

Magalhães Batista, Pedro; Ringe, Wolf-Georg

Working Paper

Dynamism in Financial Market Regulation: Harnessing Regulatory and Supervisory Technologies

ILE Working Paper Series, No. 39

Provided in Cooperation with:

University of Hamburg, Institute of Law and Economics (ILE)

Suggested Citation: Magalhães Batista, Pedro; Ringe, Wolf-Georg (2020) : Dynamism in Financial Market Regulation: Harnessing Regulatory and Supervisory Technologies, ILE Working Paper Series, No. 39, University of Hamburg, Institute of Law and Economics (ILE), Hamburg

This Version is available at:

<https://hdl.handle.net/10419/225047>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

FAKULTÄT
FÜR RECHTSWISSENSCHAFT

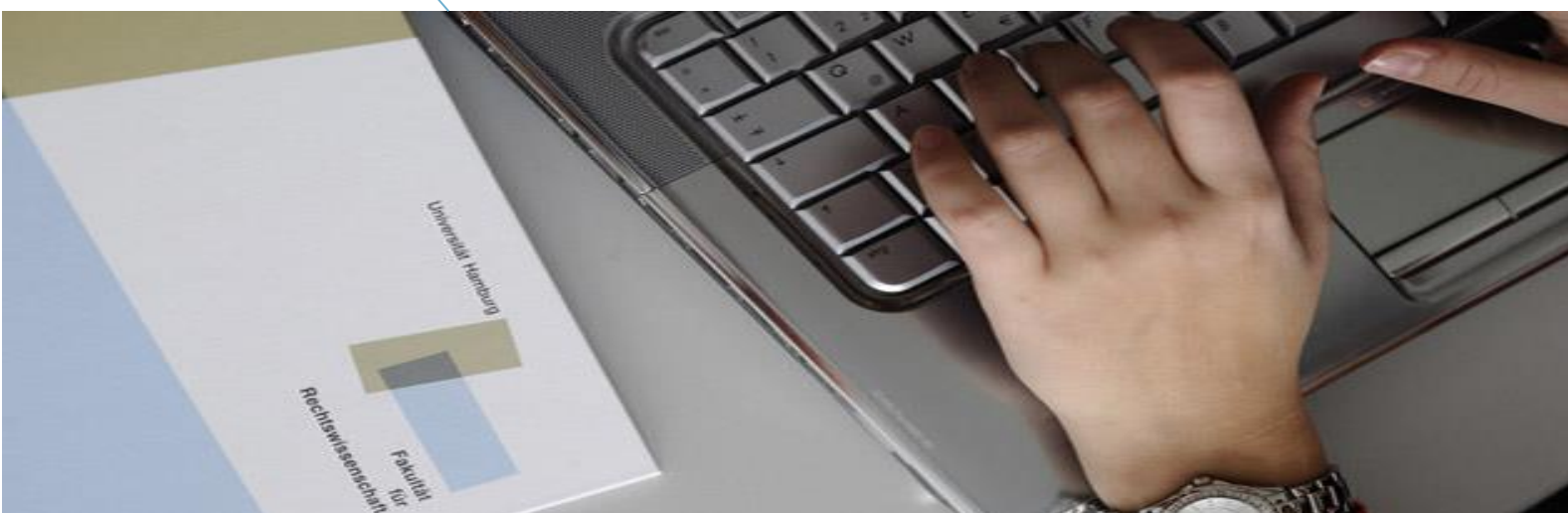
INSTITUTE OF LAW AND ECONOMICS
WORKING PAPER SERIES

DYNAMISM IN FINANCIAL MARKET REGULATION: HARNESSING REGULATORY AND SUPERVISORY TECHNOLOGIES

PEDRO MAGALHÃES BATISTA
WOLF-GEORG RINGE

Working Paper 2020 No. 39

September 2020



NOTE: ILE working papers are circulated for discussion and comment purposes.
They have not been peer-reviewed.

© 2020 by the authors. All rights reserved.

DYNAMISM IN FINANCIAL MARKET REGULATION: HARNESSING REGULATORY AND SUPERVISORY TECHNOLOGIES

PEDRO MAGALHÃES BATISTA* AND WOLF-GEORG RINGE*

The dynamic development of market practices and services frequently limits regulatory effectiveness. New technologies, however, might assist regulators in better tracking market changes. While Regulatory Technology (“RegTech”) has been vastly reducing compliance costs, Supervisory Technology (“SupTech”) has the potential to enhance data accuracy even further. Proper integration between these two will assist regulators in obtaining a continuously updated picture of their regulatees and allow higher regulatory adaptability, without incurring extensive additional costs. Still, harnessing technology for regulatory purposes might lead to an increased dependence on technology providers which risks regulatory capture. We argue in this essay that additional requirements, such as technological neutrality and interoperability, are needed to mitigate such risks. We illustrate our case through blockchain proposals for RegTech and SupTech and their interoperability challenge.

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	DYNAMISM AND REGULATION	3
III.	DIGITIZING COMPLIANCE	6
IV.	SUPTECH AND REGULATORY ADAPTABILITY	8
V.	FOSTERING REGTECH-SUPTECH INTERACTION	11
VI.	BLOCKCHAIN AND INTEROPERABILITY	16
VII.	CONCLUSION	20

I. INTRODUCTION

Regulation recurrently falls short at achieving its objectives as it fails to acknowledge market dynamism. This limitation is especially true in financial regulation.¹ As crises surface, a growing rulebook keeps mounting with higher regulatory costs that do not necessarily fix this root problem.² Meanwhile, new technologies disrupting financial services, such as artificial intelligence, big data, cloud computing, and blockchain,³ are also being directed at coping with

* Institute of Law & Economics, University of Hamburg.

¹ Dan Awrey & Kathryn Judge, *Why Financial Regulation Keeps Falling Short* (Cornell Law Sch. Legal Studies Research Paper no. 20-03, 2020), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3530056.

² Roberta Romano, *Regulating in the Dark and a Postscript Assessment of the Iron Law of Financial Regulation*, 43 HOFSTRA L. REV. 25 (2014).

³ W. Scott Frame et al., *Technological Change and Financial Innovation in Banking: Some Implications for FinTech*, in THE OXFORD HANDBOOK OF BANKING (Allen N. Berger et al. eds., 2019), 262 (for three categories of financial innovation, (i) production process, (ii) products and services, and (iii) organizational structures, and describing the impacts of innovations like big data, blockchain, and artificial intelligence, and new organizational models such as internet-only banking); See also, e.g., Xavier Vives, *Digital Disruption in Banking*, 11 ANN. REV. FIN. ECON. 243 (2019).

these rising costs.⁴ Such technologies have mostly been used by the financial industry to address business challenges and respond to regulatory oversight. If adequately tailored, however, they could also assist regulators themselves in better adapting to market changes and emerging risks.

