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FINANCING THE INTERNET OF THINGS:

AN EARLY GLIMPSE OF THE POTENTIAL

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As the Internet of Things begins to deliver gains in productivity and savings on everything from appliances and automobiles to turbines and pipelines, new opportunities have emerged in the realm of finance. The networks of sensors and Big Data analytics that help prescribe more efficient maintenance schedules and predict potential system failures can also deliver new levels of transparency to those who provide loans and insurance to these industrial and infrastructure investments. Especially in developing countries, where operational and political risks are already high, analytics that can monitor operations and

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productivity gains should help open up new pools of money from otherwise skittish lenders and investors. Initially, realizing these benefits will require the design of aggregated data streams that predict outcomes reliably based on similar equipment or installations. The longer-term challenge will be to process these data while protecting the confidentiality of the operators, satisfying the national security concerns of governments and defending against cyber-attacks. It also remains to be seen which players in these new commercial configurations will actually capture the financial benefits of the new technology. In many industries, traditional business models may be entirely transformed. Firms that now manufacture a product for sale may eventually simply sell the service their product provides: jet engine hours of operation rather than jet engines, kilowatt hours of electricity rather than turbine generators. In time, this may have a profound impact on which businesses will need to borrow and what revenue streams and balance sheets they will borrow against. Yet, the transformation is already underway on a smaller scale as business models have emerged to leverage the operational transparency that the Internet of Things can provide in order to expand financing options. In areas that range from trade finance to rural farming and energy, technology and data analytics offer the promise of tapping into new pools of finance. These cases point to the promise and highlight the challenges ahead for governments that must balance the need for data to flow for productive purposes against concerns for personal privacy and security.

A Brief History of the Internet of Things

The rapid expansion of the Internet of Things in the popular imagination has centered around quirky gadgets directed mainly at consumers: refrigerators that report spoiled food and toothbrushes that track dental hygiene. Applications are expanding rapidly, however, from passenger vehicles and health care equipment to drilling rigs and complex industrial installations. The ability to place inexpensive sensors to monitor the temperature, location and stress of almost any moving part opens up broad possibilities to monitor remote operations, whether simple household devices or systemic capital

equipment. Meanwhile, falling costs of data storage have coincided with the rising sophistication of data analytics to permit the storage of detailed historical operational data. This in turn can deliver "predictive" guidance that reduces maintenance times and extends lifespans.[2] Sooner than expected, the so-called Industrial Internet will become a driving force of modernization and productivity gains.

In international trade finance, meanwhile, sensors attached to containers or even individual items help track deliveries in real time, reducing shrinkage, streamlining routing and helping integrate supply chains more efficiently. Blockchain technology[3] combined with the Internet of Things can provide secure transactions along with information on the location and condition of collateral. For example, sensors that record real-time data on shipments can send information required in trade finance documents to banks and speed up payment processing, which eliminates manual checks and paper documentation such as bills of lading. Meanwhile, Global Positioning System (GPS) data can instantaneously notify a bank once a shipment arrives at a port, while sensors provide information on the condition of delivered goods. So-called "smart contracts" can also use real-time data to instantaneously execute once pre-defined conditions are met.[4] Similarly, asset tokenization, the process of converting rights to an asset into a digital token on blockchain, can be used by lenders to generate proof of ownership. Eliminating cumbersome,

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[2] Shawn DuBravac and Carlo Ratti, "The Internet of Things: Evolution or Revolution?," AIG and Consumer Electronics Association, December 2015, www.aig.co.uk/content/dam/aig/emea/united-kingdom/documents/aig-white-paper-iot-june2015-brochure.pdf. Nikolaus Henke, Jacques Bughin, Michael Chui, James Manyika, Tamim Saleh, Bill Wiseman, and Sethupathy, Guru, "The age of analytics: Competing in a data-driven world," McKinsey Global Institute, https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/the-age-of-analytics-competing-in-a-data-driven-world. Shefali Patel, "Unlocking Business Value Through Industrial Data Management," GE Digital, www.ge-ip.sk/media/gedis/cmsfiles/files/Unlocking%20Business%20-%20Industry%20data%20management.pdf. Steven E. Winoker and Mark L. Moerdler, "Industrial Internet: The Digital Dream – A Primer, and What It Really Means for the Future of Industrial and Software Stocks," Sanford C. Bernstein LLC, August 11, 2016.

[3] Blockchain, or decentralized distributed ledger technology, verifies and confirms transactions through the generation of records, or "blocks," that exist on computers throughout peer-to-peer networks. If a change to the ledger is recorded, every block, or copy of the ledger, is updated on all participating computers. These changes are immutable and secured by the use of cryptographic technology.

[4] Mariano Belinki, Emmet Rennick and Andrew Veitch, "The Fintech 2.0 Paper: Rebooting Financial Services," Santander Innoventures, Oliver Wyman and Anthemis Group, 2015

paper-based processes offers the prospect of freeing up large amounts of capital in the $4 trillion plus trade finance market.[5]

In developing countries, internet access may be more limited, but remote distances and difficult conditions mean that the ability to track and analyze physical operations at a distance helps improve the reliability of operations and reduce operational risks. In industry, the complexity of operations makes the potential gains even greater. Oil companies have been testing sensors on exploration and production equipment gathering readings from generators, compressors and drills to boost overall efficiency and cut maintenance costs, while data algorithms help analyze parts that need repair.[6] Airlines, meanwhile, have launched platforms that monitor mechanical conditions across all their flights in real-time. Further, analytical tools help predict precisely when aircraft components should be replaced, improving safety and reducing maintenance costs.[7] By one estimate, the efficiency gains in many industries could top 20 percent.[8]

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[5] A recent Bain & Company report estimates that annual cost savings could amount to $15-$35 billion in the financial services industry alone. See http://www.bain.com/publications/articles/blockchain-in-financial-markets-how-to-gain-an-edge.aspx. Accenture estimates that the technology could cut costs of business operations, compliance and central business reporting by 50-70 percent. See David Treat and Chris Broderson, "Banking on Blockchain: A Value Analysis for Investment Banks," Accenture, 2017. The World Bank estimates that initiatives to update payments systems and expand financial access could boost the flow of currency and trade, all while helping the World Bank achieve its goal of extending financial services to one billion people by 2020. World Bank UFA2020 Overview: Universal Financial Access by 2020. April 20, 2017. http://www.worldbank.org/en/topic/financialinclusion/brief/achieving-universal-financial-access-by-2020

