



CENTRAL BANKING AT THE FRONTIER

CREATING A DIGITAL FINANCIAL LANDSCAPE

THAMMARAK MOENJAK

FOREWORD BY

**SETHAPUT SUTHIWARTNARUEPUT,
GOVERNOR OF THE BANK OF THAILAND**



Central Banking at the Frontier

The emergence of digital financial services and, in particular, Central Bank Digital Currencies has changed the way we think about the role of Central Banks. Thammarak's insights drawn from around the globe makes this book an essential read for anyone interested in the topic.

—*Tim Allen*
Sales Director, EMEA, Consult Hyperion

Digital disruption is a complex, multi-faceted issue. Writing in a remarkably readable style, this book shows, compares, and illustrates the evolving developments and the paths on which central banks might choose to tackle current and future challenges from digital disruption. An essential read for central bankers, practitioners, academics, students, and market participants who want to understand and help shape the emerging digital financial landscape.

—*Dr Vachira Arromdee*
**Former Deputy Governor and Executive Advisor to
Digital Currency Unit, Bank of Thailand**

Many of us take for granted that the economy of the country we live in remains healthy and stable; in large part this is down to the role played by the Central Banks. But Central Banks are facing new challenges on multiple fronts. A new digital financial landscape is emerging fuelled by new technologies, BigTech and FinTech innovators and changing customer expectations. For the first time, Thammarak Moenjak has taken a Central Bank lens to these developments and provides an authoritative guide to the challenges, responses and future outlook. The author's personal experience has positioned him well to study the nature of these developments from multiple perspectives, and his global outlook is well demonstrated by multiple examples which support his narrative.

Of undoubted huge benefit to Central Bank readers, this book will also help policy makers, financial services practitioners and academics understand the challenges faced by Central Banks and the role they will need to play in the evolution of the digital financial landscape.

—*Keith Bear*
**Fellow, Cambridge Centre for Alternative Finance,
Judge Business School, University of Cambridge**

This book is a superb guide to the implications for central banking of the emerging digital financial landscape which the author, quite rightly, sees as an exciting new frontier of central banking. The book goes beyond merely providing a list of the challenges that the central banks are facing. Importantly, it focuses in detail on how the central banks might respond to those challenges to ensure that risks posed to monetary and financial stability are mitigated while at the same time enabling consumers and businesses to benefit the most from the new technologies.

—*Robert Dixon*

**Professorial Fellow, Faculty of Economics and Commerce,
Department of Economics, University of Melbourne**

There is no better introduction to the frontiers of digital finance for policymakers, researchers, and market participants than Moenjak's masterful new treatment. Drawing on his immersive grounding in the subject as a central banker with deep first-hand experience, Moenjak covers the waterfront of crucial topics, including digital identity, novel payment systems and currencies, financial stability, banking disruption, and regulation.

—*Darrell Duffie*

**Adams Distinguished Professor of Management and Professor of
Finance at the Graduate School of Business, Stanford University**

A comprehensive analysis of the role of central banks in a rapidly evolving financial landscape driven by digitalisation of payments, financial services, regulation and even money itself. Whether you are a practitioner, regulator, or teacher of financial markets, this is an essential source of information on the most recent developments.

—*Hans Genberg*

**Professor of Economics and Senior Director of Monetary and
Financial Programs, Asia School of Business, Kuala Lumpur,
Malaysia**

Digital identity is foundational to a safe, secure, privacy respecting and inclusive digital economy. It is however a complex and fragmented topic with many previous attempts to establish ecosystems and much work ongoing both in the private and public sectors. Thammarak's survey of this work will be invaluable to central bankers as they seek to understand the role digital identity should play in financial services and the digital economy more broadly and consider the role that central banks

should play in developing, promoting and regulating policies and frameworks in this area.

—*Steve Pannifer*

**Managing Director, and Digital Identity Subject Matter Expert,
Consult Hyperion**

Thammarak has identified and described some of the most critical areas for central banking in the next decade. The rapid pace of development in digital payments, and central banks' involvement in them through instant payment and settlement systems and – potentially – both wholesale and retail CBDCs will change the global payment landscape permanently. Increasingly central banks will have the means and opportunity to directly influence payment markets, and the way they use this influence will have profound implications for regulation, competition, resilience, financial stability and inclusion. *Central Banking at the Frontier* set out the challenges and identifies the tools that will be needed by central banks to meet them. As Thammarak makes clear, the future will be very different from the past.