Regulatory technology (“RegTech”) means the use of technologies to enhance compliance processes, matching regulated entities’ data to information taxonomies relevant to regulators’ oversight.⁵ As pointed out by the European Securities and Markets Authority (ESMA), the RegTech industry has been accelerating in recent years courtesy of both demand and supply shocks.⁶ On the demand side, a costly wave of new regulations that followed the financial crisis intensified RegTech’s attractiveness.⁷ On the supply side, FinTech firms, beyond disrupting financial intermediation,⁸ have also been innovating to provide new ways of reducing compliance costs significantly.⁹

Though regulated entities have been speedily making use of these tools to enhance compliance, regulators have lagged in revising themselves for the digital age.¹⁰ To correct such delay, Supervisory Technology (“SupTech”) has attracted some attention. SupTech makes use of similar tools as those applied by RegTech but is directed to the technological empowerment of regulators and market supervisors, the refinement of their oversight capabilities and data

⁴ Douglas W. Arner et al., *FinTech, RegTech, and the Reconceptualization of Financial Regulation*, 37 NORTHWEST. J. INT. LAW BUS. 371, 385 (2017).

⁵ Emmanuel Schizas et al., *The Global RegTech Industry Benchmark Report*, CAMBRIDGE CENTRE FOR ALTERNATIVE FINANCE 18-19 (June 30, 2019), <https://www.jbs.cam.ac.uk/faculty-research/centres/alternative-finance/publications/the-global-regtech-industry-benchmark-report/#.Xv0qEpMzblw>.

⁶ Patrick Armstrong, *RegTech and SupTech – Change for Markets and Authorities* (ESMA Report on Trends, Risks and Vulnerabilities 1, 2019), https://www.esma.europa.eu/sites/default/files/library/esma50-report_on_trends_risks_and_vulnerabilities_no1_2019.pdf, at 43.

⁷ Veerle Colaert, *RegTech as a Response to Regulatory Expansion in the Financial Sector* (June 2019), <https://ssrn.com/abstract=2677116>.

⁸ See, e.g., Anjan V. Thakor, *Fintech and banking: What do we know?*, 41 J. FINANC. INTERMED. 1 (2020) (on FinTech impact in a diversity of financial arenas, such as payment systems, insurance, and investment management services).

⁹ Douglas W. Arner et al., *supra* note 4, at 385.

¹⁰ Eva Micheler & Anna Whaley, *Regulatory Technology: Replacing Law with Computer Code*, 21 EUR. BUS. ORGAN. LAW REV. 349, 350 (2020) (on the need for law to be adapted because of technological changes).

accuracy, and to turn their interventions timelier.¹¹ Since market dynamism tends to magnify information asymmetries between regulators and regulatees, better integrating RegTech and SupTech could enhance needed regulatory adaptability.

In this essay, we argue that RegTech and SupTech must go hand-in-hand to counter markets' dynamism. Consequently, in the process of better embedding these technologies, regulators should enforce specific requirements on the development of these new solutions. As RegTech and SupTech are prone to monopoly tendencies and could serve as a new stage for regulatory capture, legal requirements such as technological neutrality and interoperability have to be considered by policy-makers, which can place blockchain solutions as a problematic case.

We proceed as follows. Section II. explores how market dynamism limits regulatory efficacy. Sections III. and IV. discuss how technology may assist regulators who are facing such difficulties, by arguing that RegTech (III.) and SupTech (IV.) can assist in identifying the need for adaptations and reforms in regulation. Against that backdrop, section V. will show how RegTech and SupTech solutions may backfire, thereby making a case for certain design amendments. Section VI. illustrates these technological potentials and challenges through blockchain proposals. Section VII. concludes.

II. DYNAMISM AND REGULATION

Markets are continuous fleeting targets for regulation.¹² Their inherent dynamism is partly driven by competitive pressures and market players' constant search for a more favorable regulatory environment. Thereby, this degree of mismatch between market changes and regulatory adaptation ends up limiting regulatory efficacy.

¹¹ *SupTech: Leveraging Technology for Better Supervision*, TORONTO CENTRE 10-11 (July 2018), <https://res.torontocentre.org/guidedocs/SupTech%20-%20Leveraging%20Technology%20for%20Better%20Supervision%20FINAL.pdf>.

¹² JOHN ARMOUR ET AL., *PRINCIPLES OF FINANCIAL REGULATION* (2016) 13.

In financial markets, beyond a significant shift in the way funds are channeled from suppliers to users of capital, technological advancements have reduced the costs of financial transactions and international capital flows, encouraging the emergence of new markets and risk management options. Organizational complexity has also grown with a considerable rise in the average number of subsidiaries controlled by global banks.¹³ As these subsidiaries engage with different businesses and operate in more jurisdictions, building opaque organizational structures, their regulation and supervision get ever more challenging.¹⁴

Remarkably, regulation also spurs dynamism as market actors create new ways to reduce its costs.¹⁵ This practice includes the phenomenon known as shadow banking, which gained public attention after the financial crisis. In the U.S., for instance, non-traditional banks are the ones today providing most credit to borrowers with lower credit scores.¹⁶ The increased regulatory burden has not stopped the flow of credit but has instead moved it towards sources outside the traditionally regulated ones.¹⁷

FinTech is one of these phenomena propelled by technological change and, partly, regulatory costs. Its capacity to disperse risks once concentrated in banks has produced some efficiencies and stability gains, enabling customers to access more affordable credit, amplifying liquidity, and reducing biases and negative prejudices in the credit market.¹⁸ Nevertheless,

¹³ Richard Herring & Jacopo Carmassi, *Complexity and Systemic Risk, What's Changed Since the Crisis?*, IN THE OXFORD HANDBOOK OF BANKING (Allen N. Berger et al. ed., 2nd ed. 2014) 77.

¹⁴ Kathryn Judge, *Fragmentation Nodes: A Study in Financial Innovation, Complexity, and Systemic Risk*, 64 STANFORD LAW REV. 657 (2012) (on how complex financial innovations limits transparency).

¹⁵ Kathryn Judge, *Investor-Driven Financial Innovation*, 8 HARV. BUS. LAW REV. 291 (2018) (on the unintended consequences of financial regulation in which innovations motivated by regulatory requirements can enhance efficiency but also complexity and interconnectedness).

