THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Accessing Regulated Digital Infrastructures:

A Case Study of the UK's Retail Payment Infrastructure

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Declaration

I, Kanchana Ambagahawita, certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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Abstract

This research examines how heterogeneous actors gain access to regulated digital infrastructures. As industries, businesses and customers increasingly adopt digital means, markets can shift to industry infrastructure. Market infrastructures are often regulated to ensure service quality and are dominated by incumbents due to high entry barriers. Resolving tensions between heterogeneous actors of digital platforms has been studied; however, there is a dearth of understanding of how the social-technical complexities of regulated digital infrastructure are resolved.

In this research, I conducted an in-depth study of the UK's real-time retail payment infrastructure and how third-party service providers, Fintechs, gained access to the infrastructure. The high level of heterogeneous actors, both at the infrastructure level and externally at the regulatory and policy levels, provided a rich context to explore this issue. I draw on Pickering's theoretical lens of the Mangle of Practice and subsequent research extending it to understand how sociotechnical resistances emanating from interactions of the material agency of the legacy heavy systems, disciplinary agency arising from the need to maintain financial system stability and agency of heterogeneous actors are accommodated to reach different goals of actors.

The findings indicate the overwhelming influence of disciplinary agency over the agencies of all other actors and elements. Thus resulting in processes of recursive tuning of digital infrastructure rules to balance innovation and competition while continuously maintaining system stability. Further, the presence of resistances creates new classes of actors and services that tune the resistances for the Fintechs, enabling them to reach their original or modified goals. Further, the occasional regulatory triggers imposed by policy and macro regulatory levels on the incumbents resulted in the infrastructure being remodelled for new goals after the triggers. This pattern thus makes the evolution of the infrastructure less organic and more administered.

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Contents

List of Abbreviations

ACM	Association for Computing Machinery (Conference)
APACS	Association for Payment Clearing Services
API	Application Programme Interface
ATM	Automated Teller Machine
BACS	Bankers' Automated Clearing Services Limited
BASS	BACS Approved Solution Suppliers
BIS	Bank of International Settlements
BOE	Bank of England
BPSL	BACS Payment Schemes Limited
CHAPS	Clearing House Automated Payment System
CLCB	Committee of London Clearing Bankers
CMA	Competition and Market Authority
COBOL	Common Business-Oriented Language
CREST	Certificateless Registry for Electronic Share Transfer
DBMS	Database management systems
DI	Digital Infrastructure
DNS	Deferred net settlement
EDI	Electronic data interchange
EMI	Electric and Musical Industries
EMIDEC	The EMIDEC 1100 computer was produced by the Computing Services Division of EMI Laboratories in the UK
ETS	Enhanced Transmission Services
EU	European Union
Fintech	Financial Technology
FCA	Financial Conduct Authority
FPS	Faster Payments
FSA	Financial Services Authority

FX	Foreign Exchange
GBP	Sterling Pounds (UK Currency)
HM	Her Majesty's
HMT	Her Majesty's Treasury
IBM	International Business Machines
ICL	International Computers Limited
ICMB	International Conference on Mobile Business
ICT	Information and Communication Technology
IP	Internet Protocol or Intellectual Property
IS	Information Systems
ISO	International Standard Organisation
IT	Information Technology
KPMG	Klynveld Peat Marwick Goerdeler (professional service company)
LCB	London Clearing Bankers
LLP	Limited liability partnership
LP	Long Play
LSE	London School of Economics
LV	LifeVantage (payments company)
MAP	Mastercard Authorisation Platform
MIS	Management Information System
MIT	Massachusetts Instituite of Technology
MT	Message Type
MWN	MasterCard WorldWide Network
NASA	National Aeronautics and Space Administration
OFT	Office of Fair Trading
PC	Personal Computer
PCA	Personal current account
PDI	Payment Data Infrastructure

PI	Payments Infrastructure
PIN	Personal Identification Number
PSD2	Payment Services Directive - (EU Directive 2015/2366)
PSF	Payments Strategy Forum
PSR	Payment Systems Regulator
RAND	Research ANd Development (Corporation)
RBS	Royal Bank of Scotland
RCA	Reserves Collateralisation Account
RTGS	Real Time Gross Settlement
SAGE	SAra and GEorge (Publication Company)
SWIFT	Society for Worldwide Interbank Financial Telecommunication
UK	United Kingdom
USA	United States of America
VHS	Video Home System

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Chapter 1

Introduction

Recent decades rocketed society into an era of digitalisation that democratised innovation, challenging traditional industrial boundaries, transforming businesses and business models, and creating a new benchmark for accessing digital infrastructures based on the generative openness of the Internet (Zuboff (1988); von Hippel (2005); Benkler (2006); Zittrain (2008); Tilson et al. (2010b); Yoo et al. (2010a)). Yoo et al. (2010a) (p.2) refer to digitisation as "the sociotechnical process of applying such techniques [digitising analogue to digital] across industries and contexts in ways that affect and shape their underlying infrastructures for the creation, storage and distribution of content, applications, and services." Industry infrastructures are also value delivery architectures enabling different business strategies to reach customers (Kazan et al. (2018)). The proliferation of the Internet, combined with the access to personal computers and mobile phones, enabled industries to digitalise and customers to access many goods and services digitally, thus beginning the process of digitalising entire markets. As markets and industries move to the digital sphere, the critical importance of both general purpose infrastructures (Koutsikouri et al. (2018)) such as the Internet and purpose-specific digital infrastructures, such as those enabling telecommunications, financial services and healthcare, are increasingly recognised (Hanseth and Braa (1998); Henningsson and Eaton (2022)). Increasing digitisation has reached and continues to reach in-

frastructures that are critical to society and are therefore regulated for the reliability of service, which includes a restriction on access to the infrastructure (Baldwin and Cave (1999)). Which, as industries digitalise, become the market itself. Thus, generative openness might not be achieved in regulated infrastructures, where access to heterogeneous actors and third parties is regulated.

Increasing access to markets and resolving the tussle between industry incumbents and aspiring new entrants are issues that predate the digitalisation of industry infrastructures (Baldwin and Cave (1999); Frischmann (2012)). Nevertheless, these market frictions and competitive industry dynamics have permeated into the digital era, posing new challenges to businesses, policymakers and regulators globally as they aim to balance the complex sociotechnical dynamics of digital ecosystems (OECD (2018)) in order to enable innovation and market stability. A digital entry barrier creates a new layer to industry entry barriers. It can be said that digitalisation enabled dominant industry participants to ringfence their positions into newly-created digital infrastructure and close access to outsiders. This forms the basis of many of the tensions discussed in the digital infrastructure literature – the tussle for control between incumbents, new entrants and regulators.

Even though the open Internet is considered as a benchmark for designing digital infrastructures in principle (Hanseth and Lyytinen (2010)), in practice, several sociotechnical factors create points of control within infrastructures that effectively regulate behaviour and allocation of resources. Contrary to the more widely accepted characteristics of digital infrastructures being their openness (Hanseth and Lyytinen (2004)), a cursory glance at industry-wide infrastructures show that they are restricted to those that meet access requirements.

One way the issue of access has been technological addressed is through digital platforms. The generative capabilities of the platform enable unbounded and distributed innovations, layering the complexities of the infrastructure away from distributed and heterogeneous actors (Zittrain (2008); Yoo et al. (2010a)). Digital platforms, especially mobile phone platforms such as the Apple App Store, resulted in an unprecedented generation of innovations as well

as new multi-sided markets (Gawer (2009); Eaton et al. (2018); Reuver et al. (2018)), as platforms have democratised innovation within purpose-specific infrastructures (Henfridsson and Bygstad (2013)). The digitalisation of industry-wide infrastructure is a powerful multi-dimensional phenomenon that could reap similar results if the sociotechnical architecture enables it (Henningsson and Eaton (2022)). However, industry-wide digitalisation and regulation of industry-wide digital infrastructures have been relatively less studied. Nevertheless, they have gained more academic traction recently, with scholars beginning to study government regulation of digital infrastructures (Henningsson and Eaton (2022)).

1.1 Restricting access to regulated industry infrastructures

Industries such as banking, telecommunication, defence and health have service-specific regulations when there is a significant risk to the public or the users if the service provision is not at a required standard. Infrastructures of networked industries, such as banking and telecommunications, depend on every connected participant's reliability, security and efficiency to prevent a system failure. A system failure could adversely affect customers, as well as the integrity of the system. Technologically these adverse outcomes are avoided by complying with industry standards that meet the required outcome (Hanseth and Monteiro (1997)) or by control laws that assign specific behaviour to actors (Henningsson and Eaton (2022)). However, such regulation impedes the access of unregulated third parties from using the infrastructure and can deny customers of innovative products. On the other hand, restricting access to unregulated third parties could ensure the system's stability and the service's quality.

1.2 The Research Issue: Accessing regulated Digital Infrastructures

This research adds a new dimension to digital infrastructure research that has been noted but not studied in depth, namely regulation. Henningsson and Eaton (2022) observe the lack of studies focusing on the regulated aspect of digital infrastructures. While system rules regulate digital infrastructures, standards, and other locally or mutually decided rules, having an external party impose controls on how the infrastructure operates creates issues relating to power dynamics and control (Eaton et al. (2018)). While entering regulated industries is of interest to start-ups, our academic knowledge on how they could traverse this complexity is lacking. Digital innovation has been one of the main angles from which digital infrastructure has been studied. However, there appears to be a leapfrogging from the infrastructure to platforms, as many generative innovations occur on platforms. Digital platforms are boundary resources provided by an owner of digital infrastructure or by an actor with access to the infrastructure, with the installed base that gives access to the technology and a market (Ghazawneh and Henfridsson (2013)). However, closed industry-wide infrastructures generally have restricted participants who wield access to the industry's central value-creating asset. Interbank infrastructure creates a digitised market for customers to transact with one another directly from their bank accounts. In telecommunications, customers can connect directly without seeking a third party to intermediate the connection. Such direct connectivity to the installed base of the industry's customers provides an opportunity to create value and confidence that those outside the infrastructure cannot give as easily. This value creation would often lead to zealous protection of the boundaries of the industry. Historically these industries were picked for early digitisation due to their strategic economic importance and are regulated as public goods. With these complexities, what exactly does access to the infrastructure mean when it comes to a closed infrastructure? How do third-party innovators (essentially new entrants) access the infrastructure that holds the assets with the value, or do they enjoy the value they create at the periphery if such is allowed? How does the in-

frastructure's sociotechnical structure respond to new entrants seeking a share of the value created or intended from these closed digital infrastructures? Do new entrants ever become incumbents?

1.3 The relevance of this study

First, there has not been an adequate investigation of processes that new and aspiring users must navigate to access regulated digital infrastructures (Henningsson and Eaton (2022)). Academic understanding of complex sociotechnical dynamics of the digital infrastructures in the last decade has focused on the generative capability while taking for granted that users or new entrants will be granted access to innovate on the infrastructures once they conform to the rules of the architecture. There is a recent increase in the study of digital infrastructures (Constantinides and Barrett (2015); Mora et al. (2020); Henningsson and Eaton (2022)) that have focused of regulated digital infrastructure evolution and infrastructure enabled innovation. This research aims to contribute to that area by exploring the complex processes of how heterogeneous actors gain access to regulated infrastructure by studying the UK's retail payment infrastructure that recently allowed heterogeneous firms, especially financial technology related firms referred to as "Fintechs" (Gomber et al. (2018b)), that were not banks (the incumbents) to access the infrastructure directly. The study takes a granular and pragmatic approach to unravel the sociotechnical processes that are involved by applying the theoretical lens of Pickering's Mangle of Practice as extended (Pickering (2002); Venters et al. (2014); Eaton et al. (2018)).

Further, digital infrastructures could be seen as compositions of rules, where granting access to new actors would be a process of amending rules. The research thus poses the question of how heterogeneous actors interact with rules that affect their goals. Understanding how rulemaking and rule-taking in infrastructure may have a significant bearing on how digital infrastructure rules are made and embedded into the system, as well as reveal the powers actors wield within infrastructures.

Finally, this study focuses on UK's retail payment infrastructure. The significance of understanding the evolution of user access and expansion through payment infrastructure is steeped in the history of payments and banking infrastructures. Financial services, especially banking, were one of the first industries in the world to digitalise. Besides customer-level retail payments, almost all other payments and trading in the UK's banking system are digitalised. Access to banking systems and the interbank payment systems infrastructure was restricted. The infrastructures are regulated by law to maintain financial system stability. As the Internet continues to proliferate with an increased risk of cyber-attacks, more industries will move to regulate their infrastructures. The rapid digitalisation of other industries will also impose technological barriers to entry, where entry is determined by the technological ability to connect. As more firms aim to digitalise regulated industries, understanding how heterogeneous actors navigate complex sociotechnical issues would be widely applicable.

1.4 Structure of the thesis

The structure of the remainder of the thesis is as follows:

Chapter 2 – Literature Review

The literature review begins with the literature on digital infrastructures and their evolution as sociotechnical systems. The discussion then proceeds to the different forms of access to digital infrastructures and factors that determine the nature of the access granted to different actors, such as the technological and business elements. Next, the literature relating to regulated digital infrastructures is presented. Next, the dynamics of heterogeneous actors within the digital infrastructure are examined, and we review the literature on generativity to understand how innovative firms access digital infrastructures. Finally, the study is positioned within the literature regarding gaps remaining to be addressed.

Chapter 3 – Conceptual Framework

This chapter presents the conceptual framework. I draw from Pickering (1993)'s tuning, which was subsequently extended to include heterogeneous actors (Barrett et al. (2012)) at a distributed level (Eaton et al. (2018)).

Chapter 4 – Research Design

This chapter aims to present the methodological approach adopted in the research. An interpretative, inductive, embedded case study approach (Eisenhardt (1989)) as the research issue was a new topic that required early stage theoretical understanding of the phenomenon. The research design sets out the process followed to ensure the research's quality (Eisenhardt (1989); Yin (2014)). The topic's complexity and newness required methodological rigour to unfold the multiple layers emerging during the research process. This chapter presents the research process as it evolved and explains the methodological choices undertaken.

Chapter 5 – Case Study

A case study of how entrants access the infrastructure was conducted. This chapter maps all the systems of the UK's payment infrastructure and establishes the context for the research issue.

Chapter 6 – Findings

The findings are presented through resistance – accommodation dialectic based on the sources of resistance in the digital infrastructure. The findings show how diverse actors responded to temporally emerging resistances in the infrastructure as new entrants sought their goal of direct access.

Chapter 7 – Discussion

The chapter begins by revisiting the main conceptual findings from the previous chapter. It then discusses the study's contributions, considering the findings, literature review and theoretical framing.

Chapter 8 – Conclusion

The key findings are summarised, together with the contributions and limitations of the study. The chapter concludes with recommendations for future research.

Chapter 2

Literature Review

Sociotechnical dynamics of heterogeneous actors accessing global, industry, and firm digital infrastructures for their business and innovation goals has been an area academic interest (Tilson et al. (2010b); Eaton et al. (2018); Bygstad (2017); Osmundsen and Bygstad (2022)). The understanding of how actors navigate the complex assemblages of technologies, legacies, rules, and socio-economic interests of other actors within digital infrastructures is reviewed in this chapter. The review will cover the following areas: Digital infrastructures, Access to Digital Infrastructures, Regulated Digital infrastructure, Generativity of Digital Infrastructure, Interaction between actors, technologies and social factors. As the case study is on the payment infrastructure of the UK, I show its relevance within the literature.

2.1 Digital Infrastructures

Digital Infrastructures have been defined in terms of material attributes, relationships to users or entities and morphologically, comprising both attributes of their nature and the material, human and disciplinary elements that constitute them. Digital infrastructures have been defined as information technologies and organisational structures, including the related services and affordances necessary for an enterprise or industry or the service expected

to be provided (Tilson et al. (2010b), p.748). Digital infrastructures can be defined by the entities being supported firm level, industry or macroeconomic level and at a global level (Tilson et al. (2010b), p.748). Numerous scholars have contributed towards understanding the characteristics and properties that define and classify a digital infrastructure which has been of academic interest for several years (Hanseth (1996); Hanseth et al. (1996); Hanseth and Monteiro (1997); Hanseth and Lyytinen (2004); Hughes (1987); Monteiro and Hanseth (1996); Star and Ruhleder (1996); Broadbent and Weill (1997)). A cumulation of this knowledge has been captured by Hanseth and Lyytinen (2010) who define digital infrastructures as,

> *"shared, unbounded, heterogeneous, open, and evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities." (p.4)*

The definition explains the sociotechnical nature of digital infrastructures and the nature of the technological artefact. As digital infrastructures are evolving systems, their relationships and meanings to users and their very nature can be dynamic as digital technology itself (Frischmann (2012)). Digital infrastructures can also be a progression from a localised system such as a platform or application that evolves into an infrastructure. As Star and Ruhleder (1996) observes, a system is an infrastructure only when "visible upon breakdown" (p.113); however, it can support local practices in a "natural, ready-to-use fashion" (p.114) without being custom-built every time. This relational view helps distinguish digital infrastructures at a practice level. At the same time, Hanseth and Lyytinen (2010)'s definition connotes that digital infrastructures, by definition, are generative systems that enable access to user communities to the myriad of heterogeneous systems "fostering growth and evolution over time" (Osmundsen and Bygstad (2022), p.146).

A key attribute of digital infrastructures is that they are evolving. In the 20th century, they were largely service-specific due to the "analog and inflexible nature of the underlying technologies such as devices, storage media and transmission formats" (Tilson et al. (2010b),

p.749). This resulted in an information infrastructure that had a tight coupling between the service model and the underlying technologies, which meant that the dominant service model of the industry would persist despite significant advancements in technological capabilities through digitisation. "Over time, the single-purpose nature of the services (telecommunications industry) and the high fixed cost of the infrastructure lead to the concentration of ownership and control, the need for mass markets, and a strong regulatory hand further reinforcing industry boundaries and stability." (Tilson et al. (2010b))

Digital infrastructures are a complex assemblage of technological units comprising systems, platforms, and applications. Each level is distinguished by a set of delineations created by the owner of the digital object of the unit or through use and practice, which will attribute certain distinctive features. At the same time, they are continuously vulnerable to being transformed by user interpretation and knowledge.

Concepts such as openness and shared infrastructure that enable generativity of a digital infrastructure signal toward a process which technically allows more heterogeneous actors to access the infrastructure by weaving in open and flexible organising logics into systems (Zittrain (2008); Hanseth and Lyytinen (2010); Tilson et al. (2010b); Yoo et al. (2010a)). While these concepts may, in principle, increase the access to heterogeneous users, these pluralistic goals shaped by the sociotechnical dynamics of the infrastructure could generate resistances within the material, and social elements of the artefact (Star and Ruhleder (1996); Eaton et al. (2018)). Star and Ruhleder (1996) defined infrastructures as a relational concept where "tensions between the local and global are resolved" (p.114). The digital infrastructure designs and functions depict designers' IT capabilities and the continuous negotiation and standardisation between owners of the infrastructure, its components, design communities, and users (Star and Ruhleder (1996)).

The evolution of digital infrastructures is a continuous sociotechnical dynamic where systems, participants, and rules emerge through practice as actors seek to reach certain goals and tune the systems to meet the goals (Cordella (2011)). Digital infrastructures are de-

scribed as continuously evolving and never complete due to their generative, recursive, scalable and flexible nature that fosters growth (Henfridsson and Bygstad (2013); Osmundsen and Bygstad (2022)). Gradual increases in users and functionality characterise this generation and the growth of digital infrastructures. The growth in users has been examined in open systems such as the Internet and platforms. Recent studies on platforms have revealed the distributed tuning of digital infrastructures to enable heterogeneous third parties to use infrastructures (Eaton et al. (2018)). However, access to digital infrastructures has been largely studied regarding local infrastructures such as health infrastructures or the technical adjustments needed to draw more users (Henfridsson and Bygstad (2013)). As the value that can be delivered through an infrastructure increases, there are invariably new entrants who seek access to the industry (Channon (1998); DellAriccia (2001)). To seek such access, heterogeneous actors must overcome two layers of intertwining regulation. First, the local technological access points and the second, the access points placed by regulation. The mechanism of how access to new users is granted from a sociotechnical perspective has not been discussed. The following sections will review the material or technological elements and a digital infrastructure's social and regulatory elements influencing access.

2.2 Digital infrastructures as evolving sociotechnical systems

The sociotechnical evolution of digital infrastructures is one of the main characteristics that distinguish them from other infrastructures. Digital infrastructure evolution is deemed nonlinear, path-dependent, and shaped by neighbouring infrastructure, including unbounded user and designer learning and existing IT capabilities (Hanseth and Lyytinen (2010) p 4). Hanseth and Lyytinen (2010) refer to the evolving sociotechnical system as the "installed base" (p.4). The generic definition of infrastructure in the Oxford English Dictionary has remained mostly unchanged in 2022 since it was quoted in 2010 by IS scholars (Tilson et al. (2010a)) "the basic physical and organisational structures (e.g. buildings, roads, and power supplies) needed for the operation of a society or enterprise" except the word communica-

tion is added. This functional or rational approach to infrastructure is captured in the business strategy book on leveraging "the new infrastructure" Weill and Broadbent (1998). This could be seen as an early book discussing the Internet's pervasiveness as it connects industries and public infrastructures. However, the term information technology is defined as the "firm's total investment in computing and communication technology" (Weill and Broadbent (1998) p. 6), and information technology infrastructure refers to the broader connectivity that firms could have by connecting to the systems in other private and public entities, such as relating to bank payment systems. This functional definition of digital systems and infrastructures is common in management and economic literature (Katz and Shapiro (1986a)). Management studies continued to see the information infrastructures as closed units; understanding IS's digital infrastructures was of more dynamic sociotechnical systems that continuously evolved (Osmundsen and Bygstad (2022)).

2.3 Access to Digital Infrastructure

Access to digital infrastructures lies within a broad spectrum of literature that conceptualises digital infrastructure (Star and Ruhleder (1996)), generative capacity (Henfridsson and Bygstad (2013)), generativity (Eaton et al. (2018)) openness (Zittrain (2008)), participation in firm-level or industry-specific infrastructures (Lyytinen and King (2002); Aanestad and Jensen (2011); Grisot et al. (2014); Bygstad (2017); Mora et al. (2020)), competition (Kazan et al. (2018)) and innovation (Hanseth and Lyytinen (2010); Tilson et al. (2010b)). Regardless of the type of user, granting access is a sociotechnical issue resolved by local micro-level actors and macro actors, taking into the material, human, and non-technological social agencies and constraints.

Access is generally limited to local micro-level actors who directly access the digital infrastructure to use its affordances. Access connotes physical as well as technological access to infrastructure and becomes a factor that determines the ability to use it (Star and Ruhleder (1996); Racherla and Mandviwalla (2013)). In their study on universal access to the Internet

and related infrastructure, Racherla and Mandviwalla (2013) observed that physical access to the points the Internet was accessible was a factor that acted as a barrier to access. The study also found that institutional actors and local practices of users must be taken into consideration by designers when considering technical access to infrastructures. From the final user perspective, access to connecting infrastructure is key to delivering value to customers.

A great part of digital infrastructure literature focuses on technical access by end users and service providers. Technical access is vital for end users where the service or value is delivered digitally. However, the underlying theme of sociotechnical complexities relating to digital infrastructures emerges when resolving technical access. Therefore, end users who access services from their own devices need to be able to access the Internet (Ruiz-Martínez (2015)) and then an interface or mechanism that transforms the value delivered via the digital infrastructure into a form that is accessible to the customer. Ruiz-Martínez (2015) observed that from the end user perspective, many initial technological solutions to support web payments for customers failed; in addition to Internet access, new technological components available on the web such as e-signatures, web standards, security mechanisms, enable developing solution layers that can process expectations of the particular service by the customer and operationalise them together with other regulatory safeguards. The flexibility of layered and modular architectures provides digital infrastructure routes to accommodate the material and disciplinary agencies emanating from the infrastructure and access to the end user (Yoo et al. (2010a)). The conduit between digital infrastructures and the end users is the service providers. Service providers or firms negotiate access to digital infrastructures to deliver value to end customers. The interplay of heterogeneous systems and actors has been a major point of interest for many scholars of digital infrastructure (Eaton et al. (2018); Kazan et al. (2018); Osmundsen and Bygstad (2022)). In the process of disentangling the complexity of access, a large quantum of research has been dedicated to platforms connected to digital infrastructures. Recent studies of platforms have revealed that heterogeneous actors actively seek to tune the material agency of digital platforms to accommodate the sociotechnical resistances that arise through business strategies, power dynamics and even external

influence (Eaton et al. (2018); Kazan et al. (2018)). Kazan et al. (2018) explains gaining indirect access to payment infrastructures using business strategies. However, the question of tuning for access has not been extended to digital infrastructures, the digital artefact that is characterised by continuous evolutions and dynamism (Bygstad (2017); Osmundsen and Bygstad (2022)).

Access is also determined through social factors such as business models, market actors and regulations of industry-specific infrastructures. Many industries have historically regulated the quality of service provisions and price through licensing (Katz and Shapiro (1987)). Licences create entry barriers that can be extended to digital infrastructure access. In a study of business access to sports broadcasting infrastructure, Evens et al. (2011) observed how regulators could control the level of access of both end users and service providers by using digital technologies. Traditional broadcasters and the sport's regulator determined the access granted to the business. It was found that the end user side of the market was liberalised, with the mobile phone being the customer interface. At the same time, the infrastructure that carried the content was restricted to licensed incumbents. Thus, digital infrastructures have the ability to reinforce rigidities of traditional markets (Tilson et al. (2010b)), while the very flexibility that digital technologies are lauded for through layered modular architectures(Zittrain (2008); Tilson et al. (2010b); Yoo et al. (2010b)) could be used to impose a regulative regime using the software code (Kallinikos and Mariátegui (2011)).

The regulatory regime extends to formal legislation for services, industries that impose a discipline on service provision and industries. The relationship between the innovation system, market place and the regulatory regime has been explicated to show that each influences the other (Lyytinen and King (2002)). The disciplinary agency that flows from the rule-based system has recently entered IS discourse (Venters et al. (2014)). Research on regulated industries such as telecommunication and health show how only licensed providers can access digital infrastructure and patient information. This influence of the regulator implies that the sociotechnical embeddedness of non-technological laws could influence the digital infras-

tructure affordances of microactors.

The enmeshing of the digital and the social results in continuously emerging tensions between competing interests and technological characteristics that must be resolved by the heterogeneous actors accessing, using and regulating the infrastructures. These characteristics are also trichordal and are continuously tuned by actors to reach their goals (Venters et al. (2014)).

Thus, it is important to review the understanding of the social and technological elements of digital infrastructure. I begin with the technological aspect and proceed to the social aspects of digital infrastructures.

2.3.1 The perpetuating installed base

"Infrastructure does not grow de novo. They wrestle with the inertia of the installed base and inherits strengths and limitations from its base" (Star and Ruhleder (1996) p 5). This agency manifested by the installed base can significantly determine the nature of access that is technically feasible. Traditional information infrastructures such as banking infrastructure and communication infrastructures initially replicated analogue systems into a digital form referred to by scholars as "digitising cow paths" (Tilson et al. (2010b), p. 750). A critical characteristic of an analogue system is the tight coupling of the artefact to its purpose; for example, an analogue typewriter could only type words onto paper. In contrast, the digital computer provides much more functionality to documents typed on it. Instead of designing systems that could optimise the potential for flexibility in digital technology, early digital systems were developed using centralised control logic to replicate control-based corporate structures (Ciborra and Hanseth (2000); Tilson et al. (2010b)). This process resulted in large technology investments in closed systems that could not be easily integrated into other systems. Designs following the hierarchical, centralised structures became the industry norms having a self-reinforcing effect (Arthur (1989)) as new entrants would need to adopt compatible systems to integrate into existing ones. Thus, the increased adoption of these closed,

centralised systems led to entire infrastructures locking in to replicate this design. An important aspect of the installed base is that it cannot be willed away despite its possible inertia and constraints. Hanseth and Lyytinen (2010) in the paper proposing a design theory for complex systems emphasises that "whatever is added [to the infrastructure] needs to be integrated and compatible" with the [installed] base (p.5). This requirement to be compatible with the existing structure, design, and components imposes a constraint on the developed system. This need to maintain compatibility makes infrastructure dependent on the path it has taken thus far (Arthur (1989)) along the pre-existing installed base of technologies, users, and IT knowledge (Hughes (1987); Star and Ruhleder (1996); Hanseth and Monteiro (1997)). Thus, by the time a system has evolved into a state considered an infrastructure, the past conditions the freedom actors have to direct its evolution (Venters et al. (2014)).

The past will shape the need to upgrade or redesign an infrastructure. The result is that infrastructures can accumulate a considerable level of legacy systems from the early bases. Self-reinforcing characteristics lead to path dependency following developed standards and systems (Hanseth (2000)). Further, as owners of the infrastructure move to widen infrastructure adoption, the consequent network externalities increase (Katz and Shapiro (1985)). As the number of users of the system increases, the benefits of being in the same network increase. These two consequences result in organisations and users becoming "locked-in" to systems resulting in the transition to new technologies even harder (Bátiz-Lazo (2009)).

Information Systems (IS) literature highlights the need to integrate the installed base into the new extensions. Although the material agency is not specified in all studies and the accommodations made, several studies on industry-specific infrastructure have provided examples of how the inertia posed by the installed base is accommodated through technologies, infrastructure cultivation and adoption strategies. Infrastructure literature simultaneously raises the importance of cultivating the installed base and adopting the infrastructure (Hanseth (1996); Aanestad and Jensen (2011); Grisot et al. (2014)). Developing the installed base is distinguished from constructing the installed base (Ciborra and Hanseth (2000)). In-

frastructures transition gradually as an extension and cannot immediately switch between old and new systems (Hanseth and Braa (1998)).

Infrastructure designers and users adopt many means to respond to the material agency emerging (Hanseth and Lundberg (2001)), such as the introduction of Picture Archiving and Communication Systems (PACS) in Swedish hospitals to replace analogue systems. During this process, the hospital used transitionary methods such as printers and scanners, which the authors call "gateways" until the transition is complete. Another way to overcome the mismatch between the new and old systems is through standardised interfaces that allow the two systems to connect, such as APIs (Yoo et al. (2010a)). However, using APIs does not resolve legacy systems remaining and is a contingent solution to building infrastructure.

However, despite human actors subconsciously or intentionally adopting newly decentralised, distributed organisational logic, the legacy systems remain recalcitrant (Latour (2000)). This technological recalcitrance is strengthened by the socio-economic context that further reinforces the systems that have accumulated a sizeable installed base. As a result, the exit costs become too high both economically and socially. The quote below from a telecommunication industry research emphasises the sociotechnical evolutionary process that renders systems to grow as industry-specific infrastructures:

> *"Over time, the single-purpose nature of the services (telecommunications industry) and the high fixed cost of the infrastructure lead to the concentration of ownership and control, the need for mass markets, and a strong regulatory hand further reinforcing industry boundaries and stability." (Tilson et al. (2010b), p.749)*

These combined factors reveal that the installed base of many industries that went into early digitisation comprises legacy systems designed and operated under centralised control and closed logic. Moreover, these systems, such as telecommunication (Yoo et al. (2005)) and banking (Bátiz-Lazo and Woldesenbet (2006)), which were the earliest entrants, remain with large legacy systems while enduring pressure to evolve and innovate.

2.4 Regulated digital infrastructures

Public infrastructure or any digital infrastructure used by heterogeneous actors is eventually subject to regulation to address any market failures or anomalies that may cause negative externalities (Katz and Shapiro (1986b); Baldwin et al. (2010); Frischmann (2012)). "Regulation is the technology of governance" (Wiener (2004) p. 485) that can be seen as a set of techniques for regulating the quality of service, reducing the production of undesirable outputs such as pollution, or encouraging the production of the desired output (Wiener (2004)). The influence of technology regulation can be implemented in many ways, and different regulatory designs can shape technological change and favour some technologies over others (Wiener (2004) p. 484). Regulation can be used to implement architectural controls into a digital infrastructure (Henningsson and Eaton (2022)). King and West (2002) note that innovation's social and organisational elements are linked to the industry's regulatory regime, standards and policies and market dynamics.

Digital infrastructures have two levels of regulations - technological regulations such as standards and national or industry-level regulations that generally regulate the service that the infrastructure provides (Lyytinen and King (2002); Wiener (2004)). For infrastructure level regulations, such standards and system rules are created by heterogeneous and independent participants to enable access to coordination, security and interoperability of the systems (Hanseth (2000)). When infrastructure is not a general infrastructure like the Internet, but an industry level or service-specific ones such as banking, payments, health or telecom, especially where service provision is automated via the system, the national or industry level regulations for service provision are integrated into the design. The roles of the heterogeneous actors within any of these regulated infrastructures vary. They could influence the infrastructure's overall generativity by introducing technical and economic regulatory rules (Monteiro and Hanseth (1996)). Economic and regulatory rules, especially those introduced by industry and national supranational bodies, have a legal bearing and must be followed by infrastructure systems (Baldwin and Cave (1999)).

2.4.1 Technological regulation via standards

Standardisation of infrastructures is a quintessential element of infrastructure development as digital infrastructures, by default, connect multiple systems. Standards are an area that has been studied to a great extent in IS as well as found in digital infrastructure literature. The information infrastructure development process is a standardisation process (Hanseth (1996)). Standardisation processes can be seen as a highly socio-technical process involving heterogeneous actors even across geographical locations, in the case of international standards (Hanseth (1996); Hanseth and Monteiro (1997); Scott and Orlikowski (2013)). Star and Ruhleder (1996) defined infrastructures as a relational concept where "tensions between the local and the global are resolved" (p.114). Standardisation results in creating standards, which "is a language or in technical terms known as a protocol" (Hanseth (1996), p 410). Standards can be de facto (through market mechanisms), de jure (by law), or formal standards that are officially set by a governing body such as ISO (Hanseth (1996)). Regardless of adhering to standards, it is necessary to enter or connect to a digital system or infrastructure technologically. Thus, these technical standards form a governance structure through a software code that regulates user behaviour within an infrastructure (Lessig (2006)).

Standards provide stability to a system by giving technological affordances and system rules that will ensure the safety of the infrastructure. The standard setting is a complex process involving both a local and an international level of standard make, depending on the level of interoperability required by the infrastructure. Infrastructure will have multiple standards working together to serve different functionalities (Hanseth (1996)). The experience of SWIFT and the Internet are two of the most prominent international cross-community standards-making processes. Of the two, the Internet is the epitome of successful digital infrastructure design, adoption, and scaling. The Internet and SWIFT examples demonstrate the complexity of the standardisation process or the infrastructure's design. The Internet has a vast number of standards that intertwine and interdepend to provide a seamless experience for users (Hanseth (1996); Abbate (1999)).

Standard making in practice is a consensus-based approach among a wide group of actors and a dynamic process as new requirements emerge for infrastructures. The global standard setting takes place in four ways: private standard setting, committee standardisation, network standardising (participation of all stakeholders) and organisational standardisation (rulemaking by members). How the rulemaking is done affects the enforcement and the accountability at the local level (Kerwer (2005)). Thus, while SWIFT decided on its messaging in the early 2000s, the introduction of ISO20022 required SWIFT to begin changing its hard-gained standards. The standards-making process in IS is well researched. The Internet Protocol has been one of the most successful standards that have demonstrated high stability and generativity. More recent research in standards explicates that waves of digitalisation lead to a transformation of industry standards (Scott and Orlikowski (2021)).

2.4.2 Technological regulation by design

Architecture can effectively mediate the regulation (Henningsson and Eaton (2022)). The standardisation of digital infrastructures requires negotiations between platform owners, innovators, regulators and users. Regulations can direct resources and influence behaviour in predetermined directions. Thus, if a digital infrastructure is intended to be generative, the design could enable innovation and generativity through architectural rules (Benkler (2006); Lessig (2006); Tilson et al. (2010b)). Thus a significant challenge of generativity is seen as the paradox of change and control (Ciborra and Hanseth (2000), Tilson et al. (2011); Lyytinen et al. (2017)). These are seen as paradoxes because change requires both stability and flexibility. Attracting new users of infrastructure to develop infrastructure requires stability. However, the system cannot be rigid and closed to facilitate generativity and innovation. Thus, there a decentralisation level as well (Tilson et al. (2010a)). These paradoxes make digital infrastructures living organisms that take shape due to their existence's social, technological, legal and economic dimensions (Tilson et al. (2010a)).

> *"... the need to theorise about the evolution of digital infrastructures in ways*

> *that recognise the salience of the paradoxes of change and control… observing the need to approach the topic with a theoretical and methodical elasticity that will push IS scholars outside their comfort zones…" (Tilson et al. (2010a), p. 2)*

Flexibility is a prerequisite for change in digital infrastructure. Suppose the digital infrastructure is tightly coupled to the extent that it cannot be changed. In that case, innovating on the infrastructure becomes redundant as it is not afforded. Flexibility in digital infrastructures comes as a twin of a paradox with stability (Hanseth (1996); Tilson et al. (2011); Lyytinen et al. (2017)). , Enrolling new artefacts requires stability, while flexibility is needed for growth (Tilson et al. (2011)). Flexibility is achieved through decomposing and modularisation of the infrastructure. Therefore, according to Hanseth and Braa (1998), infrastructure growth or innovations presuppose flexibility, and flexibility presupposes modularity. Modularising enables the black-boxing of core architectures, making them less vulnerable to being compromised by connecting to new, untested systems. Black boxing takes place through standardisation, so the connection between flexibility and stability becomes clear.

This existence in a paradoxical recursive state of control and change between multiple actors brings about an apparent actor-level tension that cannot be ignored. Clark et al. (2005) call the process of different stakeholders with adverse interests on the Internet vying to favour their own as a tussle. This tussle happens at redesign or reconfiguration time. The concept of a tussle is seated in our social interactions and how actors behave in a network. The tension increases when strong incumbents with centralised systems and new entrants seek more open, flexible infrastructures. According to Christensen (2011), incumbents get locked into existing technology and cannot do what is radically disruptive. Tussles can occur regarding earnings, trust and openness. Clark et al. (2005) suggests that designers must incorporate the institutional and societal tussles that naturally occur into programs. Several IS scholars have used the relatively underresearched discourse on tussles between market actors in industries such as mobile communication (Elaluf-Calderwood and Herzhoff (2011)). With the increased disruptive innovations by agile startups, this would be a challenging yet highly

relevant research area.

Empirical research on the control-tussle framework in the mobile industry has suggested that all actors dynamically shape digital infrastructures and systems. Elaluf-Calderwood and Herzhoff (2011) and Herzhoff et al. (2010) extend the tussle framework to the mobile infrastructure design and present a systems-theoretical tussle framework based on Luhmann's notion of conflict (Luhmann (1995)), aiming to provide designers with a systemic understanding of tussles. This captured the points of a clash between incumbents and new entrants into the industry, reshaping the nature of the service that could be optimally provided technologically but is constrained by the external factors that shape the technology. Elaluf-Calderwood and Herzhoff (2011) also extends the tussle framework into a mobile control point analysis. Eaton et al. (2010) extend the control points and triggers by external factors such as law, social norms, markets and architecture based on Lessig (2006) modalities to mobile service platforms. When applied to business models, this model highlights that more than the technology itself, the economic control points are stronger and triggers such as regulation can change the future business model, and the way control points are used. Thus, the culmination of this research, which broadly looks at factors that affect the business model and economic and institutional factors, has a significant bearing on the digital infrastructure's actual trajectory in use. Therefore, the generativity of digital infrastructures is not purely technological but a combination of sociotechnical factors.

Digital infrastructures can be regulated through global, national, or regional regulations targeting industry. Firms can regulate their internal infrastructures with all relevant regulations and internal governance structures. Regulation can be a powerful tool in allocating resources towards industries and the direction that industry should take (Wiener (2004)). At the global level, regulation is done through soft laws – standards (Kerwer (2005)). Standard-making bodies would coordinate. An industry is generally regulated when there is a market failure or an imbalance (Baldwin and Cave (1999)). This could increase competition and ensure a quality of service and service delivery times. When infrastructure specifically provides a reg-

ulated service or industry, the level of digitalisation of the service or the industry operations would significantly influence the design and controls embedded into the infrastructure design and functionalities. In the telecommunication industry, service providers are required to meet the communication standard to provide their services (Lyytinen and Fomin (2002); Lyytinen and King (2002)). Similarly, in banking, the need to maintain stability and security of public funds and entry to industry infrastructure is restricted to those licensed to operate as a bank or licensed to provide services to the public(Kazan et al. (2018)).

The theory of regulatory economics posits that powerful industry actors are wealthy and organised and could push their special interests resulting in regulatory capture (Baldwin and Cave (1999)). This connotes that the economic regulation, which regulates aspects such as price and market access, would favour the powerful players in the industry. The theory also states that social regulation that minimises negative externalities such as pollution and safety would be less prominent as major actors would lobby for their interest to gain profits (Wiener (2004)). However, contrary to theory, regulated industries experience several waves of deregulation that weaken the power of incumbents(Wiener (2004)).

Deregulation to increase competition and access to other service providers was prevalent from 1970 onwards in the UK and US. Industries such as banking and telecommunication were treated. Deregulation in the US was after antitrust or demand for new entrants led to the end of the AT&T monopoly in the US (Wiener (2004)). The evolution of telecommunication and health sectors infrastructures, which are regulated, have been highly researched (Hanseth and Lyytinen (2004); Yoo et al. (2005); Grisot et al. (2014); Osmundsen and Bygstad (2022)). However, banking and payment infrastructures which were at the forefront of innovation since the 2008 financial crisis have not been analysed as regulated digital infrastructure. Deregulation in banking in the UK has led to the opening of financial services to non-traditional actors and the integration of services across financial services (Channon (1998)). Channon (1998) observed that traditional banks could not access the strategic advantage of information technology to capitalise on the changes in the regulatory environment. In con-

trast, new entrants provided low-cost solutions and captured new markets. Despite further deregulation of the payments industry through the introduction of the Payment Systems Directive 2 (PSD2) regulations, the study by Kazan et al. (2018) reveals that not all new entrants have direct access to the national retail payment infrastructure but instead have alternative access routes to infrastructure through business and infrastructural arrangements. Thus, the question arises of how regulation, when interacting with the other sociotechnical factors, influences the participation of new entrants in digital infrastructures. There is a gap in the literature regarding understanding how regulated banking and payments infrastructure operates(Henningsson and Eaton (2022)). This gap in the literature will be studied in this research.

2.5 Dynamics of Heterogeneous Actors

The dynamics of heterogeneous actors' decisions and behaviours, influencing the design, structure and nature of digital infrastructures has been observed at the firm level (Ciborra and Hanseth (2000); Hanseth (1996); Henfridsson and Bygstad (2013)), at the global infrastructure level (Benkler (2006); Lessig (2006); Zittrain (2008); Frischmann (2012)) and at the industry level (Lyytinen and Fomin (2002); Scott (2010); Hedman and Henningsson (2015); Markus et al. (2016)). The actions of heterogeneous actors influencing digital infrastructures has been observed in payment messaging infrastructure standard making (Scott (2010)), mortgage banking industry (Markus et al. (2016)), the telecom industry (Yoo et al. (2005)), mobile payments (Hedman and Henningsson (2015)), airlines (Henfridsson and Bygstad (2013)) health (Aanestad and Jensen (2011)) and industries such as music and taxi services (Tilson et al. (2013)). These research studies apply methods such as actor-network theory (Latour (2017); Hanseth and Monteiro and Hanseth (1996)) and collective action theory(Markus et al. (2016)) to explain the process of designing and developing infrastructure in a dynamic heterogeneous actor environment.

The industry-level dynamics differ from firm-level interaction as the number of actors in-

creases and brings micro-level and macro-level issues (Hedman and Henningsson (2015)). There is simultaneously coevolution of infrastructures and social relationships (Lyytinen and Fomin (2002)). At an industry level, discussions are mostly around standardisation for sharing and increasing adoption. This coevolution could be a closed industry-level system moving to become an open global system, such as the SWIFT network's evolution based on heterogeneous actor negotiations (Scott (2010)). However, heterogeneous actor-based coevolution does not always expand as planned. In the example of the Danish patient record system initiative, the national initiative failed. Still, a small local solution could grow into a nationwide patient record-sharing system (Aanestad and Jensen (2011)). Henfridsson and Bygstad (2013) explain these successes and failures through generative mechanisms, dynamic factors affect the evolution and expansion of infrastructures from local systems to full-scale infrastructures.

