The analysis of the Open Banking regulatory impact on a competitive data-driven market

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September 2024

Abstract

The recent development of data-centric technologies such as artificial intelligence urges the transition from a traditional market to a data-driven market. Particularly in the banking industry, Open Banking ("OB") regulations are enforced to open access to clients' data and services. The objective of the regulations is to enhance competition through equal data access and the development of data-centric services, which in turn can create a total surplus. However, various challenges in the data-driven market are related to the problems of entrenched dominant positions, unfair practices, AI applications, and the shift in the distribution of resources and capacity.

The research examines the problems in transitioning from traditional banking to a data-driven ecosystem. Notably, it looks at the impact of OB regulations on the competitive environment. Moreover, as the regulations shift the resource distribution, the research aims to define the just distribution under which the regulatory impact can be interpreted.

The theoretical framework incorporates economics, competition, regulatory, and moral theories, applying the critical realism methodology. Quantitative methods include the Difference-in-difference method to measure the regulatory impact, big data algorithms to extract topics from tweets and user reviews, linear regression and SVM models to measure the network effect and the regulatory impact prediction.

The modelling shows that OB regulations impact the competitive environment through several significant factors. Furthermore, the regulations have increased the total surplus, but it is not efficient under the Pareto test. Lastly, it predicts a possible long-term decline in competition.

Author`s Declaration

I declare that this thesis is a presentation of original work, and I am the sole author. This work has not previously been presented for a degree or other qualification at this University or elsewhere. All sources are acknowledged as references.

Acknowledgement

The completion of this thesis owes much to the assistance and guidance provided by several individuals to whom I would like to express my deepest appreciation.

First of all, I would like to thank my supervisors — Professor Jay Cullen, Professor Phillip Morgan, Professor John Ashton and Dr Simos Gerasimou. I am especially grateful for the support and guidance of Professor Jay Cullen through the initial years of my research, which helped shape the research direction and methodology. I am deeply indebted to Professor John Ashton for his kindness and for inspiring an innovative interdisciplinary perspective in my work.

I would also like to thank my TAP member, Professor TT Arvind, for his constructive advice on formulating the interpretation framework; his insights significantly enhanced the quality of my thesis.

Huge thanks also go to my colleagues, Shivangi Gangwar and Dr Thien Le, for meticulously proofreading my thesis, and to Jonathan Fisk for his unwavering support and for bringing a strong moral perspective to this work.

Last, but not least, a special thanks to my parents and my wife for their love and encouragement throughout this journey. And my little son, who is the constant source of my happiness.

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List of abbreviations

AAC - the average avoidable cost

AI - Artificial Intelligence

AIC - Akaike information criterion

AISP - account information service providers

ANN - artificial neural network

API - Application Programming Interfaces

ASPSP - Account Servicing Payment Service Provider

ATC - The average total cost

BA - before-after

BCAs - business current accounts

C - production cost

CDR - Customer Data Rights Legislation

CFPB - Consumer Financial Protection Bureau

CHAPS - Co CHAPS Clearing Company Ltd

CMA - Competition and Market Authority

CMA - Competition and Market Authority

Competition Act GWB - German Act against Restraints of Competition 2021

DiD - Difference-in-difference

DMA - Digital Market Act

DMU - Digital Market Unit

Dodd-Frank Act - Dodd-Frank Wall Street Reform and Consumer Protection Act

DSA - Digital Service Act

EBA - The European Banking Authority

EC - European Commission

eIDAS - electronic identification and trust services

FCA - Financial Conduct Authority

FED - Federal Reserve System

FFIEC - Federal Financial Institutions Examination Council

FLOPs - the floating point operations

FS-ISAC - US Financial Services Information Sharing and Analysis Centre

GAN - Generative Adversarial Network

GPA - general-purpose AI

ICB - Independent Commission on Banking

IDF - Inverse Document Frequency

IRR - internal rate of return

LDA - Latent Dirichlet allocation

LLM - Large language models

LOCI - Logit Competition Index

LOLR - Lender of Last Resort

LRAIC - the long-run average incremental cost

MADA - Mobile Application Distribution Agreement

MBS - Mortgage-backed securities

MC - Marginal cost

MFA - Multifactor authentication

MR - Marginal revenue

N/A - Not available

NACHA - The National Automated Clearing House Association

NMF - non-negative matrix factorization

OB - Open Banking

OBIE - Open Banking Implementation Entity

OF - Open Finance

P- price

PBOC - People's Bank of China

PCA - Personal current account

PCBS - Parliamentary Commission on Banking Standards

PCR - principal component regression

PI - Payment institution

PISPs - payment initiation service providers

PLS - partial least square

POS - point of sale

PSD2 - Payment Services Directive 2

PSR 2017 - Payment Services Regulations 2017

PSU - payment service users

Q – total quantity

RSE - residual standard error

RTS - Regulatory Technical Standards

SCA - Strong Customer Authorisation

SCP - The structure-conduct-performance

SMEs - small and medium-sized enterprises

SMP - small payment institutions

SOE - state-owned enterprises

SSE - square errors

SWF - social welfare function

TBM - Tree-based model

TF - The term frequency

TFEU - Treaty on the Functioning of the European Union

TPP - Third-party provider

VAE - Variational Autoencoder

VSM - The Vector Support Model

Π – profit

1. Chapter One: Introduction and Research Question

Open Banking ("OB") can be defined as "the sharing and leveraging of customer-permission data by banks with third-party developers and firms to build applications and services, [...]".[1]

Individual jurisdictions may define open banking differently.[2] In other words, Open Banking is that stage of the banking industry where the bank opens access to its client data with consent from third-party providers ("TPP"). OB assists clients in managing and transferring client funds more efficiently.[3] By sharing the users' data and regulating the relationship between parties, the TPPs and banks can reduce product development costs, introduce new data-driven services, and expand the banking ecosystem into a data-driven market.[4] The transition to a data-driven economy is also expected to lower account switching costs and improve competition in the banking industry.

The transition to the OB ecosystem is implemented under the Second Payment Services Directive ("PSD2"). The Directive was introduced in the United Kingdom ("UK") as the Payment Services Regulations 2017 ("PSR 2017").[5] According to PSD2, all payment initiation service providers ("PISPs"),

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[1] 'Report on Open Banking and Application Programming Interfaces (APIs)' 4 <https://www.bis.org/bcbs/publ/d486.htm>.

[2] 'Report On Open Banking And Application Programming Interfaces' (Basel Committee on Banking Supervision 2019).

[3] 'WHAT IS OPEN BANKING?' (*openbanking.org.uk*, 2021) <https://www.openbanking.org.uk/what-is-open-banking/>

[4] Elias Ghanem, 'Open Banking Experiences Set The Stage For Open X' (2019) 4 Journal of Digital Banking.

[5] SI 2017/752

account information service providers ("AISPs"), or Account Servicing Payment Service Providers ("ASPSPs") are under the scope of the regulation.[6] In addition, the regulations require capital, liability, and technical standards for service providers.[7] The Regulatory Technical Standards ("RTS") are separated into a different set of requirements, which are drafted by the European Banking Authority ("EBA").[8] The organisation tasked with creating a secure, uniform standard for connections among clients, banks, and third-party providers is the Open Banking Implementation Entity ("OBIE"), which operates under the trading name of Open Banking Limited.[9] Consequently, the transition of banking to a data-driven market can present challenges and benefits.

The possible issues

The enforcement of data and payment system access regulations may encourage the development of new products and applications of data-centric services, such as Artificial Intelligence("AI"). Lower entry barriers[10] are expected to generate a surplus for clients from the competition of new participants and incumbents.[11] However, network effects may also emerge. The network effect is a phenomenon 'when the value of a product to one user depends on how many other users there are'.[12]

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[6] Art. 2(2), Art. 2(3) and Art. 2(4), PSD2

[7] PSD2

[8] Art. 95,96,97, PSD2

[9] OBIE PMO, 'Open Banking Revision To The Agreed Arrangements V2.5' (OPEN BANKING LIMITED 2018).

[10] It is " *a cost of production for an entrant that is not incurred by the established firms*", George J Stigler, *The Organization of Industry* (University of Chicago Press 1983) <https://press.uchicago.edu/ucp/books/book/chicago/O/bo3645103.html>.

[11] Alasdair Smith, Tom Hoehn and Philip Marsden, 'Retail Banking Market Investigation:Final Report' (Competition and Markets Authority 2006) <https://assets.publishing.service.gov.uk/media/57ac9667e5274a0f6c00007a/retail-banking-market-investigation-full-final-report.pdf>,

[12] Carl Shapiro and Hal R Varian, *Information Rules: A Strategic Guide to the Network Economy* (Harvard Business School Press 1999) 13.

In various data-driven markets, the network effect can lead to one company achieving entrenched dominance. Examples include search engines like Google and social networking sites like Facebook. Therefore, the regulatory impact remains unclear, making it crucial to examine this question.[13]

If OB regulations positively impact competition—i.e., reducing concentration or market power and increasing the banking system's stability—then the rise in total welfare will justify the appropriate distribution of these regulations. On the contrary, if the OB regulations negatively affect competition, total welfare will decline, and financial system instability will increase. These negative impacts contradict the objectives of the regulations. Therefore, the changes in total welfare and market competition raise questions regarding the stability, efficiency, and fair distribution of resources and capacity within the banking system.

Initially, the transformation to a data-driven market was anticipated to give tech companies advantages by deploying sophisticated data-centric AI systems. For instance, Apple and Google entered the payment market with Apple Pay and Google Pay, capturing the majority of the market share.[14] However, big tech companies have not directly entered other OB services. Instead, they enter through their foundation AI, as most large language models ("LLM") AI systems are built from foundation models.

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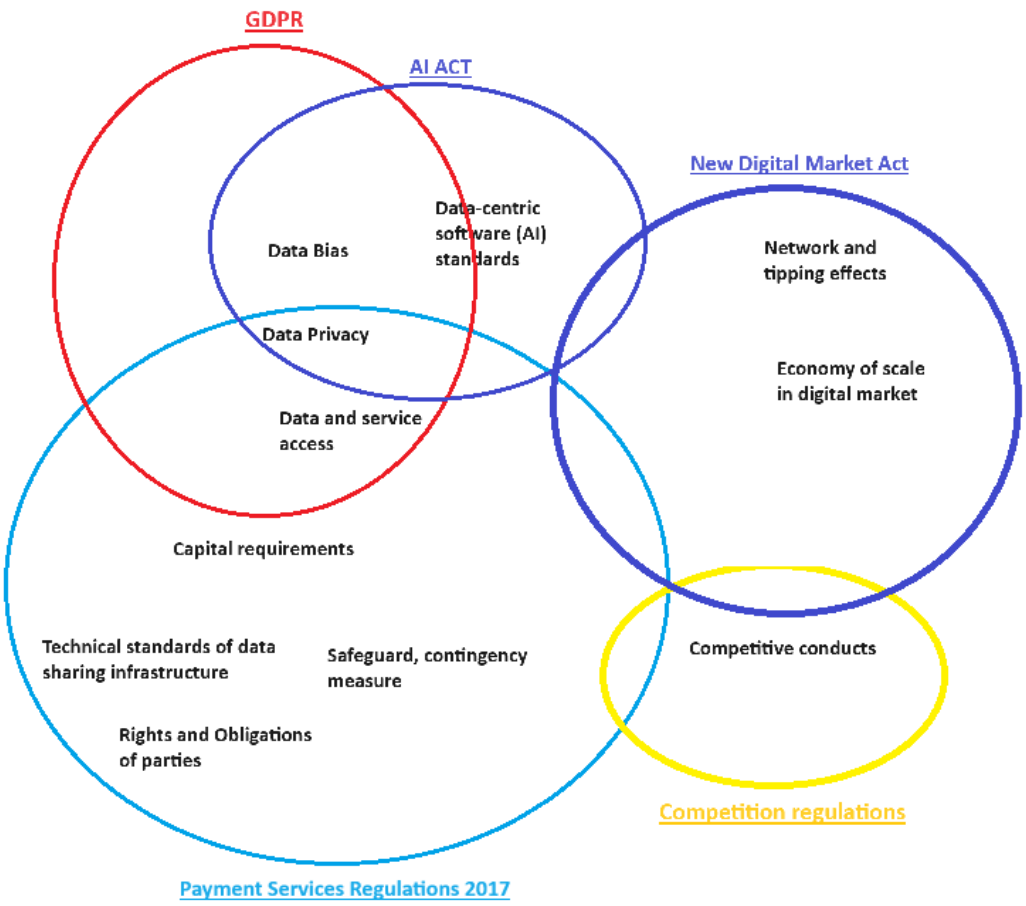
[13] 'Search Engine Market Share Worldwide 2019 | Statista' (*Statista*, 2020) <https://www.statista.com/statistics/216573/worldwide-market-share-of-search-engines/> ; 'Social Media Stats Worldwide | Statcounter Global Stats' (*StatCounter Global Stats*, 2020) <https://gs.statcounter.com/social-media-stats>

[14] Matthew Boyle, 'Digital Wallet Statistics: Usage and Market Size' (*Finder UK*, 27 July 2023) <https://www.finder.com/uk/banking/digital-wallet-statistics>.

To sum up, the problems in the OB banking ecosystem can be categorised as those related to the traditional market, the data-driven market, and the distribution of resources and capacities. The traditional market issues involve the rights and obligations of the parties, capital requirements, safeguards, and contingency measures. Additionally, the challenges in a data-driven market pertain to access to data and services, data privacy, and the technical standards of data infrastructure. Furthermore, the transition from a traditional market to a data-driven market introduces other issues related to the application standards of data-centric AI services and data-driven competition, such as the network effect. Lastly, this transition can alter the distribution of participants' resources and capacities, thereby creating issues of fair resource distribution. The problems and governing regulations in the OB ecosystem are summarised in the figure below.

Figure 1:The problems in the OB ecosystem and the regulations governing these problems.



1.1 Literature review

At the time the research project began in 2020, the OB sector was primarily governed by the Payment Services Directive 2 ("PSD2") and the CMA Order. Thus, the scope of the literature mainly focuses on either PSD2 or the Order. The literature is organised into several sections. Firstly, the PSD2 regulation will be discussed, followed by a summary of the literature on perspectives and strategies for OB implementation. Next, the literature on actual implementations and challenges will be discussed. Finally, the last section will address the implementation costs of OB regulations.

1.1.1 Payment Services Directive 2 and the enforcement progress

Before Payment Services Directive 2("PSD2"), the payment system in the UK was primarily governed by the Payment Services Regulations 2009 and the Consumer Credit Act ("CCA") 1974. The first Payment Service Directive was introduced in 2007 [15]and transposed as the Payment Services Regulation 2009 in the UK.[16] The objective of the Directive was to harmonise the intra-EU payment system.[17] The payment system includes cheques, cards, electronic money, virtual, cryptocurrency, and electronic payment transfer. Each instrument was treated differently under the Consumer Credit Act 1974 ("CCA"), while

[15] Directive 2007/64/EC of the European Parliament and of the Council of 13 November 2007 on payment services in the internal market amending Directives 97/7/EC, 2002/65/EC, 2005/60/EC and 2006/48/EC and repealing Directive 97/5/EC 2007.

[16] SI 2017/752

[17] Piotr Kuszewski, 'Impact Of The PSD2 Directive And Strategic Use Of Costly Innovation' [2018] Warsaw School of Economics, Banking Institute.,p3

the first Directive defined the authorisation regime, transparency requirement, and the rights and obligations of providers and users.[18]

The scope of PSD 2 is broader, addressing new challenges posed by technological innovation. The objective of PSD2 is to reduce the consumer data barrier for third-party providers, promote innovation, and create a secure payment system in the European Union.[19]

The regulation`s territorial application has also expanded to transactions in the European Economic Area ("EEA"). In cases where only one party of the transactions originated in the EEA, the regulation is less restrictive. To reach the objective, the third-party provider ("TPP") of the payment system was established as 'payment initiation services ("PIS") and 'account information services'("AIS") under PSD2. Furthermore, banks that are defined as account servicing payment service providers ("ASPSP") are required to give TPP access to consumer online accounts.[20] PSD2 establishes a new legal framework for TPP, banks, and users. The requirements for accessing accounts are detailed under the Regulatory Technical Standards ("RTS").[21]

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[18] 'Directive 2007/64/EC General Report On The Transposition By The Member States' (Tipik Communication Agency 2011) 5

[19] Piotr Kuszewski, 'Impact Of The PSD2 Directive And Strategic Use Of Costly Innovation' [2018] Warsaw School of Economics, Banking Institute.

[20] Art 4(10)–(12), (15)–(19), Annex I (7)–(8),PSD2

[21] Piotr Kuszewski, 'Impact Of The PSD2 Directive And Strategic Use Of Costly Innovation' [2018] Warsaw School of Economics, Banking Institute. p32

In the UK, the Directive was transposed into UK law as the Payment Services Regulations 2017[22], and is set under the authority of the Financial Conduct Authority("FCA").[23] FCA functions include monitoring and enforcing regulations, reporting, and imposing financial penalties.[24] Credit-customer relationship, contractual rights and obligations of parties, and liabilities of payment system participants are effective immediately after PSR 2017 enforcement.[25] However, the RTS regarding the requirements of application communication between third-party providers and banks were set as a separate regulation. The European Banking Authority ("EBA") was in charge of drafting the RTS under PSD2.[26] EBA officially published the RTS on 13 March 2018 and was supposed to be effective from September 2019.[27] According to the roadmap, the first technical requirements for Sterling accounts, Open data for standardised back-door products, and Service quality metrics should be implemented by September 2018. Those are requirements that the bank`s system should have to provide access to its consumer accounts with Sterling currency and several other services such as loans, mortgages, and savings products.[28] The last requirements on security measures, such as multi-authorisation, two-factor notification, dispute management system, and some other functions, should be completed before September 2019.[29] However, the deadline has been set back several times.[30]

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[22] SI 2017/752

[23] Reg 106, PSR 2017 and 'SUP 15 Annex 1 Application Of SUP 15 To Incoming EEA Firms, Incoming Treaty Firms, EEA Authorised Payment Institutions And EEA Authorised Electronic Money Institutions - FCA Handbook' (*Handbook.fca.org.uk*, 2021) <https://www.handbook.fca.org.uk/handbook/SUP/15/Annex1.html?date=2018-01-13> accessed 3 March 2021.

[24] Reg 108-115, PSR2017

[25] Iris H.-Y Chiu and Johanna Wilson, *Banking Law And Regulation* (Oxford University Press 2019),

[26] Art 95,96,97, PSD2

[27] Ibid 118

[28] OBIE PMO, 'Open Banking Revision To The Agreed Arrangements V2.5' (OPEN BANKING LIMITED 2018).

[29] ibid

[30] Steve Mansfield-Devine, 'Open Banking: Opportunity And Danger' Computer Fraud & Security,p11

Literature on the PSD2 perspective

There is limited literature on PSD2 implementation assessment at the time of the literature review, as the implementation process was still ongoing. However, various studies discuss how PSD2 will transform the banking system. Papers published by Deutsche Bank concluded that the implementation of PSD2 will positively impact the banking industry by enhancing consumer protection and competition.[31] The estimation of the implementation workload is considerable due to new regulations regarding capital requirements, value dating, and multifactor authentication.[32] The work of McKinsey & Company looked at the bank`s side and proposed a strategy to implement the requirements[33]. These strategies included defining the bank`s ambitions and preparing for rapid execution, as well as building a financial ecosystem with third-party applications or API integration with the internal system to reduce costs.

An article by Polasik and others attempts to explain the factors influencing Paytech development.[34] They applied statistical methods, collecting and grouping data from Fintechs in the EU by market potential, payment system development levels, and the public environment, then performing regression analysis to determine the correlation between these factors. Based on these positive factors, the authors identified a favourable impact of PSD2 on Fintechs. Furthermore, the OBIE report

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[31] Sharokh Moinian and Hubertus von Poser, 'Payment Service Directive 2: Directive On Payment Service In The Internal Market. White Paper, No. 2015/2366' (Deutsche bank 2016).

[32] ibid

[33] Alessio Botta and others, 'PSD2: Taking Advantage Of Open Banking Disruption' [2018] Global Banking <https://www.mckinsey.com/~/media/McKinsey/Industries/Financial%20Services/Our%20Insights/PSD2%20Taking%20advantage%20of%20open-banking%20disruption/PSD2-Taking-advantage-of-open-banking-disruption.pdf?shouldIndex=false>

[34] Michał Polasik and others, 'The Impact Of Payment Services Directive 2 On The Paytech Sector Development In Europe' (2020) 178 Journal of Economic Behavior & Organization.

concluded that OB has a bright future.[35] The report outlined benefits for customers, TPPs, and banks by the establishment of new services and the cost reduction of old services. Those services are account aggregation services, personal, SMEs financial management services, automatic overdraft, and other services.

In summary, studies indicate that PSD2 will have a positive impact on banks, customers, and fintechs, supporting our proposition that open banking will transform the banking industry.

The implementation of PSD2

In the UK, the implementation of PSD2 has some specificities. The Competition and Markets Authority ("CMA") published a report on the banking market in 2016, which suggested the need to improve market competition in the banking sector.[36] Under PSD 2, the requirement for a standardised API is not mandatory. However, to design a standard specification of API on security and messaging, manage the Open Banking Directory, and directory enrolment, the Open Banking Implementation Entity ("OBIE"), with trading name Open Banking Limited ("OBL"), was established.[37] Alongside the PSD2

[35] The Open Data Institute and Fingleton, 'Open Banking, Preparing For Lift Of' <https://www.openbanking.org.uk/wp-content/uploads/open-banking-report-150719.pdf>

[36] Competition and Market Authority, 'Retail Banking Market Investigation Final Report' (2016) <https://assets.publishing.service.gov.uk/media/57ac9667e5274a0f6c00007a/retail-banking-market-investigation-full-final-report.pdf> accessed 2 January 2021.

[37] 'About Us - Open Banking' (*Open Banking*, 2021) <https://www.openbanking.org.uk/about-us/> accessed 11 February 2021.

regulation, OBIE provides a uniform standard to secure the connection between customers, TPPs, and existing banks and building societies to share their account information since 2018.[38]

The data on OBIE implementation during the literature review in the UK indicates significant growth in users starting in 2018. There were only one million users in both 2018 and 2019; however, the number of users surged from one million in January 2020 to 11 million in 2024.[39]

Additionally, the connections between banks and TPPS through APIS increased dramatically from millions to billions. The number of registered third-party providers reached several hundred, along with several dozen Account Information and Payment Service Providers, which include AISP and PISP. Despite the large number of FCA-registered AIPSPS, the report on Open Banking API actual connections indicates that only 18 brands from 9 companies are operational for ASPSPS.

To sum up, OB is becoming increasingly significant for the financial industry. The first stage of OB was expected to be completed in 2021; however, it was delayed until 2024.[40] Implementing technical requirements is the most challenging aspect, as it involves designing and coding new software, purchasing new hardware, or replacing the existing banking information system. Upon examining the delays in the PSD2 implementation deadlines, it can be inferred that there may be underlying issues in

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[38] OBIE PMO, 'Open Banking Revision To The Agreed Arrangements V2.5' (OPEN BANKING LIMITED 2018).

[39] 'Delivering the Roadmap' (*Open Banking*) <https://www.openbanking.org.uk/delivering-the-roadmap/> accessed 18 July 2024.

[40] 'RETAIL BANKING MARKET INVESTIGATION ORDER 2017 Notice Of Approval Of Changes To The Agreed Timetable And Project Plan' [2020] CMA <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/885537/Notice_of_proposed_changes_to_the_open_banking_roadmap_-_web_publication_-_cma_gov_uk_---_May_2020_-.pdf>

this area when delays frequently occur. Thus, the next section will focus on the studies of the RTS, PSD2.[41]

1.1.2 Regulatory Technical Requirements

PSD2 was published on 12 January 2016; all service providers are subject to the regulation.[42] There are requirements regarding the capital, liability, and technical standards.[43] The RTS is divided into separate requirements, which the EBA should draft.[44]

Particularly, TPP and AISP should establish a system that complies with the regulations. The structure of regulatory requirements can be categorised into three groups: first, those related to the general structure of the system, which includes the API and the connection standards between participants. The second group pertains to the requirements for the authentication process. The third group addresses the requirements for the monitoring system, which encompasses tracking, recording, and fraud detection requirements for transactions.

Application Programming Interface

The main principle of PSD2 and RTS is technology neutrality. Therefore, the requirement on the API is neutral on the discretion of participants. However, in the UK, the API standard is developed by Open

[41] Art 5, PSD2

[42] Art. 2(2), Art. 2(3) and Art. 2(4), PSD2

[43] PSD2

[44] Art. 95,96,97, PSD2

Banking Limited to expedite system integration. The figure below illustrates the API flow between the customer, AISP and ASPSP, which can be a customer`s bank.[45]

If each PISP, AISP, or ASPSP has its own API standard, the integration of payment service providers with multiple ASPSPS must be repeated, requiring the redesign of API connections. Several groups of companies provide applications according to the Open Banking API standard or the Berlin Group API standard.[46]

For providers in the UK, the Open Banking API is designed by OBIE. The technical service providers are registered at the OBIE directory.[47] Payment Service Provider ("PSP") has the option to develop in-house or purchase a ready-made system and configure it to its specific needs from technical service providers.

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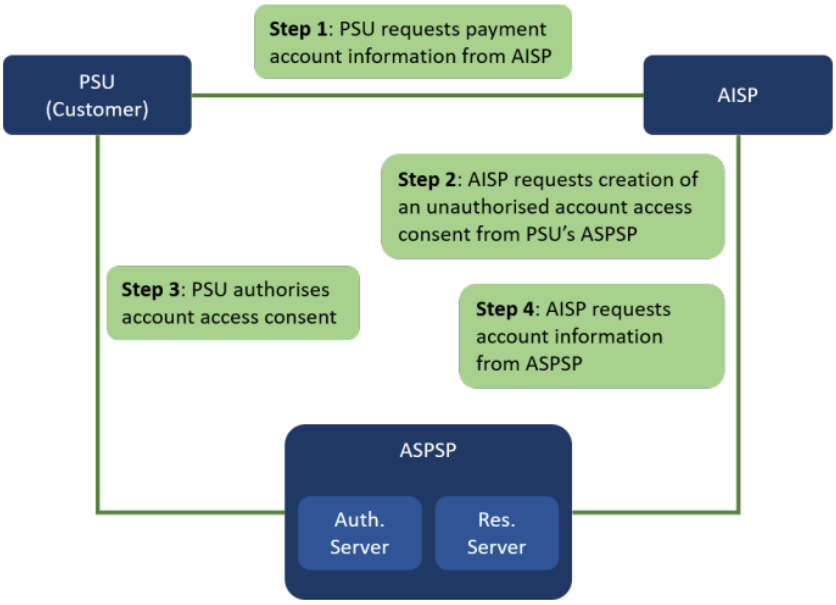
[45]Abdulaziz Almehrej, Leo Freitas and Paolo Modesti, 'Security Analysis Of The Open Banking Account And Transaction API Protocol' [2020] School of Computing, Newcastle University, UK, p3

[46] 'Identity Solutions | Nexus Group' (*Nexusgroup*, 2020) <https://www.nexusgroup.com> accessed 15 November 2020.; 'The #1 Analytic Decisioning Platform To Optimize Consumer Interactions Across All Customer Decisions' (*FICO*, 2020) <https://www.fico.com> accessed 13 November 2020.

[47] 'Regulated Providers – Open Banking' (*Open Banking*, 2021) <https://www.openbanking.org.uk/customers/regulated-providers/> accessed 3 March 2021.

Figure 2 :Data flows through the API between the customer, AISP and ASPSP.



The Account and Transaction API protocol high-level flow

Source: Abdulaziz Almehrej, Leo Freitas and Paolo Modesti, 'Security Analysis of the Open Banking Account and Transaction API Protocol' (arXiv, 28 March 2020) <http://arxiv.org/abs/2003.12776>

Regarding the security issues, Abdulaziz Almehrej, Leo Freitas, and Paolo Modesti attempted to develop an example of an Open Banking API protocol and evaluate the difficulties and security concerns associated with it.[48] Over the course of 35 days, they created a model to test eight security goals: four related to the protection of secret credentials and four focused on authentication. The tests revealed that two goals regarding the AISP's authentication of the PSU's account information from the resource server and the confidentiality of messages sent from the server to the AISP failed. This failure occurred because an intruder could replay a previous message to the AISP, pretending to be a data service

[48] Abdulaziz Almehrej, Leo Freitas and Paolo Modesti, 'Security Analysis of the Open Banking Account and Transaction API Protocol' (arXiv, 28 March 2020) <http://arxiv.org/abs/2003.12776> accessed 1 May 2025.

provider. As such, the PSD2 primary concern is likely security, as the PSU`s data is exposed to various TPPs, which may have inadequate security measures.

In addition, Markos Zachariadis and Pinar Ozcan (2017) reported that the application of open APIS can enhance the network effect.[49] A network effect occurs when platform users gain benefits as the number of users increases. Therefore, the authors argue that opening the API can alter the competitive landscape.[50] Traditional banking can transition to the 'platform–as–a–bank' model, where parties attempt to connect various providers and clients, creating a network effect to attract new customers and extract value from those interactions to gain market share.[51]

From the examples of previous attempts to create an open platform, several issues can arise during implementation, such as speed versus security, acquiring customers with a new branding environment, and determining what to develop in-house and which applications to purchase from external providers.

One example is the cooperation between the telecom and banking industries in payment services.[52] For fifteen years, the parties could not agree on the level of security in communication. Telecom providers wanted to use the existing, less secure API for transactions, while banks preferred higher security standards. At first glance, this issue resembles the delay of SCA in Open Banking

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[49] Markos Zachariadis and Pinar Ozcan, 'The API Economy And Digital Transformation In Financial Services: The Case Of Open Banking' [2017] SSRN Electronic Journal.,

[50] Ibid

[51] Ibid 13

[52] Ibid 20

implementation. However, the disagreement over security standards can be resolved by a centralised authority, OBIE, to design a standard for all parties.

In summary, for the banking sector, security is often the most concerning issue because banks open their systems through APIs to share client account data with other parties, making them vulnerable to external attacks.

1.1.3 Challenges

The implementation of regulatory technical requirements is a complex process in which providers give feedback and make requests during the implementation phase, while the competent authority adapts and responds to new challenges. The reason for the deadline pushback may stem from the complexity of implementing authentication and other security measures, which require consensus between providers and the supervisory authority on the ongoing issue. Hence, this section will utilise the reports of the EBA during the enforcement process of RTS to examine the obstacles faced by banks and TPP. Then, the literature on the technical and security challenges of PSD2 will be reviewed.

EBA reports on implementation

EBA finished final reports and guidelines on Authorisations of Payment Institutions, reporting, complaint procedures under PSD2, security measures for operational and security risks, and the RTS on SCA and CSC in 2017.[53] The objectives of these RTS requirements are to maintain 'an appropriate level of security, the safety of payment service user (PSU) data and fund, fair competition, neutrality

[53] 'Final Report On The EBA Guidelines Under Directive (EU) 2015/2366 (PSD2) On The Information To Be Provided For The Authorisation Of Payment Institutions And E-Money Institutions And For The Registration Of Account Information Service Providers' (EBA 2017)

in business model and technology.[54] As required by Article 10(1) of the EBA Regulation, the EBA must conduct a cost-benefit analysis and impact assessment.

Several options for regulations were provided based on either principle-based or specific requirements. For example, the requirements regarding communication among ASPSP, PISP, AISP, payers, payees, and other participants were presented in four options: the first is a specific technical standard; the second is a clear principle-based requirement; the third is the application of a certificate from an electronic identification and trust services ("eIDAS") trust service provider; and the fourth is the application of a certificate authority. The purpose of eIDAS is to certify that the identity or transaction is legitimate through a trusted server.[55] There was no quantitative evaluation of the option, an evaluation based on theories. Regarding the above example of options, EBA explains why the second option, which is a clear principle-based requirement, is the most suitable, arguing that other options counter the objective of promoting competition and innovation, along with the different interests and incentives of the market participants.[56]

The RTS discussion focuses on the following issues: the scope and technology-neutral objective, the exemption based on TRA analysis, and the requirements for communication and access to PSU data. Regarding the first and second issues, changes in those requirements do not lead to redesigning or recoding of the payment application system; however, there will likely be a change in system configuration.

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[54] 'Final Report On Draft Regulatory Technical Standards On Strong Customer Authentication And Common And Secure Communication Under Article 98 Of Directive 2015/2366 (PSD2)' (EBA 2017)., 39

[55] Regulation (EU) No 910/2014 of the European Parliament and of the Council

[56] Ibid 42

Additionally, requirements related to communication and access will affect the design and cost of the payment application system. For example, screen scraping, a method that allows third parties to access PSU`s data without identification, is now forbidden.[57] This requirement will amend the communication flow between PIPs and ASPSP, which will, in turn, create additional costs for system development. The regulatory requirement of strong customer authentication establishes a comprehensive set of standards for payment service providers to develop the payment system.[58] The dynamic linking, multifactor authentication("MFA")[59] may consume a lot of time and PSP resources. Technically, there must be at least two different channels using separate elements categorised as inherent[60], as possession,[61] or as knowledge.[62]

For instance, a user needs to store a user/password credential and a separate biomarker or a physical token or a bank application generating a token key. When PSU conducts a transaction, the authentication elements corresponding to the agreed transaction amount will generate a code known as 'dynamic linking', and both the payer and the payee must be aware of the transaction amount.[63] Moreover, the previous requirement on fraudulent monitoring to "prevent, detect and block fraudulent payment transactions before the PSP's final authorisation" was amended because monitoring before final authorisation means that the system should possess substantial computational resources. Furthermore, the amendment still requires 'transaction monitoring' for normal transactions and, at a

[57] Art 2, RTS

[58] Art4-9, RTS

[59] Art 5-8, RTS

[60] Art 8, RTS

[61] Art 7, RTS

[62] Art 6, RTS

[63] Art 5, RTS

minimum, on a real-time basis, each of the following risk-based factors for transactions exempt from SCA.[64] This necessitates a fast, real-time system with significant computational resources. Additionally, the authorization must be at least convenient for the user, economically designable, safe to use, and superior to that of competitors. Therefore, it presents a challenging task.

By tracking the guidelines and reports, clarifying the RTS requirements proves to be complex and time-consuming. It involves an ongoing request-response process among financial institutions, the competent authority, and the EBA during the implementation of RTS. Various guidelines and reports addressing specific implementation challenges have emerged thus far. The EBA opinion on article 32 of Obligations for a dedicated interface illustrates the intricate work involved in implementing the technical regulation.[65] The TPP reported issues with the connection to the ASPSP, where they are redirected to the ASPSP server during authentication, which, in their opinion, creates obstacles for the TPP under art 32.[66] However, EBA responds that the redirection is only an obstacle if it introduces unnecessary steps when using TPP service. According to previous EBA opinions on the

[64] Para 2, Art 2, RTS

[65] EBA, 'Opinion Of The European Banking Authority On Obstacles Under Article 32(3) Of The RTS On SCA And CSC' (2020) <https://www.eba.europa.eu/sites/default/documents/files/document_library/Publications/Opinions/2020/884569/EBA%20Opinion%20on%20obstacles%20under%20Art.%2032%283%29%20RTS%20on%20SCA%26CSC.pdf> accessed 1 March 2021.