¹⁶ Laurie Goodman et al., *Housing Finance at a Glance: A Monthly Chartbook*, URBAN INSTITUTE (April 2014), <http://webarchive.urban.org/publications/413096.html>.

¹⁷ Greg Buchak et al., *Fintech, regulatory arbitrage, and the rise of shadow banks*, 130 J. FINANC. ECON. 453 (2018); See also, e.g., Kathryn Judge, *Information Gaps and Shadow Banking*, 103 VA. LAW REV. 411 (2017) (on how shadow banking might reduce information sensitiveness by accentuating information gaps).

¹⁸ Thomas Philippon, *On Fintech and Financial Inclusion* (NBER Working Paper 26330, September 2019), <https://www.nber.org/papers/w26330>; See also, e.g., Cass R. Sunstein, *Algorithms, Correcting Biases*, 86 SOC. RES. 499 (2019) (on how algorithms are relatively easier than human beings to be designed without cognitive biases, reducing discriminatory traits).

products and services like crowdfunding,¹⁹ digital currencies,²⁰ and initial coin offerings,²¹ all seem to partly display features of solutions that evolved to sidestep regulation.²²

The disruption FinTech brings to how financial services are provided, and by whom they are provided, has forced financial regulators to widen their areas of competence and to increase the number of players they have to monitor. Moreover, FinTech competes against traditional financial institutions but has also been increasingly partnering with them, building more intricate relationships and opening the door for novel business and operational models, further limiting regulators' capacity to monitor emerging risks.²³

Regulatory effectiveness requires that policy-makers and regulators are continually learning while they regulate, monitoring how market changes can potentially lead to consumer harm or financial instability, and preparing the appropriate counter-measures. To mitigate the information asymmetry, regulators have been devising new regulatory experiments such as regulatory sandboxes and innovation hubs.²⁴ This experimentalism has also led regulators to perceive technology as an ally for boosting compliance levels. The following two sections explore how regulatory (III.) and supervisory technologies (IV.) may assist regulators in responding to dynamic market developments.

¹⁹ Georg Gutfleisch, *Crowdfunding and Initial Coin Offerings under the EU Legal Framework*, 15 EUR. CO. LAW J. 73 (2018).

²⁰ Hossein Nabilou & Andre Prüm, *Ignorance, Debt and Cryptocurrencies: The Old and the New in the Law and Economics of Concurrent Currencies*, 5 J. FIN. REG. 29 (2019).

²¹ Dirk A. Zetsche et al., *The ICO Gold Rush: It's a Scam, It's a Bubble, It's a Super Challenge for Regulators*, 60 HARV. INT'L L.J. 267 (2019).

²² René M. Stulz, *FinTech, BigTech, and the Future of Banks*, 31 J. APPL. CORP. FINANCE 86, 21 (2019) ("much FinTech activity is designed to find ways of bypassing regulations that affect banks").

²³ Luca Enriques & Wolf-Georg Ringe, *Bank-FinTech Partnerships, Outsourcing Arrangements and the Case for a Mentorship Regime* (ECGI Law Working Paper 527/2020, June 2020), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3625578.

²⁴ Wolf-Georg Ringe & Christopher Ruof, *Regulating FinTech in the EU: the Case for a Guided Sandbox*, EUR. J. RISK REGUL. 1, 12 (2020), <https://www.cambridge.org/core/product/3EE71CEEBC22E57A1BF08023073A6F/>.

III. DIGITIZING COMPLIANCE

The rising costs of compliance and the availability of new technologies have led to an intense episode of market entry and product development in recent years, especially in sectors that heavily use data.²⁵ Both phenomena fueled the development of RegTech. RegTech provides tools that can support the handling of large amounts of data, develop more sophisticated analysis, and automate reporting. As financial institutions now must submit far more data on their decisions and risk exposures, they need better informational technology systems, which forces them to rely on RegTech providers. Nevertheless, they have also been developing in-house solutions and sometimes, more critically, in collaboration with established competitors.²⁶

The range of RegTech services and products goes beyond *compliance* and *regulatory reporting*. While the first incorporates solutions that identify and keep track of changes in regulatory requirements in diverse jurisdictions and automate real-time monitoring of compliance and risk levels through the analysis of operational and internal data (such as insights from managers and employees observation), the second helps to automate and integrate regulatory reporting requirements to cut costs and increase accuracy and speediness.²⁷ It also includes *customer identification and transaction monitoring* (digitizing and updating customers and partners information and identifying suspicious transactions) and *risk management* (generating data and internal reporting, monitoring risk according to internal methodologies and regulatory definitions, and creating alerts and automated reactions to changes in risk level).²⁸

The development of RegTech solution holds great promise for reporting accuracy, cost saving, and improved dialogue between regulator and regulatee. It is, therefore, no surprise that regulators have designed ways on how to support the emergence of RegTech solutions. Already in 2016, the British Financial Conduct Authority (FCA) had summarized the following four goals

²⁵ Douglas W. Arner et al., *RegTech: Building a Better Financial System*, IN HANDBOOK OF BLOCKCHAIN, DIGITAL FINANCE, AND INCLUSION (David Lee Kuo Chuen & Robert Deng eds., 2018) 359.

²⁶ Rolf H. Weber, *RegTech as A New Legal Challenge*, 46 J. FIN. TRANSFORMATION (2017).

²⁷ John Ho Hee Jung, *RegTech and SupTech: The Future of Compliance*, IN FINTECH: LAW AND REGULATION (Jelena Madir ed., 2019) 255, 264-265.

