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On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption, and Transformation in Financial Services

PETER GOMBER, ROBERT J. KAUFFMAN, CHRIS PARKER, AND BRUCE W. WEBER

PETER GOMBER (gomber@wiwi.uni-frankfurt.de) holds the Chair of e-Finance, Department of Information Systems, Faculty of Economics and Business Administration, at Goethe University of Frankfurt, Germany. He acquired his Ph.D. from the Institute of Information Systems at the University of Giessen, Germany. He is co-chairman and member of the Board of the E-Finance Lab, an industry-academic partnership between Frankfurt and Darmstadt Universities, and leading industry partners that include Deutsche Börse, IBM, DZ Bank, Finanz Informatik, and FactSet. He is a member of the Exchange Council of the Frankfurt Stock Exchange, and the Consultative Working Group of the Secondary Market Standing Committee of the European Securities and Markets Authority. His academic work focuses on digital finance and fintech, information systems in financial markets, market microstructure theory, regulatory impact on financial markets, and innovation in electronic trading systems. He serves as editor in chief of *EFL Quarterly* and associate editor of several other journals. His research publications have appeared in *Journal of Business Economics, Journal of Information Technology, Decision Support Systems, European Financial Management*, and many other journals, research monographs, and conference proceedings.

ROBERT J. KAUFFMAN (rkauffman@smu.edu.sg) is a professor of information systems, School of Information Systems, Singapore Management University (SMU). He holds a Ph.D. from Carnegie Mellon University. He serves as associate dean (Faculty), and previously was associate dean (Research) at SMU. He was a Distinguished Visiting Fellow at the Center for Digital Strategies, Tuck School of Business at Dartmouth; the W.P. Carey Chair in Information Systems at Arizona State, and was professor and director of the MIS Research Center at the University of Minnesota, while chairing the Department of Information and Decision Science. His research focuses on technology and strategy, the economics of information technology, financial services and technology, managerial decision making, and e-commerce. His work has appeared in *Information Systems Research, Journal of Management Information Systems, MIS Quarterly, Telecom Policy, Decision Sciences, Management Science, Review of Economics and Statistics*, and many other journals. He is editor in chief of *Electronic Commerce Research and Applications*. He has served in senior leadership roles for conferences and has funded industry research projects, and has also served on

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Chris Parker (chris.parker@psu.edu; corresponding author) is an assistant professor of supply chain management in the Department of Supply Chain and Information Systems in the Smeal College of Business of Pennsylvania State University. He also works with the Information Communication Technology for Development (ICT4D) Consortium, housed in the College of Communications. He earned his Ph.D. at the London Business School in the Management Science and Operations Department. His research addresses questions at the interface of operations management and information systems. His publications appear in *Management Science, Journal of Management Information Systems*, and *Transportation Science*.

Bruce W. Weber (bweber@udel.edu) is dean of the Lerner College of Business and Economics at the University of Delaware, where he is a professor of business administration and an affiliated faculty member of the Institute for Financial Services Analytics. He serves on the Advisory Council of the SWIFT Institute. He holds a Ph.D. in decision sciences from the Wharton School of the University of Pennsylvania. He was previously a professor of information management and Subject Area Chair for Management Science and Operations at London Business School, and on the faculty of the Stern School of Business at New York University, and Baruch College, City University of New York, where he was the founding director of the Subotnick Financial Services Center. His work evaluates the economic advantages of digital markets, and highlights the new challenges facing traders, managers, and regulators in an increasingly computerized financial services industry. His research on information technology strategy, financial sector computerization, and compliance systems has been published in leading academic journals and has been cited in the *Wall Street Journal* and the *Financial Times*. His books are *The Equity Trader Course* (Wiley, 2006) and *Mastering Equity Trading through Simulation* (Wiley, 2010).

Abstract: The financial services industry has been experiencing the recent emergence of new technology innovations and process disruptions. The industry overall, and many fintech start-ups are looking for new pathways to successful business models, the creation of enhanced customer experience, and approaches that result in services transformation. Industry and academic observers believe this to be more of a revolution than a set of less influential changes, with financial services as a whole due for major improvements in efficiency, customer centricity, and informedness. The long-standing dominance of leading firms that are not able to figure out how to effectively hook up with the "Fintech Revolution" is at stake. We present a new fintech innovation mapping approach that enables the assessment of the extent to which there are changes and transformations in four areas of financial services. We discuss: operations management in financial services and the changes occurring; technology innovations that have begun to leverage the execution and stakeholder value associated with payments, cryptocurrencies, blockchain, and cross-border payments; multiple innovations that have affected lending and deposit services, peer-to-peer (P2P) lending, and social media use; issues with respect to investments, financial markets, trading, risk management, robo-advisory and services influenced by blockchain and fintech innovations.

KEY WORDS AND PHRASES: business models, digital banking, financial services, Fintech Revolution, lending, markets, market operations, payments, process transformation, technology disruption, technology innovation.

> *In every major financial market innovation, there is a lag between early adoption and regulatory acceptance. That is true of fintech, just as it was true of derivative products. . . . The maturation of fintech from its relative infancy to a more robustly understood and regulated set of products and services will be a process, and it will take time and effort. That fintech offers great promise in creating economic value is not in dispute; the issue is whether fintech products and services are transparent enough for regulatory oversight and understanding. This is going to be a challenge, as it always is for financial market innovators. But it is essential for the long-term success and public acceptance of fintech.*
>
> —Arthur Levitt, Board Member, Bloomberg, and Ex-Chairman, Securities Exchange Commission [140]
>
> *What is Fintech? Fintech is a portmanteau of financial technology that describes an emerging financial services sector in the 21st century. Originally, the term applied to technology applied to the back-end of established consumer and trade financial institutions. Since the end of the first decade of the 21st century, the term has expanded to include any technological innovation in the financial sector, including innovations in financial literacy and education, retail banking, investment and even crypto-currencies like Bitcoin*.
>
> —A definition of *fintech* [81]

The firms in the financial services industry perform a range of functions to facilitate financial economic activity in modern economies. Hatzakis et al. [74, p. 633] provide an authoritative definition of what the term "financial services firms" means, as follows: "primarily firms in retail banking, commercial lending, insurance (other than health), credit cards, mortgage banking, investment advisory, and asset management (mutual funds, hedge funds, etc.)." In 2016, financial services and insurance accounted for 7.3 percent of gross domestic product (GDP) (US$1.4 trillion) in the American economy [127], and peaked at 8.4 percent in 2011 [98]. Also in 2016 in the European economies, financial services and insurance represented approximately 5.1 percent of total GDP with about 2.6 million people employed in financial services and insurance [55].

For decades and at least until the 2008 financial crisis, the financial services industry and the firms that compose it were traditionally a bastion of corporate stability and safe employment. Today the industry is being buffeted by new forces of technological innovation, process disruption, and business transformation, resulting in a new economy playbook for the services produced and the operational

capabilities that are built.[1] Financial firms lend to business and household borrowers, provide accounts and transactions services, offer investments, debt and equity financing, and provide risk management services such as insurance policies and foreign exchange (FX) forward contracts. To do this in cost-effective ways, during the 1970s and 1980s the financial industry built mainframe computing in the commercial banking, securities, and insurance sectors that led them to become the most intensive and innovative users of information technology (IT). By the 1990s, expanding expenditures on IT was more the norm than the exception, as the industry moved into the Internet economy. An example is the merged FleetBoston, which announced in 1999 that it would spend in excess of US$100 million to launch Internet banking services to cover its main commercial and retail banking services [85]. In contrast, by 2015, leading American banks, Bank of America and J.P. Morgan, filed reports with the Securities Exchange Commission (SEC) that they would spend more than US$400 million and US$500 million, respectively, to defend against cyberattacks and ensure secure accounting, operations, data processing, and other core banking functions [113]. Overall, banking industry IT expenditures were earlier forecast to rise to US$480 billion in 2016 in total as a portion of the annual projected spending on IT of US$2.7 trillion around the world [80].

What Is the Fintech Revolution?

The new developments associated with the Fintech Revolution are best understood based on recent statistics from VentureScanner (www.venturescanner.com), which has tracked new ventures in many different start-up areas, including fintech start-ups (as well as energy, transportation, Internet of Things [IoT], 3D printing, health care, and virtual reality, among others). In the late fourth quarter 2017, VentureScanner [144] listed on the order of 1,537 companies in 64 different countries having received US $80.4 billion in venture capital funding for their fintech innovation start-up activities. In addition, it has reported that 291 other companies in 74 countries have raised US $4.5 billion for bitcoin-related initiatives. Another related fintech start-up category is insurance technology, with 61 countries and 449 companies involved, and US$19.5 billion in capital raised. The fintech start-ups are only matched in capital formation by these other areas in global entrepreneurship: transportation technology (642 companies, US$95 billion), energy technology (544 companies, US$US58.9 billion), retail technology (1,151 companies, US$54.5 billion), health-care technology (1,497 companies, US$54.2 billion), and IoT (1,291 companies, US$45.4 billion). These numbers represent a major expansion in start-up funding since the recession in the 2000s. They were only seen during the e-commerce and Internet era of the late 1990s, and then only on a much more modest scale. These capital formation activities represent one of the largest historical expansions in entrepreneurship to date among modern economies.

The foundations of the Fintech Revolution rest on three separate pillars of innovation. First, as we have noted above, are the large amounts of capital available

for technology innovation for financial services in a highly fertile area of the global economy. To wit, *The Economist* [137] noted that the

> magical combination of geeks in T-shirts and venture capital that has disrupted other industries has put financial services in its sights. From payments to wealth management, from peer-to-peer lending to crowdfunding, a new generation of startups is taking aim at the heart of the industry—and a pot of revenues that Goldman Sachs estimates is worth $4.7 trillion.

Second, these start-ups have developed new technologies and designed new services for the finance industry that are different from what the industry has been able to offer, and typically address the needs of financial services consumers in very direct, valuable, and future-forward ways.[2] Third, they have transformed business models, financial intermediation, and customer access by extending it outside branches and beyond normal banking business hours; achieved higher levels of personalization based on digital sensing and big data analytics; substituted for traditional banks and their services in new ways; financialized business processes that were heretofore operated in different ways (e.g., making lending a crowdfunded, platform-based business; and hybridized services that are delivered in new and more attractive nonbanking channels [69].

Key Forces: Technology Innovation, Process Disruption, and Services Transformation

Three aspects of the Fintech Revolution that are at work in our times deserve additional comment to set the stage for our area-by-area analysis in this article: technology innovation, process disruption, and services transformation.

Technology Innovation

Technology innovation is widely recognized as being the main engine behind economic growth and industrial transformation. And if anything is true in the technology industry, it is that the pace of technology change is ever-increasing, inexorable in its advance, and more transformative in its effects. Brynjolfsson and McAfee [19] have argued that we now are living in the "Second Machine Age," which was jump-started in 1997, when the Russian chess master Gary Kasparov was beaten by a computer chess program, IBM's Deep Blue, in a chess match conducted under the standards for chess master competitions. The authors' reference to the words "digital," "exponential," and "combinatorial" are indicative of why everything seems to be moving so fast, one innovation feeding on another before it, and these and other new emerging technologies coming together to create heretofore unseen and unimplemented new capabilities in leading global industries.