The sociotechnical evolution infers that technological extensions, additions, and human intervention coevolve continuously. The technical architecture's social element covers a broad spectrum of socio-economic factors ranging from user and designer communities to national and international legislation and political and economic events (Lessig (2006)). The actors' digital infrastructure depends on the infrastructure and its scope. For example, the infrastructure will extend beyond immediate users and designers in regulated industries and continue toward a regulatory level. If the industry is one such as banking or payments, then actors would span to international regulatory agencies as demonstrated in Hanseth and Braa (1998). The notion of heterogeneous actors includes international organisations as the standardisation processes of infrastructure invariably have to adhere to the International Standard Organisation (ISO) standards. However, where international organisations or regulatory bodies are in the network of infrastructure actors, the designer's roles could be significantly constrained or limited to the international standard. They cannot be negotiated for an individual infrastructure level.

The structure of the design community also influences the heterogeneity of actors. In the

case of international software development projects, which was the example in Star and Ruhleder (1996) 's research in 1996, actors coordinated across geographies and negotiated the design process. Several researchers have captured the dynamics between different actors. The literature on architectural shaping demonstrates how strategic actors continuously tussle for control (Clark et al. (2005); Elaluf-Calderwood and Herzhoff (2011)) over the infrastructure in the complex legal, architectural, social and economic environment for the design of infrastructure subject to the bargaining powers, business needs, and IT capabilities of actors (Tilson et al. (2010a)). Thus, infrastructure design may not be technologically optimal but creates certain anomalies for stronger groups to prevail over control points [1].

The influence of regulators and other actors becomes essential at several junctures. The introduction of standards becomes a central point. Regulators, incumbents, and the new entrant will wrestle to get the best standard for them. Further, users and developers will influence the regulatory processes. The experience from the telecommunications industry reveals how regulators can drive change to modernise industries (Yoo et al. (2005)).

2.5.1 Influence of events

The next important element is events. Events within an economy or industry could have as much a bearing on infrastructure as the influence of heterogeneous actors. Hughes (1987) presented this but stated that events that would alter infrastructures would need to be as significant as the Great Depression. On the other hand, Arthur describes the importance of small historical events that impact the course of technologies, such as managers' decisions (Arthur (1989)). For digital infrastructures, events such as the Dotcom bubble, the creation of the Internet and the PC and mobile phone could be significant events that materially changed the course of digital infrastructures that existed at the time (Benkler (2006); Lessig (2006); Zittrain (2008)).

[1] This research does not discuss power dynamics between actors as it is not the aim of this research. However, it is noted that there is a rich literature in many fields relating to power dynamics and in the case of regulated industries; it also extends to the stream of regulatory economics (Baldwin and Clark (2000))

"Market events and landmark developments have also inspired techno-innovation."
(Scott (2010) p. 6)

Regarding the financial industry, the global financial crisis of 2008 materially impacted the banking industry and its processes. As the industry is highly digitised, this impact would be reflected in the industry's market infrastructures. While events can have a significant bearing on the infrastructure's structure and design, tracing events' impact on infrastructure generativity is not very prevalent. However, several authors have broadly noted that events have had a bearing on the infrastructure-based innovation process that they have studied. For example, the global financial crisis and the introduction of the Payments Services Directive II by the European Union (Gozman et al. (2018a); Markus et al. (2016); Zachariadis and Ozcan (2017)).

2.6 Openness and heterogeneity in Digital Infrastructures

While the terms access and openness seem closely related concepts, openness mainly refers to the technological capabilities provided to different users or participants to were "new components can be added and integrated with them in unexpected ways" (Hanseth and Lyytinen (2010) p.4). Further, Hanseth and Lyytinen (2010) state that openness connotes no boundaries between those who can and cannot use or design a digital infrastructure. Openness, therefore, has been observed to be a feature that makes digital infrastructures generative, as they can connect heterogeneous systems and innovate by recombining and adding components (Hanseth and Lyytinen (2010); Tilson et al. (2010b); Henfridsson and Bygstad (2013)). However, Hanseth and Lyytinen (2010) provides this description of openness with the conditional term "in principle," (p. 4) implying that openness is not a given state in a digital infrastructure but a condition shaped by other factors.

The next is the sociotechnical shaping demonstrated through the success of the Internet. This shared notion is a composite reflection of the Internet's unanticipated use by multiple

distributed communities connected via the Internet (Benkler (2006)). Interestingly, despite the Internet being used before 2000 (Abbate (1999)), this sharing of ideas, which is a result of empirical developments, occured later.

Digital infrastructure researchers have been increasingly studying innovation and generativity (Yoo et al. (2010a); Yoo et al. (2010c); Eaton et al. (2018); Lyytinen et al. (2017); Reuver et al. (2018)). This popularity arises from the combination of several factors. Firstly, the changing organising logic of digital technologies has enabled unprecedented levels of innovations in digital infrastructure before (Yoo et al. (2010a); Yoo (2013)). Secondly, the success of the Internet. As a pervasive technology, the Internet has demonstrated the ability to change the nature of all devices connected to it (Benkler (2006)). The Internet, which began as the information superhighway (Sassen (2001)), is now the central digital infrastructure and pervasive technology that connects systems and devices across industries and geographies.

Digital infrastructures are digital artefacts that have evolved into systems that can interconnect easily to any level of innovation that it has enabled (Zittrain (2008)). Its structure has influenced other infrastructures and digital products (Hanseth and Lyytinen (2010); Yoo et al. (2010a)). The spur of interest in the concept of generativity (Zittrain (2008)) especially in other infrastructures, the global interest in digital innovation, and the proliferation of the mobile phone have increased interest and brought digital infrastructures to the forefront, with IS scholars calling for more significant research on digital infrastructures and its generativity (Tilson et al. (2010a); Yoo et al. (2010a); Lyytinen et al. (2017)).

Openness thus adds to digital infrastructure other characteristics such as evolving, shared and heterogeneous(Hanseth and Lyytinen (2010)). It also means that the infrastructure owner has no control or has not sought to curtail the weakening of control. To theoretically analyse and explain if this special evolutionary affects Fintech innovation at all, this study positions itself within the digital infrastructure literature and its branches relating to infrastructure dynamics and then brings the discourse to the domain of payments to see where there is

particular understanding relating to payments infrastructure and innovations.

2.6.1 Stability and Flexibility

Digital infrastructures began to transform from closed, tightly coupled infrastructures to flexible, easy-to-access computers as computing capabilities became cheaper, smaller, and coupled with the proliferation of the Internet that enabled access to information networks from a home computer (Tilson et al. (2010a)). Further, devices with versatile storing, processing and communicating capabilities increased in availability (Tilson et al. (2010b)). With both device convergence and network convergence, they reached a tipping point of becoming social infrastructures.

In addition to the devices and infrastructure, digital technology has three unique characteristics that distinguish it from non-digital technologies. These are 1) programmability, 2) the homogenisation of data, and 3) the self-referential nature of the digital technology (Yoo et al. (2010a) p726). These three digital technology qualities give it a standardisation quality that makes it malleable, recombinable, and flexible. Digital devices follow the Von Neuman architecture where the device and software are not tightly integrated, making software; thus, this gives both the devices and the ability to independently function. They can be designed in a continuum between closed and open as the designers wish. Zittrain (2008) described digital infrastructures were "built on the notion that they are never fully complete, that they have many uses yet to be conceived of, and that the public and ordinary organisational members can be trusted to invent and share good uses" (p.43). As the adoption of the Internet as an infrastructure increased, generative systems emerged that allowed users and organisations to "cocreate services, applications and content" (Tilson et al. (2010b)). These generative systems coupled with the neutral infrastructure, the Internet, has enabled geographical dispersion and integration(Hanseth and Braa (1998); Benkler (2006); Zittrain (2008); Tilson et al. (2010a)). While path-dependent evolution is recognised in design recommendations, designing generativity in DIs and systems is often based on the Internet, (Hanseth and Lyyti-

nen (2010); Yoo et al. (2010a); Henfridsson and Bygstad (2013)).

The Internet is often thought of as the prototype for proper infrastructure. The Internet infrastructure is recognised for its product-agnostic open design (Zittrain (2008); Yoo et al. (2010a)). DI designs recommended in literature promote designing a similar system that is modular and generative (Hanseth and Lyytinen (2010)), with the caveat of ensuring the enabling and constraining path secondary qualities are well balanced. While, in principle, these are commendable and good targets to aim for, the reality may be much different. As more and more industries are digitised and DIs have added burden to support innovation, we begin to see how they are repurposed for innovation. (Nambisan et al. (2017)). Further, DIs are exposed as it becomes clear how unprepared they are for innovation waves (Tilson et al. (2013)).

Zittrain's depiction of the Internet's hourglass layer architecture demonstrated how a single point of stability (IP) and the recombinable flexible architecture changed the Internet from merely being an infrastructure that facilitated operations to becoming an indispensable foundation for innovations. Flexibility emerges from the design's upward and downward flexibility (Tilson et al. (2010b)). This flexibility is gained through standardised physical or technological interfaces that connect across multiple modules and layers, allowing them to recombine across modules and layers and innovate, using existing capabilities to produce new products.

However, the ability to connect multiple systems increases the chances of building complex systems with contagion breakdowns. This complexity is reduced through modularisation (Baldwin and Clark (2000)) and layering of the design's architecture. Modularisation allocates specific functions to components, and system design would specify the governance relating to the interconnection between components. Modularity reduces the entire system's exposure to risks and allows individual components to be changed without changing the rest. This provides flexibility to the artefact. (Hanseth (1996); Baldwin and Woodard (2007)). The other architectural design is layering. The layering of the architecture is the

separation of the architecture between the physical, logical and content layers and providing interoperability for them to function together and independently (Adomavicius et al. (2008); Tilson et al. (2010b); Yoo et al. (2010a)). The potential of a layered modular architecture for generativity was emphasised through the success of the Internet to unbounded generative innovations.

The Internet made infrastructures "shared, open and heterogeneous" (Hanseth and Lyytinen (2010), p. 5) – thus changing the mindset. The Internet seems to have fixed what was expected of digital infrastructures, and every other infrastructure appears to be trying to emulate the Internet (Benkler (2006); Zittrain (2008); Hanseth and Lyytinen (2010); Henfridsson and Bygstad (2013)).

The opportunities that Internet provided for distributed innovations on a deficient cost model introduced digital innovators to new logic for innovation. These affordances were a stark difference to the closed, regulated traditional infrastructures. Thus, as products and services were digitised there, business and distribution models were disrupted globally. Industries that experienced dramatic disruptions were mobile telecommunication with innovations such as Skype (Lyytinen and Fomin (2002)), and the music industry with the digitisation of music no longer needing a dedicated cassette LP for the music to be stored and distributed.

Music could be shared and downloaded to the personal computer via the Internet. This disrupted the industry's distribution channel (Tilson et al. (2013)). The taxi industry underwent a similar disruption as the music industry (Lyytinen et al. (2017)). A common feature of these industries was that they were not strictly regulated. This observation is based on the banking and payments industry's ability to remain mostly undisrupted, despite being one of the earliest digitised. Fintechs have been attempting to disrupt the payment industry; however, it is unclear what has been disrupted in payment by Fintechs. Thus, this conundrum is the focal point of this research.

2.6.2 Innovation in infrastructures

What makes something *generative*? There are five principal factors at work: (1) how extensively a system or technology leverages a set of possible tasks; (2) how well it can be adapted to a range of tasks; (3) how easily new contributors can master it; (4) how accessible it is to those ready and able to build on it; and (5) how transferable any changes are to others—including (and perhaps especially) nonexperts. (Zittrain (2008) p 71)

There are two aspects to the innovation or generativity of digital infrastructures. One is the generativity for third parties or other groups to innovate on the infrastructure, and the other is the innovation of the infrastructure for its growth. However, this is a fine line as product and service applications could become infrastructures and infrastructural extensions that remain small-scale applications if not adopted. The relevance of this distinction is useful when trying to understand the purpose of infrastructure. There are two lines of literature that run closely together.

Grisot et al. (2014) study of the Norwegian patient communication system is on the latter, focusing on infrastructure cultivation. Necessary infrastructure is developed locally, and then a bottom-up approach where users and actors within the system add new capabilities and functionalities as they see a need and an affordance. This way, the infrastructure grows on a user-need basis rather than a top-down, centralised design. This method, called bootstrapping (Hanseth and Lyytinen (2010)), takes a contingent and flexible approach for new infrastructure to grow and gradually develop layers and modules to become further generative.

However, significant literature focuses on the first, where existing infrastructures provide functionalities for new entrants to innovate. This is a continuum between when a third-party innovation is a mere product that disrupts markets or an innovation extending or disrupting the infrastructure itself. However, the first aspect mentioned above is the common focus of IS literature. Unpacking this is harder as the focus of digital innovations has moved mainly to platforms. The layered architecture of the Internet has enabled sub-infrastructures such

as OS to emerge as platforms (Tilson et al. (2010a); Eaton (2012)). Thus, to understand the current idea of digital innovation on infrastructures, it would be essential to understand the platformatisation of infrastructure and its effect on generativity.

While digital infrastructures form the broader all-encompassing term for technological structures that afford generativity and interoperability, platforms function as the operational construct that facilitates these DIs' qualities. The literature on platforms flows from different fields such as economics, business strategy, innovation and information systems (Thomas et al. (2014)).

The IS, or the engineering design perspective (Gawer (2014)), focuses on platform design and how it supports innovation. Simon's earliest work on platforms in 1952 suggested a decomposable hierarchical structure that would reduce complexity. Thus, platforms have the crucial characteristic of modular architecture (Baldwin and Clark (2000)) and can be part of any technological product, for example, a car or machine where new components could be added.

The modular architecture of platforms enabled the continuous development of layers and made platforms generative interfaces that enable independent innovation(Garud and Kumaraswamy (1995); Zittrain (2008); Yoo et al. (2010a)). This is further facilitated by the Internet's hourglass model, where infrastructure, platforms, and applications are connected through a single internal protocol (Zittrain (2008)). Baldwin et al. (2010) saw the platform as a structure with a stable core and variable periphery. Thus, with this nucleus formation, the core theme of IS literature on platforms focuses on enabling innovation.

The innovation potential of platforms results from both flexibility and stability, as much discussed in the digital infrastructure literature (Tilson et al. (2011)). However, the tension between chance and control meets the core platform, creating complexities regarding maintaining technological supremacy and quality. This aspect is seen in the Apple App store, stringently regulating the boundary resources provided for apps demonstrating the constant tussles between developers and Apple (Eaton et al. (2014)). Thus, platforms' generativity

tends toward a distributed and decentralised system that creates a genuinely networked organisation that is not entirely detached from third-party innovations. Platforms like infrastructures provide boundary resources for third parties to innovate on (Ghazawneh and Henfridsson (2013)). Therefore, platforms also become a layer in the infrastructure that provides upward and downward flexibility.

Platform research was most frequently used in economics studies that viewed platforms as one that enabled connecting two sides or multiple sides of the market (Rochet and Tirole (2004)). The economic perspective of the multi-sided market sees platform participants in a transaction relationship. Thus, either agent or consumer's relationship is that of a buyer with the platform supplier who acts as a seller. Rochet and Tirole (2006); Rochet and Tirole (2003b) and Rochet and Tirole (2003a) extensively develop the concept of multi-sided platforms in the credit card market to understand the price structures and competition. Some key conclusions were that credit card companies and merchants negotiated their profit-sharing in the most beneficial way to them rather than the customer.

Some critical limitations found from the economic perspective were that platforms were seen as exogenous and fixed. The innovator who used the platform to provide complementary services was seen as buyers rather than suppliers that provided complimentary services (Gawer (2014)). From a technological perspective, platforms are thus seen as exogenous and fixed rather than the evolving, interoperable, generative foundation that the IS or engineering view or even the legal view saw. An integrative model in the business management literature has seen an interaction between platform competition and platform innovation (Gawer (2014)). This approach appreciates all angles of platforms with the apparent focus of the business strategy.

In the management literature, platforms are discussed as internal organisation platforms and organisational and external platforms that enable the organisation to become a part of the network. Thus, platforms can be organisational, industrial, and global to any extent (Thomas et al. (2014)).

There have been many cases of how competition has reduced the innovator's power. In the case of IBM being dethroned by Intel and Microsoft, it created an industry platform in the 1990s (Gawer and Cusumano (2002)). Gawer and Cusumano (2002) goes into the micro-foundations of how platforms operate as they integrate engineering and economics research. The common theme of coevolving platforms and agents is raised again. Increased knowledge of platforms continuously highlights the complexity of a high level of interoperability, modularity, network effects, and generativity. Thus, several studies have looked at how this tension is resolved to a workable solution in this dynamic coevolving environment, where change is the most certain factor.

2.7 Relationship between incumbents and new entrants

The banking industry was one of the earliest to adopt digital infrastructures, of which payment systems were new additions (Bátiz-Lazo and Wood (2002)). However, the boundaries of banks have been challenged by new entrants gaining more access through interoperable platforms and deregulation that allows non-banks such as supermarkets and other retailers and internet firms to enter the banking market (Scott and Walsham (1998)). The diverse field of banking covering several services has seen technology having a new impact on several fronts. A study of implementing new innovative decision support systems in the UK banking systems found that traditional banks' boundaries were shifting, making them more global and restructuring the existing hierarchical structure (Scott and Walsham (1998)). Banks have changed with the introduction of information technologies, with a state of disorganisation when bank clearinghouses and trading arms underwent a detachment process (Millo et al. (2005)). While most examples discuss the blurring of boundaries in industries, this example shows how information technologies allow detachment from functions and create a new organisational structure. Banks have also evolved with disruptive technology theory, as proposed by Christensen et al. (2005). They claim that incumbents do not adopt early technologies. Their large customer base does not demand this but is later challenged by new com-

petitors who have adopted these technologies and have a competitive advantage. Studies about the banking industry's reaction to the financial crisis and consequent credit risk have shown a sense of disorganisation in the banking sector, as it allows new technologies and new entrants to enter their business (Scott and Walsham (1998); Scott (2000); Barrett and Scott (2002)).

The current trend toward digital innovations and the financial crisis has led banks to combine legacy systems with new affordances (Liebenau et al. (2014)). Of banking infrastructures, payment infrastructures though used often, have remained out of the limelight. Payments are one of the earliest services to be digitised (Bátiz-Lazo and Wood (2003)) via banks' digitisation. Banks and payments infrastructures have a significant component of their IT systems as legacy systems (Liebenau et al. (2014)). Research into payments infrastructure has been relatively rare, though, amongst the few available, some have provided in-depth studies into payments infrastructures (Khiaonarong (2000), Scott and Zachariadis (2013)).

Before payment infrastructures gained popularity due to the Fintech wave, the research on payments were often descriptive studies that mapped the operational aspects of such payments instruments (Humphrey (2010); Hancock and Humphrey (1998)). Payment card research by Tirole and Rochet revealed (Rochet and Tirole (2003a)) the complex markets that form within payment instruments and participants' bargaining powers in deciding fees (Rochet and Tirole (2003a)). Thus, payments form a complex field that far surpasses pure technology and is an extraordinarily complex sociotechnical infrastructure made up of multiple layers of technological and non-technological markets and hierarchies.

At an infrastructure level, Scott and Zachariadis (2013) demonstrated the complexity of a payment infrastructure with many actors negotiating on local and global standardisation in SWIFT infrastructure. Another study traced the complex process of implementing the RTGS system in Thailand (Khiaonarong (2000)). More recently, the evolution patterns o driving a global instant payment infrastructure (Mora et al. (2020)) where the paper finds that the payment processor's higher efficiency reduced the number of processing layers.

2.7.1 Fintech Innovations in payment infrastructures

The popularity of Fintech innovations rose in the later 2000s. The term is a portmanteau of financial technology that is applied when digital technologies are used to innovate financial services(Gomber et al. (2018b)). Fintech was mostly a result of new digital start ups that aimed to bring innovation to financial services. Thus, these firms were also commonly referred to as Fintechs (Drasch et al. (2018)). It may be attributable to the changing view of infrastructure from a purpose-specific service entity to an agnostic recombinable platform for innovation. Fintech innovations in payments mostly focused on retail-level innovation (Gomber et al. (2018b)). Digital technology enabled Fintechs to reach markets through innovations such as mobile payment schemes (e.g. M-Pesa) that had not been reached in the traditional system. Further, the rise of e-commerce led to a demand for online payment solutions, leading to PayPal's innovations, which became a global online payment platform. Thus, new subcategories of payment infrastructures are being added to existing payment systems.

The phenomenon of Fintech in payments has been gaining traction with more and more dedicated research in the area (Arner et al. (2015); Gomber et al. (2018a)). At the outset, it is noticeable that most Fintech-related research follows the current digital innovation research trend of focusing on the platform level. Another outcome of the success of the Internet was the platformatisation of layers. There is a large body of research on platforms in management and IS (Gawer and Henderson (2007); Elaluf-Calderwood and Herzhoff (2011)). The popularity of platforms in IS research grew with the adoption of mobile platforms on iOS and Android phones, which allowed third-party software developers to develop software applications (Elaluf-Calderwood and Herzhoff (2011); Tilson et al. (2012)) that extended the functionality of these devices. The success of mobile platform-based applications refocused the infrastructure discourse from the focal points of Hanseth et' al's work with others in large-scale infrastructure to the mobile infrastructure's service and content layers. Thus, most of the later IS research on innovation have focused on platform-based innovations.

The interesting aspect of platform-based innovation is that the platform has technological and non-technological dynamics, like those studied by Tirole and Rochet in the card payment networks, which were also platforms(Rochet and Tirole (1996)). Around 2013, as the interest in Fintech grew, the question posed whether mobile payments were hype or a sustainable phenomenon (Flatraaker (2013)). The unmet demand in the retail payment market has led to substantial growth in payments innovations which have been studied from business strategy perspectives (Kazan and Damsgaard (2016); Kazan et al. (2018)), from the view of its specific technologies (Kazan and Damsgaard (2014); Zachariadis and Ozcan (2017)), and form the view of the tension between incumbents and new entrant Fintechs (Hedman and Henningsson (2015); Gozman et al. (2018a)).

Kazan and Damsgaard (2016) developed a platform entry that included both business and technological modes of entry. They distinguished between evolutionary and revolutionary innovations, revolutionary being entirely new, while evolutionary being instances where existing technological capabilities are extended. The findings suggest that multi-sided payment platforms leverage (1) evolutionary payment instruments and (2) payment services bridge users from the core to adjacent platform markets. In so doing, platform envelopment strengthens firms' market position in their respective core markets (ibid p. 779). The UK payments innovations competition was presented by Kazan et al. (2018). Here, several competitor innovations are analysed to understand the factors that enable their adoption and scaling. Kazan et al. (2018) also discussed platform competition through UK Fintech innovations. Here they show the different access models to the central FPS systems, where only the banks have access when the research was published. This established the formerly closed aspect of the banks to non-banks. Detailed surveys of Fintechs in the UK revealed the emergent trends in Fintech (Gozman et al. (2018b)). These demonstrated how the modularity of systems had increased the ability of those firms to grow. Further, the study by Gozman et al. (2018a) revealed that all actors cooperate to innovate and provide more services to customers.

Much of the Fintech research focuses on the tension between incumbent banks and Fintechs. The rise of Fintechs disrupted the payments market, as banks were traditionally the dominant players. While the incumbent's dominance remains, demand from Fintech to gain access to the technologies and markets has led to competition between incumbents and Fintechs (Hedman and Henningsson (2015))

2.8 Summary and research question

This chapter presented literature related to the research issue studied. The sociotechnical dynamics of access to regulated digital infrastructure is a complex intermingling of material or technological systems of heterogeneous actors, technological and industry-related regulations, and openness. The literature review demonstrated that digital infrastructure poses strong technological and non-technological complexities that need to be encountered and resolved in gaining access. Even though openness and access to digitalised markets and infrastructures had been discussed at length in the literature, understanding of how access to heterogeneous actors involved in industry-level digital infrastructures regulated by non-technological regulations such as national and industry-related laws has not been studied in depth (Henningsson and Eaton (2022)). Considering industry-level studies, there has been a considerable focus on the telecommunications and health sectors. However, banking and payments infrastructures, which have seen great pressure for access by heterogeneous actors, have not received academic attention in accessing the payment infrastructure. Given that banking and payment systems are experiencing a new wave of digital transformation, the high level of sociotechnical complexity of the infrastructure and the systemically important nature of financial systems to an economy motivates the importance of understanding how heterogeneous actors access the national payment infrastructure. Therefore, I pose the following question and sub-questions for the research and proceed to present my research in the subsequent chapters:

- RQ: How do heterogeneous actors gain access to regulated digital infrastructure?

This question is operationally answered through 2 sub-questions:

- SQ1: How do actors resolve access to a regulated digital infrastructure?
- SQ2: How do actors interact with regulations relating to digital infrastructure access?

Chapter 3

Theoretical Framework

3.1 Introduction

To answer the question of "how do heterogeneous actors gain access to regulated digital infrastructures?" the theoretical framework adopted must allow the researcher to recognise sociotechnical interactions of regulated digital infrastructure access and articulate how heterogeneous actors navigate through this complexity to achieve their goals. Pickering's Mangle of Practice (Pickering (2002)) is adopted as a theoretical lens as it provides the conceptual tools to identify control points in digital infrastructures (Tilson et al. (2010a); Eaton et al. (2018)) and how actors reconfigure the infrastructural characteristics to achieve their goals. The Mangle of Practice and its subsequent extensions made through its application to digital infrastructures and systems (Venters et al. (2014); Barrett et al. (2012); Eaton (2012)) is thus adopted in this research.

Pickering's Mangle of Practice provides a pragmatic theoretical tool to unravel emerging complex interactions between human actors and technology to capture the agency of non-human artefacts such as digital systems and the agency that emanates from rules that discipline human behaviour and decisions. This chapter presents the Mangle of Practice (Pickering (1995)) with its key concepts and subsequent developments of the theory in information

systems literature. Based on the review of the theoretical concepts, the research question and sub-questions are refined to better focus on the research issue. An analytical framework to operationalise the analysis comprising concepts derived from digital infrastructures was developed to answer the revised research question and sub-questions.

3.2 The Mangle of Practice

The Mangle of Practice advances a general schema to explain how human actors engage with non-human elements and artefacts when aiming to achieve a future goal or outcome. Pickering argues that human and non-human agencies intermingle in the path towards a particular goal. The Mangle of Practice distinguishes itself from Actor-Network Theory (ANT) by refuting the symmetry assumption between material and human agency. Instead, Pickering takes a practical stance that either agency comes into consideration when it emerges, is visible, and can be asymmetric in its influence. Agency emerges when they are used or in practice. Pickering states that material agency emerges temporally as resistances only when a particular aspect of an artefact is used. These resistances, in turn, will shape the plans, interests, and activities of human actors as they are compelled to consider such resistances to proceed. The emergence of material agency when human actors try to perform an activity involving human and non-human interaction leads to accommodations for the material agency and revising goals. This entire process is seen as a Mangle of Practice where there is a continuous dialectic of resistances and accommodations where the human actor performs acts necessary to reach their goal. This goal may also be revised based on the resistance posed by the material factor. This process, referred to as tuning, ceases only when the actor reaches The Mangle of Practice, which comprises several concepts and terms conceptualised and extended by Pickering. To develop the analytical framework and analysis, I begin with a high-level explication of the development of the concept of agency as it is adopted in the Mangle of Practice and then proceed to terms within the Mangle of Practice.

3.2.1 Agency within the Mangle of Practice

Agency is an actor's capacity to take actions that can change the status quo or reach a particular goal (Giddens (1984)), asserting the free will of the human (Emirbayer and Mische (1998)). Agency based analytical perspectives have elaborated the sociotechnical processes involved in IS innovation (Avgerou (2002)), Structuration theory (Giddens (1984); Walsham and Han (1991); Jones and Karsten (2008)), ANT (Latour (2005)) and Pickering's Mangle of Practice. These have captured how elements such as culture, institutionalised actors' performances, actors bringing out their ability to appropriate technical capabilities when performing their organisational tasks, and the material and structural properties are used in the innovation process (Avgerou (2002)). Information Systems research has been striving to understand and explain the sociology of digital technology and the sociotechnical dynamics that arise when people use or interact with technology through several theoretical approaches, including sociomateriality (Orlikowski (2007)), Actor-Network Theory (ANT) (Latour (2017)) and Structuration Theory (Giddens (1984); Walsham and Han (1991)). The Mangle of Practice builds on ANT as Pickering takes a post-humanist view of "decentering the human subject" and acknowledging the agency of non-human artefacts such as technological artefacts (Pickering (1995), p.25). However, the main divergence between Mangle of Practice and ANT is that Pickering challenges the symmetry of agency that ANT grants human and non-human agency. The asymmetry of agency allows greater flexibility to observe how human actors succeed in capturing material agency, manifesting as resistance or when they cannot capture the focus on unravelling the performative idiom of scientific practice when entwined with human intentionality.

The mangling of human and material agencies that temporally emerge as humans engage with material artefacts to achieve their goals (Pickering (1995)) result in a dialectic of resistance and accommodation, which is resolved through a process of tuning, which is referred to as the dance of agency. Pickering adopts a post-humanist view of the sociology of science (Pickering (1993)), where the human is decentred, giving space to recognise the agency

of non-human elements or artefacts. The displacement of individuals and groups from the traditional locus of interpretation provides a tool to view the effect of both the social or human and the technical or non-human dynamic in an interaction. While Pickering bases the Mangle of Practice on ANT(Callon and Latour (1992); Latour (2017); Walsham (1997)), he moves away from the central assumption of the symmetry of agency in ANT. The symmetry of agency is where humans and non-humans have a similar agency that continuously influences each other when performing tasks involving material or technological artefacts. However, ANT does shed light on an important aspect of technological artefacts that provides an analytical tool for understanding the sociotechnical nature of technological systems and artefacts. Collins and Yearley (1992a) and Collins and Yearley (1992b) critique the post-humanist view by stating that agency cannot be attributed to material artefacts. Humans represent any capabilities of material elements, i.e., scientists, sociologists, or their material elements must be either observed characteristics of material elements or are products of human agency or scientifically tested features. Thus, it can be said that Callon and Latour and Collins and Yearley reside in the two extremes of the view of giving technological or material artefacts agency.

Pickering takes a more flexible approach to agency, acknowledging that the term agency is used for non-human elements only as semiotics and not in any way life or intention to them, which is how it is seen by Latour as well (Latour (2017)). This allows the researcher to observe the dialectic of resistance and accommodations that occur during a continuous process of human actors attempting to capture material agency and making accommodations when they fail to do so, only to return to engage with it until they reach their goal. This interaction thus creates a dance of agency that leads to change on the level of resistance and accommodation.

Emirbayer and Mische (1998) disaggregated the concept of agency further by setting it within a temporal framework, where for each analytical aspect of agency, one temporal dimension is dominant and shapes how actors relate to the other temporal dimensions (p.972). Includ-

ing temporality provides the agency with an evolutionary nature, where it is bound by the past and looks to the future while manifested in the present. These characteristics provide theoretical guidance to unravel the evolution of an information system through an innovation process. Venters et al. (2014) extend the Mangle of Practice by drawing on Emirbayer and Mische (1998), developing a trichordal temporal approach of agency demonstrating that the mangling of practice is contoured by past inertias of the installed base, disciplinary agency, present mangling of practice and future projections (modelling).

The material-semiotic notion of agency is discussed in ANT, which is that material agency has the material element and a semiotic (concept) element is acknowledged and extended to material agency and disciplinary agency. Pickering refers to characteristics of non-human artefacts that prevent human actors from reaching their goals conveniently as resistances. Resistances are "the failure to achieve an intended capture of agency in practice" (Pickering (1995) p.22) and "accommodation of an active human strategy of response to resistance" (ibid), which can include revisions to goals and intentions. Goals are reflections of human intentionality, which can change when met with unknown resistances. Thus, the Mangle of Practice is a dialectic of resistances and accommodations, where a continuous process of configuring and reconfiguring is called tuning. These concepts are elaborated to understand how they can be tools to narrate the process of how new entrants gain access to digital infrastructure.

3.3 Human agency

Human agency encompasses intentionality, which manifests as goals. Human practice is called disciplined human practice, when practices are regularised, routinised, standardised, disciplined through skills and rules etc. (Pickering (1995)). The intentionality of the human actor distinguishes it from the material agency. Human actors have interests and goals and can take action. Thus, humans can decide whether their action is passive or active engagement when using their agency. Pickering uses the example of Glasser's passive role in the

dance of agency occurring in the bubble chamber practice.

3.3.1 Intentionality

Pickering's view of human and material agencies addresses the criticisms of ANT's symmetrical agency by highlighting the intentionality in humans. Intentionality swerves from the rigidities of sociotechnical approaches such as Actor-Network Theory, where both human and material agency have equal ability to influence performance. Thus, giving room for unequal forces to interact. Intentionality is the human characteristic that distinguishes humans from non-humans. According to Pickering, who develops this notion from conceptualisations of scholars such as Giddens, human actions and behaviours are based on intentions and interests, focusing on a specific or expected future state. Humans work toward these non-existent future states (Pickering (1995) p.566), which Pickering terms as goals and seek to bring about. On the other hand, it cannot be presumed that material artefacts have similar intentions to achieve some outcome. Nevertheless, material artefacts, especially digital artefacts, can impose certain rigidities that affect human decision-making and behaviour(Barrett et al. (2012)). This breaks the symmetry between agencies, giving them more flexibility in each context. The complexities of digital infrastructures are enmeshed with an intricate interweaving of people and systems where there is a continuous alignment of heterogeneous actors and bricolage (Ciborra and Hanseth (2000) p.2.) Between humans and materials, human intentionality plays a key role in distinguishing between the two.

As this research is set in a context where many human actors represent institutional actors, it is also important to recognise the concept of institutional agency. The institutional agency is decoupled from the individual agency by creating actors and roles (Abdelnour et al. (2017)). Iannacci (2010) contended that public infrastructures require institutional facts to be considered. Institutions create actors and roles so individuals can change seamlessly with minimal disruption to the institutional processes. Role structures fundamentally decouple individual intentionality to a collective intentionality Abdelnour et al. (2017)). While I do not explic-

itly take agency institutionally into the theoretical framework, nor references to institutional representatives interviewed during data collection, I will consider them to exercise an agency role on behalf of their institutions rather than further any personal agency.

3.3.2 Heterogeneous actors, microactors and macroactors

Pickering (1993) theory, connote that the Mangle of Practice and tuning of resistances occur between a single actor and materials object. However, in Pickering (1995) work, there is an opening to having many actors tuning a material object. The Mangle of Practice has been adopted in information systems research to include heterogeneous actors specifically and how they engage in the tuning process (Barrett et al. (2012); Venters et al. (2014); Eaton et al. (2018)). The context of study in this research is also comprised of heterogeneous actors who operate within the microenvironment of the digital infrastructure. In contrast, other actors are at a macro level tuning policies and laws without any direct connection to the artefact. For analytical simplicity, I adopt the terms microactors and macroactors (Pickering (1995), p.235) conceptualised by Pickering (1995) to use as analytical categories in the analysis. While I adopt Pickering's description of microactors, his notion of macroactors connotes disciplines such as science, which many human actors tune through experiments, etc. To present the analysis in this research, I adopt the term macroactors to refer to actors who can impose discipline on microactors and the material artefacts they use, such as regulators.

3.4 Material agency

The material agency is a key concept in the Mangle of Practice. The notion of material agency takes the post-humanist stance that non-human elements or artefacts can perform certain actions without human intervention and that it needs to be viewed not only as the result of human action. In the dance of agency of the Mangle of Practice described through the bubble chamber, material agency emerges and is observable when the human actor is passive. Even when the human actor does not intervene, the results of the experiments can defer. Pick-

ering uses the example of the bubble chamber experiment to describe the material agency in its strictest form. The example of the US Army continuously attempting to control the Mississippi river demonstrates that tuning for material agency can be an unending task as there will be persistent qualities. (Pickering (2007) p.7). Legacy systems and the installed base of digital systems demonstrate this persistence (Hanseth and Lyytinen (2010); Venters et al. (2014)) that leads to path-dependent architectures that endure numerous attempts to change. While the past may emanate inertias that need capture, Barrett et al. (2012) also found that groups working with persistent material agency tuned their behaviour or human agency, resulting in a boundary spanning their relations with other teams and the technological ambit leading to levels of innovations and efficiencies. The temporal dynamic of material agency emerged in the Venters et al. (2014) study of digital coordination of digital infrastructure development. Here the study found that a trichordal dynamic of the past and future influenced the tuning that was taking place in the present. The installed base, conventions of practice, and the agency of software engineering-related disciplines from the past were affecting the present mangling of resistance and accommodations. They demonstrate how the powerful qualities of a material artefact can be harnessed through digital coordination. The temporally enacted tuning process involving multiple heterogeneous actors across past, present, and future harness non-human actors to achieve accountability and predictability in addition to resource distribution for the ongoing accomplishment of work (Pickering (1995), p.944).

3.5 Disciplinary agency

> *"Disciplinary agency - the sedimented, socially sustained routines of human agency that accompany conceptual structures as well as machines" (Pickering (1995) p.29).*

As material agency arises when in practice or when material artefacts are used, disciplinary agency arises when concepts are applied in practice. Thus, Pickering (1995) states that "disciplinary agency can play an analogous role in conceptual practice to that of material agency

in material practice" (ibid, p.29). Rules, conventions and norms discipline behaviour reducing human actors' discretion to exercise their agency. Thus, another factor that mangles human agency during the performance is what Pickering refers to as disciplinary agency. Pickering refers to cultural and conceptual practices. To explain conceptual practices, Pickering uses the example of algebra, whereby the rules of algebra have tested applied and tested over time and persist as correct. By gaining proficiency in conceptual knowledge, the human actor can use it to reach a certain goal where it is applicable. The principles of algebra are not changed but passively accepted by the human actor. Thus, agency there is with the discipline. Through the example of the Bubble chamber Pickering shows that the intentional human structure is also temporally emergent and intertwined with the material and situated in the cultural field in which it operates (Pickering (1993) p.579). However, Pickering, who adopts a realist view of this theory, extends the scope of the theory to include non-human and non-material forces beyond the purview of influence of the actor engaged in practice – that is, disciplinary agency. However, Venters et al. (2014) observe that for Pickering, the trichordal of the influence of past, present and future "orientation is only weakly theorised in his definition of modelling and disciplinary agency, and the link or interplay between these concepts has not been developed" (p 931). In their study, the disciplinary agency represents the past knowledge acquired from different disciplines of knowledge and conventions of practice that is then applied for tuning or reaching a goal in the present that is oriented for a future outcome. Their findings reveal that disciplinary agency emanating from the past can influence future modelling.

Disciplinary agency connotes that rigidity of behaviour is expected in conformance with disciplines. "Persons committed emotionally and intellectually to problem-solving associated with system creation and development rarely take note of disciplinary boundaries, unless bureaucracy has taken command" (Hughes (1987), p.64). It extends Pickering's Mangle of Practice to heterogeneous institutionalised actors through a disciplinary agency. Here intentionality is depicted individually and based on institutional decisions executed by individual actors.

Disciplinary agency provides a powerful tool to understand how actors practice in an environment meshed with rules and regulations that depict conventions or accepted best practices and formal rules that reflect disciplinary practices. For example, fields such as banking have a set of industry practices that must be developed and practised to ensure the banking system's smooth functioning and avoid widespread system failures. Thus, these rules are disciplinary as bankers and financial regulators must rigidly follow them to avoid disruption. Eaton et al. (2014) found that the distributed tuning of platform boundary resources by heterogeneous actors demonstrated the power dynamics of actors that were not directly related to the infrastructure. Industry regulations manipulate industry behaviour and influence digital infrastructure design indirectly. Not complying with them creates resistance that can be illegal as well as cause systemic failure. Therefore, it could be considered that they exert a disciplinary agency manifested through rules that actors and infrastructure designers must comply with.

I include disciplinary agency into the analytical framework to understand how human agents achieve a goal, especially innovation and generativity, within sociotechnical systems with high discipline requirements. I conceptualise that disciplinary agency is often also manifested through rules and regulations that reinforce the behaviour of actors and ensure the allocation of resources.

3.6 Resistances

Resistance is an explanatory category to describe the features or characteristics of a non-human artefact or concept that obstructs the path to the human subject easily reaching their intended goal. Resistances are liminal; they are situated in boundaries of human and non-human agency, within a space of human purposes and goals (Pickering (1993) p.577). The emergence of resistance is described as an impure material and human hybrid that entangles human agency with material agency. Pickering (1995) distinguishes it from the word "constraint". The term constraint is seen as socially imposed rules and norms rather than

naturally occurring characteristics that could prevent the actor from reaching the goal. Constraints are also nonemergent and continuously socially and culturally present. An interesting characteristic of distinguishing constraints and resistances is that constraints are synchronic as they pre-exist the action or performance. At the same time, resistances are diachronic as they occur over time and change with time (Pickering (1995), p.66). Once a human agent encounters resistance from the material or non-human element, the actor makes accommodations considering the resistant characteristics of the non-human actor.

Resistances emerge both in material and disciplinary elements. Thus concepts, conventions, practices or rules that exert a rigidity that regulates behaviour also can emerge as resistances that require accommodations. Resistances in a digital infrastructure can emerge from the technology itself, its architecture, installed base (Hanseth and Lyytinen (2010); Venters et al. (2014); Eaton et al. (2018)) or from social actors and disciplinary agency. Resistance can be seen as an indication of control points and pain points that can also provide a level of inflexibility that may, in turn, generate creative solutions from human actors. Thus, actors may either tune or circumvent resistances innovatively and concurrently harness generative capacities of non-human agencies (Tilson et al. (2010a); Venters et al. (2014)).

3.7 Accommodations

Accommodations are the responses to the resistance. These can be ways that a user of the technological system attempts to circumvent the obstacle they have encountered. This can be a reiterative course of checking alternative means of reaching one's goals while being aware that resistance or obstacle exists – which was discovered when the system or artefact was going to be used. Pickering views this exercise of trying to find an alternative solution to overcome the obstacle as a dialectic of resistance and accommodation, where a user would be shifted through the space of all the potential new arrangements [of the artefact] that the user could think of (p.569). Accommodation is "an active human strategy of response to resistance, which can include revisions to goals and intentions as well as to the material form

of the machine in question and the human frame of gestures and social relations surrounding it" (ibid p.22).

Accommodations can be through material practice or conceptual practice. Conceptual practice takes place mainly through the modelling process. In material practice, the changes are made to the machine or artefact. However, in conceptual practice, it is the application of the concept or the disciplined practice that has to change (Pickering (1995)).

The dialectic of resistance and accommodation are resolved through a process that Pickering refers to as tuning. The reconfiguring of material and disciplinary characteristics to meet the goal. In tuning, the temporally emergent non-human agencies could result in actors defining new goals. The tuning process is completed once the actor has reached a desired point in the mangling process.

3.8 Temporal emergence

The Mangle of Practice is ontologically based on the performative idiom where focal issues emerge at points or instances of interactions – thus, agencies and their mangling emerge temporally. Temporal emergence connotes that the features or characteristics of an artefact or source of the agency are not always visible but manifest during the dialectic of resistance and accommodations. Practice or performance occurs in the presence of any given action. Therefore, Pickering suggests that material agency is temporally emergent. That is, material characteristics emerge when humans engage with it to perform a task to meet a goal. Without engagement, the material agency has no impact on the human or the goal. Therefore, Pickering deflects the issues raised by the humanist tradition for the agency by stating that material agency can only be encountered when human agency is exercised. Otherwise, its mere being would not affect the human to meet the goal.

3.9 Modelling infrastructure for future needs

Modelling is the term Pickering uses for the link between existing culture and the future states that are the goals of scientific practice. The link is not a causal or mechanical one: the choice of any model opens an indefinite space of modelling vectors of different goals. (p 56). "Modelling is an open-ended process, having in advance no determinate destination" (Pickering (1995), p.116), which is explained through decomposition in three stages: bridging, transcription and filling. The three stages explain that the modelling process is not unbridled, even though an open-ended process. Modelling does not arise independently but builds on the past, existing knowledge or systems. Thus, modelling begins by having a tentative or imaginary point based on the existing point, called bridging. Next, there is transcription, whereby knowledge from old established systems is copied, and finally, the process is completed by filling the remaining aspects to reach the new point, or the goal is filled. This process resonates with the path dependency theory (Arthur (1989)), which influences the design of digital infrastructures (Hanseth and Lyytinen (2010)) and provides a granular dissection and terminology to navigate the process of exercising human intentionality. Bridging and filling require imagination and innovation of human actors but also gives the actors freedom to imagine any goal and innovate new ways of reaching a goal. Transcription makes the process path dependent or, as Pickering describes, are disciplined forced moves.