²⁸ *ibid.* See, e.g., Bart van Liebergen, *Machine Learning: A Revolution in Risk Management and Compliance?*, 45 J. FIN. TRANSFORMATION 60 (2017).

regarding how to assist the RegTech industry, all of which have been replicated in some way by other regulators: (i) *efficiency and collaboration* (alternative technologies that allow efficient data-sharing, such as cloud computing and online platforms, and communication among diverse parties); (ii) *integration and automation* (technologies that close the gap between the intentions and interpretations of policy-makers and regulators or, better still, technologies that assist converting regulatory text into machine-readable formats and shared data ontologies, and the “Robo-Handbook”, tailored to assist firms’ compliance in a more precise format); (iii) *predict, learn, and simplify* (technologies that simplify data and allow for better decision-making, such as big data analytics through the creation of “data lakes”, better visualization technologies, and risk and compliance monitoring); and (iv) *new directions* (technologies that accommodate new approaches to regulation and compliance, such as system integrity and transparency with blockchain).²⁹

This digitization of financial services brings a wide range of benefits, but also some challenges. Cybersecurity is a problematic issue facing the financial markets as remote banking services grow, and this has attracted the attention of several regulators.³⁰ And now, because of the use of novel technologies for compliance, financial markets might be even more susceptible to cyber-attacks and data privacy risks.³¹ To address these emerging issues, financial institutions have more actively turned to data analysis and cybersecurity companies, increasing third-party risks from technology providers in so doing.³² Consequently, these new layers of intermediaries, which in many cases entail cross-border collaborations, pose yet another additional informational asymmetry between regulators and regulated entities. These new types of market participants

²⁹ FS16/4: *Feedback Statement, Call for Input on Supporting the Development and Adopters of RegTech*, FINANCIAL CONDUCT AUTHORITY (July 20, 2016), <https://www.fca.org.uk/publications/feedback-statements/fs16-4-feedback-statement-call-input-supporting-development-and>.

³⁰ *What is Cyber Resilience?*, EUROPEAN CENTRAL BANK, <https://www.ecb.europa.eu/paym/cyber-resilience/html/index.en.html> (last visited Apr. 30, 2020).

³¹ Jennifer Callen-Naviglia & Jason James, *FinTech, RegTech and the Importance of Cybersecurity*, 19 ISSUES INFORM. SYSTEMS 220 (2018).

³² *Financial Stability Implications from FinTech: Supervisory and Regulatory Issues that Merit Authorities’ Attention*, FINANCIAL STABILITY BOARD 17-21 (June 27, 2017), <https://www.fsb.org/wp-content/uploads/R270617.pdf>.

might end up building intense communication channels with regulators, especially after regulators start more intensely incorporating some of the solutions developed by market participants.

It is also important to emphasize that as financial markets and compliance become increasingly data-driven, they arouse the attention of large technology firms (so-called “BigTech”), who currently dominate innovations in artificial intelligence and data analysis.³³ This change in players might lead to competition concerns as one of the BigTech strategies for growth is built on identifying and acquiring promising smaller technology companies while holding extensive consumer data in their platforms.³⁴

Technological change is a driver of not only dynamism in the financial markets, but also of innovation in regulation and supervision. As the costs of regulatory arbitrage fall with better information and communication technologies, the competition among regulators intensifies, incentivizing them to perfect their institutional environment. In this sense, while RegTech development has been driven mostly by industry participants aiming to reduce their compliance costs, it has also received growing support from regulators seeking to lessen the burden they place on regulated entities and lately explore how such tools could be adapted into SupTech, improving monitoring and stability.

IV. SUPTECH AND REGULATORY ADAPTABILITY

The Basel Committee on Banking Supervision (BCBS) was one of the first observers to point out that the same technologies that improve the efficiency of banks³⁵ and FinTechs should

³³ Dirk A. Zetsche et al., *The Future of Data-Driven Finance and RegTech: Lessons from E.U. Big Bang II* (EBI Law Working Paper Series 2019-005, 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3359399, at 49; See also, e.g., *BigTech in finance: Market developments and potential financial stability implications*, FINANCIAL STABILITY BOARD (Dec. 9, 2019), <https://www.fsb.org/2019/12/bigtech-in-finance-market-developments-and-potential-financial-stability-implications/>.

³⁴ René M. Stulz, *FinTech, BigTech, and the Future of Banks* (NBER Working Paper 26312, Sep. 2019), <http://www.nber.org/papers/w26312> (“Both FinTech and BigTech are contributing to a secular trend of banks losing their comparative advantage as they have less access to unique information about parties seeking credit”).

³⁵ See, e.g., Nicola Pierre & Yannick Timmer, *Tech in Fin before FinTech: Blessing or Curse for Financial Stability?* (CESifo Working Paper 8067, Jan. 2020), https://ideas.repec.org/p/ces/ceswps/_8067.html

also be used to improve supervisory efficacy.³⁶ While RegTech assists financial institutions in complying with changing laws and regulations, SupTech is focused on enabling regulators to “conduct supervisory work and oversight more effectively and efficiently.”³⁷

The most basic supervisory need at this moment is for regulators to be able to assess and evaluate the increasing amount of material being provided by financial institutions, which is required by the wave of new regulations that came after the financial crisis. This need may also be related to, and the logical consequence of, the automation of reporting systems and RegTech. SupTech, therefore, may be seen as the “regulator’s response”, reinstalling a level of parity between supervisor and supervisee. At the outset, SupTech is mainly found in data collection and analytics.³⁸ Its most transformative potential, however, lies in its capacity to enable real-time monitoring of financial markets, improving the evaluation of compliance breaches and firms’ due diligence, as well as new risks as they unfold. This development will improve market monitoring, allowing regulators to more effectively process new types of data concerning the growing number of players under their supervision.³⁹

SupTech moves in the direction of better enabling regulators to anticipate future market changes and how firms are adapting themselves to novel regulatory requirements. In this sense, SupTech is assisting regulators in tracking the impact of novel products, services, and business models, shortening regulators’ discovery and regulatory lags. Through the use of these technologies, financial regulation is better prepared to account for market dynamism, enhancing the ability of regulators to monitor systemic implications in a timelier and comprehensive manner.

(banks with “higher IT-adoption led to significantly lower non-performing loans when the crisis hit” and that “technology adoption in lending can enhance financial stability through the production of more resilient loans”).

³⁶ Basel Committee on Banking Supervision, *Sound Practices – Implications of Fintech Developments for Banks and Bank Supervisors*, BANK FOR INTERNATIONAL SETTLEMENTS (Feb. 19, 2018), <https://www.bis.org/bcbs/publ/d431.htm>, at 43 (“Suptech (supervisory technology) is the use of technologically enabled innovation by supervisory authorities”).

³⁷ *Id.* at 35.

³⁸ Dirk Broeders & Jermy Prenio, *Innovative technology in financial supervision (suptech) – the experience of early users* (FSI Insights on policy implementation 9, July 2018), <https://www.bis.org/fsi/publ/insights9.htm>, at 6-12.

³⁹ Douglas W. Arner et al., *supra* note 25.

