Distributed Ledger Technology (DLT) is a way of managing, storing, and sharing information over a distributed network. The position of DLT in banking can be seen as controversial as it is a rapidly evolving technology with both potential benefits and challenges. The Role of Distributed Ledger Technology in Banking presents a balanced assessment of both the opportunities and risks behind such recent innovations. Combining theory and practice, it explores the impact of DLT in the banking sector and offers the opportunity to exploit different points of view from different disciplines. It presents topics from both a theoretical and practical point of view, highlighting concrete applications. Written by a team of experts from academia and the banking sector, this book looks at DLT not as a threat but as an exciting opportunity to bring the banking/financial system in the future.

SABRINA LEO is Tenure Track Assistant Professor at Sapienza University of Rome. She is a lecturer in Strategies, Performance, and Digital Innovation in banking. Her main research areas are DLT, digital payments, digital banking, and IT Governance in banks, and recently on the impact of technologies like AI/ML in the financial system.

IDA CLAUDIA PANETTA is Full Professor at the Sapienza University of Rome, where she teaches International Financial Markets and Institutions and Bank Economics and Management. Her more recent research interests (and publications) regard the impact of new technologies in reshaping the financial system, focusing in particular on Mobile Payment, DLTs, and Cybersecurity.
The Role of Distributed Ledger Technology in Banking

From Theory to Practice

Edited by

SABRINA LEO
Sapienza University of Rome

IDA CLAUDIA PANETTA
Sapienza University of Rome
Pat, Pat
Contents

List of Figures page ix
List of Tables xi
List of Boxes xii
List of Contributors xiii
Acknowledgements xviii

Introduction: The Banking in the Era of Distributed Ledgers 1
SABRINA LEO AND IDA CLAUDIA PANETTA

Part I  Why Pay Attention to Distributed Ledger Technology in Banking?
1  Blockchain and Distributed Ledger Technologies 11
CLAUDIO DI CICCIO

2  The Integration of Distributed Ledger Technology in Banking: State of the Art in Literature 35
SABRINA LEO AND ANDREA DELLE FOGLIE

Part II  Opportunities and Challenges in Crypto-Asset Regulation
3  Some Reflections on the Proposed MiCA Regulation 71
FILIPPO ANNUNZIATA

4  Crypto-Assets in Banks: Between Opportunities and Legal Uncertainties 90
ANDREA DALY

5  Cyber laundering, VASPs’ Regulation, and AML Policy Response 114
ANTONIO ADINOLFI AND EMANUELA GIUSI GAETA
## Contents

### Part III The Power of Distributed Ledgers in Payments

6. DLT in Payments: New Course of History Ahead?  
ALESSANDRO AGNOLETTI AND GIANCARLO SFOLCINI  
DLT in Payments: New Course of History Ahead?  
ALESSANDRO AGNOLETTI AND GIANCARLO SFOLCINI  

7. Central Bank Digital Currency: Rationales, Design Considerations, and Implementation Using the Algorand Blockchain Technology  
ANDREA CIVELLI, CO-PIERRE GEORG, PIETRO GRASSANO AND NAHEED IHSANULLAH  
Central Bank Digital Currency: Rationales, Design Considerations, and Implementation Using the Algorand Blockchain Technology  
ANDREA CIVELLI, CO-PIERRE GEORG, PIETRO GRASSANO AND NAHEED IHSANULLAH  

8. Opportunities, Challenges, and Design of CBDCs: The Italian Approach to a New Technology  
SILVIA ATTANASIO AND PAOLA DEL VITTO  
Opportunities, Challenges, and Design of CBDCs: The Italian Approach to a New Technology  
SILVIA ATTANASIO AND PAOLA DEL VITTO  

9. A Proposal for an Asia Digital Common Currency (ADCC) Applying Distributed Ledger Technology (DLT) and Blockchain Technology (BCT)  
TAIJI INUI AND WATARU TAKAHASHI  
A Proposal for an Asia Digital Common Currency (ADCC) Applying Distributed Ledger Technology (DLT) and Blockchain Technology (BCT)  
TAIJI INUI AND WATARU TAKAHASHI  