[66] REGULATION (EU) 2018/389 2017.

implementation[67] and the guideline,[68] ASPSPs are required to provide an interface to TPP that does not rely on their own customers' authentication methods. Therefore, an ASPSP should offer all authentication methods available to its own users; otherwise, redirection or decoupling can become an obstacle. In addition, in the case of multi-SCA, the EBA agreed that multiple SCA authentications during the transaction between the PSU and ASPSP, as part of the AISP/PISP connection, can create obstacles since the direct transaction between the PSU and ASPSP requires less SCA authentication.[69]

Another example of a complex work of RTS implementation is the contingency mechanism under Article 33(6). AIPS and PSP are required to establish a system KPI to evaluate their performance, conduct stress tests, report issues, and maintain other measures in the event of system failures.[70] For instance, there was a two-year gap in response. The guideline was issued in December 2018,[71] and the clarification on SCA was issued in 2020.[72]

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[67] EBA, 'Opinion Of The European Banking Authority On The Implementation Of The RTS On SCA And CSC' (EBA 2018) <https://www.eba.europa.eu/sites/default/documents/files/documents/10180/2137845/0f525dc7-0f97-4be7-9ad7-800723365b8e/Opinion%20on%20the%20implementation%20of%20the%20RTS%20on%20SCA%20and%20CSC%20%28EBA-2018-Op-04%29.pdf> accessed 3 January 2021.

[68] Guidelines on the conditions to be met to benefit from an exemption from contingency measures under Article 33(6) of Regulation (EU) 2018/389 (RTS on SCA & CSC) | European Banking Authority 2018 (EBA/GL/2018/07).

[69] ibid 6.

[70] Art 33 RTS on SCA&CSC

[71] Guidelines on the conditions to be met to benefit from an exemption from contingency measures under Article 33(6) of Regulation (EU) 2018/389 (RTS on SCA & CSC) | European Banking Authority.

[72] EBA, 'Opinion Of The European Banking Authority On Obstacles Under Article 32(3) Of The RTS On SCA And CSC' (2020)

Furthermore, a paper written by Sinigaglia and others examined the current status of SCA applications in banks.[73] Banks utilise various combinations of authentication elements for MFA, featuring different designs, attributes, levels of security, and user experiences. The results indicate that EU banks, on average, employ 1.4 device authenticators, and the usage of MFA is 38% among these banks. The most frequently used authenticators are phone numbers (SIM cards) and software. The requirement for a unique authentication code by RTS is met by 52% of the banks. The assessment reveals that some MFC solutions can be off-putting from the perspective of customer experience due to their complexity. Consequently, significant work remains to be addressed.

Wolters and Jacobs (2019) supported the concern about PSD2 security, aiming to examine how access to accounts regulated by PSD2 balances account security and the development of market dynamics.[74] They stated that the security and privacy of the account are inadequate. The argument was very interesting; tracing the regulatory technical requirements of RTS, it found that no requirement enabled the bank to verify authentication from the payment service provider. Therefore, the bank is in a weaker position to restrict TPP access activities and has no control over the security of TPP. As a result, the vulnerable point is the TPP`s server; if the TPP is compromised, then the bank's security is also breached.

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[73] Federico Sinigaglia and others, 'A Survey On Multi-Factor Authentication For Online Banking In The Wild' (2020) 95 Computers & Security.

[74] P.T.J. Wolters and B.P.F. Jacobs, 'The Security Of Access To Accounts Under The PSD2' (2019) 35 Computer Law & Security Review.

1.1.4 Open banking Implementation cost assessment

The industry implementation cost of PSD2 was assessed by HM Treasury; however, only the fixed costs that participants need to spend on registration, capital requirements, and system development were calculated, and the business effect was not obvious.[75] The first two costs are straightforward based on sections I and II of PSD2. However, the system development cost (one-off costs for installing new software), which is £70,000, is likely to be underestimated. Furthermore, the examination of the API alone took approximately 35 days to develop and test the API model.[76] The amount of work required for the system integration of PSPS and ASPSPS would take weeks to complete, and according to OBIE, the integration work is still ongoing with new updates since 2018. Maintaining the payment system requires one or two full-time staff members, which costs at least 20,000 GBP per year. Thus, the estimate by the Treasury is likely underestimated because not all the data were included.

Polasik and others used the number of PSD2 granted licenses as a measure of successful implementation of PSD2; the Difference-in-Difference ("DiD") method was utilised to identify the significant factors contributing to successful PSD2 implementation.[77] The results indicate that small countries have succeeded by establishing innovation hubs, and government support is a key factor for the success of PSP start-ups. Additionally, a large population and increasing online shopping users positively influence outcomes. This paper did not evaluate the impact on banks' business; the primary

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[75] 'Implementation Of The EU Payment Services Directive II' (HM Treasury 2017).

[76] Abdulaziz Almehrej, Leo Freitas and Paolo Modesti, 'Security Analysis Of The Open Banking Account And Transaction API Protocol' [2020] School of Computing, Newcastle University, UK

[77] Michał Polasik and others, 'The Impact Of Payment Services Directive 2 On The Paytech Sector Development In Europe' (2020) 178 Journal of Economic Behavior & Organization.

aim was to identify factors contributing to successful PSD2 implementation. Nevertheless, the DiD method employed in this article can also be applied to assess the impact of OB regulation on banks' operations.

Another source of literature about the OB implementation is the reports by OBIE, which include data and an assessment of OB ecosystem development.[78] It provides the assessment of OB implementation, illustrating key milestones and achievements. New services and the growth of OB customers are outlined. Additionally, more data is expected to be released as the OB ecosystem progresses. However, the report does not provide the impact assessment of OB implementation on the competitive market; it focuses on market growth.

[78]'The Open Banking Impact Report 2020 - Home' (*Openbanking.foleon.com*, 2021) <https://openbanking.foleon.com/live-publications/the-open-banking-impact-report-2020/home/>; (*Insights. The latest reports and opinions from the world of open banking*, 2021) <https://www.openbanking.org.uk/insights/>

1.2 The gap in current literature

The topic of OB was new at the time of research, and the literature is still evolving. At the beginning stage of OB in the period before 2018, most literature was focused on describing the possible changes of the financial industry. For instance, papers from Deutsche Bank[79], a paper from the consulting company McKinsey & Company[80] or the OBIE report[81] concluded a positive future for OB. Those papers are based on theoretical assumptions without empirical tests because at that period, there was no data from OB implementation. Later, during the implementation period from 2018 to 2021, more literature was published with detailed analysis focused on encountering issues such as securities.[82] Some literature provides data and assessment of OB development.[83] More data is expected to be released alongside the progression of the OB ecosystem. Some literature exists on the regulatory impact on industry development, focusing on one specific factor, but not on the entire normative impact model.

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[79] Sharokh Moinian and Hubertus von Poser, 'Payment Service Directive 2: Directive On Payment Service In The Internal Market. White Paper, No. 2015/2366' (Deutsche bank 2016).

[80] Alessio Botta and others, 'PSD2: Taking Advantage Of Open Banking Disruption' [2018] Global Banking <https://www.mckinsey.com/~/media/McKinsey/Industries/Financial%20Services/Our%20Insights/PSD2%20Taking%20advantage%20of%20open-banking%20disruption/PSD2-Taking-advantage-of-open-banking-disruption.pdf?shouldIndex=false>

[81] The Open Data Institute and Fingleton, 'Open Banking, Preparing For Lift Of' <https://www.openbanking.org.uk/wp-content/uploads/open-banking-report-150719.pdf>.

[82] P.T.J. Wolters and B.P.F. Jacobs, 'The Security Of Access To Accounts Under The PSD2' (2019) 35 Computer Law & Security Review; Federico Sinigaglia and others, 'A Survey On Multi-Factor Authentication For Online Banking In The Wild' (2020) 95 Computers & Security.;...

[83] 'The Open Banking Impact Report 2020 - Home' (*Openbanking.foleon.com*, 2021) <https://openbanking.foleon.com/live-publications/the-open-banking-impact-report-2020/home/>; (*Insights. The latest reports and opinions from the world of open banking*, 2021) <https://www.openbanking.org.uk/insights/>

They only addressed the individual factors that can affect successful implementation. Clearly, the overarching question about the impact on the competitive market remains unanswered.

To address the question, the literature must be integrated into a broader context that includes assumptions regarding how the OB regulations influence competition in the banking sector, considering the transition to a data-driven market.

1.3 Research question

The research question relates to regulatory impact studies. It explores how the regulatory transition to a data-driven market impacts the competitive environment and the market participants' resource and capacity distribution.

This research is normative with empirical elements. It aims to understand the OB regulatory impact mechanism and the factors through which the regulations will impact individual banks, third-party providers and the banking industry. Construction of the regulatory impact model can provide helpful predictions about the competitive environment. Moreover, the impact model provides an understanding of the data-driven market, the factors causing the problems in competition, resources and capacity distribution. The main research question is divided into the following sub-questions:

- How did the OB regulations impact the individual bank's operations?
- How was the bank`s competitive environment impacted? How have account switching barriers, data-centric service quantity, quality and market power changed? Does a network effect exist in the OB market?

- How equitable and efficient was the regulatory impact under the interpretation framework? How will the OB regulatory impact shape future banking structures?
- How should the existing problems caused by the OB regulatory impact be regulated?

The importance of OB and the research question

OB is continually becoming more significant in the financial industry. Five years after implementation, the number of OB users grew from less than a million to over 11 million in 2024.[84] With the current growth rate, the traditional banking industry is expected to switch to OB infrastructure. The first stage of OB was accomplished in 2023,[85] and the consultation for the next stage of Open Finance started in 2019.[86] More bank clients' data attributes and services will be available to the TPPs. The longer-term objective is to create a more open ecosystem with all banks and service providers based on open data.[87] Therefore, understanding the impact of OB regulations on the data-driven market is essential for grasping the transformation of the banking and financial industries.

The main research question examines the regulatory impact on the OB ecosystem. From a broad perspective, it is important due to the significance of OB and its effects on society. OB represents an unavoidable development in the financial industry and the economy. This ecosystem will connect

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[84] 'Delivering the Roadmap' (n 39).

[85] 'RETAIL BANKING MARKET INVESTIGATION ORDER 2017 Notice Of Approval Of Changes To The Agreed Timetable And Project Plan' [2020] CMA <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/885537/Notice_of_proposed_changes_to_the_open_banking_roadmap_-_web_publication_-_cma_gov_uk_---_May_2020_-.pdf>

[86] 'OPEN BANKING READINESS INDEX: THE FUTURE OF OPEN BANKING IN EUROPE' (Payment Industry Intelligence and Master Card 2021) <https://openbanking.mastercard.com/readiness-index/> 70

[87] FCA, 'Call For Input: Open Finance' (2019) <https://www.fca.org.uk/publication/call-for-input/call-for-input-open-finance.pdf>

banks, TPPs, and providers from various sectors, such as energy, transportation, and insurance. Consequently, the OB regulations will influence all participants in these markets.

Moreover, studying the regulatory impacts on the competitive environment is important due to the connection between competition and surplus generation. This research will help participants optimise their strategies for favourable positions and avoid unnecessary costs. Regulators with insights into issues such as resource distribution or the network effect can implement corrective measures to enhance efficiency and ensure fair distribution within the OB ecosystem. Overall, the research aims to increase total surplus and improve participant welfare under a just moral framework within the OB ecosystem.

Originality of the research question

The enforcement of OB regulations was completed in 2023. At the time of the literature review, existing studies primarily focused on isolated issues such as the OB regulations perspective,[88] the security of the ecosystem,[89] or the possibility of network effects.[90] However, there is a significant gap in studying the impact of OB regulation on the competitive environment. This research question is original, as no previous studies have examined the effects of OB regulation on competition. Additionally, it stands out because of its interdisciplinary approach and methods in analysing the influence of OB regulation.

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[88] Steve Mansfield-Devine, 'Open Banking: Opportunity And Danger' Computer Fraud & Security; Alessio Botta and others, 'PSD2: Taking Advantage Of Open Banking Disruption' [2018] Global Banking; Sharokh Moinian and Hubertus von Poser, 'Payment Service Directive 2: Directive On Payment Service In The Internal Market. White Paper, No. 2015/2366' (Deutsche bank 2016).

[89] Abdulaziz Almehrej, Leo Freitas and Paolo Modesti, 'Security Analysis Of The Open Banking Account And Transaction API Protocol' [2020] School of Computing, Newcastle University, UK

[90] Markos Zachariadis and Pinar Ozcan, 'The API Economy And Digital Transformation In Financial Services: The Case Of Open Banking' [2017] SSRN Electronic Journal

The existing scholarship on OB often addresses legal, economic, or technical aspects in isolation, resulting in fragmentation. In contrast, this research applies interdisciplinary analyses to address interconnected problems. It brings together insights from economics, competition, regulations, social justice, and computer science to form a comprehensive view of the impact of OB regulation, ranging from OB enforcement to the redistribution of resources and capacities.

To address the fragmentation problem, this study aims to quantify the regulatory impact. One reason for fragmentation is that studies lack quantification. Integrating qualitative findings from one study into another is challenging due to the absence of standardised measurement units. By quantifying the regulatory impact, this study facilitates comparisons and interpretations through various interdisciplinary lenses.

Finally, this research aims to incorporate methods from other disciplines. In particular, social economics theory, which describes the transmission of ideas and narratives based on studies of infection distribution in epidemiology, is applied to predict sentiment transmission. The sentiment analysis and topic extraction methods on big data text, commonly used in social studies, are utilised to explain the regulatory impact from the customers' perspective by tracing their sentiments and discussion topics. Lastly, a method for detecting network effects was also developed, and Support Vector Modelling was employed to predict the regulatory impact in OB.

Methodology

The thesis examines the impact of OB regulations on the banking structure by analysing the banks' operations, competitive advantages, and strategic responses.

The economic approach to regulation will be applied to assess the regulatory impact. Regulatory impact studies quantify the extent to which regulation achieves its objectives and forecast the future impact

of regulatory change.[91] Regulatory impact research is usually an interdisciplinary field that connects different disciplines' theoretical foundations.[92] The economic approach to assessing regulatory impact involves the application of economic theories, empirical techniques, and cost-benefit assessment.[93] Therefore, economic and regulatory theories and statistical methods will be applied in this thesis.

The economic approach to regulation usually covers the fields of economic regulation, social regulation, competition regulations[94] and the legal system. It looks at ex-ante and ex-post responses,[95] effectiveness,[96] and how regulations facilitate market transactions.[97] This aims to understand the extent to which the regulation meets its objectives and its overall impact by applying economic theory and empirical evidence research.[98]

Structure

The first chapter addresses literature and problems in OB enforcement, highlighting the gap in the literature to establish the research question. The next chapter discusses regulations, theory, and

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[91] Cento Veljanovski, 'Economic Approaches to Regulation' in Robert Baldwin, Martin Cave and Martin Lodge (eds), Cento Veljanovski, *The Oxford Handbook of Regulation* (Oxford University Press 2010) <http://oxfordhandbooks.com/view/10.1093/oxfordhb/9780199560219.001.0001/oxfordhb-9780199560219-e-2> accessed 24 January 2022.

[92] Peter Drahos, *Regulatory Theory: Foundations and Applications* (ANU Press 2017) p91 <http://ebookcentral.proquest.com/lib/york-ebooks/detail.action?docID=4835274> accessed 17 June 2022.

[93] Veljanovski (n 91).

[94] W Kip Viscusi and others, *Economics of Regulation and Antitrust* (MIT Press 2005) <http://ebookcentral.proquest.com/lib/york-ebooks/detail.action?docID=3338843> accessed 25 January 2022.

[95] Veljanovski (n 91).

[96] ibid.

[97] ibid.

[98] ibid.

interpretation frameworks. It looks at the regulatory approaches to OB and the scope of regulators to define the regulatory framework. The economic supply-demand theory, financial regulatory theories, and the theory of competition law are applied to create the OB regulatory theoretical framework. Additionally, stakeholder and justice theories are utilised to develop an interpretation framework. The application of impact factors by courts, regulators, and academia in case laws, market investigations, guidelines, and academic papers is analysed in the third chapter to update the impact model and methods. In the fourth chapter, data and methods will be presented, and empirical analyses will be conducted with a predictive impact model. Finally, in Chapter Five, the results of the analysis will be interpreted according to the interpretation framework. The structure is provided below:

- Chapter 1 – Introduction and Research Question
- Chapter 2 – Open Banking: Regulatory, Theoretical and Interpretation Framework.
- Chapter 3 – Practical application of impact factors by courts, regulators and academia.
- Chapter 4 – Empirical analyses.
- Chapter 5 – Interpretation of Results and Conclusion.

Findings

The findings of the OB regulatory impact study can be summarised as follows: Firstly, the modelling indicates that the regulations affect the competitive environment through several factors. The statistically significant factors include public sentiment, the number of account switches, network effects, and the number of reviews, which serve as a proxy for measuring service quantity. Secondly, the detailed impact factor analyses show that OB regulations could influence sentiment toward OB by increasing the mean sentiment score by 11%. Additionally, topic extraction reveals that some topics present during the uncertainty period were not detected after OB enforcement. Post-OB regulatory enforcement, the relevant topics are now focused on enforcement deadlines and issues concerning the

least advantageous groups, such as small firms and indigent individuals. Thirdly, the regulatory impact on data-centric service quality and quantity demonstrates a substantial quantitative increase in service demand and a possible shift in the competitive environment due to uneven regulatory impacts on service quality between banking groups. Lastly, the measurement of income, costs, account switching numbers, and network effects indicates a high probability of network effects in the market, accompanied by a weakening competitive environment.

In addition, the result of the OB regulatory impact is interpreted under the stakeholder framework. The stakeholder salience framework indicates that OB in the UK needs a balanced strategy. Powerful regulators should guide CMA9 banks in working with dependent stakeholders, including challengers, NoCMA9, TPP, and consumers with urgent, limited power. Regulators such as OBIE and JROC connect stakeholders, resolve conflicts, and ensure value for end-users. Power dynamics are flexible; banks may take a proactive approach as OB evolves, while challenger banks and TPPs could increase their influence. Regulatory pressures may also change. In addition, the CS model encourages regulators to build shared infrastructure and foster trust, while AR allows CMA9 banks to enforce data sharing. EM ensures fair competition for challengers, and MP enhances innovation for consumers and service providers. Thus, the OB governance framework adapts to balance stakeholder interests and generate joint value.

The empirical results support that OB regulations enhance joint value creation, with stakeholder SWF rising by 27 points post-implementation. Utility estimations for all stakeholders increased, except Non-CMA banks, which fell by 3 points. The CMA9 group rose by 7 points, Challenger by 8, TPP by 7, and consumers by 5 (see Table 23). Applying the stakeholder framework, the 27-point increase in SWF indicates benefits from OB enforcement. The results meet stakeholder and Kaldor-Hicks criteria, but

the regulatory implementation fails the Pareto efficiency test due to negative impacts on Non-CMA9 stakeholders (-3).

2. Chapter Two: Open Banking - Regulatory, Theoretical, and Interpretative Framework

The purpose of this chapter is to define OB and its frameworks, including the concept of OB, the current regulatory approaches governing OB, and the theoretical assumptions concerning the regulatory impact on the OB ecosystem. Lastly, it will present a framework for interpreting this regulatory impact.

Firstly, it examines the OB ecosystem to analyse the OB market structure and its underlying technologies, defining the concept of OB as the research subject. Then, we review the primary regulatory approaches that govern the OB market in jurisdictions such as the US, China, and the EU. Next, a more detailed examination of UK regulations is conducted, which includes an assessment of the UK regulator`s involvement in OB enforcement, focusing on their functions and CMA investigation reports.

After analysing regulatory approaches, the underlying theories of OB regulations are applied to assess their potential regulatory impact. Standard market, competition, and regulatory theories are aligned with specific OB regulations. For instance, the regulatory theory regarding standards is applied to OB regulation on data-sharing standards; the banking theory is applied to OB regulation on capital requirements; and standard market and competition theories are applied to the generation of market

surplus by OB regulations. This section aims to outline the factors through which OB regulations influence market competition. The findings are utilised in the Empirical Chapter to evaluate the regulatory impact model.

Lastly, in preparation for interpreting the impact model results, an interpretation framework is assessed. It examines stakeholder theory to understand the cooperation between regulators and market participants and how these stakeholders create joint value to generate surplus. Then, it considers justice theories and the structure of social welfare functions to outline the possible interpretations of results regarding joint value creation.

This chapter is divided into four sections: the first outlines OB; the second examines the implementation of OB regulations and regulators; the third discusses the theoretical framework; and the fourth addresses the interpretation framework.

2.1 OB definition and technology

2.1.1 Defining OB

The concept of Open Banking is relatively new. The implementation of OB in the UK started in 2018. In countries such as the US, China, or Canada, the authorities apply an organic approach, where the market is self-regulated.[99] In some jurisdictions, such as Hong Kong, the regulation governing OB is in the initial drafting stage.[100] There are different regulatory approaches and stages of implementation of OB, which lead to an unclear definition of OB. The definition varies across jurisdictions.[101] For instance, the USA allows scraping,[102] whereas the EU does not. Consequently, the comparison or use of one jurisdiction as an example, prediction, or measurement of OB implementation is difficult. To define the meaning of OB in a particular jurisdiction, its function and objectives will be discussed. The pre-OB industry and its underlying technologies will also be examined to clarify the concept of OB.

Preface to OB

Open Banking assumes banks open their data to third parties through Application Programming Interfaces ("API"). Traditionally, banks interacted with customers through branches or via post. Since

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[99] 'Open Banking Around The World | Deloitte | FSI' (*Deloitte Cyprus*, 2021) <https://www2.deloitte.com/cy/en/pages/financial-services/articles/open-banking-around-the-world.html?fbclid=IwAR3Rr0-mnqSFBm4LcoK79nXewuQe_OFxYyYhqsiZ2hv2iVpOmQrisoCY9Tw>

[100] Ibid

[101] 'Report On Open Banking And Application Programming Interfaces' (Basel Committee on Banking Supervision 2019)

[102] It is a technique used to collect data from the internet. This data is usually saved in a local file for manipulation and analysed.

the development of computers and the internet, new channels of banking services, such as online banking or mobile banking, have been introduced.[103] Alongside the advancement of service channels, instruments such as electronic money, payment cards, and electronic fund transfers emerged.[104] The first wave of new technologies brought tremendous benefits to the industry.[105] However, the appearance of new instruments, service channels, and procedures created a new party—the separate payment service provider. These providers are not traditional banks, and they cannot yet service the payments.[106] This change necessitates a revision of industry governing regulations.

The first attempt to regulate separate payment service providers was the First Payment Services Directive in Europe,[107] later transposed into UK legislation as The Payment Services Regulation 2009 and Financial Services (EEA) (Payment Services) Regulations 2010. This Directive deals with three issues, including the authorisation regime, transparency requirements, and the rights and obligations of providers and users.[108] The authorisation regime[109] is responsible for managing the risks and the

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[103] Alasdair Smith, Tom Hoehn and Philip Marsden, 'Retail Banking Market Investigation:Final Report' (Competition and Markets Authority 2006) <https://assets.publishing.service.gov.uk/media/57ac9667e5274a0f6c00007a/retail-banking-market-investigation-full-final-report.pdf> accessed 24 March 2021, 15

[104] Cranston R and others, *Principles Of Banking Law* (3rd edn, Oxford University Press 2018) 1-2

[105]Christian Hagen and others, 'Big Data And The Creative Destruction Of Today's Business Models' [2013] Atkearney <https://www.co.kearney.com/documents/20152/434888/Big%2BData%2Band%2Bthe%2BCreative%2BDestruction%2Bof%2BTodays%2BBusiness%2BModels.pdf/a8ba1874-dbf4-8570-8845-9b262256b378?t=1580168120000>

[106] Cranston R and others, *Principles Of Banking Law* (3rd edn, Oxford University Press 2018) 5

[107] Directive 2007/64/EC of the European Parliament and of the Council of 13 November 2007 on payment services in the internal market amending Directives 97/7/EC, 2002/65/EC, 2005/60/EC and 2006/48/EC and repealing Directive 97/5/EC 2007.

[108] 'Directive 2007/64/EC General Report On The Transposition By The Member States' (Tipik Communication Agency 2011),p5

[109] This is the process when the client is authorised to access his or her account.

requirements of granting authorisation,[110] supervision,[111] record-keeping,[112] the requirement of initial capital,[113] and other management measures under articles 5 to 29 of the Directive. The Rights and Obligations section prescribed the rules for the processing of transactions, settlement of disputes, and liabilities of the parties.[114] In addition, sufficient information related to customers' payments should be disclosed to customers so they can choose between providers in the EU.[115]

The First Directive was the regulation that defined payment service providers, their rights, and obligations. This Directive created a legal framework between payment service providers and users, focusing on the harmonisation of payment systems across the EU. The focus was on the transparency of procedures and harmonisation of intra-EU payments.[116] However, it did not fully address the regulatory technological framework, which was developing rapidly, and the existing competition barrier in the market.[117]

The competition issue regarding the creation of barriers for the new participants was raised by the Competition and Markets Authority ("CMA") in 2016 because of various concerns from the Independent Commission on Banking ("ICB") in 2011[118] and the Parliamentary Commission on Banking Standards

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[110] Art 5,10 Directive 2007/64/EC

[111] Art21, Directive 2007/64/EC

[112] Art 19, Directive 2007/64/EC

[113] Art 6, Directive 2007/64/EC

[114] Art51-83, Directive 2007/64/EC

[115] ibid

[116] Art.2 and Art.68, DIRECTIVE 2007/64/EC

[117] 'Press Corner' (*European Commission - European Commission*, 2021) <https://ec.europa.eu/commission/presscorner/detail/en/MEMO_15_5793>

[118] Those were concerns regarding the barriers from new participants and the existing customers.

("PCBS") in 2013.[119] The possibility of incumbent firms creating barriers to entry and preventing newcomers from entering the market could lead to a reduction in social welfare, as less competition is associated with higher inefficiency.[120] The CMA studied how the recent regulations cope with the banking industry development, focusing on the banking services provided to the personal current account ("PCA") customers and business current accounts ("BCAs") for small and medium-sized enterprises ("SMEs").[121]

Three main questions were examined in the study.[122] The first was concerned with customer engagement, the barriers to searching for different banks, and the ability to switch accounts, which impeded the industry competition regarding service quality, price, and innovation.[123] Customers are denied access to helpful information, so their engagement with banks and understanding of other banks (or providers) is limited. Consequently, they may be reluctant to switch to other banks, even if their service is poor. This barrier can restrict competition among banks. The second question addressed barriers that hindered the expansion of existing banks or the growth of new ones. Simultaneously, the third question examined the effect of concentration within the banking market and its impact on customers.

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[119] Alasdair Smith, Tom Hoehn and Philip Marsden, 'Retail Banking Market Investigation:Final Report' (Competition and Markets Authority 2006) <https://assets.publishing.service.gov.uk/media/57ac9667e5274a0f6c00007a/retail-banking-market-investigation-full-final-report.pdf>, 8

[120] Viscusi and others (n 94).

[121] CMA, 'Retail Banking Market Investigation' (*GOV.UK*, 29 June 2023) 7 <https://www.gov.uk/cma-cases/review-of-banking-for-small-and-medium-sized-businesses-smes-in-the-uk>.

[122] Ibid 8

[123] Ibid

The report showed that more than 50% of customers stayed with the same bank for over ten years, and only 8% of customers switched their bank accounts in the previous three years despite innovations aimed at reducing customer costs and increasing customer engagement.[124] These figures are low. In comparison, 30% of the customers switch accounts to energy and 13% to savings products. Several new banks have been registered, such as Aldermore in 2009, Metro Bank in 2010, and Atom and Starling digital banks in 2015.[125] However, the market was highly concentrated in the control of the biggest banks, and banks outside of the top nine did not possess any considerable market share.

Market share is the term used to denote the percentage of the total market controlled by an entity. The market share of the top four banks was 82% for BCA accounts and 73% for PCA accounts.[126] CMA concluded that competition was distorted.[127] Existing banks used complex charges, limiting customers' ability to compare service quality between banks. Furthermore, new and smaller banks were placed at a competitive disadvantage by creating the perception of a burdensome switching account process.[128]

OB was introduced as one of the solutions to the above issues.[129] The other solutions included account-switching, price-quality transparency, and customer prompt measures.[130] The justification was that by

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[124] Ibid 19

[125] Ibid

[126] Ibid 462

[127] Ibid 481

[128] Ibid 481-498

[129] Ibid 499

[130] Ibid 92

ordering the biggest banks to open their data through APIs, customers could more easily determine the product most suited to them, and third-party products could provide more services to customers.

2.1.2 The technology underlying Open Banking

Over the last decade, technological advancements have enabled the widespread adoption of computer applications and the processing of big data in various sectors, including financial services.[131] Key technologies such as big data, AI, open data, blockchain, and APIs drive this advancement.[132] Banks, using consumer account and transaction data, can use this information for targeted advertising, credit evaluation, and tax calculation through big data, AI, and open APIs.[133] To understand the development of OB, we will briefly examine its fundamental building blocks.

Big Data

The swift growth in computer processing speeds allows the use of smaller devices with higher computational power, such as notebooks, mobile phones, iPads, and other devices. The connection and interaction of devices with sensors have led to an explosion of data.[134] The enterprise data was

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[131] Paolo A. Gargini, Francis Balestra and Yoshihiro Hayashi, 'The International Roadmap For Devices And Systems (IRDS)' (2020) 27 IEEE <http://www.ieee.org/ns/periodicals/EDS/EDS-JULY-2020-HTML/index.html> accessed 29 March 2021.

[132] Jessica Renier and W. Moses Kim, 'A Financial System That Creates Economic Opportunities Nonbank Financials, Fintech, And Innovation' (US DEPARTMENT OF THE TREASURY 2018) <https://home.treasury.gov/sites/default/files/2018-08/A-Financial-System-that-Creates-Economic-Opportunities---Nonbank-Financials-Fintech-and-Innovation_0.pdf> accessed 15 July 2021, 18-25

[133] Ibid

[134] Raghunath Nambiar and Meikel Poess, *Selected Topics In Performance Evaluation And Benchmarking* (4th TPC Technology Conference 2012) 197

estimated to have grown seventy times from 0.5 zettabytes[135] in 2008 to 35 zettabytes in 2020.[136] The generation rate of data was the fastest in the history of humankind and is continuing to grow from all sources, like the internet and social networks, to internal organisation data.[137] Consequently, the large scale and complexity of data have required new data management strategies.[138] Big data is usually defined as 'high volume, high velocity, and/or wide variety information assets that require new forms of processing to enable enhanced decision making, insight discovery, and process optimisation'.[139] Volume refers to handling vast amounts of data, while velocity is the rapid influx of real-time data from sensors, the Internet of Things, or stock exchanges. Variety denotes the different data formats, such as spreadsheets, Word files, XML, and tables.[140]

Data holds great value,[141] with several steps in its value chain.[142] First is data acquisition, where data is gathered, filtered, and stored. Next is data analysis, which involves transforming and modelling data for decision-making. Then, data is curated, classified, and validated. Data storage ensures fast access.

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[135] Zettabyte is is a measure of storage capacity and is 10^21 bytes

[136] Raghunath Nambiar and Meikel Poess, *Selected Topics In Performance Evaluation And Benchmarking* (4th TPC Technology Conference 2012) 198

[137] Ibid

[138] ibid

[139] D Laney, '3D Data Management: Controlling Data Volume, Velocity, And Variety' [2001] Technical report, META Group <http://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf> accessed 29 March 2021.; Big data definition, archit, application 292-825-1-PB; 'Big Data' (*Investopedia*, 2021) <https://www.investopedia.com/terms/b/big-data.asp>

[140] José María Cavanillas, Edward Curry and Wolfgang Wahlster, *New Horizons For A Data-Driven Economy* (Springer International Publishing 2016) 30

[141] ibid

[142] Ibid 32

Finally, data-driven usage activities are utilised to create more value through enhanced effectiveness and performance.[143]

Requiring banks to open data means that the data will gain value. This occurs especially within data acquisition and analysis stages, where third parties can apply stream mining, machine learning, cross-sectoral data analysis, and other approaches to extract unseen value. An example of real applications of OB access to data is how third-party companies such as Alphafx provide international payment and exchange risk management.[144] Similarly, Alpha Business Solution provides fuel payment and driver data analysis,[145] Clear Score Technology provides credit reports,[146] and Cirrostratus Exedra Ltd facilitates tax advice.[147]

Artificial Intelligence ("AI")

OB regulations mandate banks to open their data. The second stage of the big data value chain is data analysis. Many companies working with data apply AI to gain value.[148]

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[143] Ibid

[144] 'Overview — Alpha FX Group Plc' (*Alpha FX Group plc*, 2021) <https://www.alphafx.co.uk/about/overview/>

[145] Alpha Solutions and others, 'Alpha Business Solutions: PEO Employee Leasing & Payroll For Business' (*Alpha Business Solutions*, 2021) <https://alphabizsolutions.com/> accessed 15 July 2021.

[146](*Clearscore.com*, 2021) <https://www.clearscore.com/> accessed 15 July 2021.

[147] 'Cirrostratus Exedra Ltd' (*Open Banking*) <https://www.openbanking.org.uk/regulated-providers/cirrostratus-exedra-ltd/>.

[148] Paul Moon Sub Choi and Seth H. Huang, *FINTECH WITH ARTIFICIAL INTELLIGENCE, BIG DATA, AND BLOCKCHAIN* (SPRINGER 2021)., 108-124

AI models learn from large datasets to perform tasks. Inspired by the biological neuron network,[149] the artificial neuron networks ("ANN") mimic the human brain's learning ability. The network consists of neurons, weights and biases. ANN-based AI systems train with large-scale datasets.[150] Adjusting internal weights improves accuracy over time through supervised or unsupervised learning, whether the data is labelled or not.[151]

ANNs use feedforward, backpropagation, and other loss functions to minimise output errors.[152] For example, when fed images of apples, an AI network learns to accurately identify apples by adjusting weights according to the above functions to generate outputs with each new input. The quantity and scale of data are crucial for AI development.[153] AI applications now vary, ranging from autonomous driving and healthcare to financial services.[154] Consequently, OB provides a valuable resource for AI advancement in the financial industry.