The Financial Stability Board (FSB) and the International Monetary Fund (IMF) have identified the need to synchronize reporting templates for systemically important financial institutions to make data analysis easier.⁴⁰ Risk data aggregation requirements were also promoted by the Basel Committee,⁴¹ which encourages institutions and regulators to focus their internal procedures on near-real-time delivery and analysis. Moreover, the FCA and the Bank of England have been operating a database named Gabriel, which is fed by electronic reports from regulated entities.⁴² As it still partly involves manual procedures, both institutions have been studying how to upgrade their system with tools such as blockchain and natural language processing to improve completeness and consistency.⁴³

The Cambridge Centre for Alternative Finance's benchmark report on RegTech pointed to a market premium for solutions offering real-time insights and the transformation of compliance and oversight into an "end-to-end process."⁴⁴ Artificial intelligence and machine learning are assisting regulators in improving their analyses over more massive data sets and, combined with big data, identifying new patterns that might indicate suspicious activities and find previously ignored correlations.⁴⁵ Digital reporting has already altered the quantity, quality, and velocity of data available to regulators, and it could soon also allow access to firms' data recorded internally in a secure manner, improving regulators' decision-making in the process.⁴⁶

Another recent experiment of the FCA and the Bank of England with language-processing technologies entails translating the reporting requirements of the FCA's Handbook from English

⁴⁰ IMF/FSB, *The Financial Crisis and Information Gaps: Second Phase of the G-20 Data Gaps Initiative (DGI-2), First Progress Report* (September 2016), <https://www.fsb.org/wp-content/uploads/Second-phase-of-the-G20-Data-Gaps-Initiative-DGI-2-First-Progress-Report.pdf>.

⁴¹ *Principles for Effective Risk Data Aggregation and Risk Reporting*, BASEL COMMITTEE ON BANKING SUPERVISION (Jan. 2013), <https://www.bis.org/publ/bcb239.pdf>.

⁴² *Gabriel*, FINANCIAL CONDUCT AUTHORITY (May 05, 2016), <https://www.fca.org.uk/firms/gabriel>.

⁴³ Eva Micheler & Anna Whaley, *supra* note 10, at 355; See, e.g., *Call for input: using technology to achieve smarter regulatory reporting*, FINANCIAL CONDUCT AUTHORITY (2018), <https://www.fca.org.uk/publications/feedback-statements/call-input-using-technology-achieve-smarter-regulatory-reporting>.

⁴⁴ Emmanuel Schizas et al., *supra* note 5, at 19.

⁴⁵ See, e.g., Karen Yeung, *Algorithmic regulation: a critical interrogation*, 12 REGUL. GOV. 505 (2018).

⁴⁶ Andrew Burt et al., *2017 Model driven and machine executable regulations and tech sprint: success criteria and recommendations* (November 20, 2017), <https://www.fca.org.uk/events/techsprints/model-driven-machine-executable-regulatory-reporting-techsprint>, p 4.

to computer code, assisting institutions to catch up with regulatory changes.⁴⁷ Nevertheless, it could go further. With the capacity to access regulated entities' data as they are being produced, SupTech could be tailored using smart contract functionalities to identify breaches and imbalances, making specific suggestions for sanctions and interventions in a timelier manner.⁴⁸

Finally, institutional differences such as the legal mandates, public accountability, lack of technological expertise, limited budget constraints, and, consequently, the risk-averse nature of regulators, leave them at a disadvantage in adopting technological innovations.⁴⁹ While the private sector is relatively well-equipped to create and adopt RegTech solutions, it has lower incentives to utilize these tools in the public interest and to assist SupTech to enhance regulatory capabilities. The question, therefore, turns to how to build a regulatory framework that embeds both technological flexibility and public accountability.

Regulators becoming better able to monitor changes in the market have the potential to produce more effective regulations, which in turn will be more flexible and adapted to emerging risks. In the process of improving their technological capacity, however, regulators may end up becoming even more dependent on technology providers, including established financial institutions which are now cooperating with regulators in building these shared infrastructures. Subsequently, how to ensure that this process does not lead to regulatory capture and reduced competition becomes the big question.

V. FOSTERING REGTECH-SUPTECH INTERACTION

We have seen so far that RegTech and SupTech both hold great promise in coping with the dynamic evolvement of financial markets: their role will – and to a certain extent, already do – go beyond mere compliance facilitation. A technology-driven framework for the supervision of

⁴⁷ *Digital Regulatory Reporting*, FINANCIAL CONDUCT AUTHORITY, <https://www.fca.org.uk/innovation/regtech/digital-regulatory-reporting> (last visited April 30, 2020).

⁴⁸ Eva Micheler & Anna Whaley, *supra* note 10, at 369.

⁴⁹ Yueh-Ping (Alex) Yang & Cheng-Yun Tsang, *RegTech and the New Era of Financial Regulators: Envisaging More Public-Private Partnership Models of Financial Regulators*, 21 U. PA. J. BUS. L. 355, 378-382 (2018).

financial services providers may partly overcome the present-day problems that regulators face – a lack of speed and sophistication, legal uncertainty of outdated regulatory frameworks, and the absence of innovative ways in approaching new products and services, to name but a few.

Nevertheless, as the RegTech industry grows and regulators become more dependent on their solutions for supervision, a new window for regulatory capture is open, which might threaten public accountability. It is our principal argument in this essay that, in this new age of financial markets governance, RegTech and SupTech solutions should first and foremost be developed hand-in-hand, rather than in insolation. We believe that RegTech and SupTech can most fruitfully interact following a number of key framework principles, such as technological neutrality and interoperability, to which we now turn.

The first issue is related to the choice of the right technology. In the current age of continuous technological exploration, it is hard to determine which technology is superior or will have higher market adherence.⁵⁰ The choice for a particular solution can lead to possible technological dependence, which is highly detrimental in public institutional models that leverage partnerships with private actors. Accordingly, because of the limitations to assess the quality and security of an adopted technology, especially new ones, which has yet to prove their validity, regulators should ensure that any partnerships entered into are straightforward and easy to exit, as a means to ensure public accountability.

An initial measure to uphold public accountability is to guarantee *technological neutrality*. Technological neutrality means that, instead of promoting and regulating the technology itself, regulators should focus on their outcomes.⁵¹ Such a step reduces the possibility that regulators are lured into endorsing certain technologies only because of pressure or influence from specific technology providers or regulated entities. In other words, technological neutrality mitigates the risk that regulatory capture would start already at the moment of choosing a particular technology.

⁵⁰ See, e.g., Joshua S. Gans et al., *Choosing Technology: An Entrepreneurial Strategy Approach* (NBER Working Paper 27489, July 2020), <https://www.nber.org/papers/w27489>.