—*Tim Richards*

**Principal Consultant, and Digital Payments Subject Matter Expert,
Consult Hyperion**

As the book demonstrates, the task of the central banker has changed radically and rapidly with the digitisation of the financial system and new skills must therefore be acquired and new tools deployed. Thammarak develops his arguments in detail and at a practical level rather than simply setting out a general overview and thus provides readers with concrete guidance as to how to deal with these new challenges. *His book should be required reading for all senior staff at the World's Central Banks.*

—*Dr Bill Roberts*

Fellow, Cambridge Centre for Alternative Finance, Judge Business School, University of Cambridge; Former Head of Open Banking at Competition and Markets Authority, UK

“*Central Banking at the Frontier: Creating a Digital Financial Landscape*” provides a remarkably comprehensive and clear guide to the new technologies, players, and financial instruments reshaping the future of finance and money globally, considered from a central banking perspective – all from the unique vantage point of somebody who has been deeply involved for many years, with a commendable attention to detail and commitment to open inquiry. The book is

timely and important given the pivotal role central banks are poised to play, and the weighty decisions they must undertake to navigate and shape this evolving frontier while upholding their core mandates of financial and monetary stability amidst the tumult of change. This authoritative work can be an invaluable guide for policymakers, regulators, industry practitioners and researchers alike, who are seeking to equip themselves to navigate with confidence and clarity this emerging landscape where complexities abound.

—*Professor David R. Skeie*

**Gillmore Centre for Financial Technology and Warwick Business
School, University of Warwick**

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Central Banking at the Frontier: Creating a Digital Financial Landscape

BY

THAMMARAK MOENJAK

Bank of Thailand



United Kingdom – North America – Japan – India – Malaysia – China

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INVESTOR IN PEOPLE

*This book is dedicated to the Bank of Thailand and the central banking profession
for their sincere attempts to help make the world a better place.*

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List of Abbreviations

AI	Artificial Intelligence
AISP	Account Information Service Provider
AML	Anti Money Laundering
API	Application Programming Interface
ARTs	Asset-Referenced Tokens
BCB	Banco Central do Brasil
BIS	Bank for International Settlements
BoE	Bank of England
BOT	Bank of Thailand
CBDC	Central Bank Digital Currency
CBUAE	Central Bank of the United Arab Emirates
CFT	Counter Financing of Terrorism
CMA	Competition and Markets Authority
CPMI	Committee on Payments Market Infrastructures
DEPA	Data Empowerment and Protection Architecture
DLT	Distributed Ledger Technology
DMA	Digital Markets Act
DORA	Digital Operational Resilience Act
DSA	Digital Services Act
DvP	Delivery-versus-Payment
ECB	European Central Bank
e-CNY	Electronic Chinese Yuan
EMTs	E-Money Tokens
EU	European Union
FCA	Financial Conduct Authority
FMI	Financial Market Infrastructure
GDPR	General Data Protection Regulation
HKMA	Hong Kong Monetary Authority
ID	Identification

xiv List of Abbreviations

IdP	Identity Provider
IOSCO	International Organization of Securities Commissions
KYC	Know-Your-Customer
MAS	Monetary Authority of Singapore
MiCA	Markets in Cryptoassets Regulation
NAS	Novel Activities Supervision Programme
OBIE	Open Banking Implementation Entity
PBoC	People's Bank of China
PISP	Payment Initiation Service Provider
PKI	Public Key Infrastructure
PoC	Proof of Concept
POS	Point of Sale
PSD2	Revised Payment Services Directive
PvP	Payment-versus-Payment
QR	Quick Response
RMB	Renmenbi (Chinese currency)
RP	Relying Party
RTGS	Real-Time Gross Settlement
SAR	Special Administrative Region
SME	Small- and Medium-sized Enterprise
SWIFT	Society for Worldwide Interbank Financial Telecommunications
UPI	Unified Payments Interface
USD	US Dollar
USDC	US Dollar Circle
USDT	US Dollar Tether
VRP	Variable Recurring Payment

About the Author

At the time of writing, **Thammarak Moenjajak** was the Chief Representative, Bank of Thailand London Representative Office, and a Senior Advisor to the Bank of Thailand's Digital Currency Unit. Currently, Thammarak is a Senior Director, International Department at the Bank of Thailand, where he also continues with his deep involvements in the Bank of Thailand's central bank digital currency (CBDC) initiatives.