Prior research has shown that technology innovation can be described in terms of three basic technology elements: components, products and services, and infrastructures [3, 4].

Together, these can be used to characterize the manner in which they can be connected in nearly "Lego building-block style" to create the new technology capabilities that characterize our world. One should view these elements as being sociotechnical in nature, and not purely technical. This is because, although the development of new technology components is mostly based on electrical and computer or software engineering (e.g., the miniaturized cameras in mobile phones, application-specific integrated circuit boards for ASIC bitcoin mining hardware, or algorithms for pattern recognition in image detection), products, services, and infrastructures are all based on societal demand. Products and services are created for consumers to buy and use them. And yet, usage and diffusion can often be dramatically enhanced by creating digital infrastructures that bring them to the wider public via the Internet, streaming music and video services (e.g., Spotify, GooglePlay, Last.fm, and others that drove the diminution of music album and movie sales in CD form in lieu of AAC, AIFF, MP3, MP4, AVI, and others). In the financial services arena, we have seen this over the years with digital brokerage and online stock trading services that are networked for trade execution in the market.

Process Disruption

Although we believe that many different processes have been disrupted by emerging fintech innovations, it is also fair to say that the entire financial services industry has been disrupted in fundamental ways. A hopeful view of this suggests that it is time for financial institutions to "embrace disruption" and prepare for the development of more effective organizational strategy in financial services by leveraging the breakthrough fintech innovations of our time. A number of technology-driven disruptions suggest how the financial service landscape will look in the year 2020, according to PwC [121, p. 6]. The disruptors they have identified include the following:

1. The fintech approach will be the new model in the industry, the sharing economy will become more fully embedded in financial services, and the mainstream of products and services will become more fully digitalized and offered through technology platforms.
2. Blockchain will take root beyond cybercurrency applications; public cloud services will dominate; robotics and artificial intelligence (AI) will continue to achieve critical mass in their diffusion in financial services, resulting in more localized services; and cybersecurity will become a more critical risk to financial services firms than fraud and money laundering.
3. Customer intelligence is likely to emerge as the most important driver of financial firm profitability, and regulators will become as active with fintech innovations as the firms it oversees.

Amid the technology platform-driven disruption, Dhar and Stein [48, p. 32] asked a key question regarding trust for fintech platform success: "Will future investors trust fintech platforms to the degree that previous generations have trusted traditional banks? What will it take for fintech platforms to be trusted sufficiently by future

generations?" Similarly, in the push of industry firms to achieve deeper customer intelligence, what can financial services customers do to defend themselves, and not lose trust related to the extent to which their product and service preferences are data-mined, digitally tracked, and technologically recovered [86]? Will "know your customer" (KYC) take on a new offensive meaning, beyond its standard defensive meaning for anti-money laundering, and customer-as-counterparty risk management?

Services Transformation

The result of these changes and transformations is that financial services will operate in new and different ways from those that have been observed before. During the prior and present eras, large financial institutions have mostly been in charge of how things work, with clearing float in bank checking transactions, delays in the transfer of funds to customers in electronic payment-related transactions, slower processes for opening bank and brokerage accounts, and costly and expensive FX currency pair trades and financial remittances overseas.

And yet, what many of us have observed over the years is less-than-best outcomes associated with innovations in financial technologies before they came to be called "fintech innovations." A fair argument to make in light of the historical developments we have observed in the past is that not many of them have been transformational or successful in the long run. Some that were less successful than was hypothesized in academic research come to mind, especially computerized loan origination systems (CLOS) [64]. Hess and Kemerer [78] sought to understand why the traditional predictions of fundamental changes to the financial services had not proved to be true, according to the electronic markets and hierarchies hypothesis [107]. Some of the main players included First Boston Corporation's Shelternet, Citicorp's Mortgage Power Plus, American Financial Network's Rennie Mae, Prudential's CLOS, and PRC's Loan Express. On the wholesale financial markets side, J.P. Morgan's CapitaLink electronic bond issuance systems in the early 1990s failed to create much impact before the Glass–Steagall shelf registration rules for debt issues by non-investment bank financial services firms were repealed [73].

Some other well-known names in financial technology entrepreneurship had similar experiences, including Mondex in the UK for cash-alternative retail transactions, and Financial Engines for corporate subscribers' employee pension fund portfolio construction. Another example is Optimark for institutional trading by price-time-quantity bids for large blocks of shares, which did not survive in spite of its major innovation of a three-dimensional order book. The same can be said for WIT Capital, the first Internet-based equity issuance firm in the United States, which was always close to contravening SEC rules for inappropriate investor solicitation and inappropriate use of the Internet.

Therefore, we ask: What is likely to raise the percentage of market successes of newly marketed and venture capital-funded fintech innovations? Will the Fintech Revolution yield a better track record compared to the past? We think that this will

come to pass in the future. Financial services are created and delivered through complex systems in business with processes, organizational and operational structures, human capital and talent, and a variety of choice behaviors, subject to ethical, regulatory, and legal restrictions. Incumbents and new entrants continuously seek to improve customers' and users' experience and raise the performance of their products, services, and capabilities, for example, related to ATMs, online brokers, and index and exchange-traded funds (ETFs).

The fundamental difference today is the new abundance of data, the increasing maturity of the data infrastructures and integrated systems that have been deployed to process it, as well as the emergence of pattern recognition, data mining, machine learning (ML), and other digital-sensing tools in the financial services environment that can utilize it. In addition, there is much broader awareness that financial institutions and fintech start-ups can be mutually supportive, and not just competitors in the same space [49]. We will argue that the preconditions are now in place to create and co-create business value through changed cost and benefit flows, and to permit the core entrepreneurial actions of start-up firms to enable them to achieve high performance in competitive markets. Fintech innovation strategies will continue to develop, involving continual experimentation, learning, and adaptation—experimenting with experimentation [35, 86].

Mapping the Fintech Innovation Landscape

We next present a new mapping to enable readers and researchers to understand the fintech innovation landscape better. Our representation is based on key elements of several prior frameworks. They enable us to make a clearer assessment of how the transformation of technological innovation, process innovation, and financial services has been occurring over the past seven or eight years, as the Fintech Revolution has intensified.

We begin with the observations that Chesbrough [28] made in his book, *Open Innovation*. He offered a 2 × 2 innovation matrix that consists of the actions and innovations that can be achieved when both the problem definition and the domain definition are either well-defined or not well-defined. He began by noting that basic research is typically conducted to establish new scientific and technological outcomes when both the problem and the domain are not well-defined. He further observed that, when the problem is well-defined but the domain is not, there is an opportunity for a breakthrough innovation that can be widely used in many settings. By the same token, Chesbrough refers to a "disruptive innovation" as one for which the problem is not well-defined, while the domain is. When both the domain and the problem are well-defined, it is a "sustaining innovation."

This conceptualization of technology innovations is useful in terms of the main constructs, but less well-suited for application in the fintech innovation context. Consider the following example. In 2008, a P2P electronic cash system proposal related to bitcoin was presented in a technical article that focused on the underlying digital cryptography for ensuring that digital coins could not be spent twice [115],

something that other digital cash proposals from the 1990s and earlier 2000s were not able to do. The widespread belief of computer scientists, banking technologists, and technology entrepreneurs has been that the idea of a blockchain—in laymen's terms at least—is perhaps viewed as the defining "disruptive, breakthrough technological innovation" of the Fintech Revolution overall [111]. And yet these words are used in Chesbrough's innovation matrix for settings in which the domain of application is not well-defined (breakthrough innovation) or the problem that is targeted for solution is not well-defined (disruptive innovation). So although the innovation matrix clearly identifies blockchain as being disruptive (which is appropriate, in our view), the domain of its application in the first publication that demonstrates its use is to cashless digital payments, and no claims are made with respect to its generality. Those would only come later.

For our own evaluative approach for identifying the different kinds of fintech innovations related to the kinds of impacts and effects they have, we further considered the more recent contribution by Pisano [119], who presented an enhanced 2 × 2 technological innovation map. Based on Chesbrough's work, Pisano's approach is useful to effectively characterize the innovations of the Fintech Revolution. Pisano's first dimension gauges whether a new innovation permits the leveraging of existing competences or requires new technical competences in the organization. The second dimension, in contrast, assesses whether an existing business model can be leveraged or a new business model must be created.

The author refers to routine innovation as that which permits existing technical competences to be utilized within an existing business model. A radical innovation, however, permits the firm to continue using its existing business model, while it must create new technical competences; and a disruptive innovation is one for which the firm is able to continue to use its existing technical competences, but must shift gears to create a new business model. As we will show, fintech innovations seem to fit into both categories of innovation—radical and disruptive, yet many seem more well-suited to being recognized as what Pisano refers to as "architectural innovations"; in other words, fintech innovations often involve new technical competences and a new business model for effective value appropriation.

With these observations in mind, we further consider two kinds of effects that occur with the introduction of fintech innovations. One is based on the manner in which the customer's experience (first dimension) is affected either by improved functionality or new products, services and functionality, and the second is based on whether there are complementary or disruptive effects from the new technology that are felt in the marketplace and in the context of firm-to-firm competition (second dimension). An older business model typically requires modest enhancement to accommodate updated processes, while a new business model may be required to accommodate the transformation of the related business process into business value. Through the application of the customer experience dimension, we are able to assess whether existing functionality is sufficient or new functionality is needed to support new products and new services. See Figure 1.

	Contrasts Between the Effects of Fintech Innovations That Are Observed	Customer Experience with the New Financial Services	
		Enhancing Experience with New Products, New Services, and New Functionality	Supplementing Experience with Improvements in Existing Functionality
Markets and Competition	**Disruptive Effects from:**		
	• New business models • New market mechanisms • Shared tech infrastructures • Disintermediation of banks • Segment-of-one marketing • Cross-border innovations	Blockchain-based markets, initial coin offerings (ICOs), cryptocurrencies, global remittances, FX applications, high-frequency trading (HFT), crowdfunding, P2P lending, online-brokerage, cross-border payments, open banking	Open banking/APIs, faster payment settlement, increased settlement efficiency with blockchain, smart contracts in trade services and lending, cross-border custody services, e-services piggybacking, higher functionality payment cards
	Complementary Effects from:		
	• Enhanced business models • Extended access by customers • Hybridized services by firms • Shared tech infrastructures • Open APIs	Social trading, digital wallets, robo-advisory services, branchless banking services, big data-supported customer intimacy, personal financial management (PFM), financial research exchanges	Investment communities, mobile payments, blockchain-based general ledger functionality, risk management technology, regtech solutions, account deposits without branches, fintech trade support

Figure 1. Fintech Innovation Landscape: The Market-Competition-Customer Experience View

In this article, we apply this new framework to the following fintech innovation areas: financial services operations, payment services, deposit and lending services, and financial market and investment-related services.