### Part IV Enabling Financial Inclusion and ESG with Distributed Ledger Technology

10. Distributed Ledger Technology and Financial Inclusion  
HARISH NATARAJAN AND BIAGIO BOSSONE  
Distributed Ledger Technology and Financial Inclusion  
HARISH NATARAJAN AND BIAGIO BOSSONE  

11. Banking, Blockchain, and ESG  
JOHN HO  
Banking, Blockchain, and ESG  
JOHN HO  

### Part V A Further Look at DLT in Banking: Lessons Learned, Current Applications, and Future Scenarios

12. A Look into the Intermediaries of the Metaverse: Halfway between the Present and the Future  
IDA CLAUDIA PANETTA AND SABRINA LEO  
A Look into the Intermediaries of the Metaverse: Halfway between the Present and the Future  
IDA CLAUDIA PANETTA AND SABRINA LEO  

13. The DLT Landscape in Banking: Key Features of Prominent Use Cases through Strengths and Weaknesses  
SABRINA LEO AND IDA CLAUDIA PANETTA  
The DLT Landscape in Banking: Key Features of Prominent Use Cases through Strengths and Weaknesses  
SABRINA LEO AND IDA CLAUDIA PANETTA  

Index 342
Figures

1.1 A simplified example of Ethereum transaction  page 13
1.2a A double-spending scheme  14
1.2b A double-spending scheme  14
1.3 Centralised and distributed architectures  15
1.4 A schematised view of the backward link–based chain of blocks  18
1.5 The Solidity code of a sample smart contract in Ethereum (Hello Token)  26
1.6 Invocation of a smart contract  27
6.1 Source of trust in different payment methods  138
6.2 Execution time and price volatility of different payment instruments  139
6.3 Crypto-payment in hands-off approach  145
6.4 Customer attitude towards crypto-payments  146
6.5 Split of transaction cost among the parties involved in crypto-payments  147
6.6a Theoretical e-money model  150
6.6b Actual implementation of e-money model  150
6.7 European market footprint of Nexi  153
8.1 Bank IT systems diagram  175
8.2 ABI Lab, conceptual diagram of the ABILabChain business zone  176
9.1a Yongle coin  190
9.1b Chinese 100 yuan  190
9.1c Japan 1 yen  191
9.1d 500 Taiwan dollar  191
9.2 Concept to issue ADCC  195
9.3 Asia Digital Common Currency (ADCC): issuing processes  195
9.4 Outline of electronic money transfer (payment) at merchant shops  196
List of Figures

9.5 Outline of transaction records by applying blockchain technology 197
9.6 Securing both countermeasures for criminal activities and anonymity 198
9.7 An image of issuing and distributing ADCC and digital wallet 199
9.8 Image of providing government bonds from each economy to AMRO 202
9.9 Image of issuing ADCC-denominated bonds using CSDs 203
9.10 Possible patterns of CBDC ledger 205
9.11 International remittance and cross-border payments using ADCC 208
9.12 Outline of electronic money (Suica) network 212
10.1a A centralised payment system 220
10.1b An illustrative example of a distributed ledger system similar to Bitcoin (blockchain) 220
10.2a Adults without an account by economy (%), 2017 222
10.2b Adults without a financial institution account reporting barrier as a reason for not having one (%), 2017 222
10.3 Adults with an account (%), 2017 223
10.4 Constraints to financial inclusion and the development of digital financial services 224
10.5 DLT features vs. economic forces vs. policy objectives 225
10.6a Cross-border payments 229
10.6b Cross-border payments 229
10.7 Low-cost providers are active in many markets 231
10.8 FinTech developments potentially relevant to the payment aspects of financial inclusion: the ‘PAFI Fintech Wheel’ 233
11.1 What is ESG investing 237
11.2 United Nations Sustainable Development Goals 249
13.1 Subjects involved in the settlement and clearing of orders when using an exchange 321
13.2 Decentralised database of different digital assets 322
13.3a Current KYC process (centralised) 329
13.3b KYC with DLT 330
Tables