An important aspect of the modelling concept is that it is open-ended, recognising that there can be multiple and dynamic goals that depend on the cultural extensions and the level of non-human agency that cannot be captured. Thus, even though human actors may form specific goals, these may transform or deviate from the original goals. The dance of agency could lead to alternate and sometimes unexpected destinations. Modelling is also a disciplined exercise, where future goals and the means of reaching them are disciplines by bridgeheads and fillings. This is especially noted in fields with higher disciplinary agency:

> *"Novel conceptual structures need to be tuned if they are to stand a chance of performing cooperatively in fields of disciplinary agency; one has to expect that*

resistances will arise in the construction of new conceptual associations, precipitating continuing dialectics of resistance and accommodation, manglings of modelling vectors of bridgeheads and fillings, and even of the descriptions under which transcriptions are carried through, that is, of disciplines themselves." (Pickering (1995) p.119)

These stages of modelling depict how the past influences the performance of human intentionality while aims for the future and while is tuned in the present. Modelling explicates how the agency could be harnessed to achieve a future goal with presently available resources to reach a future intention (Pickering (1995); Venters et al. (2014)).

3.10 Goals

The Mangle of Practice elaborates that actors would continuously configure and reconfigure human agency with material and disciplinary agencies in the scheme. This process could result in the temporal emergence of heterogonous goals and heterogeneous tuning forms. Pickering (1995) promises not to provide the neat causality of scientific or sociological study but draws from other post-humanist and humanist scholars to depict practical complexities that arise when executing human intentions in a dynamic environment.

Within the Mangle of Practice, goals are the imaginative end the human actors aim to reach (Pickering (1995)). Pickering defines goals as the construction of possible future states that have not come to exist. Goal formation is a depiction of human intentionality and manifests through modelling. However, according to Pickering, as the characteristics of a material or non-human artefact only emerge through action or engagement, there is always an element of the unknown reflected in the material agency of the artefact. This multiple temporally emergent agency could thus prevent actors from reaching the intended goal or, in the process of tuning goals, could be reconfigured in response to emergent agencies or new resources and opportunities that emerge during tuning. Thus, goals are seen as indefinite and

could be unpredictable, as is material agency.

3.11 Revised Research questions

The sociotechnical dynamics of digital infrastructures reveal the complexities that create both generative and restrictive control points that can be tuned to achieve different goals. Therefore, the research questions are refined by incorporating concepts from the Mangle of Practice to portray the complex process of tuning that actors would undergo to achieve their goals:

- RQ: How do heterogeneous actors gain access to regulated digital infrastructures?
- SQ1 How do actors tune regulated digital infrastructures for access?
- SQ2: How do actors interact with regulations relating to digital infrastructure access?

3.12 Analytical Framework

An analytical framework combining concepts from the Mangle of Practice and elements depicting the complex sociotechnical environment of digital infrastructure is developed (Figure 3.1) to analyse data. Adopting the notion that heterogeneous actors cross-tune each other, I place the key actor groups based on their status in the regulatory environment. In this framework, the disciplinary agency has a one-way arrow depicting the rigidity of the agency. Thus, it is expected that disciplinary agencies will not be tuned but instead be accommodated through other material, social or regulatory means.

Due to the complexity of the analytical framework, I have created two operational frameworks to answer the two sub-questions. First, I disaggregate each human and non-human actor group to factors that reflect agencies within them based on the literature review (Venters et al. (2014); Eaton et al. (2018); Kazan et al. (2018); Henningsson and Eaton (2022)). I then show how new entrants (Fintechs) might tune for access to digital infrastructures as

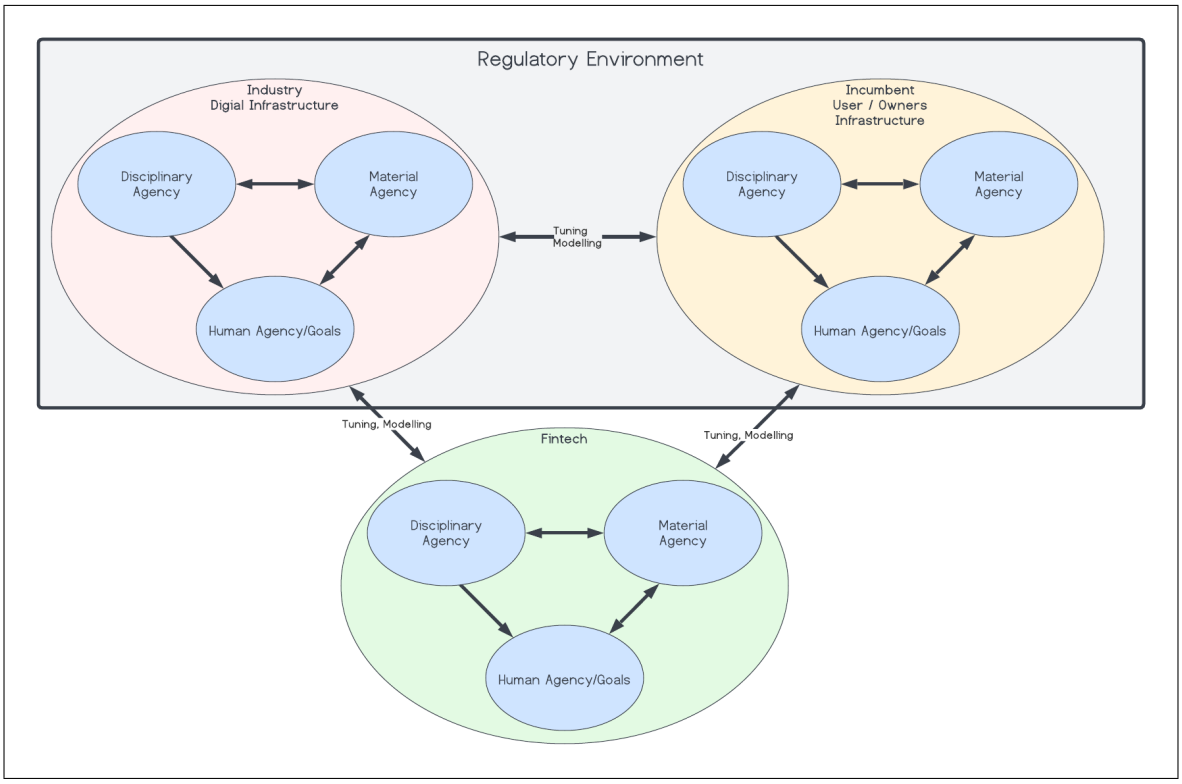


Figure 3.1: Analytical framework for tuning of regulated digital infrastructures
Source: Author

depicted in Figure 3.2.

Digital infrastructures, when regulated, gain rules that are imposed by national laws where non-adherence could amount to punitive measures. These regulations could. Regulation can control innovation, which is then embedded in digital infrastructure architecture (Henningsson and Eaton (2022)). However, rules for such complex digital contexts as digital infrastructures are less known. Eaton et al. (2014) 's study of the Apple iOS demonstrated how groups of actors change the dynamics of tuning "involving a complex web of resistance and accommodation" that cascades through the industry (ibid, p.240). In this complexity, power dynamics emerged based on access to resources and the influence of external parties such as regulatory and interest organisations. Eaton et al. (2014) explicate how heterogeneous actors create pressure on the platform owner (Apple) to change its rules. While this shows that external forces can tune rules with public opinion, the nuanced way of achieving them for national or government regulations is not known in digital infrastructure studies. This is

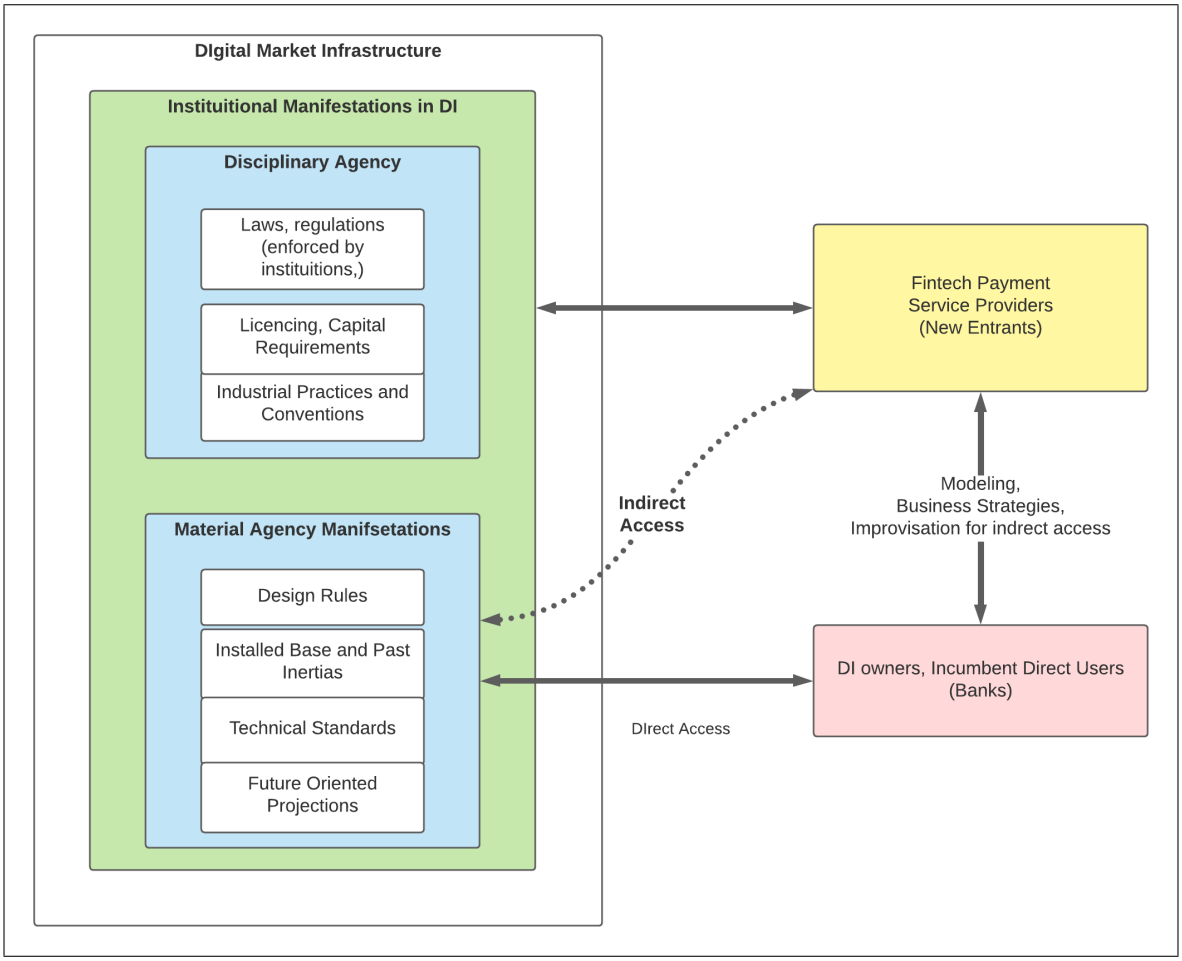


Figure 3.2: Tuning of Digital Infrastructure access for new entrants
Source: Author

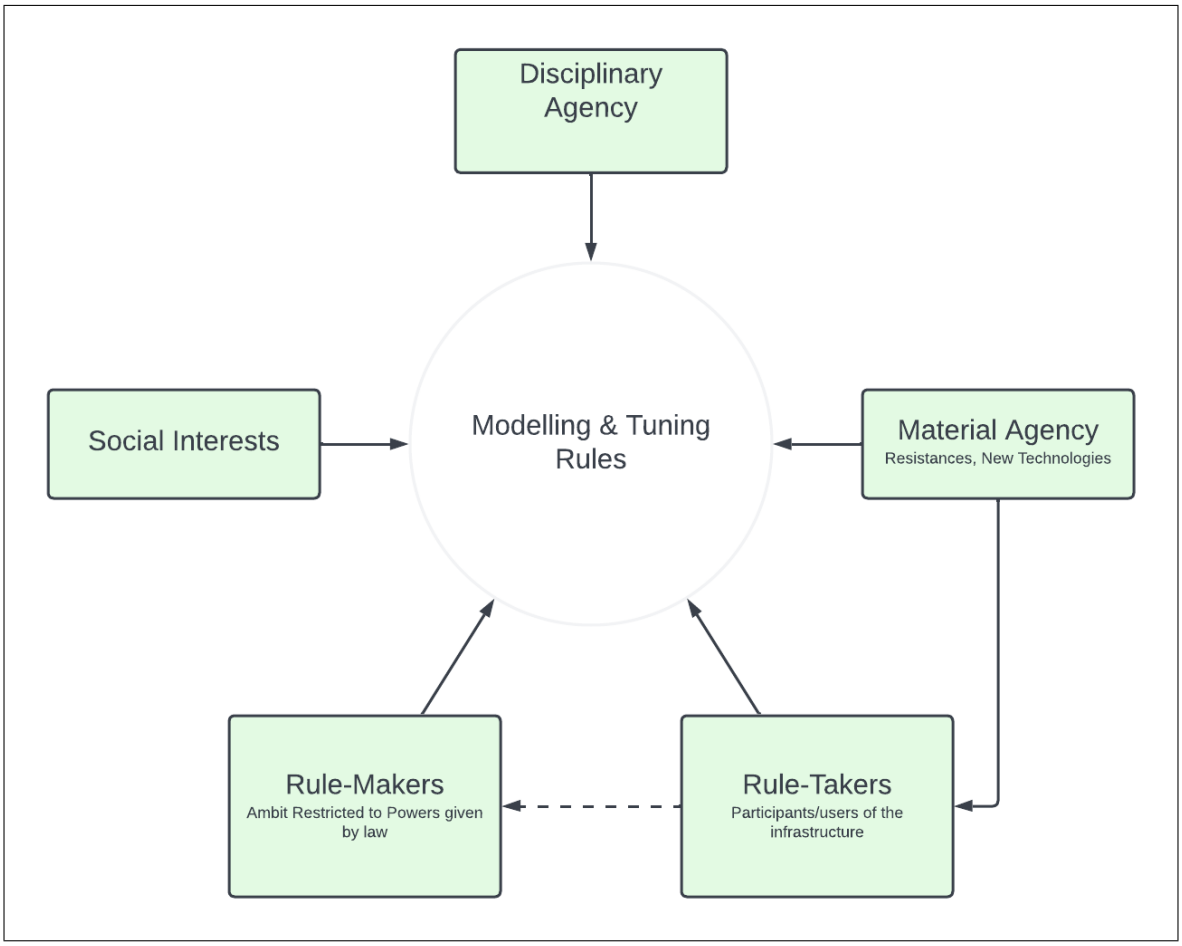


Figure 3.3: Tuning of Digital Infrastructure Rules
Source: Author

depicted in Figure 3.3 which will support answering the second sub-question.

I create a category of rule takers and rule makers as rulemaking can happen at the micro and macro levels. I derived these terms "rule maker" and "rule taker" based on the heterogeneous and dynamic tuning rules that can take place on a platform (Eaton et al. (2018)) and extend it to digital infrastructures. Here material agency also influences rule-takers by its inertias.

3.13 Summary

I adopt Pickering's Mangle of Practice (Pickering (1993), Pickering (1995)) as subsequently extended in literature to derive an analytical framework from exploring the heterogonous

tuning of digital infrastructures for access. This framework includes material, disciplinary, and other actor agencies mangling with an actor at any time. A disciplinary agency is considered rigid. Others can cross-tune agencies, except disciplinary agencies, which all actors have to accommodate. Due to the complexity of the context, I derive operational frameworks to answer the two research subquestions.

Chapter 4

Methodology

4.1 Introduction

In the previous chapter, the theoretical framework guided the refinement of the broader research question and the formulation of specific sub-questions informed by Pickering's Mangle of Practice (Pickering (1993);Pickering (1995);Pickering (2002);Pickering (2006)). This chapter discusses the research design adopted to answer these research questions.

To understand how heterogeneous actors gain access to regulated digital infrastructures, I undertook a single case study (Eisenhardt (1989); Yin (2014)) as the research issue is a new topic that required early stage theoretical understanding of the phenomenon. The research design sets out the process to ensure the research's quality (Eisenhardt (1989); Yin (2014)).

The complexity of the research issue required methodological rigour to unfold the multiple layers that emerge during the research process. This chapter presents the research process as it evolved and explains the methodological choices undertaken during the research.

The research design is presented as follows: First, I discuss the ontological and epistemological stance of this research. Then I discuss applying the case study method and the applicability of a qualitative research approach to the research question and sub-questions. It

follows on to describe the data collection strategy and the two units that are embedded in the case. Subsequently, data collection and data analysis methods are described. This is followed by discussing how the findings can be generalised and the ethical considerations in implementing the study.

4.2 Epistemology and ontology

When studying issues relating to sociotechnical artefacts, it is essential to understand the social elements that have implications on the research issue while also ensuring that the technology does not "fade into the background" as there is a tendency for the artefact to be lost in the research process (Leonardi and Barley (2010), p.32). When determining a suitable methodology, especially when studying a sociotechnical process, it must support the researcher in unravelling the complexities and dynamics of the research issue. Thus, the epistemological and ontological approaches adopted for the research would significantly impact understanding an issue. Furthermore, the research aims to understand how heterogeneous actors interact with the nature of regulated infrastructures to gain access to them. Therefore, an epistemological approach would enable an understanding the tensions that arise when heterogeneous actors and complex infrastructures interact dynamically.

Epistemology refers to the assumptions about knowledge and how it can be obtained (Myers (2004)). As defined by Crotty (1998), epistemology is "a way of understanding and explaining how we know what we know" (p.3). The epistemological stance of the research informs the theoretical perspective, methodology and methods (Crotty (1998), p.4). Theoretical perspectives and epistemology in information systems research study are applied to study relationships among information technology and people, organisations and institution (Orlikowski and Baroudi (1991)). Therefore, the most appropriate philosophical assumptions for inquiry into the relationship can be drawn from multiple research paradigms (Orlikowski and Baroudi (1991)). Orlikowski and Baroudi (1991) noted that as social processes are central to information systems phenomena, this emphasises the need to study

the interactions among people, technology and organisations, which are situated historically and contextually). IS scholars have identified three dominant research paradigms adopted in IS qualitative research, mainly positivist, interpretive and critical (Orlikowski and Baroudi (1991); Myers (1997)). More recent studies have begun to propose the advantages of applying other research paradigms such as pragmatism (Goldkuhl (2012)) and critical realism (Henfridsson and Bygstad (2013)) to explore newer concepts in information systems. Recent studies (Barrett et al. (2012); Venters et al. (2014); Eaton et al. (2018)) have adopted theoretical lens based in the pragmatic realism research paradigm advanced by Pickering (1995). This study also adopts the research paradigm of pragmatic realism as it is most suited to unravel the temporally emergent practices of heterogeneous actors within a digital infrastructure. It attempts to draw a confluence of characteristics of interpretivism on positivism to enable a realistic view of how understanding the interaction between social and technical elements emerges.

Ontology sits alongside epistemology, informing the theoretical perspective as a process of understanding the phenomenon based on how the knowledge is acquired. "Ontology is the study of being" (Crotty (1998) p.10). Ontologically the realist view enables us to understand the artefact, which emerges as an actor's attempt to use the infrastructure. The combination of ontology and epistemology provides us with a research philosophy or paradigm that allows us to obtain an understanding of aspects and perspectives of the research issue we aim to understand.

4.2.1 Pragmatic Realism

Pragmatic realism is a research paradigm that combines epistemologies and "is designed to bridge constructivist and realist views of knowledge" (Sismondo (2010) p.91). Pragmatic realism about Pickering's Mangle of Practice is based on the performative idiom, where understanding emerges from practice.

The term pragmatic realism has been coined by scholars who reject the notion in scien-

tific theories that truth has to correspond with nature (Pickering (1995); Dan (2003); Chang (2016)). Pickering (1995) 's pragmatic realism of the Mangle of Practice also adopts this departure from correspondence whereby "to distinguish it from the correspondence realism that defines the traditional realist-antirealist debate in philosophy." (p.32). Pragmatic realism does not take a position in the "debate over whether representations correspond to nature, but that it subverts that debate" (p.32). Thus, it draws on the objective existence of the artefact, which is a foundational principle of positivism. However, ontologically its existence emerges as human actors temporally interact with the artefact using their disciplinary knowledge that is derived from a sociotechnical environment. Thus, pragmatic realism would be well suited to understand issues where firstly, there is human and non-human interaction, with performance that brings out understanding of the actions taken by heterogeneous actors as they interact with multiple sociotechnical factors such as disciplinary rules, legacy systems and design architectures, which have been intentionally or unintentionally embedded into the infrastructure that emerges as users attempt to access and use it. In this research, I study the tensions that arise when human actors attempt to use a digital infrastructure bound by social and economic factors that regulate its access. In this endeavour, the questions look for actions or practices executed by actors to achieve a specific goal within evolving digital infrastructures. In addition to accumulating new systems, users and participants accumulate and are subject to rules and laws governing these systems, users and participants. Within the pragmatic realism approach, the context studies how human actors would engage or disengage with a sociotechnical technological system as they respond to the emergent attributes of the system.

Pickering's view of pragmatic realism is to address the shortcomings he sees in both the positivistic scientific realism that pertains to "mirror" reality (Pickering (1995); Dan (2003)). Pickering (1995) argues that the mangle offers a pragmatic realism that is "a realistic appreciation of scientific knowledge since it demonstrates the nontriviality of the construction of representational chains terminating in the captures and framing of material agency" (p.31). He uses the term pragmatic realism to distinguish this performative aspect of the mangle

from the correspondence realism that is central to the traditional realist-antirealist debate by subverting this debate relating to the need for knowledge through the scientific method or research to correspond to nature, as he argues that for the knowledge emerging from the performative idiom correspondence to nature no longer seems the best reasoning for the existence of such knowledge.

Pragmatic realism does not refute other epistemologies or ontologies but accepts their co-existence, each terminating in its field of machines. Pickering subverts from objectivism, where his view of knowledge emerging from the mangle or the performative idiom is objective and relative. The combination of the characteristics of objectivism and relativism is due to the knowledge emerging during practice that may not be enduring or non-emergent and humanist, whereby the human is central to the analysis. However, knowledge is emergent through the interaction of humans and material agents. Therefore, elements of objectivity remain in this approach while combining views from a worldview constructed through the dynamic interactions of human and non-human elements. Pickering's mangle also includes non-material and social elements that influence practices that are not controlled or certain. Thus, the control required for objective experimentation may not provide a strong lens to see the outcomes of these interactions. Therefore, pragmatic realism provides a more flexible approach that allows the objective existence of things as in the realist tradition while acknowledging that certain types of knowledge arise from discipline and practice.

4.3 Case study as the Research Design strategy

A good research design sets out the process to follow to ensure the research's quality (Eisenhardt (1989); Yin (2014)). The study of digital infrastructures in IS has often adopted qualitative methods to understand the phenomenon (Eaton et al. (2018); Hanseth and Nielson (2013); Henfridsson and Bygstad (2013); Aanestad and Jensen (2011); Grisot et al. (2014)). Case studies are often used in management, organisation and information systems. The phenomenon studied is bounded into a context where the researcher does not control the

behavioural events and focuses on contemporary events (Yin (2014)). Case studies are thus suitable for "how" and "why" questions as they allow explanatory research that deals with "operational links needing to be traced rather than mere frequencies or incidence" (Yin (2014) p.10). This leads the researcher to develop conceptual frameworks, concepts and theories (Eisenhardt (1989)). Thus, given that the increase in Fintechs seeking access to the payment market infrastructure resulted in a significant change in the sociotechnical architecture of the industry's digital infrastructure, it provides us with a rich environment to ask how and why questions and expand the theoretical understanding of the IS constructs.

While popular in the field of study, the case study as a research method cannot be arbitrarily selected. There are several methodologies to conduct qualitative research for "how" and "why". These are case studies, experiments, and historical analyses. To ensure the study's validity and findings, alternative methodological choices must be considered and eliminated, and the most suitable method to answer the research question is selected (Eisenhardt (1989); Yin (2014)).

4.3.1 Experiments

Alternative methods to address how and why questions are experiments or historic analysis is (Yin (2014)). Experiments are suitable for research issues that can be studied within controlled environments and are most suitable when aspects such as causal relations or the interaction between specific variables are sought (Yin (2014)). Experiments are thus suitable for theory testing rather than theory building or unclear which factors affect the changes in an environment or give rise to a particular phenomenon. Experiments are widely used in scientific research and indicate the research design and outcomes. The design structure enables large sample research designs that enable the generalisation of results. However, the experiments' controlled nature will not allow alternative variables or factors to appear from the research site.

Further, in a dynamic sociotechnical environment where variables cannot be controlled, ex-

periments do not capture the depth of the complexity of the research issue. Survey-based research is an extension of experiments that will open it to a broader range of research participants. This, too, should be based on carefully assessed theoretical or conceptual frameworks to target the variables in focus specifically. However, both methods bring rigidity into the research design that becomes counterproductive when the phenomenon under observation is dynamic and complex and a priori unclear to the researcher (Bauer and Gaskell (2000); Miles et al. (2014); Yin (2014)).

4.3.2 Historical Analysis

The other alternative to case studies is historical analysis. Like the case study method, this is a more flexible research design that can accept and absorb the shock of unexpected changes in the research process. Historical analysis is very similar to case studies, except that they focus on the past (Yin (2014)). They allow the researcher to use a full range of historical data through multiple sources to find patterns. The Historical Analysis allows the researcher to trace patterns based on events or actions to understand a phenomenon. In this research, digital infrastructures were, by definition, a variable that had history and a historical evolution attached due to its installed base and legacy system accumulation but is also continuously evolving sociotechnical systems (Hanseth and Lyytinen (2010); Tilson et al. (2011)). However, Fintech innovations are contemporary and dynamic, and digital infrastructures continuously evolve. Given the contemporary nature of the phenomenon, historical analysis was insufficient to understand the research issue.

4.3.3 Motivation to select the case study method

The motivation to study the phenomenon through a case study was primarily due to its flexibility in supporting complex, novel, and contemporary issues. Unlike the alternatives discussed above, the case study method supplied a breadth of options for the researcher to use and react to when the unexpected issue appeared agility. The purpose of the research was

not to prove or disprove a theory but to explore and explain a phenomenon that was appearing and unfolding itself in the current environment. Yin (2014) defines a case study through a two-fold proposition:

A case study is an empirical inquiry that:

- Investigates a contemporary phenomenon (the case) in depth and within its real-world context, especially when
- The boundaries between phenomenon and context may not be clear. (p. 16)

The phenomenon being studied in this research matched the requirements of the definition well.

The research issue initially arose through the interaction between Fintechs and banks, as Fintechs needed access to the banking digital infrastructure and data. This point of interaction created tensions between Fintechs and banks vis-à-vis their banking and payments industry's position and access to the payment infrastructure. The novelty of the Fintech innovation phenomenon and diversity of business models and innovations referred to even within the specific retail payments area created difficulty in setting the research boundaries. These challenges of setting the case boundaries are discussed in subsequent sections.

4.3.4 Addressing concerns about the case study method

A case study inquiry that,

- Copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
- Relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and
- Benefits from the prior development of theoretical propositions to guide data collection and analysis (Yin (2014) p.17)

These aspects make the case study format an all-encompassing research method. However, the researcher cannot hide behind the case study's flexibility and forego theoretical and methodological considerations when developing the case study (Bauer and Gaskell (2000)).

These all-encompassing characteristics often expose the case study method to researchers' derision from other methodology schools. Despite this, the case study method is widely used with good research outcomes. However, it is still essential to appreciate the concerns raised by others and explain them.

One of the common criticisms of the case study method is generalizability, as case studies are, by definition, a single, bounded context. According to Yin (2014) answer lies in what needs to be generalised. The question of the generalizability of case studies is often raised against that of experiments. Experiments use a sample and then extrapolate the findings to a population. Good experiments use falsifiable models that can be replicated on different samples, and continuous testing can be generalised to the population. It is often considered dangerous to extrapolate a single experiment to an entire population. Thus, from experiments, what we gain is statistical generalisations. The continuous testing of the models enables researchers to generalise the applicability of the findings based on probabilities.

However, the intention of case studies is different. A case study aims to expand and generalise theories (Lee et al. (2003); Yin (2014)). These are referred to as analytic generalisations versus statistical generalisations. Thus, one of the primary purposes of case studies is to develop theories or map linkages between variables that can be tested through experiments to be expanded and extrapolated for statistical generalisation. Yin's view of generalizability is shared by other IS researchers (Walsham (1995); Myers and Klein (2011)) and adopted widely in IS research.

Lee and Baskerville (2003), collating much of the knowledge in IS methodology research provided further clarity to the term "generalizability", which is misleading. Thus, they provide a guide to selecting the relevant type of generalisation applicable to the study (Figure 4.1). Thus, this research seeks the ET (empirical and theoretical) type of generalisation through

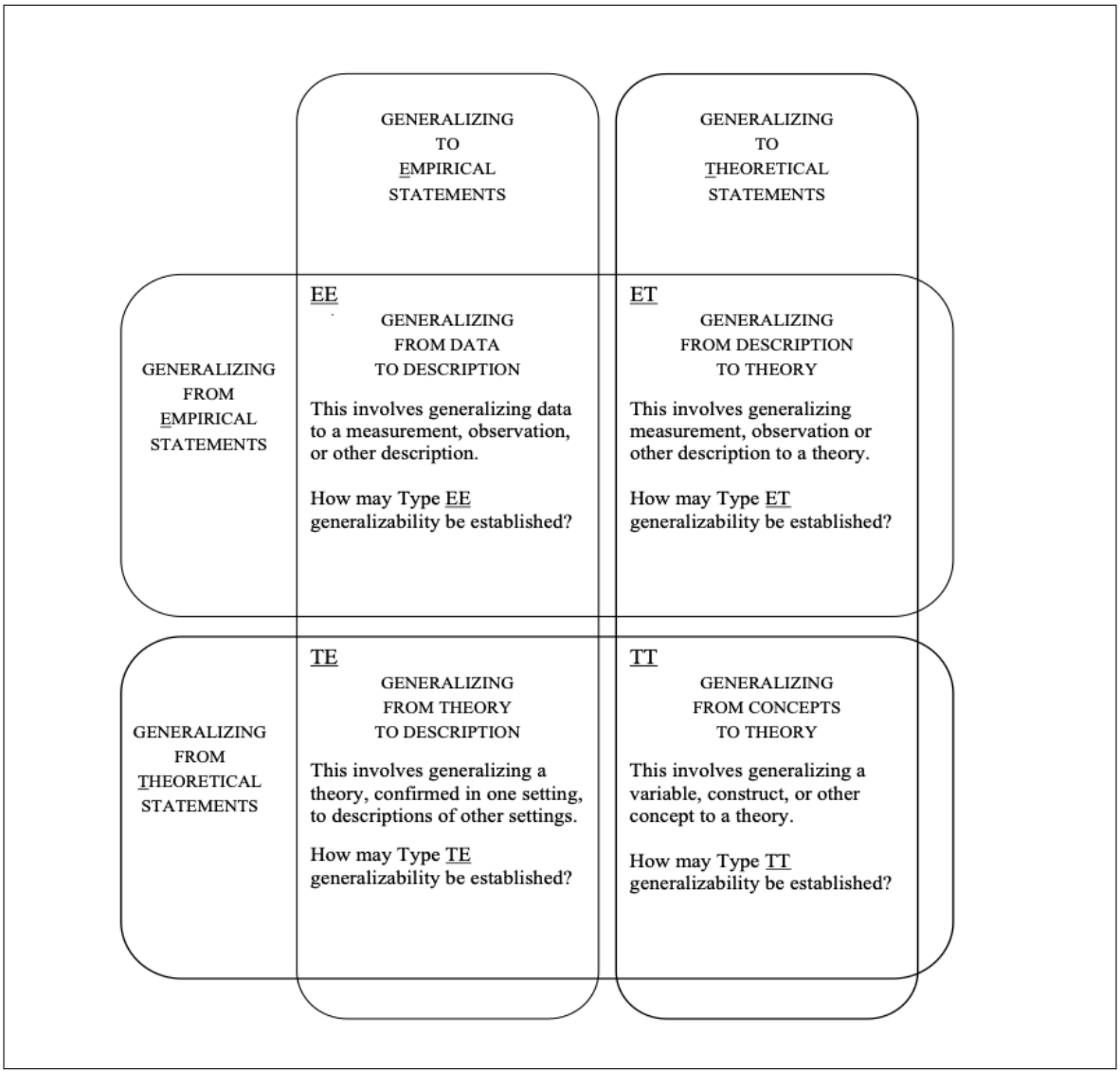


Figure 4.1: Generalizability Framework
Source: Lee and Baskerville (2003), pp233

the description. This method is the closest to the terminology used by Yin (2014) as an analytical generalisation and the generalisation by IS scholars (Walsham (1995); Myers and Klein (2011)).

4.3.5 UK's Payment infrastructure

The research question involved understanding how heterogeneous actors interact with the sociotechnical context to access regulated digital infrastructures. The research question includes sociotechnical concepts that generate complex interactions in digital infrastructures(Tilson

et al. (2010a)). To reduce the case's complexity, analysis was separated into two units first, the primary unit of the digital infrastructure itself. The theoretical conceptualisation of digital infrastructures also included rules and regulations and the actors directly connected to them (Hanseth and Lyytinen (2010)). The other is a subunit of the non-technological institutional environment that may influence access to regulated digital infrastructures. These units were theoretically derived based on the digital infrastructure literature that aims at understanding the digital infrastructures by observing the digital infrastructure itself and the more extensive socio-economic environment in which the digital infrastructure exists where their interrelationship required encompassing social and technological elements (Grisot et al. (2014); Lyytinen et al. (2017)).

This study selected UK's payments industry, a vibrant and complex industry that had accumulated a sizeable digital infrastructure and was also highly sought after by new entrant Fintech firms. It has developed a reputation for being one of the most innovation-friendly payments industries in the world (HM Treasury and Ernst and Young (2016)). Hence, there was the challenge of balancing staying at a vantage point to obtain a detailed description of the phenomenon and constructs and delimiting the boundaries of the case so that the research is confined to the theoretical motivations of the research as well as is tractable for the researcher (Eisenhardt (1989); Bauer and Gaskell (2000); Yin (2014)). However, the preliminary data collection demonstrated that access to the digital infrastructure was a crucial issue in the industry. Industry-level previous studies had been carried out in healthcare (Grisot et al. (2014)) and telecommunications (Lyytinen and Fomin (2002)). Past research showed that it was a phenomenon created not just by architectural characteristics of the technological artefacts, but the qualities of the artefacts continuously and dynamically being determined by actors who control the infrastructure component (Ghazawneh and Henfridsson (2013); Eaton et al. (2018)), the control points in the value chain (Herzhoff et al. (2010); Elaluf-Calderwood and Herzhoff (2011)), regulatory environment (Gozman et al. (2018a)), and broader socio-economic events (Hughes (1987)).

The primary unit was the digital infrastructures itself, made up of payment systems, banks and Fintechs. This research sought to understand the reasons behind a particular outcome concerning a sociotechnical artefact, in this case, the outcome access and the artefact being digital infrastructures. The digital infrastructures were understood via the actors' views and the visible outcomes relating to access that could be observed in regulations and actor relationships. The unit was delineated based on the technological boundaries of the artefact, which in this case was the infrastructure connected to the Faster Payment Scheme and actors having a relationship to the artefact. This connectivity of each payment system provided an opportunity to delve into a complex system's intricacies.

The industry's macro regulatory environment was considered the case's subunit. A distinguishing aspect that emerges when observing a case at an industry level is identifying the micro or macro level that influences digital infrastructure actor relationships and the architecture structure. The macro-level refers to the formal policy institutions with regulatory, supervisory, and advisory capacity towards the primary unit that is not technically connected to the digital infrastructure. I refer to this group as macroactors. By having two units, I avoid the risk of not missing examining the core issue and not letting the research shift focus into subunit (Yin (2014)). This method is suitable for an industry-level study. This method could be compared with the alternative of a single case study where generativity and infrastructures have been studied. For example, the case on the Apple iOS app store (Eaton et al. (2018)) focused on the distributed tuning between Apple and third-party developers. While there are heterogeneous third-party developers, the sociotechnical relationship studied is a two-party relationship between the platform owner and a third party. This study brings in the aspect of regulation and issues heterogeneous actors face when the infrastructure is regulated by law.

4.3.6 Boundaries of the Case

The case's boundaries are vital to ensure that the research is manageable and meaningful (Eisenhardt (1989); Yin (2014)). In research to understand the access to regulated digital infrastructures, it was vital to determine the social and technical elements that would bring out influence access. The payments industry is complex at both infrastructural and institutional levels. Given that Fintechs are distributed, and multiple payments for digital infrastructures and institutions, setting clear boundaries was vital for the study's feasibility.

The case was bounded regarding geography, period, points in the payments process, and actors (Yin (2014)). The delimitation of the cases resulting from the data collection led the research to sharpen the questions and precise phenomenon(Eisenhardt (1989); Yin (2014); Eisenhardt et al. (2016)).

Geographically the case is limited to the UK's payments industry. The UK's case is selected from the larger mass of the EU. The UK is a member of the EU and is centrally governed by the European Central Bank (ECB) and European Banking Authority (EBA) regulations. Fintechs can "passport" (use EU status) across the EU. The UK provided the advantage of having a comprehensive digital payments infrastructure with legacy and novelty elements and a robust institutional environment actively engaging in the Fintech - incumbent tension. The UK has emerged as a global Fintech Hub (HM Treasury and Ernst and Young (2016)), which has evolved into a "Fintech Revolution". The UK has one of the world's most extensive non-cash payment methods, with around 300 billion transactions in 2014 (Capgemini (2016)). These factors create tension between incumbents and Fintechs as payments infrastructures and new internet-based innovations.

The case was bounded at the UK industry and the real-time retail payment infrastructure to obtain a holistic picture of access through sociotechnical elements. An additional practical advantage of selecting the UK geographically was that the financial district, which included every actor related to the digital infrastructure, was located between London and London's new financial district in East London. This proximity led to many agglomeration forces

(Krugman (1991)) that encouraged collaboration and coordination between sociotechnical elements, which was fine-tuned over the research, as is typical in qualitative research (Yin (2014)). The research began in 2014 with the tension between regulation and Fintechs rising. Initial inquiry disclosed that the general findings of previous research on DIs about multi-actor influence were influencing generativity. Thus, focusing on two dimensions, such as regulation and Fintechs or banks and Fintechs, suppressed the richness that multiple dimensions provided. The complexity of digital payments infrastructure offered different points for study along the payments process, with varying levels of heterogeneity. Thus, a theoretically informed decision was made to expand the artefact's scope to the industry's digital infrastructure and understand the conditions for innovation available at each point. This also streamlined the selection of Fintechs for interviewing.

As Fintechs provided retail-level solutions and the research focused on digital infrastructure, I was mindful of setting clear boundaries relating to Fintechs. Therefore, it was decided to minimise Fintechs directly engaging with customers, as the inclusion of customers into the payment process would further complicate the study and divert attention from digital infrastructures which customers do not engage with. This was applied to all actors selected for interviews. Payments digital infrastructures do not engage with end customers; therefore, this was a clear boundary maintained in constructing the corpus of data. Thus, the boundary was one point removed from the end-user in the payment process. Thus, from the institutional perspective, institutions that engaged with end-users, that is, the public, were not included further. The focus was on central digital payments and settlements infrastructures; therefore, cash and cheque-based payment systems were not included even though digital after a point.

Further, multiple service providers provided several intermediary technologies for connecting different actors within the main digital infrastructures. These service providers were also not included as they had little influence on digital infrastructures' rules or access. Thus, the boundaries of the case, primary unit, and subunit were constructed with all these consider-

ations.

4.4 Data collection

The data collection method's purpose was to provide a level of flexibility and openness for the data to reveal undiscovered themes (Bauer and Gaskell (2000); Eisenhardt et al. (2016)). As the case was a very new and complex phenomenon with a lack of academic and industry clarity or general understanding, data collection was phased. A pilot phase was undertaken to identify critical issues that stood out, delimit the research scope, and identify the key informant. Subsequently, a primary unit and subunit were used to operationalise the case study. Below I describe how the data collection strategy was implemented.

The data collection strategy for the overall research could be divided into three stages or units:

1. Preliminary or pilot
2. Primary – digital infrastructure (microreactor) level
3. Second unit – macroactor level

Interviews were the main form of data collection and triangulated with documents. The preliminary stage is discussed first in describing the data collection strategy, followed by the general interview and data collection strategy.

4.4.1 The Preliminary Phase of Data Collection

While the formal interviewing process began after February 2016, the preliminary evaluation of the phenomenon was done from late 2013 – 2014 by attending Fintech conferences. This preliminary stage led to the tensions between actors, which became the research issue to determine the case's boundaries. Subsequently, several key informants and potential interviewees were identified. This led to the corpus construction process by developing a

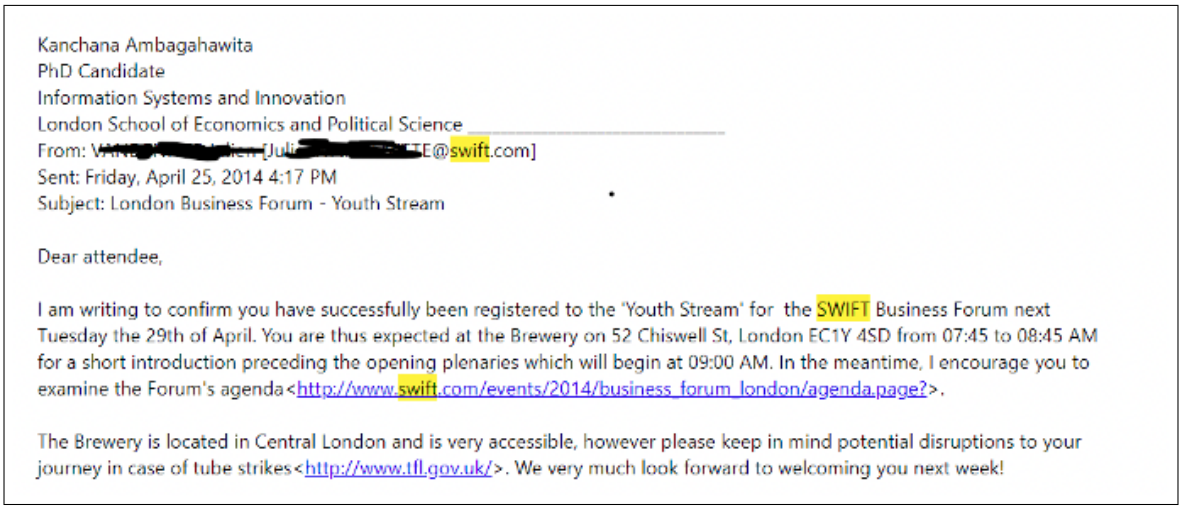
database of information sources and gathering information to develop the corpus. Industry conferences and blogs were the initial points of departure for this broad-based mapping of the research issue.

The topic was widely discussed in the industry from a more practical perspective. Therefore, this created a vibrant point of discourse at conferences and on social media. Following a method similar to Ozcan and Santos (2015) in understanding the initial failure of adopting Field communication technology (NFC) by mobile operators participating in industry conferences, the preliminary data collection began.

Nine conferences were attended from 2013 – 2017:

1. CA Expo' 13- 2013, London
2. SWIFT Business Forum – 2014, London
3. FStech & Retail Systems Payments Conference 2014, London
4. European Payments Regulation – 2015, London
5. WBS Paytech 2016: Technologies of Exchange in a Digital Economy
6. The 4th Cashless Roundtable April 7-8, 2016, Copenhagen
7. SWIFT Business Forum – 2016, London
8. Payments International Conference, London – 2016
9. Payments International Conference, London – 2017

Conferences from 2013-2015 were attended to identify the research issue. While the pre-identified purpose was to map the research issue and identify suitable interviewees, a serendipitous purpose emerged in the data collection course. The first conference was attended through publicly circulated information. The second conference, the SWIFT Business Forum, was the turning point for data collection. I was offered an opportunity to attend as one of the 5 students representing LSE as per the invitation received by an LSE professor from



Kanchana Ambagahawita
PhD Candidate
Information Systems and Innovation
London School of Economics and Political Science
From: [redacted]@swift.com]
Sent: Friday, April 25, 2014 4:17 PM
Subject: London Business Forum - Youth Stream

Dear attendee,

I am writing to confirm you have successfully been registered to the 'Youth Stream' for the SWIFT Business Forum next Tuesday the 29th of April. You are thus expected at the Brewery on 52 Chiswell St, London EC1Y 4SD from 07:45 to 08:45 AM for a short introduction preceding the opening plenaries which will begin at 09:00 AM. In the meantime, I encourage you to examine the Forum's agenda<http://www.swift.com/events/2014/business_forum_london/agenda.page?>.

