published by the UK BIS,[113] revealed that insurance product development needs to encompass the sharing economy so that consumers have peace of mind and are thus more likely to use collaborative services. A 2014 Long Finance[114] paper, "Chain Of A Lifetime: How Blockchain Technology Might Transform Personal Insurance" pointed out the opportunity to provide specific coverage for the days a person uses their car as a taxi or their home.
- SafeShare Insurance is a start-up of the shared asset insurance type. For people who wish to purchase a 'gap policy' when they rent their workspace, SafeShare provides temporary cover.
- Delivering this cover requires five parties to collaborate – the person renting the workspace, the person hiring the workspace, Vrumi making the market, SafeShare broking the insurance, a Lloyd's underwriter underwriting the gap policy – and Z/Yen provides a blockchain solution to the broking system that simplifies messaging complexity and ensures that the parties cooperate over their data.

Impacts

- The direct beneficiaries of SafeShare are clear: the markets or 'platforms' that use SafeShare give consumers peace of mind and are more likely to be used. The indirect beneficiaries are the wider society, which should benefit through better resource utilization, less consumption, less environmental damage, less parking, better infrastructure, more flexibility and more jobs.

Leadership/Ecosystem

- SafeShare and other insurance approaches have emerged in response to market opportunities provided by sharing economy approaches which, in turn, emerged in response to market opportunities from underused assets. No direct government action was needed in the UK.

Level of Maturity and Barriers for Scaling

- The potential losers from the sharing economy are asset manufacturers, e.g. automobile

producers, or traditional service providers, e.g. taxi companies. In the insurance sector, it is an open question whether firms such as SafeShare constitute a new insurance model, high-volume gap cover for the sharing economy, or whether traditional insurers will find ways to either extend their existing cover, e.g. all home policies permit sharing, or part, e.g. it is easy to purchase an extension to an existing policy.

A.5.2 SMALLHOLDER INDEX SMART INSURANCE

Problem/Solution

- The global insurance industry is acutely aware of the "insurance protection gap" – the idea that a large number of people should have insurance but do not. According to industry trade group The Geneva Association,[115] the emerging markets comprise 40% of the world's GDP but only 16% of its insured population. Globally, 4 billion people are uninsured, representing notional premiums of US$40 billion annually.
- Smallholdings contribute 70% of global food production. However, they are severely uninsured.
- Climate change will impact smallholder farmers' crop yields by as much as 17% globally by 2050 relatively to a scenario of unchanged climate.[116]
- Weather Index insurance (input or otherwise) has been tested and scaled in the developing world with mixed success.
- The combination of IoT, blockchain and AI will enable the next wave of growth of this critically important risk management capability in the developing world:
  - Using AI to process the radio signals from mobile radio towers (IoT) to generate high-resolution weather surfaces will provide the necessary weather triggers to deploy index insurance contracts at low cost, given the widespread availability of mobile infrastructure in the developing world.
  - The index insurance contract can be automated in the distributed ledger in the form of smart contracts visible to all.

Impacts

- Cumulatively, by 2015, over 800,000 farmers in Kenya,[117] Tanzania and Rwanda insured over 646 million USD against a variety of weather risks.
- Scaling this technology would protect an estimated 1.5 billion smallholder farmers[118] in the developing world from increasing weather volatility impact to agriculture.

Leadership/Ecosystem

- The ecosystem that is required to prototype and scale this technology consists of government, telecom and insurance regulators, agricultural input providers, smallholder farmer extension services and start-ups.

Level of Maturity and Barriers for Scaling

- Early stage concept.
- Governments can catalyse the development of smallholder index insurance through public extension services.

A.5.3 BASIN WATER RIGHTS MANAGEMENT

Problem/Solution

- Communities with shared common-pool resources could consider a spectrum of rights, according to Nobel Prize-winning economist Elinor Ostrom[119] – a kaleidoscope of rights from authorized users who may only access and withdraw resources to those who have those rights but can also exclude others from access, to those who hold management rights, and those that own of resource drawing rights.
- Take a case of water common-pool rights as an example. To define the water entitlements in a community basin, first a full understanding of water demand and supply baseline drivers are needed through deployment of IoT sensor packages from space and ground, and AI technologies to analyse the data.
- The water entitlements at a community level would then be replaced with 'shares' of a blockchain-enabled water rights market as a proportion to annual allocations made to a certain pool of water. Smart contracts in the blockchain would then codify the seniority of pre-existing water rights and different classes of shares can manage use priorities. Allocations made to the community water rights shareholders and a decentralized water accounting ledger would then hold everything together.