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[149] Juergen Schmidhuber, '2006: Celebrating 75 Years of AI - History and Outlook: The Next 25 Years' (arXiv, 31 August 2007) <http://arxiv.org/abs/0708.4311>.

[150] 'Over 200 Of The Best Machine Learning, NLP, And Python Tutorials-2018 Edition' (*Medium*, 2020) <https://medium.com/machine-learning-in-practice/over-200-of-the-best-machine-learning-nlp-and-python-tutorials-2018-edition-dd8cf53cb7dc>

[151] Nick McCrea, 'An Introduction To Machine Learning Theory And Its Applications: A Visual Tutorial With Examples' (*Toptal Engineering Blog*, 2021) <https://www.toptal.com/machine-learning/machine-learning-theory-an-introductory-primer>

[152] Ibid

[153] 'The Difference Between AI, Machine Learning, And Deep Learning? | NVIDIA Blog' (*The Official NVIDIA Blog*, 2020) <https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/>

[154] Alshammari, Mona Turki, Sarah Ahmed Alswedani, Waad Saud Alanazi, Kusum Yadav, and Zahida Parveen. "TECHNOLOGY: THEN & NOW THE DIFFERENCE."

Application Programming Interfaces ("API"s)

The API is a set of rules for data transmission between software and its connection interfaces.[155] It consists of specific technical specifications on how to connect the interfaces.[156] There are four levels of API openness:[157]

- Partner API: Access is restricted to private entities via individual contracts. [158]
- Membership API: Access is granted to members with certain principles, group norms and rules.
- Acquaintance API: Access is broader but still somewhat restricted.
- Public API: Access is open to everyone.

OB API falls under the second level—Membership API—where only FCA-registered third parties can connect to the UK banks' API and provide services.[159]

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[155] 'The Future Of Banking Depends On Open Banking Apis' (*The Financial Brand*, 2021) <https://thefinancialbrand.com/65975/open-banking-api-fintech-partnerships/> accessed 30 March 2021.

[156] 'What Is API: Definition, Types, Specifications, Documentation' (*AltexSoft*, 2019) <https://www.altexsoft.com/blog/engineering/what-is-api-definition-types-specifications-documentation/>

[157] Eiichiro Yanagawa, 'Open API Banking: A Powerful Trigger For The Value Chain Revolution In Japan' (2018) 3,4 Journal of Digital Banking.

[158] Ibid

[159] Reg 4-9, PSR 2017

The minimum requirement of PSD2 was to build API for account balance, verification services, and payment-related services such as payment guarantees, age verification, or payment status reports.[160] However, it is optional for account information service providers to allow more information access.[161] For example, a peer-to-peer lending platform might use an API to access bank client credit histories, with the API specifying how credit history data is requested and returned to the third party.

Future development of OB

The widespread trend in technology fields is using existing technologies to synthesise and create new ones. The ecosystem of the banking industry is the same.[162] Initially, banking services were provided through physical branches. Later, internet banking, mobile banking, and digital banking were added. Open Banking represents the next stage. The figure below illustrates the ecosystem of the banking industry.

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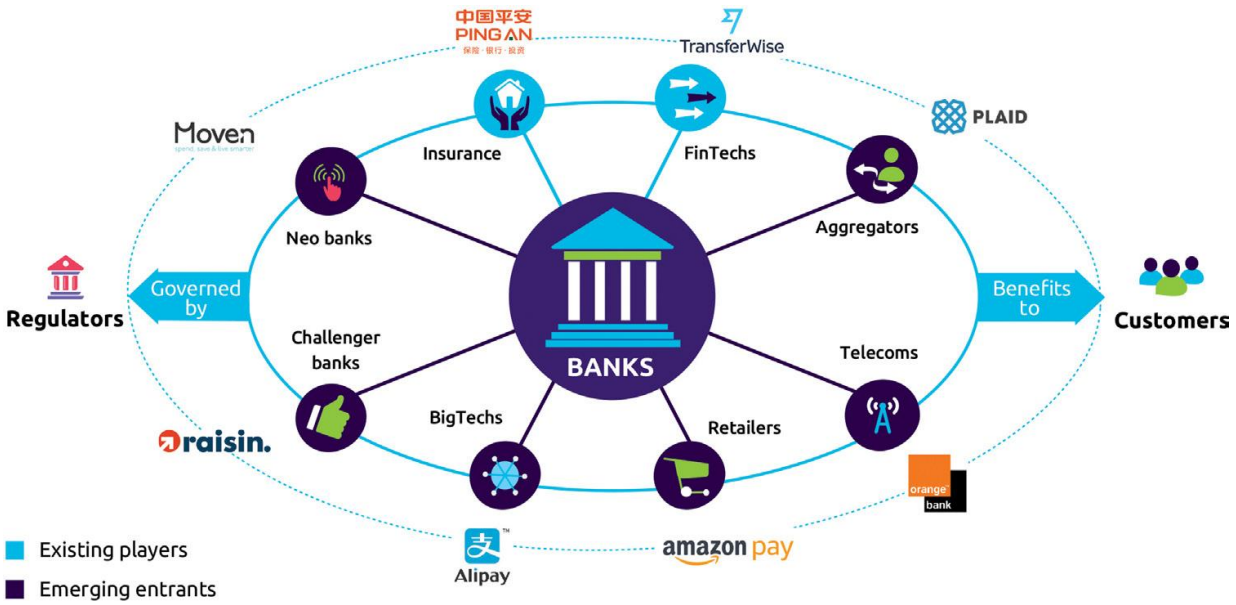
[160] Matthias Kröner, 'API Deep Dive: Who Will Thrive In An Open Banking World? Why Meeting Regulatory Requirements Is Not Enough For Banks To Remain Relevant' (2017) 2,3 Journal of Digital Banking., p202

[161] NDGIT, 'Guidelines for PSD2 Implementation' 5 <https://ndgit.com/wp-content/uploads/2019/04/NDGIT-PSD2-Whitepaper-en.pdf>.

[162] 'From Fintechs To Banking As A Service: Global Trends Banks Cannot Ignore' [2021] LSE Business Review <https://blogs.lse.ac.uk/businessreview/2021/01/19/from-fintechs-to-banking-as-a-service-global-trends-banks-cannot-ignore/>

Figure 3: The illustration of the Open Banking ecosystem. The core of the ecosystem is the banks in the centre, whereas other service providers connect to the bank's API, creating an ecosystem of services such as fintech, insurance, payment services and others.



Source: Elias Ghanem, 'Open Banking Experiences Set The Stage For Open X' (2019) 4 Journal of Digital Banking, 3

Current technologies are synthesised to create new innovations in banking by integrating existing services to enhance the customer experience. Open X could represent the next phase of Open Banking, wherein the market is shared through openness resources. Service providers, including banks, connect to provide a new, enhanced service.[163] This service will connect the banks and a network of third-party providers, creating new services. An example is the joint venture between a traditional bank, the Royal Bank of Scotland, and a peer-to-peer lending platform, Funding Circle, to create a digital bank.[164] Similarly, First Direct joined with London start-up Bud to create an API app to consolidate customer

[163] Elias Ghanem, 'Open Banking Experiences Set The Stage For Open X' (2019) 4 Journal of Digital Banking.

[164] Ibid 9

services that digital banks can use.[165] The Spanish bank, Bankia, collaborates with Eurobits Technologies, a third-party service provider, to create an invoicing platform.[166]

[165] Ibid

[166] Ibid 10

2.2 OB regulatory framework in the UK and other jurisdictions

This section will explore the international OB regulatory approach, including jurisdictions such as the United States and China. Subsequently, it will examine the approach taken by UK regulators.

2.2.1 OB approach from different jurisdictions

The technologies underlying OB are revolutionising the financial industry, and countries worldwide are attempting to adopt different regulatory approaches. In Singapore, the Monetary Authority of Singapore issued an API playbook to encourage banks to open data.[167] The API playbook identifies the common APIs within different industries and guides securities and governance models.[168] In New Zealand, banks are collaborating on the OB project.[169] In India, the public and private sectors created India Stack, an API standard for financial institutions.[170] The new Fintech Law in Mexico requires all financial services to open data access.[171] The Customer Data Rights Legislation ("CDR") in Australia, equivalent to GDPR and PSD2, allows data sharing with the user's consent across financial institutions. This sharing will help the user compare and switch accounts.[172] One of its distinctive features is that the legislation will also apply to the energy and telecommunications sectors.[173] Similarly, in Japan, the

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[167] 'Financial World, Finance-As-A-Service: API Playbook' (*Mas.gov.sg*, 2016) <https://www.mas.gov.sg/-/media/MAS/Smart-Financial-Centre/API/ABSMASAPIPlaybook.pdf> accessed 15 June 2021.

[168] Ibid

[169] Gilly Wright, 'Open Banking Goes Global' [2019] SIBOS SUPERSECTION.

[170] Ibid

[171] Ibid

[172] Consumer Data Right (CDR)

[173] ibid

revised Banking Act (2018) requires banks and fintech firms to complete API for data sharing by June 2020.[174]

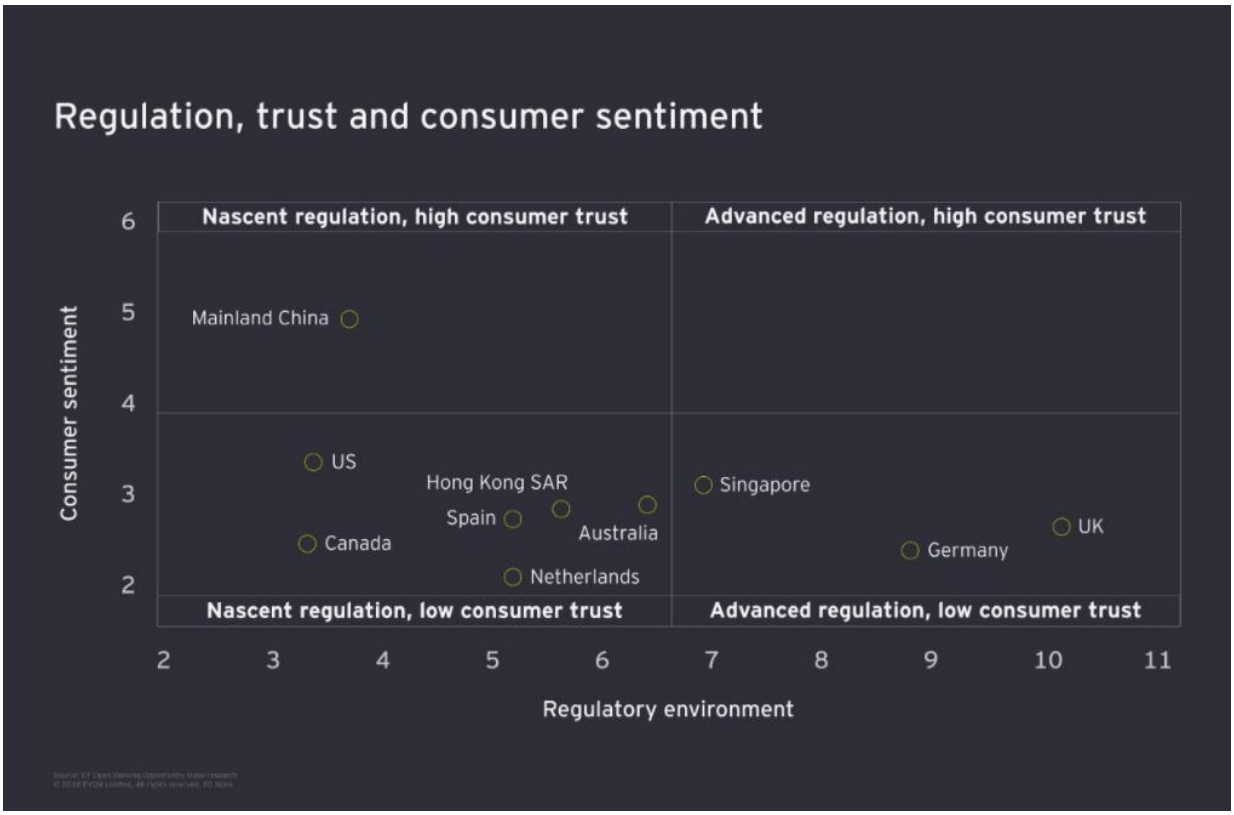
These approaches can be classified as market-driven and regulation-driven. The first approach allows the market to develop organically and to revise the existing regulations with overlapping OB activities, as seen in the US or China. In the latter approach, a specific regulation is drafted to target OB activities, such as those in the UK or Australia. Due to different regulatory approaches and definitions of OB, it is challenging to generalise the OB definition and its development. This section will consider several jurisdictions to generalise the definition of OB and outline its international regulatory trends.

2.2.2 EY Open Banking Opportunity Index

The EY Open Banking Opportunity Index (Figure 4) generalises OB development in different countries. This Index tracks the readiness of the OB environment in 10 different markets, incorporating the regulatory environment, consumer adoption, consumer sentiment, and the innovation environment. The horizontal axis illustrates the strictness of the OB sector's regulations, and the vertical axis illustrates the customer`s level of adoption and positivity with OB.

[174] Susan Pandy, 'Developments In Open Banking And APIs: Where Does The U.S. Stand?' [2020] Federal Reserve Bank of Boston.

Figure 4: The Open Banking Opportunity Index. The index illustrates the jurisdiction's regulatory environment against consumer sentiment. The UK has the highest regulatory environment with advanced regulation and consumer trust, whereas the lowest is in Canada.



Source: Hamish Thomas, 'EY Open Banking Opportunity Index: Where Open Banking Is Set To Thrive' (*Ernst & Young Global Limited*, 2020) <https://www.ey.com/en_gl/banking-capital-markets/ey-open-banking-opportunity-index-where-open-banking-is-set-to-thrive>

The index illustrates that despite the lack of mandated regulations, consumer sentiment is high, meaning consumers are positive toward OB in countries with organic approaches, such as China and the USA.

The US, EU, UK, and China, as the largest economies in the world, have the largest OB industry.[175] However, the US and China take a different approach from the EU and UK. Those markets will be examined in more detail.

2.2.3 The United States

The OB market is not strictly regulated in the US.[176] It is evolving through market-driven initiatives rather than strict regulation.

The US market

The OB in the US is market-driven, primarily without any specific regulations on OB.[177] The market structure is segmented through individual partnerships between banks and third parties without a supervisory body's mandate under PSR 2017,[178] like in the UK. For example, Oracle partners with small FinTech firms to build AP, providing access to Financial Crime and Compliance Management Cloud Services.[179] Banks also make their open data API available to TPP, as in the case of First Horizon Bank. They can also apply NCR Technology`s API to install a digital banking platform.[180] Moreover, Tech companies can develop their own API standard, like in the case of API Fintech TrueLayer.[181]

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[175] 'GDP By Country - Worldometer' (*Worldometers.info*, 2021) <https://www.worldometers.info/gdp/gdp-by-country/> accessed 15 June 2021.

[176] Susan Pandy, 'Developments In Open Banking And APIs: Where Does The U.S. Stand?' [2020] Federal Reserve Bank of Boston 4

[177] Ibid

[178] SI 2017/752

[179] 'US Inches Toward Open Banking With CFPB Notice' (*Pymnts.com*, 2021) <https://www.pymnts.com/news/b2b-payments/2020/us-inches-toward-open-banking-with-cfpb-notice/> accessed 11 April 2021.

[180] Ibid

[181] Ibid

A distinctive feature of the US market is the screen-scraping technique. The method has been used to aggregate accounts in the United States since 1990,[182] and it allows users to log in from the TPP service to access their other accounts, enabling TPP to gather financial data, such as current accounts or trading accounts, and non-financial data, including email.[183] It is used in different fields, from targeted advertising to scraping public data. Examples include Plaid and Yodlee, a US company that provides a platform for Fintech and banks.[184] They use both screen scraping when the API is not accessible.

The use of the screen scraping method yields a similar result to that of OB API authentication technology, as both provide users with access to aggregated accounts. However, under PSD2, screen scraping is prohibited[185] because of security concerns. One can scrape data and republish data without user knowledge and, therefore, may raise privacy or copyright concerns.[186]

The US Current Regulations

Several regulatory bodies and industry groups guide OB, but these guidelines are mostly non-binding. The Consumer Financial Protection Bureau ("CFPB") released guidelines on how to access consumer

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[182] Australian Securities & Investment Commission (ASIC), CONSULTATION PAPER 20: ACCOUNT AGGREGATION IN THE FINANCIAL SERVICES SECTOR 1 (2001)

[183] Han Wei Liu, 'TWO DECADES OF LAWS AND PRACTICE AROUND SCREEN SCRAPING IN THE COMMON LAW WORLD AND ITS OPEN BANKING WATERSHED MOMENT' (2020) 30 Washington International Law Journal.,p29

[184] (*Plaid.com*, 2021) <https://plaid.com/documents/Plaid-Consumer-Data-Access-RFI-Technical-Policy-Response.pdf?fbclid=IwAR34z12vdZghnyenQcaLpRLjpRBWfKyQfHXyEPpkzD3xA6zU-fOH8qEjwPc>

[185] Reg.67, PSD2

[186] Andrew Sellars, 'Twenty Years Of Web Scraping And The Computer Fraud And Abuse Act' [2018] 24 B.U. J. Sci. & Tech. L. 372.

data.[187] The guideline sections resemble PSD2 on security, transparency of consumer data collection and storage, and the provision of the dispute settlement system. The Federal Financial Institutions Examination Council ("FFIEC") issued guidance on the retail payment system.[188] Moreover, industry groups such as the National Automated Clearing House Association ("NACHA") partnered with Accenture to publish the API Standardisation Industry Group. The API provides access to fraud and risk systems, information data and payment systems.[189] To adapt to PSD2 requirements, the US Financial Services Information Sharing and Analysis Centre ("FS-ISAC") developed a standard API compatible with PSD2 to assist US and UK businesses.[190] In addition to those guidelines and API standards from regulatory bodies and industry groups, there are also APIs developed by companies such as Plaid.[191]

US regulation of open banking is market-driven to foster innovation and competition for the benefit of customers.[192] Market participants need to develop their own API standards and solve connection issues mutually. The resulting relationship is a similar group of partnerships between individual banks and TPPs. In comparison, OB in the EU is a platform connecting a bank system with multiple TPPs. Therefore, without the regulatory requirements, OB development in the US can be delayed.

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[187] 'Open Banking: US Is Next' [2018] PwC's Financial Crimes Unit, PwC <https://www.pwc.com/us/en/financial-services/financial-crimes/publications/assets/pwc-open-banking.pdf> accessed 11 April 2021.

[188] Ibid

[189] Susan Pandy, 'Developments In Open Banking And APIs: Where Does The U.S. Stand?' [2020] Federal Reserve Bank of Boston.

[190] 'Open Banking: US Is Next' [2018] PwC's Financial Crimes Unit, PwC <https://www.pwc.com/us/en/financial-services/financial-crimes/publications/assets/pwc-open-banking.pdf> accessed 11 April 2021.

[191] 'Build The Future Of Open Finance | Plaid Exchange' (*Plaid*, 2021) <https://plaid.com/plaid-exchange/> accessed 16 April 2021.

[192] 'How A Rapidly Evolving US Open Banking Ecosystem Will Take Shape' (2019) <https://www.ey.com/en_gl/banking-capital-markets/how-a-rapidly-evolving-us-open-banking-ecosystem-will-take-shape> accessed 8 April 2021.

Up to 2020, the regulator adopted a wait-and-see stage. In November 2020, the Consumer Financial Protection Bureau ("CFPB") started to draft an 'Advance notice of proposed rulemaking' on Open banking.[193] The Bureau developed regulations to implement Section 1033 of the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act).[194] This section deals explicitly with consumer access to financial records, equivalent to PSD2 in the UK. However, the earliest this regulation was proposed in 2023,[195] and it is likely to be implemented in 2024.[196]

In conclusion, the US OB sector is transitioning toward a regulated market, and the US regulatory authority may follow the European counterpart in issuing Technical and regulatory requirements for a secured API and prohibiting screen scraping.

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[193] Advance notice of proposed rulemaking 2020.< https://files.consumerfinance.gov/f/documents/cfpb_section-1033-dodd-frank_advance-notice-proposed-rulemaking_2020-10.pdf?utm_source=Triggermail&utm_medium=email&utm_campaign=Post%20Blast%20bii-banking:%20CFPB%20moves%20toward%20open%20banking%20regulation%20%7C%20Wells%20Fargo%20considers%20selling%20asset%20management%20unit%20%7C%20Danish%20neobank%20Lunar%20eyes%20buy%20now%2C%20pay%20later&utm_term=BII%20List%20Banking%20ALL>

[194] Ibid

[195] 'CFPB Likely to Punt Data-Sharing Rule into 2023' (*American Banker*, 13 January 2022) <https://www.americanbanker.com/news/cfpb-likely-to-punt-data-sharing-rule-into-2023> accessed 13 June 2022.

[196] Tom Groenfeldt, 'U.S. Regulators Are Promoting Open Banking Through Uniform Rules' (*Forbes*) <https://www.forbes.com/sites/tomgroenfeldt/2024/02/14/us-regulators-are-promoting-open-banking-through-uniform-rules/>.

2.2.4 China

The Chinese OB is market-driven, where regulatory bodies adopt a monitoring approach with strict prescriptive regulations yet to be issued.[197] The Chinese OB sector is distinctive due to its market structure and the participants. The main driving force for OB in China is the leading payment providers, Alipay and Tencent.[198]

China`s market

The market is concentrated in the hands of several TPPs, primarily Alipay and WeChat Pay.[199] Alipay, established as a payment provider, has about 1.3 billion active users annually.[200] API development has grown exponentially, with Alipay and WeChat Pay leading China.[201] These providers are building a super

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[197] Susan Pandy, 'Developments In Open Banking And APIs: Where Does The U.S. Stand?' [2020] Federal Reserve Bank of Boston, 4

[198] 'China: Market Share Of Mobile Payments 2018 | Statista' (*Statista*, 2021) <https://www.statista.com/statistics/1050151/china-market-share-of-mobile-payments/> ; China's personal information protection in a data-driven economy: A privacy policy study of Alibaba, Baidu and Tencent, p2

[199] Adrian Klee, 'Asia Is The Next Frontier In Open Banking' (*Ross Republic - A strategy consultancy*, 2021) <https://rossrepublic.com/asia-is-the-next-frontier-in-open-banking/?fbclid=IwAR0jZhYSqijZkgAjqOhzfBhvYhO-U1LyQELvGwGusmOuFVeKLyczCkLAoIo> accessed 17 April 2021.

[200] CIW Team and others, 'Alipay Profile, Trends And Insights – China Internet Watch' (*Chinainternetwatch.com*, 2021) <https://www.chinainternetwatch.com/tag/alipay/#:~:text=Alipay%20is%20China's%20leading%20online,the%20course%20of%20a%20year> accessed 24 April 2021.

[201]Gilly Wright, 'Open Banking Goes Global' [2019] SIBOS SUPERSECTION; 'From Fintechs To Banking As A Service: Global Trends Banks Cannot Ignore' [2021] LSE Business Review <https://blogs.lse.ac.uk/businessreview/2021/01/19/from-fintechs-to-banking-as-a-service-global-trends-banks-cannot-ignore/>, p2 ;

app, a system of applications which will provide various financial services.[202] At the initial stage, the providers offer payment services, and after collecting data from payment transactions, the providers can offer loans. In the case of Alipay, the loan can be invested in purchasing goods via the Alibaba e-commerce platform.[203] Therefore, the number of TPPs in China is small, and those providers provide several services in one app.

The Chinese banking industry comprises state-owned and domestic or foreign private banks with distinct performance and risk appetites.[204] State-owned banks often invest in high-risk projects with less profit than private ones, targeting projects with larger social benefits or supporting other state-owned enterprises ("SOE").[205] The government often controls those banks.[206] In the case of OB service, both the private and state-owned banks open account information services. However, third parties such as Alipay and WeChat Pay lead the market in China due to their market share. For example, the number of Alipay users alone is more than 1 billion, accounting for over 50% of the 29 trillion USD Chinese payment market.[207] Consequently, they are leading the development of API for the OB sector

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[202] 'From Fintechs To Banking As A Service: Global Trends Banks Cannot Ignore' [2021] LSE Business Review <https://blogs.lse.ac.uk/businessreview/2021/01/19/from-fintechs-to-banking-as-a-service-global-trends-banks-cannot-ignore/> accessed 12 April 2021.

[203] Ibid

[204] Yizhe Dong and others, 'Ownership Structure And Risk-Taking: Comparative Evidence From Private And State-Controlled Banks In China' (2014) 36 International Review of Financial Analysis.

[205] George R.G. Clarke, Robert Cull and Mary M. Shirley, 'Bank Privatization In Developing Countries: A Summary Of Lessons And Findings' (2005) 29 Journal of Banking & Finance.

[206] Yizhe Dong and others, 'Ownership Structure And Risk-Taking: Comparative Evidence From Private And State-Controlled Banks In China' (2014) 36 International Review of Financial Analysis.

[207] Adrian Klee, 'Asia Is The Next Frontier In Open Banking' (*Ross Republic - A strategy consultancy*, 2021).

in China.[208] The conflict between the SOE bank and the leading TPP can be illustrated by the decision of the Chinese authorities to postpone Alipay's IPO and impose a fine of 2.8 billion USD on the antitrust issue.[209]

Regulators in China

The People's Bank of China ("PBOC") regulates payment services in China under the Administrative Measures for the Payment Services Provided by Non-financial Institutions.[210] Payment service providers are required to obtain a license issued by the PBOC.[211] However, the PBOC's approach to OB is market-driven and has only issued an API financial standard for commercial banks. These standards are non-binding; they describe the security level, design standard, connection protocols, and other technical requirements.[212]

Future OB regulations from the PBOC are uncertain. However, the current concern is the monopolistic positions of dominant TPPs. The government now sees Ant Group, owner of Alipay, as an impediment to market development because of its monopolistic position.[213] The State Administration for Market

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[208] Ibid

[209] 'Chinese Regulators Fine Alibaba Record $2.8Bn' (*Ft.com*, 2021) <https://www.ft.com/content/bb251dcc-4bff-4883-9d81-061114fee87f> accessed 17 April 2021.

[210] CLI.4.134238(EN), http://www.lawinfochina.com/Display.aspx?lib=law&Cgid=134238 ; 'First-Step Analysis: Fintech Regulation In China | Lexology' (*Lexology.com*, 2021) <https://www.lexology.com/library/detail.aspx?g=67a79cf1-5a31-4b95-aca7-c042a780fa42&fbclid=IwAR2k1uiigk4PR-7UuX-JmBBNRyUgi2iQ0rla14zDk08WwAQytVJiYpsSIfc> accessed 10 April 2021.

[211] Art 3, Administrative Measures for the Payment Services Provided by Non-financial Institutions CLI.4.134238(EN)

[212] Ibid

[213] 'China'S Banking Regulator Signals Tougher Fintech Antitrust Laws' (*Ft.com*, 2021) <https://www.ft.com/content/843b3f60-292b-431f-a94c-93c78bc72bae?fbclid=IwAR2i-KJnkgSnLVm4CGgDiX23j1L8gWy6gHzp5wJA-bvcHcZ79KIkpMJv72w> accessed 16 April 2021.

Regulation has published an Antitrust regulation on the activities of payment services using customer data to target and price.[214]

2.2.5 Conclusion

The differences in OB approaches across jurisdictions reveal two issues:

- Whether the method of obtaining data is through API authorisation or not.
- Whether there are specific OB regulations or non-binding guidelines/standards.

Secondly, a general definition of OB for different jurisdictions is 'the sharing and leveraging of customer-permission data by banks with third-party developers and firms to build applications and services [...]', omitting the regulatory requirements in sharing or security standards.

Thirdly, there are two regulatory approaches: organic (market-driven) and regulation-driven.

Furthermore, the heavily regulated OB does not equate to increased consumer sentiment toward OB, as observed in China and the US, where a market-driven approach continues to enjoy high consumer sentiment.

However, the approach is exposed to several risks. In the Chinese market, there is a high market concentration of TPPS. This can distort competition, and as a result, the regulatory authority has

[214] Arjun Kharpal, 'China Faces The Challenge Of Keeping Its Big Tech In Check — Just Like The U.S. Does' (*CNBC*, 2020) <https://www.cnbc.com/2020/11/13/china-faces-the-challenge-of-keeping-big-tech-in-check.html?fbclid=IwAR2D8MYwoko3YkmgRzx1nbHpvpUpJWYQW9QYT5wilokYeZgo7ofBijfUrYU>.

enforced antitrust regulations.[215] The antitrust problem in the US sector is not significant because of the large number of existing third-party providers and account information providers. However, it does create a problem with multiple and different API standards, as each party or group creates its own standard. Currently, the API standard is not an issue for the Chinese OB sector as there is a small number of big providers. However, data privacy and security regulations are concerning. The US authorities will likely follow the EU and UK in standardising API and raising the higher regulatory technical standards for security authorisation. As a result, those jurisdictions will gradually regulate the OB sector depending on their relevant issues of concern.

[215]'China Fines Alibaba $2.8 Billion In Landmark Antitrust Case' (*Nytimes.com*, 2021) <https://www.nytimes.com/2021/04/09/technology/china-alibaba-monopoly-fine.html> accessed 15 July 2021.; 'China Fines Major Internet Companies In Anti-Monopoly Cases - Zenger News' (*Zenger News*, 2021) <https://www.zenger.news/2021/07/08/china-fines-major-internet-companies-in-anti-monopoly-cases/> accessed 15 July 2021.

2.3 Enforcement of OB regulations in the United Kingdom

Background

In the UK, the EU Payment Services Directive was transposed to UK law as the Payment Services Regulations 2017.[216] Providers such as PISPs, AISPs, and ASPSPs are under the scope of regulation,[217] which includes requirements on capital, liability, and technical standards.[218] The regulation is established by the Financial Conduct Authority ("FCA").[219] Its functions include the monitoring and enforcement of regulations, reporting, and imposing financial penalties.[220] Credit-customer relationship, contractual rights and obligations of parties, and liabilities of payment system participants are effective immediately after PSR 2017 enforcement.[221]

The RTS are the requirements of application communication between third-party providers and banks as guidance on how to implement the PSD2 Directive. It is separated into a different set of requirements. The EBA was in charge of drafting the RTS under PSD2.[222] EBA officially published RTS

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[216] SI 2017/752

[217] Art. 2(2), Art. 2(3) and Art. 2(4), PSD2

[218] PSD2

[219] Reg 106, PSR 2017;'SUP 15 Annex 1 Application Of SUP 15 To Incoming EEA Firms, Incoming Treaty Firms, EEA Authorised Payment Institutions And EEA Authorised Electronic Money Institutions - FCA Handbook' (*Handbook.fca.org.uk*, 2021) <https://www.handbook.fca.org.uk/handbook/SUP/15/Annex1.html?date=2018-01-13> accessed 3 March 2021.

[220] Reg 108-115, PSR2017

[221] Iris H.-Y Chiu and Johanna Wilson, *Banking Law And Regulation* (Oxford University Press 2019),

[222] Art 95-97, PSD2

on 13 March 2018 and was supposed to come into effect in September 2019.[223] According to the roadmap, the first technical requirements for Sterling accounts, Open data for standardised back-door products, and Service quality metrics should be implemented by September 2018. The bank`s system had to provide access to its consumer accounts with Sterling currency and other services such as loans, mortgages, and savings products.[224] The last requirements for security measures, such as multi-factor authorisation, two-factor authentication, dispute management system, and some other functions, were to be completed before September 2019.[225] However, the deadline has been revised several times.[226] The implementation deadline for Strong Customer Authorisation("SCA") was set for 14 September 2021,[227] then pushed back to 14 March 2022 with some exemptions until 30 September 2022.[228] The completion of OB implementation was announced in 2023.[229]

2.3.1 OB Regulators

The OB regulations develop in several stages, including the First Payment Directive, the Second Payment Services Directive, and the Digital Markets, Competition and Consumers Act. Along with the

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[223] Ibid 118

[224] OBIE PMO, 'Open Banking Revision To The Agreed Arrangements V2.5' (OPEN BANKING LIMITED 2018).

[225] Ibid

[226] Steve Mansfield-Devine, 'Open Banking: Opportunity And Danger' Computer Fraud & Security,p11

[227] 'UK Pushes Back Strong Authentication For Payments Deadline And European Industry Requests Extension | Biometric Update' (*Biometric Update |*, 2021) <https://www.biometricupdate.com/202005/uk-pushes-back-strong-authentication-for-payments-deadline-and-european-industry-requests-extension> accessed 12 February 2021.

[228] 'Strong Customer Authentication' (*FCA*, 2 September 2019) <https://www.fca.org.uk/firms/strong-customer-authentication>.

[229] Patrick Cannon, 'The OBIE Marks Completion of CMA Open Banking Roadmap on Fifth Anniversary' (*Open Banking*, 13 January 2023) <https://www.openbanking.org.uk/news/the-obie-marks-completion-of-cma-open-banking-roadmap-on-fifth-anniversary/>.

regulations, regulatory bodies are assigned specific functions. Oversight and enforcement of OB operations are distributed among the FCA, CMA, HM Treasury, and their joint committee and entity. Different committees and regulatory bodies participate in each stage of OB development. The roadmap of key events is depicted below:

- Pre-2016: Market Investigations and Early Data-Sharing Concepts

Market Investigations: Throughout the early 2010s, the UK banking sector faced criticisms of lacking competition, particularly in the retail and small business banking markets. Repeated studies by the Office of Fair Trading ("OFT") and the Financial Services Authority ("FSA") have found that entrenched incumbents are often not incentivised to improve their product offerings for consumers and small to medium-sized enterprises ("SME").

EU Directive PSD2: In parallel, the second EU Payment Services Directive ("PSD2"), adopted in 2015, required banks across the European Union to provide access to payment accounts and to allow regulated third-party providers to initiate payments and retrieve account information, contingent on consumers' explicit consent. The UK transposed PSD2 into domestic law in 2017 as the Payment Services Regulation 2017 ("PSR 2017").

- 2016–2017: CMA Retail Banking Market Investigation and Launch

In its final report of August 2016, the CMA identified barriers preventing customers from accessing better banking products and recommended "Open Banking" as a remedy, mandating the largest nine banks ("CMA9") to open clients' data for secure data sharing and payment initiation.

Published in February 2017, the CMA Retail Banking Market Order legally required the CMA9 to establish and fund a central implementation body to oversee the delivery of standardised OB APIs. This entity evolved into the Open Banking Implementation Entity ("OBIE").

- 2018–2020: Early Implementation and Initial Adoption

OBIE published iterative "roadmaps" detailing technical specifications, security frameworks such as strong customer authentication and data standards. By early 2018, initial read/write APIs became available for account information service providers ("AISP"s) and payment initiation service providers ("PISP"s).