The Brewery is located in Central London and is very accessible, however please keep in mind potential disruptions to your journey in case of tube strikes<http://www.tfl.gov.uk/>. We very much look forward to welcoming you next week!

Figure 4.2: SWIFT Business Forum - Invitation Confirmation

the Swift Institute (see Figure 4.2). As an official attendee and a PhD Researcher, I engaged in participatory observation as I was along with other attendees' round table discussions and participated as an audience member. Continually attending conferences over three years revealed a pattern of discourse transforming through the years. It became apparent that the conferences offered a fertile ground to identify emerging discourses between all the actors in the industry (Eisenhardt et al. (2016)). The tensions between incumbents, regulators and incumbents continued to emerge at the conferences. Due to these reasons, I continued to attend conferences until 2017 – after formal data collection was completed to gauge any changes to the industry-level view.

4.4.2 Document collection strategy

Another method of collecting data was through document analysis. Documents were both primary and supporting data to triangulate interview data. Documents were gathered in 3 ways: general search with keywords downloaded from websites of the institutions connected to the interviewees or directly provided by the interviewee post the interview corpus covered a wide area of the industry, documents were limited to those in direct relation to the digital infrastructure or regulations. Consultancy reports were used at the preliminary stage to understand the research issue. They were treated like conferences, as they too revealed

a change in discourse through data collection. However, they were not included in the main corpus.

4.4.3 Data collection strategy for the primary unit analysis

The primary unit's goal was to understand factors relating to generativity directly at the digital infrastructure level. This included technological and social elements manifested through non-proprietary familiar infrastructure owners and users, incumbents and Fintechs, who also owned and operated proprietary. Data was triangulated (Yin (2014)) to improve reliability and depth. Therefore, three forms of data were gathered: interviews, published documents, and conference proceedings.

Through a review of the literature published on the UK's payments industry and conferences, the following groups were identified as actor groups in the payments ecosystem that were to be interviewed:

1. Payments systems operators: UK's payment infrastructure comprises sub infrastructure/systems.
2. Banks
3. Card networks, including acquirers
4. Proprietary infrastructures firms providing interim processing services.
5. Fintechs who were users of existing infrastructures and innovating
6. Fintechs that had developed alternative digital infrastructure products to compete with incumbent infrastructures
7. Other incumbent e-money providers and e-commerce platforms that were accepting payments

The complexity of the ecosystem or industry with each actor was directly or indirectly con-

nected to the infrastructure for payment initiation, clearing and settlement. It indicated that a vast number of participants needed to be interviewed. The unit comprised payment systems operators, banks, Fintechs, e-money providers (incumbent), card networks and related service providers. The corpus was delimited at one step removed from the customer as far as possible, so the card acquirer and several Fintechs were excluded. The process's complexity increases when considering customer-facing points in the process.

Documents were obtained through general search terms such as "Payments innovations", "payment disruption", "Fintech innovations in the UK", and "Fintech and payment regulations in the UK". These were analysed thematically to understand the emerging themes through industry discourse. The second way documents were found was through interviewees' organisations' websites. Thirdly, the interviewees shared published documents relevant to the organisation and interview. All documents were public.

4.4.4 Data collection strategy for the sub unit analysis

The subunit of analysis was the institutional environment that payments digital infrastructures operate. UK's payments industry had a complex institutional environment with multiple layers of an institution with oversight and regulatory powers. EU and UK level regulations affected it as it was in the EU. These institutions were mapped through literature and conference participation for data collection purposes. These were targeted interviews as only one institution performed a particular task. They concerned informants from public institutions, some required approval. This was overcome in many instances by the most senior/or the approving authority being interviewed. Twelve regulatory bodies and industry bodies were identified. Ten interviews were conducted with four regulatory and industry bodies. Access to 2 regulatory bodies was not granted. One regulatory body only spoke unofficially, as clearance could not be obtained. Relevant data was not included in the analysis. All interviewees in this unit opted for anonymity.

Documents for this unit were gathered through the search terms used in unit one, "EU/UK

payments regulation". These resulted in several formal reports published by central authorities and consultant reports. As the research also required an analysis of the digital infrastructure's historical evolution, archival data was used. As the financial industry has been relatively well documented, relevant information was found through Bank of England publications.

4.5 Interview strategy and selection of interviewees

Interviews were the primary data source to identify the reasons for generativity levels in the UK digital infrastructures (for the primary unit). As this was qualitative research, the focus was on obtaining theoretical saturation (Eisenhardt (1989); Yin (2014)) rather than a large sample. To obtain theoretical saturation, it was nevertheless crucial that many interviews had to be conducted. This was because many heterogeneous actors were providing unique services related to the digital infrastructure, and Fintechs, which aimed to be disrupters and innovators, were, by definition, unique amongst each other to a certain degree. Even among groups that seemed homogenous, such as banks, there were multiple layers of heterogeneity as several had embarked on their Fintechs-related strategy. As a single researcher conducting data collection, keeping the data within tractable levels was vital. Therefore, it aimed to reach 50-60 interviews at most, with an average of about 60 minutes per interview. Thus, within these parameters, a primary criterion was to avoid duplication of views. Therefore, theoretical saturation was checked even within sub-groups. For example, if two Fintechs were mobile payment service providers, similarities would be checked, and if they are remarkably similar, only one would be selected for the interview. This strategy organically led to the number of interviews from the primary unit representative of the industry makeup. As there were many Fintechs, more Fintechs were interviewed, and then banks and specific digital infrastructure providers were selected individually, as their work was not duplicated.

Thus, members of each subgroup were perused to identify the engagement with the research issue and theoretical constructs of digital infrastructures and generativity. The informants

were gathered in several ways. First, interviewees were identified and contacted directly by me, and interviewees were connected and introduced by the PhD supervisor, key informants, and other university colleagues. Besides these, snowballing, requesting interviewees to introduce other potential interviewees (Eisenhardt et al. (2016)) was done. A description of the research was drafted with the supervisor's guidance and was used in all emails and introductions. The first mentioned methods were the most successful; snowballing was not as successful as the others. Many did not have the extensive network that the key informants, supervisors and university colleagues had. The combined methods enabled me to select 60 interviewees, of whom 55 were interviewed. The remaining five could be interviewed due to them not getting institution permission, falling outside the data collection period, or being non-responsive.

4.5.1 Interview process

Interviews were conducted simultaneously from April 2016 to January 2017. Preliminary interviews with key informants took place from April to June 2016. These were extensive interviews that lasted more than 60 mins and sometimes repeated visits. These interviewees helped hone the main topic guide for the main round of interviews. The topic guide for the main interview is in Appendix I - Topic Guide and is discussed separately. The list of interviewees is given below in Table 4.1.

Fifty-five interviews were conducted, each ranging for an average of 60 minutes. However, depending on the interviewee's expertise and experience and their role in the infrastructure, some interviews lasted longer than 3 hours and some required second and third interviews. Face-to-face interviews were the preferred interview mode, and most were in London. This was feasible. However, as there were EU interviewees based in Europe, they required skype or telephone interviews. Further, some London interviewees could only be scheduled for phone/ Skype interviews due to scheduling difficulties.

Interviews began with me introducing the research. The introduction included an explanation

of IS as a field that aims to understand information systems and technology through a social science perspective rather than a purely technological approach. To provide further context to choosing the research, I disclosed my background in law, regulation and management. This disclosure provided a better understanding of the interviewees' interest in the subject, validated my choice of research and reduced the power asymmetry between the interviewees (Bauer and Gaskell (2000)) and myself. Further, they felt that I would understand the topic of payments and saw practical value in the conducted theoretical research.

After this point, interviewers were provided with a printed sheet with a brief description of the research and options relating to ethical questions. The form included the option to be recorded and anonymised. Upon this, interviewees expressed consent to be recorded, and the recorder was switched on. The form was read in the case of telephone interviews, and consent was given. One regulatory institution interviewed kept the form but said they could not sign the document but continued with the full interview (this was not included in the analysis but is listed under interviews).

Codes for Table 4.1: Code = Interviewee Code, Mode = Mode of interview, P = Person, S = Skype, T = Telephone, Rec.d = Recording Method, N = Notes only, Conf = At Conference, R = Recorded Length, Length = Length of Interview in Minutes

Table 4.1: List of interviewees

Code	Mode	Interviewee description	Institution	Date	Rec.d	Length (min)
i1	P	VP - Information Technology	Bank	2016-11-15	N	45
i2	P	Director of Market Development, Digital Business	Bank	2016-12-05	R	45
i3	P	VP Corporate Banking	Bank	2016-11-01	R	45
i4	P	Director of Strategic Partnerships	Bank	2016-11-28	R	60
i5	S	Head- Transaction Banking	Bank	2016-10-28	R	60
i6	P	Payments/Banking Systems Architect	Bank	2017-03-21	N	60
i7	T	Head- Payment	Bank	2016-05-03	R	60
i8	P	Corporate relations	Card	2016-11-14	R	45
i9	P	Director Digital Payment Development	Card	2016-11-14	R	45
i10	T	Group Head - Acceptance and Emerging Payment	Card	2017-01-10	R	30
i11	P	Payment innovations lead	Card	2016-04-26	R	60
i12	P	Product Manager - National Payments Card in EU	Card	2016-04-26	R	60
i13	P	Payments card infrastructure manager - EU	Card	2016-04-26	R	60
i14	P	Director - Open Banking consultancy	Expert	2016-02-16	N	60
i15	P	Director - Open Banking consultancy	Expert	2016-03-26	R	60
i16	P	Director - Open Banking consultancy	Expert	2016-08-24	R	80

Code	Mode	Interviewee description	Institution	Date	Rec.d	Length (min)
i17	P	Director - Payments consultancy firm	2016-06-12	R	45	
i18	S	Senior Payments Consultant/Ex-banker	Expert	2016-12-12	R	50
i19	P	Founder - Fintech Consultancy	Expert	2016-12-12	R	60
i20	T	Managing Director, IT strategy consultancy & implementation	Expert	2017-11-29	R	50
i21	P	Expert-Payment Consultant	Expert	2016-10-20	R	60
i22	P	Expert-Payment Consultant	Expert	2016-11-02	R	45
i23	P	Director - Payments Solution Design Consultancy	Expert	2016-11-23	R	120
i24	P	Director - Payments Infrastructure Provider	Expert	2016-11-28	R	80
i25	P	Founder/CEO	Fintech	2016-10-13	R	90
i26	P	Founder/CEO	Fintech	2016-10-26	R	60
i27	P	Head of Product Strategy & Commercialisation	Fintech	2016-10-20	R	60
i28	P	CEO and Founder of Open API Payments Platform/Ex-Banker	Fintech	2016-10-21	R	80
i29	T	Head - Digital Payments Card acquirer	Fintech - Acquirer	2017-01-09	R	60
i30	P	Head - Europe, Intl. retail payments Ex-banker	Fintech - backend	2016-10-27	R	50
i31	P	Cloud-based payments infrastructure/ Ex-banker	Fintech - backend	2016-10-27	R	80
i32	P	Inter-Bank retail payment system architect	Fintech - backend	2016-11-03	R	130

Code	Mode	Interviewee description	Institution	Date	Rec.d	Length (min)
i33	P	CEO- Payments solution provider	Fintech - Bank based	2016-11-15	R	45
i34	P	CEO / Founder FX management /Ex-Banker	Fintech - PI FX	2016-11-23	R	60
i35	P	Head - EU Government relations - Digital Wallet	Fintech -PI	2016-04-20	N (Conf)	20
i36	S	The mobile payment service provider	Fintech -PI	2016-11-14	R	30
i37	P	Founder E-commerce company	Fintech -PI	2016-11-16	N	20
i38	P	Founder - Blockchain payment clearing company	Fintech DLT	2016-11-07	R	60
i39	S	Director Startup incubator	Fintech- institution	2016-10-24	R	50
i40	P	Head - Fintech Industry Thinktank	Industry	2016-11-01		30
i41	P	Manager, European Developments at Industry body	Industry body	2016-10-25	N	60
i42	P	Industry relations - the industry body	Industry body	2016-11-02	N	60
i43	T	Investment Fintech	Investor	2016-11-08	R	30
i44	T	Eu Payments regulations Lobbyist/ Lawyer	Lobbyist	2017-01-17	R	45
i45	P	Online on-payment service innovator	Fintech	2016-11-23	N (Conf)	20
i46	P	E-commerce company	Fintech	2016-11-24	N (Conf)	20
i47	P	Head of Development - Retail payments infrastructure	Payment infrastructure	2016-11-29	R	120

Code	Mode	Interviewee description	Institution	Date	Rec.d	Length (min)
i48	S	Head of Standards - International financial messaging system	Payment infrastructure	2016-11-29	R	60
i49	S	Board member- Large Value payments infrastructure	Payment infrastructure	2016-10-26	R	70
i50	T	Market Infrastructure Expert	Regulator	2016-12-08	N	45
i51	P	Executive Director	Regulator	2016-10-26	N	30
i52	P	Financial Market Infrastructure - Head	Regulator	2016-11-08	N	45
i53	P	Regulatory Incubator	Regulator	2016-11-08	N	45
i54	T	Dep. Head Financial Market Infrastructure	Regulator	2016-12-08	N	45
i55	P	Head of Policy	Regulator	2016-12-06	R	50

4.5.2 Topic Guide

Due to the novelty of the research subject and theoretical constructs, the research adopted an exploratory approach to data collection so that themes could emerge and be discovered. In this spirit, as is common in qualitative research, the topic had mostly open-ended questions that made the interviews semi-structured. The interviewees were provided with the freedom to narrate their experiences in the industries and express personal views (Gaskell (2000)) on evolution and tensions.

The topic guide (Appendix I - Topic Guide) was structured as follows: Self-introduction of the interviewee, the firm, their job, and experience. When asked this question, I explained to them that I had already researched the company's background on the web and the person through publicly available sources, which allowed me to understand their view of these aspects and adjust the questions accordingly. This approach helped in many interviews as it appeared that public sources had not shown interviewees' many facets of experience in the industry and some of the areas they oversaw. Further public information on several interviewees was scarce or only had official statements. This also balanced the power dynamics between the interviewee and interviewer, as it provided a level of empowerment to the interviewee.

In the first interviews, the topic guide was followed in numerical order with a broad, open-ended descriptive question regarding the causes of the Fintech revolution and the actors shaping the industry. As the early interviews were with experts, this gave them the breadth to discuss issues widely. This was also helpful as it began to depict how each person viewed the Fintech revolution based on their position and exposure in the industry. After around eight interviews, these questions reached conceptual saturation, and they were moved to the end of the topic guide so that they would provide triangulation (Eisenhardt et al. (2016)). As the interviews progressed, the most exciting research issues emerged: access to infrastructure and its impact on Fintech innovation. This was contrary to popular conference discourse, which saw regulation as a central obstruction. Thus, the topic guide's focus changed, and

the questions on digital infrastructure access were addressed earlier. Thus as the interviews progressed, the questions became more targeted, allowing more in-depth discussions on the issues. (Gaskell (2000))

4.6 Data analysis

The interview process created large volumes of unstructured data that needed to be analysed. This is one of the biggest challenges in qualitative research. Thus, the researcher needs to bring as much structure to the data as possible to analyse it fairly and efficiently.

4.6.1 Preparation for data analysis

Interview data was available in notes and recordings. The recordings were transcribed personally and through a third-party transcriber recommended by and registered with the university. Transcribing at least a few narrative interviews personally is recommended as a starting point for initial analysis (Jovchelovitch and Bauer (2000)). The first point analysis followed this. Notes were of interviewees who did not want to be recorded. These were typed out personally. The third-party transcriber adopted a confidential process where all the interviews were password protected and uploaded to a password-protected storage link. The transcriber informed me that all the files were deleted after they were transcribed and sent to me. The quality of transcribing (Gill (2000); Jovchelovitch and Bauer (2000)) was checked by sending the transcriber the relevant acronyms used in the interviews. The transcriber left blanks with timestamps at the point where she could not decipher what was being said. After receiving the transcripts, I listened to interviews identified to have vital discourses while reading the transcript. Through these methods, quality was ensured. Transcribing the data was the first point of standardising it.

Subsequently, all the interviews were uploaded to NVivo according to the actor group folder to help code.

4.6.2 Thematic Analysis

Thematic analysis (Gill (2000)) of data was done using NVivo. Transcribed data were coded on the first line by line. The early interviews were to identify emerging themes. This is the standard way of beginning coding as the researcher looks for unknown themes. As expected in this type of coding, many codes were generated in the first coding round. In the second round of coding, there was more aggregation of codes and clarity regarding which themes were most important to answer the research question.

Despite using coding software, in qualitative analysis, the burden of analysing falls almost entirely on the researcher as the software merely helps to order the data for analysis (Kelle (2000)). Thus, the analysis was driven by the following themes emerging relating to innovation and access to digital infrastructures rather than the earlier themes relating to tension between regulators and Fintechs. This choice was made as this area required deeper theoretical understanding, and the data supported the research question well.

Thematic Analysis of the data

A thematic analysis of data was undertaken with three rounds of coding of the 55 interviews. In the first coding round, the interviews were open-coded by groups of actors in the industry. Open coding resulted in 67 preliminary codes. Amongst these codes, those that could be aggregated were brought together, and the top 15 codes are presented in Table 4.2. The interviews were semi-structured, and the interviewees were purposively selected to represent all actors identified from preliminary and snowballing techniques. Two themes recurred that emerged consistently across interviews. First, interviewees' observations tended towards discussing access issues relating to the payment and clearing infrastructure that payments of incumbents or Fintechs used. Access-related codes and references were the highest. Regulation, compliance banks and Fintech being frontend emerged as themes. Connected to access was infrastructures as a theme. It emerged that the Faster Payments Scheme (FPS) appeared to be relevant to several Fintechs trying to enter the payments industry mainly

through FPS, and concurrently, other actors mentioned it as it was a response to regulatory and market calls to increase market competition through improving access to the digital infrastructure. The first coding round was done halfway through the interviews to see where the data was leading. As access emerged as an issue with infrastructure, more focus was made during interviews on that.

Table 4.2: Thematic Coding - Round 1

Row	Round 1: Main codes	No. of instances
1	Access	35
2	What Fintech does (included non-Fintech descriptions)	28
3	Technology (e.g. API, Blockchain)	29
4	Regulation	23
5	Banks (referred by other actors)	36
6	PSD2	18
7	PayPal key disruptor	17
8	Fintechs more front end	17
9	Compliance	16
10	Payment infrastructure	15
11	Key event encouraging/inhibiting	23
12	Industry collaboration	13
13	Faster Payment system	11
14	Bank Fintech relationship	15
15	Regulation cumbersome	15

The second coding round began after the interviews were conducted in Table 4.3. Shows the top codes relating to access and resistance, such as legacy systems, the relationships be-

tween banks and Fintechs and how multiple actors were coming together to resolve issues. Points of tension and resolutions were emerging together with actor interactions. Thus 4 main themes were derived from that, access, legacy systems, multiactor relationships and infrastructure innovations/Opening. Resistances related codes were Legacy systems, installed base, regulation, cost, banks, and domain knowledge. Resistances and accommodations emerging, however, complexity of the context meant that at a given time an actor was cross tuning for many resistances. The data was coded for tuning to understand how these complexities were resolved.

Table 4.3: Thematic Coding - Round 2

Row	Round 2: Main codes	No. of instances
1	Access - closed group	6
2	Access challenges	5
3	Access innovations starting	3
4	Different way to connect non-technical methods to connect	8
5	Payment infrastructures opening up different types of FI types	3
6	Paypal access FPS thru barclays	4
7	Range of connectivity options	3
8	Legacy systems - banks challenge	18
9	Legacy systems upgraded	11
10	Interdependent mutliactor relationship	10
11	Innovtive payment infrastructure	7
12	Core unchanged	4
13	Incumbent-incumbent support	2
14	Evolution of infrastructure	11

Row	Round 2: Main codes	No. of instances
15	Distinctions Banks vs fintechs	3
16	Bank fintech relationship	9
17	Reasons for Fintechs being frontend	8
18	Regulator - related	27

Tuning for Access

The third and final coding round was informed by Pickering's notion of tuning with a view of innovative processes that actors were engaged in. Due to the heterogeneity of the actors, a large number of tuning processes emerged. The number of references was low due to the heterogeneity, but a wide range was found. Data was also coded under "what Fintech does" and "what actors do" to understand the heterogeneous intentionality of the actors. Table 4.4 includes 34 tuning-related codes at a disaggregated level. These codes were then aggregated to the following themes: Incumbent level tuning, incumbent-Fintech tuning, infrastructure tuning and regulator level tuning.

Table 4.4: Thematic Coding - Round 3

Row	Round 3: Tuning	No. of instances
1	Tuning - underlying negative tension for other actors performing	2
2	Tuning - tension access to third parties	2
3	Tuning - tension - bank high risk	2
4	Tuning -role of different actors	5
5	Tuning - PSD2 giving interface	3

Row	Round 3: Tuning	No. of instances
6	Tuning - difficult to bring new payment products	3
7	Tuning - bank-fintech customers	3
8	Tuning - what is the need	1
9	Tuning - using regulation for clever solutions	3
10	Tuning - technology enabler for regulation	2
11	Tuning - self correcting	1
12	Tuning - resolving user-backend - infrastructure connectivity	4
13	Tuning - resistance - network closing down time	1
14	Tuning - regulator push	2
15	Tuning - Regulation informs technology and vice versa	3
16	Tuning - PSD2 brought fintechs operating in grey areas under regulations	3
17	Tuning - open is not free	1
18	Tuning - legacy systems less systemic risks	2
19	Tuning - infrastructure provider	4
20	Tuning - incumbent resistance	3
21	Tuning - having regulation reduced impact of financial crisis	2
22	Tuning - gradual innovations	2
23	Tuning - Fintech working with regulation	2
24	Tuning - fintech will specialise in products	1
25	Tuning - FIntech provides solutions for others in tech	2
26	Tuning - Fintech innovates for market	2
27	Tuning - Fintech first mover	2
28	Tuning - engineering solutions	3

Row	Round 3: Tuning	No. of instances
29	Tuning - digital bank but e-money license	1
30	Tuning - different connectivity to different sized banks	3
31	Tuning - developers and banks	
32	Tuning - coordinating with multiple actors	3
33	Tuning - business model	4
34	Tuning - APIs resolves tension of innovation risk	3

Another unique feature that emerged during open coding is the temporality of the changes taking place in the digital infrastructure. Clear timelines emerged as the retail digital payment infrastructure was introduced. FPS was launched in 2008. However, it was initially proposed as a concept in 2000. There are three identified periods 2000-2007, 2008-2016, when Fintechs began to demand access to the FPS infrastructure and 2017 -2018 when actors made accommodations to introduce a New Access Model for Fintechs.

Analysis of the documents

To understand the subunit of macroactors, documents published by macroactors relating to the issue of access and infrastructure were analysed. The documents were not coded on NVivo but read and summarised by me. Table 4.5 contains the main documents that were analysed. In addition, these industry reports from private actors such as Fintech firms were also analysed to understand the context. The importance of Table 4.5 is that the initials documents triggered the entire process of opening the infrastructure and bringing more competition to the industry. The subsequent document traces the continued pressure on the Bank of England, which was a macro and microactor, and other macroactors to open the infrastructure. The final documents capture the change in rules to give Fintechs direct access to the infrastructure.

Table 4.5: Banking Reports

Year	Name	Quote	Bib. Ref.	Page
2000	Competition in UK Banking - A Report to the Chancellor of the Exchequer	*"The determinants of equilibrium prices are (i) the magnitude of the cross-group externalities, (ii) whether fees are levied on a lump-sum or per-transaction basis, and (iii)whether agents join one platform or several platforms."*	Cruickshank (2000)	
2008	Personal current accounts in the UK: An OFT market study	*"The OFT has found evidence of competition in the PCA market. Banks can also demonstrate high consumer satisfaction and low fees on many of the more visible elements of current accounts such as withdrawals from ATMs. Internet and telephone banking have also made it easier for consumers to manage their account."*	Office of Fair Trading (2008)	p. 96

Year	Name	Quote	Bib. Ref.	Page
2010	Review of barriers to entry, expansion and exit in retail banking	*"Barriers to entry, expansion and exit, which can be a natural feature of the market or be created, or exacerbated, by the behaviour of incumbent firms, are critical to these developments. If firms face significant difficulties in entering and competing in the market, incumbent firms will not face the threat of new firms challenging them for business and will have little incentive to reduce costs, innovate and price competitively to retain and attract customers. Similarly, if there are barriers to exit, these may prevent inefficient incumbent firms from being replaced by more efficient entrants and thus dampen incentives for market entry."*	Office of Fair Trading (2010)	p. 4

Year	Name	Quote	Bib. Ref.	Page
2013	A review of requirements for firms entering into or expanding in the banking sector	*"Granting the firm an authorisation, but with a restriction that will enable the firm to then mobilise the remaining requirements such as capital, personnel, IT and other infrastructure. Firms have told us that it will be considerably easier to mobilise if they can tell potential backers that they are already authorised."*	Financial Services Authority (2013)	p. 10
2014	Data sharing and Open Data for Banks: A report for HM Treasury and Cabinet Office	*"Greater access to data has the potential to help improve competition in UK banking."*	Fingleton Associates and Open Data Institute (2014)	p. 4

Year	Name	Quote	Bib. Ref.	Page
2014	Banking services to small and medium- sized enterprises. A CMA and FCA market study	*"However, significant barriers to entry and expansion remain: despite substantially increased usage of online and mobile banking, and reduced usage of branches, branches are still valued by most SMEs, so that a network of local branches still seems necessary to be a significant competitor in the sector; and concerns have been expressed to us about the cost and difficulty for smaller and newer banks to gain access to payment systems which are key to offering BCAs."*	Competition and Markets Authority and Financial Conduct Authority (2014)	p. 9

Year	Name	Quote	Bib. Ref.	Page
2014	UK Payments Infrastructure : Exploring Opportunities (Report prepared for FCA and PSR)	*"However, the UK payments infrastructure landscape is technically complex and costly to maintain. The existence of multiple layers of operators and infrastructureseach with specific standards,connectivity, rules and operating modelshas arguably introducedgreater complexityandhigher costs,and has made access more difficult for new entrants."*	KPMG LLP (2014)	p. 4

Year	Name	Quote	Bib. Ref.	Page
2016	Introducing the Open Banking Standard: Helping customers, banks and regulators take banking into a genuinely 21st-century, connected digital economy	*"Anyone supplying or accessing data already has obligations under existing legal and regulatory frameworks, such as the Data Protection regime. The Open Banking Standard would not alter that. Where customers grant consent for the use of their data, provided that consent is in a format easily understood and verifiable by the all parties, there should be no ambiguity under law as to what data was supplied and what it was to be used for. The role of any authority would be to set minimum clear standards for what that consent might look like."*	Open Data Institute (2016)	p. 10

Year	Name	Quote	Bib. Ref.	Page
2015	The Open Banking Standard	*"An Open Banking API could eliminate the friction involved in the download/upload model andmaterially improve the consumer experience. A consumer would simply give a price comparisonservice permission to access their bank account data and the rest would happen behind the scenesand in real time. This service could even be engaged as an ongoing service with regular automaticreviews, or respond to new offers launched into the market. The principle could also be extended toother personal financial products, in particular credit cards and mortgages."*	Open Banking Working Group (2015)	p. 19

Year	Name	Quote	Bib. Ref.	Page
2017	Blueprint for the Future of UK Payments - A consultation paper	*"The combination of a thin centre, overlay services and interoperable standards provides the basis for future payment systems infrastructure to be more agile and flexible than what exists today, while maintaining security, stability and resilience. It aims to drive competition and innovation across the value chain in the interest of users. Where there is demand, there should be the ability to launch new services more quickly. This approach is proven in other industries, such as telecommunications, and is being adopted by other countries as they transform their payment systems."*	Payments Strategy Forum (2017)	p. 5

Year	Name	Quote	Bib. Ref.	Page
2017	A blueprint for a new RTGS service for the United King-dom	*"A new testing framework reflects the responses to theconsultation, which showed the current testing regime to bethe most frequently-cited burden on participants wanting touse RTGS to join CHAPS, and a significant barrier to directparticipation. The second most frequently-cited barrier wasthe on-boarding process for new members. The Bank willexplore ways to continue to streamline this process."*	Bank of England (2017c)	p. 13

4.7 Ethical Considerations

Ethical considerations in qualitative research are of utmost importance as human participants are concerned. To ensure that ethical standards were met, clearance was obtained from LSE ethics by submitting the research methodology. As there were no sensitive issues or vulnerable participants involved, and there was no threat to the researcher, there were no concerns flagged. As a researcher, ethical concerns such as informed consent and anonymity were observed to ensure the research and practicality of conducting the research (Gaskell (2000)).

4.7.1 Informed consent

Consent forms were prepared using the university's standard consent form available to PhD students. A tentative title was "The role of financial technology (Fintech) innovation in unbundling banking services: A case study of the payments industry". Before asking interviewees to sign the consent form, I explained the research, why it was selected and how it will be used – published in the thesis. Accordingly, interviewees with pre-scheduled in-person interviews were given the form to be filled out. Those virtual interviews were read out, and verbally they agreed to participate. This also included the option to be recorded and their identity disclosed or anonymised. Many interviewees agreed to have their identities disclosed. However, as several interviewees wanted to be anonymised, it was decided to anonymise all interviews.

4.7.2 Confidentiality and Anonymisation

As a researcher, it is essential to ensure confidentiality and, if needed, the anonymity of the sources. The consent form above (Appendix II - Consent Form) had a second section on confidentiality and anonymity. Interviewees were asked if they agreed to be recorded. Several sources wished to be anonymous. Therefore, for standardisation, all interviewees were anonymised.

As it was an industry-level study with many actors supplying the same service, it seemed easier to anonymise.

4.8 Summary

This chapter describes the methodology undertaken to ensure the quality and completeness of this research. The research was a qualitative embedded case study of the UK's digital payments industry. A primary and secondary analysis unit was identified to implement the embedded case. The first was the digital payments infrastructure and the second unit was the institutional infrastructure that shaped the environment that governed the digital payments. Fifty-five interviews were conducted in both units. Thematic analysis was conducted, and the subsequent chapter will discuss the outcome of implementing the research methodology.

Chapter 5

A Case Study of the Interbank Real-time Retail Payment System in the UK

5.1 Digital Payment Infrastructure of the UK

This chapter introduces numerous payment infrastructures that the UK has accumulated over the decades, which make up its national payment infrastructure. It also contextualises the research issue presented in detail in the Analysis chapter. The status quo at the beginning of the research and the historical context are presented to describe the socio-technical composition of the payment infrastructure. This is important to understand where points of resistance exist and whether the status quo is, in fact, a result of an accommodation of a previous wave of resistance which predates Fintech innovation.

Like most digital infrastructures, UK's digital payment infrastructure is composed of a hierarchical set of socio-technical subsystems and strata. It is a wide network of digital payment systems operated by multiple actors and institutions that facilitate the use of several types of payment instruments, regulated by legislation implemented by multiple regulators, and system participants with varying levels of access, all of which collectively enable the individuals and entities to complete payment. Figure 5.1 provides the traditional payment process,

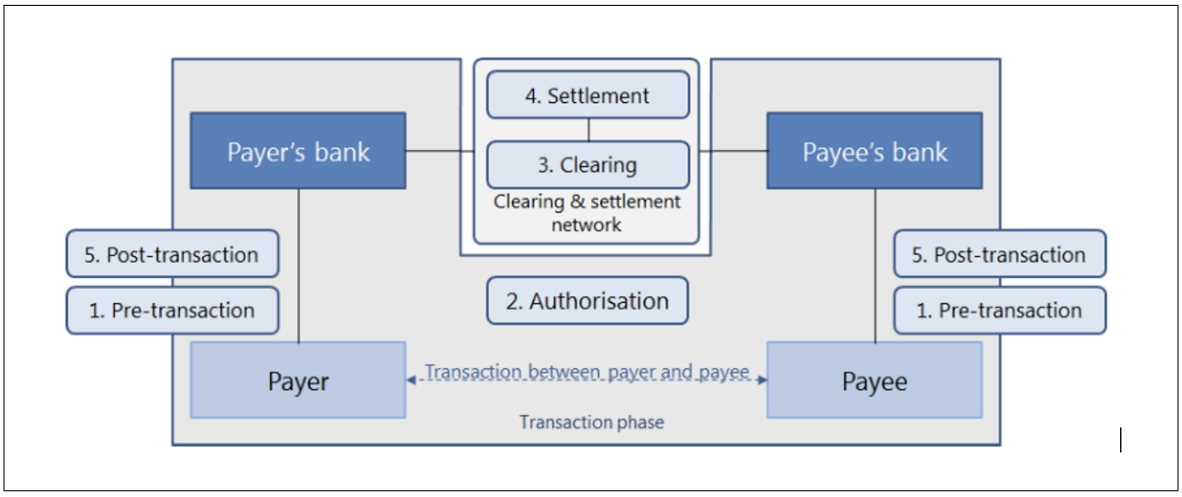


Figure 5.1: Traditional Payment Process
Source: Committee on Payments and Market Infrastructures (2014), p.10

where banks are the only intermediaries between the customer and the clearing and settlement infrastructure. The functional and institutional structure of the payment infrastructure is evolved to provide different options to make payments, where a payer could select the most optimal payment method to complete a given transaction. This optimality can be based on several aspects, such as the time that a payment needs to be made, the value of the payment, the level of security required, and the relationship between the payer and payee. To charter through the UK's complete payment infrastructure, we try to understand how actors innovate on the digital infrastructure understood from the smallest level of the systems, which is the payment instrument level and proceed to illustrate the technological relationship between the payment instruments and the subsequent systems that ultimately form the digital infrastructure of the payment infrastructure.

The core payment systems that form the payment infrastructure are digitalised. However, at the end-customer level payment, this has not been so. UK's Payment infrastructure falls under the broader digital infrastructure termed "financial market infrastructures" (Bank of England et al. (2019)). Financial market infrastructures are defined by the Bank of International Settlements, which is the international governing body for financial regulation, as infrastructures that facilitate the clearing, settlement, and recording of monetary and other financial transactions which can strengthen the markets they serve and play a critical role

in fostering financial stability (Committee on Payment and Settlement Systems (2012)). In the UK, financial market infrastructures are categorised into three broad functions: payment systems, central securities depositories (CSDs) and central counterparties (CCPs) (Bank of England et al. (2019) p.7), which cover significant transactions in terms of value and volume in the economy. Among the three, payment systems capture the widest range of transactions, from systemically important large value payments to day-to-day transactions such as small value card payments or withdrawing cash from an automated teller machine (ATM) (Bank of England et al. (2019)). CSDs maintain the records of ownership of securities, for example, government securities or securities of a publicly listed firm. They facilitate the trading of securities by providing a secure system to transfer ownership of securities between buyers and sellers. CCPs are another specialised infrastructure serving a specific purpose that significantly affects the financial system's stability. CCPs provide an intermediary function to parties of financial contracts. CCPs absorb the risk of a contract failing by assuring that the obligations of those contracts will be fulfilled. When parties to a contract agree to have the contract centrally cleared, as opposed to individually by themselves, the CCP enter the arrangement. Instead of holding the contract with each other, the buyer and seller each hold their side of the contract with the CCP instead. To ensure the contract's execution, the CCP holds collateral from both parties to honour the contract if a party fails to do so (Bank of England et al. (2019)).

The operation of Financial Market infrastructures (FMIs) has a contagion effect of interconnected infrastructures would do to an economy. FMIs command an almost monopolistic status within the respective markets and have remained to do so despite the climate of disruptive innovation for financial services that has been escalating circa 2012/2013. The view of the Bank of England (2013) was

> *"In many cases, market participants have few, if any, practicable alternatives to using these infrastructures" (Bank of England (2013) p.3).*

This was the pre-Fintech innovation era, prior to Fintechs aiming to build alternatives to key

FMIs. However, even after the sharp rise of Fintech and the creation of multi-actor forums to evaluate and redesign the UK's payment infrastructure (Payment Systems Regulator (2015)), some that were targeting developing entire payment and settlement systems, the Bank of England stated:

> *"Typically, the users of FMIs have no viable alternative to settle payments and securities transactions. As such, they must operate reliably and in the public interest" (Bank of England et al. (2019) p.7).*

Thus, it appears that the market is highly dependent on the smooth functioning of these FMIs, with a high concentration of risk to the economy, in the case of a failure. This group of payment infrastructure poses the highest risk due to a complex number of participants and users, especially the public. Therefore, payment systems are required to minimise risks and guarantee a smooth operation within and outside the economy.

5.2 The socio-technical evolution of the installed base (legacy) of the UK's payment infrastructure

A payment clearing system has existed in London for over 200 years, albeit not digital and was owned and controlled by the major retail banks through the Committee of London Clearing Bankers (CLCB) (Bank of England (1987), p.392). The payment infrastructure evolved in a laissez-faire market economy with government intervention for limited purposes. This context allowed private commercial financiers to design the clearing system and determine its membership (Bank of England (1987)). The major retail banks-maintained control of the CLCB but allowed others to participate. The Bank of England was allowed to participate in clearing from 1864 (Bank of England (1987)). This market arrangement has a significant bearing on the following structure of digital payment systems and the research issue, which is accessible to Fintechs. The length of time that the UK's payments infrastructure has been evolving with a level of freedom for infrastructure and services to take their nat-

ural course provides us with an opportunity to connect historical dots to attempt to draw a path-dependent lineage in the infrastructure.

Concurrent with the manual clearing operations in London, communication technologies were introduced to banks. The banks' earliest adoption of electronic technology was the telephone in the late 1800s (Bátiz-Lazo and Wood (2002)). This connectivity facilitated real-time communications from securities trade that reduced price differentials between New York and London as the time of completing transactions reduced from six weeks to one day (Bátiz-Lazo and Wood (2002)). It demonstrated the banking functions that were prioritised for speed. The initial use of technology was not for core banking functions such as payments (fund transfer) or credit but for faster communication of time-sensitive price information between head offices and branches. The gradual movement towards mechanising work and moving away from manual entry begins (Bátiz-Lazo and Wardley (2007)) through the introduction of the calculating machine. Thus, begins changes to the internal work processes of banks.

Thriving from the technologies developed during the Second World War, banks acquired new digital computers for their work. Imports from US-based suppliers such as IBM, Xerox and Burroughs (later Univac and Unisys) of mainframe processors, database management systems (DBMS) and electronic data interchange (EDI) introduced British banking to automation from the 1950s (Bátiz-Lazo and Wood (2002)) as seen in Table 5.1. These systems were used as management information systems and process automation as demand for banking services increased (Bátiz-Lazo and Wood (2002)).

Table 5.1: Main UK banks that pioneered in IT adoption

Source: Bátiz-Lazo and Wardley (2007)

Bank	**Year**	**System**
Bank of Scotland	1959	IBM 1401
Lloyds Bank	1960	Burroughs B. 101 Sorter-Reader

Bank	Year	System
Barclays Bank[1]	1961	EMIDEC 1100
Westminster Bank	1962	Machine-readable cheques
Bank of England	1961	Power-Samas Tabulators[2]

While computers were introduced to banking systems very early, digitisation was mainly a process of pre-digital ossified organisational structures and inefficiencies being coded into systems without question. An example of this computerisation process was the replacement of manual pass-book, and transaction slips with electronic slips and accounting of transactions were digitalised (Bátiz-Lazo and Wardley (2007)). Interviewee (i24) noted the evolution of the banking systems he witnessed during this period, which started a new phase of the UK's banking infrastructure.

> *"...automation, ATM creation, you know, the beginnings of cash management services and the connection of treasury or ERP systems, accounting systems incorporate to their banking partners. Moreover, that was the 70s and 80s; you have networks. Suddenly networks were easier. I was a network specialist for a while. So you know, the battle between IBM SNA and X25" (i24)*

However, the digital infrastructure of banks mirrored the siloed structure of financial products that pre-existed digitisation. The banks were organised functionally according to the management theories of control and division of work together with Weberian bureaucratic structures; the closed structures, control processes, and divisions were coded into the information systems. Thus, an individual process had a closed system. Thus, each core system would have duplicated information about the same customer. Under the separation of function logic, the focus was on product lines rather than the customer. Therefore, systems could

[1] From 1961 to 1974 to put all its retail bank branches 'on-line', Barclays built around Burroughs 8500 system, enabling it to introduce its network of automatic teller machines (ATM) in the mid-1970s.

[2] replaced by an ICL 1309 (working in tandem with an IBM 360) in 1967

not provide an integrated view of the customer's financial position across products. These rigidities were coded into the information systems at the time and persisted until the time of the research about 40-50 years later, as seen by the quote by a retired systems architect (i32) below.

> *"So these are generally just called payment systems, but both in technical terms and in business terms, the banks are completely siloed. So the people in the card world would often be in a separate building from those in the payments world." (i32)*

In the 1950s, customer relationships remained the responsibility of personal branches and additional services such as mortgage specialists and savings banks were able to use banks to access customers (Bátiz-Lazo and Wood (2002)). Thus, retail payments were not a priority for banks and technology was focused on high-value trades and efficiency-improving technologies. The following sections will describe how each new payment system was eventually introduced to the infrastructure. This will reveal the social elements that drove this evolution and how socio-technical interaction leads to enduring legacy systems.

5.3 Digitisation of the UK's Payments infrastructure

Along with automating the internal bank processes, a digital payments infrastructure began emerging in the 1950s. A payment process was first automated in the 1950s using a DBMS system and was called the "Interbank voucherless payment facility" (Bátiz-Lazo and Wood (2002)). This system was called Bankers' Automated Clearing System or BACS and the Girobank for national and international money transfers via the Post offices. DBMS was introduced to overcome the limitations of conventional filing systems and formed the backbone of the payment infrastructure we see today (Bátiz-Lazo & Bátiz-Lazo and Wood (2002)).

5.3.1 BACS Payment Schemes Limited

BACS[3] is the first centralised payment system in the UK payment infrastructure and the longest-running retail payment infrastructure. In 1968, BACS started as the Inter-Bank Computer Bureau to facilitate electronic fund transfers between banks. The primary goal of the system was to improve the existing clearing system by avoiding the need for paper documents and rationalise the system (Bank of England (1987); Bátiz-Lazo and Wood (2002); KPMG LLP (2014); Payment Systems Regulator (2016); Limited et al. (2017)). In 1971 the Interbank Computer bureau was renamed Bankers Automated Clearing Services, and, in 1986, the company shortened its name to BACS Limited.

BACS infrastructure technology

The infrastructure used by BACS has changed over its 40 years. Besides, the ownership of the infrastructure also changed. This emerged from a division of infrastructure providers and operators. BACS electronic fund transfer data was initially exchanged in magnetic tapes cycled across the city. In 1983 BACStel telephone service was introduced to increase the speed of information exchange and security. The introduction of BACStel increased the volume of interbank transactions processed by BACS. In 2005, all users made it compulsory to migrate to BACStel-IP software. This system allows users to submit and monitor payments via the Internet. Those failing to migrate had to revert to using cheques for BACS transactions.

Changes in the access technology were also coupled with changes to the institutional arrangements of the infrastructure. On 1st December 2003, BACS Payment Schemes Limited (BPSL), the management of the payment system, was separated from the infrastructure (Payment Systems Regulator (2016)). This created BACS Limited: BPSL as a "not for profit" body with members from the banking industry promoting the use of and setting the rules for electronic payment schemes. BACS Limited owned the infrastructure to run the schemes.

[3]BACS description based on multiple sources cited here including information from BACS website https://www.bacs.co.uk (Bank of England et al. (2017); Bátiz-Lazo and Wood (2002); KPMG LLP (2014); Payment Systems Regulator (2016);Limited et al. (2017)).