1.1 Blockchain types according to their visibility and consensus mechanisms page 32
2.1 Literature on DLT in the banking industry 42
2.2 Other research strands: DLT in central banking 49
2.3 Other research strands: financial institutions and business models 50
2.4 Other research strands: fund industry 52
2.5 Other research strands: insurance 53
2.6 Other research strands: Sukuk (Islamic investing) 54
2.7 Other research strands: post-trading industry 55
2.8 Other research strands: DLT and regulatory frameworks 56
2.9 Other research strands: cryptocurrencies 57
2.10 Other research strands: crypto-assets 60
6.1 Categories of crypto-assets most relevant in payments 139
6.2 Possible merchants’ approach in managing crypto-payments 145
9.1 Key design features of ADCC 192
13.1 Traditional taxonomy of the DLT financial landscape 296
13.2 A new taxonomy of DLTs in the banking 297
13.3 Comparison between account-based and token-based payments 299
13.4 Characteristics of bank guarantees 306
13.5 Major crypto legislation 323
## Boxes

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Distributed ledger and blockchain</td>
<td>12</td>
</tr>
<tr>
<td>1.2 Smart contracts</td>
<td>28</td>
</tr>
<tr>
<td>1.3 Token versus cryptocurrency</td>
<td>29</td>
</tr>
<tr>
<td>5.1 The UAE policy on cryptocurrencies</td>
<td>125</td>
</tr>
<tr>
<td>11.1 Case study: project genesis</td>
<td>252</td>
</tr>
<tr>
<td>11.2 Case study: Project Greenprint</td>
<td>255</td>
</tr>
<tr>
<td>11.3 Case study: IBM’s Food Trust</td>
<td>256</td>
</tr>
<tr>
<td>11.4 Case study: UNHCR humanitarian payment using blockchain payment solutions</td>
<td>257</td>
</tr>
<tr>
<td>11.5 Case study: Carbonplace (carbon transaction network)</td>
<td>258</td>
</tr>
<tr>
<td>11.6 Case study: principles for responsible investment</td>
<td>259</td>
</tr>
<tr>
<td>11.7 Case study: IHS Markit Meta-Registry for carbon credits</td>
<td>260</td>
</tr>
<tr>
<td>11.8 Use case: BBVA blockchain green bond</td>
<td>262</td>
</tr>
<tr>
<td>13.1 Payment instruments and services use cases</td>
<td>301</td>
</tr>
<tr>
<td>13.2 Lending use cases</td>
<td>304</td>
</tr>
<tr>
<td>13.3 Bank guarantee use cases</td>
<td>308</td>
</tr>
<tr>
<td>13.4 Trade finance use cases</td>
<td>311</td>
</tr>
<tr>
<td>13.5 Syndicated loan use cases</td>
<td>317</td>
</tr>
<tr>
<td>13.6 Derivatives use cases</td>
<td>319</td>
</tr>
<tr>
<td>13.7 Digital asset use cases</td>
<td>324</td>
</tr>
<tr>
<td>13.8 KYC use cases</td>
<td>331</td>
</tr>
</tbody>
</table>
Contributors

ANTONIO ADINOLFI is a lawyer and lecturer at Scuola di Polizia Tributaria (Guardia di Finanza). Since 2003, he was Head of Unit (within the Treasury Department, DG Prevention of Use of the Financial System for Illegal Purposes, now DG Banking and Finance, Ministry of Economy and Finance). In 2015, he became a member of the G7 Cyber Expert Group. In 2018, he was appointed the co-chair of International Co-operation Review Group (ICRG)- Financial Action Task Force (FATF). In 2022, he became FATF Head of Delegation of Italy. In 2020, he became a substitute member of Financial Security Committee. Until 2020, he served as Director of the Central Means of Payment Anti-Fraud Office.

ALESSANDRO AGNOLETTI is Head of Digital Currency & DLT at Nexi, with responsibility for positioning the company both in the field of digital currencies and in the application of DLT technologies to new inclusive and systemic payment solutions. He was previously Head of Innovation at SIA and has also held various roles in the areas of strategy and innovation at Bain & Company, H-Farm, and CDILabs, a startup he co-founded. Alessandro holds a degree in International Management from the Università Cattolica in Milan and an MBA from the Collège des Ingénieurs in Paris.