[6] Even firms that have begun to develop an industrial internet strategy are far from exploiting its full benefits. For example, on average only 1 per cent of the data collected on an oil rig with 30,000 sensors are currently examined. Even that sampling is mainly analyzed to detect operational anomalies rather than improve efficiency or foresee problems. See James Manyika, Michael Chui, Peter Bisson, Jonathan Woetzel, Richard Dobbs, Jacques Bughin and Dan Aharon, "The Internet of Things: Mapping the Value Beyond the Hype," McKinsey Global Institute, June 2015. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/Unlocking_the_potential_of_the_Internet_of_Things_Executive_summary.ashx. See also Mark Troman, Alexander Virgo, Alexander Obin, John P. King, Michael Kaloghiros, and Jeremy Elster, "Global Primer: Digital Machinations," Merrill Lynch, September 9, 2016.

[7] Van Wagenen, J. "Lufthansa Launches Predictive Maintenance Platform," Aviation Today, 19 October 2016, www.aviationtoday.com/2016/10/19/lufthansa-launches-predictive-maintenance-platform/.

[8] Marco Annunziata, "The Moment for Industry," General Electric, October 2015, www.ge.com/digital/sites/default/files/Annunziata_Momentfor-industry.pdf.

Leveraging Financial Benefits from Operational Gains

If data increases transparency and transparency reduces risk, then an important by-product of the "Internet of Things" will be a lower cost of financing. Naturally, this is less true of household items that are connected to the grid than more complex industrial installations, but there should be applications across the spectrum. All else equal, a simple loan for a power plant that provides regular reports on its operations and maintenance, monitors gains in efficiency and updates the likely lifespan of the installation should be less risky and less expensive than one that does not. The insurance industry is already wrestling with the promise of predictive analytics in order to price property and casualty coverage for consumers and will likely soon turn to industrial clients as well.[9] Similarly, it is easy to imagine commensurate savings on the costs of a lease, especially if the lifespan of the equipment can be monitored more closely. Ratings agencies might also incorporate operational data into their analyses of infrastructure bonds along with traditional revenue and cash flow metrics. With these metrics refreshed and reported regularly, productivity dynamics could drive market yields higher or lower along with other news flow about the borrower. For a straight loan, the bank itself could set operational targets in addition to cash flow requirements that might move the interest rate lower or higher depending on management's results.[10] The greater transparency and lower risk should also make it easier to find financing from more risk-averse insurance and pension funds.

The real benefit will come from data that show not only trends in current operations, but help reliably predict potential problems. While these developments are similar to the analytical innovations in the consumer insurance business, the task is more challenging in industry where the systems are fewer in number, more heterogeneous, and therefore more difficult to compare reliably. Still, if sound data over

[9] "Innovation in Insurance: How Technology is Changing the Industry," International Institute of Finance, September 2016, www.iif.com/system/files/32370132_insurance_innovation_report_2016.pdf.

[10] Jim Eckenrode, "The Derivative Effect: How Financial Services Can Make IoT Technology Pay Off," Deloitte University Press, October 13, 2015, https://dupress.deloitte.com/dup-us-en/focus/internet-of-things/iot-in-financial-services-industry.html.

the initial operations of a power plant can be a predictor of an extended lifespan, for example, then lenders may gradually lower rates in anticipation of longer cash flows. A series of mishaps early in the plant's life, on the other hand, may suggest the need for an enhanced maintenance schedule and a higher borrowing rate to reflect the elevated risk and the shorter lifespan. Of course, there will need to be some provision for Black Swans that the algorithms fail to predict, too. These new arrangements that share more data and risk will also need some precise contractual terms in case of major unforeseen equipment failure.

Data analytics from the Internet of Things may be especially useful to development banks and agencies, which lend in support of broader policy goals. Since efficiency gains from an investment can be measured more precisely, it becomes much easier to justify the initial loan decision as aligned with their missions. Thereafter, it becomes easier to link a loan to more specific improvements in management, regulation and industrial policy. A power sector loan that requires local regulators and operators to reduce system losses, for example, might well trigger a refund in interest costs or a penalty depending on the reported results.

Data Challenges and Data Risks

Perhaps the greatest challenge in exploiting the promise of these new data streams comes in the management of the streams themselves. With industrial applications, for example, their real value stems not from the operation of a single jet engine or CAT scan machine, but from comparisons to the operation of similar equipment in similar circumstances. This means that different operators must be willing to share their data, and these data must be aggregated and analyzed. Should this be the task of the operators themselves or should the manufacturers deliver the analyses? How well can one manufacturer analyze the operation of a competitor's product that may be part of the same installation? Or should customers pool their data with a third party that can be trusted to aggregate and share it?

These applications are still very much in their nascent stages and the business models are evolving rapidly. Just because data analytics from the Internet of Things may reduce the risks of loans and insurance doesn't mean that all will share in those particular gains. Will the sellers of the equipment actually see better financial terms or will the operators or consumers benefit instead? Will the banks and insurers protect similar lending margins with lower losses and less risk? Will the manufacturers derive any benefit from data that they themselves have made possible? In one configuration, the manufacturer might continue to book sales of hardware with embedded analytics, while the customer and its bank share the savings of more efficient operations at a lower risk. Here, what may be even worse for the manufacturer is that traditionally lucrative service contracts may become far less lucrative if there is less prophylactic maintenance to perform. In a different configuration, the manufacturer would not only develop the analytical software, but retain control of the equipment, analysis and maintenance. This places the manufacturer more in the role of selling operational service (kilowatts or jet engine hours) rather than mainly hardware. It would also retain a central role in maintenance, which would presumably enhance the predictive value of the analytics. Meanwhile, the lender, who is getting operational reports directly from the manufacturer who knows the most about the equipment, might be more prepared to reflect the lower risk with a lower interest rate. Finally, the customer, who no longer actually owns the installed equipment may be more open to sharing the operational data since the equipment is not on its balance sheet.