During this period, the FCA played a crucial role in authorising new TPPs, while the PSR worked to ensure that the UK's payment systems, such as Faster Payments and Bacs, supported the emerging open banking payment flows.

- 2021–2023: Expanded Scope, JROC Formation, and Wider Ecosystem

By 2021, TPPs had begun to mature and incorporate OB into consumer finance apps, SME cash flow tools, and streamlined payment solutions. The number of OB users in the UK reached over 7 million consumers and businesses. However, the deadline of OB implementation was delayed several times, which led to the creation of an assessment group and an investigation into OBIE. As a result, the new Board of OBIE was elected.

The Joint Regulatory Oversight Committee ("JROC") was established in March 2022 by HM Treasury, the FCA, the PSR, and the CMA to oversee the next phase of OB, aiming to expand data sharing across other markets, such as energy, transportation, or tax data.

- Post-2023: Transition to Future Entity

In early 2023, OBIE substantially completed the CMA Order "Roadmap," leading the CMA to declare the completion of the first stage. JROC proposed transitioning from OBIE's implementation phase to a broader, industry-funded Future Entity.

In summary, different regulators are involved in each period of OB implementation. They include HM Treasury, CMA, FCA and others. The scope and involvement of regulators are explained below.

2.3.2 HM Treasury

The Treasury is responsible for economic policy, which aims to achieve sustainable economic growth. Its responsibilities include controlling public spending, shaping financial services policy, overseeing the tax system, and managing UK infrastructure investment.[230]

Particularly for the financial services sector, its priority is to manage stronger, safer banks and increase access to financial services, enhancing competitiveness across the sector to achieve strong, sustainable growth.[231]

One of the UK government's policies to support sustainable economic growth is the use of the Smart Data scheme. It is the policy to form a portable data economy that drives growth and innovation based

[230] 'About Us' (*GOV.UK*) <https://www.gov.uk/government/organisations/hm-treasury/about>.

[231] ibid.

on open data.[232] The implementation of the policy in the financial sector is assigned to HM Treasury along with other regulators. The implementation can be divided into two stages: the first is OB, and the second is OF. During the first stage, the client`s data of the UK's nine biggest banks, CMA9, is shared with other financial service providers. During the second stage, the open data scheme will be extended into other sectors. The UK government's vision is to increase UK GDP by £28 billion through smart data sharing.[233]

At the first stage, the Treasury requested an examination into the data application by the Open Data Institute and Fingleton Associates in 2014. Based on the examination recommendation to establish a standardising API to share banks' data, it formed an Open Banking Working Group ("OBWG") in 2015 to examine the possible way for an open data standard in payment transactions, saving, borrowing and investment.[234]

The OB Standard, issued by OBWG, establishes key principles for implementing the API.[235] The standard should be transparent, support accessibility, usability and innovation. Regarding the implementation, the access to customer data is through consent, subject to restrictions in time or size. The existing data

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[232] 'The Smart Data Roadmap: Action the Government Is Taking in 2024 to 2025' (*GOV.UK*) <https://www.gov.uk/government/publications/the-smart-data-roadmap-action-the-government-is-taking-in-2024-to-2025>.

[233] Joint Regulatory Oversight Committee, 'JROC's Proposals for the Design of the Future Entity for UK Open Banking'.

[234] Kirstin Baker, 'Open Banking Lessons Learned Review: Report by Kirstin Baker' <https://www.gov.uk/government/publications/open-banking-lessons-learned-review-report-by-kirstin-baker>.

[235] 'Unlocking Digital Competition, Report of the Digital Competition Expert Panel' (*GOV.UK*) <https://www.gov.uk/government/publications/unlocking-digital-competition-report-of-the-digital-competition-expert-panel>.

standards should be reused as appropriate. Moreover, the oversight of implementation should be assigned to a newly created independent authority. Lastly, the scope of implementation is based on the "minimum viable product" ("MVP") principle, which dictates the launching of lower-risk, easily implementable components first.

At the second OF stage, the Treasury's responsibility is to develop the OF implementation strategy in the banking and financial sectors.[236] At first, the Centre for Finance, Innovation and Technology ("CFIT") issued the OF blueprint.[237] Its findings suggest that OF will increase SME lending. In addition, data sharing will generate tailored financial services to assist vulnerable people in alleviating financial stress. For example, the OB integration with HMRC VAT data can increase the application by 20%-40% by cutting the processing time by half. This will include more than 150,000 customers annually in the sector and increase the UK GDP by £30 billion.[238] On the technical side, the consent period's length, the consent's design and authorisation flow, and the screens are important to the solution, as they influence the customer's understanding of their sharing decision regarding whom and how to share data.

In addition, the Joint Regulatory Oversight Committee ("JROC") was established in March 2022 to design and oversee the OF phase. The JROC consists of FCA, PSR as co-chairs and Treasury and CMA as members. JROC has published recommendations and the roadmap for the next phase of OB.[239] As a

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[236] 'The Smart Data Roadmap: Action the Government Is Taking in 2024 to 2025' (n 233).

[237] 'Embracing the UK's Open Finance Opportunity' <https://cfit.org.uk/open-finance/>.

[238] ibid 8.

[239] 'Recommendations for the next Phase of Open Banking in the UK' (*GOV.UK*) <https://www.gov.uk/government/publications/recommendations-for-the-next-phase-of-open-banking-in-the-uk>.

result, a long-term regulatory framework was proposed, and a Future Entity Working Group ("FEWG") was established to examine the options for the future entity regarding its funding, role, structure, and governance.

Lastly, based on the CFIT blueprint and JROC recommendations, the Treasury proposed the Data Protection and Digital Identity ("DPDI") Bill to set up a long-term OB regulatory framework.

2.3.4 Financial Conduct Authority ("FCA") and Prudential Regulation Authority ("PRA")

The FCA regulates the conduct of financial service firms in the UK. Its roles include ensuring a fair, competitive, and honest financial market by preventing harm, setting high standards, and promoting competition. Since 2003, its secondary objective has included facilitating international competitiveness and economic growth in the medium to long term.[240]

FCA operates under the Financial Services and Markets Act 2000. It is an independent public body, the funding derived from the fees of regulated firms, and it is accountable to HMT and the Parliament. Additionally, FCA collaborates with other regulators to achieve its objectives. These include the PRA, which regulates around 1500 banks, building societies and other financial firms.[241] The FCA assesses fairness on the consumer credit side, whereas the PRA maintains microprudential regulation.

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[240] 'Background to the PSR' <https://www.psr.org.uk/about-us/background-to-the-psr/>.

[241] 'Prudential Regulation' (10 April 2025) <https://www.bankofengland.co.uk/prudential-regulation>.

PSR was formed under the Financial Services (Banking Reform) Act 2013, which regulates the designated eight payment systems in the UK.[242] These include BACS for direct Debits, CHAPS for high-value transactions, Mastercard, Visa, and others. The overall transaction volume of the systems is around 22 billion transactions a year.[243]

The objective of the PSR is to set out a regulatory framework to promote innovation and competition, communicate with participants and investigate complaints in the payment systems.

In OB, FCA is delegated the task of authorising and supervising OB providers.[244] According to Regulation 106a of the Payment Services Regulations 2017, the development of OB technical standards is also under the FCA's responsibility.[245] Moreover, FCA and FSR generally participate in the OF through the co-chair of the Joint Regulatory Oversight Committee ("JROC"), which is responsible for implementing the OF.

2.3.5 Open Banking Implementation Entity ("OBIE") and the future entity

OBIE is responsible for the implementation of OB regulations.[246] Its core tasks include delivering secure, standardised APIS, data formats and operational guidelines.

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[242] 'Who We Regulate' <https://www.psr.org.uk/how-we-regulate/who-we-regulate/>.

[243] 'When You Make a Payment' <https://www.psr.org.uk/how-we-regulate/when-you-make-a-payment/>.

[244] Payment Services Regulation 2017 (SI 2017/752)

[245] 'TECHNICAL STANDARDS ON STRONG CUSTOMER AUTHENTICATION AND COMMON AND SECURE METHODS OF COMMUNICATION INSTRUMENT 2020' ch 3.

[246] 'About the OBIE' (*Open Banking*) <https://www.openbanking.org.uk/about-us/>.

Over the years of implementation, it has published several updated OB standards with enhanced security, improved information flow, such as payment status and error messaging. Additionally, it has produced four impact reports with various other documentation.[247]

With the completion of the CMA Roadmap, OBIE's function has moved from an "implementation" focus to a broader governance and maintenance role. JROC's 2023 recommendations propose transitioning to a "Future Entity" in the stage of OF, possibly overseeing new functionalities such as premium APIs, variable recurring payments, and data-sharing expansions into energy, transportation and other sectors.[248]

2.3.6 Competition and Markets Authority ("CMA")

The CMA was established by the Enterprise and Regulatory Reform Act 2013. It possesses strong enforcement powers, incorporating functions from the Competition Commission and the Office of Fair Trading that were transferred to the CMA in 2014. Currently, it is responsible for ensuring competition in the markets for the benefit of consumers both inside and outside the UK. In particular, these include:[249]

- Investigates and intervenes in mergers that may substantially lessen competition.
- Takes action against cartels and restrictive business practices.

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[247] 'Delivering the Roadmap' (n 39).

[248] Joint Regulatory Oversight Committee, 'Update on Actions to Enable the next Phase of Open Banking in the UK' <https://www.gov.uk/government/publications/joint-regulatory-oversight-committee-update-on-actions-to-enable-the-next-phase-of-open-banking-in-the-uk>.

[249] CMA, 'About Us' (*GOV.UK*) <https://www.gov.uk/government/organisations/competition-and-markets-authority/about>.

- Addresses unfair trading practices and systemic market issues.
- Investigate markets where competition or consumer concerns arise.
- Advises government and regulators on competition policies.
- Reviews price controls and related regulatory issues.
- Provides information on competition and consumer law.
- Monitors and reports through the Office for the Internal Market.
- Advises and monitors government subsidies via the Subsidy Advice Unit.

The structure of CMA comprises a Board and the Chief Executive. It is an independent non-ministerial department. The OIM, a unit of CMA, is responsible for monitoring and reporting on the competition in the internal market. [250] Distinctively, the SAU provide advice to authorities regarding the harmful effects on competition and investment.[251]

From January 2025, new responsibilities for the CMA came into force under the Digital Markets, Competition and Consumers Act 2024 ("DMCC Act").[252] Under the Act, the regulation of competition in the digital market is conferred to the CMA.[253] This includes the power to designate the undertaking market status,[254] impose a conduct requirement on the undertaking to promote competition, [255]

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[250] ibid.

[251] ibid.

[252] 'How the UK's Digital Markets Competition Regime Works' (*GOV.UK*, 23 January 2025) <https://www.gov.uk/guidance/how-the-uks-digital-markets-competition-regime-works>.

[253] Chapter 1, Section 1, DMCC Act 2024

[254] Chapter 2, DMCC Act 2024

[255] Chapters 3 and 4, DMCC Act 2024

initiate investigation and compliance report.[256] In addition, the Digital Markets Unit ("DMU") was established to fulfil its additional responsibilities. The 'digital markets competition regimes' amend the Competition Act 1998 to regulate competition in the digital market.[257]

The Act allows the CMA to investigate an undertaking with strategic market status ("SMS").[258] Those are undertakings that have digital activities linked to the UK that bear special conditions that resulted in an entrenched dominant position.[259] If the regulator finds an adverse effect on competition, it can provide tailored guidance on the undertaking`s behaviour through tailored conduct requirements.[260] There are various options for conduct prohibition, such as providing unclear information, unreasonable period of notice, using data unfairly or restricting users from using other providers' products.[261] In addition, the regulator can target specific harmful behaviour in a specific digital sector through a pro-competition intervention remedy.[262] In this approach, CMA begins with an investigation in relation to the undertaking.[263] Then, based on the investigation, it may issue a pro-competition order to address issues found in the investigation.[264]

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[256] Chapter 6, DMCC Act 2024

[257] 'How the UK's Digital Markets Competition Regime Works' (n 253).

[258] Chapter 3, DMCC Act 2024

[259] Art 2-6, DMCC Act 2024

[260] Art 19-20, DMCC Act 2024

[261] Art 20, DMCC Act 2024

[262] Chapter 4, DMCC Act 2024

[263] Art 47, DMCC Act 2024

[264] Art 51,DMCC Act 2024

CMA investigations in the financial market and OB

Over the past decade, the UK CMA has conducted numerous market investigations and studies focused on financial services and, more recently, data-driven digital markets. These investigations cover personal banking, credit, online platforms, and Big Tech ecosystems, all aimed at protecting consumers from harm and designing appropriate remedies.

The transition to a data-driven economy requires new regulations for the digital market; there are two investigations that lay the groundwork for future remedies and legislative frameworks. The first was the Online Platforms and Digital Advertising Market Study, conducted from 2019 to 2020. The second is the market study into Mobile Ecosystems between 2021 and 2022. Following the enactment of the DMCC Act 2024, the CMA launched two investigations into the Strategic Market Status of Google and Apple.[265]

Regarding the OB market, CMA initiated the retail banking investigation in 2016. The investigation focused on personal current accounts for individuals and business current accounts for SMEs.[266] It examined the dominance of the UK's largest banks and issues such as low customer switching rates and opaque fees. The CMA implemented a wide-ranging package of remedies to address the issues of weak competition and consumer harm in the investigation. Central to these was the introduction of the OB standard. CMA ordered the nine largest banks (the "CMA9") to open access to clients' data to

[265] 'Invitation to Comment: SMS Investigations into Apple and Google's Mobile Ecosystems' (*CMA Connect*) <https://connect.cma.gov.uk/invitation-to-comment-sms-investigations-into-apple-and-google-s-mobile-ecosystems>.

[266] CMA, 'Retail Banking Market Investigation' (n 121).

form the OB ecosystem.[267] Moreover, the OBIE, which is the OB implementation body, operates under the supervision of the CMA. The CMA is responsible for appointing its Board members. Furthermore, the CMA also takes part in the subsequent stage of OF; its representative serves on the Joint Regulatory Oversight Committee.

During the OB enforcement, CMA exercised its authority to intervene when implementation issues arose. It initiated an independent investigation into OBIE following several delays in OB deadlines. These investigations include Alison White's report and Kirstin Baker's Review.

Alison White investigation.

During the investigation, 28 people provided evidence regarding complaints of bullying, harassment, and discrimination.[268] The problems were identified in both the individuals and the organisation's culture. To summarise, the investigator believes that OBL was not properly managed in accordance with the CMA Order.

The investigation revealed the problem with decision-making. For instance, the resourcing was based solely on the contract model. Moreover, there were delays in management actions, such as the Director`s remuneration. In addition, there was a failure in the treatment of employees and conflict mitigation. Lastly, it failed to maintain effective communication among key stakeholders, namely CMA and CMA9 banks.

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[267] 'CMA Paves the Way for Open Banking Revolution' (*GOV.UK*) <https://www.gov.uk/government/news/cma-paves-the-way-for-open-banking-revolution>.

[268] Alison White, 'Open Banking Limited Independent Investigation Report' (*GOV.UK*, 16 December 2021) <https://www.gov.uk/government/publications/open-banking-limited-independent-investigation-report>.

To sum up, the investigator does not believe that OBL was managed properly according to the CMA Order. Consequently, several recommendations were proposed. Firstly, appoint new independent non-executives, process an independent internal audit of the risks, and conduct an external review of HR functions. In addition, review organisational processes and redesign the governance structure with the Board`s oversight. Secondly, it is recommended that the previous management be excluded from the design and governance of the reviewed organisation. Lastly, the remedy for whistleblowers should be considered, which could take the form of an apology.

Kirstin Baker Review

Following the Alison report, the CMA appointed Kirstin Baker, an independent non-executive Director of the CMA, to lead the review of OBIE's operations.

The review revealed substantial shortcomings in the CMA's initial remedy design.[269] Specifically, the complexity, costs, and implementation timeline were not accurately estimated. Originally projected to take two years, the project has now been ongoing for more than five years, incurring significant costs that exceed initial estimates. Furthermore, the CMA did not adequately anticipate governance challenges or the need for extensive stakeholder coordination.

Governance at the OBIE faced challenges, including inadequate corporate governance structures, excessive concentration of power, and a lack of sufficient checks and balances. These challenges resulted in failures to manage internal conflicts, procurement, and financial oversight effectively.

[269] Kirstin Baker (n 235).

Internal oversight was found to be lacking in strategic risk management and the clear delineation of roles among stakeholders. These include the CMA, CMA9 banks, and OBIE. Furthermore, the CMA's resources were insufficient to monitor and implement the remedy, lacking dedicated project management and strategic oversight, exacerbating governance issues.

To address these problems, the review makes seven strategic recommendations aimed at enhancing the CMA's oversight, governance, and implementation of complex market remedies. These include establishing more robust governance processes, clear internal decision-making structures, and periodic strategic review points. Additionally, the CMA is advised to proactively manage stakeholder relationships and ensure ongoing risk assessment and sufficient resource allocation to support effective remedy implementation and monitoring.

2.3.7 Conclusion on regulatory framework

To sum up, there are two regulatory approaches to the OB ecosystem. The first is organic (market-driven), which gives market providers the freedom to create their own API standards or other tools for data sharing. In these markets, such as the US, several API standards can compete with each other. Another example is the Chinese market, where two providers dominate with their own API connections.

The second is regulation-driven, which includes EU and UK jurisdictions. This approach utilises regulations that obligate providers to share data. The UK approach is regulation-driven, and open banking (OB) is even more regulated through standardised data-sharing APIS.

In this approach, regulators collaborate with various stakeholders to implement OB regulations. The key regulators include HM Treasury, the FCA, and the CMA. Their roles and interventions vary at different stages of OB development. The cooperation between regulators and stakeholders reveals several issues that have led to delays in OB implementation. As a result, the CMA had to intervene to rectify these issues.

The alignment between the literature review and the CMA investigation focuses on implementation issues. The examination of documents in the literature review section reveals problems with communication between regulators and the technical aspects of implementation. Furthermore, the CMA investigations uncover deeper issues related to the implementation body, OBIE, including problems with the decision-making process, resource allocation, and stakeholder relationship management. Consequently, seven recommendations to enhance the CMA's governance and oversight were proposed.

In the next section, the theoretical framework will be explored. The underlying economic and regulatory theories are assessed to evaluate the possible factors through which the OB regulations impact the OB market.

2.4 Theoretical framework

Introduction

The section aims to develop the theoretical framework of OB regulatory impact. It applies standard market, competition, and regulatory theories to link the impact assumptions. The section seeks to illustrate how OB regulations influence the competitive market and total surplus theoretically. Furthermore, it aims to develop the theoretical interpretation framework of these regulatory impacts. The structure of the regulatory impact theoretical framework is as follows:

- First, the research framework and its approach are described.
- Second, the OB regulatory framework is assessed using economic, competition, and regulatory theories.
- Lastly, the theoretical framework is concluded.

2.4.1 Research Framework

This section aims to set the research framework and then narrow it to a theoretical one. The research is a regulatory impact study conducted under a critical realism framework. It applies an economic approach with interdisciplinary and legal pluralism characteristics. The discussions of the framework characteristics are under the following parts:

- Critical realism.
- Interdisciplinary.

- Legal pluralism.
- Economic approach of regulatory impact studies.

Critical realism

The research framework consists of three steps.[270] The first is the theoretical part, which captures the connection between participants. The second is the methodology or research strategy. The final step involves the methods or techniques used for analysis.

The theoretical part consists of the rationale and epistemology. The rationale is the worldview and approach to its examination, while epistemology is the theory of knowledge guiding the methodology.[271] The common theoretical rationales in social science include positivism, constructivism and critical realism.[272] The positive rationale implies that there is a single, objective truth that can be found through examining the causal relationship of observable empirical events.[273] The constructive rationale view holds that the truth is socially constructed, and therefore, the research is focused on people's subjective understanding.[274] Critical realism acknowledges unobservable interactions in the real world, those that cannot be captured by empirical research. It accepts knowledge claims but critically assesses the validity of the conceptualisation. The reality domains of critical realism are separated into *empirical*, *actual* and *real,* as illustrated in the following figure:

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[270] Michael Crotty, *The Foundations of Social Research: Meaning and Perspective in the Research Process / Michael Crotty.* (Sage Publications, Sage Publications 1998).

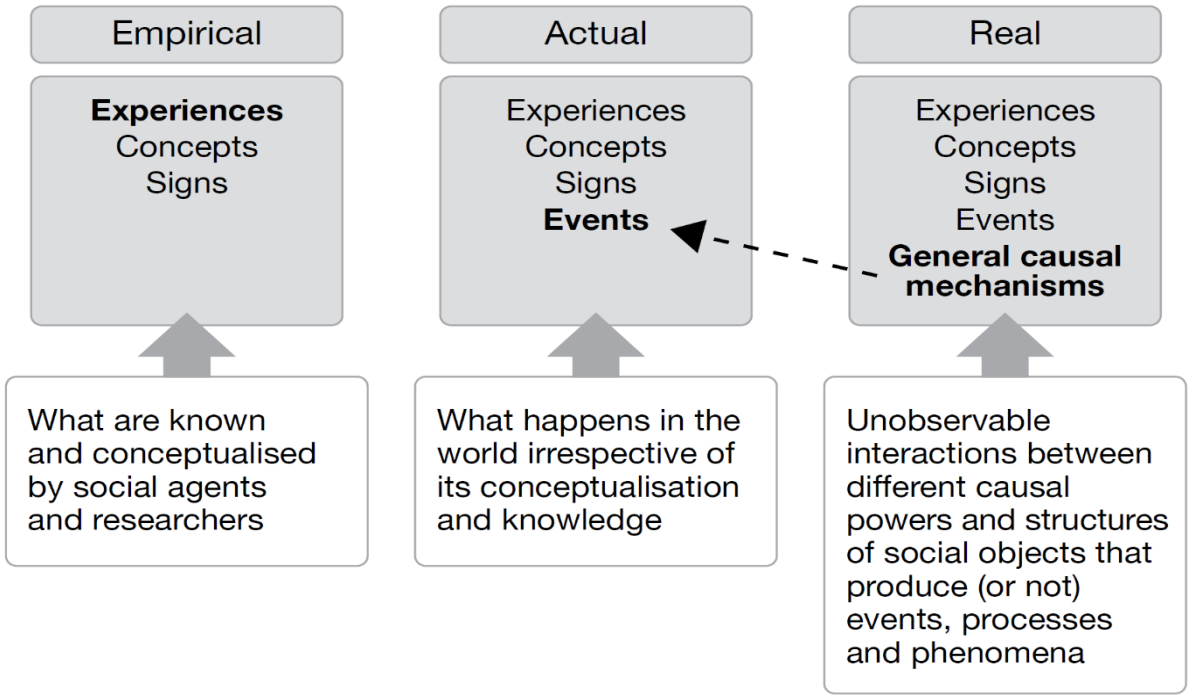
[271] ibid 3.

[272] Drahos (n 92) 81.

[273] Matthew B Miles, A Michael Huberman and Johnny Saldana, *Qualitative Data Analysis* (SAGE 2014).

[274] Martyn Hammersley, *Questioning Qualitative Inquiry: Critical Essays / Martyn Hammersley.* (SAGE 2008) <http://ezproxy.york.ac.uk/login?url=http://SRMO.sagepub.com/view/questioning-qualitative-inquiry/SAGE.xml>.

Figure 5: The reality domain of critical realism. The figure shows the gap between the three domains in critical realism.



Source: Peter Drahos, Regulatory Theory: Foundations and Applications (ANU Press 2017) 83

<http://ebookcentral.proquest.com/lib/york ebooks/detail.action?docID=4835274>

In this research, statistical methods are applied to assess data events generated by the causal mechanism of the natural world. Accepting the reality domains means that there are effects that are not observable by data and not all data can be collected by the statistical method. Therefore, statistical results should be critically assessed with validity, and the results of the statistical tests need to be explained with the possible unobservable factors captured by data.

The regulatory study examines complex processes with structural and systemic conditions between people and organisations.[275] The study involves theoretical foundations in different disciplines,

[275] Drahos (n 92).

explaining the interplay and causal mechanisms.[276] On the contrary, the research can be fragmented without a theory that connects the disciplines.[277] As such, the research applies an interdisciplinary approach.

Interdisciplinary

The relationships in OB are those between service suppliers and consumers, the competitive suppliers in the same market, and suppliers and their employees. OB regulations do not regulate the relationship between service suppliers and the employee; they only regulate the relationships between suppliers and consumers and between the incumbent supplier and newcomers.[278] Economic and regulatory theories are selected based on OB regulations, regulatory impact assumptions and this thesis's objective. OB regulations include capital requirements, safeguards, technical standards, and supervision requirements.[279]

Intuitively, the first set of assumptions is that the service supplier has initial conditions. The regulatory enforcement affects the firm's revenue and costs, altering the entry conditions and pre-enforcement advantages positions, which evoke the firm's strategic responses. Ultimately, this leads to a new equilibrium in resource allocation, welfare distribution, and market structure.

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[276] T Iosifides, 'Migration Research between Positivistic Scientism and Relativism: A Critical Realist Way Out' [2012] Handbook of Research Methods in Migration 26; Margaret R Somers, '"We're No Angels": Realism, Rational Choice, and Rationality in Social Science' (1998) 104 The American journal of sociology 722.

[277] Drahos (n 92) 127.

[278] Payment Services Regulation 2017 (SI 2017/752).

[279] ibid.

Consequently, several theories need to be examined. First, the economic supply-demand theory can be applied to assess the change in revenue, cost, and profit of participants or their operations. Second, the financial regulatory instruments will be examined to outline the regulations' objective and impact on the whole system. Lastly, from competition theory, the barriers to entry and strategic behaviour can be analysed. This will help explain changes in the competitive environment caused by the behaviour of incumbents and newcomers and influenced by changing regulations.

Regulatory pluralism

Regulatory research often involves regulatory pluralism, as in this research on OB.[280] The term includes "a much wider range of policy mechanisms than traditionally assumed of law and policy, including economic instruments, self-regulation, information-based strategies, and voluntarism".[281] While a single regulatory instrument has advantages and limitations, a set of regulatory instruments may complement each other to create a positive effect.[282] The command and control regulations can be specification standards that prescribe the specific process and performance standards. These regulations specify the duties, while the process standards focus on the targeted result.[283] Though predictable, they are often rigid and inefficient.[284]

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[280] Drahos (n 92) 137.

[281] Neil Gunningham and Darren Sinclair, 'Regulatory Pluralism: Designing Policy Mixes for Environmental Protection' (1999) 21 Law & Policy 49.

[282] JB Opschoor and RK Turner (eds), *Economic Incentives and Environmental Policies: Principles and Practice: 1* (Softcover reprint of the original 1st ed 1994 edition, Springer 2012).

[283] United States Osha Task Force, *OSHA Safety Regulation: Report of the Presidential Task Force / Edited by Paul W. MacAvoy.* (American Enterprise Institute for Public Policy Research 1977).

[284] Gunningham and Sinclair (n 282).

Resource permits and taxes are the economic instruments that broadly affect the market. In addition, there are specific economic instruments such as subsidies or other types of legal liabilities.[285] They are flexible and unpredictable. Information-based strategies and self-regulation are usually more cost-effective but lack dependability.[286] For instance, the right of the community to know the firms' information can incentivise the firms to improve their performance. However, it does not guarantee the firms' performance in achieving regulatory objectives.[287] Regulations are the optimal combination of regulatory instruments to achieve their objectives.

OB regulations are a combination of instruments. They are a mixture of command and control regulations, economic instruments and information strategies. Thus, the regulatory instruments such as capital, safeguard requirements, technical and information standards, data requirements and competition provisions will be analysed.

This study aims to connect interdisciplinary theories to formulate principles for assessing OB regulatory impacts. It uses the economic approach to regulatory impact studies, which involves the application of economic theories, empirical techniques and cost-benefit assessment on regulatory impact studies.[288]

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[285] ibid p54.

[286] Gunningham and Sinclair (n 282).

[287] ibid 55.

[288] Veljanovski (n 91).

Economic approach

Economics plays an important role in the drafting and assessment of regulations.[289] There are two types of economic approaches under the "public interest" theory: the normative (what should be) and the positive (what is).[290] Normative economic theories attempt to create regulations based on economic concepts.[291] They aim for efficient resource allocation. Economic efficiency is when the resources are allocated to the highest expected value. The market creates a maximum surplus. However, it can fail, and this surplus decreases during the market failure, resulting in inefficient allocation and undermining the public interest. Therefore, regulation is enforced by the demand of public interest to correct the failures.[292] The normative theory looks at the root of market failure: market power, externalities, public goods and asymmetric information.[293]

Positive theory examines the nature and development of regulations, explaining when and why regulations occur.[294] Regulatory impact is usually examined through statistical analysis or cost-benefit assessment.[295] Normative theories can inform positive theories by suggesting why regulations should be established and how they are made.[296] However, critiques of the normative analysis show how it prescribes regulation based on public demand for social welfare gains, but doesn't address how public

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[289] ibid.

[290] ibid.

[291] ibid 4.

[292] Richard A Posner, 'Theories of Economic Regulation' (1974) 5 The Bell Journal of Economics and Management Science 335.

[293] Veljanovski (n 91).

[294] Viscusi and others (n 94) 377.

[295] Veljanovski (n 91).

[296] Viscusi and others (n 94) 378.

demand transforms into regulation.[297] Furthermore, evidence suggests that regulations can be irrational for social welfare gains.[298]

Another normative regulatory theory is the capture theory, which suggests that regulations are formed by interest groups rather than the public interest.[299] The industry often controls or captures the regulator's responses.[300] This theory faces several critiques as it doesn't explain how industries capture regulation. Moreover, empirical evidence shows that regulations sometimes do not support group interests or may even reduce industry profits.[301]

George Stigler suggested that regulators maximised the national interest and were captured by economic interests.[302] Sam Peltzman and other authors continue to develop the model of the economics of regulation.[303] This includes three key assumptions: regulation's primary role is wealth redistribution in society, maximising political support forms regulatory proposals, and interest groups competing for favourable regulations. Gary Becker and Richard Posner further expanded on this, focusing on competition among interest groups[304] and the use of regulation to distribute wealth.[305]

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[297] Viscusi and others (n 94).

[298] ibid 378.

[299] Posner, 'Theories of Economic Regulation' (n 293).

[300] Viscusi and others (n 94).

[301] ibid 380.

[302] George J. Stigler, "The Theory of Economic Regulation," Bell Journal of Economics 2 (1971): 3–21

[303] Sam Peltzman, "Toward a More General Theory of Regulation," Journal of Law and Economics 19 (1976), Roger Noll, Reforming Regulation: Studies in the Regulation of Economic Activity (Washington, D.C.: Brookings Institution, 1971), and Roger Noll, "Government Administrative Behavior and Private Sector Response: AMulti-Disciplinary Survey," Social Science Working Paper Number 62 (Pasadena: California Institute of Technology, 1976).

[304] Gary S Becker, 'A Theory of Competition Among Pressure Groups for Political Influence' (1983) 98 The Quarterly Journal of Economics 371.

[305] Richard Posner, 'Taxation by Regulation' (1971) 2 Bell Journal of Economics and Management Science 22.

Application of Economic Approaches

The economic approach to regulation usually covers the fields of economic regulation, social regulation, and competition regulations[306] and the legal system. The economic and social literature is applied to the regulation design, which consists of several elements.[307] The first is the economic analysis of ex-ante and ex-post responses.[308] In this field, Ehrlich and Posner classified the types of costs that influence the regulation—the fixed costs of rule-making, enforcement costs, compliance and social costs (harm costs).[309] The second factor is the comparison of effectiveness.[310] This comparative factor examines why the regulation is effective in one country or industry but not in another. It can include transactional costs specific to the industry or country.[311] Lastly, the market-based element of the regulation is essential to regulate outcomes rather than inputs. This element encourages regulation to create a market (the output).

The Economic Approach to Regulatory Impact Studies

The regulatory impact studies seek to evaluate whether the regulations achieve their objectives and predict future impacts.[312] Applying economic theories, empirical techniques, and cost-benefit analysis

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[306] Viscusi and others (n 94).

[307] Veljanovski (n 91).

[308] ibid.

[309] Isaac Ehrlich and Richard A Posner, 'An Economic Analysis of Legal Rulemaking' (1974) 3 The Journal of Legal Studies 257.

[310] Veljanovski (n 91).

[311] Pablo Spiller and Brian Levy, 'The Institutional Foundations of Regulatory Commitment: A Comparative Analysis of Telecommunications Regulation' (1994) 10 Journal of Law, Economics and Organization 201.

[312] Veljanovski (n 91).

is challenging due to the broad effects of regulations, data availability, and the complexity of prediction.[313]

This thesis is a regulatory impact study, and its objective is to explore the impact of OB regulations on competitive markets. It focuses on how regulations affect bank and client operations and resource and capacity distribution. The economic approach is applied to assess regulatory impact, using normative analysis and positive explanation based on theories of market failure and competition.

[313] ibid

2.4.2 Theoretical framework

The economic approach involves economic theories to justify regulations and their possible impact. The OB regulations regulate the relationship between suppliers and consumers and between the incumbent supplier and newcomers in the competitive market. Therefore, the theories describing the OB regulatory impacts are standard market, competition and regulatory theories.

This section aims to establish the theoretical relationship between OB regulations and the competitive market, as well as between the competitive market and the total surplus. Consequently, it seeks to establish the OB regulatory impact on the competitive market and the resource capacity distribution.

2.4.2.1 Relationship between transaction cost and regulation

Coase`s theory is an economic theory that describes the bargaining process and the outcomes based on transaction costs.[314] It posits that in negotiating a deal, the buyer and seller initially set the threat value (the value at which they stop negotiating the deal) and the surplus from cooperation. Afterwards, they reach a consensus on the distribution of surplus.[315]

The outcomes show that bargaining is more beneficial than legal responsibility enforcement, and the choice depends on the transaction costs.[316] If the transaction costs are zero, private bargaining will happen regardless of the initial rights. It is illustrated that cooperation or bargaining maximises the benefit.[317] On the contrary, if the transaction costs are high, the regulatory rules will take place: "If

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[314] Robert B Cooter and Thomas Ulen, *Law and Economics* (6. ed., Pearson Education UK 2013) 61.

[315] Cooter and Ulen (n 315).

[316] The costs associated with negotiating or enforcing a contract

[317] Cooter and Ulen (n 315).

bargaining is costly and information is imperfect, then liability rules help to achieve optimality, and the party that has the least costly way of dealing with the harmful effects of an externality should be made responsible for paying the costs associated with the externality".[318]

Accordingly, market failures can be addressed through bargaining or regulatory measures, depending on transaction costs.[319] If the cost is low, the bargaining method can prevail. Otherwise, the regulatory liability will prevail. Consequently, these assumptions can lead to regulatory or deregulatory measures to cut transaction costs in economics and social regulations.[320] In the case of OB regulations, a balance is achieved by raising regulatory compliance costs and lowering the switching and data costs.