Impacts

- Given the increase of the impact and frequency of weather extremes, thereby increasing the water inter-annual and intra-annual variability of available water resources, rational use of scarce water resources will be mandatory worldwide.[120]

Leadership/Ecosystem

- A public-private partnership that includes governments, technology providers, start-ups and NGOs would be needed to scale systems across multiple basins.

Level of Maturity and Barriers for Scaling

- The concept idea is being incubated by Space Time Ventures in partnership with leading philanthropic foundations as part of the Amazonian Library of Alexandria (ALA) initiative.
- Water governance at basin level enabling water rights management has been historically difficult (or impossible) to be implemented, given the complexities around the political economy of water simultaneously as an economic resource, as a human right, as a religious right in different cultural settings and as an environmental good.

A.5.4 AGRICULTURAL CREDIT RISK MANAGEMENT

Problem/Solution

- One of the biggest challenges of financing the agricultural sector[121] and land-related activities is monitoring a volatile sector impacted by increasing weather volatility (volatile prices, volatile climate conditions, volatile yields, volatile returns).
- IoT and AI can have great impact on risk mitigation strategies for banks as it would allow for better portfolio management, better risk mitigation strategies regarding socio-environmental risks (deforestation), natural capital risks (water basin risks), climate risks (rainfall and temperature), agronomic risks (yields and soil), geographical concentration risks (portfolio distribution) and collateral evaluation (farm infrastructure), to mention but some.
- The Brazilian Environmental Rural Registry (CAR) to be open to all through a distributed ledger with 100% of farms location, shape and land use (production and conservation areas would enable the next wave of socio-environmental risk analytics, facilitating banks due-diligence, resulting in better finance terms for farmers in compliance with conservation requirements while, at the same time, providing for higher control over high risk areas. In addition and most importantly, in the future trading of environmental liabilities and rights over a blockchain platform may unlock a large funding pool to transform landscapes in Brazil for much greater long-term sustainability.[122]

Impacts

- Banks can reduce uncertainties and monitoring costs, increasing their efficiency and underwriting capacity in lending processes. More and better contextual risk information can improve the capacity of banks to treat different clients differently with "tailor made" risk approaches, charging more for clients with higher risks and less for clients with lower risks.
- Consumers/clients/farmers can benefit for more specialized risk evaluation. Banks usually have developed risk models (credit and socio-environmental) that take into account regional characteristics. It ends up harming early adopters of resilient practices and benefiting laggards. Agricultural credit risk analytics powered by AI platforms provide tailored risk analytics for micro-segments of farmers.

Leadership/Ecosystem

- Leaders in agricultural financing are increasingly partnering with agribusiness AI start-ups to combine their joint expertise in addressing the market demand fully.

Level of Maturity and Barriers for Scaling

- Financing agriculture has historically been a difficult task that requires a long experience in the sector. These specificities, such as volatility in the short term and deep dependence on uncontrolled factors, such as climate, have made it difficult for non-specialized banks to enter the segment. Traditionally, agricultural credit expertise and a deep knowledge of the sector have created

"barriers of entry". The use of AI and IoT in the rural banking business can potentially decrease such entry barriers. With more easily available information, non-specialized banks can use AI start-ups to participate in the market without the need for agricultural financial sector expertise.

- The issue of data protection for farmers is a potential challenge for such a development. In the same way an air ticket price can increase for a consumer constantly searching for it online, as the technology could be used to improve access to finance to low-risk farmers, it would also allow for the better exploration of the consumers' surplus. In other words, with more data available, the financial institution could cross data to price financial products in order to adjust it exactly to the farmers' willingness to pay.

Inputs kindly provided by Luiz Amaral, Rabobank

A.6 PERFORMANCE AND DISCLOUSURE

A.6.1 WATER ASSET REGISTRY AND RATINGS

Problem/Solution

- Providing an immutable global register of all biophysical assets in the planet whose ecosystem services are directly related to underlying economic assets and activity.
- Characterizing the demand and supply drivers of these biophysical assets would create the necessary baseline to understand fundamental biophysical risk associated to scarcity, resilience and reliability. These drivers can then be modelled stochastically with scenarios of possible resource futures to inform more realistic economic asset risk ratings of the credit rating agencies.

Impacts

- Providing the biophysical supply baseline in terms of intra- and extra-annual variability would inform the construction of specialized risk ratings of the underlying economic assets.