Early Illustrations and Policy Challenges

While it remains too early to see large-scale financial innovation that incorporates and benefits from the data around the Industrial Internet, there are emerging trends that help illustrate the promise. In particular, technology that can monitor, analyze and adjust the operations of remote equipment or installations has particular value in the developing world, where conditions, maintenance and operations

are often more challenging. Our research has yet to find definitive evidence of risk-averse pension managers feeling significantly more secure investing in developing country infrastructure because they can track its value and life-span in real time. Nevertheless, there are business models that embrace the new technology in ways that lever financial support in creative ways, while current trends suggest these models will grow more sophisticated and sustainable. Some of the most successful applications appear to be in the realm of trade finance, where large amounts of cash flow have been tied up in an antiquated, paper-based system. The combined power of blockchain and the Internet of Things offers the prospect of freeing up enormous pools of financing that are currently trapped in a system dominated by paper bills of lading[11]. Meanwhile, in developing countries, creative combinations of carbon credits, micropayments and remote sensor networks seem to have launched bankable business models to support electricity supplies and agricultural finance.

While many of the models are still under development, they already point to thorny policy changes that must be addressed in order to boost the chances of success.

Privacy Protection: Whenever consumer data is collected, aggregated and analyzed, it triggers worries over the protection of privacy. The rules governing consumer consent on the use of their data vary widely across jurisdictions as consumer preferences themselves evolve rapidly. Even limited clarity on regulatory frameworks would help accelerate the development of these business models.

Data ownership: Governments will also need to improve their laws around the protection and ownership of data so that firms can leverage the analytics most effectively. Often, companies will need to draw on many data streams in order to conduct robust analyses, while the legal understandings around what data can be used for what purposes are often spelled out in a complex web of bespoke contracts rather than in standard sets of rules.

[11] One estimate put the unmet demand for trade finance at $1.4 trillion in 2014. "2015 Trade Finance Gaps, Growth, and Jobs Survey", ADB Briefs No. 45, October 2015, Manila: Asian Development Bank. https://www.adb.org/sites/default/files/publication/175855/2015-trade-finance-gaps-growth-jobs.pdf

Data standards: Tracking physical operations or transactions across distant jurisdictions will require careful alignment of data standards and protocols. This is especially important in the area of trade finance where data, payments and goods move across many jurisdictions. Continuing upgrades of system hardware and software may create opportunities for legacy systems and standards to become more synchronized, but this will also require careful thinking by policymakers and industry participants.

Trans-border data flows: If data analyses are to be most useful, they must be compared against a larger universe of industrial operations, which means regulators and governments must allow data in their jurisdictions to cross borders freely so that the operations of a gas pipeline network in Brazil can be compared to one in Turkey. This will be tricky when some authorities continue to insist on data localization in a misguided attempt to make the data more secure. Ironically, the new Comprehensive Trans-Pacific Partnership that was signed in 2018 without the United States includes a strong chapter on protecting data flows that was initially authored and championed by the United States.

Infrastructure security: Sharing industrial data widely may be viewed as a risk to national security and prompt far tighter control. There will also be fears of cyber-attacks. Yet, better analyses of operational data can also enhance safety and the regulation of key industries. Officials will need to strike a balance between protecting the data from malign actors, while allowing enough freedom of movement to permit meaningful, real-time analyses of air traffic, gas pipelines and electrical grids.

Financial regulations: Banks, insurance companies and investment firms, which already face a web of conflicting requirements around their use and protection of client data, will need clearer guidance on how best to keep data safe, while providing regulators a clear picture of financial stability or illicit activity.

Government data access: Many governments keep troves of proprietary data on the demographics of their citizens, the patterns of their weather and the flows of their traffic. These should be opened and made more available to private firms that can, for a fee, develop useful and bankable business models across a range of areas.

Private sector engagement: All of these rules and laws involve complex and rapidly evolving technology, which means they must be set in cooperation with industry. Yet the private players may have conflicting incentives. Those who derive profit principally from hardware sales may be more concerned about data sharing that reveals design secrets, while those who will shift their focus to selling software and analytics will have a larger stake in the free flow of data.

Conclusions and Next Steps

The picture that emerges from the case studies that helped shape this inquiry is of many different business models grappling with emerging technology to tap into new pools of finance. Those working in trade finance are well on their way to unlocking trapped working capital, although there is clearly much more scope for greater efficiency. Intriguing models in developing countries have yet to mobilize large new investments, but they nevertheless demonstrate the potential that comes from the ability to monitor and analyze physical operations to help mitigate risks and explore new sources of finance. These examples all help point up both the potential gains as well as the legal and regulatory challenges as personal, commercial and industrial data increasingly shape new ways to provide innovative goods and services. More detailed analyses of these tradeoffs in specific industries would help accelerate the ability to make the most of these opportunities. As the Internet of Things rebalances the equation between investment risks and potential returns, the work of entrepreneurs, financiers and policymakers has only just begun.

APPENDIX: CASE STUDIES

Blockchain, Trade Finance and Remittances

Dubai—Trade Finance: Trade finance market participants have begun to explore how blockchain technology expands opportunities to trade commodities securely and reduce counterparty credit risk. IBM has partnered with a freight company, telecommunications service provider, and several banks to conduct a trade on blockchain and track a cargo shipment of fruit from India to Dubai. The payload will be monitored using sensor-enabled devices provided by Emirates Integrated Technology Company, operating as "du." Dubai's largest bank, NBD, will issue letters of credit to Santander, while Aramex, a freight and logistics firm, will ship the goods. Smart contracts will execute on "Hyperledger," a distributed ledger platform and rely on transaction data provided by du's Internet of Things (IoT) devices, all confirmed by IBM's artificial intelligence platform, Watson.[12] In a parallel development in March 2017, IBM provided support for Trafigura, a commodities trading house, and Natixis, a French bank, in a test of blockchain in the settlement of U.S. oil market transactions. The test represented the first blockchain transaction in commodity trade finance and allowed real-time data to be shared with all participants through 14 distinct steps of the transaction.[13]