2.4.3 Relationship between regulations and competitive market

The regulatory theories describe the effects of regulations on their governing actors, and the strategic response theories explain how the actors strategically behave in the competitive market. These theories are applied to establish the link between OB regulations and the competitive market.

The core OB regulation, PSR 2017, consists of several parts.[321] The first part regulates the registration and authorisation of payment institutions.[322] The second part is the information required for payment services. The third part is about the rights and obligations of the providers. The fourth part is the access

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[318] Yunxian Chen, *The Dual-Entity of Market Competition: Establishment and Development of Mezzoeconomics* (Routledge 2021) 265.

[319] ibid 265–270.

[320] ibid.

[321] Payment Services Regulation 2017 (SI 2017/752).

[322] ibid.

to the payment system and its regulatory technical requirements. The last part is about supervision and penalty. Its impact on the actors will be assessed.

2.4.3.1 Registration and Authorisation

Payment institutions, small payment institutions, their agents and account information service providers must register with FCA.[323] Their records are public online.[324] For the authorisation of the providers, the applicant should submit a set of documents describing its evidence of initial capital, business plan, operational and risk assessment procedure, structural organisation, and governance principles.[325] To be authorised, the applicant must meet several FCA thresholds, such as having a registered head office, having operations in the UK, and having minimum manager qualifications.[326]

A payment institution is considered small if its monthly average transaction amount in 12 months, including its agent in the UK, is less than 3 million euros. [327] For small institutions, a special authorisation regime is applied. The application of small payment institutions is not significantly varied from the standard procedures, except that the business related to the applicant cannot be account information services or payment initiation services.[328] Whereas, for the regular payment institution, the above services can be provided with covered insurance.[329] This prohibition may be justified by the

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[323] Reg 4, ibid.

[324] ibid

[325] Schedule 2, Payment Services Regulation 2017 (SI 2017/752).

[326] Reg 6, ibid

[327] Reg 14 (3), ibid

[328] Reg 14(4), ibid

[329] Reg 6 (7) (e-f), ibid

ability of small institutions to cover the risks related to transactions. There is a limitation of services between regular and small payment institutions.

Another distinction is the different capital and safeguard requirements for the service providers.[330] The initial capital requirement is fixed based on the services from the number of services (a) to (f) in paragraph 1, Schedule 1.[331] The fee table is shown below.

Table 1: The initial capital requirement

Payment services	**Initial capital requirement**
Services specified in paragraph 1(h) of Schedule 1	None
Services specified in paragraph 1(f) of Schedule 1 (money remittance)	20,000
Services specified in paragraph 1(g) of Schedule 1 (payment initiation services)	50,000
Services specified in paragraphs 1(a) to (e) of Schedule 1	125,000

Source: para 2, Schedule 3, PSR 2017

In addition to the initial capital, services-specific capital is required. There are three methods to calculate funds: A, B, and C.[332] For method A, the own fund equals 10% of the institution`s previous

[330] Reg 22, 23, ibid

[331] Para 1, Schedule 1, Payment Services Regulation 2017 (SI 2017/752).

[332] Para 3, 8,9,10, ibid

year's fixed overhead.[333] Usually, overheads can constitute office rental, business insurance, salaries and other fixed overheads.[334] For other methods B and C, the capital requirement accumulates according to the institution`s revenue and services. The higher the transaction volume, the larger the capital requirement.[335] For example, according to method B, the own capital equals the sum of the thresholds multiplied by the scale factor. There are several thresholds, such as if the payment volume is less than 5 million pounds, four per cent will be applied, the next payment volume of 5 million pounds will be 2.5%, and so on.[336] The total sum is then multiplied by the scale factor.[337] The factor depends on how many services the institutions provide. Therefore, with the high payment volume, more services require higher capital.

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[333] Para 8, ibid

[334] *Chapter 8: Accounting for Overheads* (International Federation of Accountants (IFAC)) <https://kfknowledgebank.kaplan.co.uk/acca/chapter-8-accounting-for-overheads>.

[335] ibid

[336] Para 9 (2), ibid

[337] Para 9(4), ibid

Registration and Authorisation Regulatory Impact

The OB capital requirement is imposed in addition to the banking reserve capital requirement and is not significant to the money creation market. The requirement serves as a safety net that protects customers' funds in case of liquidation, not creating a disadvantageous cost burden between small and large payment institutions ("PI").

There are three theories of money creation: agent theory, fractional reserve theory, and credit theory. Agent theory suggests that banks act as an intermediary.[338] They facilitate credit by accepting deposits from creditors and lending them to borrowers.[339] They do not create any additional money but merely act as agents.

Banks also act as an intermediary according to the fractional reserve theory.[340] While an individual bank cannot create money, the whole banking system can. The theory states that when an individual bank creates a credit for the borrower from its deposits, the borrower receives a new fund. The new fund will leave the bank. Therefore, an individual bank does not create more money. However, the banking system will have more money because the new funds will be transferred to another bank. The credit can be multiplied several times to create additional money through the process of lending to

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[338] 'A Lost Century in Economics: Three Theories of Banking and the Conclusive Evidence | Elsevier Enhanced Reader' 362 <https://reader.elsevier.com/reader/sd/pii/S1057521915001477?token=56443CD16014D72A2038860462B7FC7E9FE8E44A04635C990DDE0B348F9721B7D7ECFE4C07E0F5DCCB53A73D2042E997&originRegion=eu-west-1&originCreation=20211205212551>.

[339] ibid

[340] 'A Lost Century in Economics: Three Theories of Banking and the Conclusive Evidence | Elsevier Enhanced Reader' (n 339) 364.

create funds. Under this model, the central bank can influence money creation through reserve requirements.[341]

The third theory is the credit creation theory. Banks do not need an initial deposit to create credit; it is a 'none to many' credit creation model.[342] Banks do not loan out the deposits when they create credit. Once the credit is created, the amount is used to open a deposit corresponding to the opened credit.[343] Therefore, banks loan credit to create new money from their promise by using credit to create a deposit. Empirical research shows that banks create money according to the credit creation theory.[344] When creating credit, the bank issues credit and then creates a deposit of the same size as the credit. They do not use the reserve or existing deposits to make loans. Those operations are reflected on the bank balance sheet.[345]

Consequently, OB capital requirements increase the provider`s reserve held in the account but have an insignificant impact on the money creation market. First, the absolute amount of OB capital requirement is small relative to the central bank`s reserve requirement. As such, the changes in the central bank`s reserve requirement based on the analysis of demand-supply expectations have a much higher impact than the fixed OB capital requirement.[346] Moreover, under the credit creation theory,

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[341] CAE Goodhart, 'The Continuing Muddles of Monetary Theory: A Steadfast Refusal to Face Facts' (2009) 76 Economica 821, 10–12.

[342] Robert C Hockett and Saule T Omarova, 'The Finance Franchise' 102 CORNELL LAW REVIEW 77, 13.

[343] 'A Lost Century in Economics: Three Theories of Banking and the Conclusive Evidence | Elsevier Enhanced Reader' (n 339) 367.

[344] Ibid 370-373

[345] Michael McLeay and Amar Radia, 'Money Creation in the Modern Economy' 14, 16.

[346] Goodhart (n 342) 12–20.

the interest rate is the most significant tool for regulating the money demand-supply balance. It is more effective than the reserve requirement. Therefore, the OB requirement primarily serves as a safety net to protect customers' funds.

In addition, the registration costs increase the PI's fixed costs. However, the amount is not significant compared to other compliance costs.

2.4.3.2 Safeguarding

The PI must also comply with safeguarding measures.[347] The measure is imposed on the service user`s fund. It includes the funds received or on behalf of the user.[348] If the payment fund is held on the following day after receipt, it should be kept at the Bank of England account or the authorised credit institution.[349]

User funds should be kept in a segregated account from the service provider`s. Additionally, the payment institution should maintain the relevant records and cover the funds with an insurance policy or a comparable guarantee, payable in the event of insolvency.[350] If the payment institution provides services other than payment, it should submit to the FCA separate audited information regarding payment services.[351] The measure will benefit consumers. However, it may raise the record-keeping and fund insurance costs for the payment institutions.

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[347] Reg 23, Payment Services Regulation 2017 (SI 2017/752).

[348] Reg 23(1), ibid

[349] Reg 23 (6), ibid

[350] Reg 23(11)-(15), ibid

[351] Reg24, ibid

Safeguard Regulatory Impact

Private banks hold reserve accounts at the Bank of England.[352] The interbank clearing of the large-value transaction is done through CHAPS.[353] There were only 17 direct participants, and the transaction was cleared daily before OB regulations.[354] Other non-bank institutions could indirectly access the settlement system through the above banks.

OB enables a non-bank PI to open an account for settlement. This safeguard requirement will lower the barrier between banks and non-bank institutions. This might create more competition, increasing total welfare and customer inclusion.

2.4.3.3 Information requirement

The information requirements, rights and obligations define the contract between the payment provider and the user. The information on the transaction is required before the single service contract, after the initiation of the payment order, and after receipt and execution of the order.[355] The prior contract information can be the name, head office of the provider, charges on the transaction and possible exchange rates.[356] Other information during the transactions can be the status of the transaction.[357] The exception of information requirements applies to low-value payments. The

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[352] 'Reserve Ratios: Further Definitions' 5 <https://www.bankofengland.co.uk/-/media/boe/files/quarterly-bulletin/1971/reserve-ratios-further-definitions.pdf>.

[353] The Banking Act 2009 (c 1) part 5.

[354] 'Payment, Clearing and Settlement Systems in the United Kingdom' <https://www.bis.org/cpmi/publ/d105_uk.pdf>.

[355] Reg43-46, Payment Services Regulation 2017 (SI 2017/752)

[356] Reg 43, ibid

[357] Reg 44-46, ibid

framework contract permits charges for additional information beyond what is required.[358] In the case of failed information provision, the burden of proof lies on the service provider.[359]

The information disclosure imposed on service providers makes comparing the product between different PIs easier, reducing price differences and user costs.[360] Moreover, if information related to service quality is disclosed, the user may be willing to pay a higher price for higher quality, switching accounts to better providers. This will increase market competition and total welfare. Therefore, the provision benefits users and the total market surplus.

2.4.3.4 Rights and Obligations

The rights and obligations requirements define payment as only being initiated with the payment user's consent. The charges are agreed upon between the parties and are reasonable for the provider`s cost.[361] In addition, if the fund transaction is covered by a credit line, the Consumer Credit Act 1974 may apply.[362] The most important obligation is concerned with the user`s funds and security. During the access to payment accounts, PISPs and AISPs must provide data or initiate transactions only with the user`s explicit consent and keep the data and the user`s credentials secure.[363] The provider should

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[358] Reg 57, ibid

[359] Reg 59 , ibid

[360] AI Ogus, *Regulation: Legal Form and Economic Theory / Anthony Ogus.* (Hart Publishing 2004) 126–144.

[361] Reg 66, Payment Services Regulation 2017 (SI 2017/752)

[362] Reg 64, ibid

[363] ibid

not hold the user`s funds or send or store sensitive payment data.[364] In case of user data leaks and other compliance failures, the FCA can impose a penalty on the service provider.[365]

Rights and Obligations regulatory impact

Because the security and operational liabilities are on the provider, the maintenance of the provider's liability is costly. A provider should have a secure system, which requires investment in staff, office, and system infrastructure development costs. In addition to infrastructure costs, service providers bear the possible legal costs in case of a security breach. If the security obligation cost is high, the more well-capitalised institutions will have the advantage over the small capital institutions, the new non-bank service providers.

2.4.3.5 Access to payment system and bank account

The central provision of OB regulations requires banks to grant payment service providers access to the user`s bank account.[366] The condition of the access should be on a non-discriminatory and proportionate basis,[367] and the access should be sufficient for providers to provide their registered services. [368] In addition, when direct or indirect access to the payment system is allowed, the rules should be objective, proportionate and non-discriminatory.[369]

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[364] Reg 70,71,73, ibid

[365] Reg 111, ibid

[366] Reg 105 (1), ibid

[367] Reg 105 (1), ibid

[368] Reg 105(3), ibid

[369] Reg 103,104, ibid

Access to payment systems and bank account regulatory impact

This OB regulation can reduce switching costs and increase total welfare by enhancing competition. The assumption consists of the following step-by-step arguments from strategic response theory.

Firstly, the higher the cost of entry K, the fewer providers are willing to enter the market because of the reduced profit. This follows from the relationship between profit and entry cost. If all providers have access to the same technologies and input prices and, therefore, have the same cost function.[370] The number of providers is denoted as n, and the profit of each supplier with a total of n active suppliers is denoted as π(n). If the providers compete by setting the production quantity, the Cournot model will apply.

$$\pi(\mathrm{n}) = P^c q^c - C(q^c),$$ [371]

where q^c is the Cournot firm output (where a higher n implies a lower q^c), P^c is the Cournot price, and $C(q^c)$ is each firm's cost of producing q^c (not including the cost of entry).[372] The discount rate is r.

Let's denote K as the cost of entry, and n^e is the free-entry equilibrium where the provider is profitable, then:[373]

$$\frac{\pi(n^e)}{r} - K > 0 > \frac{\pi(n^e+1)}{r} - K.$$

[370] Viscusi and others (n 94) 165.

[371] ibid.

[372] ibid.

[373] ibid 166.

From the above equation, the equilibrium point is when the entrant has a positive profit, and the next entry has a negative profit. As the number of participants n is the reverse of the profit, more new entrants to the market will lower the profit. Subsequently, the cost of entry K will rise, and fewer providers will be willing to enter the market because of the reduced profit.

Second, the OB regulation can alter the entry cost (post-entry demand or cost function), forcing the incumbent to apply a strategic response that does not impede competition. Furthermore, it enhances competition to create a higher total surplus.

The incumbent can apply several strategic responses. These include limit pricing, investment in cost-reducing capital, raising rivals' costs and pre-emptive brand proliferation. Limit pricing involves setting a low pre-entry price to deter newcomers, influencing the post-entry demand or cost function, which in turn affects the newcomer's profitability.[374] The investment in a cost-reducing strategy aims to exclude the opportunity of newcomers by incorporating their capacity into its own.[375] This follows from Avinash Dixit's model with simplified competition between two firms. The model describes the relationship between the cost function as a dependent variable and the ith firm's output x_i, capacity k_i (x_i<=k_i) fixed set-up cost of ith firm f_i, a cost per unit of capacity r_i , the average variable production cost output w_i as independent variables:[376]

$$C_i = f_i + w_i\, x_i + r_i\, k_i.$$

[374] James W Friedman, 'On Entry Preventing Behavior and Limit Price Models of Entry' in SJ Brams, A Schotter and G Schwödiauer (eds), *Applied Game Theory: Proceedings of a Conference at the Institute for Advanced Studies, Vienna, June 13–16, 1978* (Physica-Verlag HD 1979) <https://doi.org/10.1007/978-3-662-41501-6_15> accessed 31 March 2022.

[375] United States v. Aluminum Co. of America 148 F.2d 416

[376] ibid

Accordingly, the incumbent firm can alter post-entry conditions by choosing capacity k_1 to deter entrance or seek advantage in the case of the entrance.[377]

Raising rivals' costs aims to bind competitors with market regulations, which can severely impact competitors' costs and deter them from entering, giving them an advantage after entry. Pre-emption and brand proliferation strategies aim to create new brands or products that occupy niches and discourage newcomers.[378]

To exercise these strategies, post-entry demand or cost function should depend on pre-entry output so the incumbent can influence the newcomer post-entry profit. The argument is based on the concept of adjustment costs, which is the cost of changing the production rate.[379] The adjustment cost can be a learning curve and switching cost. The learning curve happens when complicated labour skills are required, such as aircraft assembly or computer manufacturing.[380] Labour acquires skills from the previous production, so the cost function decreases with accumulative past productions. The high pre-entry output can lower costs due to learning curves, giving incumbents a post-entry cost advantage.

Consequently, the OB regulation targets the learning and switching costs that will form incumbent strategic responses, leading to increased competition and welfare. The learning cost in the OB ecosystem depends on data access because the present service quality is influenced by the past customer`s data, such as the client's data history and preferences. The typical incumbent response in

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[377] ibid

[378] Viscusi and others (n 94) 194.

[379] M Therese Flaherty, 'Dynamic Limit Pricing, Barriers to Entry, and Rational Firms' (1980) 23 Journal of Economic Theory 160.

[380] Viscusi and others (n 94) 188.

the learning curve industry is to set a high pre-entry output, resulting in a lower marginal cost and post-entry cost advantage.[381] It is similar in OB. The incumbent banks can increase pre-entry output by investing more in acquiring users to gain a post-entry advantage.

Additionally, they can apply strategies such as cost-reducing, raising rival costs, pre-emption and brand proliferation. These strategies aim to protect the incumbent's advantageous position by limiting the newcomer's post-entry growth, potentially deterring entry and harming the competition. On the contrary, when OB regulations open data access, learning and switching costs are reduced. Incumbent banks will favour under-investing in the pre-entry customer base, focusing on stronger competition in the post-entry period. This will lead to more efficient resource distribution and induce more participants to enter the market. According to the link between a competitive environment and total welfare, the OB regulation can increase total welfare.

2.4.3.6 Supervisor and Penalty

The FCA is the designated authority that supervises and enforces payment regulations, except for the access to the payment system provisions.[382] FCA is authorised to outline the general policy and principles to implement the provision according to several principles, such as the requirement for efficiency, proportion, and transparency.[383] The FCA requires reports and statistical data on fraud from participants. If, in the process of monitoring, the FCA finds that the party does not conform to the

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[381] Drew Fudenberg and Jean Tirole, 'Learning-by-Doing and Market Performance' (1983) 14 The Bell Journal of Economics 522.

[382] Reg 106, Payment Services Regulation 2017 (SI 2017/752)

[383] Reg 107, ibid

Regulations, the FCA can publish a statement or impose a financial penalty.[384] In a situation where the contravention of a payment service provider accumulated the provider`s profits and adversely affected other persons, the FCA may require restitution to pay the appropriate person.[385] Until 2024, no penalty has been imposed under OB regulations, yet[386] there was only a sixteen million pounds penalty on Tesco Personal Finance for a security user`s data breach in 2018.[387]

The reporting, monitoring, and supervisory requirements increase PI`s fixed costs for the data and application system. However, it increases the user's confidence in the system, benefiting users. In addition, more users can use the service because they are more confident in the system's security and safety.

2.4.3.7 Regulatory Technical Standards ("RTS") and API requirements

The RTS is drafted under regulation 98 of PSR 2017, which is about managing operational and security risks.[388] The regulatory technical standards require a new system workflow design with more robust safety measures to provide secure access and storage of client data.

The connection to the user's online bank account should be separate.[389] In the first step, the user connects to the TPP`s interface to get the authentication code.[390] Next, the user consents to TPP to

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[384] Reg 110,111, ibid

[385] Reg 114,115, ibid

[386] '2024 Fines' (*FCA*, 25 March 2024) <https://www.fca.org.uk/news/news-stories/2024-fines>.

[387] 'FCA 2018 Fines' (*FCA*, 8 January 2018) <https://www.fca.org.uk/news/news-stories/2018-fines>.

[388] Reg 98, Payment Services Regulation 2017 (SI 2017/752)

[389] ibid

[390] Art 4-9, FCA 2020/70 and Reg 67,69,70, Payment Services Regulation 2017 (SI 2017/752)

access the data by confirming with ASPSPs.[391] The consent procedure is created by the user logging in to his online account and accepting the authentication code provided by the TPP.[392] Therefore, the previous screen scraping method is prohibited, and access to the user`s online account is direct without the intermediation of a third-party interface. This process reduces the risk of compromising the user`s credentials by sending it over the third-party interface.

In addition, a more enhanced authentication security method is applied. The authentication code should not be generated based on previous information that can be forged.[393] Besides that, the login credentials to a third-party account held in the third-party system and the regeneration of the authentication code should be based on the three independent elements categorised as knowledge, possession, and inherence.[394] Those elements require different environments to be transferred and stored securely.[395] The knowledge element can be the user`s password, the possession can be a physical token key or his laptop, and the inherence element can be the fingerprint. All these elements must be securely stored in different environments and transferred through different transportation methods.[396] This requirement enhances the system's safety. However, it will lead to further complications in system design.

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[391] Ibid

[392] Ibid

[393] Art 1(2), FCA 2020/70

[394] Art 6-9, FCA 2020/70

[395] Art 9(1-3),Art 22-27, FCA 2020/70

[396] Art 22-27, FCA 2020/70

Moreover, several support systems are required. These include the risk and fraud analytics system to calculate the fraud rate of different payment methods.[397] If the fraud rate exceeds the limits, strong customer authentication is required. In addition, the monitoring and reporting system should be able to store analytical data according to PSR 2017 [398] and the traceability requirements in FCA rules.[399] However, the biggest challenge for ASPS providers may be the requirement to provide contingency measures in case of an unexpected system breakdown.[400] The measure provides TPP with alternative access to the user`s interface,[401] leading to additional changes in the bank`s system to reroute the workflows and secure and monitor the activities. The cost of the security system will likely be split between banks and TPP. However, if the cost is expensive, banks and incumbents have an advantage because of their capital size. For the contingency system, the investment cost of the system is on the bank`s side, whereas the TPP need to invest in the fraud and risk analysis system.

Lastly, the enforcement of OB in the UK is placed under Open Banking Limited to develop a uniform API standard.[402] The standard is gradually incorporating additional services.[403] At the beginning of the roadmap, essential functions to request account data through API were implemented, whereas at the end of OB implementation, more value-added services were implemented. This includes the current

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[397] Art 19, FCA 2020/70

[398] Reg 67(2), PSR 2017

[399] Art 19, FCA 2020/70.

[400] Art 33, ibid

[401] Art 33(4), ibid

[402] 'Open Banking Read-Write API' <https://openbankinguk.github.io/read-write-api-site3/> accessed 1 December 2021.

[403] 'Notice of Approval of Changes to the Agreed Timetable and Project Plan' <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/885537/Notice_of_proposed_changes_to_the_open_banking_roadmap_-_web_publication_-_cma_gov_uk_---_May_2020_-.pdf>.

sweeping standards, allowing connection between TPPs and banks and enabling users to transfer funds between their accounts in different banks automatically.[404]

RTS and API regulatory impact

A standard is a form of social regulation prior to being imposed on the suppliers of products or services to control their behaviour and eliminate future quality-related problems.[405] There are three types of standards: specification, performance, and process.[406] Their administrative costs and applications depend on the situation.[407] The performance standard focuses on the outcome without prescription, and the process standard focuses on the procedures by controlling the parameters.[408] For the specific standard of safety measures, the compliance cost will be higher for a new participant.[409] Standard differentiation for the incumbent participants can create issues with entry barriers, raising the cost of entering the market. Therefore, standards can create an advantageous position because of differences in compliance costs.

To implement the above OB standards, the banks and the TPPs invest massive capital in technology to redesign the system. It is not clear which sides bear a more substantial investment burden. However, the incumbent CMA9 banks are better-capitalised than the new participants. The technological costs will be more burdensome for the TPP. The heavy investment cost in technical standards will likely give the incumbent bank an advantage.

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[404] ibid 13

[405] Ibid 150-179

[406] Gunningham and Sinclair (n 282) 5.

[407] Ogus (n 361) 167; Jim Potter, 'Chemical Accident Prevention Regulation in California and New Jersey' (1993) 20 Ecology Law Quarterly 755.

[408] Potter (n 408).

[409] Ibid

The liability for the users is to securely store their credentials, such as user, password, and other categorised elements.[410] They do not bear the infrastructure investment costs. Therefore, users benefit from securing their data and the new data-centric services.

Regarding the API standard, the compliance costs to implement the API standards on the system are relatively high. The implementation time was about three years.[411] The services are constantly being supported and updated, and the providers must maintain staff to develop APIs and integrate and upgrade the system. On the other hand, the compliance cost distribution can be unequal. The development cost is upon the CMA9 as they must develop the connection interface, whereas TPP or other banks bear the system integration and maintenance costs. Once the API is standardised, the TPP integration cost is significantly reduced. Consequently, the API cost burden is weighted more for CMA9 banks.

2.4.3.8 Conclusion

In summary, the OB regulations impact the competitive market through factors such as implementation and future costs. In addition, regulations reduce the learning and switching costs, leading to more favourable strategic responses from incumbent banks, enhancing service quality and application of new data-centric services. Furthermore, the reduction in adjustment costs lowers entry barriers. In total, they create a more competitive environment. Next, the connection between the competitive markets and the total surplus is examined.

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[410] Reg 77, Payment Services Regulation 2017 (SI 2017/752)

[411] 'Delivering the Roadmap' (n 39).

2.4.4 Relationship between competitive market and total surplus

The standard market theory and the competitive market establish the relationship between the competitive market and the total surplus. Firstly, standard market theory shows that total surplus is maximised at equilibrium. Second, the competition theory shows that the type of competitive market changes the demand and supply curve`s form, creating a new equilibrium. Consequently, the different competitive market types generate different levels of total surplus. As a result, the OB regulatory impact shifting the competitive environment will change the total surplus level and distribution.

The standard market theory operates under rationality assumptions, including participants having preferences, consistency in these preferences, and self-interested choices.[412] It describes the changes in market surplus in relation to demand and supply functions. The demand and supply functions are expressed by the relationship between price P and quantity Q. The higher the price P, the lower the quantity Q. This is because the quantity Q equals the total sum of money willing to be paid divided by the price P; the higher the price, the fewer quantity buyers can buy.[413] On the contrary, the lower the price, the higher the demand.[414]

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[412] Rakesh V Vohra, 'Prices and Quantities: Fundamentals of Microeconomics' (*Higher Education from Cambridge University Press*, 17 February 2020) 3–5 <https://www-cambridge-org.libproxy.york.ac.uk/highereducation/books/prices-and-quantities/DF45DFA6BE48B9B82C83DF57C85DDC02>.

[413] Richard A Posner, *Economic Analysis of Law / Richard A. Posner.* (Ninth edition, Wolters Kluwer Law & Business 2014) 5–6; N Gregory Mankiw, *Principles of Economics* (8th edn, Cencage Learning 2016) 67–69.

[414] Posner, *Economic Analysis of Law / Richard A. Posner.* (n 414) 5–6; Mankiw (n 414) 67–69.

The aggregate demand and supply curves intersect at the equilibrium point, where the total surplus/welfare (sellers' plus buyers' surplus) reaches its maximum.[415] Any price other than the equilibrium will decrease the total surplus area, creating a deadweight loss.[416]

In addition, there are three types of competitive markets: perfect competition, duopoly/oligopoly and monopoly. In a perfectly competitive market, suppliers competing with similar products take the price as given, and there are no entry or exit barriers.[417] The demand curve moves toward price P = MR = MC, where MR is marginal revenue and MC is marginal cost.[418] The suppliers will increase production if MR > MC, and newcomers will enter if MR> MC. A monopoly is a market with a single supplier.[419] In this market, the demand curve is downward-sloped, and monopolists can set prices higher than the level in a competitive market to maximise profit.[420] As a result, the total surplus can be reduced if the monopolist abuses the market power to raise prices, restricting the output.

The number of providers in the duopoly/oligopoly market[421] is important as it influences the demand curve's slope and market competitiveness. As more suppliers enter, the market tends towards perfect

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[415] 'General Equilibrium.Pdf' <https://web.stanford.edu/~jdlevin/Econ%20202/General%20Equilibrium.pdf> accessed 5 December 2021.

[416] This argument is derived from the definition to calculate the surplus and the recalculation of surplus of any different price other than the equilibrium.

[417] Chaberlim Eward, *Theory of Monopolistic Competition: A Re-Orientation of the Theory of Value*, vol 1 (8th edn, Harvar University Press 1962) 17 <https://heinonline.org/HOL/P?h=hein.beal/thmoncp0001&i=1> accessed 5 December 2021.

[418] Marginal revenue is the additional revenue for another unit of output, and marginal cost is the additional cost for an additional unit of output

[419] Posner, *Economic Analysis of Law / Richard A. Posner.* (n 414) 331; Cooter and Ulen (n 315) 29.

[420] The monopolist's profit maximising function indicates that it reaches the maximum profit if MR equals MC.

[421] These are markets with two or more suppliers.

competition, with the demand curve approaching P = MR = MC. Additionally, the entry barriers are essential as high barriers discourage new entrants, maintaining existing providers' market power.[422]

Consequently, the shift in the competitive market impacts the total surplus in the ordering: perfect competition to monopoly, where perfect competition generates the most surplus and monopoly generates the least.

Furthermore, the OB ecosystem is an oligopoly, with the nine biggest banks capturing about 80 per cent of the market share. The OB regulations impact the income, costs and capacity distribution, altering the providers' strategic responses. This leads to changes in market power, entry barriers and number of providers. Accordingly, if the OB oligopoly moves toward perfect competition, it can create more total surplus. Otherwise, if it moves toward monopoly, increasing market power and concentration will reduce the total surplus.

2.4.5 Conclusion of the theoretical framework

To sum up, the OB regulations influence the competitive environment, altering the distribution of total surplus.

First, registration requirements raise the PI fixed cost; however, the increase is not significant. Capital regulation does not affect the money creation market and serves as a safety net to protect customers' funds. The safeguard measures lower the barrier between banks and non-bank institutions, increasing customer inclusion. The information disclosure requirements benefit users, while the rights and

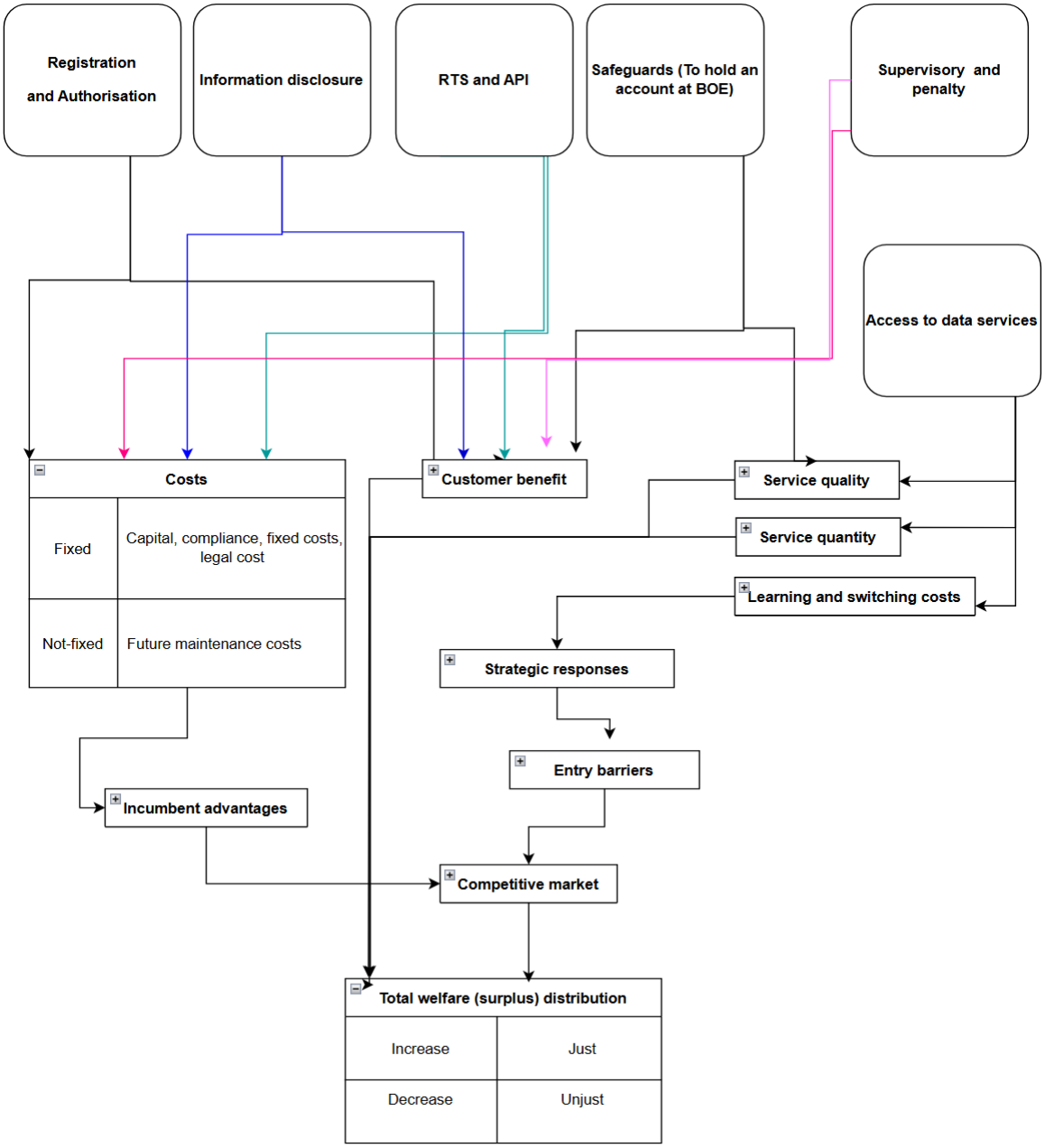
obligations require investment in staff, office, infrastructure, and legal costs, giving a cost advantage to well-capitalised institutions.

In addition, access to payment and account services reduces learning and switching costs, altering possible strategic responses for incumbents and lowering the entry barrier. The regulation increases service quality by applying data-centric software. The supervisory and penalty regulations impose fixed costs on PI to develop monitoring systems. On the other hand, they enhance the user trust, leading to higher use of services.

Furthermore, technical standards such as strong authorisation or API impose technological costs on providers unevenly, leading to the advantage of incumbent banks. However, users will benefit from secure data and the application of new data-centric services.

Consequently, the impact on OB's competitive environment and its components, such as income, costs, strategies and consumer benefit, leads to the change in total surplus. The diagram of the theoretical OB regulatory impact is as follows:

Figure 6: The flow of OB regulatory impact to the competitive market and total surplus distribution. The first layer comprises OB regulations labelled Registration and Authorisation, information disclosure, and other requirements; the second layer comprises impact factors such as costs, customer benefit, service quality, and others. The arrows show the direction of the impact. The last layer is the Total Welfare (surplus) distribution.



2.5 2.5 Theoretical Interpretation Framework

Introduction

This section aims to develop the interpretation framework, which will be applied to empirical results. The interpretation framework commonly considers efficiency and just criteria, which are often in conflict with each other.[423] The efficient allocation and production increase the total surplus, which can lead to uneven welfare distribution between groups.[424] Conversely, the just redistribution of welfare can conflict with efficiency, creating additional costs.