⁵¹ Douglas W. Arner et al., *FinTech and RegTech: Enabling Innovation While Preserving Financial Stability*, 18 GEO. J. INT. AFF. 47, 53 (2017); Dirk A. Zetsche et al., *Regulating a Revolution: From Regulatory Sandboxes to Smart Regulation*, 23 FORDHAM J. CORP. & FIN. L. 31, 96 (2017).

Regulators should focus on outcomes; thereby, if a more efficient competing solution delivers better results, it should be preferred instead of another just because it embeds the use of a desired technology.

In Europe, Directive 2009/140/EC enshrines the requirement for technological neutrality for electronic communication networks.⁵² But it is paramount to expand these requirements for the emerging RegTech and SupTech industries. Regulators, thereby, should not be promoting or discouraging certain technologies over others, but should instead adopt a neutral stance. For example, it is not necessarily algorithmic trade that is the problem, but rather the risk of fraud. And it is not blockchain data pools that should be the goal but secure data pools, which may end up being developed on a blockchain or not. The FCA, for instance, is neutral towards the technology used by the entities it regulates, so it does not matter how firms maintain their records or organize themselves as long as they produce the reports required and comply with the rules contained in its Handbook.⁵³

A further measure is to ensure that the solutions adopted by the industry and, even more importantly, by the regulators themselves, are *interoperable*. Interoperability means the capacity of a product or service to communicate with or function alongside other products and services which might be technically diverse.⁵⁴ Interoperability invites more competition as it avoids technological dependency and potential regulatory capture. The characteristics of the RegTech and SupTech industries are somewhat akin to those of the digital platform economy, which is another major topic of interest among policy-makers in recent years, particularly concerning its competition risks and political influence. Among others, a major common characteristic shared by these industries is a tendency towards monopoly. The following features illustrate this characteristic: (i) *strong network effects* (the adoption of a certain RegTech or SupTech solution

⁵² Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009 amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities, and 2002/20/EC on the authorisation of electronic communications networks and services [2009] OJ L337/37.

⁵³ FINANCIAL CONDUCT AUTHORITY, *supra* note 43.

⁵⁴ Wolfgang Kerber & Heike Schweitzer, *Interoperability in the Digital Economy*, 8 J. INTELL. PROP. INFO. TECH. & ELEC. COM. L. 39 (2017).

makes it more appealing to others firms and regulators); (ii) *strong economies of scale and scope* (the costs of producing more and moving to other market segments decrease as the size of the technology provider grows); (iii) *low marginal costs* of serving additional customers; (iv) *increasing returns from data use* (the more firms and regulators a technology provider attends to, the more data it will control and more leverage it will acquire); and (v) *the low global distribution costs*.⁵⁵

This confluence of characteristics might lead to increased market concentration and the establishment of a few dominant players. The Cambridge Centre's benchmark report has already pointed to a growing saturation in the RegTech market.⁵⁶ Interoperability is not an uncontroversial topic, as the incentives for investment might decrease if customers can migrate more easily to other solutions.⁵⁷ Accordingly, producing an interoperable product is a strategic business choice: companies with larger networks will tend to offer products or services that are not interoperable with products or services from other companies, to maintain their position. Nevertheless, these concerns are allayed when the focus switches to technologies with a more public purpose such as regulatory compliance and oversight, which requires a higher degree of public accountability. RegTech and SupTech might be of even greater concern than digital platforms because, as they evolve, they turn into essential public facilities in financial regulation and supervision.

Public *consultations* are essential in this regard because of information asymmetries between regulators and RegTech and SupTech providers. Consultations are paramount in governance systems with diverse participants with unique interests and demands which are hard to reconcile.⁵⁸ This is especially true in highly dynamic environments, such as the financial markets. A problem, however, arises where better-funded market actors can participate more

⁵⁵ Luigi Zingales & Filippo Maria Lancieri, *Stigler Committee on Digital Platforms: Policy Brief*, STIGLER CENTER FOR THE STUDY OF THE ECONOMY AND THE STATE 3-4 (September 2019), <https://research.chicagobooth.edu/-/media/research/stigler/pdfs/policy-brief---digital-platforms---stigler-center.pdf>.

⁵⁶ Emmanuel Schizas et al., *supra* note 5, at 13.

⁵⁷ In Lee, *An optimization approach to capacity evaluation and investment decision of hybrid cloud: a corporate customer's perspective*, 8 Journal of Cloud Computing 1 (2019) ("interoperable cloud systems require time and investment by the users and/or cloud providers and there exists a diminishing return on the investment");

⁵⁸ John Armour et al., *supra* note 12, at 556-560.

actively.⁵⁹ As the RegTech and SupTech industries grow, dialogues among regulators, financial institutions, and technology providers will intensify, and this might lead to collusion and higher barriers to entry for newcomers. This risk is accentuated by the rising compliance costs,⁶⁰ which turns these tools into indispensable requirements instead of mere options, as well as the limited political influence of newcomers when compared to larger financial and technology firms.

Network externalities represent another concern, and not a new one either. It was previously present in the phone industry and was solved by forced interoperability among various phone companies. Today, in most jurisdictions, no network can block calls from another.⁶¹ For instance, in the cloud computing industry, a significant challenge in many cases is the absence of an interoperable Application Program Interface (API).⁶² Mandating an open and common API, which consists of a particular set of rules that software programs must follow to facilitate communication and interaction with other software, would allow different RegTech and SupTech solutions to connect better and migrate more easily.⁶³ This requirement would avoid “lock-in”, a vital issue with cloud services,⁶⁴ which is now the most commonly used technology in RegTech.⁶⁵

Hence, if not adequately designed, RegTech and SupTech, rather than reducing costs and increasing competition, might generate the complete opposite. In financial markets, a common form of capture is related to the constructed need of intermediaries, even when more efficient alternatives already exist. Better politically positioned intermediaries might promote self-serving

⁵⁹ *Id.* at 558-560.

⁶⁰ See, e.g., Ellinor Johansson et al., *RegTech – A necessary tool to keep up with compliance and regulatory changes?*, 8 ACRN J. FINANCE RISK PERSPECT. 71 (2019).

⁶¹ Luigi Zingales & Filippo Maria Lancieri, *supra* note 55, at 11.

⁶² Justice Opara-Martins, Reza Sahandi & Feng Tian, *Critical analysis of vendor lock-in and its impact on cloud computing migration: a business perspective*, 5 J. CLOUD COMPUT-ADV. S. 1, 16 (2016) (“most customers are unaware of proprietary standards which inhibit interoperability and portability of applications when taking services from vendors”).