Accessing New Finance: The digitized crude oil transaction placed the buyer, seller, and banks on the same distributed ledger network, allowing them to access deal status in real time, including trade confirmation and validation, final delivery and inspection and termination of the letter of credit. Historically, these transactions have required intricate workflows and cumbersome paperwork. With a

[12] http://www.reuters.com/article/us-dubai-fintech-idUSKBN15M0RR. The Hyperledger initiative has been created to help foster blockchain adoption by corporations and promote cross-industry blockchain technologies. Hyperledger Fabric is a hosted framework for developing blockchain applications and requires participants to propose transactions that are ordered, validated and executed by consensus on a distributed ledger. http://searchdatamanagement.techtarget.com/feature/Hyperledger-Fabric-offers-path-to-enterprise-blockchain-future

[13] Hawser, Anita. "Chain Of Crude." Global Finance. 14 June 2017. https://www.gfmag.com/topics/global-banking/chain-crude

single distributed ledger, the sharing of bills of lading and delivery and payment status occur immediately. All parties to the transaction receive simultaneous updates, while each additional transaction generates an unalterable record in the shared ledger. Digitization thus reduces overhead costs and transaction processing times while eliminating intermediaries and excess paperwork.

Crucially, this process shortens the cash cycle and slashes the requirements for working capital.[14] In fact, approximately 80% of global merchandise trade is supported by financing or credit insurance.[15] Trade finance relies heavily on letters of credit, which are written obligations to pay, generally issued by the bank of the importer to the exporter, but the digitization of the trade finance lifecycle will shrink those needs and open up new channels of capital. Indeed, in one estimate, courier charges could be reduced by $125 per letter of credit.[16] Replacing paper-based processes with digital transactions should also help reduce bank operational and compliance risks and allow for the more secure digital transfer of ownership.

Prospects and Policy Challenges: Dubai serves as a trading hub and re-export center of goods traded between the Africa and the Middle East and Asia, with $176 billion of non-oil trade during the first half of 2016.[17] Recognizing blockchain's promise, the port has set a goal to complete all transactions on distributed ledgers by 2020. Success requires close collaboration among all parties involved in a particular trade chain, as well as support from governments which may need to adjust regulations and laws that govern financial transactions, contracts, and ownership rights. It also involves a much greater flow of sensitive commercial and sometimes personal data across many jurisdictions each with their own data rules. Efforts to protect privacy or reinforce digital infrastructure against cyber-attacks may erode

[14] "Natixis, IBM and Trafigura Introduce First-Ever Blockchain Solution for U.S. Crude Oil Market. IBM. 28 March 2017. https://www-03.ibm.com/press/us/en/pressrelease/51951.wss

[15] "Trade Finance and SMEs: Bridging the Gaps in Provision." World Trade Organization. 2016.

[16] "Rethinking Trade and Finance: An ICC Private Sector Development Perspective." International Chamber of Commerce. 2017.

[17] "Dubai Government, Companies Team up With IBM on Blockchain Project." Reuters. 7 February 2017. https://www.reuters.com/article/us-dubai-fintech/dubai-government-companies-team-up-with-ibm-on-blockchain-project-idUSKBN15M0RR

some of the gains, but the potential savings remain significant, especially for small- and medium-sized enterprises that struggle to secure trade finance.[18]

Multilateral institutions are already hard at work to lower the cost of trade, and their efforts may accelerate with the adoption of blockchain technologies. The World Trade Organization's Trade Facilitation Agreement (TFA), for example, seeks to simplify paperwork, modernize procedures, and harmonize customs requirements.[19] Moreover, the International Finance Corporation's Global Trade Finance Program created a global banking network that links emerging market companies with 280 financial institutions across 90 emerging markets, guarantees trade obligations, and covers all country and commercial risks of trade instruments issued by emerging-market banks. Furthermore, the IFC's Working Capital System Solutions offers short-term loans to emerging-market banks to inject dollar liquidity into low-income countries that face foreign exchange disruptions.[20]

A key policy challenge remains the harmonization of electronic standards in trade finance which could help to ease the transition away from the current paper-based system. For example, the International Chamber of Commerce is working to ensure "electronic" compliance and the development of electronic universal product codes so that banks can accept electronic verification. Enforceable and common rules and standards should help facilitate the digitization of trade documentation. Pending changes to bank letters of credit through the SWIFT messaging system offer the opportunity for banks to upgrade their systems, which could include more digitization and straight-through processing.[21] In the end, digitization can lower the cost of processing letters of credit and trade finance in general, while the transparency inherent in blockchain could attract more risk-averse sources of capital.[22]

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[18] More than half of trade finance requests from small and medium enterprises are denied, compared to just 7% for multinational companies. See Trade Finance and SMEs

[19] "Trade Facilitation: Cutting 'Red Tape' at the Border." World Trade Organization. https://www.wto.org/english/tratop_e/tradfa_e/tradfa_introduction_e.htm

[20] "Rethinking Trade and Finance"

[21] "SWIFT 2018/19 Cat 7 Changes: Compliance and Next Generation Digital Trade." Software Brief. MISYS. 2017.

[22] "Rethinking Trade and Finance"

Stellar.org -- Remittances: Stellar.org, which focuses on connecting poor households to low-cost financial services, has entered a partnership to develop a regional blockchain payments solution that has the potential to revolutionize global remittances. The partnership includes IBM and the KlickEx Group, a peer-to-peer foreign exchange platform that is building a network for foreign exchange transactions without bank intermediaries. KlickEx was created to meet remittance and foreign exchange needs in the South Pacific region and its regional cross-border payments system focuses on developing emerging-market financial infrastructure that has already facilitated the adoption of digital financial services in unbanked regions throughout the world. KlickEx also serves as a regional compliance system, and through ownership of the largest money transfer operations in the Pacific, is the region's largest clearing hub, accounting for over 60% of annual retail foreign exchange transactions in key currency corridors.[23] While Stellar issues digital assets called Lumens, IBM's blockchain technology helps reduce cross-border transaction costs and increase transaction speeds. The Stellar network allows for low-cost, scalable, and essentially frictionless cross-border payment transactions and has the capability to securely process more than 1,000 transactions per second with one billion unique user accounts.