The justifications of just distribution are related to different philosophical ideas. They will not be included in the thesis because of the broad scope of the topic. This section only provides a functional description to create an interpretation framework, which will be applied to interpret the results of OB's regulatory impact on the competitive data-driven market associated with the social and regulatory context. The framework section is structured as follows:

- First, the stakeholder theory and its framework are evaluated.
- Second, the theories of justice are examined and classified.
- Next, the social welfare function ("SWF") is defined based on justice theory.

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[423] Mankiw (n 414) 242–244.

[424] ibid

- Lastly, the stakeholder distribution framework will be developed.

This section explains the definition of stakeholders, their relationships, and how they create value. Next, the theory is applied to describe the creation of total surplus by the OB regulations and the framework for results interpretations.

2.5.1 Stakeholder theory

Stakeholder theory perceives the research subject[425] as a system of chains and a network of stakeholders.[426] The theory defines the scope of each component and examines the interactions between system components, particularly among stakeholders with differing interests and stakes. Consequently, the theory argues that the organisation creates value for stakeholders, balancing their long-term interests to promote joint welfare.

The shirking problem in economic organisation

Economic organisations address challenges faced by firms, households, and market entities to foster cooperation and enhance productivity.

Team production involves members collaborating to create an output.[427] In this scenario, a participant may tend to shirk, meaning they reduce their effort since the cost of one member's lower contribution

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[425] commonly applied in management theories

[426] R Edward Freeman, Robert Phillips and Rajendra Sisodia, 'Tensions in Stakeholder Theory' (2020) 59 Business & Society 213.

[427] Armen A Alchian and Harold Demsetz, 'Production, Information Costs, and Economic Organization' (1972) 62 The American Economic Review 777, 777.

is partially absorbed by other team members. If identifying shirking is costless, everyone would be held accountable, eliminating the possibility of shirking. However, in reality, monitoring individual work is expensive, leading individuals to prefer more leisure time. This preference arises because both leisure and income are components of an individual's personal utility function. Moreover, if the cost associated with the leisure taken by participants is less than the actual cost of leisure, the burden falls on other team members. Consequently, this allows individuals to purchase more leisure, providing them with greater motivation to shirk.

To solve the problem of shirking, there are two forms of organisation that can lower the cost of monitoring the shirking problem: through market competition or a specialised monitor.[428] The first is a decentralised organisation of team members, which works through market competition to form productive members. Any member who shirks or produces less can be eliminated through the competition. More efficient newcomers can replace the unproductive incumbents. There are several limitations of this organisational method. Firstly, when shirking happens, the team member is replaced, and the consequence of shirking is detectable, but the problem`s normative cannot be identified. For instance, it is not clear where the shirking occurs or how serious the shirking is. Moreover, in situations where there is an entry cost, the newcomer only enters the market when the entry cost is less than the sunk detection costs. As such, the incumbent tends to shirk when there is an entry barrier cost.

The second organisation method, the Alchian and Demsetz model, is the delegation of the specialised monitor. In this method, a specialised monitor is assigned to manage the cooperation between the team members. In addition, the monitor should possess a bundle of rights to influence the performance of team members, which include the right to claim the residual, to monitor input behaviour, to

[428] ibid 778–789.

represent the central agent in input contracts, and to sell these rights. The monitor is situated within the vertical hierarchical coordination structure, where the principal serves as the monitor and the agents, such as employees or other team members, are monitored. This type of organisation deals with information problems better than the competitive market type, and it is applied in the firm, labour unions and other team organisations.[429] The limitation of this model is that it ignores horizontal team cooperation, such as the processes between colleagues in the same department and peer-to-peer collaboration.

In summary, the corporation's team production is organised using a specialised monitoring model, where the Board of directors acts as the monitor.

The accountability and objectives of the monitor to stakeholders

The monitor is specialised in detecting shirking and managing team production to create joint value. It has the right to residual claims and is assigned to create incentives among team members. The more team production residual is generated by reducing shirking, the higher the reward the monitor receives. The argument for stakeholders' inclusion in team productions follows from the accountability of the monitor to the team and the objective of the monitor.

In a company organisation, the monitor is integrated into the internal governance structure, the hierarchy model.[430] The Board of Directors works as a monitor to manage team production from the inputs. The Board of Directors ("BoD") has the right to monitor and perform three main functions: coordinate the activities of team members, allocate the resulting production, and mediate disputes

[429] Alchian and Demsetz (n 428).

[430] Margaret M. Blair and Lynn A Stout, 'A Team Production Theory of Corporate Law' (1999) 85 Virginia Law Review 247.

among team members over that allocation. As such, there is a discussion about the purpose of the Board of Directors, specifically whether the Board should prioritise the interests of shareholders or the entire team.

There are three approaches to the Board's obligation: the principal-agent, property rights, and team production. In the principal-agent approach, the principal hires the agent to manage the firm. The approach focuses on the relationship between the principal and the agent, motivating the agent to achieve the principal's objective. The property rights approach views the firm as a bundle of assets; the owner of the assets is the firm's owner.[431] Both approaches signify the role of shareholders as the principal. The principal owns the assets used in the production, and the principal delegates his rights to the agent to manage the assets.

On the contrary, under the team production approach in public companies, the rights to the residual income are argued to be held by stakeholders. Firstly, the model emphasises that the firm's production is created by the team comprising different parties. The net result is that, by forming a corporation, the original team members agree to relinquish control rights over the firm's output and inputs. As such, the incorporation means that there is no principal.[432] In addition, the residual surplus is also created by horizontal team production, not only by the vertical Principal – Director – Employees order. Many firms' activities are managed by team members at a horizontal level, as only when a dispute arises among members does it come to the Board for settlement. Lastly, from a legal perspective, the

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[431] Sanford J. Grossman and Oliver D. Hart, '(PDF) The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration' (1986) 94 JOURNAL OF POLITICAL ECONOMY 719, 693.

[432] Margaret M. Blair and Lynn A Stout (n 431).

corporation is a separate entity.[433] Consequently, the duty of the Board is to the corporation, which includes the duty of care, the best interests of "The Corporation", but not only to shareholders. The corporate interest is defined not as shareholders' interest alone but as the joint welfare of all who contribute to the firm's value.

In summary, the discussion revolves around the principal-agent, property rights, and team production models. The former indicates the Board's purpose is to reduce the agency cost, in other words, to protect the principal interest, mainly the shareholder, whereas the view from the team production perspective suggests the Board's duties to reduce the shirking cost to facilitate the team production, which includes shareholders, employees and other stakeholders.

Regarding the OB, it is a type of market organisation. Suppliers and consumers form a market, and the team production among suppliers operates through market competition. However, as mentioned earlier, there are limitations to information asymmetry and issues related to market failure. Therefore, a regulator serves as a specialised monitor. It represents the market's stakeholders with the role of managing cooperation among participants to reduce shirking costs. In this context, shirking costs refer to barrier costs.

Stakeholders in joint value creation

When multiple stakeholders, such as regulators, providers, consumers, and others in a market, or employees, suppliers, and customers in a firm, have independent incentives, they encounter the team production problem. The individual contributions of effort or resources can be costly, and if others

[433] ibid 287.

contribute, one may benefit without contributing, which is the free-riding or shirking problem. The key challenge is managing the relationships between individual stakeholders to create joint value.

Classical economic theories assume that individuals are purely self-interested and will contribute to collective action if they are properly incentivised or monitored. The solution is often to align incentives through contracts, monitoring, profit-sharing, or to assert authority to compel contributions.

The behavioural theory builds on Relational Models, which argue that people can frame their relationships with other stakeholders differently.[434] There are four basic relational models which shape their perception of joint value creation.[435] These models interpret the stakeholders' emotions, motivations, and evaluative judgments that trigger their social behaviour.[436]

The first is Market Pricing ("MP"). The model is driven by rational self-interest and cost-benefit analysis. Individuals define themselves as independent economic actors who compete to maximise personal outcomes. Relationships are transactional, and resource allocation follows the equity principle. Decision-making is individualistic and decentralised, often governed by market forces rather than collective agreement.

The second is communal Sharing ("CS"). It is based on a shared group identity, where personal identity is secondary to collective belonging. This model emphasises altruism, cooperation, and resource

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[434] Flore Bridoux and JW Stoelhorst, 'Stakeholder Theory, Strategy, and Organization: Past, Present, and Future' (2022) 20 Strategic Organization 797.

[435] Alan P Fiske, '(PDF) The Four Elementary Forms of Sociality: Framework for a Unified Theory of Social Relations' (1992) 99 Psychological Review 689.

[436] ibid.

distribution based on need rather than individual contribution. Decision-making occurs through consensus, collective participation and shared responsibility.

The third is Authority Ranking ("AR"). It is characterised by a hierarchical order with mutual duties of protection and obedience. Individuals perceive their identity as tied to their position within the hierarchy rather than their personal attributes. Superiors exercise power and control over subordinates, who defer to their authority. Resource allocation follows a status-based distribution—higher-ranking members receive greater rewards. Decision-making follows a chain of command, with directives flowing from the top down.

The last one is Equality Matching ("EM"). It is achieved through a relationship of equals, maintaining balance and reciprocity. Individuals define themselves as distinct entities, but they operate in an environment where everyone has the same duties and privileges. The guiding principle is fairness and equal participation. The decisions are made by one person, one vote, rather than hierarchical authority.

Consequently, the stakeholder theory asserts that a collaborative (or "relational") approach outperforms a purely self-interested approach in joint value.[437] Bridoux and Stoelhorst theorise that stakeholder contributions to joint value creation will increase as the relationship model moves from transactional (market pricing) toward communal sharing (with authority ranking and equality matching in between).[438] If stakeholders view their relationship in a communal framework, they are likely to contribute more to joint efforts out of a sense of loyalty or identity, without expecting immediate

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[437] Bridoux and Stoelhorst (n 435).

[438] Caterina Tantalo and Richard L Priem, 'Value Creation Through Stakeholder Synergy' (2016) 37 Strategic Management Journal 314.

payback. In contrast, a pure market frame leads them to contribute only if it directly maximises their own payoff.

Stakeholder framework and concepts

There are two views on stakeholder definitions: broad and narrow. The difference between the definitions lies in the fact that the latter focuses on the limited practical resources available to address stakeholders' external responsibilities, whereas the former focuses on the possible impacts on the organisation. The broader the definition, the more resources the entity needs to invest in stakeholder relationships.[439] The limited resources view led to the definition in terms of an organisation's necessity for survival. For instance, stakeholders are defined as those who are exposed to the risk in the relationship or as participants in the relationship contract with the organisation.[440] According to this definition, stakeholders can include shareholders, employees, core suppliers, key customers, and essential creditors or regulators who are crucial for the organisation's survival.

On the contrary, the broad view defines any party, organisation or individual that 'can affect or is affected by the achievement of an organisation's objectives'.[441] This broad definition encompasses secondary or indirect stakeholders, including local communities, activist groups, governments, competitors, the natural environment, and future generations.[442]

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[439] Ronald K Mitchell, Bradley R Agle and Donna J Wood, 'Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts' (1997) 22 The Academy of Management Review 853.

[440] ibid 857.

[441] R Edward Freeman and David L Reed, 'Stockholders and Stakeholders: A New Perspective on Corporate Governance' (1983) 25 California Management Review 88, 91.

[442] Mitchell, Agle and Wood (n 440).

In summary, stakeholders can be persons, groups, neighbourhoods, organisations, institutions, or societies essential to an organisation's survival or affected by or affecting its objectives.

The framework introduced by Mitchell, Agle, and Wood consists of three attributes for identifying and prioritising stakeholders: power, legitimacy, and urgency.[443] Power refers to a stakeholder's ability to influence the organisation or others, for instance, through control of resources, legal authority, or strategic position. Legitimacy denotes the perceived validity or appropriateness of a stakeholder's involvement, essentially a "rightful" claim or relationship. This can arise from legal obligations such as a regulator's mandate or a shareholder's ownership, moral standing, or contractual duties. Urgency is the degree to which a stakeholder's needs or claims require immediate attention. It has two dimensions: time-sensitivity, a delay in addressing the stakeholders' concerns that is unacceptable to them, and criticality, the importance of the issue to the stakeholders.

Using these attributes, stakeholders can be classified by their salience (prominence) to decision-makers. For instance, a stakeholder possessing power and legitimacy is considered a "dominant" stakeholder, likely to have their interests strongly considered. One who has legitimacy and urgency but lacks power might be a "dependent" stakeholder; their claims are valid and pressing, but they rely on others' power to be heard. A stakeholder with power and urgency but no legitimacy is sometimes labelled "dangerous". They can impose their will quickly, even unlawfully, as in the case of rogue actors or aggressive pressure groups. Stakeholder salience is not static, it can shift as power, legitimacy, or urgency evolve over time.

[443] ibid.

2.5.2 Applying Stakeholder Theory to UK Open Banking

The major stakeholders in the UK Open Banking ecosystem are mapped against the attributes of power, legitimacy, and urgency.

Regulators such as the CMA, FCA, PSR, and HM Treasury can be salient stakeholders. They possess power as CMA's legal enforcement mandates the banks' participation, while the FCA and PSR have supervisory and rule-making authority. They also possess strong legitimacy as public authorities responsible for protecting consumers and promoting competition. The evidence of the regulator's urgency was the 2016 market investigation, which aimed to improve banking competition and consumer protection. The outcomes were a pressing policy goal, with tight timelines set for OB implementation.[444]

Thus, regulators can be classified as definitive stakeholders in the OB ecosystem. Their power, legitimacy, and sense of urgency meant that the OB initiative prioritised their requirements. Without the regulators' impetus, banks would likely not have opened their data voluntarily.

Another group of stakeholders is the CMA9 banks. These large UK banks hold significant power in this ecosystem by controlling the customer accounts and data that TPPs want access to. They also possessed the necessary financial and technical resources to build API infrastructure. Banks' legitimacy in OB comes from two sources. They are legally obligated under the CMA Order and PSD2, and as providers of accounts, they are core to delivering OB service. However, banks typically did not perceive

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[444] 'The Future Oversight of the CMA's Open Banking Remedies' (*GOV.UK*) <https://www.gov.uk/government/consultations/future-oversight-of-the-cmas-open-banking-remedies/89831fe5-0de6-4429-a4bc-aafcfc0e379e>.

the same level of urgency for OB as regulators or TPPs did. They viewed OB primarily as a compliance rather than an immediate opportunity. Therefore, in stakeholder theory terms, CMA9 banks could be seen as "dominant stakeholders," powerful and legitimate but not inherently urgent.

TPP and challenger bank stakeholders benefit from OB and should push for its urgent development. These firms generally lack the power to compel CMA9 banks to cooperate, particularly as newcomers or startups, compared to established banks. However, they have legitimacy as stakeholders because they are licensed by the FCA and represent the competitive innovation that OB aims to foster. They also embody urgency: quick access to CMA9 bank data and payment functionality is critical to their business models, and delays or restrictions by banks directly impact them. Under Mitchell et al.'s framework, these companies are "dependent stakeholders." They depend on regulators to enforce rules and on CMA9 banks to supply the data. Their claims are legitimate and time-sensitive, as they require reliable APIs, the resolution of issues, and the extension of API functionalities. However, without direct influence, they must rely on regulators.

The last group of stakeholders is consumers. Individual retail consumers and small businesses are the intended beneficiaries of the OB transition. As a diverse group, their power is limited. They lack coordination and must rely on regulators or consumer groups to represent their interests. However, consumers have high legitimacy as the CMA order exists to serve their needs and rights. Moreover, they have certain aspects of urgency. For instance, vulnerable consumers urgently need better financial inclusion and services, as well as improvements in data management and security. Consumers can also be viewed as dependent stakeholders, as they have legitimate and urgent expectations, such as improved budgeting services, easier switching between providers, and increased financial inclusion.

However, they rely on regulators to enforce protections, on TPP to supply services, and on CMA9 banks to share data.

Next, the relational models are applied to OB stakeholders to explain the team production in OB enforcement.

OB relational model in joint value creation

In this section, the collaboration between multiple stakeholders in OB is assessed. The OBIE, CMA9 incumbent banks, challenger banks, TPPs, and consumers jointly create value by sharing and utilising financial data. The interaction is explained through Relational Models Theory, which outlines four fundamental relationship models that govern social exchange: Communal Sharing ("CS"), Authority Ranking ("AR"), Equality Matching ("EM"), and Market Pricing ("MP"). Each stakeholder is matched to its primary relational model and examined for the implications of collaboration, power dynamics, and resource distribution.

Regulators and OBIE - Communal Sharing mode

Regulators function as specialised monitors in team production to reduce barriers in the OB ecosystem. Specifically, OBIE was established to implement a shared technical infrastructure, including standardised APIs, data formats, and security protocols, that all participants could trust and utilise. It operates in the CS model with the objective of collective stewardship and team coordination in OB implementation.

In the communal sharing model, members treat each other as part of a single group with a collective identity, pooling their resources for mutual benefit. OBIE exercise this by convening working groups of banks, TPPs, and user representatives to develop standards jointly. It outlines team cooperation rather than competitive rivalry. The OBIE's funding model is also communal; the CMA9 banks collectively contribute funds to build a common platform for the benefit of the entire ecosystem. Moreover, OBIE did not claim residual profit; it operates under the mandate to enforce OB transition.

CMA9 banks - Authority Ranking mode

The CMA9 banks are likely to engage with OB through the authority ranking lens. In authority ranking relationships, a clear hierarchy exists: superiors exercise command, and subordinates show deference. In OB, CMA9 is subject to regulatory mandates, including the CMA9 order and PSR 2017, which require them to open their clients' data. Therefore, the CMA9's primary mode of interaction is compliance with top-down directives. They must follow OBIE's technical standards, meet deadlines, and submit to oversight and performance monitoring. Moreover, the authority ranking framework is crucial for initiating the OB transition. In the absence of the CMA's binding order, the big banks had little incentive to open up their data to competitors.

The authority ranking model changes the power dynamic in the industry dominated by the big banks. Regulators overtake the superior rank in setting the rules, restricting incumbent banks' ability to control customer data unilaterally. However, CMA9 banks still have a significant advantage due to their capital size and the number of users.

Challenger Banks – Equality Matching mode

Challenger banks are newer, smaller, and fintech-driven institutions. The larger incumbent banks possess more advantages, leading challengers to view OB as an opportunity for balanced exchange, fair resource access, and equal service offerings. They analyse OB through the lens of an Equality Matching framework.

In this framework, parties see each other as equals who should reciprocate in kind and share benefits and burdens evenly. In OB, the standardised API is equally applied to all. The data access resembles reciprocity, as banks can access each other's data. Therefore, challenger banks are supporters of collaborative industry efforts to improve OB and ensure fairness in technical quality.

However, they can revert to authority ranking or market pricing model if the fairness in the equality model is violated. For instance, if the CMA9 API is frequently slow, challengers can revert to the authority ranking model and seek regulators with a higher ranking to resolve the conflict.

TPPs – Market Pricing

Third-party providers offer services such as budgeting apps, loan aggregators, payment initiation, and other data-driven products within the OB ecosystem. TPPs seize opportunities where banks underserve customers in certain areas, and by accessing bank data, TPPs compete to fill those gaps. Their relationship with customers is a market exchange; consumers pay fees or a subscription to receive services like personalised financial insights, better deals, or convenient payment options. Similar to the MP model, TPPs are motivated by self-interest, aiming to maximise utility or profit from exchanges. They advocate for OB implementation because it allows them to enhance both the quality and quantity

of their services. Lastly, when the TPP becomes dominant, it can undermine joint value creation; therefore, OB regulatory governance is necessary.

Consumers – Market Pricing

Consumers engage in OB through the MP model. They use market pricing calculations for their choices. With OB, they have a less locked-in relationship with the service providers, a more competitive market, and more choices. They also become active stakeholders, as they have the option to share their data. Moreover, operating in the MP model, if they perceive OB as a driver for improved service quality and quantity, they are more likely to support its implementation.

Lastly, the role of consumers in joint value creation involves providing data and demand. Their financial data serves as input for new services, while their demand for improved service quality drives innovation.

OB Team production dynamics

To sum up, applying the stakeholder salience framework shows that OB in the UK requires a balanced approach: Regulators with high power and high legitimacy must compel and guide dominant stakeholders, CMA9 banks with power, to cooperate with dependent stakeholders such as challengers, NoCMA9, TPP, and consumers with urgent needs but less power. The OBIE and now JROC/future entity act as bridging mechanisms to align these stakeholders, manage conflicts, and ensure that the initiative stays on course to deliver value to end-users. The power dynamics are not static. As OB matures, banks that see an increasing commercial benefit may become more proactive, and challenger banks and TPPs that scale up might gain more influence, while regulatory pressure can also change. Therefore, the governance framework is designed to adapt to these shifts, maintaining equilibrium among stakeholder interests.

To sum up, from the stakeholders' perspective, the UK OB approach demonstrates a combination of relational models among stakeholders to enable substantial joint value creation. It applies the CS model for regulators to build a shared infrastructure and foster trust among stakeholders, and AR for CMA9 banks to mandate the sharing of clients' data. EM, applied by challengers, maintains fairness in competition, while MP is utilised for service providers and consumers to enhance innovation, service quality, and quantity. Therefore, this approach should increase joint value creation in OB.

The research question focuses on the impact of OB regulation on competitive markets and resource distribution. The application of stakeholder theory suggests a potential increase in joint value creation. Therefore, the next section will explore the measurement of stakeholders' surplus in OB and how they interpret changes in value creation surplus.

2.5.3 Justice (moral) theories

Depending on the interpretation of justice, there are three main theories: Utilitarianism and consequentialism, Contractarianism and Libertarianism.

Utilitarianism justifies the action as just if and only if it maximises total well-being. Another version is rule utilitarianism, which follows the rules that maximise total well-being. The well-being can be understood as the quality of life, measured in pain and pleasure, happiness or preferences.

The targeted objective of utilitarianism is the consequences of the actions, examining whether these consequences maximise total well-being. By doing so, it faces several critiques. Firstly, the requirement of maximisation of the total population's well-being restricts individual liberty. In some cases, an action that brings pleasure to an individual that does not maximise total well-being falls outside the scope of utilitarianism. Secondly, contrary to pleasure, an action that brings pain to an individual can also be acceptable under utilitarianism if it increases total well-being. It can be argued as morally unjust. These critiques lead to the third question about unequal distribution. The distribution of well-being (pain or pleasure) among individuals can be unequal, even if the total well-being is maximised. Lastly, it is criticised for focusing only on the consequences of actions or the future impact of the action, neglecting past wrongdoing.

Rule consequentialism aims to overcome the above obstacle by advocating for rules that promote total well-being instead of directly assessing maximisation. Indirectly assessing maximisation through rules provides flexibility to avoid shortcomings mentioned in the above critiques, such as restrictions on individual liberty, causing harm to others, or insensitivity to past wrongdoing.

Contractarianism posits that the action is just when justified by an agreement of society members under specific conditions. Contractarian theories construct relationships and justify actions by indirectly interpreting hypothetical agreement rules or actual agreements. Consequently, the central questions of the constructed agreement are about the non-agreement outcome, the party's positions in society and beliefs, the interests of parties, and how they select the terms.

There are three leading schools of thought within Contractarianism. These include Hobbesian, Lokean and Kantian.

Hobbesian theory suggests that parties are necessarily and exclusively self-interested[445] and have beliefs and understanding about their position in society. For example, a person who understands their position wants self-preservation and self-protection, leading them to voluntarily surrender their rights by a contract in exchange for authority protection.

Lockean theory views the parties' positions differently and examines how they enter into an agreement. The first difference is that humans also lived in the State of Nature, but this state is not selfish and miserable. It is good and enjoyable, as all people are equal and have the liberty to conduct their lives. However, this state has limitations to secure one's property, as there are no established laws, judges, or enforcement of natural law. Therefore, there is a difference in how parties enter the agreement and which rights they surrender. Parties agree to maintain order but do not surrender all their rights. Natural rights, such as the right to life, liberty, and others, are retained. Moreover,

[445] According to Hobbes, prior to social contract individual lives in the state of nature with fear and Selfishness.

Hobbes's view on non-agreement outcome assumes a non-moral state of nature,[446] whereas, in Lokean's view, the non-agreement is caused by the lack of various goods.[447]

Kantian theory suggests that parties choose the terms for their interests. However, as they are unaware of their position in society, they will select the terms based on considerations that apply equally to all parties. The foundation of Kantian moral theory is the categorical imperative, which morally binds everyone because it is based on universal reason. This principle justifies actions through generalisation. An action is morally permissible if the maxim can become a universal law. In other words, to assess whether it is possible for everyone to act according to the same maxim of that action. An example is whether lying is justified to get out of trouble. The action is not permissible as everyone cannot lie to escape trouble. Consequently, relationships and overall functioning may collapse without trust in society.

Another version of Kantian thinking is Rawls's justice theory. Rawls' theory argues that people have advantages, such as someone being talented in a subject, whereas others are not. Therefore, the distribution of advantages is not fair. The principles of the 'original position' and the 'veil of ignorance' are introduced. The "veil of ignorance" is the abstract situation where people imagine that they do not know their advantages, so everyone is set in the "original position" and has to decide how to distribute welfare.[448] They do not know their advantages at the "original position"; thus, they need to choose a distribution (or social contract) to protect the most affected.

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[446] Hobbes, T, *Leviathan [1651]* (Cambridge University Press 1990).

[447] John Locke, *TWO TREATISES OF GOVERNMENT* (Cambridge University Press 1963).

[448] 'A Theory of Justice' (*Corporate Finance Institute*) <https://corporatefinanceinstitute.com/resources/knowledge/other/a-theory-of-justice/>

The third major tradition of justice theory is libertarianism. Unlike total well-being, it focuses on individual liberty. It states that an action is just only if it does not interfere with anyone's rights. Basic libertarian rights include the right to full self-ownership and the moral power to acquire unowned property rights. Full self-ownership encompasses complete control rights over the use of one's person, full compensation rights to require others to compensate for violating one's rights, and full rights to transfer these rights, such as through sale or loan. Consequently, consent is crucial within this framework. Killing, torturing, or taking physical actions against a person without their consent is always unjust.

Libertarians' views on the distribution of natural resources can be divided into right and left-libertarianism. The right-liberal view on the resources not created by humans is that they can be acquired privately without significant redistribution to other members of society. The acquisition can be through discovery, claim or application of labour. The left-liberal view of natural resource distribution is egalitarian. The typical left view is that the right to natural resources can be privately appropriated through payment of competitive value.

There are several critiques of the assessment of justice theory. They are the sensitivity to past or future wrongdoing, the balance between social and individual, the vagueness of the assumption or gap between theoretical assumptions and the real world, and the balance between justice and efficiency.[449]

[449] Fulvio Castellacci, 'Innovation and Social Welfare: A New Research Agenda' (2023) 37 Journal of Economic Surveys 1156.

2.5.4 Formulation and Application to Distribution Framework

Justice theories are applied to society's structure, relationships, conduct, and distribution through establishing institutions and laws and enforcing policies and regulations. In this part, the particular application of justice theory to the just distribution is assessed, focusing on how regulations impact the just distribution of resources and capacity.

The application of justice theories can be categorised as consequence-based or conduct-based. The Utilitarian and Kantian theories assess the maximisation of well-being and the application of the general will as just conduct. The assessment of these conducts is based on the consequences of the conduct concerning the total population. Therefore, they can be classified as consequence-based. In contrast, libertarian theory focuses on rights and their interference by conduct. To assess justice, the interference caused by conduct should be examined, with the focus on the agent's conduct and the rights of others. These principles are applied directly to law, as seen in the ordoliberal approach to competition law in the EU.

Utilitarianism and Kantian justice principles can be formulated into social welfare functions ("SWF") based on consequences. The function measures the outcomes of conduct and evaluates public choice in welfare economics.[450] The SWF is a function of individual utilities in a given social alternative,

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[450] John Weymark, *Social Welfare Functions*, vol 1 (Matthew D Adler and Marc Fleurbaey eds, Oxford University Press 2016) <http://oxfordhandbooks.com/view/10.1093/oxfordhb/9780199325818.001.0001/oxfordhb-9780199325818-e-5> accessed 31 December 2021.

assigning a value of welfare to that alternative. The SWF compares different social alternatives, helping to understand which is the most efficient or just one to pursue.

The ordering and SWF are described as follows.[451] The individual can be a person in society, a supplier in the market, or any member of a group. Alternatives can include a person's political state for an election, a distribution of economic resources, the outcome of a policy, or any other options. Each individual has preferences. To generalise the ordering, the preferences are assigned with the letters x, y, and z in the set S of all alternatives. An individual's choice can be marked as R, which means preferred or indifferent, and P is preferred. Let n be the number of individuals in the society, and there are n sets of individual orderings R_1,....., R_n. Each set of individual ordering explains that individual's preference over the alternative social states. Similarly, the social ordering R is dependent on the individual ordering R_1,....., R_n. The SWF is the function (or rules) that corresponds the individual ordering to the social ordering of alternative social states.[452] The task of the regulator is to maximise the value of the function.

The rules for social ordering depend on the view of justice theory. Let n be the total number of individuals in the group (society). X_i is the allocation of resources and capacity to i^{th} member by the X alternative. The $\mathrm{U}_i(\mathrm{X}_i)$ is the utility or well-being of the ith individual received from alternative X.

[451] Kenneth J Arrow, 'A Difficulty in the Concept of Social Welfare' (1950) 58 Journal of Political Economy 328.

[452] ibid 8–15.

The utilitarian theory suggests that humankind is governed by pain and pleasure.[453] Under this theory, legislators maximise the total utility in the society.[454] Therefore, the utilitarian social welfare function can be described as the sum of an individual's well-being or utility:

$$\mathrm{SWF}\ (\mathrm{X}) = \sum_{i=0}^{n} \mathrm{U}_i(\mathrm{X}_i)$$

However, this version is often criticised for inequality, as different individuals can be distinct. Another version is *weighted utilitarianism*, where each individual is assigned a weight to adjust their position in society targeted by government policy. Another version is the *single-parameter Gini* SWF. It is based on the Gini inequality index and is defined as the weighted sum of individual welfare, where the worse-off member's weight is ranked higher.[455]

The Rawl's SWF would be the maximisation of the minimum U_i, among all n-individuals utility allocated from the alternative social state. At the "original position," because they do not know their advantages, they need to choose a distribution (or social contract) to protect the most affected. This principle implies choosing a distribution that maximises the person's welfare with a minimum distribution. The social welfare function SWF under Rawls's definition will be:[456]

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[453] Jeremy Bentham, 'An Introduction to the Principles of Morals and Legislation' <http://www.utilitarianism.com/jeremy-bentham/index.html>.

[454] Ibid

[455] Thibault Gajdos, 'Measuring Inequalities without Linearity in Envy: Choquet Integrals for Symmetric Capacities' (2002) 106 Journal of Economic Theory 190; 'A Single-Parameter Generalization of the Gini Indices of Inequality' <https://ideas.repec.org/a/eee/jetheo/v22y1980i1p67-86.html> accessed 2 March 2024.

[456] Oded Stark, Marcin Jakubek and Fryderyk Falniowski, 'Reconciling the Rawlsian and the Utilitarian Approaches to the Maximization of Social Welfare' (2014) 122 Economics letters 439, 440.

$$SWF = \min \{ U_1(X), \dots, U_n(X) \}$$[457]

Other variations of SWF are applied according to specific situations. Typically, the welfare function U(X) can be partially constructed by analysing data or creating theoretical estimations when the data is unavailable.[458]

2.5.5 Assessment criteria of social alternatives

There are two efficiency assessment criteria of the social alternatives, Pareto and Kaldor- Hicks efficiencies.[459] The theories work under the prior assumption that all goods are tradable in a perfectly competitive market condition with no transaction costs.[460] Pareto equilibrium is the set of points where a change in policies or any redistribution of resources cannot make one person better off without making another person worse off.[461] At this set of points, the market is efficient, where the production and allocation of resources are optimised.[462] Therefore, under Pareto efficiency, only policy changes that make some people better off without making anyone worse off are considered efficient.

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[457] The formula describe social welfare SWF according to the Rawl`s definition of least advantage position. The function equals to the minimum (the least) from the group of n number of utility functions of n parties affected by the distribution. In other word is to compare utility of n parties and find the least advantaged, it will be the SWF function to be maximised by the policy or regulation.

[458] Ogus (n 361) 160.

[459] ibid 24–26.

[460] 'Pareto Efficiency Definition' (*Investopedia*) <https://www.investopedia.com/terms/p/pareto-efficiency.asp>.

[461] ibid

[462] 'Equity-Efficiency Tradeoff' (*Corporate Finance Institute*) <https://corporatefinanceinstitute.com/resources/knowledge/economics/equity-efficiency-tradeoff/>.

Another test to measure allocation efficiency is Kaldor- Hicks criteria. It is likely that, in practice, it is challenging to achieve Pareto efficiency because few policies or regulations can make people better off without making anyone worse. In Kaldor- Hicks test, the requirement for efficiency is only for the total utility gain disregarding the individual utility.[463] Therefore, under this test, a policy that made some agents better off and some agents worse can be allocation efficient if the total utility (better off utility minus worse off utility) caused by the policy increases.

Both tests can be used interchangeably to evaluate the policies related to the aforementioned test properties. The change in welfare due to a regulation or policy can be assessed through total welfare (Kaldor-Hicks test) and the existence of those worse off (Pareto test).

In addition to efficiency criteria, the assessment of the distribution framework is applied. The objective is to compare two social alternatives based on our justice theory. The first is without enforcement of OB regulations ("NOB"), and the second is with OB enforcement ("OB").

[463] Stephen Martin, 'The Kaldor–Hicks Potential Compensation Principle and the Constant Marginal Utility of Income' (2019) 55 Review of industrial organization 493, 494.

Stakeholder SWF

The stakeholder theory objective is maximising stakeholders' surplus through joint value creation. The stakeholder literature proposes to calculate the total surplus as a function of all stakeholders' surpluses.[464] For instance, in some versions, the weights are assigned to each stakeholder.[465] In the real economy, it is often challenging to measure weights,[466] so equal weights are applied. As such, the stakeholders' assessment framework taking a utilitarian view of just distribution will be as follows:.

$$\mathrm{SWF\ (X)} = \sum_{i=0}^{n} \mathrm{U}_i(\mathrm{X}_i)$$

Where, X_i is the allocation of resources and capacity to i^{th} stakeholder by the X alternative. The $\mathrm{U}_i(\mathrm{X}_i)$ is the utility or well-being of the ith stakeholder received from alternative X.

The criteria for successful implementation of regulation is that the welfare value of SWF function with OB enforcement is higher than without:

$$\mathrm{SWF\ (X)}^{OB} > \mathrm{SWF\ (X)}^{NOB}$$

This means that after OB enforcement, the total surplus for all stakeholders should improve to meet the Kaldor-Hicks criteria. For Pareto efficiency, the total surplus and the surplus of each stakeholder need to increase.

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[464] Freeman, Phillips and Sisodia (n 427) 227.