How the Fintech Revolution Is Changing Financial Services Operations

Operations are a key feature of financial services including systems design, performance analysis and productivity, forecasting, inventory and cash management, waiting line analysis for capacity planning, personnel scheduling, operational risk management, and pricing and revenue management [74]. Key components of financial services operations include high volumes and significant customer heterogeneity, repeated services interactions, and use of technology in the service encounter. The new fintech approaches are changing all these things in dramatic ways: by creating a new basis for harmonizing investments across business partners and competitors too; through the new availability of products and services that have a different operational basis, with diminished human involvement on the purely transactionsal aspects, supported by machine intelligence where that is appropriate, and human involvement when that can add value; via the reduction of cross-border breaks in transaction servicing; and with new approaches to the management of customer and operational risk through new ML and AI applications.[3]

Relatively recently, the cost to launch a tech start-up began dropping because of open source software (e.g., the Tensorflow library to support machine intelligence, www.tensorflow.org), and easily scalable infrastructure (via Amazon Web Services, Google Cloud, etc.). This has allowed new entrants into the market to create niche products that target very specific groups of customers based on their characteristics. The problem for incumbents is that the highly targeted companies are attacking each product they have on offer, and that this leads to the unbundling of financial services [31, 100]. These new fintech business models have forced businesses to become

more customer-centric by offering customers just what they want through more effective bundling [71], and also have changed how researchers think about operations within financial services. We focus on four core aspects of financial services in which large operational changes are driving significant improvements: transitioning to branchless banking, real-time transaction and credit monitoring, credit scoring and approval, and transformations in customer acquisition and retention.

Transitioning to Branchless Banking

Traditionally, physical bank branches have served as the primary point of contact for facilitating retail banking and customer transactions. As technology improves, customers are switching from in-person to digital transactions through a complementary effect delivered by the enhanced access to digital banking services, and an enhanced experience of new digital access products, services, and functionality. For example, many banks now allow for physical checks to be deposited through a mobile application on a smartphone with a camera. The transition has also opened up the market for nonbank firms to offer financial services. Millenials are particularly susceptible to new entrants as 84 percent now would consider obtaining their banking services from a major tech company such as Google or Apple [97].

Given the relatively recent innovations, very little is known about how mobile banking influences consumer behavior. Campbell and Frei [24] have reported that the adoption of online banking can result in substitution by alternative service channels, changes that require services to be provided by them, as well as an overall increase in the number of transactions that the alternative channels have to process. These three levers combine to actually increase the short-term costs of serving a customer, but online banking services increase the likelihood of long-term customer retention. Liu et al. [104] have shown that consumer use of mobile apps has led to increased demand for other digital services, and complementary effects between mobile and tablet use. They also report that mobile phone and tablet users are less likely to pay credit card fees. The combined effect of the changes in customer behavior is a net benefit to the bank of about US$0.07 per month for the average customer. The extent to which these factors affect bank profitability and retention appear to be moderated by the customers' efficiency of use of the digital offerings [152]. Trust also plays an important moderating role in facilitating the transition from offline to online transactions [10].

Lower transaction volumes at physical branches and the reduced costs of facilitating transactions digitally create a strong incentive for banks to reduce their branch footprints. This is because bank branch systems are known to facilitate relationship-based banking better than transaction-based banking, which has paved the way for technology substitution [65]. It has also been reported that banks with extensive branch systems may underperform others that are more committed to operating in multiple channels [47]. Combined with bank consolidation in the wake of the 2008 financial crisis in the United States, the changing economics of physical branch

networks led to significant declines in the number of branches throughout the country [2], and this trend seems to be continuing unabated as the Fintech Revolution has advanced.

Researchers are now beginning to get a better picture of the impact of branch network changes on customer banking behavior as well. Abhishek et al. [1] have shown that branch openings increase digital and nondigital transactions, while branch closures generally lead to increases in cost-effective transitions of costs to digital channels. Interestingly, there is significant customer heterogeneity in response to changes in branch networks though. Customers who are heavy branch users, and who may reasonably be expected to be the most affected, are less affected by changes to the branch network.

In addition to the transition to more digital transactions, banks are continually experimenting with new models to reduce the cost of their physical bank branches. For example, in the past USAA collaborated with UPS to allow check deposits at any UPS store, thus, in principle, reaching customers who did not have a smartphone. Although USAA canceled this program due to operational problems, this situation demonstrates that business models targeted at bringing cash and physical checks into the digital banking system are needed. In fact, more research is worth undertaking so we can better understand how relatively underserved customers can be brought into the formal financial system in a cost-effective manner.

Real-Time Transaction and Credit Monitoring

From the customer perspective, monitoring transactions and credit has historically been stressful and subject to significant time delays. Customers generally had to rely on fraud detection algorithms and notifications from their bank. Through the substantial efforts that various authors have put into improving the models [56, 96], the high costs associated with missing fraudulent transactions continue to create the impetus for significant investments in developing sophisticated algorithms for detection (e.g., Fawcett and Provost [56] and Kou et al. [96]) The advent of mobile banking means that ML models being deployed by financial services firms today are able to leverage real-time location data to improve detection of fraudulent transactions.

Despite improvements in individual firms' algorithms, consumers seeking to track their transactions must still monitor multiple different websites to remain alert to possible fraudulent activity. Businesses have responded by providing their customers with free access to a consolidated view of their transactions, via services like Mint.com (www.mint.com) or offered within the retail banks themselves, and credit monitoring via CreditKarma (www.creditkarma.com). In both cases, the business models deployed rely on creating a holistic view of an individual's personal finances, and selling targeted ad space to potential creditors. Personal financial management (PFM) services are a major element in contemporary fintech-enabled services innovation, and a way to create a greater degree of customer informedness

in the marketplace. Mint and CreditKarma enhance existing bank and credit monitoring business models by introducing easily accessible and understandable products.

The creation of a one-stop-shop for transaction monitoring and the combination of traditional credit and transaction data in one location makes for interesting opportunities in detecting fraudulent behavior. Location-based rules for credit monitoring have prevented a card from being used in one location and then again 15 minutes later over 100 miles away. Simple rules can allow the monitoring of cards jointly for fraudulent transactions based on when another card was used. Careful profiling of customer purchase patterns on one card can also help develop purchase patterns for infrequently used or potentially new cards. It is possible that fraudulent credit applications can also be denied or put into a process for further customer verification by determining the types of credit a customer may apply for.

The consolidation of data also creates a single point of failure where hackers can gain access to all of a customer's financial data. The rapid uptake of monitoring services shows that consumers currently value the consolidation more than the unknown future cost of a breach, despite large security failures at, among others, Equifax. Furthermore, little is known about how they affect consumer behavior. On the one hand, CreditKarma reduces the cost of monitoring credit and therefore may lead to more responsible credit behavior. On the other hand, the cost of applying for new credit is also reduced, possibly resulting in an increase in revolving-credit accounts and a general degradation of credit. This is a difficult empirical question that requires a careful consideration of how borrower selection works at CreditKarma, how borrowers choose to apply for new credit there, and what the nature of their large and rich data set is.

Credit Scoring and Approval

Credit scoring is the process a company uses to decide whether to grant or deny credit to a potential borrower.[4] Consolidated data have also led to changes in credit scoring itself. In developing economies, alternative credit scores are being built based on mobile phone usage, such as the call records and billing data. Alternatives are also appearing that combine mobile phone, browser, social network, and traditional transaction and credit data to create credit scores, such as Lenddo in Singapore (www.lenddo.com).

In developed economies, data mining has the potential to revolutionize mortgage approvals. Despite an estimated US$1.8 trillion in mortgage originations in 2017 [58], much of the process of applying for and being approved for a mortgage is still manual. Several companies are attempting to disrupt this market by moving manual processes online in an attempt to reduce both financial and time costs of obtaining a loan. SoFi (www.sofi.com) moves much of the approval process online and incorporates an applicant's education in their determination of whether to provide a loan. Rocket Mortgage (www.rocketmortgage.com) from Quicken Loans has regional mortgage

application reviewers that are familiar with local regulations and standardize the process. Sindeo [128] (www.sindeo.com) claims to be able to close in 15 days compared to an average of 46 days.

Businesses are setting up to simplify the data collection and verification processes more broadly than just for mortgages. For example, Plaid (www.plaid.com) has created a backend platform and application programming interfaces (API) that allow users to connect their bank accounts seemlessly within another app. Plaid's platform can then verify income based on historical deposits, streamline automated clearing house (ACH) authentication, and verify the identity of a customer to ensure adherence to KYC protocols. Two processes that are being streamlined involve getting data directly from a customer's bank and then using it to validate the person's income. Companies such as Waddle (www.waddle.com.au) and Wave (www.waveapps.com) do something similar for business loans based on invoice data, while Mint, Earnest (www.earnest.com), and CreditKarma use transaction and/or credit data to recommend financial products to individuals with some level of confidence that the application will be approved.

Loftium (www.loftium.com) is an example of another emerging business model targeted at making mortgages easier. Loftium provides up to US$50,000 toward a down payment in exchange for a fraction of 12–36 months of shared AirBnB income in the new home. The requirement is typically to have your room listed for all but eight days of the year with Loftium, with approximately 65 percent occupancy expected.

Advances in the credit scoring market are broadly complementary due to the relatively behind-the-scenes nature of new credit scoring and approval models. With the exception of Loftium, many of the innovations in this area supplement the customer experience. Researchers need to understand how simplifying credit scoring and approval impacts customers. Search and transaction costs have been dropping, and this has been leading to a more efficient market for PFM services. Small business can also more easily smoothe their cashflows. Both of these should lead to lower defaults for individuals and businesses. However, current research shows that online lending made available by Lending Club has resulted in an 8 percent increase in personal bankruptcy filings [145]. More research is needed to understand the short- and long-term consequences of ease of access to credit and how this interacts with customer heterogeneity.

Transformations in Customer Acquisition and Retention

One of the major promises of the Fintech Revolution has been to create the ability to reliably reduce customer acquisition costs. For example, companies such as CreditKarma and Mint were created to mine data in order to build highly-targeted recommendations to consumers in an attempt to reduce acquisition costs.[5] They partner with credit card companies, banks offering traditional and/or online-only checking and savings accounts, a large range of investment firms, and auto and life insurance providers. Major companies leverage the platforms to attain new

customers at a relatively low cost compared to traditional physical mailings. In doing so, they improve customer intimacy through big data as the result of new, hybridized products and services.

However, the same forces that have led to a reduction in customer acquisition costs have also reduced the cost of a customer's switching to a competitor. For example, a customer on Mint is constantly bombarded with ads from competitors, and is even shown ads for a different card within the same firm, creating intrafirm competitive forces. This makes customer retention a more difficult problem, and firms must now become much more coordinated and customer-centric. Operational costs such as increased call-center volume or the creation of intelligent AI chat bots for customer service are needed to retain customers.

The need to be customer-centric is especially important among fintech firms, which usually implement business applications that require high levels of self-service by their customers. Scherer et al. [126] have reported that the shift from personalized service to self-service initially leads to decreases in customer defection, but later exhibits an inverted U-shape, such that defections begin to increase again as the extent of customer self-service continues to climb. They also found that the effect diminishes over time, and recommend that the beginning of a financial services relationship should be more personal-service-oriented, and followed by a transition to self-service later. This is inconsistent with the way many fintech firms are set up and must be further explored in research.