Accessing New Financing: Stellar's open-source blockchain network is geared towards the exchange of digital assets, which are issued on the Stellar network in lieu of foreign exchange and allow for nearly real-time settlement of transactions. Banks will complete transactions using Lumens and then convert them to local currency through local market makers. This transforms the current process, in which banks hold foreign accounts in local currency to arrange payment and can be slow and tie up capital. KlickEx Group operates as the core financial institution for the region, servicing banks, retail clients and consumers throughout the network, while IBM provides the underlying blockchain platform to transfer payments across parties. Each transaction is immutable once recorded, while the settlement instructions are provided via smart contracts, again on "Hyperledger." The process also allows financial

[23] "IBM Announces Major Blockchain Solution to Speed Global Payments." IBM. 16 October 2017. http://www-03.ibm.com/press/us/en/pressrelease/53290.wss

institutions to choose their preferred settlement network. For example, the network allows a farmer in Fiji to sell to a buyer in Malaysia with blockchain recording the contract terms, managing the documentation, allowing the farmer to put up collateral and secure letters of credit, and finalize transaction terms with immediate payment.

Prospects and Policy Challenges: The system is currently being used by members of the Advanced Pacific Financial Infrastructure for Infrastructure (APFII) public-private partnership, which was set up by the United Nations and SWIFT. It is expected to process up to 60% of cross-border payments in the South Pacific's retail foreign exchange corridors. So far, the cross-border payments solution has processed live transactions in twelve currency corridors across the Pacific Islands, Australia, New Zealand and the United Kingdom with a widening array of regional banking powerhouses engaged in the development process.[24] While the savings and efficiency gains are unquestionable, further expansion of currency trading on blockchain may present fresh challenges to regulators who care most about market stability and transparency. SWIFT has also announced a test blockchain application in cross-border payments designed to test whether distributed ledger technology can assist banks with the reconciliation of international "nostro" accounts, accounts that banks hold in foreign currency at another institution. The twenty eight banks participating hope to streamline the monitoring of international nostra accounts by using blockchain to provide real-time information on liquidity. Participants hope that with more efficient liquidity management, additional capital could be made available for investment.[25]

Separately, the technology may help address the challenges to banks of meeting increasingly difficult compliance requirements, which has led to "de-risking" as lending institutions withdraw from fragile jurisdictions altogether. As capital reserve requirements have risen, the supply of bank capital has

[24] The list includes Banco Bilbao Vizcaya Argentaria (BBVA), Bank Danamon Indonesia, Bank Mandiri, Bank Negara Indonesia, Bank Permata, Bank Rakyat Indonesia, Kasikornbank Thailand, Mizuho Financial Group, National Australia Bank, Rizal Commercial Banking Corp. (RCBC) Philippines, Sumitomo Mitsui Financial Group, TD Bank, and Wizdraw (HK) of WorldCom Finance. https://www.stellar.org/blog/IBM-KlickEx-Partnership/

[25] "22 Additional Global Banks Join the SWIFT GPI Blockchain Proof of Concept." SWIFT. 6 July 2017. https://www.swift.com/news-events/press-releases/22-additional-global-banks-join-the-swift-gpi-blockchain-proof-of-concept

declined, while Anti-Money Laundering and Know Your Customer regulations place further constraints on cross-border capital flows. Digital technologies should help make compliance processes more reliable and less expensive. One estimate suggests that with digitization, 350 million additional businesses could begin to reach external markets and boost the digital economy by $29 trillion over the next decade.[26]

New Sources of Agricultural Finance

Zenvus – "Smart" Farming in Nigeria: Zenvus collects and aggregates data from farms, helps farmers make better decisions to improve their yields and offers access to financing that was previously out of reach. Its proprietary solar-powered sensors, called "SmartFarm," can be placed in the soil to collect information on humidity, moisture, nutritional content and more. These sensors also have an in-built GPS that collects information on location and size of farms. The data are then transmitted over cellular and WiFi networks and aggregated on a web-based application. Zenvus also sells special cameras that analyze crop images and help track crop health and predict pest outbreaks.[27] Farmers can use both these tools to make better decisions, while Zenvus aggregates the data to help the farmers secure financing.

Accessing New Finance: SmartFarm costs from $200 to $650 depending on size and scope of the sensors as well as data transmission source (cellular, WiFi or satellite),[28] but the data also allows farmers to access financing that was previously out of reach, including insurance, loans or investment. The central source of new money comes from financers who pay subscription fees to access aggregated, anonymized farmer data that allows them to vet potential investments and track their performance.[29]

Among the specific products:

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[26] "Rethinking Trade and Finance"
[27] Zenvus. https://www.zenvus.com/
[28] Zenvus. https://www.zenvus.com/
[29] Iruoma, Kelechukwu. "How agro-tech helps farmers increase productivity" Vanguard. 29 August, 2017.

- *ZCapital*: Farmers upload business plans that lenders review and that Zenvus can independently verify using the data it collects. Lenders pay a subscription fee to view farmer profiles and make commitments, which can take the form of equity, loans or hybrid capital. While the terms are agreed between borrower and lender directly, Zenvus gives the process greater transparency and credibility.
- *ZInsure*: Similarly, farmers can apply for insurance by uploading data about their farm, which is also independently verified by Zenvus. Further, insurers can view each of these applications based on real-time data from the farms and make coverage decisions. Not only do insurers benefit from access to standardized, verifiable information but farmers are also able to access customized insurance, which helps reduce premiums.
- *ZCrowdfund*: Farmers who may not qualify for ZCapital can post a campaign to raise money from nearby investors, and in return, provide them with produce. [30]

Prospects and Policy Challenges: Zenvus was initially funded through seed capital in the form of grants amounting to $50,000 from USAID and Western Union Foundation, made to Fasmicro, the parent company of Zenvus.[31] While revenue is generated through subscription fees from lenders, insurers and other financial agents, it remains to be seen how this model will adapt to scale. In addition to the existing Nigerian states where Zenvus operates, Zenvus sensors are currently being piloted with the African Development Bank (AfDB) with potential for scale-up to all AfDB-affiliated farms.[32] In fact, with the Nigerian government refocusing on its agricultural promotion agenda, there is potential to bring in players like Zenvus that can leverage IoT to ease financing flows to farmers.[33]

[30] Zenvus. https://www.zenvus.com/

[31] Onyewuchi, Ikechukwu. "Nigerian start-up FASMICRO gets N10million Western Union, USAID grant." The Guardian. 17 October, 2015.