Leadership/Ecosystem

- Start-up Space Time Analytics has been piloting this concept starting with global water assets: creating the world's first dynamic baseline of intra- and extra-annual variability of the hydrological cycle in more than 2,000 river sub-basins worldwide. This would provide the basis for more sophisticated predictive risk scoring of assets at risk in the sub-basin.

Level of Maturity and Barriers for Scaling

- Early concept prototypes.
- The barriers for scaling are technical in nature (processing petabytes of information with AI technologies) and procedural and standard-based (to enable next generation ESG[123] ratings on assets and securities by rating agencies).

A.6.2 FISH SUPPLY CHAIN TRACEABILITY

Problem/Solution

- End-to-end fish catch documentation system to enable local fishermen in South-East Asia is needed to provide end-to-end traceability to their customers.
- Accurate recording of where the fish are caught, when and by whom provides the basics of any traceability system.
- Combining blockchain with the IoT could enable a 'smart fish' that would record any transaction where ownership changed hands or alert parties that terms of a contract may not be satisfied.
- Fish supply chain traceability and tracking on the blockchain would provide the fishermen with an immutable record of their catch provenance and sales revenues to enable them to obtain bank loans, be paid electronically and empower them to take control of their own destiny.

Impacts

- The local communities and fishermen benefit by having permanent auditable catch records that enables them to obtain credit and reduce their reliability on third party intermediaries at much higher costs.
- The assessment of local fish stocks can be strictly controlled reducing the effects of overfishing and illegal, unreported and unregulated fishing. Accurate real-time records are available for multiple government agencies.

Leadership/Ecosystem

- A public-private partnership that includes governments, technology providers, start-ups and NGOs would be needed to scale systems across multiple fishing sites.

Level of Maturity and Barriers for Scaling

- Resistance from the local agents and middlemen who have controlled the supply chain in the past must be addressed.
- A catalytic policy would involve mandatory requirement of whole fish supply chain traceability by both governments and retail buyers.
- Market forces are forcing the requirement for full traceability. The combined actions of retail, the public demands for traceable food and government enforcement make for compelling change.

Inputs kindly provided by Chris Botsford of ACM Capital

A.6.3 CLIMATE MONITORING, REPORTING AND VERIFICATION

Problem/Solution

- Public and private sector leaders agree that there are three basic requirements for mitigating and adapting to changing climate: (1) GHG reduction targets to remain in a safe operating space; (2) large-scale predictable and sustainable financing for mitigation and adaptation strategies, and (3) the creation of a globally trusted mechanism for measurement, reporting, and verification (MRV).
- While measurement is third on the list, it is the essential precondition to unlock financial flows. The simple axiom that "you cannot manage what you cannot measure" holds true.
- Addressing climate change requires literally billions of small and large decisions, taken one at a time. Currently, players are forced to make these decisions with only partial knowledge of options, benefits, costs, and risks of their decisions in an environment of increasing complexity and uncertainty. The decision-makers are, in essence, "flying blind".
- At global and local levels, they lack a "trusted MRV infrastructure"[124] for mitigation of, and adaptation to, climate change. A climate MRV platform can be thought of as a globally pervasive nervous system (a planetary skin) assimilating and analysing disparate and siloed data sets held in public and private databases into an AI-powered distributed ledger for full end-to-end auditability.

Impacts

- A global public good MRV utility would provide the key decision-support capabilities required for mitigation of, and adaptation to, climate change.
- This trusted decision information infrastructure would *enable* large financial flows to decarbonize the global economy, capture the massive energy efficiency opportunity, expand and conserve global carbon sinks, and adapt to potential catastrophic climate change risks.

Leadership/Ecosystem

- Moving to a low-carbon economy and adapting to the large-scale risks associated with climate change (and the implied changes to production and consumption) requires a range of actors, including governments, corporations, research institutions, nongovernmental organizations (NGOs), and communities to collaborate in building and maintaining this MRV infrastructure. The Planetary Skin Institute, together with its partners University of Minnesota, NASA, INPE and many other world class R&D institutions, started this journey in 2008.

Level of Maturity and Barriers for Scaling

- Large public, private, and not-for-profit investment flows are required to fund and operate a global public good MRV infrastructure:
  - requires public investment on a large scale in science, applied R&D, space-to-ground sensor IoT capabilities and the MRV distributed ledger.
  - requires public and private investment a wide array of AI skills, assets, and capabilities that suggest public-private partnerships.
- Convening world class research institutions, public sector organizations, NGOs, scientific organizations, space agencies, think tanks, universities and start-ups from around the world that have been developing specific biophysical data sets and analytic capabilities and applications required, will be key.

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