One way that firms can distinguish themselves is to make traveling and purchasing abroad easier. For example, 45 percent of Gen Y professionals in Australia surveryed by KPMG [97] responded that they find easy access and management of funds while traveling abroad to be extremely important. Another option is to take advantage of network effects and socialization like those seen in the P2P money transfer platform Venmo (venmo.com). Nevertheless, all firms will need to carefully monitor their key metrics in this area, as the acquisition and retention landscape will become more competitive as big tech companies such as Apple and Google wade into the personal finance space.

Toward the Cashless Society: The Fintech Transformation of Payment Services

Payment services have always been at the forefront of technological change and of innovative approaches that have been used to transform the nature of payment processes for consumers. For example, in the 1970s and 1980s, the cooperative Society for Worldwide Interbank Financial Telecommunication (SWIFT) was a leader in implementing a global telecom network that carried different kinds of short preformatted messages in support of international banking communications. Later, stand-alone bank-connected ATMs were deployed, followed by shared networks of multiple banks' ATMs [90], and later network universality capabilities that brought CIRRUS and PLUS together in the United States [92], and then around the

world. So, when it comes to considering the application of financial technology solutions in the payments arena, it is not a matter of a handful of isolated events, but instead a developing stream of innovations that eventually led to the transformation of services access, higher functionality, and ultimately new revenue strategies and sources for commercial banks that deployed credit card services [62]. McKinsey & Company [12] has commented that the payments sector is currently undergoing digital disruptions via the entry of nonbank digital competitors, the modernization of payments infrastructures around the world, the move to establish new efficiencies in cross-border payments, and the broader digitalization of domestic banking transactions.[6]

The Forces at Work for Fintech Innovation to Address Faster Settlement of Payments

One of the leading targets of the Fintech Revolution has been to speed up the settlement of domestic payments. This has been recognized as an increasingly important public policy issue for banks and the governments that regulate them. The definition of "faster payments" is that they involve "domestic, inter-bank … purely electronic payment systems in which irrevocable funds are transferred from one bank account to another and where confirmation back to the originator and receiver of the payment is available in one minute or less" [57, p. 12]. Faster payments (also referred to as "faster settlement") typically mean that funds are transferred from one financial institution to another, such that the payee benefits from the receipt of irrevocable funds that can be immediately deployed for any purpose [11]. Different countries typically view "faster" in relevant terms (whether within minutes or hours during the same day), since some already have relatively fast mechanisms to make funds available to their customers, while others have achieved some form of "faster," though there are no global standards recognized by any payments standards or operational process regulators.

There are a variety of interpretations as to why this is so important. A simple explanation is that the world has changed so much in the past fifty years, with faster computers, more capable networks, competition, technological innovation, and social demands that change is inevitable amid the forces. For example, an industry-leading payment services provider has commented on why e-commerce has been so central to recent developments:

> Many payment systems around the globe are undergoing fundamental changes to reflect the new realities of digital commerce, especially when it comes to the speed in which payment requests are processed. The electronic payment systems that were designed in previous decades can no longer meet all of the expectations of a society where devices with enormous computing power are literally in the hands of most adults and instantaneous response has become the norm, even when it isn't necessarily required for business reasons [57, p. 9]

Yet, the norm in most of the world is that payment settlement is governed by substantive and complex considerations about payment settlement mechanism design, incentive compatibility, and liquidity management from the viewpoints of financial institutions and their regulators [70].[7] Some countries have sought to move aggressively to embrace faster payment, including Australia, Singapore, Sweden, and the UK, where the regulatory and political situations are conducive to such change. In this context, it is important to distinguish between delayed net settlement (DNS) and real-time gross payment (RTGS) systems.[8] DNS involves the accumulation of payments, so that one can be netted against another, before irrevocable funds are made available, in a way minimizes the need at any time for additional liquidity to make settlement possible, but this also makes the delay of funds availability likely at times. In contrast, the RTGS approach supports the individual processing and settlement of payment transactions, resulting in the irrevocable availability of funds on an immediate basis. The complications that arise are due to the need for central bank involvement to inject intraday liquidity, so that the effects of payment imbalances are neutralized in the process of continuous, real-time settlement, albeit with higher operational and monitoring costs [13, 125]. Central banks typically have provided liquidity for a cost of funds-plus fee to make the payment settlement process smooth, or they may require participating banks to back any liquidity loans with collateral, so the intraday credit risk that the central bank assumes is strictly limited [5].

RTGS systems have been implemented since the 1990s, especially for the exchange of large payments between banks [6], but their benefits have not been extended to retail banking customers. The current work in the fintech arena is to make faster settlement of payments work for small-value retail payments. The number of such transactions is far larger, though the total dollars that are transacted are typically an order of magnitude or two less in value. Similar to large-value payments, it is also possible sometimes for there to be payment transaction value imbalances that make it more difficult for a settlement intermediary to operate without prior agreement with the central bank on how liquidity injections will be handled. Recent research has aimed to test the effectiveness of a hybrid near real-time gross settlement system, first proposed by Willison [148] in simulation research conducted at the Bank of England in the early 2000s. This approach makes it possible for the intermediary to obtain prioritization information from bank participants on payments that can be settled via the RTGS approach, while holding back other payments for handling via the DNS approach [70]. The benefit of a hybridized approach [69] is that it will permit faster payment settlement to be continued after the normal operating hours of the central bank in a country, much as cross-networks permitted after-hours equity trade matches in the financial markets.

Major real-world experiments have been occurring with faster settlement for smaller-value payments since the mid-2000s. They include: The UK's implementation of the Faster Payments Service (www.fasterpay-ments.org.uk), the Swish mobile payments system (www.getswish.se) implemented in 2012 in Sweden [16, 118], and the 2012 rollout of the Giro 3 (G3) Clear2Pay and MEPS+ systems in Singapore [135].

These real-world investments in faster payments infrastructure emphasize the variety of research issues that are in play: network sustainability and value; an effective process for joint public–private shared payment infrastructure investments in an economy; whether the various participants have sufficient compatible incentives to bear their fair share of the investment required to achieve network and settlement mechanism viability; and how well they do with respect to the multiple goals of consumer access and handling the costs of liquidity. In addition, Australia's New Payments Platform (NPP) is currently in the process of implementation, and has one of the most comprehensive approaches to the realization of faster payment settlement. Both Australia's NPP and Singapore's G3 are viewed as having appropriate sharing of responsibility between private commerical banks and the central bank regulators for encouraging but not mandating participation.[9]

The fintech examples are representative of the following categories in our fintech innovation mapping: disruption from new business models and market mechanisms, and shared technology infrastructures crossed with effects for supplementing customer experience. This is occurring through improvements to the existing functionality of payment settlement, and the changed expectations consumers have about how banks handle electronic payments in small-value retail transaction-making.

Blockchain, Distributed Ledger Technology, and New Cybercurrencies

One of the characteristic technological innovations for financial services is the blockchain, which enables prior applications to be improved, and new applications to be deployed that were heretofore uneconomical or impractical. Underwood [143, p. 15] also commented that this

> distributed ledger technology is expected to revolutionize industry and commerce and drive economic change on a global scale because it is immutable, transparent, and redefines trust, enabling secure, fast, trustworthy, and transparent solutions that can be public or private. It could empower people in developing countries with recognized identity, asset ownership, and financial inclusion; and it could avert a repeat of the 2008 financial crisis, support effective healthcare programs, improve supply chains and, perhaps, clean up unethical behavior in high-value businesses such as diamond trading.

The central technical innovation associated with blockchain is distributed ledger technology (DLT), which is defined as the use of decentralized digital trust verification through encrypted digital signatures. An important positive assessment of blockchain technology was made a couple of years ago in the *The Economist* [138] that one should view the technology as a "trust machine." The article also encourages the reader to distinguish among three key things that need to be more fully understood: blockchain in the form of the bitcoin cybercurrency; the construction and details of the blockchain that makes it possible to use it to represent and

record value in transactional exchanges;[10] and the more general idea behind the technology innovation that it offers for more widespread use.

The first major application of blockchain was for bitcoin, which spiked to a value of nearly US$20,000 in late 2017. Yet due to the degree of its volatility over the prior five years [120] and recent meteoric price rise and fall, many observers have questioned the rationality behind its valuation. For example, the Nobel Prize–winning economist Robert Shiller has indicated that bitcoin may be subject to widespread misunderstanding because its applications are out of sync with its current valuation [53]. In addition, "the story" that underlies bitcoin's market acceptance is similar to other stories that have been associated with market bubbles. They include the Dow Jones Industrial Average run-up from October 1927 to August 1929 before the crash that began the Great Depression in the United States, the 3,000 percent rise in the value of Qualcomm stock from February 1998 to December 1999, and the rapid rise in silver prices from March 1978 to January 1980 [51]. Another Nobel Prize economist, Joseph Stiglitz, stated that bitcoin should be outlawed because it is likely to repeat the pattern of the U.S. stock market crash [53], while Jamie Dimon, the chief executive officer of JPMorgan Chase, has referred to bitcoin valuation as a fraud and a Ponzi scheme [130].

And yet there are other interesting developments with cryptocurrencies that are worthy of study. We can do better to theorize about what is happening, as well as examine bitcoin market activities with empirical research designs, because large-scale data sets have become widely available. One such example is an article on bitcoin research that goes beyond the earlier empirical work of Polasik et al. [120]. Mai et al. [106] explore the extent to which social media chatter influences bitcoin price volatility, and whether longer blog posts or brief tweets have differential impacts. Using data mining and explanatory econometrics methods, they report that the silent minority of social media participants who are fewer in number and who post more rarely seem to wield greater influence on bitcoin price changes than do the vocal majority with more voices and more frequent posts. They further found that brief tweets of 128 characters did not create as much influence on bitcoin value changes as did more thoughtful, in-depth blog posts. Another recent study was motivated by the catastrophic failure of the Mt. Gox Bitcoin Exchange platform in Japan in 2014. Geng and Kauffman [63] used cross-sectional data on bitcoin transaction penetration in 217 countries around the world to estimate a base geospatial model, as well as presecurity event and postsecurity event transaction penetration performance. They reported for the time period of their study that bitcoin's global diffusion was jointly influenced by economic, technological, and policy issues, while its penetration was held back from penetrating more widely by cybersecurity and bitcoin exchange issues. This, the authors argued, is of greater general interest, since fintech cybersecurity issues and questions about platform viability over time are likely to affect many such fintech innovations.

In spite of these concerns, the more general applicability of the technology has reached extraordinarily high interest among technologists, entrepreneurs, and investors alike [138].[11] There is nothing to hold back changing the manner in which

blockchains work, for example, by adjusting their security levels, shifting them from having public and transparent contents to making them available for private viewing and interaction only, and thereby reducing the expense for the digital cryptography hash key. Some of the blockchain applications beyond bitcoin that we have been tracking include initial coin offerings (ICOs). They involve bitcoin and ethereum blockchain apps, in which investors are able to acquire ownership of cybercurrency tokens in a start-up venture, enabling the entrepreneurs to bypass the typical reporting, due diligence, and regulations associated with initial public offerings (IPOs) of stock for equity ownership. Other financial applications include the representation in smart contracts for lending, trade finance, online identity management for transactions, pollution credit trading, as well as nonfinancial applications such as time-stamping, the tokenization of digital assets, the sharing of secure medical and legal records, the tracking of artworks and diamonds, uniquely identifying cultural and regional products in international trade, and more.[12]

Relative to the fintech innovation mapping that we have proposed, blockchain and DLT are widely recognized as having disruptive effects, by supporting new business models and transforming market mechanism services. They also have an impact on commercial banks and even central banks, due to their capacity to support financial transaction-making disintermediation. They also support an improved experience for consumers, especially due to the new services that they are making possible, while improving the existing functionality of general ledger accounting, by tying it to digital cryptography.