⁶³ *RegTech in Financial Services: Technology Solutions for Compliance and Reporting*, INSTITUTE OF INTERNATIONAL FINANCE 19-21 (March 2016), https://www.iif.com/Portals/0/Files/private/iif-regtech_in_financial_services_-_solutions_for_compliance_and_reporting.pdf, at 15.

⁶⁴ Sally Weston, *Improving interoperability by encouraging the sharing of interface specifications*, 9 LAW INNOV. TECHNOL. 78, 79-80 (2017) (“there is evidence that lack of interoperability causes a problem for users and results in expense, waste, reduced efficiency and lock-in which affects competition”).

⁶⁵ Emmanuel Schizas et al., *supra* note 5, at 9 (“about two thirds (66%) of the sector delivers its offerings through the cloud, with 56% of vendors employing machine learning and 43% using predictive data analytics to describe patterns or predict behaviours”).

arrangements.⁶⁶ Thus, neutrality and interoperability are essential requirements to reduce the incentives for RegTech and SupTech firms to attempt to create dependable relationships with regulators and, consequently, with other firms to whom they might provide their products.

In Europe, the Revised Payment Services Directive (“PSD2”) includes the promotion of an innovative payment system through open banking, open APIs for banking services, and open-source technology that enables third-party developers to build competing applications and services around all financial institutions.⁶⁷ This development also links to solutions such as data ownership and portability, illustrated by regulations like the EU General Data Protection Regulation (GDPR), which imposes portability across the entire economy, not only in the context of payments.⁶⁸ Finally, the use of these new tools will undoubtedly raise data-related issues that are sector-specific. Increased interoperability and data exchange among, and within, jurisdictions should go some way to resolving these issues though. Notably, only a shared understanding of legal concepts and a common technical approach can deliver open regulatory standards and cross-border platforms.⁶⁹

VI. BLOCKCHAIN AND INTEROPERABILITY

A significant technology being explored by the industry and regulators for RegTech and SupTech solutions is blockchain. The existing blockchain architecture, however, is usually not

⁶⁶ See, e.g., Kathryn Judge, *Intermediary Influence*, 82(2) UNIVERSITY OF CHICAGO LAW REVIEW 573 (2015) (on how some institutional arrangements are not necessarily the result of more efficient arrangements to reduce transactions costs, but the result of intermediary influence to maintain structure that yields them higher fees).

⁶⁷ Oscar Borgogno & Giuseppe Colangelo, *Data, Innovation and Competition in Finance: The Case of the Access to Account Rule* (Jan. 2020), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3251584 (on the value and challenges for interoperability and APIs standardization); Christopher C. Nicholls, *Open Banking and the Rise of FinTech: Innovative Finance and Functional Regulation*, 35 BANK. & FIN. LAW REV. 121 (2019).

⁶⁸ Dirk A. Zetsche et al., *The Future of Data-Driven Finance and RegTech: Lessons from E.U. Big Bang II* (EBI Law Working Paper Series 2019-005, 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3359399, at 19.

⁶⁹ Andrea Renda, *The promise and preconditions of RegTech*, CLUB OF REGULATORS/OECD NETWORK OF ECONOMIC REGULATORS (Nov. 27, 2018), http://chairgovreg.fondation-dauphine.fr/sites/chairgovreg.fondation-dauphine.fr/files/attachments/181127_Synthese.pdf.

interoperable.⁷⁰ We dedicate this last section to analyze some of these proposals, highlighting the challenge of blockchain interoperability, and thereby attempting to guide regulators in being more careful on how they go into promoting and incorporate its use.

Blockchain, just like other technologies discussed in this essay, is present on both sides of the regulatory arena. It is disrupting financial markets and generating new challenges that demand public attention,⁷¹ while at the same time it can also be harnessed to increase compliance levels and solve past coordination problems, which might have been the justification for earlier interventions. Blockchain was initially proposed as an infrastructure for an “electronic payment system based on cryptographic proof instead of trust,”⁷² delivering a new way to store and monitor the exchange of information and digital assets.

Blockchain is composed of a combination of several technologies, including append-only databases and peer-to-peer networks, creating decentralized and more secure data records. Its application extends beyond cryptocurrencies to areas as diverse as supply chain platforms, utility markets, shared registries, and corporate governance, and is well-equipped to prevent cyber-attacks, data privacy risks, and data alteration.⁷³ Blockchain cryptography is transforming data into a more secure format to facilitate compliance with data-sharing regulations, such as PSD2 and GDPR,⁷⁴ thereby diminishing data security concerns for big datasets by providing customized access.⁷⁵

⁷⁰ Paolo Tasca & Riccardo Piselli, *The Blockchain Paradox*, in *Regulating Blockchain: Techno- Social and Legal Challenges* (Philipp Hacker et al. eds., 2019) 27, 36.

⁷¹ Stuart Levi, Gregory Fernicola & Eytan Fisch, *The Rise of Blockchains and Regulatory Scrutiny*, HARVARD LAW SCHOOL FORUM ON CORPORATE GOVERNANCE AND FINANCIAL REGULATION (March 9, 2018), <https://corpgov.law.harvard.edu/2018/03/09/the-rise-of-blockchains-and-regulatory-scrutiny/>.

⁷² Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System* (2008), <https://bitcoin.org/bitcoin.pdf> (last visited Apr. 30, 2020).

⁷³ TORONTO CENTRE, *supra* note 11, at 4; See also, e.g., Patricia L. De Miranda, *Cybersecurity and Blockchain*, in *FINTECH: LAW AND REGULATION* (Jelena Madir, ed., 2019) 208; Daniel Cooper & Gemma Nash, *Blockchain and Privacy*, in *FINTECH: LAW AND REGULATION* (Jelena Madir, ed., 2019) 232.

⁷⁴ TORONTO CENTRE, *supra* note 11, at 5.

⁷⁵ INSTITUTE OF INTERNATIONAL FINANCE, *supra* note 63, at 12.

Blockchain is also assisting financial institutions in facilitating the storage of information and know-your-customer (KYC) procedures and anti-money laundering (AML) requirements.⁷⁶ As KYC tasks are repetitive, which can lead to inconsistencies, and AML compliance requires extensive documentation, FinTech firms and the banking industry have been exploring how blockchain can improve their data collection. One possibility is to develop internal KYC blockchains that enable the sharing of data across a firm's divisions, such as an "internal KYC platform," and, possibly among several firms, a "multi-participant KYC registry."⁷⁷ Thereby, blockchain could also be combined with artificial intelligence to monitor the records of a broader range of transactions and firms.