Prior to his London posting, Thammarak worked in the planning of virtual banking licence and managing digitalization projects done with FinTech firms and commercial banks to help improve SME financing at the Bank of Thailand. Thammarak's involvement in CBDC initiatives at the Bank of Thailand started since the planning of its wholesale CBDC project (Project Inthanon) in 2017. A career central banker, Thammarak has also worked in the areas of monetary policy, reserves management, corporate strategy and financial institutions policy.

Thammarak's previous book, *Central Banking: Theory and Practice in Sustaining Monetary and Financial Stability* (John Wiley and Sons, 2014), has also been translated and released in Mandarin.

Thammarak has a PhD in Economics from the University of Melbourne, Australia, Master in Public Management from Lee Kuan Yew School of Public Policy, National University of Singapore, Singapore, and BSc (Econ) from the London School of Economics and Political Science, UK. He was also a Lee Kuan Yew Fellow at Harvard Kennedy School, Harvard University, USA, in 2013, and the Assistant Chief Representative, Bank of Thailand New York Representative Office in 2008–2009, during the height of the Great Financial Crisis.

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Foreword

Technology is not only changing the way we do finance but also the way we regulate it. As a central bank, we have a dual responsibility: to protect consumers and the financial system and to foster innovation and competition in the financial sector. This is a delicate balance that requires careful judgement and constant adaptation. We are living in an exciting time, where technology is reshaping the finance industry. Technology is also transforming the role and functions of central banks, creating new opportunities and challenges for us.

To take advantage of the opportunities that technology has to offer while mitigating the accompanying risks will require the central banks to navigate terrain that is new to many of us. Like most central banks, the Bank of Thailand is now trying to navigate this exciting new frontier of technology and finance. I believe that our journey is not unique but rather reflects the common issues and trends that are affecting many central banks around the world.

One of the most noticeable changes is the emergence of non-bank players, such as FinTech and BigTech, that offer innovative and convenient financial services, especially to the underserved segments. These new players are disrupting the traditional dominance of banks in most markets and pose new questions for regulators and policymakers. How can we ensure a level playing field for different types of players? What are the necessary digital infrastructures and how should we design the rules for them to access and utilize such infrastructures? How might these players respond to financial stability measures and affect the transmission of monetary policy?

Another challenge is to balance the potential benefits and risks of new technologies such as artificial intelligence (AI). At the Bank of Thailand, our approach is to encourage greater AI adoption in the financial sector rather than imposing stringent regulations on it. At the present junction, the arrival of generative AI has produced a step change, but its impact in the financial sector is yet to be realized, whether in terms of benefits or risks, as the technology itself is fast evolving. Given uncertainty regarding the risk-reward trade-off, we need to carefully calibrate our response to ensure that we can harness the potential of AI such as improved efficiency, accuracy and customer experience while addressing potential risks properly. Although we think that many of the risks associated with AI, such as IT and cyber risk and data security and privacy, are currently adequately addressed by existing regulatory frameworks, the remaining primary concern that we have is the issue of transparency and the potential misuse of AI by malicious actors for fraudulent activities.

Finally, technology also presents opportunities for central banks to innovate and enhance their core functions, such as issuing and managing money. Central bank digital currencies (CBDCs) are at the forefront of this innovation, as they aim to provide a digital form of central bank money that can meet the needs of the modern economy. The Bank of Thailand, in partnership with BIS Innovation Hub Hong Kong Centre, the People's Bank of China, Hong Kong Monetary Authority and the Central Bank of the United Arab Emirates, has developed a platform for wholesale cross-border connectivity – mBridge – designed to support real-time, cross-border payments using CBDCs. The platform shows clear potential benefits, such as faster transfer time (from 3–5 days to several seconds) and significantly lower funding, foreign exchange and compliance costs.

While different jurisdictions might have challenges that are unique to their own contexts, the author's comprehensive take on the issues surrounding the emerging challenges of financial disruptions, available policy tools and relevant policy trade-offs will be useful for those who are dealing with the challenges that digital disruption is bringing to the financial sector globally. This timely book provides a big picture view together with the necessary practical details that will put policymakers, practitioners, academics and students right at the exciting new frontier of central banking.

Sethaput Suthiwartnarueput
Governor
Bank of Thailand

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In writing this book, the author greatly benefited from the insights shared by various central bankers, practitioners, academics and thought leaders from around the world. Although it is impossible to thank everyone whose conversations, insights and meetings the author has learnt and benefited from, the followings are worth special mentions.