[465] Michael Magill, Martine Quinzii and Jean-Charles Rochet, 'A Theory of the Stakeholder Corporation' (2015) 83 Econometrica 1685, 1688.

[466] Magill, Quinzii, and Rochet (2015), The stakeholder corporation and , p 2557

3. Chapter Three: Practical Application by Other Actors and Reassessment of the Impact Model

We have developed the OB regulatory impact model in relation to the theory and variables considered in other empirical studies undertaken by academia, courts, and regulators. This section will examine the factors and models employed by the aforementioned entities to reassess the models used in the thesis.

We initially outline different competition laws and policy objectives and how this influences the interpretation of market power and other competitive issues. Secondly, we examine approaches adopted by courts, regulators, and academia in past studies, which inform the approaches used in this thesis to explore the impact of OB regulation.

3.1 Differences in the competition law objective and market power by schools of thought

Competition law and policy primarily aim to enhance consumer welfare and promote efficiency.[467] Efficiency can be allocative, productive, or dynamic. Allocative efficiency represents the optimal use of resources through distribution driven by suppliers' incentives to compete in the market until marginal cost equals price in a competitive market.[468] Productive efficiency is the best allocation of resources by a supplier in production. An example is allocation, where the cost will be the lowest at the given technology level.[469] Dynamic efficiency is the efficiency in an innovative market where the supplier can introduce new products or technologies to reduce marginal costs.[470] In a monopoly, there can be dynamic inefficiency as the monopoly has no incentive to innovate.[471]

There is a correlation between efficiency and consumer welfare, which is explained by normative theory. The theories explain how the efficient distribution of resources can maximise consumer welfare.[472] The aim of competition law can be set to favour a specific type of efficiency to maximise welfare. For example, suppose efficiency is defined through the total welfare. In that case, the competition law will favour protecting dynamic and productive efficiency rather than allocative efficiency because these efficiencies will increase the producer surplus by lowering the costs and

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[467] UNCTAD, 'Objectives of Competition Law and Policy: Towards a Coherent Strategy for Promoting Competition and Development' 4, submitted for the OECD in 2003. Doc. CCNM/GF/COMP/WD (2003) 31.

[468] Liza Lovdahl Gormsen, *A Principled Approach to Abuse of Dominance in European Competition Law* (Cambridge University Press 2010) 23 <http://ebookcentral.proquest.com/lib/york-ebooks/detail.action?docID=502478> accessed 23 January 2023.

[469] ibid

[470] ibid

[471] Mankiw (n 414).

[472] Oliver E Williamson, 'Economies as an Antitrust Defense: The Welfare Tradeoffs' (1968) 58 The American Economic Review 18.

increasing output, increasing the consumer and total welfare.[473] Consequently, there are some differences in competition law objectives by schools of thought, leading to different theories' development.

3.1.1 Harvard Structural School

The Harvard School of Competition policy was developed from an early antitrust judgment and focused on the structuralist interpretations of markets.[474] Notable developments of the Harvard School included the S-C-P paradigm, which proposed a causal relationship between market structure, suppliers' conduct and performance.[475] This approach to competition assessment focuses on barriers to entry and market concentration. High barriers can lead to a high concentration of expected collusion.[476] Moreover, the School argues that within a market with high concentration, the firm can exercise market power to pursue high profits rather than superior performance.[477]

The school does not believe in a single objective of the competition law, yet it pursues multiple objectives. These encompass the optimal distribution of equity and resources, economic stability, decentralisation, and consumer freedom.[478] Therefore, the growth of the large firm represents a threat

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[473] Katalin Judit Cseres, *Competition Law and Consumer Protection* (The Hague: Kluwer Law International 2005) <https://law-store.wolterskluwer.com/s/>.

[474] Liza Lovdahl Gormsen, 'The Parallels between the Harvard Structural School and Article 82 EC and the Divergences between the Chicago- and Post-Chicago Schools and Article 82 EC' (10 June 2008) <https://papers.ssrn.com/abstract=2400378>.

[475] ibid.

[476] Ibid, Bain (1956), supra n 11.

[477] Joe S Bain, 'Relation of Profit Rate to Industry Concentration: American Manufacturing, 1936-1940' (1951) 65 The Quarterly Journal of Economics 293.

[478] 'J. S. Bain Industrial Organization. Second Edition. New York, London, J. Wiley & Sons, Inc., 1968, XIV p. 678 p., 97/—.' (1969) 35 Recherches Économiques de Louvain/ Louvain Economic Review 225.

to the market. In addition, vertical restraints such as tying, bundling, exclusive dealing and other types of restraints were considered illegal as they can cause a change in market structure regardless of effects on consumer welfare, efficiency or freedom of competition.[479] Therefore, large firms need to be strictly controlled by the authorities. As in *Standard Oil*, the concentration of wealth was considered a threat to economic and political order.[480]

[479] Sam Peltzman, 'Aaron Director's Influence on Antitrust Policy Comment' (2005) 48 Journal of Law and Economics 313.

[480] *Standard Oil of New Jersey v United States 221 US 1, 50 (1911).*

3.1.2 The Chicago School

The Chicago School does not believe in the causation of concentration, conduct and performance. The social-economic objectives of competition law were rejected as vague and not pursuable.[481] It argues that the aim of competition law is maximising economic efficiency. Once the objective of economic efficiency is achieved, consumer welfare is maximised.[482]

The term consumer welfare, defined by the School, can be described as total welfare, including the producer`s welfare.[483] Economic efficiency is "the increase of allocative efficiency without impairing productive efficiency greatly to produce net gain or loss in consumer welfare".[484] The correlation between economic efficiency objectives and consumer welfare can be explained as follows. As allocative efficiency is the best use of resources distributed in the market toward perfect competition,[485] and productive efficiency is the best distribution of resources by a producer, the increase of allocative efficiency should increase the total market with a fair distribution[486] of surplus between producers and consumers. In total, economic efficiency should lead to improved consumer welfare.

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[481] Herbert Hovenkamp, 'Post-Chicago Antitrist: A Review and Critique' (2001) 2001 Columbia Business Law Review 257.

[482] Robert H Bork, 'Legislative Intent and the Policy of the Sherman Act' (1966) 9 The Journal of Law and Economics 7.

[483] Robert H Lande, 'The Rise and (Coming) Fall of Efficiency as the Ruler of Antitrust' (1988) 33 The Antitrust Bulletin 429.

[484] Bork (n 483).

[485] ibid

[486] The meaning of the definition without impairing productive efficiency greatly .

In pursuing this objective, the school attempts to replace Harvard's process-oriented approach with an outcome-oriented approach.[487] It aims to eliminate social and political concerns by focusing on the firm`s practices of efficiency and price rather than market concentration.[488] The economic theories' primary assumption is that market participants are rational and producers pursue profit maximisation objectives. [489]

From these starting points, market power, predatory pricing, tying and other vertical restraints are viewed differently from Harvard Structural and European Ordoliberal schools.[490] These schools view the vertical restraints negatively, yet they are permissible within the Chicago school system.[491] Another conflicting view is predatory pricing. The effect of predation can increase competition, except in the case where the predator has eliminated other competitors.[492] The view of the Chicago school on predation is positive, yet not from different perspectives.

Regarding market power, the assessment is still connected to market concentration. However, as the school applies the outcome approach, it does not assess market share separately but in connection with the conduct or possible efficiency. The efficiency and price are not expressed directly but through other factors, such as the number and strength of competitors and price sensitivity.[493]

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[487] Eleanor M. Fox and Lawrence A. Sullivan, *Antitrust-Retrospective and Prospective: Where Are We Coming From? Where Are We Going?,* (NYU L REV 1987).

[488] Lovdahl Gormsen (n 475).

[489] Mankiw (n 414).

[490] Jonathan B Baker and Timothy F Bresnahan, 'Empirical Methods of Identifying and Measuring Market Power' (1992) 61 Antitrust Law Journal 3.

[491] Lovdahl Gormsen (n 469).

[492] ibid.

[493] *Rural Tel. Serv. 737 F. Supp. 610, 617*

3.1.3 The post-Chicago school

The school developed from the critiques of the Chicago School. The first critique addresses the positive view of the market, leading to different results for post-Chicago schools regarding market power, predatory pricing, and types of vertical restraints, such as tie-ins, vertical contracts, and mergers. The second critique concerns the objective of the school. Consequently, post-Chicago schools developed theories to refute the conclusions of price theory and created more complex assessment methods.

The first critique of the economic efficiency objective can be divided into three parts: political factors, underestimation of welfare, and efficiency measurement. Firstly, the assessment of the economic efficiency objective excludes political values.[494] The post-Chicago School argues that it is impossible because the economy reflects political preferences. It is not the only relevant factor in policy-making. Therefore, 'wealth maximisation must include everything to which people assign a value'.[495] Secondly, the welfare measurement is also restricted through the connection with economic efficiency. This leads to the first critique that there are factors besides economic efficiency.[496] Lastly, the definition and measurement of efficiency are problematic. The definition proposed by the Chicago School is not quantifiable when making the measurement.[497]

The second critique is about the Chicagoans' positive view of the market. This means that market failure is self-correcting[498] and undermines the role of regulatory intervention. Market perfection is

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[494] Herbert Hovenkamp, 'Antitrust Policy After Chicago' (1 May 2009) <https://papers.ssrn.com/abstract=1396788>.

[495] ibid.

[496] Lovdahl Gormsen (n 469).

[497] ibid.

[498] Hovenkamp (n 482).

based on price and general economic theories with rationality assumptions.[499] The development of behavioural economics indicates that participants are not always rational, and the market can be imperfect.[500] Moreover, the role of entry barriers is considered generally artificial and more important than previously thought as a natural phenomenon under the price theory.[501] As such, several conclusions about competitive issues in Chicago schools can be refuted.

In addition to a view of an imperfect market, the application of game theory in economics supports that argument. As game theory achieved a prominent status in economics, the post-Chicago School started to apply it in competitive legal studies.[502] They developed new models explaining efficiency and market dynamics. Those models describe strategic behaviours, the behaviour decided by the individual based on the expectation of other individuals' actions,[503] and its potential end game. Those game theory models with market imperfection conditions illustrate more anticompetitive results than the Chicago School`s view in vertical restraints, oligopoly, mergers, and predatory pricing.[504]

An example can be the position on predatory pricing. The positive position of the school on predation is justified based on the perfect market. As the participants are rational and the market is perfect without information asymmetry, the predation is irrational, and it can be a success only if the predator

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[499] Lovdahl Gormsen (n 469).

[500] Cass R Sunstein, *Behavioral Law and Economics / Edited by Cass R. Sunstein.* (University Press 2000) <https://doi.org/10.1017/CBO9781139175197> accessed 29 January 2022.

[501] Hovenkamp (n 482).

[502] Douglas Baird, Randal Picker and Robert Gertner, *Game Theory and the Law* (Harvard University Press 1994) <https://chicagounbound.uchicago.edu/books/333>.

[503] ibid.

[504] Michael Jacobs, 'An Essay on the Normative Foundations of Antitrust Economics' (1995) 74 North Carolina Law Review 219.

can trade off the predation loss with the post-market profit.[505] On the contrary, the post-Chicago school argues that predation is profitable because of the information gap between parties.[506] The predator can deter the competitor`s behaviour by predation as the competitors do not possess information on the cost and profit of predation.

The same reasoning for the imperfect market can be applied to other issues of vertical restraints. The highlight of the post-Chicago assumption of an imperfect market was in the case of *Kodak.*[507] The court recognised the imperfection of the market, especially the switching cost and information asymmetry. Kodak, at that time, did not possess dominant power in the photocopier market. However, it had significant power in the spare parts markets.[508] Users do not have information about long-term and repair costs, so switching to other brands is high. Therefore, the court held that users were "locked in" to their brand in recognition of the imperfect market.

Following the above critiques, the market model by the post-Chicagoans is considered imperfect. It is more complex with failure factors than the Chicago school model; thus, the market power model is more complicated. Later, schools developed various empirical techniques in measurement that were far more complex than previous market share-based tests.[509] Those methods apply based on the following factors: residual demand, cost variation, price response to variation of elasticity of demand, and the detection of price abnormality.[510]

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[505] ibid 243.

[506] Janusz A Ordover and Robert D Willig, 'An Economic Definition of Predation: Pricing and Product Innovation' (1981) 91 The Yale Law Journal 8.

[507] *Eastman Kodak Co. v. Image Technical Servs., 504 U.S. 451 (1992).*

[508] ibid

[509] Jacobs (n 505).

[510] Baker and Bresnahan (n 491).

In general, the post-Chicago School theories refute the conclusions of the previous price and general economic theories, which are fundamental to Chicagoans. They apply game theory and strategic behaviours in the generation of new theories and expand the methods of market power assessment models.

3.1.4 The ordoliberal school

The ordoliberal school emerged from Europe in the 1930s and developed into the idea of the social market economy.[511] The school opposed the Nazi regime's consolidation of the private economy leading to the abolishment of democratic principles. It believes that the accumulation of power results from an ineffective legal system to balance and check the power.[512]

The school views the idea of the market economy as order-based. It consists of two orders: the transactional order, in which the economy is processed through transactions of private parties, and the administered economy, in which the external economic system organises the economy.[513] In this system of orders, the self-correcting mechanism of the market can be rejected, and the economic order is formed in conjunction with the administrative order by policy and regulations. The school is more

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[511] H. Giersch, K. H. Paque, and H. Schmieding, *The Fading Miracle: Four Decades of Market Economy in Germany*. (Cambridge University Press 1993) <https://econpapers.repec.org/article/cupjechis/v_3a53_3ay_3a1993_3ai_3a04_3ap_3a942-943_5f05.htm>.

[512] Lovdahl Gormsen (n 469); Robert author O'Donoghue, *The Law and Economics of Article 102 TFEU / Robert O'Donoghue and Jorge Padilla*. (Second edition, Hart Publishing 2013).

[513] David Gerber, 'Constitutionalizing the Economy: German Neo-Liberalism, Competition Law and the "New" Europe' (1994) 42 The American Journal of Comparative Law 25.

prone to regulating the market, and competition law is considered one of the main factors in controlling private power or its harmful effects.[514]

The objective of competition law is "to protect individual economic freedom in the interest of a free and fair political and social order" by controlling private market power.[515] Its core is economic freedom.

Implementing the regulatory objective is through the condition of "complete competition". It is a market with individual economic freedom, where the parties have no power to coerce the conduct of others.[516] The condition of complete competition is required on both the supply and demand sides. This means that no individual participant should be able to restrict the freedom to compete on either the supply or demand side. Complete competition can be considered equivalent to perfect competition; it is defined as competition with the freedom to compete, whereas in perfect competition, competition is described through conditions such as free entry barriers.

Therefore, it is possible that predatory pricing and vertical restraints can be considered unlawful as the conduct can impede competition, and the defence of conduct on the ground of efficiency cannot be reached, as in the cases of the Chicago school of thought.[517] Moreover, market power is unacceptable under the condition of complete competition, as the power can be used to restrict the conduct of other parties. Therefore, according to the school, the market power should be limited,[518] and the firms with

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[514] ibid.

[515] Lovdahl Gormsen (n 469).

[516] ibid.

[517] *Case 85/76 Hoffmann-La Roche AG v. Commission [1979] ECR 461* (An exclusive agreement from one supplier)

[518] Lovdahl Gormsen (n 469); Roger Van den Bergh and Peter D Camesasca, *European Competition Law and Economics: A Comparative Perspective: A Comparitive Perspective* (2nd edition, Sweet & Maxwell 2006).

market power should be controlled and imposed with obligations. The obligation of the firm with market power is to behave as if the firm were in a condition of complete competition.[519] This means the firm cannot abuse its power to restrict others' freedom to compete. The assessment of market power involves examining concentration, barriers to entry theory, and the test of eliminating effective competition.

The concept of dominant position under Article 102 of the Treaty on the Functioning of the European Union ("TFEU") is likely to be under the influence of the school.[520] The dominant position refers to undertakings with a certain degree of market power.[521] In *United Brand*, the dominant position was defined as a position "which enables it to prevent effective competition being maintained on the relevant market by affording it the power to behave to an appreciable extent independently of its competitors, customers and ultimately of its consumers".[522] The interpretation of the abuse of the dominant position is attached to the independence of competitors, customers and consumers. In other words, it stems from the notion of freedom under the ordoliberal school. The objective of economic efficiency under the Chicago school can be applied as a defence but not as a primary purpose.[523]

The school's fundamental view of the regulatory objective differs from those of Chicago and Harvard. It holds a concept of complete competition that resembles perfect competition. In both of these market conditions, market power is inconsistent with the market. The treatment of market power in an

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[519] Bergh and Camesasca (n 519); Lovdahl Gormsen (n 469).

[520] 102 TFEU

[521] Alison Jones, Brenda Sufrin and Niamh Dunne, *EU Competition Law: Text, Cases, and Materials* (Oxford University Press) <https://>.

[522] *Case 27/76, United Brands v. Commission, [1978] E.C.R. 207 at para. 65*

[523] Lovdahl Gormsen (n 469).

ordoliberal school can be more restrictive than in the Chicago School, as the former emphasises the need for control and obligation, whereas in the latter, power can be defended as economic efficiency.

3.1.5 Conclusion

The schools are pursuing different objectives regarding competition policy and law. Harvard`s structural objective is to optimise welfare, efficiency, and the distribution of justice while maintaining the freedom to compete. The Chicago and post-Chicago schools focus on a single goal: economic efficiency. The ordoliberal school aims to protect individual economic freedom.

These objectives' fundamental differences lead to different factor weights and assessments. According to the Harvard School, the highest weight is on market concentration and entry barriers. In the Chicago school, price, cost, and profit have the highest assessment weight. In Ordoliberal schools, the effect of factors on the freedom to compete is the most significant factor. Ultimately, different jurisdictions can have other explanations on issues such as vertical restraints or predatory pricing due to the influence of economic schools.

The weight and underlying approach of the factors justification are different. However, all factors of all schools can be listed as follows:

- Market power: concentration, price, profit and cost variation and indexes.
- Barriers to entry: costs related to sunk costs, the economy of scale, switching costs, and strategic and consumer behaviours.

3.2 Application of methods and factors by academia, courts and regulators

Introduction

Three main actors in measuring competition regulations are academics, regulators and courts. Each of the actors focuses on different objectives. The academics focus on more theoretical parts with broad application, and courts and regulators apply the theories and methods from academia. In addition, they tailor methods to specific needs. The courts focus on particular cases, whereas the regulator's objectives are monitoring and proposing measures on the market competitive environment and investigating pre- and post-merger cases.

This section will be divided into three subsections. The first is about applying assessment methods by the courts, the second is by the regulators, and the third is about academics. The regulator`s subsection consists of two factors: the traditional market and new market factors. In the last subsection, some studies on factors will be shown as examples of the application of statistical methods.

3.2.1 Application of Factors in Courts

The primary reason for judges to assess the impact on the competitive environment is to determine the ability of the supplier to raise profit above the competitive level.[524] The crucial element of antitrust offences is the market power or, to an extreme degree, the form of monopoly power and its anticompetitive effects.[525] In this section, the assessment of definition elements, types of abusive practices and the practice`s effect tests by the Courts will be examined to outline the application of factors such as output, price, cost, profit, entry barriers and other factors.

3.2.1.1 Definition elements

Under competition or antitrust law, two steps exist to establish competitive conduct. First is to establish the monopoly power or the dominant position, then the effect or abuse of the power. The factors applied in assessing the above two steps will be discussed below.

The distinction between US and EU regulations begins with the elements of market power` definition. Both definitions include the power to raise prices above the competitive level; however, the element of competitive restraint is more significant under EU regulation. Under the US jurisdiction, market power is defined as "the ability to raise prices above those that would be charged in a competitive market," and monopoly power as "the power to control prices or exclude competition."[526] The monopoly power incentivises the firms to invest, increase service quality and promote economic

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[524] John B Kirkwood, 'Market Power and Antitrust Enforcement' (2018) 98 Boston University Law Review 1169.

[525] Louis Kaplow, 'On the Relevance of Market Power' (2017) 130 Harvard Law Review 1303.

[526] U.S. DEPARTMENT OF JUSTICE, 'Competition and Monopoly : Single-Firm Conduct Under Section 2 of the Sherman Act' <www.usdoj.gov/atr/public/reports/236681.htm>.

growth, so the mere monopoly is not considered illegal. However, when the monopoly power is obtained through anticompetitive conduct and is abused to distort the competition, it is under the objective of antitrust law. Under this definition, the elements of price and the level in a competitive market are important. The dominant position under the EU is defined as " the undertaking`s economic strength enabling it to prevent effective competition to an appreciable extent independently of the competitors and customers.[527] This definition implies the competitive constraints which can be imposed by the undertakings. Economic strength is described as "capable of profitably increasing prices above the competitive level".[528] The definition under EU jurisdiction contains three main elements: price level, competitive constraints, and the period of substantial market power. Therefore, in addition to the US definition, competitive constraints are significant in the EU.

3.2.1.2 Factors in market power assessment

Under the US definition, market power is defined as an ability to " profitably raise prices substantially above the competitive level."[529] The market share of the relevant market and the entry barriers are considered in the assessment by the US Courts.[530]

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[527] Case 27/76 *United Brands Company and United Brands Continentaal* v *Commission* [1978] ECR 207, paragraph 65; Case 85/76 *Hoffmann-La Roche & Co.* v *Commission* [1979] ECR 461, paragraph 38.

[528] Communication from the Commission — Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) 2009 [2009/C 45/02] para 11.

[529] *United States v. Microsoft Corp., 253 F.3d 34, 51 (D.C. Cir. 2001)*

[530] 'Competition And Monopoly: Single-Firm Conduct Under Section 2 Of The Sherman Act' (25 June 2015) <https://www.justice.gov/archives/atr/competition-and-monopoly-single-firm-conduct-under-section-2-sherman-act> accessed 12 March 2023.

There are three main methods for identifying market power applied by US courts. They are based on market shares, direct evidence from accounting figures and competitive effects.

The Court often first examines the undertaking's market share to establish its market power position. The market share level of monopoly was previously considered as ninety per cent, "is enough to constitute a monopoly",[531] then decreased to seventy[532] and fifty-five[533] per cent. The high market share alone does not indicate monopoly power, as the duration of the high market share period and market entry factors are also considered.[534] It is also possible to establish a monopoly position with a market share under fifty per cent through direct evidence. Under these methods, account data such as high profits, price-cost margins and demand elasticity can be applied to illustrate the market power. This method bears the critiques of accounting, which does not always reflect the actual economic situation.[535] The last method is based on the evidence of anticompetitive effects. The effect of competitive harm is often measured by the effect of the conduct on net surplus (on the output), profit sacrifice or efficiency.[536]

The dominant position under EU law is also assessed through factors such as market share, market entry and the additional factor from the consumer, which is the countervailing buying power.[537] The

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[531] *United States v. Aluminum Co. of America* 148 F.2d 416, 424 (2d Cir. 1945)., *American Tobacco Co. v. United States* 328 U.S. 781, 81314 (1946)

[532] *Exxon Corp. v. Berwick Bay Real Estates Partners, 748 F.2d 937, 940 (5th Cir. 1984)*

[533] *United States v. Dentsply Int'l, Inc., 399 F.3d 181, 187 (3d Cir. 2005)*

[534] *Tops Mkts., Inc. v. Quality Mkts., Inc., 142 F.3d 90, 98 (2d Cir. 1998)*

[535] Stephen Martin, 'The Misuse of Accounting Rates of Return: Comment' (1984) 74 The American Economic Review 501.

[536] U.S. DEPARTMENT OF JUSTICE (n 527).

[537] O'Donoghue (n 513) 143–173.

market share is also considered the first indicator of a dominant position.[538] Under the guidance of the EC, market share should be interpreted with other factors like market conditions. In addition, the dominant position`s market share is usually not below forty per cent.[539]

3.2.1.3 Factors in anticompetitive effect assessment

The EU approach to abuse is moving from form-based to effect-based tests. Under the form-based approach, establishing the specific form of the dominant undertaking`s practice is sufficient to illustrate the abuse.[540] However, under the effect-based, the harmful effect of undertaking practice on the competitive environment should be proven. [541]

The courts apply several effect-based general tests. Those tests are affect balancing and disproportionality,[542] profit-sacrifice or no-economic-sense and equally efficient competitor tests.[543] The effect balancing and the disproportionality tests focus on the impact of the practice on consumer welfare or the net harm of consumer welfare. The effect balancing seeks the net harm, which is challenging to evaluate, whereas the disproportionality test requires only approximating the positive impact over the negative impact on consumer welfare. The main assessment factors are the output and price that the consumer pays, and the relevant factors are service quality and innovation.[544]

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[538] *Case 85/76 Hoffmann-La Roche & Co. v Commission [1979] ECR 461, para 39-41*

[539] Communication from the Commission — Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) (n 529).

[540] Jones, Sufrin and Dunne (n 522).

[541] ibid.

[542] *Verizon Communications Inc. v. Law Offices of Curtis V. Trinko, LLP, 540 U.S. 398 (2004) (No. 02-682)*

[543] Jones, Sufrin and Dunne (n 522) 372–380; O'Donoghue (n 513) 224–237; U.S. DEPARTMENT OF JUSTICE (n 527).

[544] O'Donoghue (n 513) 234; U.S. DEPARTMENT OF JUSTICE (n 527).

The profit-sacrifice test evaluates the pricing of the undertaking to seek a short-term profit sacrifice that can be recouped from the long-term profit after the exclusion of the competitors. Lastly, the efficiency test requires that the "challenged practice excludes from the market an equally or more efficient competitor".[545] The factors of efficiency comparison are the price and the costs, as the most efficient firm is associated with the lowest costs, and the undertaking should be allowed to decrease the price to the average variable cost according to the profit maximisation rationale.[546] For the court`s preference, the US courts consider the Equally Efficient Competitor Test for Section 2 of the Sherman Act,[547] whereas the EU courts prefer the Consumer welfare test.[548]

In summary, at the first step, the US and EU courts evaluate the market share factor of undertakings, followed by the consideration of accounting figures such as market share, high profit, price-cost margin, demand elasticity, and entry barriers in the assessment of market power and abuse practices. The application examples of these factors in accounting figures will be discussed next.

3.2.1.4 Price

One of the methods to define market power is examining the price related to its changes and discrimination.

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[545] Richard A Posner, *Antitrust Law, Second Edition* (University of Chicago Press 2019) 194 <https://press.uchicago.edu/ucp/books/book/chicago/A/bo3628468.html>.

[546] O'Donoghue (n 513) 231.

[547] U.S. DEPARTMENT OF JUSTICE (n 527).

[548] Communication from the Commission — Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) (n 529); O'Donoghue (n 513) 237.

The characteristic of price discrimination or price change stems from the definition of market power. The US Supreme Court defined it as "the ability to raise prices above those that would be charged in a competitive market"[549] and by the European Court of Justice as the ability of a firm to project "power to behave to an appreciable extent independently of its competitors, its customers and, ultimately, consumers".[550] Following this definition, the ability to change the price above a certain imposed level can constitute market power.

The ability to discriminate price was defined as evidence of market power.[551] In *Brand Name Prescription Drugs Antitrust Litig.*,[552] Judge Posner stated that price discrimination is the power to "increase price above the costs" without a comparable revenue reduction. He argued that price discrimination is evidence of market power because "If the lower price covers the seller`s cost, a higher price must exceed it".[553] It means that the competition is weak because, otherwise, the force of competition should reduce the price to the level of the cost.

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[549] *NCAA v. Board of Regents, 468 U.S. 85, 108 n.38 (1984), Eastman Kodak Co. v. Image Technical Servs., Inc., 504 U.S. 451, 464 (1992)*

[550] *Hoffmann-LaRoche & Co. AG v. Commission, 1979 E.C.R. 461, 38-39; Case T-102/1999 Gencor v. Commission 1999 E.C.R. 753,200*

[551] *United States v. Eastman Kodak Co.,63 F.3d 95, 106 & n.6 (2d Cir. 1995); Coal Exporters Ass'n v. United States, 745 F.2d 76, 91 (D. C. Cir 1984)*

[552] *Brand Name Prescription Drugs Antitrust Litig., 186 F.3d 781, 78 t Litig., 186 F.3d 781,783 (7th Cir. 1999)*

[553] *Brand Name Prescription Drugs Antitrust Litig., 123 F.3d 599, 603 (7th Cir. 1997)*

However, there are several critiques of this approach. It is not always that price discrimination can be profitable; in some markets, without price discrimination, the firm can be insolvent.[554] In a market with high fixed costs and sunk costs, the market demand is divided into subgroups with different demands, such as medicine, theatres or air transport tickets.[555] If price discrimination does not produce profit but is just a tool to survive, it cannot be considered market power or price maker, and the firm can be defined as a price taker.

Another approach to market power is also inferred from the court's definition. It looks at the change in the price. From the example above, in some markets, the rise of the price does not lead to a substantial increase in the profit that can be constituted as market power. In the first stage, a firm's market share is applied as a proxy of the ability of a firm`s market power.[556] For example, in *Spirit Airlines, Inc. v. Nw. Airlines*, the market power was inferred from the dominant market share of the firm.[557]

In addition, the price change is usually assessed by comparing the before and after prices, but not with the costs. There are two types of tests.[558] In the first one, a prevailing price level is set in the market, and then the firm`s price is assessed to determine whether it is above that level. In the second test

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[554] William J Baumöl and Daniel G Swanson, 'The New Economy and Ubiquitous Competitive Price Discrimination: Identifying Defensible Criteria of Market Power' (2003) 70 Antitrust Law Journal 661.

[555] ibid 15.

[556] *Walker Process Equip., Inc. v. Food Mach. & Chem. Corp., 382 U.S. 172, 177 (1965)*

[557] *Spirit Airlines, Inc. v. Nw. Airlines, Inc., 431 F.3d 917, 935 (6th Cir. 2005)*

[558] Kirkwood (n 525).

("but for"), if the firm can prevent the price from falling to the prevailing level, it can be inferred as having market power. The test is primarily under the stage of scholars' proposals.[559] The measurement can be constructed from business plans, actual entry and entry from other markets and the court`s prediction on the effects of a merger.

In assessing the prevailing price in the first test, judges usually infer from the anticompetitive effects produced by the price above that market or product level. Then, from the effect, they assume the prevailing price and the existence of market power. In *It's My Party, Inc. v. Live Nation, Inc.,*[560] the artists were asked whether they would use the service of a promoter outside the region if the price were increased above a prevailing level. In some cases, the anticompetitive effects of the challenged conduct are used to determine the prevailing price. For instance, in *United States v. Visa U.S.A., Inc.,*[561] the market power was established by assessment of the price changes of the product without a substantial decrease in clients.

In the EU, the price factor is significant in the assessment of undertaking conduct. It is applied in the anti-competitive foreclosure test. Its objective is to detect the harmful effects of the practice on consumers.[562] The price factor is evaluated based on customer welfare to assess whether the

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[559] Lawrence J. White, 'Market Power And Market Definition In Monopolization Cases: A Paradigm Is Missing' [2015] COMPETITION LAW AND POLICY <https://www.justice.gov/atr/market-power-and-market-definition-monopolization-cases-paradigm-missing-0>; Dennis W. Carlton, 'Market Definition: Use And Abuse' (2015) 3 COMPETITION POL'Y INT'L <https://www.justice.gov/atr/market-definition-use-and-abuse> accessed 6 February 2023; Steven C Salop, 'The First Principles Approach to Antitrust, Kodak, and Antitrust at the Millennium' (2000) 68 Antitrust Law Journal 187.

[560] *811 F.3d 676 (4th Cir. 2016).*

[561] *344 F.3d 229 (2d Cir. 2003).*

[562] Communication from the Commission — Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) (n 529).

undertaking profitably harms customers. An example is *Irish Sugar*, where the undertaking imposed prices on selected customers, which can harm welfare or choices. [563]

In addition, the price factor is applied by EU Courts in the cases of price-based exclusionary conduct, exclusive purchasing obligation (rebate), tying and bundling, predation, margin squeeze and other practices. It is likely the most critical factor in determining the practice effect. In the cases of price-based conduct, the sales price of the dominant firm, relating to its costs, is examined to define the foreclosure conduct. As in *AKZO*, *Akzo's* rivals were as effective as the dominant firm. However, because of the price set below the average total cost and the smaller financial resources, the rivals were forced out of the market.[564] In the case of tying and bundling, the undertaking is dominant in the tying market and attempts to tie the tying product to another tied product.[565] The court assesses the price factor in the tying and tied market to compare the harmful effect on consumers.[566] In *Microsoft*, the Commission was concerned about tying the Microsoft web browser to its Windows Operation system.

Moreover, the price factor is a significant indicator in predation cases.[567] The price is examined concerning competitors, but not with the consumer, as lowering will likely benefit consumers.[568] It will

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[563] *Case T-228/97 Irish Sugar v Commission [1999] ECR II-2969*

[564] *Case 62/86 AKZO Chemie v Commission [1991] ECR I-3359*

[565] Communication from the Commission — Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) (n 529).

[566] ibid.

[567] Predation is when the undertaking deliberately incurres losses or foregoing profits in the short term to foreclose one or more of its actual or potential competitors with a view to strengthening or maintaining its market power

[568] *Case 62/86 AKZO Chemie v Commission [1991] ECR I-3359*

be assessed on the ability of the undertaking to raise the price above the persisting level to show the intention of predation.[569]

3.2.1.5 Cost benchmarks

The more traditional way the US courts define market power is to compare the price with the costs. In *Geneva Pharm. Tech. Corp. v. Barr Labs. Inc*[570] and *PepsiCo, Inc. v.Coca-Cola Co.*,[571] the Court stated that the market power should be assessed through the cost benchmark. It is derived directly from the competition theory; in perfect competition, the price is equal to the marginal cost, as a higher price would induce more firms to enter, reducing the price to its marginal cost.[572] Market power exists when the competition is not perfect; it is the ability of a firm to raise the price above marginal cost.[573]

The marginal cost can be measured directly or indirectly. Firstly, if the information about the firm`s production is available, the MC can be measured directly. Secondly, it can be inferred from other sources, such as the elasticity of demand or the persistence of price discrimination. In the elasticity of demand, the marginal cost is substituted by the elasticity of demand in the Lerner index, where the marginal price can be inferred from calculating the available data on the input price ratio relative to the revenue.[574] In other situations, applying price discrimination, selling one product at different prices means that the average total should be above marginal cost; otherwise, the firm would bear a loss. It

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[569] Communication from the Commission — Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) (n 529).

[570] *Geneva Pharm. Tech. Corp. v. Barr Labs. Inc., 386 F.3d 485 (2d Cir. 2004)*

[571] *PepsiCo, Inc. v.Coca-Cola Co. 315 F.3d 101 (2d. Cir. 2002)*

[572] Mankiw (n 414).