New Directions in Cross-Border Payments, Global Remittances, and Foreign Exchange

One of the "high frontiers" of fintech application is to diminish the high transaction costs associated with conducting business (e.g., trade contracts, FX trades, paycheck remittances, etc.) across national borders. Cross-border transactions of all sorts tend to have higher standard costs to set them up, track their progress and monitor the attendant risks, and bring them to a successful conclusion. And yet all international trade, by definition, occurs on a cross-border basis, and it acts as one of the main engines for global and domestic economic growth. The first interest in the cross-border fintech innovations area focuses on their impacts on payments, although there are applications for cross-border risk management, smart contracts, structured finance deals, and global securities custodian applications. We briefly discuss cross-border payments, global remittances, and FX market applications, with our fintech innovation mapping in mind.

Cross-Border Payments

The International Monetary Fund (IMF) is among the most incisive observers and analysts that have sought to understand the tranformation of cross-border payment

services with fintech innovations. In a speech, Dong He [75], deputy director of the Money and Capital Markets Department, indicated that the new technological approaches associated with fintech innovation are likely to affect both the nature of the services that are offered and the market structure for how the service providers are organized. He also argued that a payment is just a payment, regardless of whether it crosses a border, much the way a package is just a package whenever FedEx or global next-day shipping firms contract to deliver it.

To date, many observers have suggested that a panacea for reducing the costs and streamlining cross-border can be found in blockchain-based cryptocurrencies, such as bitcoin and ethereum. The staff economists at the IMF have been investigating whether DLT-based solutions will work well enough, but they concluded that their price volatility is a concern, as is the lack of trust in decentralized DLT operations, which may affect the value of the cryptocurrency, and the lack of cryptocurrency interoperability is likely to be detrimental to value, and will lead to undesirable network effects.

Global Remittances

The World Bank [142] estimated that the total market size for global remittances was about US$596 billion in 2017. The business area associated with global remittances is widely recognized as the domain of "finance for the poor," even though regulations have been increasing costs on the margin for sending money overseas to relatives [139]. So the large size of the market is a strong wake-up call for social entrepreneurs who wish to support the United Nations Sustainable Development Goals, especially the first one: "No Poverty." Fintech innovations for remittances provide much lower cost and more accessible services for moving money from one country to another, for family maintenance, repayment of family and community loans, sharing of expenses for international travel and education, and many other purposes. And they are creating enormous disruption for the entrenched incumbents of the global remittance industry, Western Union and Moneygram. Meanwhile, the average cost for transferring the benchmark remittance of US$200, has fallen dramatically over the years, based on the average percentage of the transaction amount charged by an average of banks and money transfer operators (MTOs), or specialty remittance services firms [141]. See Figure 2. The general business model approaches of the main start-ups in this fintech area are to create a different basis for competitive advantage, by disintermediating the highly expensive and slower turnaround bank and nonbank players, while transforming customers' service experience with much faster and cheaper remittance deliveries.

We observe from the linear global average for all remittance service providers that the percentage prices for the value of a transaction fell at roughly the same rate, but are higher for the MTOs. Their prices seem to have leveled off at 8.16 percent, while the average overall was 7.21 percent, both in Q3 2017. These represent large price

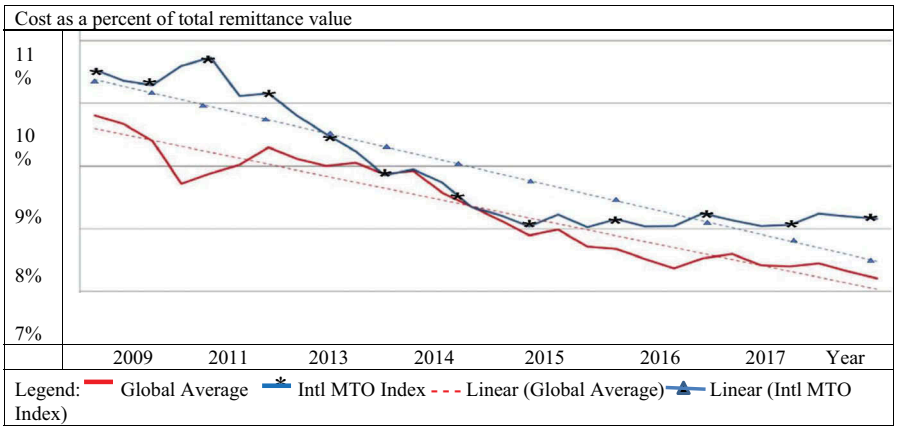

Figure 2. Average Cost for Sending a US$200 Remittance, 2009–2017
Note: Adapted from World Bank [141].

reductions in comparison to earlier, when MTOs charged about 10.6 percent in Q1 2009 on a US$200 remittance and the overall average was 9.61 percent.

There are ample opportunities for research in the remittance area, in order to gauge the effects that the fintech sector firms are having over time as their entry into the market creates a greater share of transactions. It will be interesting to empirically test how the costs of intermediated remittance services change for country origins and destinations, and the extent to which the G8, G20, and developing countries experience somewhat different, though changing costs. In addition, with the many new fintech start-ups, there will also be new contexts in which to develop theoretical insights on the basis of very large fintech-based remittance data sets. Some of them will be naturally-experimental events that country-pairs are experiencing (e.g., the entry of new fintech firms, the changes in percentage rates over time, and the extent to which causal research designs can be leveraged). Empirical cases involving longitudinal tracking of firm performance, changes, and market adaptations are also possible, since many firms track the extent to which the start-ups succeed with venture capital and other forms of fundraising. These offer IS researchers new contexts for studying fintech organizational performance that will go beyond what we see with the emphasis to date on P2P lending and crowdsourcing firms.

FX Applications

Although there are many FX applications that individuals need, the bulk of the activities in the FX area involve business-to-business (B2B) applications. The marketplace for correspondent banking services is recognized to be global and widespread, but also relatively inefficient due to the difficulty associated with generating profitability in markets that cannot easily sustain revenue-producing correspondent banking relationships. This offers opportunities for new nonbank

FX fintech start-ups to enter the market and create disintermediating P2P FX transaction platforms. These can be nearly instantaneous in their production of FX trades between counterparties, so long as there is a willingness for the paying counterparty to have some form of escrow or external guarantees.[13] American Express recently coined the term "conditional payments" for use specifically in situations where FX cross-border payments need to be carefully scrutinized to avoid counterparty fraud and default [39]. Another interesting direction is the combination of enterprise resource planning (ERP) capabilities with big data for a firm's payables and receivables that are denominated in FX, which enables dynamic hedging strategies to be undertaken, so that it is possible for a firm to strictly limit its FX exposures by adopting currency pair by currency pair hedging strategies.[14]

Fintech innovations for cross-border payments, global remittances, and FX applications can also be viewed through the analytical lens of our innovation mapping approach. Most observers will agree that cross-border payments are due for major process, pricing, and functionality changes in the coming years, due to the force of fintech entrepreneurs, who are focused on developing new products and services, new experiences for consumers, and new ways to create value in financial services. So we see a blend of disruptive and complementary effects in markets and firm-to-firm competition, especially due to the cross-border business services transformations that are already occurring. Consumers for these services will also experience the gamut of beneficial effects, including new products, new services, and new functionality that will lead to more customer-centric services. Combined with big data approaches, we expect that consumers will enjoy a new level of intimacy in their experience with payment services.

Fintech Approaches to Deposit Services, P2P Lending, and Charitable Giving

The areas of lending and deposit services are core to commercial banking at the retail and wholesale levels, and both have felt the impacts of fintech innovation. They have created a significant challenge to bankers, as P2P lending has opened up new services for many kinds of clienteles (especially artists and musicians, ethnic minorities and immigrants, and social entrepreneurs) who lack credit fundamentals, and small-business people who are unable to offer appropriate collateral or do not have sufficient personal assets or business experience. As a result, they typically are not viewed as "bankable" in credit-scoring terms: their likelihood of loan default is greater than the likelihood of their loan's profitability to the lender. Fintech lending has opened up new avenues for charitable giving in the form of loans and affinity lending, to people who are "unbankable" but nevertheless offer interesting value propositions for the craftwork they do, for example. Others may need funds due to the damage caused by natural events beyond their control (e.g., hurricanes and typhoons, agricultural droughts, tsunamis, and electrical damage to their homes and businesses).[15]

The situation on the deposit services side is different. Traditional KYC restrictions limit the ability of banks to permit new customers to open accounts or make fixed deposits, or existing customers to become involved in other kinds of riskier deposit arrangements (e.g., structured deposit products that have embedded derivatives and more complex risk profiles). The role of fintech innovation for the latter is much more focused on financial education for consumers, since current legal codes protect banking customers from signing up for structured deposit products without first gaining a solid understanding about how they work. In the remainder of this section, we will examine recent developments in these areas using our fintech innovation mapping perspective to identify the extent to which they are transforming the market, the competition among the financial services players, and the role of new technologies in these areas that are changing the customer experience. We will also assess the extent to which new directions for IS research are opening up, beyond the high populatory of mechanism design and performance in P2P lending.

Deposit Services Innovations

Providing deposit accounts, such as checking and savings accounts, and giving retail and commercial customers access to their funds remain the most fundamental and pervasive banking functions. Historically, demand deposit accounts (DDAs) or current accounts have provided for check writing and immediate on-demand withdrawals of funds including at ATMs. On the other hand, savings accounts have not been linked with checkbooks or debit cards, and may require advance notice for withdrawals, but generally paid a higher interest rates to depositors.

Making deposit accounts more convenient has been a focus for innovators seeking to provide a better customer service experience and user interface. While the PC and Internet eras have produced successful customer-facing products and services in many industries, many technologists complain that banks have largely failed to deliver innovative services fueled by new technology to retail deposit customers [121]. Until recently, the progress has been evolutionary rather than revolutionary. Important but incremental developments include ATMs and remote access so that the vast majority of retail banking services no longer occur in a brick-and-mortar branch. Moreover, checks can be deposited via smartphones, and retail deposit accounts can be opened and closed without a customer going inside a bank branch.

Fintech innovations and entrants into the deposit services market are likely to become transformational in the near future in this area. While some advances will be driven by new technology capabilities, other areas of progress lie in new analytics frameworks for classification and prediction of accounts and behavior that lead to improvements in performance compared to traditional bank methods [27]. Several examples show how this disruption might occur.