At the Bank of Thailand, Governor Sethaput Suthiwartnarueput has given kind encouragement and insightful guidance that helped form the key tenets of the book. Former Deputy Governor Vachira Arromdee, Executive Advisor to Bank of Thailand's CBDC team kindly also helped review the manuscript and provided insightful suggestions. Assistant Governor Piti Disyatat and Research Advisor Krislert Samphantharak provided valuable inputs that helped inform the book's key discussions. Samphantharak, who is also a Professor at University of California, San Diego, has also been kind enough to review the manuscript and give valuable comments despite his busy schedule. Assistant Governor Titanun Mallikamas has also given kind advice and guidance that made the author's London posting more fruitful and beneficial to the writing of this book.

The book has also greatly benefited from the expertise of Dr Bill Roberts and Keith Bear, who are both Fellows, Cambridge Centre for Alternative Finance, Judge Business School, University of Cambridge. A former Head of Open Banking at the Competition and Markets Authority, the UK, Dr Roberts has kindly shared the thinking and practice behind global open banking initiatives and provided insightful suggestions and comments on the manuscript. Keith Bear, who is a well-known global expert in central bank digital currency, distributed ledger technology, AI, and FinTech circles has also kindly given many insightful and valuable suggestions to the manuscript.

From Consult Hyperion, a premier global technical consulting firm on the future of payments, identity and transit fare collection based in the United Kingdom, Steve Pannifer, Managing Director, and Digital Identity Subject Matter Expert, was kind enough to help review and provide valuable inputs and suggestions on digital ID. Tim Richards, Principal Consultant, and Digital Payments Subject Matter Expert also took his time to kindly review and provide valuable comments on digital payments. Tim Allen, Sales Director, EMEA has kindly taken the time to help coordinate with the author and reach out to the experts.

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Introduction

Abstract

This introduction chapter provides a map for the rest of the book. It starts with the rationale why this book is needed. It then provides an overview of the book, which has four parts. Part I examines how emerging new technologies are leading to new types of players, new types of products and business models, which are foundation to the emerging digital financial landscape which in turn, is itself rife with new challenges for the central banks. Part II examines regulatory updates, the first area of response that the central banks can engage in to help the address the challenges from digital disruption in the financial sector. Part III examines how central banks can engage in the promotion of open digital infrastructures, the second key area of response that the central banks can engage in to address the challenges and shape the digital financial landscape. Part IV examines how central banks might need to upgrade their internal capabilities, such that they can effectively operate in the emerging digital financial landscape, which is a new frontier of central banking.

Keywords: Digital disruption; digital financial landscape; central banking; emerging new technologies; regulatory upgrades; open digital infrastructures; internal capabilities

The financial sector is on the cusp of digital disruption. In recent years, new technologies, new types of players and new types of financial products are structurally changing the demand and supply dynamics in the financial sector. New business models are arising, and with them new challenges that could affect both monetary stability and financial stability, the two mandates of most central banks. To help ensure that monetary stability and financial stability will be preserved in this emerging digital financial landscape, the central banks will need to respond. Arguably, central banks will need to make sure that the risks to monetary and financial stability reasonably are mitigated while consumers and businesses can benefit the most from what new technologies and innovations bring.

2 *Central Banking at the Frontier*

This book aims to be a guide into the emerging digital financial landscape from the lens of central banking, providing a glimpse into the challenges that the central banks are facing, and how the central banks might be able to respond to those challenges. Unlike the strategy and operations in relatively well understood territories of monetary policy, financial market operations, and banking supervision, the operations of central banks to help mitigate risks from digital disruption in the financial sector and shape the emerging digital financial landscape will be a new frontier in an unfamiliar terrain. To successfully fulfil their tasks, the central banks will need to be intimately familiar with a new disparate set of concepts and issues and understand how they could be affecting monetary and financial stability.

While it is incumbent to the central banks to help make resource allocation in the emerging digital financial landscape safe, efficient and secure, currently, there is not a book that maps together the disparate concepts, issues and challenges that the central banks are facing, and how the central banks might need to respond to them. This book aims to provide just that. The book aims to equip the reader, which could be a central banker, a policy-maker, a student of public policy, an academic or a practitioner in the financial sector, with a map that helps with the navigation into this exciting new frontier of central banking.