[32] Spore 185. "The growth of inclusive digital agri-finance" June-August 2017

[33] Iruoma, Kelechukwu. "How agro-tech helps farmers increase productivity" Vanguard. 29 August, 2017.

Dattabot / Hara – Boosting Harvests in Indonesia: Founded in 2003 as a media monitoring company, Dattabot has grown into one of Indonesia's largest data analytics firms encompassing demographic, social media and other data streams. It operates in a variety of industries including fast-moving consumer goods, financial services, and government.[34] Through a partnership with General Electric's Digital Division, the company helps improve constant real-time tracking and monitoring of industrial equipment breakdowns. The partners use smart censors to collect millions of data points in power plants to predict breakages, downtime and maintenance requirements. Among Dattabot's more intriguing spin-offs is Hara, which capitalizes on Big Data analytics technology to improve the welfare of farmers by developing products that can be used in the agricultural sector to improve productivity and efficiency.[35] An initial trial was launched on a rice paddy outside Jakarta at the foot of Mount Gede, where the company experimented with drones and weather censors to monitor soil conditions and ultimately identified three challenges to improving productivity of Indonesian agricultural practices.[36] First, farmers lacked data: particularly, they had no historical data on soil nutrients, weather, climate condition, or water sources. Second, farmers operated based on trial-and-error, and without a proper understanding of their field conditions. Finally, they responded too late to the onset of pests and disease, which often led to failed harvests.

Hara combines historical data, manual feedback, sensor input, satellite imagery and a powerful analytics engine. Data acquisition technologies eliminate unreliable and time-consuming paper-based reporting systems. Analytics then facilitate the monitoring of farming progress and efficiency through millions of data points collected across thousands of hectares of agricultural land. Finally, precision insights deliver strategy recommendations to ensure efficiency and optimal agricultural productivity. Hara has helped farmers to achieve a 60% improvement in crop yield, a 50% reduction in farming inputs,

[34] https://dattabot.io/what-is-dattabot/the-business/

[35] http://www.fareasternagriculture.com/technology/machinery-a-equipment/bringing-big-data-to-farming-in-indonesia and https://www.techinasia.com/ci-agriculture-precision-farming-indonesia

[36] http://ci-agriculture.com/about

and a 25% reduction in crop failure rates.[37] The firm works with over 1,300 farmers and plans to play a significant role in Indonesia's agricultural security.

Accessing New Finance: Dattabot initially had a hard time attaining funding, but in the words of its CEO, "[bootstrapping] helped us look for a sustainable business model, to be profitable, while at the same time improving and building our own technology." The firm secured its first contract in 2010, worth $4.7 million over 3 years, which proved to investors that the underlying technology had marketplace potential. Following a restructuring in 2015 to focus on data integration, Dattabot closed its first round of funding (for an undisclosed amount/valuation) led by Alpha JWC Ventures, a VC firm that specializes in socially-driven fintech and Big Data. The firm is now planning a double-digit Series A round.[38]

Prospects and Policy Challenges: Indonesia boasts one of the world's largest populations, at 250 million, but the nation's main challenge is availability of data. Dattabot's CEO cites the difficulty of finding basic data such as how many people live in a certain area, gender ratios and age distribution. With its growing technological prowess and marketplace awareness, the firm is pioneering an open data movement for citizens that will enable Indonesians to access basic public data more easily. The GE partnership has given Dattabot and Hara international credibility and has enabled the leveraging of GE's Predix software to save time and money by using pre-existing code and allowing the firm to focus on business development. GE Digital is also helping Hara's expansion throughout the agricultural value chain in other countries, which includes wider distribution throughout Southeast Asia and into other verticals - including consumer goods, financial institutions, healthcare and government. These opportunities would be easier to exploit with easier access to anonymized government data, such as its land registry, weather stations and census data. A government open data portal could help turbocharge firms like Dattabot and Hara expand their services more rapidly. Government capital and or risk-sharing

[37] https://www.ge.com/digital/sites/default/files/Dattabot-GE-Predix-case-study.pdf

[38] Company website and https://www.digitalnewsasia.com/business/mediatrac-wants-create-big-data-wave-indonesia

for innovative ideas to enhance agricultural productivity might also accelerate the adoption of these new technologies.

New Financing Models for Distributed Energy and Water Solutions

M-Kopa – Grid Connections in Kenya: M-Kopa, which is derived from M for "mobile" and "kopa" for the Swahili word for borrowed, was officially founded in 2011[39] to help connect Kenyan households to the electrical grid at a lower cost. Although 96% of Kenyans have access to mobile phones, only 15% are connected to the national grid, while the rest often rely on kerosene, batteries and long walks to charge their phones.[40] M-Kopa's solution is to offer a solar-powered "micro-grid" to each household with IoT technology that supports financing of the investment. The system, which includes a small solar panel, a small rechargeable battery and a SIM card, provides enough electrification for lighting, phone charging, a radio and small electrical appliances. The SIM card included (and powered by) the kit allows for live monitoring of electricity consumption at M-Kopa headquarters in Nairobi. While home solar kit prices have fallen dramatically, at $200 they remain too expensive for most families in rural Africa. M-Kopa installs the systems for $35 and allows families to gradually pay off the cost of the solar kit,[41] which provides electricity to homes for around 45 cents/day and allows most households to pay off the installed equipment within a year. About one quarter of M-Kopa customers purchase additional products. A few weeks before the solar system is paid off, an M-Kopa representative offers financing for fuel-saving stoves, rainwater tanks, mobile phones and school fees.[42]

Accessing New Finance: At its core, M-Kopa's innovation is about financing, not the physical product. "What we've done is to give the customers some collateral and a line of credit," in the words of