Channels for Deposit Services

Branch-based banking began its steady decline in the late 1980s. The most successful branchless bank, First Direct, was launched in 1989 by Midland Bank in the UK [79]. It was separately branded and operated independently of Midland's branch banking network. First Direct quickly demonstrated that superior banking services could be delivered over the telephone, and later via SMS messaging and the Internet. Its distinctive presence within financial services eventually enabled it to attract 1.4 million customers, or about 15 percent of the UK current account market. Its levels of service and brand loyalty measure among the best of any financial institution. In the United States, ING Direct once pursued a branchless, Internet-only banking model, but it was acquired by Capital One in 2011. Currently, a few other players operate in this space in the U.S. market with mobile-only services, including Simple, Moven, BankMobile, and GoBank. As a channel for the delivery of financial services, branches were once dominant, as we noted earlier. Today though, through innovation and competition, and changing customer preferences, branches have been overtaken but not eliminated as part of multichannel strategies pursued by the major banks, as there is still demand for deposit services via bank branches.

Digital-Only Entrants and Challenger Banks

Atom Bank (www.atombank.co.uk), a UK start-up, launched in 2014 as a mobile-only bank that targets millennial consumers. It has offered savings accounts and small business and mortgage lending via a mobile-only platform. It has also received high ratings for the simplicity of its applications, the rate of interest it has paid, and the ability to personalize its applications for customers, including its use of biometrics instead of passwords for account entry.

Along with other challengers, Atom seeks to attract Gen Y and millennial customers by providing engaging ways to help them manage their money, a characteristic of fintech deposit services. According to *Retail Banking Strategies* [108], 88 percent of millennials do their banking online and half use their smartphones to bank; in addition, 73 percent of millennials report they are "more excited about a new offering in financial services from Google, Amazon, Apple, Paypal or Square than from a traditional bank." This is suggestive of the large threats to traditional banking firms—banking services providers may not necessarily be banks. These customer-centric, technology-driven firms and mobile-only challenger banks are capable of developing engaging and convenient ways for millennial customers to manage their money. Banking is poised to move away from its traditional utility service role that relies on functioning as an unexciting necessity for other aspects of consumers' lives. Millennials will be attracted to challenger banks that make their services engaging, and that recommend and provide personalized advice proactively.

Open Banking Platforms for Fixed Deposits

Open banking allows customers to share access to their financial data with third parties whose applications and features may give customers a better banking experience. APIs enable the integration of a third-party firm's software applications with those of a bank [17]. Currently, third parties such as Facebook, Google, and other leading technology firms are working directly with leading financial services firms.

One such third party and provider of open banking services is PayPal (www.paypal.com), which has over 218 million accounts and is one of the world's largest nonbank financial institutions. In 1998, PayPal began as an independent provider of online money transfer services. Its growth was aided by the growth of eBay, and more than 70 percent of all eBay auctions accepted PayPal payments by 2002. In 2002 eBay acquired Paypal, and later spun it off in 2015 due to the challenges of developing two separate high-tech business infrastructures [82]. Today, a personal PayPal account can be set up with a unique e-mail address, and a bank account or credit card will generally be associated with it. After opening a PayPal account, the user can receive funds from another bank account, or a credit or debit card, and can send funds to another PayPal account holder or to someone with an e-mail address but no PayPal account. To access the funds, the recipient will need to open a PayPal account and then transfer the funds to their own bank account.

Another interesting fintech challenger is the Europe-based Deposit Solutions (www.deposit-solutions.com), an open banking platform for deposits that was founded in 2011 in Hamburg, Germany. Its aggregation business model is based on providing APIs that enable any bank to easily connect and attract deposits to expand its funding base, or by offering its own clients choices of deposit products from other institutions. For its partners, Deposit Solutions maintains one master account that aggregates the funds attracted. As of late 2017, its banking solution was used in 50 European banks by over 85,000 retail customers, who left €4 billion in deposits at the firm.

As open banking and interinstitutional APIs become more mainstream, the deposit services market will face substantial fintech-driven disruption [153]. Fundamental issues will include who controls customer data, and what security controls are needed when a customer conducts financial transactions through a linked network of fintechs, service providers, and bank deposit takers. Participating in open banking platforms creates opportunities and vulnerabilities as in any network market, with rent reappropriation threats counterbalancing the larger potential user bases on open banking platforms [52].

Regulatory Risks and Accommodations

A number of fintech approaches to new financial services offerings have been shown to contravene critical regulations, such as the USA PATRIOT Act of 2001, and its related KYC regulations. KYC compliance requires financial institutions to verify the identity of their clients. Since 2001, all U.S. banks have had to demonstate KYC

procedures, develop customer identification programs (CIP), and implement detailed transaction monitoring. These guidelines are intended to avoid bank involvement, however unintentional, in criminal money-laundering activities.

Financial institutions have generally found it difficult and expensive—not to mention operationally risky—to comply with KYC regulations that require acquiring and storing sensitive personal data, while also meeting their customers' expectations of privacy. Many fintechs have helped banks meet their need to deliver increased security through enhanced KYC capabilities, identity validation, and fraud detection. Examples include Fraugster, Mitel, Net Guardians, BillGuard, Bionym, and Feedzai, among many others. Other fintechs have found it challenging to innovate and grow within the regulatory framework that applies to retail deposit services.

Overall, the fintech-led disruption of deposit services is accelerating. Innovations to date in virtual account services have primarily complemented encumbent and traditional offerings. More radical innovations that can substitute for current deposit service offerings are on the horizon, and are likely to transform one of the major segments of the banking industry, even though they have not been able to accomplish this to date.

P2P Lending and Financial Inclusion

The purpose of all lending, whether via banks, credit unions, finance companies, or the new fintech lending platforms, is to address the core problem of borrowers' cash flow mismatches. This problem arises in situations where artists, musicians, craftspeople, and small-business entrepreneurs need to produce artifacts, create products, and find buyers to sell to before they can generate the cash flow to purchase raw materials and supplies, pay for the advertising services, rent their workspace, or offer payroll compensation to their employees. The prior research literature suggests that lenders (other than those who charge exorbitant interest rates) are usually unwilling to step into these situations with preferential lending services, lower-rate loans, or other terms that are likely to be attractive to the people who wish to obtain presales cash flow to power new small business activities. This is easier for banks that specialize in small and medium enterprise (SME) banking.

One interesting aspect of the current developments in this space is the extent to which we observe similarities—albeit in digital form today—to the social lending and account management activities offered by microfinance providers in developing countries [150]. Best known among them is the Grameen Bank of Bangladesh, and its founder in 1976, Muhammad Yunus, who was awarded the Nobel Peace Prize in 2006 for proposing and implementing the microfinance approach to bring small financial lending services to the unbanked poor people in his country. Over time, this financial inclusion approach grew, resulting in nonprofit and for-profit microfinance institutions (MFIs) in many developing countries around the world, peer-to-peer (P2P) lending markets as we know them today, and nongovernmental organizations (NGOs) that sought to shine a spotlight on the need for financial inclusion [91].

MFIs and P2P lending markets grew to focus on lending to women but also toward creating lending platforms to address the financial needs of poor people in developing nations.

One such MFI that has had considerable success since its founding in 2005 is California-based Kiva (www.kiva.org), which acts to make loans in association with network-based field partners who identify and make the case for a borrower to be funded. The borrower's reputation is derivative of that of its field partner [112]. Kiva, as a result, works like a multilevel advocacy—assessing risk-taking, on behalf of lenders who are willing to commit money to borrowers, with payback required in spite of the enhanced social welfare that is the main intention of its market mechanism. This is an extension of past approaches intended to reduce information asymmetry in the lender, borrower, and intermediary triangular relationship [102, 122], by adding an infomediating lending agent. Since IS research has focused on the development of market mechanisms and trading microstructure designs that mitigate the negative aspects of such asymmetries, it is natural for researchers to probe the limits of fintech-driven market mechanism innovations that will move the market from concerns about efficient financial resource allocation to new clienteles for social value and financial inclusion [35, 83].

Charitable Crowdfunding for Natural Disasters, Weather Events, and Social Needs

Fintech is not limited to the for-profit sector. In fact, new financial models have quickly emerged as an opportunity for savvy nonprofits and community groups. Charitable crowdfunding is the most visible innovation and refers to any effort to raise money with donations from a large number of people. Leading platforms are GoFundMe (www.gofundme.com) and KickStarter (www.kickstarter.com), which offer donors nonfinancial rewards or products as encouragement. Initially entrepreneurs used payment-enabled websites to attract low-value investment into for-profit ventures. Crowdfunding grew from this, and provides a new platform for fundraising for charitable nonprofits.Websites provide appeals tailored to showcase specific projects or causes, or community-building events.

Hurricane Sandy along the U.S. East Coast in 2012 led the Red Cross to embrace crowdfunding with two different websites, IndieGoGo (www.indiegogo.com) and CrowdRise (www.crowdrise.com). They reported that the two sites generated more than $2 million. Overall, the Red Cross received $170 million in total donations in 2012 of which more than half went to long-term Sandy rebuilding. Some universities also have been experimenting with crowdfunding for encouraging donations, such as Oklahoma State University's PhilanthroPete (philanthropete.osugiving.com).

A Pew Research Center report on the digital economy found that contributions to help an individual in need are the most common type of crowdfunding donation. It also noted that "crowdfunding donors value their personal connection to the projects

they support and the ability to highlight causes that might not get much attention from established charities" [129, p. 48].

Charitable giving and donors' motivations for philathropic gifts have been topics of interest to economists for decades. Fintech, crowdfunding platforms have been shown to alter giving behavior. In particular, Klinowski et al. [95] found that donors in a charitable crowdfunding platform prefer to give, and give more, when they are completing requests and enabling the recipient to reach their fundraising target. The authors find that crowdfunders "feel more impactful over recipients when they complete requests versus when they donate at any other stage of the fundraising campaign" [95, p. 14]. They also " find that other aspects of the recipients profiles also attract faster donations, particularly making reference to difficult circumstances such as a personal crisis, incarceration, and disability"[95, p. 14].

In a study of a crowdfunded market for online journalism projects, Burtch et al. [20] found that contributions in this marketplace are subject to a crowding-out effect. That is, potential donors are less likely to give when it appears that the gift has become less important to the recipient. Similar to Klinowski et al. [95], the authors found empirically that social influence and behavioral signals are highly influential in crowdfunded marketplaces.

While financial regulations generally keep many countries' consumer financial service markets separate, crowdfunding has proved to have strong appeal in the international setting. Donation and reward-based crowdfunding platforms in Asia attracted funds to help with the 2013 Typhoon Haiyan in the Philippines. Online alternative finance has been a surprising success story of the Fintech Revolution. With fewer regulatory obligations, crowdfunding platform can innovate extensively, and will continue to alter charitable giving, and benefit individuals and communities in need by expanding the scale of their appeals.