According to the separation agreement, BACS Ltd was given one year to change its name to avoid confusion. BACS changed its name to VOCA in 2004. Thus, beginning the payments infrastructure giant VOCA. When the BACSTEL-IP service has introduced, all software used to make a connection to BACS required approval. Connecting with software from the BACS Approved Solution Suppliers (BASS) list or using an approved bureau is now possible. BACS is a payments system recognised as critical under the Banking Act of 2009, which sets out the criteria for a systemically important payment scheme. Today it primarily clears two types of retail value, regular, interbank transactions – Direct Debit and BACS Direct Credit (Payment Systems Regulator (2016)).

Membership and Access

The pressure from the socio-economic context principally ended the dominance of the original BACS structure after 16 years. However, the membership criteria to date have not drawn large numbers. In early 2018 (after the end of data collection), it had 19 leading banks and building societies in ownership.

BACS Members

1. Allied Irish Bank
2. Bank of England
3. Bank of Scotland Plc
4. Barclays Bank
5. Citibank Na
6. Clearbank®
7. Clydesdale Bank Plc
8. Coutts & Co [4]
9. HSBC Bank Plc
10. Lloyds Bank Plc
11. Nationwide Building Society
12. NatWest
13. Northern Bank
14. Santander
15. The Co-Operative Bank
16. The Royal Bank of Scotland
17. TSB
18. Turkish Bank UK
19. Virgin Money

[4] Coutts, NatWest, and The Royal Bank of Scotland are all part of The Royal Group.

BACS has three types of access options that differentiate based on meeting technical and operational requirements. Direct participants get full access and can sponsor access to others. Direct participants are mostly the few large banks and institutions continuously dominating the industry.

After the formation of BACS, it took nearly 35 years for the next payment systems to be introduced. This was a result of the findings Child Report, which led to the Association for Payment Clearing Services (APACS) being established (Bank of England (1987)). APACS created three clearing companies for the UK:

1. Cheque and Credit Clearing Company Limited.
2. Clearing House Automated Payment System (CHAPS) and Town Clearing Limited: CHAPS, was in operation from 1984, settled high value, same-day (at the time, now real-time) transactions. Town Clearing was for clearing high-value cheques within the City of London.
3. BACS Limited (formerly Bankers' Automated Clearing Services Limited): BACS provided electronic bulk clearing for direct debits, standing orders and other automated credit transfers. BACS has been operating since 1968 and was incorporated in 1978.

5.3.2 CHAPS

CHAPS is the only payment system that uses the real-time gross settlement (RTGS) model. Gross settlement is where funds for every individual payment are settled individually by the bank. CHAPS is the designated high-value payments systems of the UK, and there is no minimum value limit for any transfer. The rules of CHAPS require participants to hold sufficient liquidity for real-time settlement of funds between banks. As it is a high-value system, the liquidity requirement could be very high, depending on the bank. Therefore, it is not only a critical payment system but also a method of ensuring the availability of liquidity to implement monetary policy (Bank of England (1994); Bank of England et al. (2017)). Thus, CHAPS

is a systemically important infrastructure with high membership thresholds.

CHAPS was launched on 9th February 1984; the CHAPS guaranteed the same-day settlement finality for payments of any value. Delaying settling large value payments creates credit risk for the bank waiting for the payment so their customer can use it. As shown in Figure 5.2 CHAPS has used an enhanced Real Time Gross Settlement (RTGS) system and infrastructure of the Bank of England SWIFT MT messaging infrastructure since 1996. Each payment is settled in real-time across its Participants' settlement accounts at the Bank of England.

> *"It used to be people running between banks with slips of paper making agreements to pay each other. Twenty years ago, I did not know the driver, but eventually, there was the decision to make CHAPS payments via the settlement banks' reserve accounts with the Bank of England. If I had to guess, the driver was about managing credit risk because financial markets were, you know, twenty years ago, probably 10% of the size of what we are looking at today. They had been on an exponential growth pattern. For a long time, financial markets are here, and then they start to grow and probably the CHAPS, people were saying, hang on, having some guy run between building is starting to look a bit risky." (i49)*

CHAPS is one of the largest RTGS services in the world, with over 21 direct participants. Besides, over 5,000 financial institutions also make CHAPS payments and settle through agency arrangements with the Direct Participants(Bank of England (1994); Payment Systems Regulator (2016)).

The criteria for joining CHAPS are like that of BACS. However, there are only two access options – direct and indirect. In late 2017 CHAPS was absorbed into the Bank of England. CHAPS settlement accounts are at the top of Bank of England's settlement account hierarchy (Bank of England et al. (2017)). The CHAPS infrastructure demonstrates the advancement of the UK's payment infrastructure for large-value payments as it has nearly 100% availability. CHAPS indicate the points of the payments infrastructure that have been prioritised for high performance.

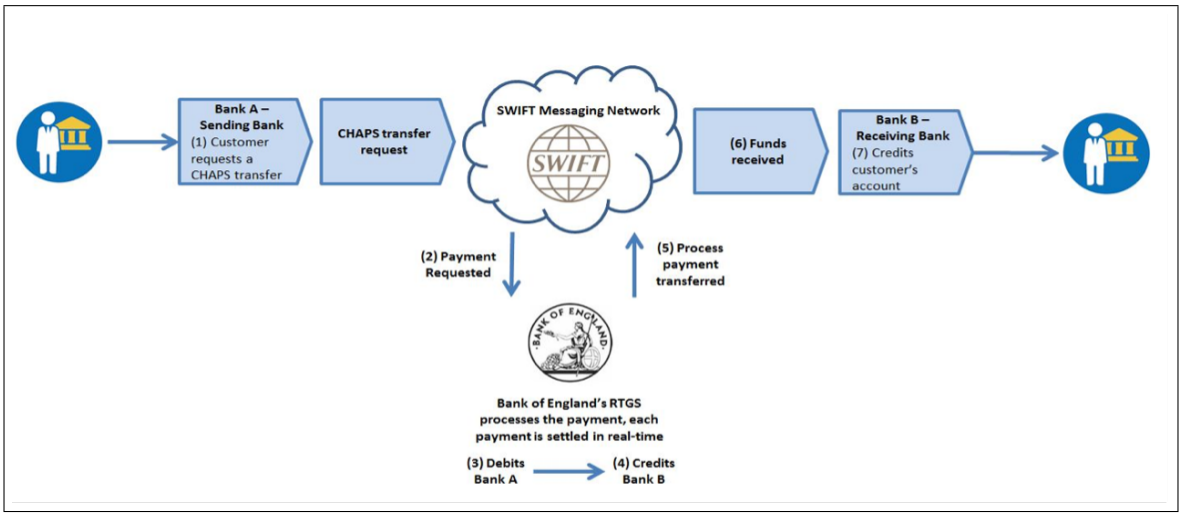


Figure 5.2: Chaps Mechanism
Source: Bank of England (2022a), p.1

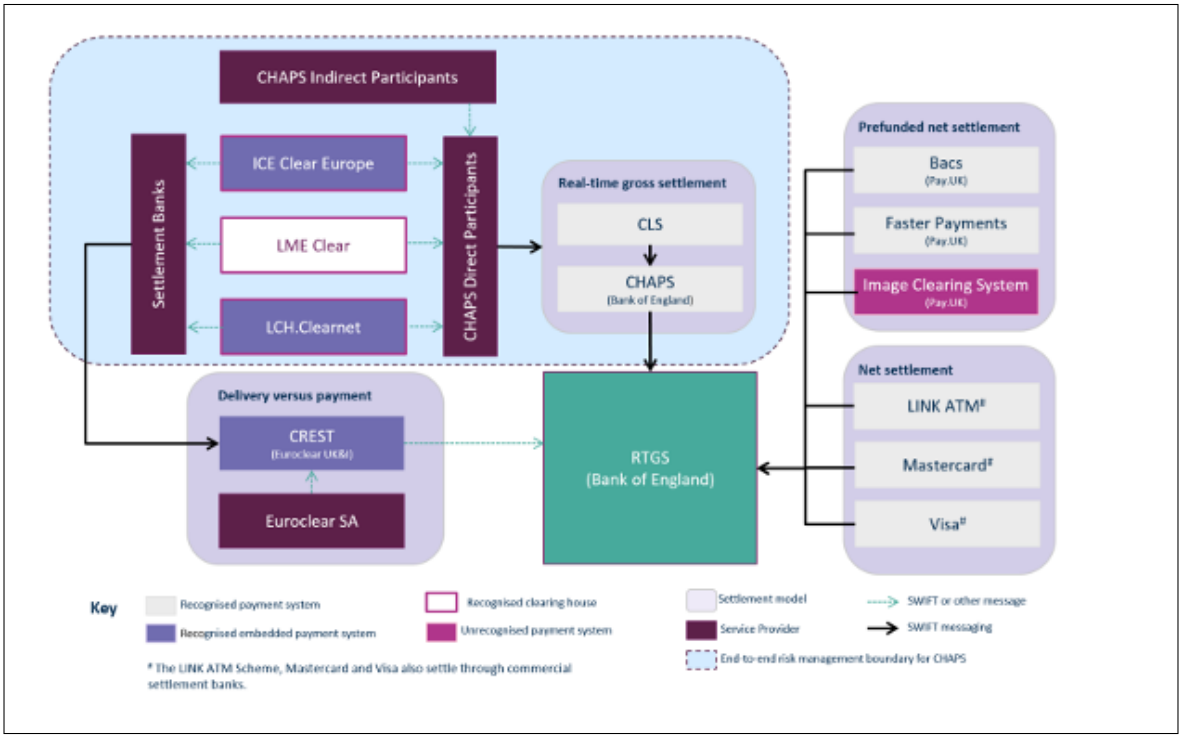


Figure 5.3: Interlinkages between RTGS, CHAPS and Financial Market Infrastructures
Source: Bank of England (2021), p.5

5.3.3 Real-time gross settlement system (RTGS)

History of RTGS of UK

RTGS in the UK began in 1989 when the Governor of the Bank of England encouraged a wide-ranging debate on wholesale payments systems in the UK (Leigh-Pemberton (1989)). This set the stage for the introduction of RTGS in the UK. In 1992, the Association of Payment Clearing Services announced that the infrastructure would be developed to settle CHAPS payments through RTGS. This led to RTGS being launched in 1996. CHAPS use RTGS infrastructure according to the RTGS model, and in November 2017, the Bank of England took over CHAPS operations. However, other clearing systems, BACS, CCC & C, FPS, and LINK, all settle through the RTGS infrastructure on the deferred net settlement (DNS) model as commercial banks accounts are at the Bank of England.

By the 1980s, other clearing systems had started settling both electronic and interbank transactions via the Bank of England. These settlements were all done on the DNS model, where the final transfer of funds occurs later after netting payment liabilities between banks. Under the DNS model, customers receive funds after some delay. The setting up of RTGS infrastructure was aligned with a global move by central banks towards RTGS clearing. This was mainly due to two changes in the technological and policy environment. Firstly, by the 1980s advancement of technology-enabled real-time accounting was feasible. Secondly, the critical policy driver was the global recognition by regulators of the systemic risks inherent to large-value payments being settled in the DNS system. Banks may suddenly have liquidity issues if the customer has transferred large amounts out of the bank while less came in. This is due to banks moving funds in their central bank account throughout the day until settlement time. The real-time settlement addressed this risk by ensuring that banks maintained sufficient balances continuously to meet their settlement obligations. There are several advantages and disadvantages to both DNS and RTGS models. The primary difference between the two is the liquidity requirement.

For DNS, banks only provide liquidity for net obligations when clearing. This increased liq-

uidity efficiency but increased settlement risk. The settlement risk increases as banks do not have to commit to funds when clearing. The delay creates a credit exposure, which could crystallise into a loss if the paying bank defaults before settlement. This could have a contagion effect as other banks relied on default payments. These credit risks could be mitigated through default funds, loss-sharing agreements, net debit caps, and pre-funding requirements (Dent and Dison (2012)). Settlement risks do not occur in the RTGS system as banks have sufficient funds in real-time. However, the liquidity effect is low due to banks having to maintain sufficient funds with the settlement agent for real-time settlement. Also, this requirement precludes payment institutions with insufficient capital from participating directly. Globally there was a shift to RTGS systems for large value settlement from the 1980s onwards (Dent and Dison (2012)). Therefore, RTGS was introduced much like the systems based on a person's advocacy or the public.

Access to RTGS

RTGS is the core of the payments infrastructure as it is where the final settlement of funds takes place. It was also connected to bank accounts at the Bank of England. In addition to the settlement, the RTGS system is used to implement monetary policy through the movement of liquidity in the market if needed. Due to the importance of RTGS to the entire economy, access to the system is limited. As shown in figure 5.4, access is limited to the payment clearing systems, including Visa Europe. To become an RTGS participant, one must adhere to strict liquidity and technical security measures. Thus, while RTGS could connect with any, it maintains a closed network. The Analysis chapter will trace how theRTGS system finally granted access to non-banks by revamping the system.

> *"... it is worth talking to those guys at the Bank of England because they are looking at redesigning the central bank or RTGS system. They are looking at Blockchain, and they are looking at APIs, and they are trying to figure out what is the market going to look like." (i21)*

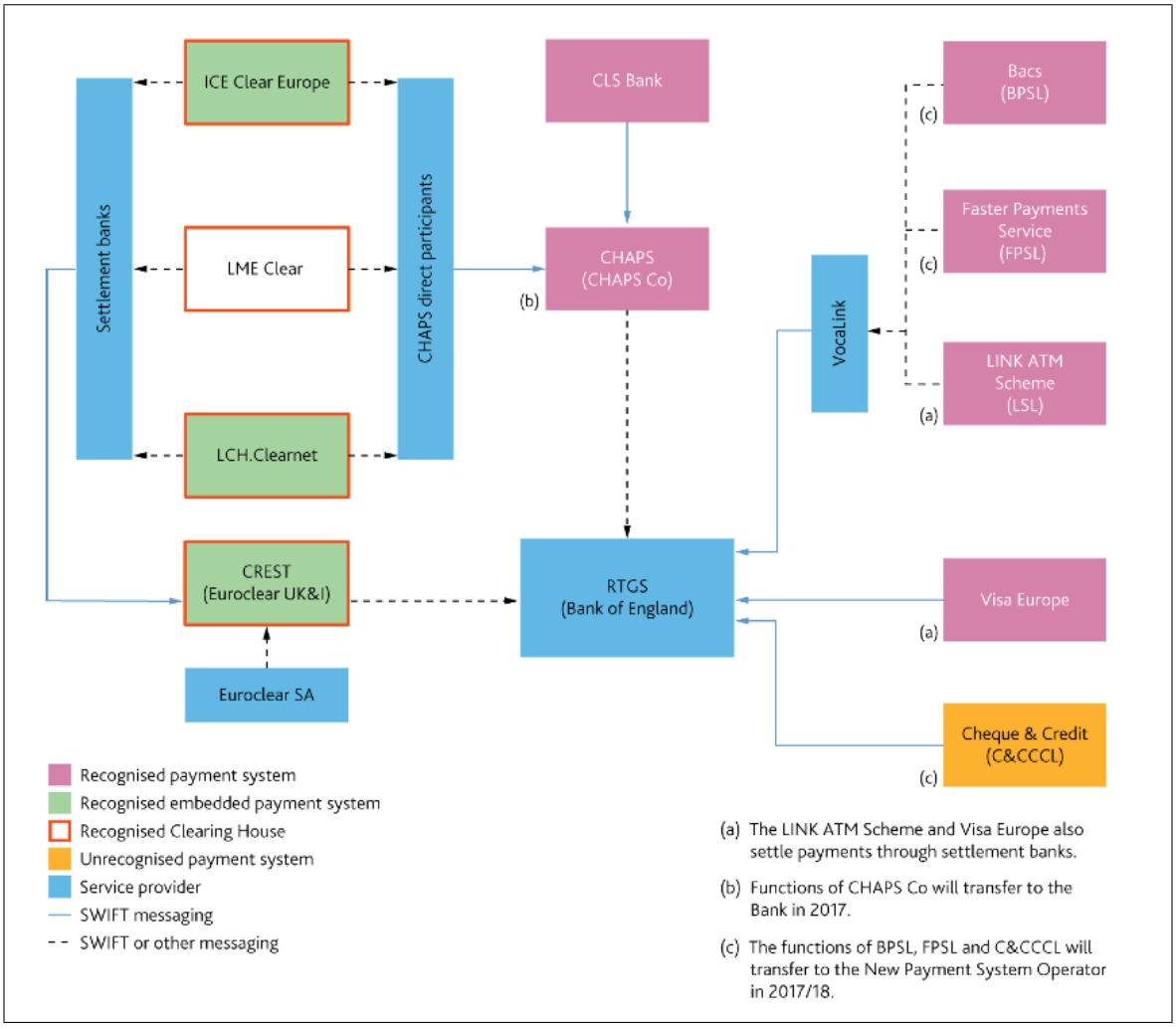


Figure 5.4: Interlinkages between RTGS and Financial Market Infrastructures
Source: Bank of England (2017b), p.6

5.3.4 Faster Payments

Faster Payments (FPS) is a retail payment infrastructure launched in 2008, and it is the main focus of this study. It enables real-time electronic payments via the Internet, telephone and mobile banking applications, and standing orders. Unlike BACS, FPS allows non-routine retail payments and non-bank payment services, especially overlay services, to participate in the infrastructure. Faster payments had several access options for banks and other payment institutions, including recent access innovations such as third-party aggregators to enable non-banks to participate. It had a pre-funded settlement system to mitigate settlement risk within the RTGS infrastructure, which is used for settlement (KPMG LLP (2014); Faster Payments (2014); Limited et al. (2017)).

Faster Payments had used the VOCALINK infrastructure through competitive bidding for several years. SWIFT is the messaging service and ISO 8583 messaging standards were needed to enable real-time return notification. These elements give it the customer-oriented aspect of the Card network, which also can immediately send back a notice of payment verification. As depicted in Figure 5.6, FPS settles transactions via pre-funded accounts called the Reserve Collateralisation Account (RCA) in the Bank of England. Pre-funded accounts provide a buffer for FPS if participants do not have sufficient funds for its deferred net settlement (DNS). FPS provides flexibility for participants by allowing them to determine their credit exposures in the system by setting a Net Sender Cap (NSC) at a level above their normal flow of funds (Faster Payments Scheme (2018)).

The central architecture of FPS in Figure 5.5 becomes the centre point for the research issue in this case study as non-bank Fintechs, who is not featured in this figure, seek access to FPS. The detailed process of tuning taking place to gain access is discussed in the Analysis chapter.

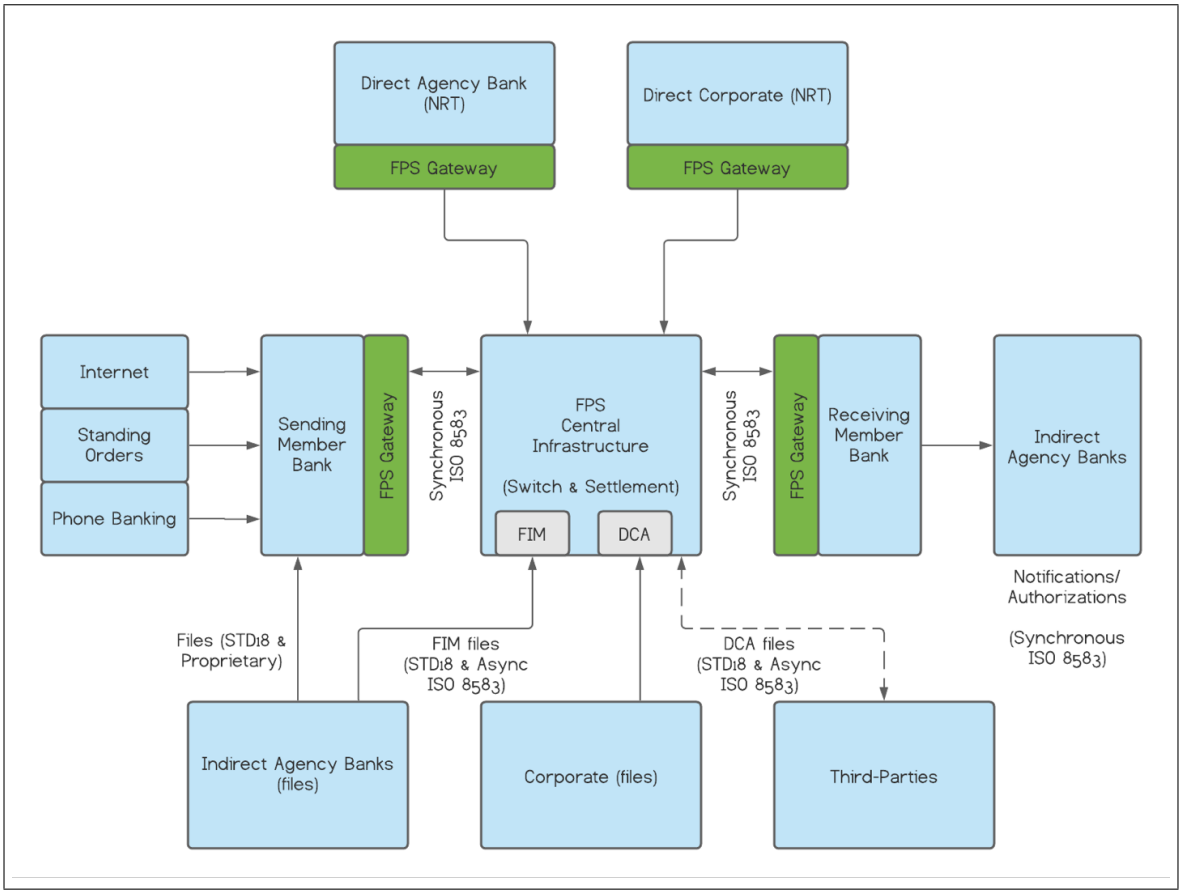


Figure 5.5: Faster Payments (FPS) central infrastructure; see 5.2 for abbreviations and terminology

Source: KPMG LLP (2014), p.25.

Table 5.2: Abbreviations and Terminology for Figure 5.5

Abbr.	Description
FPS	Faster Payments Scheme
NRT	Near Real-Time
STD 18	Standard 18 is proprietary data standard of BACS which comprises both a record structure and a field structure within those records. This message format supports BACS' highly efficient bulk overnight payment processing (BACS (2017))
ISO8583	Card payment processing data standard
FIM	File Input Module
DCA	Direct Corporate Access (DCA) is a file based payment submission method at present offered for FPS by one direct member to its sponsored corporate customers. This allows a corporate to submit multiple payments in a single file. With DCA, FPS payment files are input using a Secure-IP solution (similar to BACStel-IP), using the same standard file format as BACS transactions (Standard 18) or ISO 20022 XML.
Synchronous payment	The payment action is handled in the same transaction as the order process.
Asynchronous payment	Payment is not time-bound, e.g., one party is not online 24/7, has throttled payments outbound or has a stand-in service in place to manage the receipt of payments when the internal systems of the organisation are not online to support immediate processing (KPMG LLP (2014)).

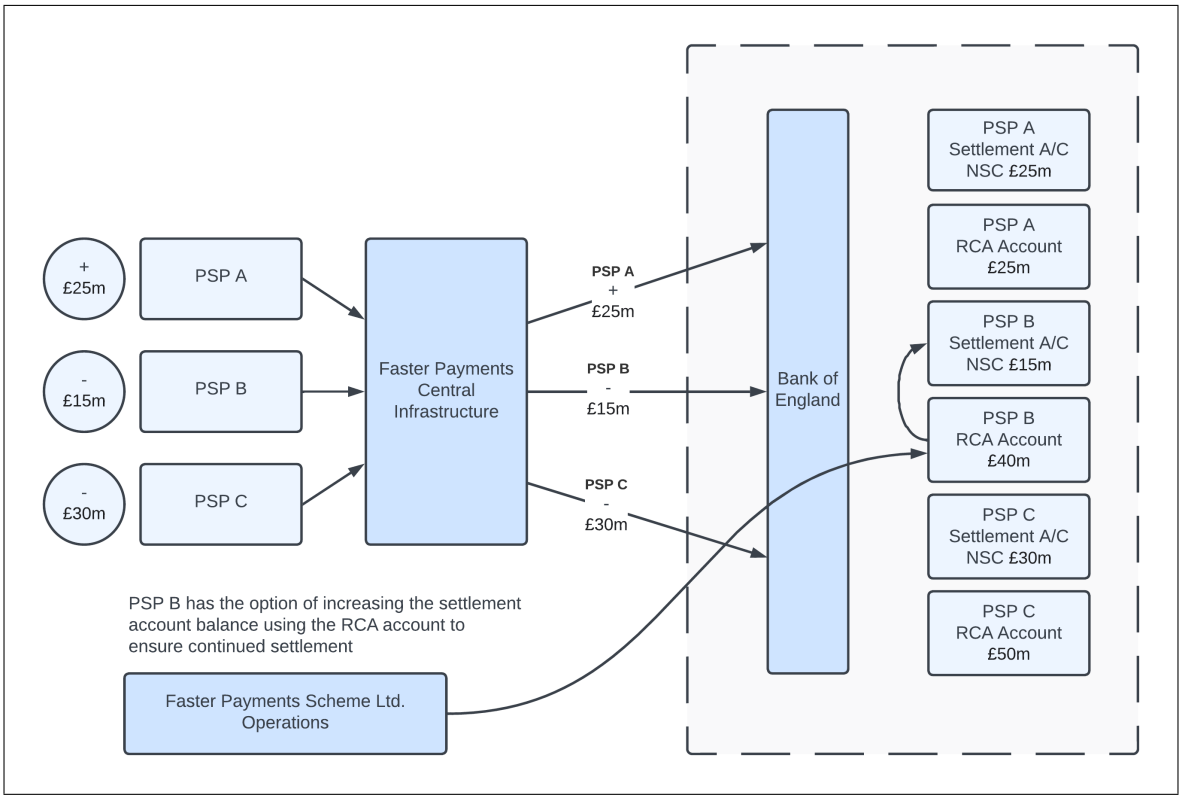


Figure 5.6: FPS Payment Pre-funded settlement system
Source: Bank of England (2013), Faster Payments Scheme (2018) and interview data

5.3.5 Card Networks

Payment cards are one of the earliest and most established cashless retail payment innovations. Cards are an early payment innovation around the 1950s and have captured several features that have made them relevant globally even 50 years after their initial introduction. Subsequently, credit cards launched by Bank of America were introduced in the UK (Salmon (2013); Stearns (2011); Evans (2003)). Despite the introduction of Visa cards in the 1960s, digitalisation of payment infrastructure was primarily focused on the backend systems to improve efficiencies for banks rather than the retail consumer. Thus, from the 1950s onwards UK's digital payment infrastructure begins to form.

Cards networks primarily provide proprietary infrastructure for clearing and settlement of payments initiated via a card issued by a card issuer. Cards can be credit, debit, prepaid or charge cards.

Card networks provide infrastructure for the full payment process from real-time payment initiation point to clearing and settlement. Cards carry unique information such as a 16-digit card number and security information that enables authentication of the holder and authorisation of the payment. While none of the card networks provides financial services such as issuing cards, credit or acquiring payments, they allow issuers (mainly banks) to issue cards bearing their logos to indicate the network to which the card belongs. The technological transitions made by card networks from the early punch–card–telephone era (Stearns (2011)) to present-day internet-based authentication systems and tokenisation have demonstrated the adaptability of the card.

There are several card networks in the UK: Visa, Mastercard, Diner's Club, and American Express. This research only focuses on Visa and Mastercard, serving about 95% of the card market. Both Visa and Mastercard use the four-party model to complete a transaction. The four parties depicted in Figure 5.7 are:

- Cardholder (Consumer): The customer who is issued with a card connecting to Visa or Mastercard issued by his/her bank. The cardholder presents the card to pay for a transaction.
- Card Issuer: Issues card to a customer who presents it to the retailer to pay for transactions.
- Retailer – submits transactions as batch files with account numbers and amounts to the card acquirer (retailer's bank).
- Card acquirer – submits the transaction to the card issuer to be honoured (collects Visa/Mastercard payments on behalf of the merchant).

Then the card issuer debits the customer's account for the price that appears in the statement. The acquirer pays retailers the amount (less merchant service charge, which is negotiated between acquirer and retailer). The issuer approves the transaction and remits the amount to the acquirer (less an interchange fee) (KPMG LLP (2014), i10). The above pro-

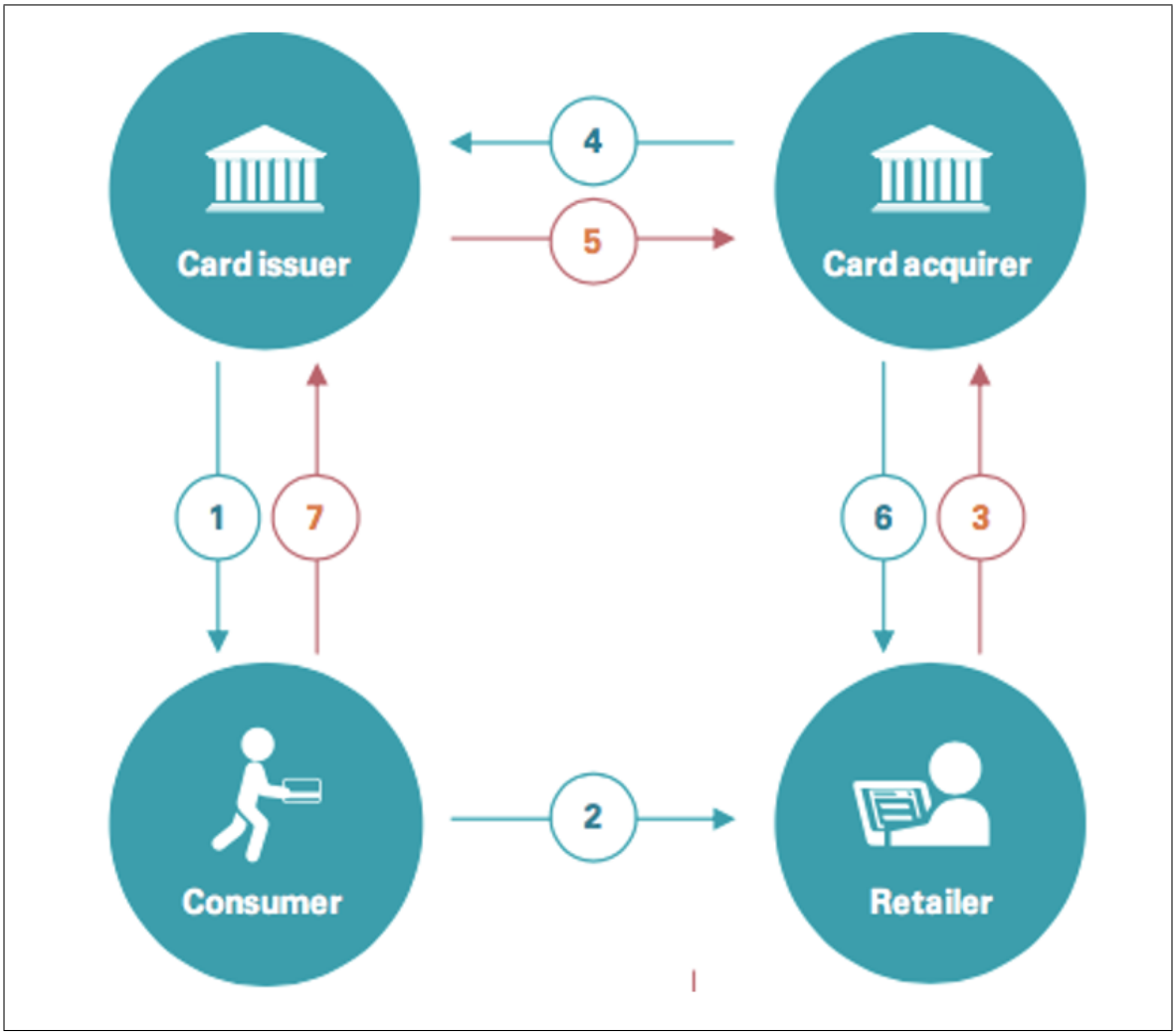


Figure 5.7: Visa Europe Four party model of a card transaction
Source: KPMG LLP (2014), p.32

cess comprises two mandatory phases: the authorisation, done by the customer's bank (the issuer). This approves the transaction or declines instantly if the funds in the customer's account or credit limit are insufficient. This next phase consists of clearing and settlement – the process where the retailer and the financial institutions that intermediated the card payment are paid. Card transactions can occur through multiple channels – the physical point of sale with the cardholder present, non-physical – e-commerce or telephone where the cardholder is not present. Multiple channels open card transactions to security risks. Thus, EU regulations on cardholder authentication differ for cardholder present and absent transactions. Card companies and banks must take responsibility for these risks (i10).

Historical evolution of payment cards

The global reach and scale of payment cards have made them the most successful cashless payment methods. Cards are globally accepted and interoperable due to the standardisation of size, design interoperability, and terminal compatibility. All cards have a magnetic strip or chip with information about the cardholder and the issuer. Cards were also one of the earliest payment technologies introduced. What began in 1958 in the USA as a credit card issued by Bank of America (BoA) soon came to the UK under a BoA license (Bátiz-Lazo and Wood (2002)). Visa and Mastercard dominate the card market. Their sophisticated payment infrastructure enables the processing of millions of retail payments within seconds. Even though similar in-service Visa and Mastercard are two different entities that influence the UK's payments infrastructure differently, both Visa and Mastercard do not issue financial or payment services or cards.

Participating banks called "issuing banks" issue cards. These two companies are primarily infrastructure companies that facilitate the intermediation of non-cash payments by card for banks and other card issuing institutions. The payment infrastructure and the governance model are significant differences between the two.

Visa Europe

Visa is a non-profit cooperative of members (banks) that determine the rules and infrastructure provided for its members for payment processing. Visas relationship is with card issuer and acquirer – banks and issuer can issue cards with the Visa logo. The logo indicates that the payment will be ultimately processed through the visa payment infrastructure. However, there is no relationship between cardholders and Visa. Visa is an evolutionary result of the Bank of America card in 1958 and expanded to the UK as the Barclay Card in the 1960s (Stearns (2011)).

Visa Infrastructure

Visa Europe has three infrastructure components of payment acquiring: authorisation, clearing and settlement. This makes Visa Europe the most self-contained payment infrastructure that provides near end-to-end infrastructure. The first-mover advantage that Visa enjoyed has allowed it to scale its membership and deepen its infrastructure. The infrastructure layers are the Regional Network Infrastructure (RNI), the network that links Visa Europe, its member banks and processors; the linking infrastructure is provided by British Telecom (BT) (KPMG LLP (2014)). The real-time authorisation of transactions at the point of sales takes place through the T Visa Europe Authorisation Service (VEAS), a real-time service. The Visa Europe Clearing and Settlement Service (VECSS) is a batch service that manages the clearing and settlement of authorised transactions between Visa Europe member banks. It uses the ISO 8583 messaging standard that provides a return message to validate that the transaction has been processed to handle the high volume of transactions (KPMG LLP (2014)).

Transactions are finally settled multilaterally via the RTGS system daily. Visa's settlement structure is adapted to its members' access to settlement infrastructure. Therefore, banks with settlement accounts in Bank of England settle directly through them. At the same time, those without are allowed to settle through other commercial banks with settlement accounts, or Visa organises settlement through another commercial bank account if neither

RTGS settlement account access is available. This alternative arrangement provides flexibility to participants and makes the infrastructure more accessible (KPMG LLP (2014)).

Mastercard

Mastercard was developed as an alternative to Visa in 1966 by a group of Californian banks called the Interbank Card Association (ICA). Mastercard refers to itself as a technology company rather than a payment card company[5]. It has its proprietary card technology and settles via commercial banks rather than RTGS like Visa.

Mastercard's proprietary infrastructure comprises three components: the MasterCard World-Wide Network (MWN), which links all Mastercard members and MasterCard processing centres; the Mastercard Authorisation Platform (MAP) – an international message processing platform and the Global Clearing Management System (KPMG LLP (2014)). The company positions itself as innovation-friendly adopting new technologies such as tokenisation to serve emerging market demands for multi-channel availability and security needs. Access to Mastercard is like Visa, as it is used as a payment infrastructure selected by issuing banks. In effect, to the customer, there is little difference regarding experience as Visa and Mastercard are interoperable and connected within their systems (KPMG LLP (2014)). Other card networks such as Diner's Club and American Express are not discussed in detail here, as their scale is smaller and are not seen as systemically significant payment infrastructures.

Card Networks are the most enduring and adaptable retail payment innovation. It has remained relevant and interoperable to meet the technological changes in its environment.

> *"We provide the rails, the rules, the scheme, the licenses for others to take advantage of all that technology to operate their businesses upon. We see our role as a middle man, providing technology solutions and others to whomever we feel can get value out of them. So, you know, traditionally, you know, our, we are two major customers who are issuers, which are normally, you know, banks and acquirers*

[5] "MasterCard" - https://www.encyclopedia.com/finance/encyclopedias-almanacs-transcripts-and-maps/mastercard

for the likes of well paid, etc. However, over the past few years, particularly over the last couple of years, that is beginning to expand hugely." (i10)

Card networks have played a pivotal role in Fintech innovations. This will be discussed in the second section.

5.3.6 Underlying technology infrastructures

SWIFT

Society for Worldwide Interbank Financial Telecommunication (SWIFT) is an international financial messaging service used by most payment infrastructures and banks for transactions. Founded in 1977 by a cooperative owned by banks, SWIFT is one of the large global financial infrastructures (Scott and Zachariadis (2012)).

SWIFT embodies the cooperative centralised infrastructure model as banks work together to decide on messaging standards and governance structures to ensure the smooth flow of transaction-related messages(Scott and Zachariadis (2013)). A SWIFT payment message is an instruction to transfer funds; the exchange of funds (settlement) subsequently takes place over a payment system or through correspondent banking relationships (Committee on Payment and Settlement Systems (2003), p. 47). Therefore, SWIFT does not only view itself as a messaging service for corporates and banks but as a standards organisation well-positioned globally to disseminate standardised practices for transactions (Scott and Zachariadis (2013)). SWIFT also has different membership and access levels like other infrastructures. Like FPS, it has adopted flexible access models for smaller and non-banks. SWIFT has been evolving as well, moving into the ISO20022 standard.

"The key standard is the [sic]; there is a correspondent banking standard or set of standards. And then on top of that, we have been working for the last 12 years or so on the ISO20022 standard, which, as the name suggests, is an ISO standard. It is not SWIFT IP, but we have put much energy into creating the content of that

standard and the technology. To, we operate the registration authority, which is the publisher of the content of the standard if you like." (i48)

Vocalink

Vocalink is a key infrastructure provider for BACS, FPS and LINK ATM services in the UK. Vocalink is formerly the BACS infrastructure that had to split after a recommendation from the Cruickshank report in 2000. It recommended separating payment schemes (systems) and their infrastructure operations to increase competition. As a result, BACS Payment scheme limited was separated from BACS Limited in 2003. BACS Limited changed its name to Voca in 2004.

Having merged with LINK ATM infrastructure later, it became Vocalink. Vocalink was owned by 18 UK banks[6] In 2017 Vocalink was acquired by Mastercard. The Competition and Markets Authority approved this acquisition upon Mastercard agreeing to open up Vocalink to other service providers and contribute to the costs of LINK members who want to change suppliers (see footnote 2)

Vocalink provides direct connectivity to banks, government, corporates and non-banks to facilitate the smooth collection of bills, social welfare, and payroll. This is a unique feature in the UK (KPMG LLP (2014); Limited et al. (2016)). This connectivity allows end-users to access payments infrastructure without going to banks infrastructure directly. Nevertheless, the settlement has to happen through a bank or settlement agent.

5.3.7 Historical beginnings of the research issue

Lord Cruickshank, in his critical report on the competition in UK's banking industry, to the Chancellor of the Exchequer (Cruickshank (2000)), which was pivotal in increasing competition in the UK's payments industry, noted that even though banks were to be regulated by

[6] "Mastercard wins approval for £700 Mn Vocalink Deal" 11/4/2017 https://www.ft.com/content/1f721c0a-10e9-37b0-89ec-0854a1773577

government institutions that there was a strong convergence of interest between the two emanating in the form of an informal contract.

> *"Historically, the most likely explanation for this special treatment lay in the existence of an informal contract between successive governments and banks, designed to deliver public confidence in the banking systems" (p.vii)*

Public confidence in the banking systems was a top priority and was connected to maintaining financial system stability. The loss of confidence could result in a bank run and economic crash. Maintaining public trust was crucial for banking as well. The status was evolutionary co-dependency between the business of banking and the responsibility of the banking regulator – the Bank of England. Banks gained this special status as they were licensed as "deposit-taking institutions". Although other firms, such as credit unions (Financial Conduct Authority (2014)), were licensed to take deposits from the public, banks were the dominant deposit taker. This meant that banks were the firms holding the funds that were needed to be used within the payment infrastructure to complete a payment required them to provide payment services to the public as well. Banks were businesses that were intermediaries that safely channelled money from those who had surpluses to those who needed loans. To be eligible to take and hold funds from the public was a highly risky task. Therefore, to obtain a banking license, firms needed to raise capital that could be liquidated to repay the depositors at any given time. At the same time, the banks loaned the funds to earn interest.

> *"Banks make enormous investments to make sure the systems are safe. We have to maintain liquidity requirements so that the payment systems work. No one seems to talk about these. They think these are free." (i7)*

With the high costs were the high return. Banking and payments were highly lucrative to banks that had a dedicated market. Banking being a networked industry conceptually led to banks emulating their close network into the digital interbank payment infrastructure. However, regardless of the good intentions of the bankers, the outside world saw them differently. An e-money licensed Fintech stated the following, showing the barrier between banks

and others:

> *"They [the banks] are a club, and it is very difficult to join the club." (i25)*

Over the years, the banks, together with regulators, had developed a fairly well-functioning infrastructure. However, the time had come when innovative digital firms, Fintechs, wanted to share the pie. However, as the senior payment specialist remarked, while all the payment infrastructures described above were well functioning, accessing them comes at a high cost:

> *"A few. A few. There are people that, first of all, I think the thing to say is that these entrepreneurs will attack anywhere. Anywhere where they think there may be an opportunity, either because they have a good idea or what is more reliable because they are responding to an area of gross inefficiency. Now the interesting thing is that payments in this country, on the whole, work quite well. Faster Payments are good. CHAPS works well. BACS seems to suit its purpose. It is reliable. It is expensive, but the costs are hidden everywhere, so people do not realise how expensive it is. Thus, by and large, it is not a fruitful place to attack if you are a disruptor with a better proposition. The attack is the wrong terminology. If you are looking for a place where you can make a big difference, payments are quite a hard place to go." (i3)*

The next chapter presents how Fintechs and other actors navigated through these complexities to reach their goal of directly accessing the payment infrastructure.

Chapter 6

Analysis

> *"They [Banks] see FinTech as anything from disruptors to challengers to potential partners to life savers to, they are all things in between. It depends on the particular FinTech. Some of them are very keen to work alongside or inside financial institutions, helping them to do new things. Some of them are a direct challenge to some of the businesses that the banks are in. Most of them, some fall somewhere in between. It really does depend." (i43)*

To understand how heterogeneous actors gain access to regulated digital infrastructures, I analysed the data using the analytical and operational frameworks developed in Chapter 3, which were based on Pickering's (1993,1995) Mangle of Practice, his subsequent explications of it and its subsequent extensions by other authors. The case study research of the UK's retail payment infrastructure was conducted when tensions between Fintechs (new entrants), incumbents (banks and card networks) and regulators had heightened over the issue of granting Fintechs direct access to the national payment infrastructure, which was heavily regulated. The findings are presented along the following themes:

1. Intentionality of heterogeneous actors
2. Tuning technological artefacts for alternative access methods

3. Tuning rules relating to digital infrastructure access

4. Modelling regulated digital infrastructure

6.1 Intentionality of heterogeneous actors

The analytical framework grouped actors and technological artefacts against the demarcation of whether or not they were subject to disciplinary agency imposed by the regulatory environment. The framework also conceptualised that the tuning of agencies took place at multiple levels, that is, within a firm or between microactors, macroactors or between micro and macroactors. Figure 6.1. depicts the categorization of the micro and macroactors that are in the regulated digital infrastructure environment. Microactors are those who connect or use the infrastructure directly or indirectly for their operations. Macroactors are at a policy level and do not connect to the system for operational purposes. The Bank of England is both a micro and macroactor because it owns and operates the RTGS system as a microactor of the digital infrastructure and also has legal regulator powers. Macroactors included both stability and competition regualators both at national and supranational (EU) level. Microactors included both authorized and third-party service providers (Fintech). Thus, this allowed seeing the interplay between agencies in the infrastructure.