[39] http://www.shellfoundation.org/Our-Focus/Partner-Profiles/M-KOPA/Summary
[40] https://www.ft.com/content/ccfaa1ba-d0f1-11e5-831d-09f7778e7377
[41] https://www.triplepundit.com/2016/01/m-kopa-pay-as-you-go-solar-africa/
[42] https://www.bloomberg.com/features/2015-mkopa-solar-in-africa/

one company official.[43] Payments are conducted online through M-Pesa, a mobile phone-based money transfer and microfinancing service previously launched by M-Kopa's strategy director. If users don't pay, service is suspended, although power can be restored within five minutes of catching up on payments. By electrifying over 600 new homes each day, M-Kopa is essentially extending new loans worth $100,000 daily. "We're really taking a bet on anyone who is willing to give us their phone number, their ID number, and a down payment," says one executive. Repayment rates are 93% for the solar system and 98% for secondary products.[44] The firm has discovered that its best credit risks are its poorest customers, who are also the most likely to rely on it as their sole electricity provider. One customer estimates savings of KS20 (about 20 cents) per day on power – about one third of their total cost of electricity, in addition to the convenience of not having to secure kerosene and batteries.[45]

The company has raised about $36 million in equity, and notable investors include London-based Generation Management, founded by former US vice-president Al Gore, Richard Branson of the Virgin Group, and AOL co-founder Steve Case.[46] At the end of 2017 the firm secured $80 million of commercial debt that will be used to finance further solar installations.[47]

Prospects and Policy Challenges: The team's initial goal was to sell 1,000 units a week within the first three years, but that milestone was achieved within 12 months. As of January 2018, M-Kopa has electrified over 600,000 homes across Kenya, Uganda, and Tanzania.[48] The firm estimates that it provides 75 million hours of kerosene-free lighting each month and will save customers over $450 million over the next four years. Other solar financing firms have employed similar models. In Tanzania, Off-Grid Electric provides clean, affordable energy to households using a distributed micro-solar leasing model. Unlike M-Kopa's upfront $35 fee for units manufactured in China, Off-Grid charges only $6 to

[43] https://www.bloomberg.com/features/2015-mkopa-solar-in-africa/
[44] https://www.bloomberg.com/features/2015-mkopa-solar-in-africa/
[45] https://www.ft.com/content/ccfaa1ba-d0f1-11e5-831d-09f7778e7377
[46] https://www.ft.com/content/ccfaa1ba-d0f1-11e5-831d-09f7778e7377
[47] http://solar.m-kopa.com/wp-content/uploads/sites/4/2015/02/M-KOPA-Debt-Announcement.pdf and https://www.crunchbase.com/search/funding_rounds/field/organizations/funding_total/m-kopa
[48] https://www.bloomberg.com/features/2015-mkopa-solar-in-africa/

install its system, which is designed and manufactured in-house.[49] After installation, households "unlock" electricity to power lights and small household appliances by sending a payment through their mobile phone, paying on average $5-10/month for electricity.[50] Off-Grid's backers include impact investing firms DBL Partners and Omidyar Network, as well as the World Bank's International Finance Corporation and USAID.[51] These models might benefit from targeted government subsidies to help poor households afford the upfront installation costs, as well as concessionary-rate capital to grow more quickly as impact investor and development institutional capital reach their constraints. Such government financing might also support solar electrification of entire villages, which could then support power needs for larger appliances like refrigerators. The benefits to government could be significant if these business models share their data to help identify where power demand may be rising quickly and government prioritize grid connections.

Project Surya – Sensor-enabled climate financing for clean cook-stoves in India: Project Surya incentivizes usage of clean cook-stoves in rural households in India. The clients, mainly women, borrow the $57 to buy the Surya clean cook-stove, which is fitted with a sensor that tracks its usage.[52] The sensor is solar-powered and generally lasts up to three days once charged. All data is communicated over cellular networks and those monitoring cook-stove usage can log into a web-based server and track how many hours the household used the stove for cooking on a given day and compare usage by region or demography.[53] This usage is then converted to equivalent climate credits and each user receives money based on the climate credits generated. While initially the payments were deposited in the bank accounts,

[49] HBS Case: "DBL Partners: Double Bottom Line Venture Capital" and https://www.ft.com/content/ccfaa1ba-d0f1-11e5-831d-09f7778e7377

[50] HBS Case: "DBL Partners: Double Bottom Line Venture Capital"

[51] http://offgrid-electric.com/about-us#leadership and HBS Case: "DBL Partners: Double Bottom Line Venture Capital"

[52] Ramanathan, Tara, et al. "Wireless Sensors Linked to Climate Financing for Globally Affordable Clean Cooking." *Nature Climate Change*, vol. 7, Oct. 2016, p. 44.

[53] Nexleaf Analytics. http://nexleaf.org/cookstoves/

Project Surya has now partnered with M-Pesa in India, which provides a mobile money application to allow borrowers to directly track payments and easily access money from remote locations.[54] The payments are currently funded by contributions from donor organizations pooled together in a climate fund. Currently in pilot stage, the project estimates that roughly 850 households in rural Odisha, on the Bay of Bengal, have reduced 490 tons of equivalent carbon dioxide (which approximates to 1.2 million fewer miles driven) thus far.[55]

Accessing New Finance: Rather than providing climate credits to the manufacturers of cook-stoves, Project Surya tries to bring the carbon markets directly to the users. Using the StoveTrace sensors, Project Surya can directly track cook-stove usage and reward the women in equivalent climate credits for reduced pollution based on sensor data. Reduced emissions of carbon dioxide and short-term climate pollutants are priced at $6/ton of equivalent CO_2. Given that each household uses the cook-stove on average for 4-5 hours per day, each client can earn up to $30 per year, and therefore, recover the capital cost of the cook-stove in roughly two years (and reduce emissions by roughly 5.3 ton of equivalent CO_2 per cook-stove user per year). The company estimates that its clients' household incomes average less than $3 per day on average.[56]