The Changing Landscape of Investments in the Fintech World

Underlying Technology Changes in the Financial Markets

While innovations in the digital financing, insurance, and payment-related business functions mostly emerged in the past few years and primarily targeted retail financial services, innovation and digitalization in the investment, trading, and financial markets domain on the institutional side have built a tradition of transformation for more than 20 years [66].[16] The key disruptive trigger that significantly enhanced user experience based on completely new functionalities was the electrification of major securities exchanges in the early and mid-1990s, providing order matching and price determination in the markets' back-ends without human intervention. Central limit order books have made it possible to aggregate and store open limit orders in a transparent ledger, and to match executable orders in real time. Trading from remote locations with decentralized market access made trading on the physical floor obsolete. Market users, specifically institutional investors, mirrored the

digitization of markets, by implementing electronic surveillance and automated quote machine methods. From the early 2000s, institutional investors established electronic trading desks to source liquidity from multiple brokers and trading venues, and implemented order management systems (OMSs) based on the Financial Information eXchange (FIX) protocol, the de facto messaging standard for pretrade and trade communication. In parallel, the sell side first implemented algorithmic trading engines to speed up and reduce costs in proprietary executions, and subsequently started to offer algorithmic services to buy-side clients by providing front-ends for clients' individual algorithm creation and parameterization. This enabled buy-side trading desks to backsource responsibility for trade execution from intermediaries, which created a disruption but enhanced user experience.

Regulators triggered competition between exchanges and alternative trading systems—especially electronic communication networks (ECNs) in the United States and multilateral trading facilities (MTFs) in Europe—paving the way for today's multiple-market system [67]. High-frequency trading (HFT) emerged and was primarily debated in expert circles until the 2010 U.S. Flash Crash dramatically changed the perceptions of policymakers, regulators, and the public toward electronic trading [110]. HFT strategies were also a disruptive force, but they enhanced the quality of the user experience overall, and led to massive increases in turnover velocity. Meanwhile, they further enabled the generation of significant total profits based on small profits per trade by instantaneously reacting to profitable situations in a highly complex and fragmented trading environment. The empirical literature, however, devoted more emphasis to the controversial aspects of HFT. For example, Hendershott et al. [77] and Brogaard et al. [18], among others, typically analyzed single markets, and hence underestimated the true impact of HFT on aggregated market quality by excluding cross-market strategies.

Risk Management, Blockchain, and Regulatory Considerations in Markets

Risk Management Technology

Financial markets are about managing risk. Technology in markets, in contrast, acts as a central tool to make the management of risk economically feasible. Speed in trading, low-latency technology, colocation and proximity services all enable firms that specialize in HFT to minimize their exposure to market price risk and stay as close as possible to their positions and open orders. But technology may also lead to new types of risk or exacerbate existing ones. Multiple flash crash events have revealed that academic research has not yet provided a full understanding as to why extreme, flash-type market situations occur in the first place, how market participants can manage risks and exposures in these situations, and how regulators may be able to preempt such events by imposing adequate regulation.

A further category of risk and worthwhile topic for research that has not yet materialized in extreme market events is cyber risk. The increasing concentration of infrastructure at a limited number of participants (e.g., banks and broker-dealers providing trading technology and infrastructure to others), or central counterparties that concentrate and manage risk, but also represent a potential bottleneck in our markets, requires more detailed analysis.

Blockchain Technology for Financial Markets

In the financial markets arena, blockchain technology is perceived as a game changer [116], as it enables functional improvements, innovations in existing business models or even disruption through the creation of new business models and truly new products and services (disruptive, enhancing user experience). Applications that primarily supplement existing functions already exist in the area of securities settlement, for example, to increase settlement efficiency, shorten settlement times, and reduce reconciliation effort. However, concerning securities clearing and trading, multiple problems in the technical (scalability, IT security) and nontechnical (legal, regulatory, and tax treatment) domains have yet to be solved. In clearing and settlement, for example, credit and counterparty risks are inherent, which requires backing by a legal entity and cannot solely be solved by blockchain technologies. In trading, as well, high-throughput and low-latency requirements hinder the usage of current blockchain implementations for high-volume asset classes such as equities and listed derivatives. Here, research can serve to identify and integrate both technical and nontechnical solutions to unveil the full potential of blockchain technology for financial market applications.

Regulatory Considerations

Today, regulatory compliance and dealing with legacy systems are the biggest operational pain points for investment firms active in financial markets. Regtech solutions involve technologies that aim to ease regulatory compliance and substitute for manual labor in standard regulatory and compliance processes. They also apply AI and deep learning methods to trigger alerts for exception handling, and thereafter, deeper human analysis. Regtech offers promising complementary solutions that are viewed as being able to provide significant improvements in functionalities and processes [99].

On the flip side of the regtech coin are the market regulators and surveillance authorities themselves. They have to reflect the technology-driven changes in trading and investments in their rule-making, enforcement, data acquisition, and analysis strategies. Regulation plays a critical role in facilitating market-enhancing innovation. Yet given the nature of innovation in fintech and digital finance, policymakers and regulators can only realize their key goals if they have suitable and modern tools, frameworks, and regulatory approaches that help them to generate real

information from petabytes of data. In the past ten years, numerous new regulations were implemented that have required increased transparency and have generated massive amounts of data. All the data have to be absorbed by regulators in order to meet their expanding duties and more challenging tasks, specifically the requirement to establish more proactive, data-driven regulation and surveillance approaches.

Regulators often cannot adequately process and analyze these massive amounts of data, however, due to a lack of people, skills, and technological support that are needed. Moreover, it may take months to derive conclusions out of the data that are acquired; for example, this was especially true in the case of the U.S. Flash Crash [26]. Academic research (e.g., Chung and Cunanan [29] and Degryse et al. [44]) has intensively analyzed the impact of new regulations on market quality, financial stability, and investor protection, thereby supporting more effective regulatory impact analysis (RIA) [54]. Yet, academic research is often only known to regulators after the respective projects are executed and published, which leaves limited room for mutually shaping their research questions and directions. Furthermore, most researchers implement a "one problem, one data set, one publication" approach, and target isolated events or use single-market data. They more rarely seek to carry out analyses over longer periods of time with multimarket data.

Moreover, different methods, dissimilar national and regulatory contexts, and alternate time horizons or data fields within the empirical or self-established data sets (for simulation and scenario analysis) often lead to contradictory results. This lessens the generalizability of the findings, and thus limits their value for actual policymaking and regulation. A prominent example of this phenomenon is the analysis of HFT. Despite a research history on this topic of nearly ten years and hundreds of papers that analyzed the impact of HFT on market quality and integrity [110], there is still no general agreement in academia on whether HFT strategies are positive or dangerous for markets and investors. In addition, there is no consistency in the views about whether and to what extent these strategies need to be regulated. Other still heavily debated topics include, for example, the question of whether the mandatory usage of central counterparties actually reduces, or possibly even increases systemic risk in markets. A related question centers on the adequate levels of transparency required for less liquid asset classes.

Academic researchers should play a central role in assisting regulators and policymakers in evidence based policymaking (EBPM) before regulations are drafted [46] and sound RIA once regulations are applied. Regulators need tools, methodologies, and infrastructure to conduct rigorous EBPM and RIA, and to identify solutions that serve the goal of better regulation. Systematic and joint academic-regulatory topic identification, research agendas, and systematic exchanges of methodologies have the potential to significantly improve the analysis of regulatory effects and financial regulation itself. These also relate to the impact of new technologies (e.g., blockchain, new payment solutions) on regulators' work. They will also support the assessment of how technologies like ML or AI can assist regulators in their tasks, including developing a deeper understanding of trade manipulation, market abuses, and cross-market surveillance.

In the retail trading space, online-brokerage technology enabled retail investors to access markets and market data similar to the way in which professional traders do so. This democratization of markets and access (disruptive, and enhancing user experience) was completely unthinkable in times of floor-based trading. However, the digitization of markets and trading differs across asset classes. While in liquid asset classes (e.g., equity, FX, and futures trading) a high level of electrification and HFT is prevalent, in the context of less liquid instruments (e.g., corporate bonds, small cap equities), mechanism design and adequate market models represent a promising route for academic research inquiry.

The Rise of Robo-Advisory Services and Social Trading Platforms in Investments

In the digital investments business function for retail customers, robo-advisors [7] (i.e., "algorithms to develop automated portfolio allocation and investment recommendations tailored to the individual clients" [45, p. 1]), and social trading platforms [68] (i.e., "a combination of a social network and a trading platform offering users the possibility to share their investment ideas . . . [and to] . . . copy ideas and/or trades of other users" [123, p. 2]) are discussed intensively. They promise to offer more cost-efficient and customer-oriented ways to set up and manage investors' portfolios. They offer complementary value in tandem with other approaches and also enhance the user's experience. These fintech offerings in digital investments cherry-pick point solutions that represent small parts of the whole range of services that large financial service providers can offer. They also disintermediate markets that incumbents—in this case financial advisers or asset managers—have created and developed over decades.

Robo-advisors enable automated acquisition of information and data processing to provide investment proposals with little or no human intervention based on predefined parameters of customers' investment goals, financial background, and aversion to risk. They make use of established theories, such as the perennially applicable modern portfolio theory of Harry Markowitz [124]. They also usually offer a limited set of asset classes, such as equities or ETFs to provide investors with low-cost solutions. However, they are typically not designed to consider the more personal aspects of financial investments like real estate or individual tax situations. Furthermore, they focus solely on the investment aspects of financial advice, and are not able to provide financial solutions that integrate additional aspects of investing, financing, tax considerations, and insurance solutions. Such an integration of a diverse range of fintech and non-fintech solutions will be able to generate cash flow and risk structures that come closer to meeting customers' specific situations and individual goals.

Furthermore, from the customer viewpoint, there has been considerable fragmentation among the new and traditional services. The new services are represented by robo-advisors and social trading platforms, while the traditional services occur as

broker-based investment advice and market newsletters. Customers are required to handle a multitude of providers with specific apps, identification procedures, and fee structures, which generate complexity and reduce ease of service usage. Testing innovative fintech solutions may be of specific interest for a technology-savvy clientele, and the innovativeness of individual applications may attract initial clients, but most providers of robo-advisory services and social trading platforms are hardly able to achieve sufficient revenues or profits to sustain their business models. So the providers and those who undertake research efforts in this direction should keep in mind that, for customers, financial products are not an end in themselves but are often seen as a disliked but necessary means of fulfilling life-driven goals. Some of the common goals involve funding children's education, new house purchases, and early retirement portfolios.

We see high potential for academic research that contributes to sophisticated fintech aggregations that include innovative and complex financial strategies designed for multiple customer age and wealth groups. These include less affluent customers, as well as those other than millennials who lack experience with mobile devices. This approach to high automation finance makes use of innovative technologies, such as neural networks, deep learning, and big data. It also applies DLT and smart contracts to perform intelligent data collection and integration strategies, as well as innovative financial management and financial engineering to combine fintech offerings that result in personal and tailored customer solutions [149]. Specific research topics in this area relate to high-quality customer profiling and client segmentation based on individual financial data and risk perceptions. The identification of concepts and methodologies based on big data analytics to identify trigger points within customer digital history and online search behavior records to actively propose tailored financial services is also worthy of research. High automation finance methods can be further enhanced through the study of innovative user experiences supported by knowledge for just-in-time financial literacy to provide customers with personal digital financial twins that will be able to mimic their personal circumstances and help them to identify appropriate investments.