There was a high diversity in the goals and aims of actors even within a group. To understand the intention, I present the access authorisation obtained (Table 6.1). I use this because it indicates the level of integration the actors want within the industry. For example, obtaining a banking license required substantial capital, technological investment, and compliance procedures. Thus, obtaining a banking license connotes that the overall goal was to remain within the industry for a long period. Similar intentionality can be understood for card networks and incumbents with similar investments. However, in terms of e-money institutions and Fintechs, they have become very diverse. E-money institutions referred to themselves as Fintechs. One of the e-money institutions (i25) interviewed was one of the earliest in the

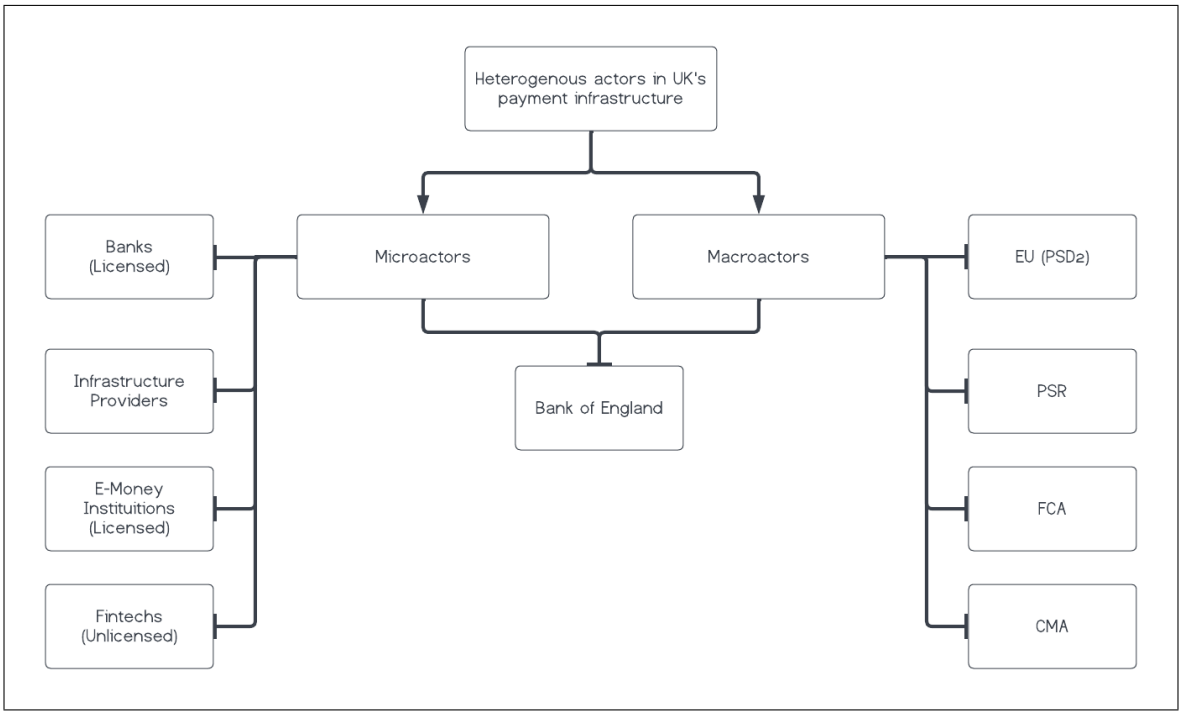


Figure 6.1: Heterogenous Actors in the UK's Payments Infrastructure
Source: Author

UK to obtain an e-money license when the regulation was published in 2000 and referred to itself as Fintechs. The heterogeneity increased with unlicensed Fintechs as they were innovating for a different payment process and infrastructure level and had different business strategies.

Table 6.1: Access status of the actors accessing/using payment infrastructure (during the period of the interviews)

Authorisation	**Institution/firm (no. interviewed)**	**Level of access to the payment infrastructure**	**Example quotation**
Licensed	Bank (6)	Primary membership. Secondary membership (choice based on investment) of both clearing system and settlement system.	*"We became a Faster Payments participant, direct participant over the summer. And we are now looking at providing sponsored access to Faster Payments to other PSPs." (i4)* *"Exiting the retail market as the low-cost margins are not profitable and focusing on the corporate market." (i5)*

Authorisation	Institution/firm (no. interviewed)	Level of access to the payment infrastructure	Example quotation
Licensed	e-money institution (4)	Access to payment systems via banks	*"All the software piece is on top of the transactional platform. The platform and we still process the transaction. We see the values more like software than the transaction. During the transaction, you can always have someone doing it cheaper."(i34)*
Unlicensed	Fintechs (10)	Uses indirect and innovative access methods through licensed entities	*"We are not licensed ourselves, but we work with some partners who are licensed"(i27).*

Authorisation	Institution/firm (no. interviewed)	Level of access to the payment infrastructure	Example quotation
Authorized	Card Network and Card Infrastructure provider (4)	Designated as a Financial Market Infrastructure by the Bank of England	*"Our absolute business priorities upgrading our network from physical shopping to digital shopping and enabling that for all our customers." (i10)*

Further, each bank had different plans when engaging with Fintechs. While some were managing new investments to partner with Fintechs, other banks had begun completely exiting the retail payment market as they no longer found it profitable to compete within the changing context (i5).

However, 17 codes relating to access to payment infrastructure emerged as a core theme in the study, coded in most interviews (61 instances). Thus, access emerged as an overriding issue that was not included in the questionnaire but emerged during interviews. Thus, this research focuses on access, and the rest of the analysis will reveal how the varying intentions of actors are tuned against the material and disciplinary agencies of the digital infrastructure.

6.2 Tuning within and between heterogeneous actors

6.2.1 Incumbents

As stated in the case study, the banks still suffered from the loss of confidence caused by the 2008 financial crisis. However, banks still held an important position in the industry as they were the most regulated and had made large investments in technological systems and compliance. These costs were far more than other entities in the system. As a senior payment consultant stated in the interview:

> *"And so the cost to a bank of, know your customer, so onboarding, anti money laundering, all of the other regulatory obligations that they have regulatory reporting every day on their positions and their risk profiles and their security requirements. So all of the other business paraphernalia that is required to run a very complex financial institution is an overhead that they carry with payment operations. To some extent, if you look at what people like say, PayPal are doing, they are riding on the rails of the banking system and they are actually, to a large extent relying on the banks having that anti money laundering know your customer and all those processes in that. The banks are paying for that. It's really*

expensive. Incredibly expensive. And the fines involved if they get it wrong are so high that they could break a bank. PayPal and those guys aren't paying for that." (i21)

Banks had tuned the infrastructure, banking procedures, and compliance to meet the disciplinary agency of the industry, mainly emanating from systemic risk. The 2008 experience was also closely in their mind; banks seemed to have almost over-conservatism. This was, however, recognised and rewarded. A banking license itself provided more leverage regarding access to the payments systems and infrastructures.

"We've taken a view now that if you have been given a license to operate as a bank by the FCA and/or the PRA then we shouldn't be questioning the stuff they have already examined. We try and target on things that only we are interested in." (i47)

However, even banks faced high entry barriers when seeking access to national/ industry payment infrastructures. The following quote is from a system architect connected with the FPS (i32). FPS was designated a financial market infrastructure, meaning any breach or disruption could affect the entire financial system directly or indirectly. Therefore, participants had to overcome numerous technological and regulatory barriers to gain membership. Due to this, not all banks were direct members of FPS.

"But, this bank [joining FPS] can't settle unless they have already settlement accounts with Bank of England and that has been the real big blocker, because it is such a big, heavy, long winded process to get one of these settlement accounts. There are all sort of hoops to jump through and capital adequacy tests, etc, etc, etc. Even a lot of banks find that difficult to do. And FinTech who wants to move into this space, absolutely impossible." (i32)

The issue of risks to the financial system was prevalent in all rules and regulations. The regulations often manifested the financial stability risk in the rules and directed behaviour and

business decisions to avoid them.

The Financial Conduct Authority (FCA), commenting on the policy for licensing new banks (including challenger banks), stated:

> *"It is essential that new entrant banks meet basic standards that prevent undue risks to the financial system and to customers. But as long as basic standards are met, we should aim to make entry, and subsequent expansion, as easy as possible. A balance therefore has to be struck between the risk that new entrant banks will fail, and the benefits of easy entry." Adair Turner, FSA Chairman (Financial Services Authority (2013) p.6)*

Even under more relaxed regulations in the banking sector for entry, the issue of risk mitigation was key. Even though there was a view of allowing banks to fail, the rules for infrastructure access did not seem to compromise on technological and regulatory requirements for access (Bank of England et al. (2017))

Thus banks with access were those for tuned their systems to overcome these requirements. These requirements had the effect of barriers but ones that were considered necessary to accommodate the disciplinary agency of the industry. However, not all banks were happy about making these investments. Under new regulations such as the Payment Service Directive that was about to be implemented in the UK during the interviews, Fintechs were given access to bank customer data and increased payment service access. A banker (i7) who was not in favour was Fintech gaining easy access to the systems the banks had invested a lot on observed this:

> *"They ask us to do all these investments to join these systems... but who are we doing this for?" (i7)*

"They" here referred to the regulator, and "who" was Fintechs. Thus, it showed an underlying frustration towards all parties as tensions grew.

6.2.2 Tuning material resistances

The term "legacy systems" was commonly used by the interviewee, blogs, and conference panellists as a significant pain point preventing banks and Fintechs from innovating. The payments infrastructure's legacy systems comprise payment systems accumulated by banks and incumbent payment systems providers such as card companies. The primary villain was the legacy systems of the banks, especially the core banking systems. The core banking system has been defined as,

> *a back-end system that processes daily banking transactions and posts updates to accounts and other financial records. Core banking systems typically include deposit, loan, and credit processing capabilities, with interfaces to general ledger systems and reporting tools. (Gartner (2022))*

Most of the core banking systems were installed in UK banks in the 1970s and 1980s (Bátiz-Lazo and Woldesenbet (2006); Bátiz-Lazo and Wood (2002)). The age of the payment infrastructures is based on the time they were launched. Having worked in banking as a system specialist at the time (i24), shared this memory:

> *"For instance, in London, I was in London. So, the first round in the 70s and 80s was the automation of existing paper processes using mainframe, steam driven, hard core, expert run specialist systems that sat in cold rooms at the back of offices, enlarged bunkers run by experts. The days of big tin, very broadly. And in payments that was automating accounting systems. It was automating exchange of value systems. We then got some bits started to move out from the central accounting, whether that be central or a commercial bank, central bank or a commercial bank accounting systems. And looked at delivery of service to end point. So forage automation, ATM creation, you know, the beginnings of cash management services and the connection of treasury or ERP systems, accounting systems in corporates to their banking partners. And that was really 70s, 80s, 80s you've got networks. Suddenly networks were easier. I was a network specialist for a*

while. So you know, the battle between IBM SNA and X25, it's ancient history." (i24)

The combination of bank and payments systems would process a payment in the following manner:

"An interbank payment would be initiated from a "customer's bank where account and balance data would flow from the core banking system, which is about 30-40 years old. This would flow into a clearing system that is at least 12 years old (based on the age of FPS) and then go to the RTGS systems, which are also around 20 years old and return to the payee's bank's core system, that is also approximately 30-40 years old" (i19)

By the end of 30-40 years of operations, the core banking systems' architecture had evolved into siloed structures as subsequent banking products were installed under separate functional lines of the banks (depicted in Figure 6.2). Several factors appear to have contributed to legacy systems' perpetuation in their early form. The first is that the nature of banking and payments had not changed over many decades. Much of the investment in information systems was for internal management and control purposes and large value payments rather than retail products (Bátiz-Lazo and Wood (2002)). Second, functional components were designed and developed in closed functional groups without integrating services. Third, existing systems were locally configured to meet changing regulatory requirements, such as anti-money-laundering rules and fraud detection. This highly siloed structure was that the bank systems were not necessarily designed for functional lines coordinating and providing integrated solutions to the customers.

This is problematic today, as a trend in IT products offers conveniences and efficiencies to customers by providing integrated solutions. A bank system architect noted the following:

"People say banks are digitalised, but this is a fundamental level of digitalisation sometimes. People think there are these complex sets of pipes taking data to

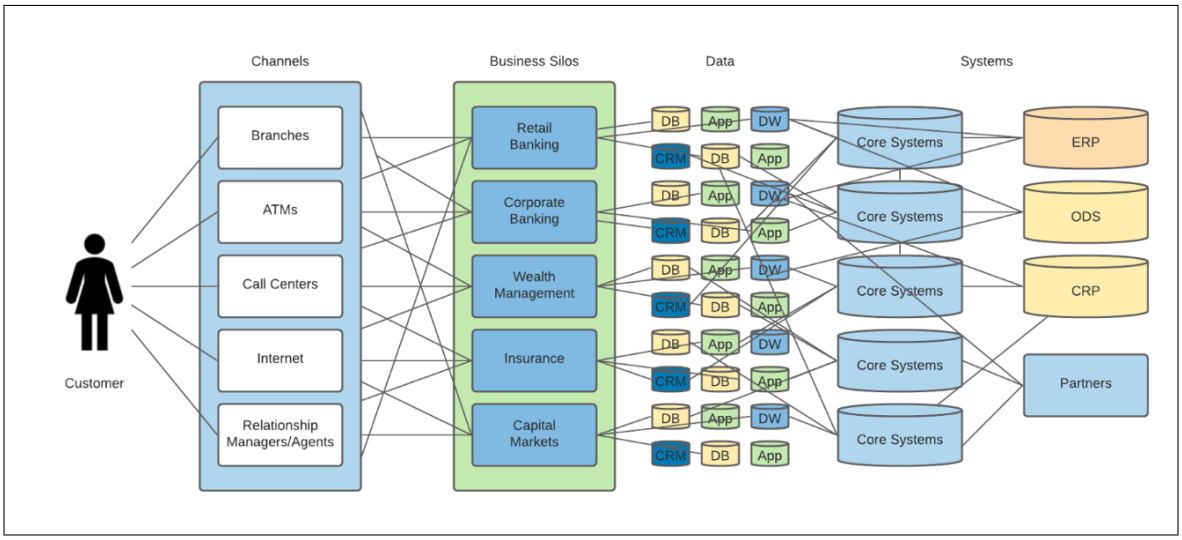


Figure 6.2: Siloed Structure of Banking Architecture
Source: Simmons: (2008)

each department in the bank. However, I have seen different. There have been instances where silos email entire databases to other silos at the end of each day to complete processes" (i6)

Thus, banks appear to have been tuning their behaviour to accommodate the material resistances arising from legacy systems and the siloed architecture. However, they persisted in meeting the required service reliability to complete the processes as needed.

"I will explain to my first ever holiday job was in town clearing in London for Citi Bank. On my first day at work I, it was a holiday job, I was 14 years old, I lost two and a half million pounds, because I pressed the wrong button and the little bits of paper were carried by men in bowler hats around the City of London in little envelopes. Somebody just, and I was really terrified. My colleagues in Citi Bank seemed very relaxed in London wall. I went home terrified going, that's 67,000 years and this is a long time to pay back the money. And they simply phoned up NatWest and said, can we have the money back, because some idiot forgot to press clear. So, the first generation of changes was automating paper processes in a way that allowed visibility and systemic risk reduction." (i24)

These siloed architectures of the legacy systems that were tightly coupled and not interoperable reduced banks' ability to recombine their digital systems and innovate. This added pressure nevertheless was experienced at bank levels, as it appeared that the system crash frequently.

> *"Banking systems crash so frequently inside, but it is rarely spoken of externally. It is because the systems are siloed. They are patching things up on a daily basis almost" (i6)*

Material resistance of the installed base temporally emerged frequently, yet banks were capturing the agency using bug fixing techniques to keep the system running. For disruption of banking or payment services was too systemically risky. Therefore, the disciplinary agency of the bankers tuned the material agency to keep the goal of system availability going.

6.2.3 A language barrier

Several interviewees whose work related to payment system software within banks cited the lack of knowledge of legacy coding languages as a barrier to upgrading or overhauling legacy systems.

> *"The main language in banks is COBOL. You do not even find people now to code in COBOL. They are all retired or whatever. It is a big issue." (i34)*

Fintechs with banking experience and payment system operators highlighted the computer languages of the legacy systems as a critical issue. Knowledge of languages such as Fortran and COBOL has decreased as they were no longer popular among software developers. This has resulted in present-day staff being unable to upgrade systems to meet more modern demands for agile and integrated systems due to the risk of them crashing. When discussing this issue with a senior consultant/former system architect who was being interviewed (i32), he revealed that he knew these languages and was often offered to work by banks.

Even though these past inertias were burdening banks, several interviewed had aimed to

evolve with Fintech innovation. Thus, very old banks were using different methods to capture material agency. One large bank (i3) set up its Fintech incubator, where Fintechs had a strong assurance the bank would acquire them. The bank did not want to expose its systems to innovations directly but wanted to benefit from innovation:

> *"I think the one thing that is clear is that we can't do this ourselves. And you need therefore to be close to people who are innovating. If you do that then your own people start to learn and they start themselves to break out of conventional thinking. So it's both. But the latter is very hard. The breaking out of your conventional thinking is extremely difficult to do… But once you create the environment for it, it is, to me it is remarkable how many people will respond to that and become themselves innovative in their own way. We have a number of examples of how that is now working." (i3)*

Another bank which was over 160 years old (i2), stated that they,

> *"moved aggressively towards becoming a digital bank."*

These banks were well aware of the resistance in their systems. Still, they seemed determined to move ahead, thus adopting Fintech innovation to circumvent the resistance when they could not capture it.

6.2.4 Card networks

Cards provided versatile interfaces through all digital delivery channels. It was the only retail electronic access point to the interbank payment infrastructure until systems such as FPS were introduced. However, cards did not offer real-time settlement like in FPS. Therefore, merchants must wait a few days to receive the money paid through cards. The payment card networks were legacy systems running since the 1960s and accumulating the installed base. However, the staff were very reluctant to tamper with the system as they were not sure of the resistance that would emerge nor their ability to capture it. Therefore, like banks, the

card networks too chose to keep their legacy systems.

> *"We have not made changes, and that is because our core system is something we do not meddle with very much. After all, it is our business; it is enormous. Our Switch is switching billions of transactions every day. It is not something you can quickly change because 99.999% availability of that, we can have as many exciting applications as we want, but if our system, if our core system is not all for clearing and settling every day, then we have not got a business any more. …*
>
> *… I think the trend is across the whole banking sector in financial services. Most banks still have substantial legacy systems that cost millions and millions to run. They have not changed them either because it is too expensive or too risky." (i10)*

(i10), who was a senior manager, went on to cite the ATM outage as it related to retail value. In September 2014, NatWest Bank and RBS bank customers had not withdraw cash from other bank ATMs due to a technical issue for 2.5 hours. He cited this as a scenario that no bank wanted to experience. Such outages highlighted the payments infrastructures' vulnerabilities and the actors' motivation to forego flexibility to preserve stability.

Despite these inertias, the card networks continued to innovate and absorbed all the complexity of payment systems by simplifying the interface down to a card or, more recently, a virtual card.

> *"Our main goal is to ensure that our customers and merchants can make their payments through means they wish at any time… we try to ensure that our card processing technology is cutting edge so that we can support a wide range of innovation". (i10)*
>
> *"Our absolute business priorities are upgrading our network from physical shopping to digital shopping and enabling that for all our customers. So it's absolutely, what I am doing is a key priority for our business, globally." (i8)*

To evolve with technological and business developments, the network referred to itself as a technology company and no longer a network provider. They were repositioning themselves as a boundary resource for Fintechs and other digital firms.

Thus in light of them keeping their legacy back-end, it could be said that they were modelling their infrastructure to reach new goals. In bridging and filling the modelling process, the networks relied on banks who issued the cards to ensure regulatory compliance to all the new Fintechs and others who were using the infrastructure.

> *"Yes. We don't do as a business. We don't do the, you know, we rely on these great new companies coming into the market, the start ups, the FinTech companies to build those user experience and those front ends. We just open up our network to enable them to connect in and use our user network...So, we rely on our issuing customers. They are regulated by the FCA in this case. We, obviously, have strict membership rules and regulations and policies for anyone to become a *** member. In the same way, even though we open up our APIs to ensure that new companies can use our technology and use our products and services, we would always ensure that any of those companies that needed to use our services were compliant with whatever regulations they need to be compliant with. A big one is, PCI compliance to make sure that we are dealing with card data. That anyone connecting to our network has a business that's robust enough and secure enough to keep those details secure." (i9)*

The incumbents effectively provided access infrastructure to the core systems and were impacted by material resistance and disciplinary agency. The compliance for disciplinary agency by networks focused on system security and availability mainly. At the same time, banks had to accommodate the compliance risks and disciplinary systems. Overall, both incumbents were using innovative solutions to capture the material agency arising from the installed base and legacy systems while adhering to the disciplinary agency of the industry. In the case of some banks and the card network, in addition to tuning, it appears they were modelling

themselves as platform-styled infrastructure to evolve with the time.

6.3 Tuning between Fintechs and Incumbents

All Fintechs interviewed had heterogeneous business models, products and even views of banks and regulations. Fintech's views on the tension and gaining access were also widely varied. Some were aiming to disrupt the entire banking industry with technology and innovation. There was a narrative that too many services were concentrated in banks in siloes, which made banks inefficient and the customer at a loss. Thus, it was proposed that these horizontal silos should be an entity of the past whose work should be modularised. Fintechs such as (i38) invested heavily to overhaul the payments infrastructure.

> *"We think in terms of the stack through going from the very bottom rung of the stack. We are replumbing the network. Whereas most in the FinTech go for the top list go for the app don't they, because that's your classic, that's your quick way. That is your quick hit, quick fix. We are different. We are a much slower burn." (i38)*

This was not, however, the dominant theme that arose in the interview. Tuning between incumbents and Fintech emerged as a stronger theme. Within this theme, it emerged that Fintech harnessed its payment industry and banking domain knowledge and also had an awareness of the disciplinary agency and the value of accommodating disciplinary agency within a regulated industry.

6.3.1 Domain knowledge

Fintechs in the payments industry was largely innovating for the retail customer. This was also due to the legacy of banks focusing more on automating back-end and internal processes and developing systems for corporate customers. In contrast, the retail customer historically offered only credit cards for electronic payments until Fintech, such as Paypal,

entered the market. The retail end of the payment process led to most Fintechs concentrating on aspects of payment initiation, i.e. capturing the payment digitally to move in the system.

> *"Innovation that we see in the payment space and the FinTech space is in the consumer space. It is not only the last mile, I would argue that it's the last half centimetre" (i30)*

The mobile phone had made Fintech innovation from a technological standpoint easy, as many were mobile apps. However, the complexity of a Fintech app arose when it needed to connect to the payment infrastructure to be processed. The infrastructure was not open like the Internet, and obtaining authorisation meant a much higher financial and technological commitment and domain knowledge. Therefore, it appeared that even though developing a Fintech app was possible, becoming a viable product was a more arduous journey.

> *"The world is littered with the dead bodies of mobile start ups that have started and died in the last decade." (i30)*

The analysis showed a distinction between Fintechs with more domain knowledge of the payments industry and banking (with former bankers or card network staff in decision-making positions) and others. Experienced Fintechs saw investment banks and card companies made on efficient payment infrastructures and compliance as strategic resources that could be harnessed to tune front-end innovations. These Fintech solutions often partnered with incumbents to provide mutually beneficial business arrangements.

Even though the front end in retail payments was left largely neglected by incumbents, the rest of the payment process functioned efficiently in the UK regarding reliability and regulatory compliance. Some Fintech solutions were able to extend the existing payment infrastructure to innovative solutions.

> *"But yet, the wondrous innovative exciting Apple Pay depends on plastic debit and credit cards which run on 30 year old credit card rails which in turn, put money*

from the 35 year old, 40 year old, Fortran and Cobol systems that computers, that banks are running as a core banking platform… Most of what's happening in FinTech today is we are taking the engine of a beat up Ford that's 35 years old and we are putting it inside of a beautiful carbon fibre Ferrari. "(i30)

Apple Pay was an example of how technological resistances were tuned by innovation. This was not a one-sided tuning. Payment card companies have continuously innovated their infrastructure and front-end to make cards a versatile boundary resource.

"What's interesting is that Apple needed to use our network. There was no way they were going to be able to launch their product unless they used our network. It's such a big job that we do in terms of maintaining that acceptance and maintaining that network. Would any company, they just wouldn't be able to do it themselves. Even a company the size of Apple would find that difficult. "(i10)

There were also Fintechs that did more advanced innovative solutions based on their knowledge of payments. An interviewee of a regulated Fintech that facilitated low cost remittances (i30) noted how they innovatively recombined existing infrastructure and harnessed existing investments of incumbents to enable low-cost cross-border remittance. This innovation rested on the legacy infrastructure of banks. Still, it developed a lightweight network using the Internet for customers to access the system and create what appeared to be like a complete payment flow.

*"What ******** has done is a pragmatic innovation which is to stretch an operational technical and legal framework on those points of light surrounded by darkness on the map [drawn during the interview] and connected them, so that we create a global ACH infrastructure by in effect repurposing infrastructure which is already paid for, already exists and is already really well used "(i30)*

Another Fintech founded by a senior banker showed another approach to utilising his disciplinary agency. Due to his knowledge of the regulations, he admitted to finding them ex-

tremely cumbersome. Therefore, his business used Cloud infrastructure to resolve compliance issues that banks or licensed entities need to make large technology investments for compliance purposes. However, the Fintech itself was consciously operating in a regulated space.

> *"We do the boring pieces in the background, but we do it well. This still means every single payment goes through our infrastructure. So we take away a big headache and the guys who are not from the payment industry to basically just connect to us. Not even through proprietary technology and it's all in the Cloud. They don't need the infrastructure whatever. We provide APIs back into that system." (i31)*

The Fintech (i31) catered to 2-tier and 3-tier banks and licensed Fintechs and used the economies of scale of Cloud technology to overcome the prohibitive costs for smaller actors. (i31) being a former banker was aware of the financial, technological, logistical and know-how related issues that banks faced when meeting technological requirements to access industry infrastructure. Bank infrastructures were regulated and supervised as they linked to the national payments networks and held confidential customer information. However, meeting those requirements came at a high price. (i31) used his domain knowledge and disciplinary agency and provided technological solutions such as multitenancy cloud solutions, enabling smaller banks and Fintechs to meet regulatory requirements at a fraction of the investment.

> *"[Cloud] Multi tenancy is basically the fact that different banks are on the same platform. Multi tenants on that platform, which basically means that we preconfigure the infrastructure in a way that it doesn't become a bespoke environment for every single customer. What happens today is if you are a bank, if you want to build a payment infrastructure you go to that provider and buy a piece of that. You go to that provider and buy a piece of that and then you plumb it all together and you have your head of IT and you have a data centre and everything to basically make it work. That's not very efficient for a small bank. They haven't got the*

money to justify this. It's also not very efficient. If you need to make changes to the infrastructure it's not very efficient because you pay every single one of these providers a licensing fee for what you do and the maintenance and this and that. They come up with new releases and there is regulatory change and you may want to put a new front end in place, so you are basically fiddling with the systems all the time. That is not efficient." (i31)

Figure 6.3 captures the innovative relationships formed by heterogeneous Fintechs with banks which allows smaller firms to gain access to the infrastructure while being regulatory compliant. This access also connects third party Fintechs to the system, creating a generative environment as well.

6.3.2 Tuning for regulation

Within the heterogeneity of Fintechs, a group saw being regulated or coming within a regulatory ambit as empowering. Thus, they ranged from becoming licensed themselves or partnering with licensed banks so that they can expand along the regulated value chain.

"So, the conclusion he came to was wait a second, we could change banking. This could be massive. But in order to do that, you need like real people, real compliance process, real compliance officers, real compliance department, ISO certification and FCA licensing. He went down the path to do that and like massively professionalise the company. He started that five or six years ago. And so the first bank customer came about three and a half years ago and has been building and building and so now has Standard Chartered, HSBC, Bank of America, Banco Brazil, Santander, Japan Postbank, etc." (i30)

(i30) 's experienced revealed that obtaining a license is a major and time-consuming commitment. It also showed the time a Fintech start-up takes to become a viable firm through that process. Options that were somewhat less complex were also available. Fintechs were able to tune for their lack of disciplinary agency through licensed banks, creating a partnership to

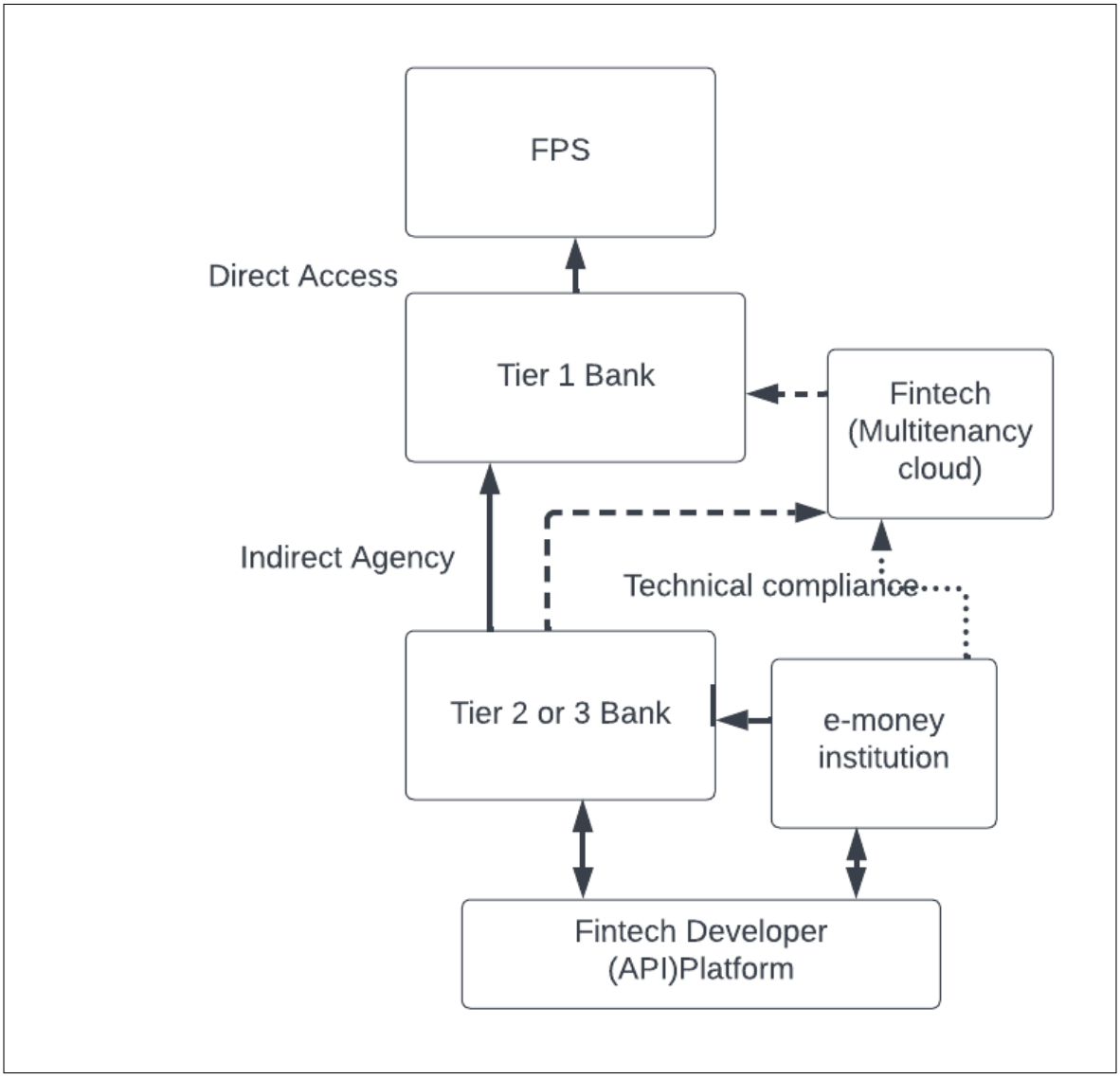


Figure 6.3: Innovative access paths formed between banks and Fintechs
Source: Author

harness the value of being regulated.

> *"I think it's more hype than FinTech will eat the business from banks. In the end, banks are not going to go anywhere, I think. Because banks are the ones who were the proper, let's say, regulated entities. They are doing all the compliance leg work. It's the banks who have access to the clients. All the big clients that anybody wants. It's the banks who have them. In the end, FinTech are not, it's going to be difficult for every FinTech to be able to succeed independently off another bank. At the end of the day, any FinTech for that matter somehow bank is connected. You talk about all these innovative payment companies. At the back of it, in the end the banks are still the ones for moving the money. I don't think the banks are going to go anywhere. There is not tension per say. I mean, the way we speak to banks is about sort of being their innovation partner. We can be their partner to allow them to develop and sell innovative products or solutions to their clients." (i27)*

(i27) was a Fintech that issued virtual payment cards using the white label of a licensed bank. Unlike other Fintechs interviewed, (i27) it seemed that Fintech had reached its goals regarding the business it wanted to run. Their sponsoring bank (i4) was also interviewed. They noted that this was the bank's business strategy as they were using their banking license to offer a strategic business partner who would reach the customer and they had obtained direct participant membership to FPS just for this purpose. This convergence of disciplinary and material agencies with actor interests was rare; only one other Fintech and the card network displayed the same.

> *"We became a Faster Payments participant, direct participant over the summer. And we are now looking at providing sponsored access to Faster Payments to other PSPs." (i4)*

Sponsor banks were nevertheless absorbing many risks, especially related to anti-money laundering (AML) laws. Thus, while banks like (i4) adopted it as a strategy, it was informed

that some banks had started to pull away from sponsoring due to the lack of disciplinary agency of Fintechs :

> *"The alternative is to go through a sponsor bank. This is where AML I think sort of start colliding. The sponsor banks are understandably relatively risk averse. They have and we have seen examples over the last couple of years, because sponsor banks are starting to pull away from offering services to certain types of PSP or they are concerned that the PSP may not have the appropriate AML and KYC checks in place" (i47)*

The above sections presented how firms – incumbents and Fintechs tuned the material, disciplinary and heterogeneous agencies of actors emanating from the installed base, legacy systems, business goals, as well as regulation to move forward and innovate.

Several innovative strategies were used to access the infrastructure or facilitate the access by tuning the actors. An interesting observation was that the notion of access seemed to have a more dynamic meaning within these actors as they could resolve their access issues until FPS gave direct access locally. Based on their interviews, it could be that these partnerships may persist beyond FPS giving direct access as most of the resistances have been tuned between actors.

6.4 Modelling a new generation retail payment infrastructure

This section presents the 18-year journey of tuning and modelling technologies and rules for Fintechs to gain direct access to FPS with settlement capabilities. The journey of building the Faster Payments Scheme (FPS) and its infrastructure provided an enlightening example of how material agencies and disciplinary agency are tuned to harness the versatility of digital technology. In response to the Cruikshank (2000) report's proposals to provide better services for SMEs and retail levels, the FPS retail real-time payment infrastructure was launched in 2008. FPS was explicitly made to bring retail payments to the real-time settlement frame-

work and provide the general public with a digital payment method with the quick finality of a cash payment. However, any new system needed to overcome the inherent rigidities of the industry infrastructure's technological architecture and disciplinary agency.

A guide to UK payments schemes published jointly by all payments schemes in 2016 (Limited et al. (2016)) stated:

> *"Faster Payments is the UK's 24/7 real-time system… FPS is a functionally rich, real-time system, 24/7" (p. 10)*

Technologically, developing a faster retail payment system for the UK was difficult for the banking industry. FPS targeted serving the growing retail payment needs in a digitalised economy. In the year 2000, the existing interbank electronic retail payment system was BACS, which had been operating since 1968. BACS was UK's bulk payment system. Retail payments, including salaries, were posted in bulk by banks to the BACS centralised system before the cut-off time of 22.30, two days before settlement on the value date (Limited et al. (2016) p.4). BACS settled on a net multilateral basis by calculating the settlement totals and forwarding payment files to all participant banks. Upon receiving the file, each Bank posts transactions to recipient accounts. Posting and settlement co-occurred on the same day, two days after payments were submitted (Limited et al. (2016)). When FPS was designed, the only retail payment infrastructure available was still BACS. The Voca infrastructure provider ran BACS. However, a systems architect involved in the designing of FPS recalled :

> *"BACS was the only retail payment system available and was run by VOCA. It settled on t+3, Voca was unable to figure out how to make it faster… I think APAC was then the association of UK banks put out a tender for a Faster Payments solution under pressure from it, and it was a Cruickshank report. And various companies responded. So Voca responded by saying, we will speed up the batch clearing to do it the same day or twice a day." (i32)*

Despite the regulators and the government pushing for change in the retail payment infras-

tructure, the technological solution appeared less clear. Even though real-time payments were taking place in the UK's banking system, the ability to apply that knowledge practically in a highly heterogeneous environment was unknown. The BACS architecture and the banks' databases did not have the technological capabilities to convert the architecture and clearing processes already agreed to by participants. Therefore, BACS could only offer shorter clearing times that may have been allocating lesser time for any manual processes involved in posting payments or settlement would be shortened. However, as the need was to reach real-time, UK's ATM infrastructure provider LINK offered real-time payment:

> *"But LINK said, we can do real-time payments using the same sort of technology that we use for the ATMs. So the decision was to go with the LINK solution rather than the Voca solution." (i32)*

Even though LINK had the technology to provide real-time payments, it did not have the domain knowledge for payment clearing and processing, especially regarding the payment files needed to calibrate with the banks' files.

> *"But Voca had a much better view of the settlement process, and so the banks said, we own both of these organisations, and it's silly, so let's bang the two organisations together, and LINK can do real-time payments. Voca can do the settlement piece; off we go. So that was how that happened. (i32)*

Thus, to overcome the material agency, the solution for Faster Payments in the UK was a combination of two unrelated payment technologies, which brought speed through the VOCALINK ATM infrastructure technology and the domain knowledge and access to bank systems BACS had in processing retail payments. This led to the creation of VOCALINK, which today has a near-monopoly as an infrastructure provider to most of the UK's payment schemes.

LINK offered real-time messaging by using ISO8583 messaging format. The ISO8583 is the messaging for card payments. A unique feature is that there is a real-time message returned

confirming payment. This was one component of demonstrating speed to the payer and payee. However, BACS technology was needed to access the account with the funds. BACS used the Standard 18 messaging format to retrieve payment information from banks, which was incompatible with ISO 8583. The banks being siloed also meant that card payments and BACS payments were processed by entirely separate units that did not know each other's messaging formats:

> *"LINK,…they are running ATM networks, and those are connected to a card processing system within the bank. That card processing system uses particular technical messaging types to talk to LINK. LINK routes the messages to sum up the payments made in each direction and look after the settlement. Meanwhile, we have Voca over here, and the same banks are talking to Voca, but it's completely different technical systems.*
>
> *…..So the payments world was using standards like Standard 18, and it certainly has 18 characters of reference data in it. And they were using SWIFT or ETS transport to get the files through to Voca, and then Voca would do it. Your file would go into one bank, and then the files would go out to other banks. So, suddenly you have got payments that originated on this side of the house, having to go over a technology that is familiar to the other side of the house, and so the people at this side are saying, whoa, this is hard work." (i32)*

To resolve this incompatibility between the messaging standards, the designers proposed to develop a gateway between BACS and LINK:

> *"The solution was designing a gateway that could bridge between those two worlds, the world of technical card processing standards and the business world of old fashioned payment's processing" (i32)*

While the solution to developing a gateway was:

> *"theoretically possible, the system was too heavy to handle the number of trans-*

actions expected as well as add on to every bank" (System Architect i32)

The system architect referred to the BACS and LINK infrastructure as two worlds. BACS was the tried and tested technological solution for batch retail payments. Thus, the success of the outcome had to be seen.

Again domain-specific issues emerge to prevent an otherwise theoretically feasible solution. Retail payment systems experience a high volume of low-value transactions. As payment systems are primarily messaging infrastructures, transactions volume importance is more applicable than the transaction value. Therefore, working with an incompatible system would result in lost real-time processing.

> *"So to build that we went and found a third party who had a little lightweight card processing system and we instructed them how to convert it so that it would bridge between these two worlds. So that was back in 2006/7 and went live in 2008, I think, so that was that. So following that, everyone in VocaLink said, wow..." (i32)*

This is a clear example of tuning material agencies emanating from the installed base by using flexible solutions such as gateways and APIs to merge two and three technologies to create a new system. The central architecture thus designed and developed is shown in Figure 5.5, with four gateways to address compatibility issues and allow different participants to access the systems via direct participants. FPS is a centralised switching and settlement infrastructure, together with features in Table 6.2. All transactions are centrally processed, and the message is sent to the recipient's bank that such a payment is received.

The interesting aspect of FPS settlement was that, during a transaction, the recipient's bank transfers funds to the recipient as a temporary loan to the payer's banks. The actual settlement takes place up to two hours after an automated netting process between the banks. Making this not only technologically innovative but also innovatively using domain expertise to accommodate disciplinary agency. The FPS emulated real-time settlement but used de-

ferred netting. The solution was to make a rule for system participants to temporarily pay their customers until the money is received from the payer's bank. As retail payments were high volume and low value, this solution reduced the load on the system by reducing settlement frequency to batches.

The design allowed flexibility for overlay services to drop in and out. As shown in Figure 5.5 of the architecture of FPS, the final access point to the infrastructure was via a direct member bank. Corporate customers of direct members could submit files to the FPS system; even though file submission services were available to settle funds, they could only take place via a direct member.

The design was tuned to enable Fintech innovation using a layered modular architecture that allows the core to be simple and for Fintechs to join via banks using overlay services. This allowed the core to remain secure, with only direct members who met the high system security requirements to connect. This architecture, thus, tuned for the disciplinary agency that would emerge if the core was unsecure. The layered architecture also allowed banks that did want to make the investment needed to be direct participants to membership tiers, as shown in Table 6.2, which provides the requirement table provided to the public by FPS. Accordingly, the tiered membership appeared as a business decision as well.

> *"We think with FP that the answer for the next generation of this culture is a refreshed, new, centralised model. So having spoken with participant banks connected to the infrastructure. That solution, at its heart, should be around a real-time 24-by-7 push payment. But with overlay services, it would allow maybe batch processing. Allow for the payment request and even for direct debits. All those things could happen before the money moves from my account to yours. ..*
>
> *What we need to work through is that my preference is that that central thing, whatever it may be, needs to be as slim and small and efficient as possible and allow overlay services to be developed and do all the exciting, interesting bits. You want to keep the call simple. The more complexity you build into the core,*

the harder it becomes to upgrade the core. Whereas, if you've got a simple core with lots of overlay services, then the overlays can drop in and drop out as and when they need to through replacement" (i47)

The architecture and access model accommodated the disciplinary agency by limiting direct settling participants to those with Bank of England settlement accounts. While this may have burdened the direct settling partner, it is the membership that the bank gives after ensuring they can meet the criteria and system obligations set out by the bank (Bank of England et al. (2017)). This access model is fairly similar to BACS, but as there have been no system issues, emulating may be considered prudent for disciplinary agency purposes. Faster Payments was set up in 2007 as a recommendation of the Office of Fair Trade (Faster Payments Scheme (2015)) and Cruickshank Report, thus commenced services to give customers 24/7 real-time account to account real-time transfer. The service started at a maximum of GBP 10,000 and has been increasing.

Table 6.2: Three access models to join FPS

Source: Limited et al. (2016)

Requirement	**Direct Settling Participant**	**Direct Non-Settling Participant**	**Indirect Participant**
Bank of England settlement account	Mandatory	Not required. The settlement provided by the Direct Settling Participant	Not required. The settlement provided by the Direct Settling Participant
Direct technical connection to the FPS Central Infrastructure	Yes	Yes	No. Connection between the indirect participant and its Sponsor Bank
The ability to receive payments 24/7	Mandatory	Mandatory	Not mandatory
Liquidity and risk management tools	Required	Not Required	Not Required
Service offering			Fully reliant on the service offering of the Sponsor bank

Requirement	Direct Settling Participant	Direct Non-Settling Participant	Indirect Participant
Cost	Higher. Technology, Build, Operational Costs, Assurance Costs	Medium. Connectivity Cost, Security, e.g. PKI (Public Key Infrastructure) and HSM (Hardware Security Module)	Lower. Liquidity Costs, Scheme Membership, Settlement account cost

6.5 Barriers to FPS access

Even though FPS was a technological tuning marvel in terms of payment infrastructure, it did not solve the main problem: easy access to the retail payment infrastructure by non-banks. The non-direct participants still had to access FPS through a direct participant – a bank with the Bank of England Settlement Account. A manager at FPS noted that even though there was a barrier, this was a place to ensure the system's safety. The actor and the action of the FPS demonstrated the strength of the disciplinary agency.