FILIPPO ANNUNZIATA is Associate Professor of Financial Markets and Banking Legislation at Bocconi University. He was Co-Director of the RULES Unit, Baffi-Carefin Centre, Bocconi University; Academic Board Member of European Banking Institute; Academic Member and Fellow of Jean Monnet Centre of Excellence EU Sustainable Finance and Law (EUSFIL); and Board Member of European Society for Banking and Financial Law (AEDBF) of Italy.

SILVIA ATTANASIO is Head of Innovation in Associazione Bancaria Italiana (ABI) since May 2019 and Member of the ECB Digital Euro Market Advisory Group. She graduated in Statistical Science and
Economics. She worked for more than 15 years starting from its foundation in ABI Lab Consortium. Since 2017, she has been project leader for the Spunta project, an initiative of implementation of DLT applied to the interbank reconciliation process.

Biagio Bossone is Economist and a financial advisor to international institutions, national governments, and private sector financial institutions. He is also a banker and former central banker. He is the (co-)author of several studies and publications on economics, finance, and economic development.

Andrea Civelli is Associate Professor in Economics at the Walton College of Business (University of Arkansas) and former Senior Economist at Algorand Inc. Andrea’s research interests focus on monetary policy transmission and inflation modelling, with a particular interest in the role of the banking sector and business loan supply in the propagation of macroeconomic shocks. His research has been published in numerous economics and financial journals. Andrea received a PhD in Economics from Princeton University in 2010 and also held visiting positions at UT Austin and NC State University.

Andrea Daly is graduated in Law from ‘Università degli Studi di Torino’. After working as a lawyer, Andrea entered the Sella Group Compliance in 2015, specialising in investment services and then in crypto-assets regulation. Currently, he is Head of ‘Compliance Investment Services Research and Consulting & Digital Assets’ at Banca Sella Holding.

Paola Del Vitto has worked in the Innovation Office of ABI since January 2020 until March 2023 following the evolution of the ECB project on the digital euro and other subjects concerning digitalization of Financial Institutions.

Andrea Delle Foglie received a PhD in Banking and Finance (Sapienza University of Rome) and is currently Contract Professor at the Department of Law and Economics, University of Macerata and Postdoctoral Research Fellow in Banking and Financial Intermediaries at the Department of Management, Sapienza University of Rome. He focuses on the field of international financial systems, particularly the regulatory framework of the banking system, Islamic Banking and Finance, sustainable finance, and financial markets’ technology application.
List of Contributors

Claudio Di Ciccio is an associate professor at the Department of Computer Science at Sapienza University of Rome (Italy). His research spans across the domains of process mining, formal logics in AI, and blockchain technologies. He is Member of the Steering Committee of the IEEE Task Force on Process Mining.

Emanuela Giusi Gaeta received a PhD in Political Economy Sapienza University; she was Researcher in Political Economy Tor Vergata University and Supervisor of Research Projects in Criminal Economy. She teaches courses on Political Economy, Political Economics, Monetary Economics, International Economics, Applied Economics, Criminal Economy, and Endogenous Growth course at the Research Doctorate. Her research areas are Cryptocurrencies Market, Energy-Saving Technologies, Technological Transfer, and Criminal Economy.

Co-Pierre Georg is Associate Professor at EDHEC Business School. Previously, he held the South African Reserve Bank Research Chair at University of Cape Town. He is Director of the Algorand-UCT Financial Innovation Hub. Co-Pierre teaches courses on ‘Fintech and Cryptocurrencies’. His research interests focus on the nexus of financial innovation and financial stability. He obtained his PhD from the University of Jena in 2011 and has published both in finance and interdisciplinary journals. Co-Pierre’s research has received awards from the Algorand Foundation, the Ripple University Blockchain Research Initiative, the European Central Bank, and the Volkswagen Foundation. He has been a consultant at various central banks and held visiting positions at MIT, Oxford, Princeton, and Columbia University.

Pietro Grassano is Business Consultant in the Asset Management and Fintech space. He has been Business Solutions Director – Europe at Algorand between 2019 and 2022. At J.P. Morgan Asset Management from 2002 until 2019, Pietro has been Head of Sales for Italy, responsible for business in Greece, and Country Head for France. Having previously worked in BNP Paribas and Accenture, he has more than 20 years of experience in the asset management sector. He holds a master’s in economics and social sciences (DES) from Bocconi University in Milan.