Conclusion

Assessing the innovations, disruptions, and transformations in the Fintech Revolution will need to be done on a repeated basis going forward, since emerging technologies, reengineered and new processes, and customer-friendly and value-bearing products and services seem to be undergoing continuous development and implementation. The take-aways that we have to offer the reader consist of several main points related to how the fintech sector will develop over time, and what IS researchers can do in order to contribute new knowledge in this vibrant area of technology innovation, process disruption, and services transformation. They are:

1. It will be difficult for larger incumbent firms to match small entrepreneurial start-up firms at producing value-creating fintech applications with major

innovations, without major spending to acquire knowledgeable human capital that is in such short supply in the marketplace.[17] As a result, it will be appropriate for larger firms to outsource these applications, instead of trying to create them in-house.

2. The fintech sector is likely to experience significant adjustment and evolution as time passes and it matures into a typical industry sector, as opposed to one of the newest among them, and probably sooner than many observers may expect.[18]
3. The opportunities for developing a new research agenda for IS research in the fintech application areas that we have reported on in this article have strong potential for creating high-value academic knowledge. The new research agenda also can deliver important and useful insights to practitioners and managers as well as meaningful new observations and ideas that can aid regulators in better overseeing the new developments in a way that will maximize their positive potential to support economic growth, new jobs for the high-tech workforce, and improved profitability around more customer-centric and value-bearing services.

Some of the new research questions that we envision the new agenda for fintech-focused IS research will include are:

1. What will be the aggregate value of the fintech sector's contribution to financial services GDP? What will be the drivers for success among fintech start-ups, as the market becomes more crowded and the "low-hanging fruits" of technology innovation are harvested in industry? Will knowledge from the development and marketing of fintech innovation-based products and services spill over into other areas of business involving technology?
2. Will the fintech sector be characterized by centripetal forces that lead to its agglomeration (market linkages, local knowledge externalities, thick labor markets, and national regulations)? Or will we instead observe the domination of centrifugal forces, leading to the globalization of the industry with punctuated equilibria of local innovations that are spun off for increasingly international R&D-driven service transformation? What theoretical basis is appropriate to apply or develop to understand the geographical locations of the core fintech innovations?
3. Can we expect to see a fintech value paradox, analogous to but different from the IT productivity paradox reported on by IS and economics scholars? Will a continuing lack of standards, incomplete systems integration, and remaining "islands of data" within industry firms and across the industry overall be as harmful as before? What can IS scholars do to identify the tactics that firms can employ to appropriate the greatest amount of value from the fintech-based products, services, infrastructures, and innovations they deploy? Will it be possible to characterize different but unique value appropriation paths that banking firms can follow to maximize their success with fintech value

appropriation? If so, what theoretical perspectives will support such an effort?

4. Will the issue of ownership of systems reemerge in the Fintech Revolution, making it so that not all of the incentives of stakeholders are properly aligned? Can we expect to see individual firm value maximization gradually transition to shared views of valuation harmonization in fintech application areas that require more infrastructure than what any firm can provide? Will such fintech innovation activities as faster payments infrastructure, multifirm cybersecurity investments, and social investing platforms create the impetus for greater cooperation among firms?
5. How will the business models, operations, and microstructure of leading financial markets be affected by the developments that are occurring in the fintech sector, specifically as blockchain technology might challenge their very foundations? Will exchanges implement the highest-tech approaches, involving ML, AI, and data stream sensing analytics, beyond what we already observe is being done by firms to understand the role played by social sentiment, the sudden injection of new information, and the other quantitative indicators in guiding market trading? How will market operators respond to the threats due to ICOs that might disintermediate the concept of traditional IPOs and how will regulators be able to secure investor protection in this context?
6. How will regtech innovations come into the industry? Will there be a need for new models of technology adoption that are specific to such concerns as cybersecurity and regtech investments? These models will aim at diminishing the rising risks of high-tech and machine-based fraud.

These are among the numerous and unique research questions that await further study in this interdisciplinary area of IS research. Clearly, there is room for developing threads in new fintech research that incorporate existing knowledge from a range of interdisciplinary sources. They include: IS, finance and economics, strategy and organizations, marketing, statistics and data science, operations management and management science, and computer science. Studying the issues associated with the Fintech Revolution in future years will be more effective when IS researchers employ interdisciplinary research designs, theory and thinking, and methodologies.

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Notes

1. The IS literature offers many theory-based explanations of technology-driven transformations in the financial services industry. For studies on strategy and market transformation, the interested reader should see, among others: Clemons et al. [33] on the competitive disadvantage associated with market dominance; Han et al. [73] on IT ownership amid market transformation; Goh and Kauffman [65] on firm strategy and the Internet in commercial banking; and Clemons et al. [35] on the information-driven transformation of strategy and society, including financial services.

2. These developments are described in a National Public Radio show on the "Digital Industrial Revolution" [136].

3. Financial services operations, along with the business value and profitability that they can create, have been studied by researchers and practitioners since the 1980s [109, 132]. The respective themes include: the economics of electronic banking strategy and shared ATM networks [30, 87]; process variation as a basis for service quality and performance [59]; retail banking strategy when electronic distribution technology costs influence bank competition and performance [23]; the economic effects of technological progress on banking [15]; system design and process performance in trade finance operations [43]; customer intimacy strategies with IT for small bank-offered financial services [134]; nowcasting machine-based forecasts for GDP [60]; new management science approaches to credit card risk scoring [27]; and support vector machines [14] and other ML algorithms [94] for consumer credit scoring.

4. For an early review of models, see Capon [25].

5. There is an interesting similarity here to how the credit card lender, Capital One got its own start, with the slogan "Don't call us, we'll call you," based on their effort to do data mining on potential customers to figure out what card-related interest rate would match the levels of risk of default on loans that were involved [36].

6. Research on issues associated with payments in the global economy have been covered by: Clemons et al. [34] on how Mondex reengineered money with nondebit, noncredit plastic cards in the 1990s; Au and Kauffman [8, 9] on how electronic billing infrastructures developed, and on the economics of mobile payments; Staykova and Damsgaard [131] and Kazan et al. [93] on market competition for mobile payments platform; and [76] and Liu et al. [105] on cooperation, competition, and regulation related to mobile payments market changes and ecosystem changes. There have been many others, though these are representative.

7. Some of the key issues here involve the cohesiveness and performance of the faster payment settlement system as a business network. In other theoretical analysis work, a variety of issues are highlighted that make procurement platforms, loyalty networks, and group-buying systems all have difficult issues in regard to network viability [35], including: the likelihood of long-term network sustainability; the extent of process standards that support a network; the extent of firm and customer informedness about network and system performance; demand-driven complementary network value; sustainable network value; performance monitoring and fair value sharing [88].

8. For several reviews of payment, clearing, and settlement systems around the world by the Committee on Payment and Settlement Systems (CPSS) economists of the Bank for International Settlements (BIS), the interested reader should see the series of white papers that the BIS published in the 2010s [40–42].

9. In an interview that the SWIFT Institute [133] conducted in 2015, NPP's chief executive officer Chris Hamilton pointed out the contrast between the low-value payment focus of NPP and its approach to managing liquidity, in comparison to the hybrid settlement system.

> Each participant would keep a pool of funds at the central bank segregated for the NPP. The liquidity inside each pool would be managed by a set of highly automated and effective tools

> that monitor the transactions of each participant in their respective pool and allow drawdown and top-up on parameters set by the participant. Each individual payment is settled through the pools in real time, creating an account-netting effect in each pool. The netting efficiency would essentially depend on the size of participants, relative to the nature of their transaction flows [133, p. 1].

10. For details on the technical underpinnings of blockchain technology, see Mueller-Eberstein [114].
11. Blockchain has also garnered the interest of central bankers. For example, He [75, p. 3] proposed the use of a central bank digital currency (CBDC), defined as

> a digital form of central bank money that can be exchanged in a decentralized manner. In other words, it can be transferred or exchanged peer-to-peer, directly from payer to payee without the need for an intermediary. . . . Such a CBDC would be exchanged at par with the central bank's other liabilities (its cash and reserves)—either through banks or directly at the central bank.

The ramifications of such a choice on the part of central banks—to issue their own digital currencies—is fraught with technological and public policy issues that parallel those faced in other complex and sensitive domains, such as cybersecurity, the control of fake news, the patenting of digital innovations, and the control of sharing economy innovation [35].

12. These kinds of innovations reflect Chesbrough's [28] argument about breakthrough innovations for which the general problem is identified (digital cryptography, in this instance), but the domain will only become known over time as entrepreneurs develop new ideas for their application.
13. This is much like what the University of Pennsylvania Wharton School start-up, buySAFE, did. It originally teamed with eBay to diminish the all-in transaction costs between buyers and sellers, who had asymmetric information about the demeanor and performance reliability of their counterparties [32].
14. This parallels what was observed with airline price forecasting tools like FareCast (acquired by Microsoft in April 2008), and other oil and gasoline forecasting tools for energy producers and transportation fleet cost management.
15. Unlike several of the other fintech innovation areas that we have discussed, the applications in lending services have been very well-studied since the mid-2000s, especially P2P lending, and more recently, charitable crowdfunding and equity crowdfunding. Some of the most interesting works that have appeared in the literature to date make contributions related to fundamental and more advanced issues. For P2P lending, they include: the differences between alternate market mechanisms in P2P lending relative to repayment and other aspects of their performance [147]; how borrower participation in friendship networks may reveal their propensity for P2P loan repayment or default when there are lender-borrower information asymmetries [102]; how loan default can be mitigated with borrower information from social media in P2P lending [61]; how informal lender-borrower social communication influences default rates in P2P lending [151]; and finally, the extent to which platform choice, observed herding in decision making, and regulation influence P2P lending returns [84]. Some of the findings interested readers may wish to see in the current literature on crowdfunding include: the impacts of home bias effects, the tendency for transactions to be made by counterparties from the same geographic area instead of outside it, in online campaigns [103]; the effects of provision point rule restrictions on the amount of funding an entrepreneur can draw from a fundraising campaign [22]; and the extent to which information hiding and participant contributions influence crowd campaign outcomes [21].
16. For studies on financial markets and firm strategies in the investment and trading industry, see: Clemons and Weber [37, 38] on competition between exchange and off-

exchange venues for equity trading; Weber [146] on open-outcry and order-matching systems in futures markets; Levecq and Weber [101] on the strategic implications of financial market design choices; Han et al. [72] on JPMorgan's partial divestment of RiskMetrics for value-at-risk metrics infrastructure to Reuters [117]; Parker and Weber [11] on the effects of order-routing on new option market success; and Kauffman et al. [89] on technology ecosystem transformation in high-frequency trading systems.

17. This will likely be caused by their lack of technical expertise in some domains of emerging technologies, including ML and AI, natural language processing, blockchain app development, data science and IoT sensors, and the exploitation of open APIs. It is unlikely that the demand for the software development and hardware specialists, along with cybersecurity experts, will abate anytime soon. As a result, financial services firms in many countries around the world will be forced to outsource for application, product, and service development assistance.

18. Dietz et al. [50] have pointed to multiple kinds of changes that are likely to occur: expansion in the scope through the value chain of fintech innovation application; fintech start-up diversification in technology, segment, and geographic terms; partnerships and alliances to achieve new functionality and higher business value, as well as industry consolidation due to scale-focused acquisitions; a slowdown in value growth to more normal market valuations for fintech start-ups; regulators' involvement in the development of fintech clusters; and finally, the emergence of much larger fintech ecosystems that span industries and geography.

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