> *"The barriers to entry were seen as, the multiple barriers. The main ones being, cost, complexity and our assurance models. So we were quite vigorous around what banks have to do to prove their capability and stuff. And that's because frankly we are running at a systemically important system. If we ever have an organisation in that has very poor security, we jeopardise the whole system." (i47)*

Thus, despite all the technological innovations to tune the clashes of standards, load and ensure the service quality, the system had not fully accommodated the needs of all the actors demanding direct access due to disciplinary agency requirements. Thus, e-money services wanted access but had to do with sponsorship.

> *"When Faster Payments came along, only the big banks had done it. But, PayPal was the second biggest user of direct debit in the country. I can't remember who the biggest one was. I think it was Royal Mail or the Post Office or British Telecomm or somebody. I forget which it was. But we were the second biggest user of direct debit and we were not doing it directly. We were of the top big ten biggest users of direct debit, more of them were connected directly to the direct debit infrastructure except PayPal. We wanted to use Faster Payments. So when we were talking to Faster Payments the scheme, they said, you are going to be a big user of Faster Payments, aren't you? We want you to connect directly, because we don't want you to do what you are doing with direct debit and go and*

use somebody else." (i23)

This rule also created an entry barrier and favoured big banks, and only 13 big banks had direct membership. A point of resistance meant that the system could not be entered without the non-direct participant having a business relationship with the direct member.

> *"So in order to be a full member of FPS you have to have a settlement account at the Bank of England. And so the big 13 have those. But an direct agency doesn't. And, therefore, the direct agency has to maintain an account with what's called a sponsor bank." (i32)*

As Table 6.2 shows, the indirect partner fully depended on the quality of the service the indirect member and their customer got. Another bank that used to be an indirect member noted:

> *"Under FPS architecture, your connection is as good as [name of direct member bank] 's architecture" (i4)*

This regulatory resistance discouraged Fintechs from using FPS and using alternate access methods to fulfil the payments needed for their applications. One Fintech, which was providing a front-end payment app, noted:

> *"We use cards for our payments. FPS cost 2x or 3x more. Its not worth it." (i36)*

6.5.1 RTGS Settlement Account – highly resistant regulatory control point

The Bank of England settlement account emerged as a dominant control point in the interviews that prevented access of third parties to FPS. Despite overcoming the material resistances emerging from the infrastructure, obtaining a settlement account, a prerequisite to joining FPS, was a hurdle that even banks faced, not only Fintechs. The systems architect(i32) to FPS made the observation below, quoted earlier, to show the barriers faced by banks. This is a rare situation where banks and Fintechs face the same barrier to accessing a system.

"But, this bank [joining FPS] can't settle unless they have already settlement accounts with Bank of England and that has been the real big blocker, because it is such a big, heavy, long winded process to get one of these settlement accounts. There are all sort of hoops to jump through and capital adequacy tests, etc, etc, etc. Even a lot of banks find that difficult to do. And FinTech who wants to move into this space, absolutely impossible." (i32)

There was a sense of frustration among even senior industry members that a small group of banks had privileged access, which could also be commercialised.

"So you've got the biggest institutions in the UK that have access to those. Typically, the American banks also have access, so J P Morgan, Citi Bank and all those guys are directly on that platform. Everybody else relies on one of those banks to get into that system." (i22)

To triangulate the issue, I revisited the Bank of England Guide to the RTGS to understand why the control point was created. It stated that:

"The Bank of England also offers reserves accounts (held in RTGS) to eligible institutions as part of the framework for its operations in the sterling money markets, which in turn are designed to, on the one hand, implement monetary policy and, on the other, meet the liquidity needs of the banking system as a whole.

The reserves account balances play a key role in ensuring that the Monetary Policy Committee's decisions about Bank rates are transmitted through to market interest rates. Reserves account balances, remunerated at Bank Rate, also count towards an institution's liquid assets buffer as laid down by the Prudential Regulation Authority's liquidity regulations." (Bank of England (2013))p.9)

A footnote to the above statement further explained, "It is possible for payment systems to have categories of a direct member who are ineligible for an RTGS settlement account. In such cases, those members will use the services of one or other of the direct members who

has such an account, and who will then be responsible for settling the net obligations of the non-settlement members for whom they act" - p.9

Settlement accounts were the main policy tool the Bank of England used to manage the economy. The purpose of the settlement account reaches much wider than the payment settlement. Thus regulators tuned the rule, prioritising the regulatory obligation of system stability and economic management and provided alternative solutions for other purposes.

6.6 Overcoming the lack of direct access

Responding to continued pressure from Fintechs to provide direct access, FPS published the vision for a new access model in 2014 (Faster Payments (2014)). Due to the connection to core banking systems that use BAC, keeping the central infrastructure secure was vital while giving Fintechs and other non-bank PSPs access to the FPS scheme (see Figure 5.6). Accordingly, in a New Access Model, FPS accepted TransferWise first as a non-bank FPS member in May 2018[1], ending the bank monopoly. Both these solutions were found using gateways that allowed BOE and FPS to provide secure connections to those outside their immediate network. The New Access Model harnessed the flexibility of the FPS architecture to integrate other schemes' transactions as well (see Figure 6.4). The layered, modular architecture allowed it to maintain the safety and robustness of the system. The single-tenant and multi-tenant aggregators provide services to payment service providers such as Fintechs access to FPS. The FPS must approve the aggregators to connect to the system. By the end of 2020, FPS had 30 direct participants; 25 are challenger banks or Fintechs. It is important to note that until TransferWise joined as a direct participant in 2018, there were only five direct settling participants in the FPS infrastructure.

> *"It would be great if everyone was up for doing all these new things. As long as you've got one, that starts to help. If we hadn't done our New Access Model made it easier for Raphael to join. I don't think they would have joined on the old way*

[1] TransferWise becomes first non-bank to join BoE payment system Financial Times (2018)

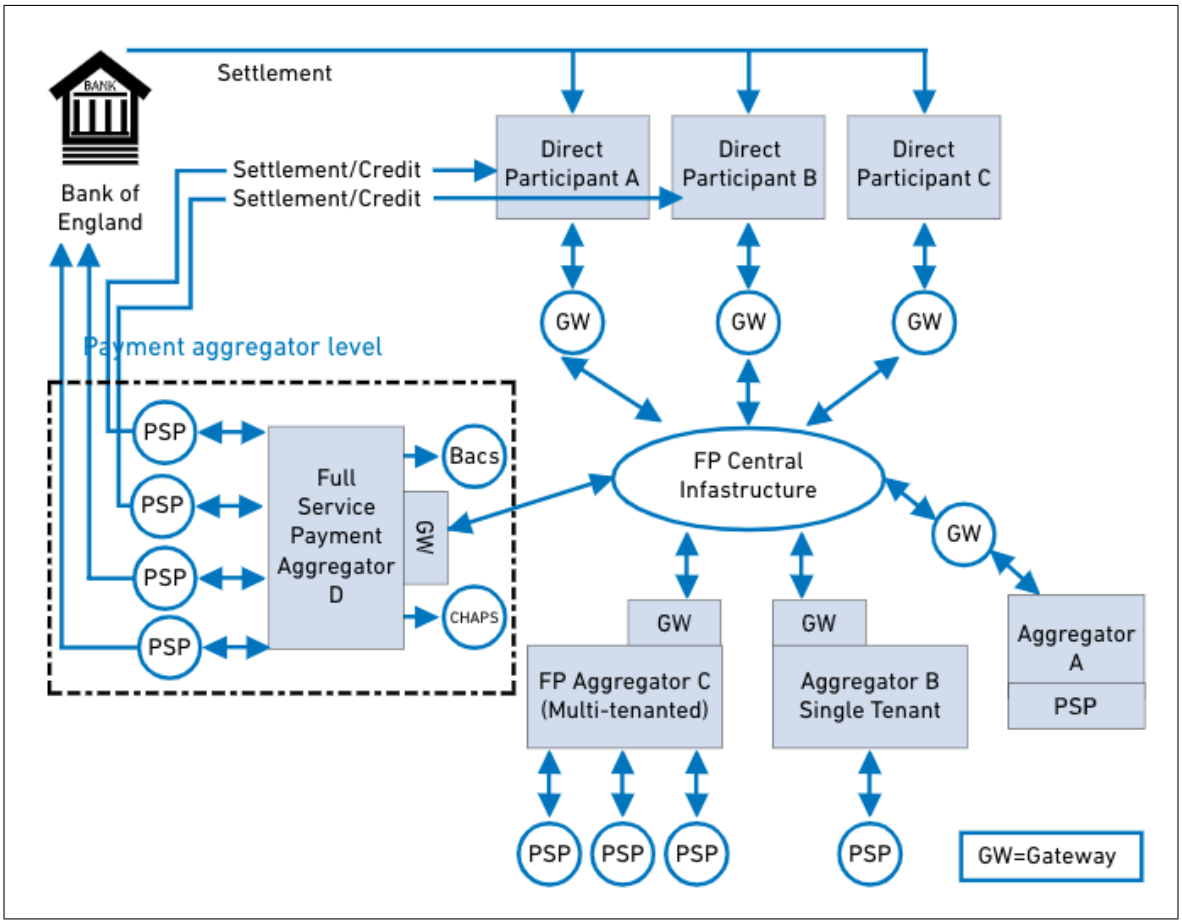


Figure 6.4: New Access Model of the FPS Architecture
Source: Faster Payments (2014), p. 12

of doing things, which would mean that we didn't have an answer for these non-bank PSPs." (i47)

The New Access Model was a turning point in the UK's payment infrastructure history as it was the first time the access monopoly of banks was broken. However, the disciplinary agency was strongly reflected through the rules as modular access options such as using an aggregator. Effectively, in this solution, it appears the infrastructure operators tuned the agency of the Fintechs and other heterogeneous actors and disciplinary agencies by using the layered modular architecture. Aggregators still acted as gatekeepers unless Fintech was resourced enough to make the commitments needed for full access.

6.7 Macroactors tuning for RTGS

While the RTGS persisted in not changing the settlement account, there was a growing demand for change. The statement below from (i22), who a senior industry representative at industry forums. Thus, this view could be considered a reflection of a general issue burdening the industry. However, another important revelation for this analysis within this quote is the entry of another macroactor, the Payment System Regulator (PSR), which is expected to resolve the industry's issues and ensure the payment infrastructure matches the economy's demand. The interviewee described the Bank of England's regulatory barriers that limited eligibility to obtain RTGS settlement accounts as a "stranglehold" constraining the public from participating in the economy.

> *"There is a profound issue that the PSR has been looking at which is, are these number of banks that have settlement accounts constraining the ability of other parties to participate in the economy and to offer services then to other consumers, businesses, government departments, etc. And to what extent can we ever have proper evolution of services or any kind of innovation where there is that stranglehold on the actual settlement piece in the middle. And also can we improve the settlement cycle in the middle, because it's pretty awful, actually. The RTGS system needs to be replaced. It's been slated for replacement and they have tried three times in the last ten years." (i22)*

A payment system regulator (i55) noted the awkwardness that arises when the government or the public demand changes to regulation and stated that regulators needed to focus on setting the industry regulatory framework so that they would encourage innovation.

> *"Historically, say, for example, the introduction of Faster Payments happened because the government told industry to do something, rather because industry had a set of arrangements, a set of incentives, a set of structured that encouraged them to innovate themselves. I think the purpose of us as a regulator is to try and*

avoid those situations where government gets frustrated and feels they have to tell industry what to do. It's that they can be driven by more of a sort of a market competitive structure, plus some role for regulation that drives those types of outcomes." (i55)

The Bank of England had the more difficult regulatory ambit of maintaining system availability and stability for the entire financial system, not only payments. The stability framework limited access to the core settlement system to only thoroughly verified stable participants. And within the larger picture, uninterrupted banking services' were not to be compromised for innovation. The banks' vulnerability could cause a systemic disruption as the banks are connected to the Real Time Gross Settlement (RTGS) of the Bank of England. Like other payment schemes, FPS also settled transactions with the RTGS, where licensed commercial banks that met the membership criteria held settlement accounts. The risk exposure is minimised by organising the architecture to shield the central infrastructure by limiting access; this prevented system overload and any related contagion risk to the entire financial system.

This risk was highlighted in the RTGS system failure on 20th October 2014, as the Bank of England's RTGS system experienced an outage of around 8hrs (Deloitte (2015) p. 35) from 6 am, past its official close time of 3.30 pm. To explicate the gravity of system failure due to updating legacy systems in payments, the full episode is related as it took less than 12 hours; however, it significantly impacted actors' decisions.

In light of the system failure, the Bank of England released the following press release:

"20th October 2014 11:14 - Bank of England statement: RTGS The Bank of England has identified a technical issue related to some routine maintenance of the RTGS payment system and has paused settlement while we resolve it. We are working to address this issue as quickly as possible and restart the RTGS payment system in a controlled manner. The most critical payments are being made manually, and we can reassure the public that all payments made today will be processed." (Bank of England (2015))

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News release

20 October 2014

Bank of England statement - RTGS

The Bank of England has identified a technical issue related to some routine maintenance of the RTGS payment system and has paused settlement while we resolve it. We are working to address this issue as quickly as possible, and restart the RTGS payment system in a controlled manner. The most important payments are being made manually and we can reassure the public that all payments made today will be processed.

ENDS

Figure 6.5: Bank of England News Release on RTGS
Source: Bank of England (2014)

The delay in the announcement indicated that the Bank of England tried to settle the system without causing panic in the markets. The failure had occurred in the CHAPS system connected to the RTGS system. Newspaper articles published on the day reported that many home buyers and estate agents could not close transactions and move into new houses (Treanor et al. (2014)). On 14th October 2014, the Bank of England continued to update the market on resolving the issue (Bank of England (2015)). On 20th October 2014, the bank announced an independent review of the incident (Bank of England (2015)). This incident revealed systems' interconnectedness, complexities, and vulnerabilities in technology and knowledge. An independent review of the outage reported several issues that the massive RTGS/CHAPS infrastructure faced due to its size and nature. During the review, interviews exposed that the multi-layered system's technological complexity increases its vulnerability to outages and incidents.

An issue of staff not knowing the RTGS legacy systems emerged:

"increased difficulty understanding the system from an operational perspective, due to the need to provide such a wide variety of functionality" (Deloitte (2015) p.60).

This was supported during an interview with a regulatory body. They admitted to not knowing how to operate specific old system components, mostly as they were not proficient in the programming language and those components.

The report also revealed many regular cycle incidents that the staff resolved internally (see Figure 6.6). The figure shows nearly 20 RTGS functional errors in 2014 when all outages were under 15 in other years. Thus, the technology behind the extensive payment system was not foolproof, but the essential element was the speed they were fixed without disrupting economic activity.

The RTGS outage was found to be a result of two new programs being added to the system - Liquidity Saving Mechanism (LSM)[2] and the Market Infrastructure Resiliency Service (MIRS)[3]. These two programs were added to CHAPS over the weekend just before the outage on Monday as new resilience measures. The two new programmes resulted in older programs that supported CHAPS crashing under pressure. RTGS had begun introducing solutions to isolate such failures from having a contagion effect. The RTGS system used the process of "lock-stepping" in their system (Deloitte (2015)). However, this was shared by other systems such as CREST and SWIFT but not CHAPS. Thus, this gap led to an incident that became an international example of the systemic importance of core payment systems.

The 2014 RTGS outage was etched in many incumbents' and senior actors' memories. This was cited as an example of a shock to the systemic stability with similarities drawn to the

[2] "These are set payment profiles which CHAPS members use to define the maximum net position they may have with each other member (bilateral limits) and against all other members as a whole (multilateral limits). 'Start of Day' profiles have relatively tight limits compared to 'Peak day', and 'Contingency' profiles" Deloitte (2015) p. 75

[3] A contingency payment settlement service provided by SWIFT that offers a market infrastructure operational resilience in the event of unavailability of its RTGS system. Once activated, MIRS calculates accurate balances for all RTGS accounts and provides final settlement in Central Bank Money for CHAPS Payments and Clearings and RTGS Transfers. Deloitte (2015) p. 75

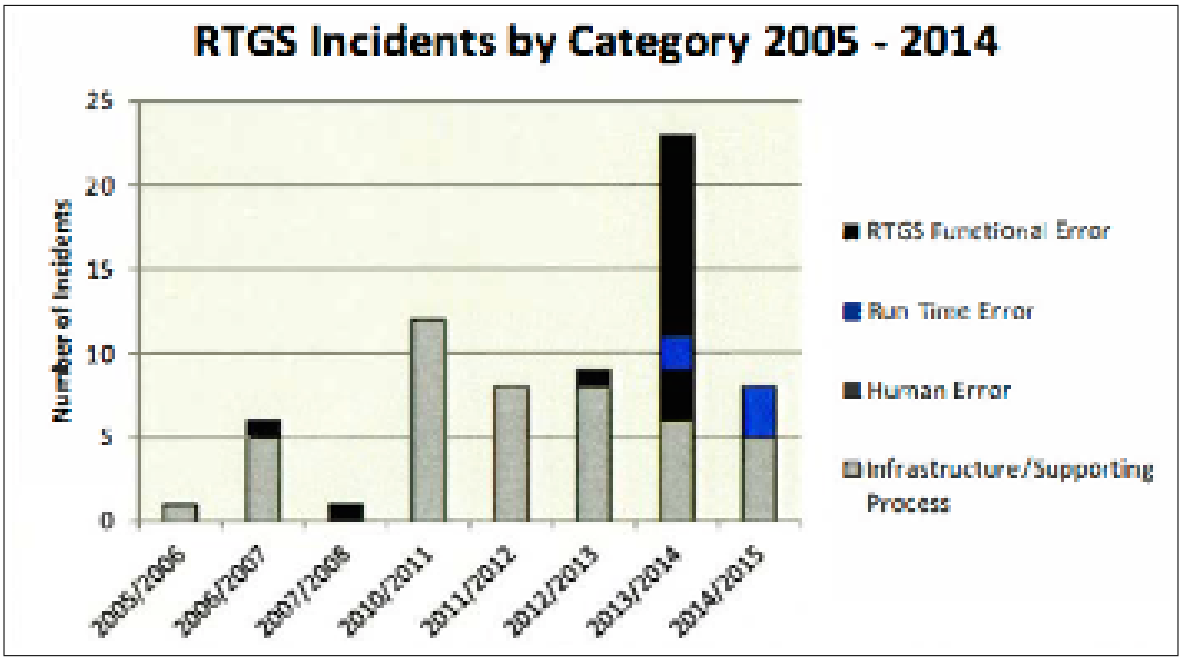


Figure 6.6: RTGS Incidents by Category since 2005 (excluding the RTGS outage on 20th October 2014)

Source: Deloitte (2015), p. 28

financial crisis. This has resulted in legacy infrastructures zealously protecting the core systems to avoid an outage, which in their view, is a catastrophic situation.

> *"CHAPS on its own going down is bad enough. However, imagine all the systems like CHAPS going down simultaneously and the correspondent-banking network went down as well. That would be pretty chaotic. So, to stay up under all conceivable circumstances is priority one." (i47)*

Securing the core is seen as a sure way of maintaining uninterrupted availability. Dominant incumbents, including card networks, with large infrastructures uniformly prioritised core stability for continuous availability. Minimising systemic risks was far more important than innovation to them. They often juxtaposed stability and innovation where innovation was more an optional exercise that can be done when the main tasks are functioning well.

In May 2017, the Bank of England announced, through a Blueprint, its decision to amalgamate CHAPS into its systems and increase its resilience (Bank of England et al. (2017)). More importantly, it set out how it would widen participation by non-banks in the RTGS system.

The Bank of England's first major announcement was designing a blueprint for a new RTGS that responded to changing demands while maintaining its resilience. It was made when Deputy Governor Minouche Shafik gave a speech titled "A New Heart for a Changing Payments System" (Shafik 2016) in January 2016. This was followed by the Governor of the Bank of England, Mark Carney, speaking in June 2016 on "Enabling the FinTech transformation: Revolution, Restoration, or Reformation?" (Carney 2016). The speech's title alluded to the non-committal disposition that the Bank of England had towards Fintech, despite their peer institutions having strongly advocated Fintechs (Financial Conduct Authority and Payment Systems Regulator (2015)).

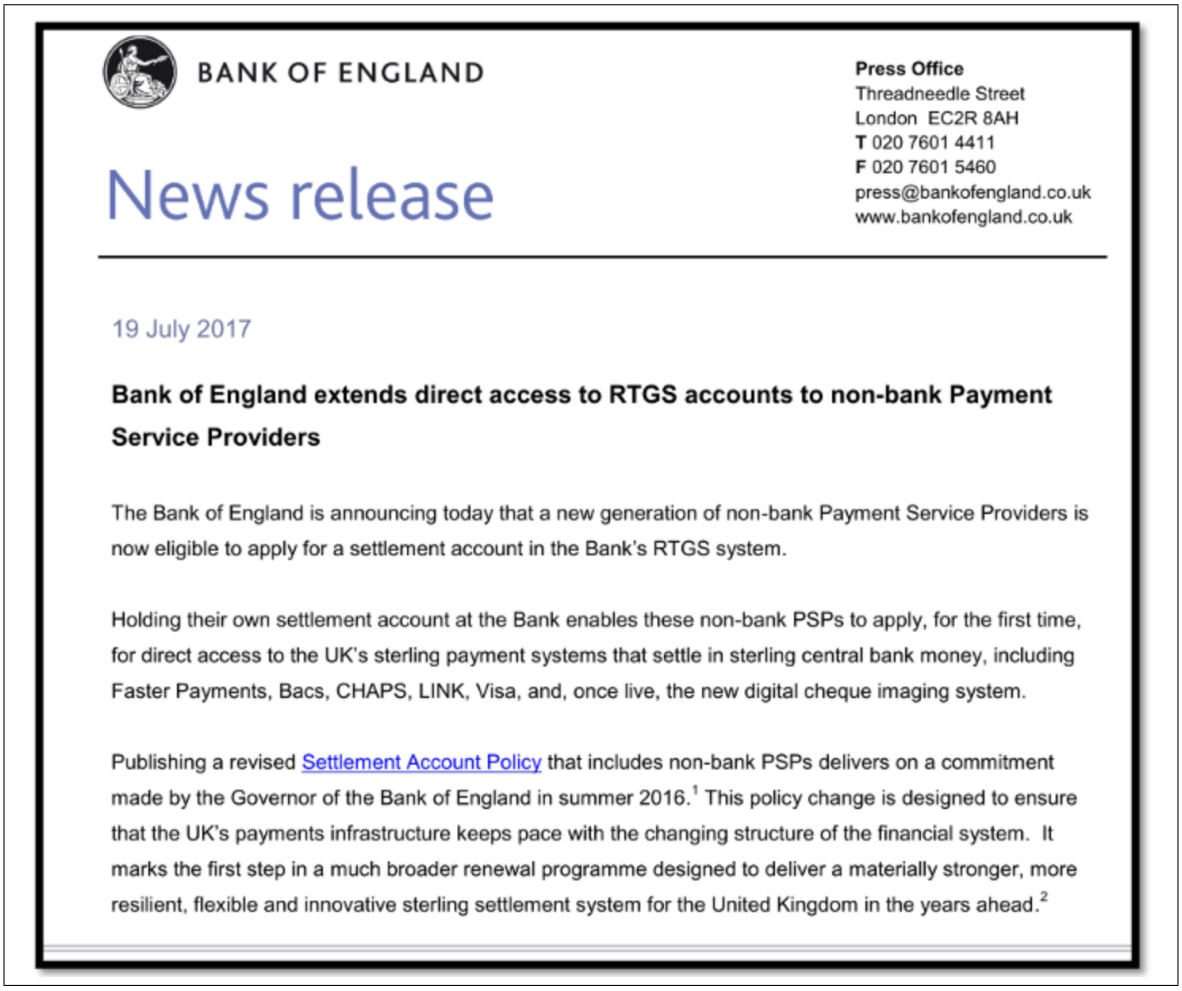
Mark Carney, the Governor of the Bank of England, stated:

> *"Indeed, sometimes when I hear of democratising finance, spreading risk in capital-light originate-to-distribute models, I think I haven't been this excited since the advent of sub-prime… My own forecast is that FinTech's consequences for the bank's objectives will not become fully apparent for some time. Many of the technologies needed to deliver such transformations are nascent – their scalability and compatibility untested beyond Proofs of Concept. Moreover, the bar for displacing incumbent technologies is very high. Nor will the Bank of England take risks with the resilience of the core of the system. Disruption will not come either easy or cheap" (Carney (2016) p.5)*

Despite some apprehension, the Bank of England announced that it would open the RTGS system to non-bank participants in July 2017 (see Figure 6.7).

The statement went on to show that the Bank of England had closely worked with other regulators to find a solution to the access issue faced by non-banks. More importantly, here, too, the disciplinary agency had taken precedence to ensure a comprehensive risk management framework.

> *"That is why the bank has been working over the past year with the Financial Con-*



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News release

19 July 2017

Bank of England extends direct access to RTGS accounts to non-bank Payment Service Providers

The Bank of England is announcing today that a new generation of non-bank Payment Service Providers is now eligible to apply for a settlement account in the Bank's RTGS system.

Holding their own settlement account at the Bank enables these non-bank PSPs to apply, for the first time, for direct access to the UK's sterling payment systems that settle in sterling central bank money, including Faster Payments, Bacs, CHAPS, LINK, Visa, and, once live, the new digital cheque imaging system.

Publishing a revised Settlement Account Policy that includes non-bank PSPs delivers on a commitment made by the Governor of the Bank of England in summer 2016.[1] This policy change is designed to ensure that the UK's payments infrastructure keeps pace with the changing structure of the financial system. It marks the first step in a much broader renewal programme designed to deliver a materially stronger, more resilient, flexible and innovative sterling settlement system for the United Kingdom in the years ahead.[2]

Figure 6.7: Bank of England News Release announcing direct access to RTGS
Source: Bank of England (2017a)

duct Authority (FCA), HM Treasury, HM Revenue & Customs, the Payment Systems Regulator (PSR) and the payment system operators to develop a comprehensive risk management framework to ensure the continued resilience of the Bank's RTGS service.

Before non-bank PSPs can open a settlement account, they must demonstrate compliance with this risk management framework. Several legislative changes also need to complete their passage through Parliament. Consequently, the bank expects that the first non-bank PSPs will join RTGS during 2018." (Bank of England (2017e)).

PSPs (Fintechs) were granted access; however, they needed to conform with the disciplinary agency of the financial system and demonstrate compliance as well.

"To be eligible for a settlement account, a firm must hold a reserves account or be a financial market infrastructure or an e-money or payment institution authorised in the UK by the Financial Conduct Authority. They must also meet the criteria for settlement participation in the relevant payment systems." (Bank of England (2022b))

While there are relatively heavy system requirements to meet, banks' core payment infrastructure monopoly has ended. The RTGS was underway to be replaced with a new and more open architecture, and the Bank of England has stated that it would be designed with industry engagement and consultation.

"The content of this blueprint has been heavily shaped by the responses to the Bank's Autumn 2016 consultation… Overall, respondents voiced strong support for the vision set out in the Consultation Paper. But in a few areas the responses have led the bank to tailor its plans, further strengthening the final blueprint." (Bank of England (2017d))

Thus far, the entities it monitored and supervised had standardised business models and

systems based on international banking regulations and practices. However, with the opening to non-banks, especially those that deem themselves innovative, the Bank of England needed to change its supervisory model to a more flexible one. It also became apparent that the industry valued stability. However, understanding where the market was heading, the Bank of England yielded to the market and took the rules proposed by the new entrants and other regulators. This highlighted the more complex tuning that macroactors face in the light of new entrants accessing a regulated infrastructure.

6.8 Staggered evolution of payments infrastructure

The Cruickshank Report (Cruickshank (2000)) and the Review on Entry Barriers to Retail Banking (Office of Fair Trading (2010)) triggered the opening of the retail payment infrastructure. It took 8 eight years for FPS to be launched to upgrade BACS, which had been operating since the 1960s. It then took another 8 eight years for the New Access Model to be launched (Faster Payments (2014)) for Fintechs to access the system and RTGS to open RTGS accounts to non-banks to settle FPS transactions. The Bank of England announced that the new RTGS system would be launched in 2024. This timeline also showed the time taken for regulated infrastructures to evolve (Bank of England (2022c)).

An interesting point is a trigger by other macroactors that led to a large transformation of the retail payment infrastructure in the UK. Drawing back historically, a document published by the Bank of England in 1987 on the recent development of payment systems (Bank of England (1987)) noted how reports such as the Price Report in 1978 and Child Report in 1984 changed the structure of the UK's payments industry. The lack of access to other payment institutions was the driving force for changing the organisational structure. Observing the type of change that FPS and the new RTGS aims to bring, it could be said that these infrastructures are modelled considering the competing material, disciplinary agencies and agencies of heterogeneous actors. However, as the evolution takes place in much more complex socio-technical settings, with the rigidities of disciplinary agency, the evolution seems less

organic and more administered (See Figure 7.2).

6.9 Interaction between rules and heterogeneous actors

The previous section presented a detailed account of the findings that emerged as heterogeneous actors tuned material resistance in the complex digital infrastructure with the heterogeneous goals and intentions of incumbents, Fintechs and regulators while adhering to the disciplinary agency of the industry. This section analyses rules and how actors interact with them to gain access. The analysis showed three types of interactions between actors and rules and making rules. I conceptualised two actor groups in the theoretical framework called rule takers and rule makers. The terms regulator and regulated were not used as those were terms flowing from formal regulations. As digital infrastructure owners also were able to make rules – these two terms were used to conceptualize actors and their need to make rules or make rules to meet a goal or a responsibility. Analysis of digital infrastructure tuning revealed that rule making and rule taking were dynamic processes, and some actors simultaneously moved between these two states in a continuum (See Figure 7.1).

The three types of interactions are

1. Innovative Rule takers
2. Dynamic rule making and rule taking of microactors
3. Rulemaking dynamics among microactors and macroactors

6.9.1 Innovative Rule takers

Rules governing access to payment infrastructures were broadly two-fold. The first, competition-related laws, the focus of the previous section, and the second, banking and financial sector-related laws, including stability-related laws. Regulatory resistance was a theme which frequently emerged as incumbents and regulators grappled with the complex and dynamic rules

that were being introduced to the industry. An industry body representative commented on the burden that regulations were posing:

> *"There is so much change going on in the sector. The industry is looking at moving to ISO20022, there is a discussion for RTGS opening to TPP [third party providers] and members have a lot of regulatory changes to consider".(i41)*

The payment infrastructures' stability, structure and operations were anchored on rules emanating from multiple domains within the financial sector. These were much larger challenges than gaining technological and regulatorily authorisation to access systems. The authorisation was subject to domain-specific laws such as anti-money laundering, counter-terrorism financing, fraud prevention and safekeeping public funds. As a payment system Board Member (i49) noted the challenge was complying with other financial laws:

> *"The challenges that they have are, I mean, I think, you know, if the dealing with other people's money, today is the compliance and the regulation and the capital required is so significant when the competition authorities talk about the barriers to entry they primarily think about the other participants in the market and anti-competitive behaviour on their part and yet if you think about barriers to entry into the, into managing, into touching other people's money, it has nothing to do with the other competitors as much as it has to do with current regulations. It's your big barrier tank. The compliance, the regulation and the capital required is significant. That's where the challenge I think really comes. If you can find these, if you can see an opportunity, but getting the capital behind you to do it properly is where the challenge is." (i49)*

As a regulated digital infrastructure, most rules, either private infrastructures such as banks and card networks or industry infrastructure such as FPS, were adhering to either broad or specific national regulations or international requirements. Non-compliance could be equivalent to punitive consequences, including losing access to the infrastructure or license altogether. Success in financial services requires a substantial commitment to rules and regu-

lations. This risk led to actors harnessing the resistance by creating products that eased the complexities of regulatory compliance:

> *"We think that unless you have a scalable engineering solution for compliance and security it will always remain an engagement of banks with developers it will always remain very slow and definitely friction and a very high bar of entry. However, if we can solve these problems, in an effective automated way, we would lower that bar and we can have mass adoption of developers. So we did a number of designs and we did a few things, and in the end this is all very well, this should work and as a company we should not do this repetitive work in the hope it will be a success eventually." (i25)*

From the Fintech, which issued white label virtual cards, (i27) made the following observation which resonated with the statement by (i25) above:

> *"Regulation, you can't replace regulation by technology. What you can try and use technology for is to ensure maximum compliance with regulation." (i27)*

(i27) was the head of product and strategy at Fintech. Fintech had a clear understanding of its regulatory obligations to the sponsoring bank and the role of the bank. The products they were offering had found a niche control point within the regulatory context that had flexibility. Within this flexibility, they had a standardised process that was efficient and regulatory compliant. They had clarity of the rules they were fulfilling and were satisfied with the balance the solution offered:

> *"It's standardised. But yet it has to be taken to the bank. But then, with the bank it's not normally a negotiation per say. It's more an approval process. For example, if you talk about a card programme, if somebody comes to us and they tell us that they want to use a platform to launch a new travel card product on the market. Something like Revolut for example. The bank just has to make sure that the people that we are engaging with they have been KYCed [sic]. Any material*

that has been produced with regulation, that is, typically sort of rules governed by Mastercard or Visa and it complies with all of that. And then, that's it. So, the whole process is already streamlined and so it's not so much of a negotiation or an approval from the bank, it's a more like, okay, here is an opportunity. These are the rules that we are fulfilling and that's it." (i27)

(i27) would be a classic rule taker who focused on thriving in the new markets where technology had enabled unlicensed actors to extend a regulated value chain. The bank also could reach markets through Fintech that it otherwise could not. Thus, there was a mutually beneficial relationship and a positive take of regulation. This was one end of the continuum.

Two other Fintechs interviewed were tuning technology to navigate complex regulations, and this was a value proposition of their product. They developed Fintech solutions to help Fintech developers and smaller banks are regulatory compliant at a lower cost and retain the freedom to innovate. A founder of Fintech (i25), a licensed e-money institution, was developing a super app that gave other payment institutions and Fintechs a single access point for multiple banks and other financial services to develop products. He noted that the introduction of PSD2 eased the development regulatory compliant interoperable platforms:

"It's like solving a puzzle, there are many many ways around the problem. One route is to link it to the gateway with a bank. Other banks have their own projects that open up their internal, which we are working with. So the PSD2 just makes that a lot faster. I mean that when we connect two banks rather than connecting per bank, certainly with the European zone and hopefully the UK follows suit at the same model." (i25)

Within this high-risk context, there were heterogeneous approaches to interacting with the regulation and the rulemaking process. These ranged from actors who thrived within the regulatory boundaries and felt that regulation was not something the regulated could tamper with to those who thought otherwise. Costs of compliance emerged as one of the main reasons for Fintechs and even smaller banks to use services that addressed their ability to

meet these regulatory requirements. However, it was also a reason that Fintechs could not survive in the industry.

> *"They have and we have seen examples over the last couple of years, because sponsor banks are starting to pull away from offering services to certain types of PSP or they are concerned that the PSP may not have the appropriate AML and KYC checks in place." (i47)*

The quote by (i47) highlighted the level of risks banks were bearing and why Fintechs may not be unable to cope with domain-specific regulations. This revealed that Fintechs joining the industry with minimum investment in infrastructure and without licenses were largely at the mercy of the licensed incumbent providing them access. It also revealed that as rules were manifesting in disciplinary agencies, that non-conformance or non-compliance could be a high-risk strategy for Fintechs. Thus, to survive and excel in the sectors, it appeared that Fintechs had to be rule takers even though most of their models were to minimise regulatory interactions.

6.9.2 Dynamic rule making and rule taking of microactors

During the analysis, incumbents demonstrated their ability to make rules while conforming to industry regulations and disciplinary agencies. This was seen at the private infrastructure level at banks and card networks and a payment infrastructure level. Thus, while analysing subthemes relating to tuning, it emerged that there was a process of dynamic rulemaking where they had a control point within their licensing ambit.

Incumbents were almost licensing and supervision agents of regulators as incumbents evaluate the new entrant's eligibility and compliance levels when deciding to provide the connections. This control was also technologically imposed within the law. PSD2 was not in operation at the time of interviewing, and many modalities relating to it were being finalised. However, a banker (i5) involved in industry-level discussion relating to its adoption in the UK noted the following:

"I think what we will see is that we will see APIs coming up and some will be good and some will be crap. And then over time, hopefully in the banks' own interest they will publish good APIs and they may not all be the same, but my feedback from a lot of FinTech was it doesn't really matter if the APIs are the same or not. As long as it's API technology, we can actually implement that connectivity pretty quickly." (i5)

Banks were already expected to manipulate the control point relating to APIs for their interest. However, connected to this quote implies that Fintechs, even though they are rule takers, is seen as if they are happy with any API versus none.

Another reason this category is dynamic is the time it took for actors to make rules. Infrastructure owners locally change rules; therefore, it takes much less time:

"The issue with regulation is that it takes years to come out. The regulator has so many processes to follow before a regulation is ready. Where as if you take a card network, the rules are made by them and ready to be implemented." (i21)

This microlevel ability to make rules was also a power that payment infrastructures had and was used to ensure that all participants met the access requirements:

"No, we tell VocaLink our infrastructures require to log a bank off and they will log them off. Whilst 40 people within Faster Payments here, there is about 400 people in VocaLink involved in running FP for us. We have SLA's [service level agreement] and protocols and all sorts of stuff. If there have to be a corporate bank having displayed very erratic technical behaviours, we can require VocaLink to log them off if the bank won't do it themselves, we have those powers. And with our rules we have the ability to suspend pockets, being found and suspend them." (i47)

Modular architecture allowed the infrastructure owner to enforce a rule, and the authority given to them by law gave them the discretion to ask the infrastructure provider to suspend

the problematic connection if the participant did not comply with the request. This power and discretion ensure that the risk brought in by the participant to the system is not spread to the rest of the system.

Microlevel rulemaking also appears to flow from a disciplinary agency as those with rulemaking powers could lose their position if the system operated by them or the Fintech they provide access to exposes the system at risk. The level of disciplinary agency exercised by actors demonstrated the level of material risk embedded within the payment infrastructure through interconnectivity, necessitating enforcement of discipline via laws.

6.9.3 Rulemaking dynamics among microactors and macroactors

Due to the vibrancy of the UK's payment industry, the UK has become a global Fintech hub:

> *"That's why London ended up becoming a FinTech hub for example, because you have access to financial services. You have access to investors, the UK government is quite favourable and the regulator is quite favourable to innovation." (i27)*

It also had an extremely complex institutional framework where both system stability and competition were regulated. As seen in Figure 6.8, which plots all actors against institutions and timelines. This was plotted based on the documentary research. There are multiple regulators and microactors. The key event and timeline of the infrastructures indicate that events and government reports trigger the change in the industry. It must be noted that the competition regulators were established after 2000. The institutional framework appears dynamic, with the government responding to changing needs of the market. Both regulators see the attempt to bring Fintechs into disciplined practices having a Fintech sandbox and an accelerator.

Even though the regulator has the legal power to make rules, the UK adopted a participatory approach to rulemaking at a macro level. Thus, industry forums such as the Payments Strategy Forum enabled industry actors to develop the national payment strategy and present

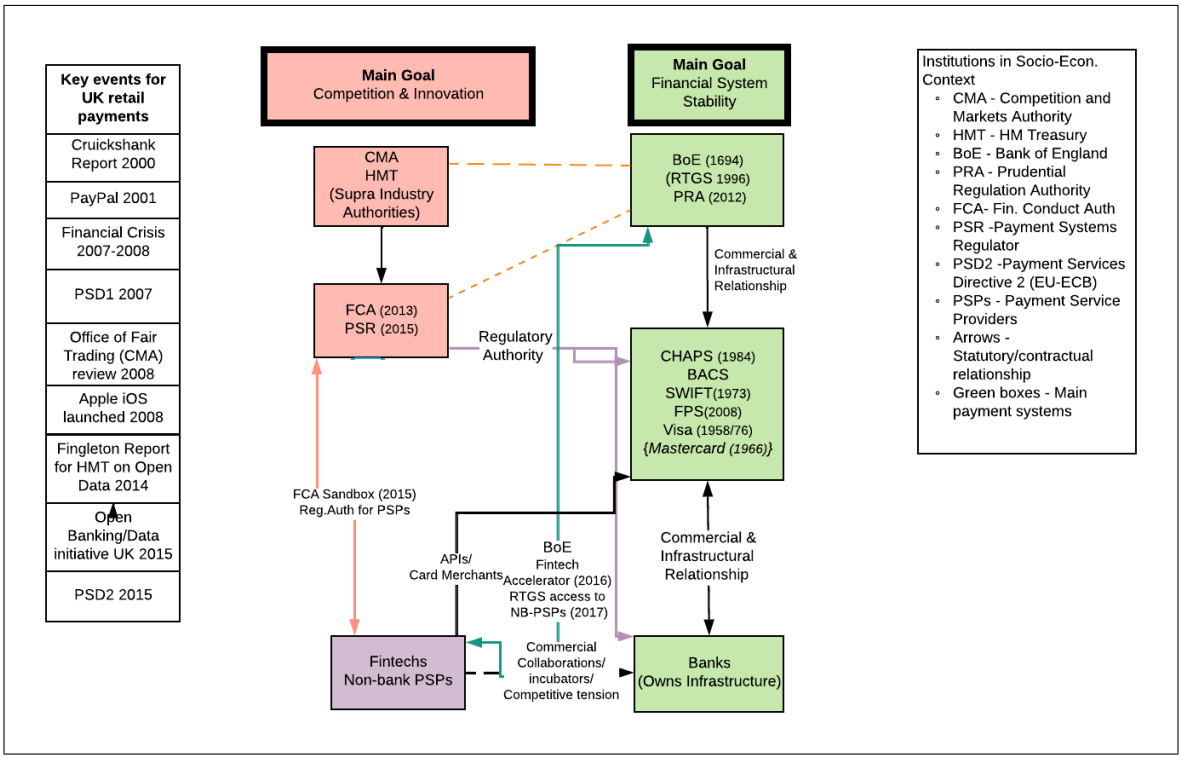

Figure 6.8: Institutional framework of the UK's payment industry
Source: Author

it to the regulators for implementation (Payments Strategy Forum (2016)). During the interviews, a member of the forum shared the plans to merge the retail infrastructure in the future. The "New Payment Architecture" referred to below was announced (after data collection was completed).

> *"If we talk, for example in the UK payments regulator context where I am on the Strategy Forum, we are actually creating a payment eco system of the future which will have API as an enabling access route to payment systems. And we will potentially merge CHAPS, BACS and Faster Payments all on one platform and then API would be a functionality to access and choose whether you want to pay through CHAPS or Faster Payments or something else. API has not only PSP information travel between third parties and banks, but it would allow lots of other things to be done, which is why the UK open banking sort of initiate is much broader than of course, PSD2 and I think that's where the future is going, that API will be secure." (i5)*

The regulators also understood that financial system stability was crucial even though they were regulating for different purposes.

> *"We also work very closely with the Bank of England who are rightly very focused on the sort of financial stability resilience and quite rightly again if they feel there is a concern they will talk to us about any concern they have about the way that we are going. But overall I think they have a coherent set of duties and I don't think they automatically have to conflict." (i55)*

The findings revealed that national, industry level and system level regulations and rules governing access to UK's payments infrastructure are not developed in isolation by the relevant regulatory authorities. Instead, access rules to payment infrastructure were almost like a composite manifestation of complex micro level and macro level tuning of interest and goals of heterogeneous actors and material and disciplinary agencies. Thus, rulemaking was a consultative process where microactors felt ownership of the rules and infrastructure being implemented, thus, giving them flexible roles within the rulemaking structure.