The book benefits from the fact that the author himself has to grapple through his work as a central banker in a region where FinTech and BigTech firms have been very active in financial services. This is a region where the central banks try to respond quickly to emerging challenges via various means, ranging from regulatory updates to meet the challenges associated with emerging new players and cryptoassets, to the introduction of new initiatives such as digital identification (digital ID) systems, domestic and cross-border faster payments and central bank digital currency (CBDC). From 2021–2024, the author was posted to London, the United Kingdom, a leading global financial centre. The author's mandate has been to learn from leading global regulators, think tanks, academics, and private sector players who often convened in both the United Kingdom and Europe, including at Bank for International Settlements in Switzerland, on how to best meet the challenges of digital disruption in the financial sector. Through numerous open and Chatham House rule conferences, seminars, meetings, and one-on-one interactions with leading global thinkers and practitioners on various digital-related topics, coupled with his own experiences in helping with regulatory formulation and driving FinTech, CBDC, and digitalization projects at the Bank of Thailand, the author tries to draw out the lessons learnt that he hopes will also benefit the reader.

It is expected that once the reader understands the background concepts and frameworks provided in this book, the reader should be able to pick a topic of interest and take a deeper dive into it if they wish to. With the map provided, it is expected that the reader can also help contribute positively to the shaping of the emerging digital financial landscape, whether through policy debates or actual policy implementation.

Part I of the book provides an overall picture of the emerging digital financial landscape, its challenges, and how the central bank might respond to them. Chapter 1 reviews six new technologies, four new types of players and new types of financial products that are forming the foundation of the digital financial landscape. Chapter 2 reviews how the new technologies, new types of players and

new types of products are fundamentally changing the demand and supply dynamics, giving rise to new business models that are altering the financial landscape. Chapter 3 examines arising eight challenges that come with the new digital financial landscape, with two coming from new business models, two coming from new forms of money and four that come with digitalization of financial services in general. Chapter 4 provides an overview of the implications of the challenges on monetary and financial stability, the key central bank remits, and how the central banks might be able to respond to them.

Part II takes a deeper dive into the first key area of possible response to the emerging challenges: regulatory updates. Chapter 5 first reviews four dominant regulatory approaches: market-driven, state-driven, rights-driven and innovation driven as respectively practiced in the United States, China, European Union and key global financial centres (the United Kingdom, Singapore and Hong Kong SAR). The chapter then reviews possible regulatory updates in response to two key challenges arising from the emerging business models: walled gardens and shadow banking. Chapter 6 reviews possible regulatory updates in response to two challenges arising from the possible new means of payment in the digital financial landscape: monetary sovereignty and singleness of money. Chapter 7 reviews possible regulatory updates in response to challenges that come with digitalization of financial services in general: customers' rights, AI ethics, cyber-security and financial exclusion.

Part III takes a deeper dive into the second key area of possible response to the emerging challenges: promotion of open digital infrastructures as public goods that are foundational to universal adoption of digital financial services. Chapter 8 first reviews the needs for the central banks to get involved in the promotion of open digital infrastructures to help deal with the challenges arising in the digital financial landscape. Chapter 9 reviews technical concepts to provide a background on open digital infrastructures, and reviews the key layers of digital infrastructures, from those for digital ID, digital payments and data sharing. Chapter 10 examines different models for digital ID, the foundation layer for digital financial services, crucial for customer onboarding, user authentication and transaction authorization. Chapter 11 examines various models of digital payments, from retail, wholesale, to cross-border payments, as the layer fundamental to digital financial transactions. Chapter 12 examines various models of open banking, the infrastructure for data sharing among financial services providers, based on customers' consents, which can bring more personalized financial services to meet customers' needs. Chapter 13 reviews the background concepts relating to CBDC and dive into wholesale and cross-border CBDC. Chapter 14 reviews the core components relating to retail CBDC, and how various jurisdictions are approaching retail CBDC.

Part IV takes a deeper dive into the third key area of possible response to the emerging challenges: upgrading of central banks' internal capabilities. Chapter 15 first examines why the central banks might need to shift their mindset towards resilience rather stability-at-all-cost change their mode of operations towards being goal-based rather rule-based, embark more on collaboration, innovation and digitalization of their operations. Chapter 16 examines the tools and governance needed to promote more innovation in the financial system and internally.

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Part I

The Emerging Digital Financial Landscape

Part I provides an overview to the emerging digital financial landscape, to set the stage of the current environment, and the challenges that are arising.

Chapter 1 reviews new technologies that are bringing in new types of players and new types of financial products, all of which render obsolete the branch network as a key competitive advantage in financial services.