A tool through which this could be done would be the establishment of a "Data Storage Cell Level Security"⁷⁸ with a cryptography application that only allows authorized parties to access the information shared on the blockchain data pool, protecting business-sensitive information⁷⁹ without compromising the needed secrecy of banks' strategies.⁸⁰ Market participants can develop a blockchain system through which they hold and transfer financial assets connected with regulators' SupTech solutions, thus enabling close monitoring and auditing.⁸¹ This system would also allow for exploration into new ways to aggregate information currently held by different regulators, and to produce a more complete and accurate picture of the financial system, incorporating new metrics to assess financial stability more broadly.

Remarkably, blockchain is more prevalent in applications tested by regulators than by the industry overall.⁸² A reason for this might be the capacity of blockchain to develop smart

⁷⁶ Esman Kurum, *RegTech solutions and AML compliance: what future for financial crime?*, J. FINANC. CRIME (2020), <https://www.emerald.com/insight/content/doi/10.1108/JFC-04-2020-0051/full/html>.

⁷⁷ *Cryptotechnologies: Improving Regulatory Compliance*, EBA CRYPTOTECHNOLOGIES WORKING GROUP (2018), https://www.abe-eba.eu/epaper/epaper-EBA-Cryptotechnologies-2018/epaper/EBA_Cryptotechnologies.pdf, at 12-15.

⁷⁸ INSTITUTE OF INTERNATIONAL FINANCE, *supra* note 63, 12.

⁷⁹ *Id.* Eva Micheler & Anna Whaley, *supra* note 10, at 355.

⁸⁰ See, e.g., Gary Gorton, *The Development of Opacity in U.S. Banking*, 31 YALE L. ON REG. 825 (2014) (on the competitive value of banking secrecy).

⁸¹ Garrick Hileman & Michel Rauchs, *Global blockchain benchmarking study*, CAMBRIDGE CENTER FOR ALTERNATIVE FINANCE (2017), [https://www.ey.com/Publication/vwLUAssets/ey-global-blockchain-benchmarking-study-2017/\\$FILE/ey-global-blockchain-benchmarking-study-2017.pdf](https://www.ey.com/Publication/vwLUAssets/ey-global-blockchain-benchmarking-study-2017/$FILE/ey-global-blockchain-benchmarking-study-2017.pdf), at 64; Eva Micheler & Anna Whaley, *supra* note 10, at 353.

⁸² Emmanuel Schizas et al., *supra* note 5, at 63.

contracts, which are, in essence, computer protocols that can self-execute a transaction upon the satisfaction of pre-defined conditions, thereby reducing settlement risks.⁸³ Such a feature could also assist in the automation of certain regulatory interventions.⁸⁴ Much of this rambling about the blockchain's potential for RegTech and SupTech, however, is still conjectures. And some of the features that turn blockchain into an exciting technology for specific products and services, like its tamper-proof nature, may not be interesting for solutions that require more flexibility and adaptation, such as financial regulation and supervision. These regulatory and supervisory solutions may end up turning into new problems because of the blockchain interoperability limits.

There are multiple reasons for the lack of blockchain interoperability. Part of them is economical, as explained earlier. For instance, when designing blockchain for the governance of cryptocurrencies, the founders recognize that part of its value comes from the enlargement of its network, which increases its acceptability. So, its developers are motivated in maintaining their users within the system; thereby, developing a system to better communicate with others might be economically disadvantageous as it eases customers' exit. Another reason is more technical and based on the "trust" element of blockchain. As the interaction of nodes verifies every transaction, the network monitors itself, and thereby interoperability could frustrate its operating rules. For Tasca and Piselli, "[i]n relation to the impact upon the market, [blockchain] non-interoperability could strengthen technological lock-ins and could block the competitive and prosperous development of a market for the downstream applications of the ledger."⁸⁵ This limitation could end up leading to the emergence of a few dominant systems which can harm the market of blockchain-based applications, thereby being detrimental to further innovation.⁸⁶

⁸³ Joshua S. Gans, *The Fine Print in Smart Contracts* (NBER Working Paper 25443, January 2019), <https://www.nber.org/papers/w25443> (on smart contracts' improved observability and reduced costs of verification).

⁸⁴ Philip Treleaven & Bogdan Batrinca, *Algorithmic Regulation: Automating Financial Compliance Monitoring and Regulation Using AI and Blockchain*, 45 J. FIN. TRANSFORMATION 14 (2017) ("smart contracts can define strict rules and consequences in the same way that a traditional legal document would, stating the obligations, benefits, and penalties that may be due to either party in various different circumstances").

⁸⁵ Paolo Tasca & Riccardo Piselli, *supra* note 70, at 37.

⁸⁶ *Id.*

On the positive side, recent years saw significant research on defining protocols for interoperability across independent blockchains, especially for crypto-asset cases.⁸⁷ The basic proposal for interoperability would be to turn digital assets defined on blockchain X to serve as a backing store for “shadow assets” in blockchain Y.⁸⁸ How such solution could be translated to the RegTech and SupTech products and services is yet to be seen. Nevertheless, exploring paths to mitigate network externalities and the risk of technological lock-in in blockchain systems should be a paramount concern for public authorities considering to adopt these solutions.

VII. CONCLUSION

Regulatory effectiveness largely depends on the establishment of a more adaptable dynamic to counter emerging risks. Consequently, regulatory and supervisory technologies will be an essential key to the development of a new framework for market governance. To achieve such a goal, regulators must ensure better integration between the RegTech’s potential to reduce the firm’s costs of monitoring regulatory changes and the SupTech’s potential to expand data accuracy and timely interventions. In the process of achieving this integration and higher regulatory adaptability, however, established market players and technology providers might attempt to create self-serving relationships through technological dependence which can lead to new forms of regulatory capture. We argue that the interplay of RegTech and SupTech should be at the forefront of the regulatory activity in the near future. Inter alia, this involves strict adherence to technological neutrality and interoperability between the two twins to avoid any lessening of market competition.

⁸⁷ Zhuotao Liu et al., *HyperService: Interoperability and Programmability Across Heterogeneous Blockchains* (Proceedings of the 2019 ACM SIGSAC Conference on Computer and Communications Security, 2019), <https://arxiv.org/abs/1908.09343>.

⁸⁸ Sarah Allen et al., *Design Choices for Central Bank Digital Currency: Policy and Technical Considerations* (NBER Working Paper 27634, August 2020), <http://www.nber.org/papers/w27634>, at 54.