Prospects and Policy Challenges: Project Surya is a partnership between Nexleaf Analytics, The Energy and Resources Institute (TERI) and the University of California, San Diego. Currently, financing for the climate credits is provided through a network of donors and aid organizations including Beneventures Foundation, Leslie & Mac McQuown and Qualcomm Wireless Reach.[57] With the sensor data, financiers can directly verify whether or not the cook-stove is being used, allowing for greater transparency and accountability in the financing process. While the operation is currently being funded by

[54] StoveTrace: How data can help steer clean cooking in the right directon. Nexleaf Analytics, IoT for development series. 2017. https://nexleaf.org/reports/IoT-Series_StoveTrace-PDF-Report_2017.pdf

[55] Nexleaf Analytics. http://nexleaf.org/impact/

[56] StoveTrace: How data can help steer clean cooking in the right directon. Nexleaf Analytics, IoT for development series. 2017. https://nexleaf.org/reports/IoT-Series_StoveTrace-PDF-Report_2017.pdf

[57] Ibid

donors, the founders hope to tap into registered carbon trading schemes once they have achieved scale.[58] Nexleaf has made several modifications to its system to boost adoption, including a partnership with Vodafone M-Pesa in India to enable faster, more direct payments as well as stronger after-sales service. Initial findings from the pilots of these new technologies seem promising – not only are women using the cook-stoves for longer durations, but also usage is sustained over time.[59] The success of StoveTrace sensors has yet to be proven at scale with market-based financing, but targeted government support or investment guarantees might help Surya demonstrate the value of leveraging IoT technology to reduce financing risk under remote and difficult conditions.

SweetSense Inc.--Improving accountability of development aid in Kenya: Originally developed at the Sustainable Water, Energy and Environment Technologies Laboratory (SWEETLab™) in Portland, Oregon, SweetSense Inc., a start-up based out of Portland, Oregon, manufactures sensors that can help track functionality of water pumps, water filters, latrines and even cook-stoves across developing economies.[60] As part of a landmark project, SweetSense joined as a founding member of the Kenya Resilient Arid Lands Partnership for Integrated Development (RAPID), a public-private partnership led by the Millenium Water Alliance. The goal of RAPID was to pilot a project that increased water coverage across five counties in Northern Kenya (Garissa, Isiolo, Marsabit, Turkana and Wajir). Sensors manufactured by SweetSense are installed on local water infrastructure (bore-wells, hand pumps). Implementation is integrated within the county-level government, with the goal of increasing accountability and building feedback loops between donors, users and governments.[61]

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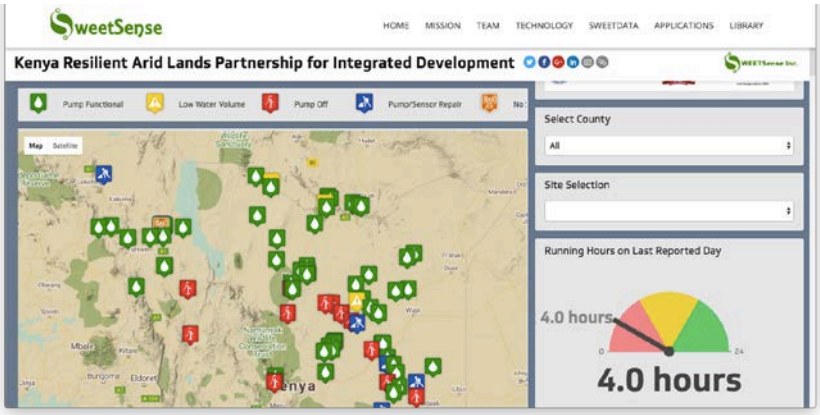
[58] Stacey Kiran. "India: Cooking up a recipe for clean air". Financial Times. December 21, 2016.

[59] StoveTrace: How data can help steer clean cooking in the right directon. Nexleaf Analytics, IoT for development series. 2017. https://nexleaf.org/reports/IoT-Series_StoveTrace-PDF-Report_2017.pdf

[60] SweetSense. http://www.sweetsensors.com/

[61] USAID Kenya RAPID Fact Sheet – January 2018. USAID. https://www.usaid.gov/sites/default/files/documents/1860/Kenya_Rapid_Fact_Sheet_Jan_2018.pdf

Accessing New Finance: SweetSense produces low-cost, remote monitoring sensors that are then attached to electric boreholes in the RAPID project area.[62] These solar-powered sensors record not only borehole functionality but also water utilization rates. Data from the sensors is then transmitted to the web using cellular networks. Each sensor costs between $300-600. Once the data is transmitted, government and donors can monitor each individual borehole and view both the operating hours and the volumes used from each one. The dashboard also tracks the status of each borehole – the pump's status, repair needs or water volume levels. Reports from each monitoring visit from the county-level workers can also be tracked.[63]



Dashboard Example: http://www.sweetsensors.com/sweetdata/kenyarapid/

The $35.5 million project was funded through grant donations including a $12.5 million grant by USAID as well as contributions from the Swiss Agency for Development and Cooperation (SDC).[64] The program is meant to run from 2015-2020 and target roughly 450,000 people. Further, each of the five counties, the Millennium Water Alliance, private sector partners (including SweetSense, the IBM

[62] SweetSense. http://www.sweetsensors.com/
[63] SweetSense. http://www.sweetsensors.com/sweetdata/kenyarapid/
[64] USAID Kenya RAPID Fact Sheet – January 2018. USAID. https://www.usaid.gov/sites/default/files/documents/1860/Kenya_Rapid_Fact_Sheet_Jan_2018.pdf

Foundation, the Coca-Cola Foundation) also hold a stake in the project whether through contributions of human capital, technology or financial resources.[65]

Growth Prospects: While the core of this initiative enables project managers to track performance of local water infrastructure, this model may also open up new sources of capital in two ways. First, the opportunity for international organizations to directly track their investments can potentially increase transparency and accountability, and therefore, facilitate additional capital flows. Second, aggregated data on water infrastructure performance in developing countries can help inform market research and therefore, facilitate private sector capital in supporting innovations in water delivery.[66]

[65] Ibid

[66] SweetSense Inc. Case Study. Aeris Communications, Inc. 2016. http://info.aeris.com/hubfs/SweetSense_Case_Study.pdf