John Ho is Global Head of Legal, Financial Markets for Standard Chartered Bank. He is a mentor for the UK FCA Digital Sandbox.
and is an active participant in the industry’s Fintech events and is a public speaker on topics such as Blockchain, Digital Assets, Financial Markets, Sustainability, and Regulatory Reforms.

Naveed Ihsanullah is VP of Engineering Research at Algorand where he focuses on future technology and features for Algorand’s blockchain platform. He is a senior engineering leader and technologist with more than 20 years of experience and continues to be fascinated by distributed systems and performance. Most recently of Mozilla, Naveed was instrumental in designing and leading the Quantum Flow program that focused 400 engineers to double Firefox’s performance in just one year. He also led the adoption of new technologies across all the major browsers (Chrome, Safari, and Firefox) to close the performance gap with native applications. These technologies include WebAssembly, SIMD.js, and Shared Array Buffer. Naveed is also previously of Carbon Black (then Bit9) where his teams developed next-generation application security software and cloud-based software reputation services. Passionate about improving how enterprises use technology, he has consulted on large organisational-level projects for Fortune 500 companies including Boeing Jeppesen.

Taiji Inui is proposing Asia Digital Common Currency (ADCC) with Professor Wataru Takahashi. He proposed a digital currency before Bitcoin. He is a JICA expert, an ADB consultant, and an ISO/TC68 member. He worked for BOJ and NTT Data developed payment infrastructures in Japan. He was also a member of BIS meetings.

Sabrina Leo, a PhD graduate in Banking and Finance, is Tenure Track Assistant Professor at Sapienza University of Rome. She is a lecturer in Strategies and Performance of bank accounts and Digital Banking. Her main research areas are DLT, Digital Payments, Digital Banking, and IT Governance in banks, and recently on the impact of technologies like AI/ML in the financial system.

Harish Natarajan leads a global team working on payments and market infrastructures topics in the Finance, Competitiveness, and Innovation Global Practice at the World Bank. His work spans Payments and market infrastructures, Financial Inclusion, Digital ID, Digital Economy, and FinTech. He represents the World Bank in several international working groups on these topics.
List of Contributors

IDA CLAUDIA PANETTA, a PhD graduate in Banking and Finance, is Full Professor at the Sapienza University of Rome, where she teaches International Financial Markets and Institutions and Bank Economics and Management. Ida’s more recent research interests (and publications) regard the impact of new technologies in reshaping the financial system, focusing in particular on Mobile payment, DLTs, and Cybersecurity.

GIANCARLO SFOLCINI is a senior product manager within Digital Currency & DLT at Nexi, with focus on new business models enabled by emerging technologies. He has developed various experience leading innovation project in energy (ENI), telecommunications (BT), and managing consulting (EY).

WATARU TAKAHASHI received MPhil in Economics from Oxford University in 1984 (Tutor; Prof. John Muellbauer, Nuffield). Prior to the current position, he had worked at the Bank of Japan for 35 years, mostly in academic research sections. He also worked for international affairs as an advisor to the Governor from 2001 to 2006.
Acknowledgements

Dear Readers,
First of all, we want to express our sincere gratitude to you for expressing interest in our book and wanting to take the time to read it. Your interest means a lot to us, and we are honoured to have you as part of our audience.

We want to express our heartfelt gratitude to all the authors for their work. Your contributions have not gone unnoticed, and we truly appreciate the time and care you have taken to help bring our project to life. We thank you for believing in it as much as we do. Your insights and expertise have had a significant impact, and we are grateful for the opportunity to work with you.

We want to extend special thanks to Alicia Brewer and AcademicWord, whose tireless efforts and attention to detail significantly improved our chapters in this book.

We would also like to convey our appreciation to Vincenzo Contri and to the Editorial Team at Cambridge University Press for their expert guidance and recommendations throughout the publishing process. We appreciate their commitment to making this idea a reality and their conviction in it.

Finally, we would like to acknowledge our Families, whose encouragement and support made this book possible. Their love and belief in us have inspired us, and we are forever grateful for their unwavering support.