Chapter 2 examines the emerging digital financial landscape from the viewpoint of the changes in demand and supply of financial services, as well as the changing competitive environment. Importantly, new business models that are emerging are examined as they potentially can raise challenges to the central banks' remits.

Chapter 3 examines key emerging challenges that are arising in the digital financial landscape, both those that are specific to emerging business models and those that are general to digital financial services.

Chapter 4 first reviews how the emerging challenges discussed in Chapter 3 threaten monetary and financial stability, the two key remits of most central banks, before delving into how the central banks might be able to respond to such challenges.

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Chapter 1

The Driving Forces of the Emerging Digital Financial Landscape

Abstract

This chapter reviews new technologies, new types of players and new types of financial products that together are fundamentally affecting supply and demand dynamics in the financial sector and contributing to the emerging digital financial landscape. The aim of this chapter is to set a common understanding on the underlying forces of digital disruption in the financial sector before exploring the challenges to monetary and financial stability that are arising. In later chapters, the book will examine how central banks might deal with the challenges and help shape the emerging digital financial landscape.

Keywords: Digital disruption; digital finance; cloud computing; application programming interface (API); FinTech; BigTech; super apps; virtual banks; artificial intelligence (AI); distributed ledger technology (DLT)

The financial sector is on the cusp of digital disruption. While other industries such as retail, transport and entertainment have already been thoroughly disrupted in the past decade, the disruption in the financial sector, the sector which has been more tightly regulated and populated with long-entrenched incumbents with economies of scale, is only being keenly felt worldwide in the wake of the COVID-19 pandemic. The forces of new technologies along with new types of players and new types of products are ushering in new business models that are fundamentally changing demand and supply dynamics in the financial sector. Together, the new technologies, new types of players, new types of products, new business models and the changes in new supply and demand dynamics are giving rise to a new financial landscape that is digital in nature. The emergence of this digital financial landscape is likely to have vast implications on both monetary stability and financial stability, the two key mandates of most central banks.

1.1 New Technologies

Key technologies that have emerged and drastically changed financial services in the past decade include (1) smartphones, (2) cloud computing, (3) biometric authentication, (4) application programming interface (API), (5) artificial intelligence (AI) and (6) distributed ledger technology (DLT). Advancements in these technologies have fundamentally changed the way people access financial services and how financial services providers conduct their businesses. Fig. 1 below illustrates the different technologies that drive digital disruption in financial services and their implications.

On their own, smartphones and cloud computing are primary drivers that change demand and supply dynamics in financial services. Smartphones allow consumers to have easy access to digital financial services 24/7 from anywhere with internet connection, reducing the need for financial services providers to have large branch networks. Cloud computing has lowered barriers to entry for new types of players into provisions of financial services and allows banks and new types of players to scale their operations to meet the needs of millions of customers who want to access financial services digitally, at lower costs. Biometric authentication, API and AI are key supporting technologies that allow digital financial services to be provided securely, efficiently and cheaply over digital channels, particularly via smartphones and mobile devices.

DLT, also known as blockchain, is a prospective technology that has demonstrated (via the popularity of cryptoassets such as bitcoins and ethers, as well as central bank digital currency projects) how transactions could be done in a peer-to-peer manner, how assets could be tokenized and how payments could be programmed for automated executions via ‘smart contracts’.

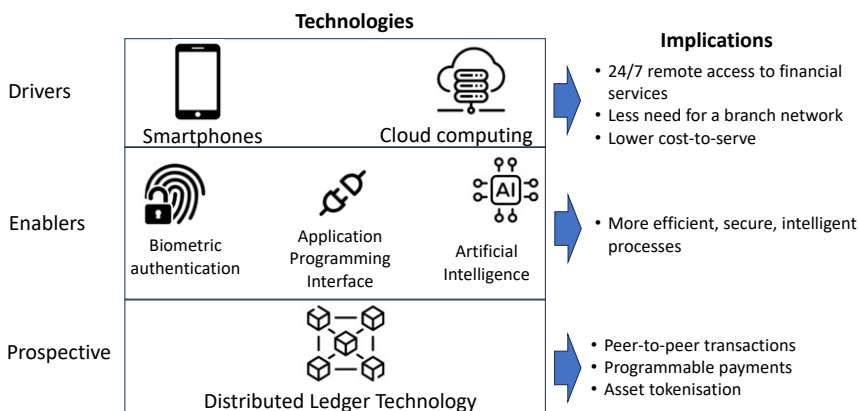


Fig. 1. Key Technologies Driving Digital Disruption in Finance.