6.10 Answering the research question and subquestions based on the empirical findings

I begin by answering the first subquestion: "How do actors tune regulated digital infrastructures for access?". This question focused on the material aspects of digital infrastructure, where actual technical access was gained. To analyse the data, I developed an "Analytical framework for tuning regulated digital infrastructures" where heterogeneous actors were grouped by their legal status within and outside the regulated environment. It was conceptualised that three agencies were emanating in the context: disciplinary agency arising from the financial system – where actors had to adhere to a certain discipline often manifested by law, to maintain system stability, the material agency of the technological systems, and the agencies of the heterogeneous actors.

Due to the complexity of the context, the analytical framework was operationalised through a framework that depicted alternative avenues of tuning for access by Fintechs. The results showed that all actors tune material agencies and heterogeneous actor relationships in gaining access. For example, banks tune their firm and conduct along disciplinary agency and technical requirements, gaining the highest level of access as a bank. This is similar to card networks. However, a banking license is insufficient to gain full direct access to the payment infrastructure. Banks must meet high disciplinary agency and technical standards set by the regulator to gain full access to a payment and settlement system. To avoid ineligible actors exposing the system to risk, the regulator and operator introduce tune entry requirements to ensure that the participants pose no risks to the system.

Due to the high technological and regulatory entry barriers, Fintechs began harnessing the versatility in digital technology to find indirect access paths to the infrastructure. Some incumbents tuned their legacy systems to move into more platform-based service, while others made their regulatory status a strategic resource to connect Fintechs to the infrastructure. However, all combinations of tuning showed the innovative use of systems architecture and the boundaries of licenses.

Payment infrastructure was remodelled, reflecting market needs. This process took longer than changing private infrastructure. Tuning of access to infrastructures also accommodated resistances arising from legacy systems and the installed base. It revealed that when material resistance cannot be accommodated, tuning becomes ineffective, and a new system will need to be modelled for actors' goals.

The interactions demonstrated how significant disciplinary agency was. While actors gained access through direct and multiple indirect means, all actors were brought into the disciplinary framework to ensure that regulator compliance and financial system stability were ensured.

SQ2: How do actors interact with rules governing access to a digital infrastructure?

The digital infrastructure had regulators and regulations. While regulators had the formal legal authority to regulate, incumbents exercised discretion in implementing rules within their infrastructure. Fintechs, having no license or infrastructure, appeared only to be rule takers. However, incumbent cards and banks used control points created by law to generate value through innovations. Finally, at the regulator level, regulators allowed microreactors to participate in the rulemaking to ensure a balanced view of many participants, thus, in turn, ensuring that all actors were subject to fair laws and rules.

Chapter 7

Discussion

This chapter discusses the empirical findings relating to how heterogeneous actors gain access to regulated digital infrastructures along the themes identified in the literature review to contribute to the literature. In the literature review, I drew from the expanse of digital infrastructure research to anchor the study within the area of access to regulated digital infrastructures. I explored the issue of access to regulated digital infrastructures through the theoretical lens of the Mangle of Practice advanced by Pickering (Pickering (1993);Pickering (1995);Pickering (2002);Pickering (2006)) and extended within information systems research (Barrett et al. (2012); Venters et al. (2014); Eaton et al. (2018)) to dissect complex sociotechnical interactions where actors seek contest with the material environment to reach desired goals.

The findings draw upon broad themes identified in the literature review and recently emerging in information systems-related literature. Referring to key observations made during the empirical study, I present the contribution they offer to the literature.

I begin with regulated digital infrastructures, which is a highly under-researched area (Henningsson and Eaton (2022)) but growing in importance as regulated sectors adopt digitalising their sectors (Ozalp et al. (2022)). I present the significant findings related to the research relating to regulated infrastructures and payment systems.

Further, I review how the definition of digital infrastructures to the definition provided by Hanseth and Lyytinen (2010) as "shared, unbounded, heterogeneous, open, and evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities" relate to open, heterogeneous, installed base and aim provided a framing to distinguish regulated infrastructure for analytical clarity.

7.1 Regulated Digital Infrastructure

7.1.1 Strategic importance of Disciplinary Agency during tuning for access

The findings showed that disciplinary agency had overriding strategic importance permeating every aspect of the payments industry and infrastructure. The disciplinary agency was manifested through regulations, systems architectures, system rules and access rules and was integrated into measures to avoid systemic risk before any other goals. The actions and decisions of regulators, system operators and incumbents were highly disciplined to avoid any systemic risk that could easily be spread to the entire system (contagion effect). Regulations relating to payment infrastructures often reflected prudential requirements to ensure financial system stability.

The findings also showed that disciplinary agency had become a strategic resource for actors within the payment infrastructure. Many Fintechs lacked disciplinary agency as they were not from the domain. Therefore, together with former bankers, both banks and Fintech had created partnerships that rested on providing services specifically relating to accommodating disciplinary agency. These included partnerships such as being a sponsor bank or white-labelling or commercialising their knowledge relating to the disciplinary agency itself through incubators and acquiring Fintechs. Fintechs with disciplinary agencies offered to tune for the system requirements that we needed yet could not be afforded by smaller banks and Fintechs. Thus, the market reached different business relationships other than a

competition to operate with it (Hedman and Henningsson (2015)).

As the disciplinary agency was a conceptual extension from Pickering's Mangle of Practice (Pickering (1995)) into the realm of infrastructure rules, I was conscious of the characteristic of rigidity that Pickering had given disciplinary agency. Thus, the underlying purpose of reflecting system rules and regulations that temporally emerged in discussions was considered to see whether they emanated from competition rules or disciplinary rules. The findings were consistent with Venters et al. (2014) study where actors with knowledge of the discipline ensured that it was always applied, resulting in either positive collaborations with other actor groups or sometimes collaborations with Fintechs were rejected.

Installed base

The asymmetry of agency (Pickering (1995)) often arose even though the heterogeneity of actors, the inertia of legacy systems and the installed base (Hanseth and Lyytinen (2010); Venters et al. (2014)) made agencies of actors and material artefacts individually very strong. Through experience, training and law, the financial sector focused on ensuring the system's stability. Thus, decisions to isolate risky systems or replace them also were largely anchored on the disciplinary agency. How the payments industry used technology to tune resistances emanating from disciplinary agencies reflected the versatility of the layered modular architecture of digital technologies. Actors, when trying to reach their goals, harnessed the versatility of digital technology, such as modularity and layered architecture, and connecting technologies such as APIs to isolate components that would pose a high risk of failure during an upgrade or even routine operations, thus regulating the behaviour of systems through architectural measures (Henningsson and Eaton (2022)). Given the large installed base of legacy systems with incumbents, the material agency was very pronounced and risky. In addition to technological means, non-technological ways to capture material agency were used, such as Fintech acquisition, so that the core banking systems were not directly exposed and banks could still reap the benefits of Fintech. Where resistances could be captured, architectural means succeeded at capturing the material agency. However, where inertia was so strong

and such modularising was no longer feasible, actors would make the costly and difficult decision to replace the system with a new one or replace the system. This was observed in the industry payment infrastructure itself. However, consistent with the literature on installed base (Hanseth and Lyytinen (2010); Venters et al. (2014); Osmundsen and Bygstad (2022)), with the example of FPS, it is seen that even new infrastructure was tuned to fit the legacy messaging standards of bank systems using gateways while new architectural solutions (Yoo et al. (2010a); Henningsson and Eaton (2022)) allowed risk-based tiered access to new entrants.

Regulatory compliance

The strength of intentionality of all actors was revealed as each furthered their goals. The Fintechs often sought the support and influence of external actors such as the competition regulator and lobbyists to drive a wave of change in the industry infrastructure architecture. This finding is similar to distributed tuning in the Apple iOS platform as developer power dynamics and influence of actors resulted in actor reaching their goals (Eaton et al. (2018)). However, the major distinguishing factor is that this infrastructure was regulated, which placed a rigid requirement that all actors had to comply with. One of the developers' main actions in Apple iOS was a jailbreak. In a regulated infrastructure, jailbreaking would be a criminal offence. Further, the regulators were also limited in the regulatory scope, which was subject to the disciplinary agency. Therefore, compliance requirements resulted in the regulation of openness, heterogeneity of systems and actors' actions. This was reflected in how licensed actors were responsible for the security and compliance of the apps and systems they provided infrastructure to, including compliance with banking regulations, making the disciplinary agency a strategic resource for those with it.

7.1.2 Socially determining access, locally determined openness

The continuous journey of the Fintechs and the industry for over 15 years until direct access was achieved is indeed laudable. The journey also made way for innovations and partnerships

between banks and Fintechs, and the creation of new businesses that tuned resistances for both Fintechs and smaller banks, increasing openness at the firm level. This process showed the modification of actor goals (Pickering (1993)) to solutions that appeared more advantageous to them than direct access. This was reflected as they had ceased tuning and felt they had found the best path. The mangling of agencies at both the macro and micro levels was prevalent in the final solutions relating to access. Fintechs needing access was required to meet technological and financial requirements similar to banks, and new actors were created in the infrastructures (aggregators) so that Fintechs were not compelled to use banks for access. However, FPS aggregators acted as gatekeepers similar to banks in the previous model. Each control point created business relationships and needed technological investments to maintain disciplinary agency and compliance with regulations effectively. This resonated with Wiener (2004) 's observations that regulation directed resources to policy priorities. Thus, having high regulatory and technological safeguards to the core infrastructure exposed the actual intentions in most Fintechs, which appeared to be not always direct access, but the most feasible business solution.

Technological advancements enabled faster clearing and settlement of transactions. However, to reap the benefits, participants had to make substantial investments. The service goal of payment infrastructure was high reliability and security. Thus, any actor joining the core system must be able to commit to the hardware and communication link requirements along with mandatory testing. Further, banks also had to maintain sufficient funds in their settlement accounts to ensure real-time settlement. Thus, many smaller banks opted out of direct access and obtained agency access. Some smaller banks made large investments as a business strategy to provide access to payment systems to Fintech. This indicates that access had yet again become an economic issue with either regulatory or business solutions (Baldwin and Cave (1999); Frischmann (2012); Kazan et al. (2018)). However, the business value came in the sponsor bank taking on the risk of the Fintechs lacking disciplinary agency by providing them access via their systems or licence.

This aspect demonstrated that a technological characteristic enabling interoperability and sharing could also expose everyone to risk. Technological risks have been a key element considered by networked industries, which require technological and financial resources to fulfil. Digital infrastructure literature mostly has focused on the generativity and evolution of digital infrastructure (Zittrain (2008); Henfridsson and Bygstad (2013); Osmundsen and Bygstad (2022)), highlighting the benefits of increasing infrastructure usage. However, risks of openness may require academic attention as regulated industries increasingly adopt digital infrastructures. Therefore, understanding the risks of access would be needed.

This research also showed that the notion of access had evolved with technology. With older technologies, access was almost a binary option based on licensing. However, with secure connecting technologies and flexible architecture, the concept of access has become layered, where actors can determine access to infrastructure through local negotiations as well and connect indirectly with relative ease (Hanseth and Lyytinen (2010); Yoo (2012); Eaton et al. (2018); Kazan et al. (2018)). This observation expands the conceptualisation of access to digital infrastructures. The research very specifically focused on the conceptual point of access, whereas most research had focused on technical access, while a few referred to physical access to infrastructures (Star and Ruhleder (1996); Racherla and Mandviwalla (2013)). In this research, I concentrated on technical access and how actors tune various sociotechnical factors to access regulated digital infrastructures. As the findings show, access is sociotechnically determined by a three-way mangling of disciplinary, material agencies with agencies of heterogeneous micro and macro actors, thus bringing more social factors into the determination process. Therefore, even if regulated, access rules can still be changed through tuning. However, an actor may take an alternative access path given the costs and time taken to tune access in their favour.

7.1.3 Dynamic Rulemaking and Disciplined Rule Taking

Even though the financial and payment sectors had very powerful regulators with a wide rulemaking ambit, the findings demonstrated that rulemaking was a tuning process that considered disciplinary agency, material agency and competing goals of all actors, including the regulators themselves. The presence of regulators from two disciplines – system stability (prudential) and competition authorities provided an amplified view of regulatory power conflict and convergence. Multiple regulators overseeing the industry, where participants were divided between regulators, demonstrated the complexity of the social context within the UK's digital infrastructure as well as the goals of regulators. While the Bank of England was to prioritise stability, the competition authorities furthered competition in the industry. However, it was observed that disciplinary agency emerged here, too, as the rules giving Fintechs direct access to clearing and settlement systems required a Fintech to make large investments similar to banks concerning infrastructure access. Even though Fintechs often promoted low-cost business models, the system operators maintained the disciplinary agency embedded in the rules. The material agency also emerged as Fintechs wanting direct access required to meet the technical standards of banks.

The high level of cross-tuning revealed that regulated microactors acquired dynamic roles as they interacted with rules. Incumbents and infrastructure operators held control points (Tilson et al. (2010a); Eaton et al. (2018)) with the digital infrastructure that gave them the discretion to make rules. Their rulemaking was subject to the regulated powers, such as licences or ownership and operation of regulated infrastructures. These control points governed access resulting in microactors taking the role of rule makers within the contexts. Nevertheless, the regulator remained a rule maker that balanced views of heterogeneous actors to reach a common goal while not comprising disciplinary agency.

The knowledge on rulemaking in information systems is largely from standards making (Hanseth and Monteiro (1997); Hanseth et al. (2006); Scott and Orlikowski (2013)) and regulation through the use of architecture has been studied within frameworks such as tussle-control

between competing actors (Clark et al. (2005); Elaluf-Calderwood and Herzhoff (2011)). More recent research by Henningsson and Eaton (2022) developed a conceptual model that showed how regulation related to digital innovation was mediated through architecture. They make this contribution by noting the lack of conceptual models within regulated digital infrastructures as the area has not received much academic attention. The recent study by Gozman et al. (2018a) conceptualises four roles in open banking. Their study begins to fill the relatively large void relating to understanding actors' roles in infrastructures and financial services. In this study, I contribute to this new area of literature with a model depicting how regulated microactors acquire a dynamic role between rule takers of regulators and rule makers for unregulated actors who seek access via them. The concept proposed in Figure 7.1 shows that rule makers either have legal powers to regulate or can make rules at a micro level by owning regulated infrastructures or having a licence. Fintechs that are not licensed nor have regulated infrastructure are pure rule takers. Regulators remain rule makers. I attempted to understand rulemaking through Pickering's tuning to see which actors influence a rulemaking decision. Conceptualising actors in roles reveal aspects of their agency and influence. As tuning is based on performance and the dialectic of resistance and accommodation, the purpose of a rule was inferred to understand the factors that influence decisions and rulemaking. This study contributes by giving an insight into the heterogeneous actors' intentions and thoughts. It is expected that conceptualising roles within a dynamic continuum provides flexibility to see the emergence of the agency of actors.

7.1.4 Extending the Mangle of Practice to regulated digital infrastructures

The Mangle of Practice was a suitable theoretical framework for this study. I extend the theoretical framework, based on Pickering's Mangle of Practice, as developed by Barrett et al. (2012), Venters et al. (2014) and Eaton et al. (2018), to the regulated environment and conceptualise that microactors engage in local tuning and can influence macro-level tuning when the need arises. The asymmetry of agency allowed the different agencies to be in a dance of agency. This demonstrated a three-way mangling between material resistances

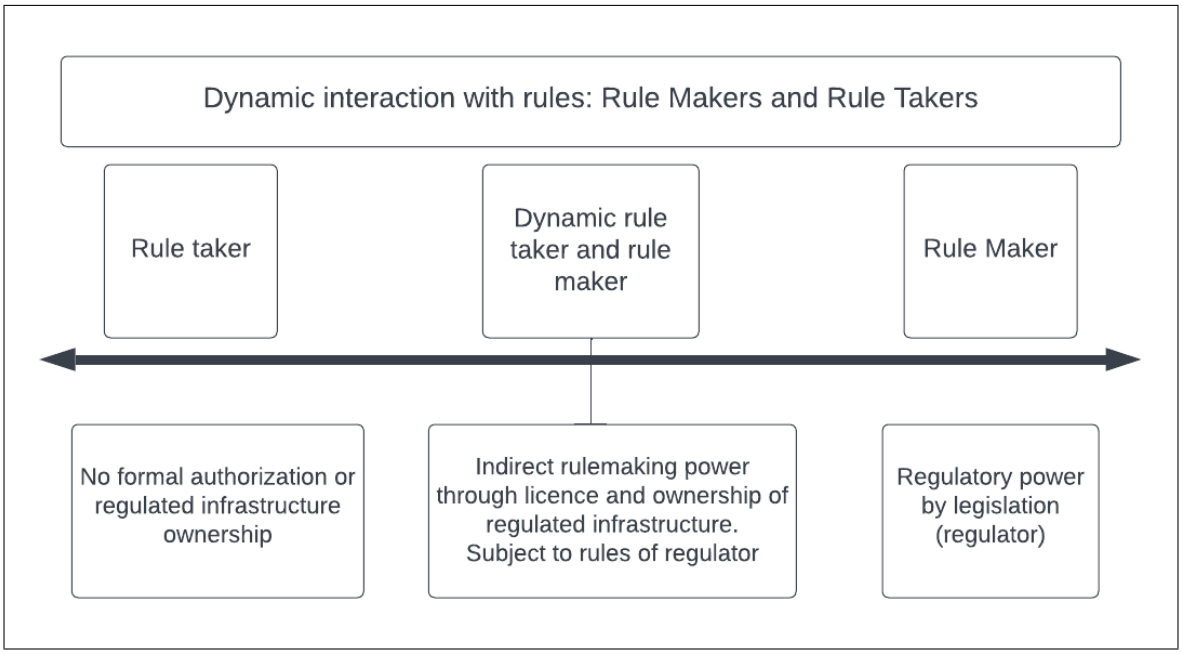

Figure 7.1: Dynamic interaction with rules: Rule Makers and Rule Takers
Source: Author

and human agencies, tuning between heterogeneous actors and material agencies, all while accommodating disciplinary agency into solutions. The findings revealed the rigidities of regulation encompassing disciplinary agencies that directed behaviours to achieve desired outcomes. Further, actions to accommodate material and disciplinary resistances led to actors harnessing each other's resources to find an innovative solution. The regulatory control that actors had over the digital infrastructure allowed them to model (Pickering (1995); Venters et al. (2014)) the infrastructure to achieve desired outcomes for the industry taking into consideration past inertias, disciplinary agencies and the interests and goals of heterogeneous actors.

7.1.5 Access and Evolution of Payment infrastructure

This study contributes to the growing literature on payment systems and infrastructure by providing a disaggregated view of how heterogeneous actors navigate through the complexities of a retail payment infrastructure to gain access to the system. The issue of technological access to payment infrastructures has been studied by Kazan et al. (2018) in the context

of the UK's payment infrastructure. Kazan et al.'s study was limited to actors gaining indirect access, and they explained different access paths using business strategies between incumbents and contenders, who in this research I refer to as Fintechs or new entrants. The findings of this study are in keeping with their study in terms of the strategies adopted by Fintechs to access the system via banks. My findings contribute to the literature and extend Kazan et al.'s work by revealing how actors underwent an extensive tuning process to gain direct access and other alternative access routes that did not require banks, such as payment aggregators. Further, it may not be possible to adopt business strategies to explain opening the final level of access, as the final level of infrastructure was owned and operated by the regulator and used for national economic policy implementation. Thus, even though actors may pay to obtain access, it was not a business relationship. Recently, payment systems have been studied in information systems largely through platform-related perspectives and in light of Fintech (Kazan and Damsgaard (2013); Staykova and Damsgaard (2015); Gomber et al. (2018b); Kazan et al. (2018)). This study joins a growing literature on payment infrastructures and the interactions between micro and macro-level actors to resolve sociotechnical issues (Liu et al. (2015); Mora et al. (2020)). The case study of the UK's retail payment infrastructure and its interaction with Fintechs contributes to a study of global payment infrastructure and notes that with evolution, the number of layers processing a payment reduces(Mora et al. (2020)). This study shows that layers reduce if participants want to accommodate the disciplinary agency and obtain a direct partnership. If not, they can forge business partnerships in the periphery and create new layers. The more peripheral the layers, the less actors are subject to regulation. This study adopts analysing tuning at the firm level of incumbents, tuning between incumbents and others who use or want access to the infrastructure, which I demarcate as the micro level, and then finally, the interactions between the macro and micro levels. Thus, this study resonates with the micro, meso and macro analysis used to understand market cooperation when new actors enter the payment industry Hedman and Henningsson(2015).

Staggered evolution

Strategies adopted by global payment infrastructures to evolve are transactional, modular and institutional (Mora et al. (2020)). There is a significant shortage of literature relating to payment infrastructure when considering the innovations in the industry. I further contribute to that literature by mapping the evolution of the UK's payment infrastructure. It emerged that the infrastructure added a new system almost regularly, every 10-15 years.

The evolution of the infrastructure was mapped along with micro and macro tuning of the infrastructure (Figure 7.2).

It is observed that regulated infrastructure does not organically or continuously evolve as stated in literature on digital infrastructures (Tilson et al. (2010a); Osmundsen and Bygstad (2022)). While regular tuning may take place at the local level generating apps and other connecting systems, the infrastructure itself evolved after significant tensions and tussles between multiple heterogeneous actors were resolved. The findings showed that UK's payment infrastructure is remodelled every seven to ten years as technologies, standards, and expectations change (Scott and Orlikowski (2021)). As new technologies could provide better services and expand participation, the infrastructure could no longer tune its core systems due to the load of the installed base, and new infrastructure and systems had to be installed to model the goals and interests of actors. Figure 7.2 captures this evolution. It depicted how heterogeneous actors would tune the system at a given time until tuning is no longer feasible and an infrastructure level change is needed. At this point, the institutional macro level also is connected to the process. Where the macroactors can remodel an infrastructure, they would do so, but where the past inertias accumulate to a level that cannot be accommodated, the macroactors may decide to replace the infrastructure or components of its. This provides a preliminary conceptualisation of the evolution of regulated infrastructures to understand how regulatory forces limit organic evolution and generation of digital infrastructures (Henningsson and Eaton (2022); Osmundsen and Bygstad (2022)).

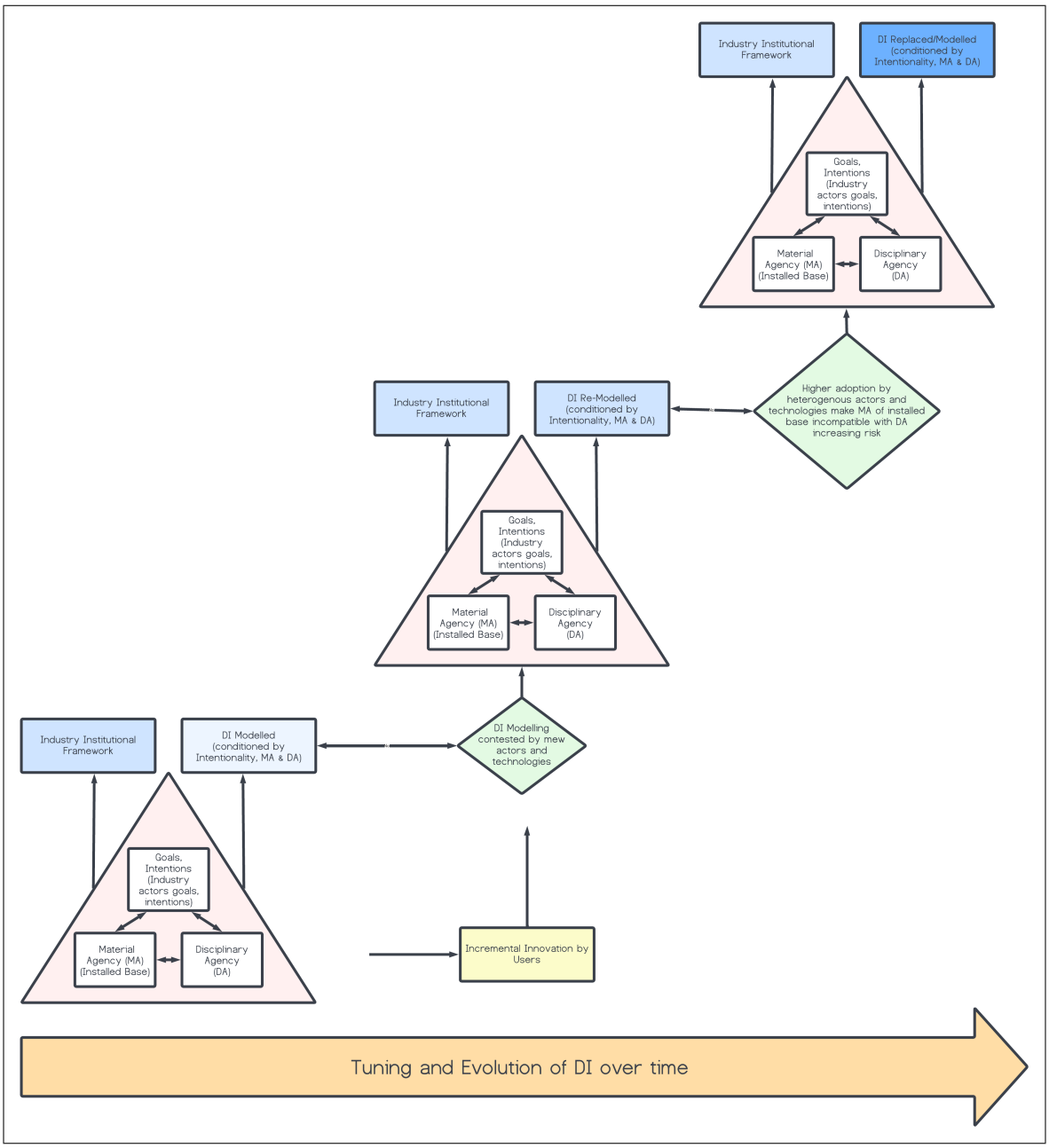

Figure 7.2: Evolution of tuning of regulated digital infrastructure for heterogeneous
Source: Author

Chapter 8

Conclusions

8.1 Overview of the thesis and summary of the findings

8.1.1 Background and research questions

The widespread adoption of digital infrastructures by regulated industries and public services minimises negative externalities on the economy and the public (Frischmann (2012)). This research aimed to extend our understanding of the sociotechnical dynamics of digital infrastructures into the area of regulated services, where actors have to operate by service domain rules in addition to the generally followed technological rules of a system, such as standards (Hanseth (2000)). Services are generally regulated when there is a high risk to the public if the service provider does not consistently meet a minimum standard (e.g. payment services, healthcare telecommunications and education). This also results in licensing for service provision. These rules are written into the software of the digital infrastructures and architecturally controlling access to only eligible actors (Baldwin (2015); Henningsson and Eaton (2022)).

The research was motivated by a dearth of understanding of this dimension of digital infrastructures. Until recently, digital infrastructure-related studies had an underlying assump-

tion of openness and generativity for digital infrastructure (Henfridsson and Bygstad (2013); Grisot et al. (2014); Osmundsen and Bygstad (2022)). While this is true for the contexts studied in those research, there were growing tensions between incumbents of regulatorily ringfenced industries, innovative technology firms and industry regulators, as unregulated technology firms were attempting to access and use core industry infrastructures to innovative and implement new business models. Recently there has been a growing recognition of purpose-specific digital infrastructure regulation across industries and its effect on innovation from an architectural perspective (Henningsson and Eaton (2022)) and disruptive innovations in regulated industries through different business models and architectures (Kazan et al. (2018); Ozalp et al. (2022)). In this study, I take a more granular approach by tracing through the complex sociotechnical milieu of a regulated industry to see how the interests of heterogeneous actors, sociotechnical resistances and externally- imposed laws are navigated so that heterogeneous actors gain access to regulated infrastructures.

This question was explored using Pickering's theoretical lens of the Mangle of Practice (Pickering (1993), Pickering (1995)), which provided performance-based flexible tools to deconstruct tensions and resolutions between actors. The Mangle, as extended by subsequent studies (Barrett et al. (2012); Venters et al. (2014); Eaton et al. (2018)), provided a theoretical framing which enabled me to focus on the resistances that arose as heterogeneous actors interacted with the sociotechnical structure of the digital infrastructure. The findings showed how they either captured or accommodated agencies emanating from the material artefacts, the inherent discipline of the domain or service, and other actors are accommodated in the recursive tuning process. To bring structure to the analysis and draw from the extensive concepts provided by Pickering (1995), in addition to the core concepts in the Mangle, I extended the notion of microactors to actors of the digital infrastructures who are directly connected to the infrastructure, and macroactors to those which have a non-technological legal responsibility or economic interest in the infrastructure, and developing on Eaton et al. (2018), Venters et al. (2014) and Barrett et al. (2012), and bringing heterogeneous actors to the analysis at an infrastructure level. I extended the dialectic of resistance and accommodation of

the Mangle to develop an analytical framework of a three-way mangle of human, material and disciplinary agencies, which concurrently interacted and influenced the path towards the outcome. To operationalise the three-way analysis, I developed a framework depicting the cross-tuning and modelling in digital infrastructures. Finally, as digital infrastructures are made of rules, I developed a conceptual framework to understand how technological, disciplinary and non-technological actors tune rules. This framework helped draw out roles that actors acquired in interacting with rules.

To explore the research question, I studied the tensions between heterogeneous Fintech firms, incumbent banks and regulators as Fintechs sought access to the UK's retail payment and settlement infrastructure. The UK's retail payment infrastructure provided a rich context as it is an almost fully-digitalised, mature industry infrastructure that has evolved for several decades, gaining many sociotechnical layers. At the time of the research, especially during fieldwork, the industry was heavily challenged by Fintech firms and their innovations. At the same time, concurrently, the EU and UK banking and payment regulations were being revised to increase access to non-bank firms to connect to the payments' infrastructures digitally.

The significance of this research is that it provides an in-depth analysis of an almost fully digitalised market infrastructure at a rare juncture of transition when heterogeneous third parties seek access and the infrastructure moves from being closed to more open. There have been calls for research on digital infrastructure (Tilson et al. (2010a)), and such calls have resulted in research focused on a wide range of areas, such as developing new infrastructures while taking into account an institutional-level installed base (Aanestad and Jensen (2011)), the cultivation of corporate infrastructures (Henfridsson and Bygstad (2013)) and the understanding of how distributed actors of digital infrastructures coordinate (Venters et al. (2014)) and the collective action of heterogeneous actors for digital infrastructures governance (Constantinides and Barrett (2015)). This research also conceptualises the relationship between regulated digital infrastructures and architecture-based innovation (Hen-

ningsson and Eaton (2022)). Concurrently, there is a lot of interest in Fintechs, especially payment Fintechs (Hedman et al. (2016); Gomber et al. (2018b)). The UK's payment infrastructure provides a rare opportunity to study the impact of a sociotechnical infrastructure that has evolved over a long period, developing more closed structures. This study complements the more recent work on government regulation of digital infrastructure by Henningsson and Eaton (2022). As the world turns its focus to regulating Big Techs and other large digital giants in the services they provide and the safeguards of the digital infrastructures they have created and extended globally, the understanding of how access is resolved in digital infrastructures has become a timely academic exercise.

8.1.2 Empirical findings

The complex tuning by heterogeneous actors resulted in new entrants gaining access to infrastructure, which was their original goal. Other points in the infrastructure also opened during the tuning process, creating indirect access points to the infrastructure. The tuning process revealed many of the features that have developed in the infrastructure to ensure its higher objective of maintaining financial stability.

The most significant finding was the overriding importance of disciplinary agency emanating from the requirement for financial system stability. All actors and agencies were subject to it as the risk and cost of financial system instability surpassed all other benefits that would accrue by giving prominence to other agencies. This influence extended to the agency of macroactors who had the power to make industry structure-changing laws to achieve their goal. Thus, despite years of tuning by heterogeneous actors to gain market access for Fintechs, the actual entry rules were based on prudential requirements to minimise risk to the payment and banking systems, and the common-control regulation to open access (Henningsson and Eaton (2022)) was tuned to accommodate the disciplinary agency of the domain. The rulemaking process was recursively tuned against macroactors by microactors, material agencies and the disciplinary agency.

Another important finding was that the evolution of regulated digital infrastructures may not always be organic and need not be cultivated by the owners themselves as in digital infrastructure (Grisot et al. (2014); Osmundsen and Bygstad (2022)). Rather they may be modelled for a specific purpose and reach a steady state until an external actor or event compels the owners to remodel the infrastructure. The findings showed that due to the recurrent triggers by macroactors, incumbents move to remodel substantial parts of infrastructure rather than only tune for resistance. In addition, the UK conducted an active consultation process to address market needs. These reports recommended introducing new payment infrastructures that would allow more industry participation and better customer service. The vehement push from the macro and social levels thus resulted in the creation of the Faster Payments Scheme (FPS), the New Access Model of the FPS and the eventual change of the RTGS system. All these changes aimed at Fintechs gradually gaining direct access to the retail infrastructure. During this process, the infrastructure was modelled to enable new goals of actors and this involved connecting back to the past systems to evolve forward.

The recurrent remodelling of the digital infrastructure also indicated the level of material inertia of the installed base. However, in line with the literature, we found that the installed base was accommodated (Hanseth and Lyytinen (2010)) and decommissioned in the worst-case scenario. A new system will recursively need to connect to older systems of other firms, thus bridging the old system into the new.

The accumulation of several generations of legacy systems meant that material agency emerged persistently for all incumbents and affected new entrants, preventing them from making gainful connections with the industry. The incumbents demonstrated that they had evolved and adapted the versatility through technological affordances such as gateways and APIs to connect the old and the new. The extreme inertia emanating from the RTGS system resulted in the systems being replaced.

The industry also increased its openness while securely maintaining the legacy systems due to the risk of crashing during upgrades. The payment card industry made innovative leaps

by becoming an important boundary resource that obscured the infrastructure's complexity and enabled third parties to innovate. It provided a high level of versatility to accommodate most types of payments by Fintechs. However, Fintechs requiring completely direct access continued tuning through the macro and industry levels for direct FPS access.

The tuning for access happened at local and macro levels, which can also be considered social. At the local level, microactors modified resistances for the Fintechs to reach their goals or a modified version. At a social level, we saw the enormous energy taken to tune laws and reach widely accepted solutions.

8.2 Contributions to literature

8.2.1 Access to Digital Infrastructure

The disciplinary agency demonstrated overriding strategic importance relating to access to digital infrastructure that permeated into every sociotechnical aspect of regulated digital infrastructures. Actors with the disciplinary agency could use it to create value-based relationships with actors without the knowledge and discipline needed to maintain industry stability. The disciplinary agency was rigid and was manifested through rules and regulations. Any actor who needed access to core needed to demonstrate that they had met disciplinary agency requirements regardless of other laws permitting their entry.

The literature review demonstrated that access to digital infrastructures was an understudied area. Access seemed to have been outshone by openness, which is similar but not the same. Access refers to more direct access to the core functionalities and economic benefits of being a full member (similar to access to the Internet, perhaps a rare example of access to an open system). Openness in practice has largely provided indirect access through platforms (Parker and Alstyne (2018)) –meaning selected affordances provided by platform owners that enable users to innovate. Thus, the openness of platforms such as Google or Facebook is subject to the affordance they provide. In this research, I contribute to the lit-

erature by clearly distinguishing the two through studying an infrastructure that provides both direct and indirect access to infrastructure. In addition, access to closed and regulated infrastructures is enmeshed by continuous sociotechnical resistances emerging from heterogeneous actors and technological systems as well as the discipline of the domain. Thus, in gaining access, actors would seek alternative access points, generating new innovative actors. Thus, I note that openness is locally determined between firm-level actors. At the same time, access itself is gained through complex sociotechnical tuning and modelling processes by heterogeneous micro and macro actors, making access socially determined. This complements the discourse on control points (Tilson et al. (2010a)) that can have a generative effect on the infrastructure. This research also demonstrated that the notion of access has evolved with technology as it is no longer a binary option. Still, there are multiple levels of access leading to different ends.

8.2.2 An in-depth case study of the UK's retail payment infrastructure

This case study is especially significant as it took place during a period where it experienced a substantial level of tuning from heterogeneous actors that changed the entire socio-economic, regulatory and technological structures of the industry and infrastructure. Large market infrastructures often require long-term stability to ensure a smooth operation; structural changes at both technological and social levels are rarely witnessed but have long-term effects on the industry and the economy, nationally and internationally. Understanding the processes of tuning that the infrastructure must undergo is pivotal to understanding modern digital infrastructures, where the influence of heterogeneous actors, especially at the social level, is inevitable.

This contribution is also significant to the literature on payments. Much of the payments literature has looked at untangling the platform level, as much of the innovation occurs at that level. However, there is a shortage of understanding of payment infrastructures at the holistic level. This study provides insight into multiple processes that will expand knowledge

of this critical public infrastructure and avenues for future research.

Payments infrastructures are ahead of most other public infrastructures in terms of evolution. We see the evolutionary trajectory from being a privately-owned infrastructure to a public one and the complete digitalisation of a market. The case study is therefore pivotal for policy and academia at a time of rapid digitalisation in many industries.

8.2.3 Extending the Mangle of Practice to Regulated digital infrastructures

I extended the theoretical understanding of the Mangle of Practice, as developed by Barrett et al. (2012), Venters et al. (2014), and Eaton et al. (2018) to the regulated environment and conceptualise that microactors engage in local tuning and can influence macro-level tuning when the need arises. The flexibility of the asymmetry of agency in the Mangle of Practice allows us to see that in the case of domain-specific infrastructures, the discipline imposed by the domain will have a strong influence on the tuning process and could only be accommodated through a mangled approach by other agencies. This contributes to Pickering's theoretical lens of tuning. The process of analysing intentions, goals and accommodations as they temporally emerged in practice enables us to see that each actor was different in their responses to the overall phenomenon taking place, thus extending the Mangle to both micro and macro actors.

8.2.4 Dynamic interaction with rules

Digital infrastructures are sets of rules ascribing behaviour and technological standards to ensure the required level of performance (Monteiro and Hanseth (1996); Hanseth and Braa (1998)). While standard making has been heavily studied in information systems, the complexities of tuning national policies and laws into the digitalised marketplace while balancing the disciplinary agency are less understood. This nuance is discussed in digital infrastructure through power and control shifts (Eaton et al. (2018)). The findings demonstrated that even command and control regulations (Henningsson and Eaton (2022)) were not accepted liter-

ally but in principle and adapted to meet the risk mitigation and market safeguards. Thus, the presented model can identify the factors that influence rulemaking and address those in initial rulemaking. From this model, I conceptualised that actors acquire dynamic roles making them rule makers and takers. The analysis showed that incumbent microactors with regulatorily authorised access or ownership of regulated infrastructure played a dynamic role of being a rule-taker regarding rules by the regulator and a rule maker for those using the infrastructure or license to access the infrastructure. Regulators remained rule makers, balancing heterogeneous views while prioritising disciplinary agency. Unregulated Fintech was found to be mostly rule takers.

8.3 Policy implications

The study has several significant policy implications relating to proliferating regulated digital infrastructures.

Gaining access is not a straightforward exercise and cannot be achieved by only amending laws. Regulation could be a less efficient rulemaking process depending on the goals the actors seek. Instead, evaluating the need of actors and tuning socio-material non-regulatory resistances preventing access may be the first to resolve access issues locally. Thus, creating a core-periphery model using architecture (Yoo et al. (2010a)) or licensing (subordinated rulemaking) may be more efficient.

The research further showed that openness and access are not similar to innovation. Therefore, policymakers must decide whether it is needed for openness (indirect access) or direct access that is needed. There are also risks to balancing innovation and stability with costs. Actors who sought direct access to the payment and settlement infrastructure pursued it to circumvent rulemaking microactors imposing higher costs on them. Thus a business control point is removed. Alternative cost-based options such as aggregator services were introduced to reduce the dominance of the incumbent banks about access. However, these ser-

vices were for more mature Fintechs with higher capital to make the necessary investments. In the case of payment markets with existing digital infrastructure, such as the UK, the decision to open payment infrastructures may need to take into consideration the maturity of the firms and balance the cost of opening the infrastructure with the gains to the public at the level to which it would be used. Where the markets have less advanced Fintechs or disruptive firms, having more open architectures such as platforms may provide a more cost-efficient and low-risk alternative to direct access to encouraging innovation and generativity.

Policymakers, too, can consider modelling infrastructure and the regulatory framework to develop a market most suited for the economy. A finding that emerged was that the delay in opening the infrastructure, and the substantial technological and business investment needed to connect to national infrastructure and comply with the regulations, resulted in new Fintechs emerging to resolve these issues through solutions such as cloud services, white-labelling. Policymakers must also remember that it is a regulated industry. Therefore, regulators need to decide the number of firms they can supervise and at what level – this would be an important consideration before opening infrastructures. If regulators cannot regulate large numbers, they need to consider which path would enable them to do so. Finding the right timing to tune infrastructures, high regulatory safeguards, and the balance of pricing access could also act as a generative control point for generating new businesses and business models.

8.4 Validity and research limitations

This research followed the in-depth case study method proposed by Yin (2014). An inductive approach was adopted as the context and phenomenon were both new, thus requiring themes to emerge from the context rather than seeking validation of hypothesis or prior research. An extensive data collection process was undertaken and analysed using the standard qualitative software. Ethical standards regarding the confidentiality of participants and their data were met through anonymising. The findings' validity was analysed against a con-

ceptual framework developed on a conceptual model based on Pickering's tuning and the dynamic nature of the framework of the role.

The research nevertheless has its limitations. This was a complex industry-level infrastructure case study conducted by a single researcher. Although the highest amount of effort was taken to ensure that both the breadth and depth of the issue were captured, this is no doubt less than exhaustive. There may be accidental and unintentional discrepancies, for which I take responsibility as the researcher.

Furthermore, as this is a case study, the common issue of generalisability arises. However, I generalise to theory rather empirically (Eisenhardt (1989); Lee and Baskerville (2003); Yin (2014)). Therefore, the theoretical findings from this research could be validated on a larger scale, as purpose-specific regulated digital infrastructures are increasing rapidly across the globe.

8.5 Future research

This study covered a broad context with many complexities and aspects that could be further researched. The study showed how regulated infrastructures are accessed. The findings of this research can be extended to studying and prescribing how to regulate infrastructures to manage innovation. The research studied an infrastructure regulated by domain-specific and competition regulations. The findings relating to disciplinary agency may be different if high disciplinary agency is absent within the infrastructure. This could also be studied further.

Another area that could be explored is the heterogeneity of infrastructures. While its flip-side, generativity is studied, we still have a limited understanding of heterogeneous actors. The study introduced three models of providing an analytical framework to disaggregate the complexities of sociotechnical interactions and to guide the modelling of infrastructures. I provide one conceptual model derived from the findings on dynamic interactions of rule makers and rules takers, as well as an analytical framework to explore data using concepts from

Pickering's Mangle of Practice. These can be applied in different regulated infrastructures for validation.

Appendix I - Topic Guide

Appendix I: Interview Guide

Research Question: How do Fintechs reshape the payments industry?

Institutional

Interview Guide - 24th Oct. 2016

1. What are the key events that you think have driven/inhibited the role of Fintechs shaping the payments industry, which has been bank-based?

2. Who are the key actors who have shaped the industry?

Banks-

Regulators-

Investors-

Policy experts –

Consultants –

3. How has technology shaped the industry?

4. How are issues overcome through technology-based solutions?

5. Is there a tendency to use regulation or market power or networks to influence the industry?

6. How do you see this reflected in the organization structure of banks and banking practices?

7. In terms of the service that your Fintech provides, where do you see it in the payment process and what has it innovated?

8. What is the license that you use to operate and how do you connect to the payments infrastructure?

9. How do you comply with regulation? Are there automatic processes or do you stay below a reporting threshold?

10. The institutional environment such as BOE is increasingly opening up to non-bank payment systems providers to connect to RTGS, Faster payments etc, what is the impact of this?

11. On January 13, 2018, PSD2 comes into effect. Are you innovating for that?

12. Bio - LinkedIn

13. Would you be able to connect us with others?

Appendix II - Consent Form

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

CONSENT FORM

Full title of Project: The role of Financial technology (Fintech) innovation in unbundling banking services: A case study of the payments industry

Name, position and contact address of Researcher:
Kanchana Ambagahawita, PhD Candidate, Department of Management, London School of Economics and Political Science, Houghton Street, London, WC2A 2AE

	Please initial box
1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.	☐
3. I agree to take part in the above study.	☐

	Yes	No
4. I agree to the interview being audio recorded and transcribed	☐	☐
5. I agree to the use of anonymised quotes in publications	☐	☐
6. I agree that my data gathered in this study may be stored (after it has been anonymised) and may be used for future research.	☐	☐

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

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