[573] Marginal cost is the cost for the addition product

[574] Sebastian J. A. de-Ramon and Michael Straughan, 'Competition Indicators for the UK Deposit-Taking Sector' Bank of England 37.

is assumed that the lower price is below MC, the higher price is higher than MC, and from this position, to estimate the MC.

In addition, in some cases, the average cost is applied to substitute the marginal cost for several reasons. Firstly, in some new economies, such as software, the initial fixed cost and development cost are substantial, whereas the marginal cost for additional software is substantially low. Therefore, the price should always be above the marginal cost to maintain solvency even if the firm has no market power. The R&D cost is associated with increased product quality, which can turn into customers' welfare rather than the firm`s profit.[575] In this case, the measurement of marginal cost is not significant to the market power. If the average cost is used instead, the fixed costs and capital costs are included in the measurement. Secondly, even if the marginal cost is significant, sometimes defining marginal cost is problematic in the real world. However, the average cost is more accessible to estimate from financial data and can be applied in different types of markets.

The EU courts apply cost factors in the establishment of practice`s effect under EU regulations.[576] As a price factor, the courts often evaluate costs in assessing the market barrier to determine the market power. In addition, the factor is considered when evaluating the practice`s effect in the cases of predation, tying, and margin squeeze.[577] The average total cost ("ATC"), the average variable cost

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[575] Inge Graef, 'Market Definition and Market Power in Data: The Case of Online Platforms' (8 September 2015) <https://papers.ssrn.com/abstract=2657732>; Xiaohua Sun, Fang Yuan and Yun Wang, 'Market Power and R&D Investment: The Case of China' (2021) 30 Industrial and Corporate Change; Baumöl and Swanson (n 555).

[576] Daniel Mandrescu, 'Abusive Pricing Practices by Online Platforms: A Framework Review of Article 102 TFEU for Future Cases' (2022) 10 Journal of antitrust enforcement 469.

[577] Communication from the Commission — Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) (n 529).

("AVC"), the average avoidable cost ("AAC")[578] and the long-run average incremental cost ("LRAIC")[579] are assessed with the price to determine the practice effect. Those costs are compared with the undertaking price to outline the impact of pricing. The cost factor is applied as a benchmark, which, below or above it, can indicate the effect. For example, if the undertaking sales price falls under AAC, this means that the undertaking is sacrificing short-term profit and can inflict losses on the equally efficient rivals. As the LRAIC includes the specific product fixed costs before the conduct has taken place and it is the cost to produce an additional product line, the price below LRAIC can be the indication of foreclosure of equal efficient competitor from capturing the market.[580] The EU courts applied the LRAIC cost benchmark in *Deutsche Post Ag* and *Wanadoo*[581] to assess the predation practice of undertakings, whereas, in *Akzo*, the AVC benchmark was compared with the price. In *United Brands,*[582] the production cost was compared with the selling price to assess the profit margin. In summary, the cost factor is often applied as a benchmark level to define the practice`s effect, or it can be used with other factors to indicate the practice.

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[578] is the average of the costs that could have been avoided if the company had not produced a discrete amount of (extra) output

[579] the average of all the (variable and fixed) costs that a company incurs to produce a particular product

[580] Mandrescu (n 577).

[581] *Case COMP/35.141 — Deutsche Post AG, Wanadoo Espa~na v Telefo´nica (Case COMP/38.784) Commission decision of 4 July 2007*

[582] *Case 27/76, United Brands Company v. Commission [1978]ECLI:EU:C:1978:22,*

3.2.1.6 Profit

Market power is defined as the ”ability of firms profitably to maintain price”[583] by the US Department of Justice and “ the ability to raise price... without losing sales so rapidly that price increase is unprofitable...”[584] by Posner. These definitions of market power have the element of profit instead of “ability to raise price above competitive level” or “ power to control the price”. The profit factor is also an essential element of EU Court decisions. The Commission guidance defines the dominant position as a “capable of profitably increasing prices above the competitive level...”.[585] In addition, the profit factor is also included in the assessment of entry barriers, exclusionary conducts, price-based, predation, refusals or other anti-competitive practices.

Therefore, profit is an essential element of market power under US and EU jurisdictions as the objective of the firm is profit maximisation, and the reduction of rivals' profit can foreclose rivals from the market.

The theory behind the assessment of profit is to identify any abnormal behaviour in the competitive environment. If the market is competitive without a barrier to entry, in the short-run, any abnormal profit should be removed because new entry will come, and the competition will reduce the abnormal profit. If the market is toward monopoly with a high barrier, the abnormal can persist longer because the competitive forces are weak.

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[583] U.S. DEPARTMENT OF JUSTICE, ‘Antitrust Division | Horizontal Merger Guidelines’ (25 June 2015) <https://www.justice.gov/atr/horizontal-merger-guidelines-0>.

[584] Richard Posner and William Landes, ‘Market Power in Antitrust Cases’ (1980) 94 Harvard Law Review 937, 937.

[585] Communication from the Commission — Guidance on the Commission’s enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (Text with EEA relevance) (n 529).

For instance, in *United States v. Dentsply Int'l, Inc.*, the artificial tooth business is so profitable that it covers losses in other businesses. A persistent high profit in United States v. Microsoft Corp was a major factor in the court's consideration of market power. In *Deutsche Telekom*, the margin squeeze practice is considered abusive if the undertaking charges on the downstream rivals deprive them of profit.[586] Profit is also an essential factor in assessing excessive pricing practices; the level of profit margin is defined as excessive.[587] The profitability assessment is the first step in the evaluation under the United Brands test.[588] The test requires profit to be significantly persistent under the investigation`s market context. The profit can also be assessed with a reasonable acceptance level in other sectors to define the appropriate level.[589]

In summary, the courts often assess the profit when defining the anticompetitive effect of practices such as entry barriers, exclusionary conducts, price-based practices, predation, refusals, or other anti-competitive practices. The reason is that the low profit of competitors can foreclose them from the market, and the high profit of undertaking can indicate a high entry barrier.

3.2.1.7 Conclusion of courts` application

Both courts recognise the critiques of accounting figures, which do not always reflect the actual economic conditions of the undertaking. However, applying factors is common as those data are the most available tools. Courts apply accounting figures factors such as market share, high profit, price-cost margin, demand elasticity, and qualitative factors such as market dynamics, conditions, and entry

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[586] Commission Decision of 21 May 2003 relating to a proceeding under Art. 82 of the EC Treaty (Case COMP/C-1/37.451, 37.578, 37.579 – *Deutsche Telekom AG*), O.J. 2003, L 263/9

[587] *Case C-177/16, Latvian Copyright, [2017] EU:C:2017:689*

[588] *Case 27/76, United Brands Company v Commission [1978] ECLI:EU:C:1978:22*

[589] Mandrescu (n 577).

barriers to assessing market power and its abusive practices. The factors are applied through the tests constructed according to the economic school of thought: efficiency, welfare or constraint. The distinction between these two jurisdictions is that in US courts, the factors are often applied as direct evidence, whereas in the EU, they are frequently used as the proxy measurement of the effect of undertaking practices.

3.2.2 Application of factors by the regulator

The regulatory authority's objective is broader than that of the courts; regulators are responsible for monitoring and investigating the entire market, rather than just the impact of competition cases. As discussed above, the objectives of competition law and policy may vary depending on the jurisdiction and economic schools.[590] In the UK, the primary objective is to support market competition and protect vulnerable consumers, which is aligned with the European ordoliberal school.[591] The objective of consumer protection includes the outcomes of a lower price, higher quality, and the launch of new products and services, whereas the objective of a competitive environment includes promoting competition and supporting welfare growth. [592] Their actions consist of monitoring the competitive environment, investigating merger cases, and proposing to improve the specific market competitive environment.

In addition to the broader objective, the funding, available resources, and the structure of the regulatory body are more robust, resulting in the more specialised broad application of the technique

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[590] 'The Parallels between the Havard Structural School and Article 82 EC and the Divergences between the Chicago and Post-Chicago Schools and Article 82 EC' (2008) 4 European Competition Journal 213; David Gerber (n 514); Hovenkamp (n 482).

[591] 'Mergers - the CMA's Jurisdiction and Procedure: CMA2' (*GOV.UK*) <https://www.gov.uk/government/publications/mergers-guidance-on-the-cmas-jurisdiction-and-procedure> accessed 9 February 2022; CMA, 'Regulation and Competition: A Review of the Evidence' <https://www.gov.uk/government/publications/regulation-and-competition-a-review-of-the-evidence>; 'Market Studies and Investigations - Guidance on the CMA's Approach: CMA3' (*GOV.UK*, 5 July 2017).

[592] CMA, 'Regulation and Competition' (n 592).

in the assessment.[593] Because of a wide scope of objectives, various resources and more funding, their tools are interdisciplinary with sophisticated knowledge. Moreover, regulators constitute an organisation with better access to resources than courts dealing with specific cases.[594]

Consequently, in addition to the factors and tools applied by the courts, such as concentration, effects on price, cost variation and profit variation, and effect on competition tests, big data and consumer behaviour factors are incorporated into the assessment.

This section will discuss the distinction between traditional and new markets, as well as the regulator`s assessment tools.

3.2.2.1 Traditional and New Markets

In traditional markets, there are typically only suppliers and consumers; their products consist of traditional goods and services. However, with the advancement of digital technologies, new markets have emerged, such as digital ads (Google and Yahoo), search engines (Google and Bing), transaction platforms (Alibaba and Amazon), and various other online platforms.

According to the UK Government White Paper, the Fourth Industrial Revolution is a "fusion of technologies that will disrupt nearly every industry in every country, creating new opportunities and

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[593] 'CMA Structure' (*GOV.UK*) <https://www.gov.uk/government/publications/cma-structure/cma-structure-chart-as-at-march-2019>.

[594] Stefan Hunt., 'The Technology-Led Transformation of Competition and Consumer Agencies: The CMA's Experience' <https://www.gov.uk/government/publications/the-technology-led-transformation-of-competition-and-consumer-agencies-the-cmas-experience>.

challenges for people, places and businesses".[595] In new or existing markets, competition is pressured by emerging technology and the accompanying business model. For instance, the traditional UK broadcast market faces competition from new streaming services such as Netflix, Disney+, and Amazon Prime.

The features of the new market can be the multisided dynamic market with digital products and network effects. The product of a new market can be traditional goods or services or a digital product such as software, data or online service.[596]

The multisided market can be two or more. The two-sided platform provides goods or services to two groups of customers, and the platform acts as an intermediate between customers.[597] An example can be Amazon, which provides a platform for producers to sell their products to consumers. These multisided platforms or markets find, match and facilitate a transaction between members, which reduces the finding and matching costs; accumulate audiences, which can result in the network effect;

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[595] CMA, 'Regulation and Competition' (n 592).

[596] 'Movies on Pay TV Market Investigation (CC)' (*GOV.UK*) <https://www.gov.uk/cma-cases/movies-on-pay-tv-market-investigation-cc> accessed 31 January 2023; 'Mobile Ecosystems Market Study Final Report' (*GOV.UK*, 4 August 2022) <https://www.gov.uk/government/publications/mobile-ecosystems-market-study-final-report> accessed 4 February 2023; 'Payment Protection Insurance (PPI) Market Investigation (CC)' (*GOV.UK*) <https://www.gov.uk/cma-cases/payment-protection-insurance-ppi-market-investigation-cc>.

[597] David S Evans, 'The Antitrust Economics of Two-Sided Markets' [2002] YALE J. ON REG 325.

and share resources between groups, minimising the costs of services.[598] Compared to the traditional market, they are more cost-effective[599] and featured with the network effect.[600]

The competition in a new market can be dynamic. Dynamic competition is where incumbents and newcomers compete through continuous innovation, and participants are under pressure from the new product, technology, or business model.[601] Newcomers or incumbents can use innovation to enter or redefine the market.[602] Technological advantage is essential in this type of competition, and competition frequently occurs through technological innovation. Examples include social media platforms (Facebook, Twitter and TikTok) with constant updates or streaming services (Netflix, Disney Plus or Amazon). In these markets, the initial investment to build a customer base, achieving a network effect, can be costly and take an extended period.[603]

In summary, the new markets possess distinctive features compared to traditional markets. Therefore, new factors were developed for assessing these markets, such as network effect, data access, switching costs, and customer responses.

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[598] David S Evans, 'The Industrial Organization of Markets with Two-Sided Platforms' (*Competition Policy International*, 19 April 2007) <https://www.competitionpolicyinternational.com/the-industrial-organization-of-markets-with-two-sided-platforms/>.

[599] Baumöl and Swanson (n 555).

[600] A detailed discussion about network effect will be in the "New market assessment factors" part.

[601] CMA, 'Regulation and Competition' (n 592).

[602] 'Dynamic Competition in Online Platforms. Evidence from Five Case Study Markets' (*GOV.UK*) <https://www.gov.uk/government/publications/dynamic-competition-in-online-platforms>.

[603] 'Mergers - the CMA's Jurisdiction and Procedure: CMA2' (n 592).

3.2.2.2 Assessment Tools

In addition to traditional tools, regulators have utilised big data and AI to assess dynamic competition.

Data collection tools

In addition to traditional data collection from financial reports and private databases, a new technique has been developed in the collection and processing of data: the collection of big data, web scraping, complaints, and data analysis with AI applications.

Big data and data pipelines

In response to disruptive technology changes, regulators shift to enhance data acquisition capability by creating data units such as the Strategic Data Analysis Unit of the ACCC and the AdlC.[604] These units are responsible for data collection and analysis.

In Google's and Bing's search market assessment, a massive amount of 4TB of data was collected to analyse the effectiveness of Google search results compared to Bing and the relationship to the price of targeted advertising.[605] An AI application matched the search data from Google and Bing to compare the effectiveness of search engines. It was found that Google's search on less common searches was 30 times better than Bing's. In the case of mobile ecosystems, 500 GB of data from Apple and Google Play was collected to assess the competitive environment, and it was concluded that the search

[604] '2021 Compendium of Approaches to Improving Competition in Digital Markets' (CMA) <https://www.gov.uk/government/publications/compendium-of-approaches-to-improving-competition-in-digital-markets>.

[605] Simeon Thornton, Chris Jenkins, Giacomo Mason and Dan Griffiths (2020), Opening the Black Box: An Analysis of Google's Behavior in Search and Display Advertising Using Large-Scale Datasets, Competition Policy International Antitrust Chronicle October 2020

algorithm was more important than other app discovery channels.[606] Big data analysis can also be used pre- and post-announcement of the merger to assess product quality.[607] Big data analysis is essential in finding competitive advantages and market power in those new markets.

Another method to acquire data is to establish data pipelines. A pipeline is a connection between the data source and the destination of the data application. In the case of pipelines, new data updates automatically, providing frequently refreshed data for processing. CMA has established several pipelines. One is CMA's Covid Taskforce pipeline, where data on company obligations to consumers relating to Covid is updated. This pipeline enables CMA to respond rapidly to the situation regarding COVID-19 restrictions. Another is the complaint pipelines, where data on complaints is uploaded, allowing CMA to understand the company's issues in the market sector. To process the vast number of complaints, around 5000 per week, CMA applied AI with natural language processing techniques to process the complaints. Currently, CMA is working on the pipeline from Companies House. The pipeline will gather intelligence on companies and the state of the market, such as market share and profits.[608]

Scraping

Scraping is the automatic collection of web data through software. The data from scraping with AI or human data monitoring can detect market issues, such as price spikes or service quality, from the

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[606] 'Online Platforms and Digital Advertising Market Study' (*GOV.UK*, 1 July 2020) <https://www.gov.uk/cma-cases/online-platforms-and-digital-advertising-market-study>.

[607] 'Using Natural Language Processing in Competition Cases' (*Compass Lexecon*, 22 March 2022) <https://www.compasslexecon.com/the-analysis/using-natural-language-processing-in-competition-cases/03-22-2022/>.

[608] Stefan Hunt. (n 595).

consumer experience side.[609] CMA scraping applications are built from company website data to check complaints and social media endorsements.[610] An example is the payday lending market investigation, where data scraping from the lender's website was used to verify compliance.[611] Web scraping and innovative data analysis techniques offer significant potential for market investigation and monitoring.

[609] Le Chen, Alan Mislove and Christo Wilson (2015) Peeking Beneath the Hood of Uber in Proceedings of the Internet Measurement Conference (IMC 2015),

[610] 'Social Media Endorsements' (CMA 2022) <https://www.gov.uk/cma-cases/social-media-endorsements> accessed 6 February 2023.

[611] 'Payday Lending Market Investigation' (CMA) <https://www.gov.uk/cma-cases/payday-lending-market-investigation>.

3.2.2.3 Assessment structure

The current approach by the authority is the market-based assessment. According to this approach, the authority constructs a theory of harm specifically adapted to the type of market and then conducts the evaluation.[612] The conduct of competitive market assessment can be divided into two steps.[613] In the first step, a theory of harm, or the specificities of the targeted market, is constructed based on how competition is weakened due to the targeted market characteristics.[614] The first step is to establish an assessment framework based on the general characteristics of the market, which can be assessed in the next step by relating these framework factors. The second step is to select factors relevant to the framework and conduct the analysis.

In the first step, the analysis of the positions of firms, nature of the products, customer base and the nature of competition, and possible strategies of the firms and the growth of the market.[615] The competition in a dynamic market will likely differ from that in a stable market, as well as from an expanding market and from markets with network effects compared to those without. The competitive characteristics of the market can vary and be specific to the target market.[616]

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[612] 'Market Investigations Guidelines: CC3' (*GOV.UK*, 5 July 2017) <https://www.gov.uk/government/publications/market-investigations-guidelines> accessed 29 January 2023; 'Mergers - the CMA's Jurisdiction and Procedure: CMA2' (n 592).

[613] 'Mergers: Guidance on the CMA's Jurisdiction and Procedure' 140; 'Market Investigations Guidelines: CC3' (n 613).

[614] 'Mergers: Guidance on the CMA's Jurisdiction and Procedure' (n 614); 'Market Investigations Guidelines: CC3' (n 613).

[615] 'Market Investigations Guidelines: CC3' (n 613).

[616] ibid.

The factors are selected with weights according to the assessment framework in the next step. The possible factor groups include unilateral market power, barriers to entry and expansion and customer response. In addition, new market factors include data access, switching costs and network effects.

Lastly, a model based on the factors is constructed using assessment methods. There are qualitative and quantitative methods; regulators often apply a mixture of methods in market competition assessment. Behavioural factors on the consumer and supplier sides[617] can be captured better through surveys and interviews.[618]

3.2.2.4 Assessment factors and methods

The factors examined by regulators are separated into the traditional and new economy groups.

3.2.2.4.1 Traditional factors

Factors related to production quantity and quality, costs, profits, employment, time and consumer benefits are commonly used to measure the competitive environment.[619] They can be grouped as monetary or non-monetary. For instance, costs and profits are monetary factors that provide a standard comparison unit. Other factors, such as consumer surplus or employment, can be converted

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[617] 'Unlocking Digital Competition, Report of the Digital Competition Expert Panel' (n 236).

[618] Lucian Alexa, 'Methods of Analyzing Market Power' (2015) 35 ROM. COMPETITION J <https://papers.ssrn.com/abstract=2714347>.

[619] 'Competition Assessment Toolkit - OECD' <https://www.oecd.org/competition/assessment-toolkit.htm> accessed 4 December 2022.

to a monetary unit for comparison and application using different calculation methods. These independent variables, in combination, create a market power index, barriers to entry and expansion, and customer response. The barrier and market power assessment can be concluded by analysing independent factors.

3.2.2.4.1.1 Entry and Expansion Barriers

The high entry barriers can also be associated with harm to competition. In the banking industry[620]or merger case investigations,[621] CMA found that high entry barriers could lower the competitive environment, with several common types of barriers.[622] The first one is the high initial set-up costs. If a high proportion of investment cost is sunk, it can act as an entry or expansion barrier. As in *Tobii AB*,[623] the newcomers are deterred by unrecoverable costs.

Another type of barrier is switching costs, which include supplier reputation and brand loyalty. This occurs when the product is essential or tied to a long contract or exclusive agreement with high costs. For instance, in the investigation of the mobile market, users switching to other devices can lose access to the existing services and ecosystem.[624] As such, users are reluctant to switch to another brand. In

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[620] 'Digital Comparison Tools: Summary of Final Report' (*GOV.UK*) <https://www.gov.uk/government/publications/digital-comparison-tools-summary-of-final-report/digital-comparison-tools-summary-of-final-report> accessed 4 December 2022.

[621] In Yorkshire Purchasing Organisation/Findel Education Limited , Prosafe SE/Floatel International Limited, Arriva Rail North/Northern rail franchise

[622] 'Market Investigations Guidelines: CC3' (n 613); 'Mergers: Guidance on the CMA's Jurisdiction and Procedure' (n 614); 'Competition Assessment Toolkit - OECD' (n 620).

[623] Tobii AB/Smartbox Assistive Technology Limited and Sensory Software International Ltd

[624] 'Mobile Ecosystems Market Study Final Report' (n 597).

the EV charging market investigation, a long-term exclusive agreement between Electric Highway, with 80% of the market share and the other three suppliers was found, which created an entry barrier.[625]

The third type of barrier can be the presence of economies of scale. In a market with economies of scale, the initial investment is high. Therefore, the entry should bear high entry risk. Other barriers, such as network effects and technological barriers, are usually associated with a new market, where competition is dynamic with innovation.[626]

Lastly, the incumbent can benefit from an early mover advantage due to the combination of high switching costs, network effects, and other barriers. Since some of these barriers have cumulative effects, the incumbent can gain a data and loyalty advantage over newcomers.[627]

3.2.2.4.1.2 Market power factors

The market power factors are concentration, price, costs, profitability and the indices derived from them. In addition to these price factors, other non-price factors, such as product quality and innovation, are considered.

High market concentration is often associated with a less competitive environment. The investigation of advertising services and the retail grocery markets concluded that the high concentration harmed

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[625] 'Electric Vehicle Charging Market Study' (*GOV.UK*, 25 March 2022) 25 <https://www.gov.uk/cma-cases/electric-vehicle-charging-market-study>.

[626] 'Market Investigations Guidelines: CC3' (n 613).

[627] Viscusi and others (n 94).

the competition.[628] Concentration measurement can be conducted using market share, concentration ratio, HHI index, or other concentration indices. In addition, the UK authority applies the Logit Competition Index ("LOCI"), which is computed as one minus the suppliers` weighted average market share across its submarket. The weight of the market share is assigned by the significance of the submarket to the supplier.[629]

The authority often uses price patterns and price comparisons.[630] The abnormal price pattern may indicate a lack of competition. The price patterns, such as a stable price trend or a gradually increasing price, can be an indication of high market power. On the other hand, the price adjustment of competitors at one time can indicate coordinated effects.[631] The pattern can be assessed in conjunction with other factors. For example, in the grocery and bus service markets, the prices were compared with concentration in different local markets.[632] A high price of the same product in a more concentrated area can mean a lack of competition.

Moreover, the price-cost margin can be applied to the assessment. It is calculated as a measurement of marginal cost and revenue, presented as a percentage of revenue.[633] A pattern of high price-margin costs may indicate high switching costs or information asymmetry, as customers cannot switch to other

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[628] 'Market Investigations Guidelines: CC3' (n 613).

[629] 'Groceries Market Investigation (CC)' (*GOV.UK*) <https://www.gov.uk/cma-cases/groceries-market-investigation-cc> accessed 31 January 2023.

[630] 'Market Investigations Guidelines: CC3' (n 613).

[631] ibid.

[632] 'Local Bus Services Market Investigation (CC)' (*GOV.UK*) <https://www.gov.uk/cma-cases/local-bus-services-market-investigation-cc> accessed 31 January 2023; 'Groceries Market Investigation (CC)' (n 630).

[633] 'Groceries Market Investigation (CC)' (n 630).

providers and have to pay high prices. However, high price-margin costs may indicate weak competition if the MC is below average costs, such as in the case of digital products.[634]

Profitability

The UK regulator's measurement of profitability depends on two conditions. These include the data validity and sector specificity. For example, the return on equity ratio is considered an indicator of profitability in the financial sector,[635] whereas the return on capital ratio can be applied in the sectors with high capital investment.[636] In the sector with long-term high-capitalised investment, the cash flow model with an internal rate of return ("IRR") can be used to calculate the profitability.[637] The accounting standard for measurement is UK GAAP.

High profit can be interpreted in several ways. A static level of high profit can indicate weak competition as competition often creates a profit fluctuation and reduces the profit margin to a rate lower than the "normal" rate in the long term.[638] Additionally, high profit can indicate high market power or an entry barrier.[639] However, it can also stem from cyclical factors, such as higher productive efficiency or innovation. Therefore, this factor should be examined in conjunction with all other factors.

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[634] 'Market Investigations Guidelines: CC3' (n 613); 'Unlocking Digital Competition, Report of the Digital Competition Expert Panel' (n 236).

[635] 'Payment Protection Insurance (PPI) Market Investigation (CC)' (n 597).

[636] 'BAA Airports Market Investigation (CC)' (*GOV.UK*) <https://www.gov.uk/cma-cases/baa-airports-market-investigation-cc> accessed 31 January 2023.

[637] 'Movies on Pay TV Market Investigation (CC)' (n 597).

[638] Bergh and Camesasca (n 519).

[639] 'Market Investigations Guidelines: CC3' (n 613).

Market indexes

Individual factors such as price, cost, and profit can be combined to create more sophisticated measurement indexes. The indexes, such as Panzar-Rosse, Lenner, and Boone, were designed to measure market power. They are based on the principle of general economic theory, which states that market power is the ability to raise prices above the competitive level. These indexes measure the price relative to a level defined as the normal level. In the case of Panzar-Rosse, the normal level is defined through revenue; for Lenner, it is defined through marginal cost; and for the Boone index, it is defined by profit.

3.2.2.4.2 New market factors

In addition to traditional markets, new markets such as search and digital advertising,[640] mobile ecosystems,[641] digital comparison tools[642] , and app stores[643] have been established utilising technological advancements. Therefore, new assessment factors were defined according to the new market characteristics. The new market characteristics are dynamic competition, multisided platforms and possible digital products. The assessment factors include the network effect, the role of data, and

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[640] 'Online Platforms and Digital Advertising Market Study' (n 607); 'Antitrust: Google Fined €1.49 Billion for Online Advertising Abuse' (*European Commission - European Commission*) <https://ec.europa.eu/commission/presscorner/detail/en/IP_19_1770>.

[641] 'Mobile Ecosystems Market Study Final Report' (n 597).

[642] 'Digital Comparison Tools: Summary of Final Report' (n 621).

[643] 'Investigation into Apple AppStore' (*GOV.UK*, 31 October 2022) <https://www.gov.uk/cma-cases/investigation-into-apple-appstore>.

the switching costs, which can arise from qualitative factors such as product or service quality (content, features, functionality, and performance) and brand loyalty.

The assessment includes factors such as network effect, multi-sided market, and the role of data in the new economies.[644]

- Access to data. It can be a competitive advantage in the market where the business model is based on the monetisation of data.[645] In the digital ad market, the data is used to provide search results, which are monetised with advertisements. In *Microsoft/Yahoo,* the European Commission found that the data scale is irrelevant;[646] however, in *Google* and *Bing*, the amount of data is found relevant to the search result.[647]

- User behavioural and qualitative factors, such as content and brand loyalty, features, functionality, and performance, can constitute a high switching cost factor.[648]

- Switching costs. In the mobile market investigation, the switching costs are found to be the primary competitive advantage of iOS and Android.[649] The independent factors influencing switching costs include barriers such as consumer disengagement, satisfaction with the

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[644] '2021 Compendium of Approaches to Improving Competition in Digital Markets' (n 605).

[645] Graef (n 576).

[646] *Case No COMP/M.5727 – Microsoft/Yahoo! Search Business, 18 Feb. 2010, paras 160-174*

[647] K. O'Toole, *Susan Athey: How Big Data Changes Business Management. The Stanford economist explains how troves of digital data will reshape competition*, Insights by Stanford Business, 20 Sep. 2013, available at http://www.gsb.stanford.edu/insights/susan-athey-how-big-data-changes-business-management

[648] 'Mobile Ecosystems Market Study Final Report' (n 597).

[649] ibid.

characteristics of Android and iOS devices, and brand loyalty. The investigation showed that 31% of iOS users and 35% of Android users did not see benefits from switching, which constitutes a high entry barrier.[650]

- Network effect. In the data-driven market, where data is acquired and monetised, the economy is usually characterised by economies of scale and the network effect.[651] The network effect competition can turn into the tipping effect. It is the effect of competition, and where there is fierce competition at the initial stage of building a customer base, one platform becomes dominant over other platforms.[652] In assessing the new market, one of CMA's primary concerns is the network effect and its derived tipping effect.[653] For example, in the merger inquiry Facebook/Giphy, the CMA assessed the potential effect on market power with the acquisition of Giphy, strengthening the Facebook network effect.[654] In the gaming industry, where a high customer base can attract more customers, Microsoft attempted to acquire ABK, a game provider, to increase its network effect and raise barriers to entry.[655] In summary, the network effect is a strong indicator of a barrier that can evolve into a tipping point.

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[650] ibid.

[651] Graef (n 576).

[652] Jean-Pierre H Dubé, Günter J Hitsch and Pradeep K Chintagunta, 'Tipping and Concentration in Markets with Indirect Network Effects' (2010) 29 Marketing science (Providence, R.I.) 216.

[653] 'Mergers: Guidance on the CMA's Jurisdiction and Procedure' (n 614).

[654] 'Facebook, Inc (Now Meta Platforms, Inc) / Giphy, Inc Merger Inquiry' (*GOV.UK*, 9 January 2023) <https://www.gov.uk/cma-cases/facebook-inc-giphy-inc-merger-inquiry> accessed 4 February 2023.

[655] 'Microsoft / Activision Blizzard Merger Inquiry' (*GOV.UK*, 5 January 2023) <https://www.gov.uk/cma-cases/microsoft-slash-activision-blizzard-merger-inquiry> accessed 4 February 2023.

3.2.3 Academic Assessment Methods

In this section, the methods applied in academia will be examined. In the academic evaluation of the assessment factors and their impact, statistical methods are applied. Firstly, at the initial stage, the theoretical model will be constructed. In the next stage, the data collection will be processed. Lastly, the appropriate model with factors will be defined to test the theory. The regression models and comparison of factors are applied to find the correlation and explain the interaction. The DiD model is usually used to measure the impacts, especially the regulatory impact.

Moreover, in some cases where the impact cannot be calculated with the DiD model, several correlation tests are conducted to infer the impact. Academics develop assessment theories or models with their factors, which are then applied by courts and regulators. Some recent papers on the assessment factors with the application of DiD methods and regression models in academia or applied by CMA[656] will be illustrated below.

3.2.3.1 Application of the regression model

In this section, several studies will be illustrated as examples of model application. One of the pioneering papers on competition policy was a study on concentration by Bain.[657] The author argues that concentration in the market leads to high profit or monopoly power. Financial data of US companies from 1936 to 1940 was collected to test with a market and profit model. The objective of the model was to find a significant correlation between market concentration and company profit. The result is not conclusive, as there is no significant correlation.[658]

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[656] CMA, 'Regulation and Competition' (n 592).

[657] Bain (n 478).

[658] ibid.

Another is Egert's research on the innovation level.[659] Data on companies' regulation and innovation levels from 34 OECD countries over 30 years was collected to create a productivity model. They find that the level of regulation can be explained by productivity in capital and labour distribution and that the impact of the level of regulation on productivity is correlated with reduced research and development activities.[660] The performance of community banks was measured in the paper by Fayman et al. Financial data from community and non-community banks were modelled to outline the performance. Nguyen and Barth conducted a paper on the regulatory impact on small businesses loans.[661] A model with a dummy variable for community or non-community banks was tested. It finds that the community banks' factor is significant in the provision of small business loans.

3.2.3.2 Application of DiD method

DID model and its derivative model are often used to measure the impact. The following papers applied the methods to measure the regulatory impact of factors such as price, output, cost, profit and entry barriers.

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[659] Balázs Égert, 'Regulation, Institutions, and Productivity: New Macroeconomic Evidence from OECD Countries' (2016) 106 The American Economic Review 109.

[660] ibid.

[661] Nguyen TH Nguyen and James R Barth, 'Community Banks vs. Non-Community Banks: Where Is the Advantage in Local Small Business Funding?' (2020) 48 Atlantic Economic Journal 161.

Bagchi and Sivadasan analysed the regulatory impact on price by applying the DiD method.[662] The regulation changes affect the entry barrier, which in turn alters the price across 19 states in the US. They find that the regulatory impact of lowering the entry barrier resulted in a 5.5% to 6.8% reduction in prices, but the regulation had no impact on the quality.

Guiomard conducted another research that applied the DiD method to the impact of airport slot regulation and the competition environment. The author used Dublin Airport as a case study.[663] The author concludes that the effects of changing from the grandfathered rule to the auction slot rule increased 24 million passengers/ year and EURO 31 billion of consumer welfare gain.

An illustration of regulatory impact research on cost and profit with a more sophisticated version of the DiD method can be the research on the US local telephone market by Fan and Xiao.[664] The authors applied the DiD principle of counterfactual analysis. Before 1996, the market was a monopoly under Bell Children Companies, and the reform of regulation allowed other carriers to enter the market. Data on entry was collected from 1998 to 2002, the date of regulatory enforcement, to predict potential entries and then compared with actual entries to create a control group. The treatment group was established through the change of the model subsidy policy parameter, which was compared to the control group to estimate the impact.[665] The authors find that a subsidy equals 5% of entry cost and reduces the share of the monopoly market to 32% (compared to 52% in the data) in 1998 and to 7%

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[662] Sutirtha Bagchi and Jagadeesh Sivadasan, 'Barriers to Entry and Competitive Behavior: Evidence from Reforms of Cable Franchising Regulations' (2017) 65 The Journal of Industrial Economics 510.

[663] Cathal Guiomard, 'Airport Slots: Can Regulation Be Coordinated with Competiton?' (13 March 2016) <https://papers.ssrn.com/abstract=2769849>.

[664] Ying Fan and Mo Xiao, 'Competition and Subsidies in the Deregulated US Local Telephone Industry' (2015) 46 The RAND Journal of Economics 751.

[665] ibid.

by 2001 (compared to 23% in the control group).[666] This means that a subsidy in entry costs can stably reduce monopoly power. However, comparing the size of the market, the research finds that it is more effective in a small market.

There are various studies on competition law, such as a study on the regulatory impact on firms by Bailey and Thomas.[667] It finds that new firms established in a regulated market are fewer than in a less regulated market. Another study by Ohsfeldt and Li examines the regulatory impact on the quality of the health sector.[668] They compare two groups: one in the state with a certificate-of-need ("CON") policy and another without such a policy. They find that the likelihood of states with these restrictions having high ratings is lower than that of states without restrictions. [669]

In summary of the methods from the above studies, the dataset of parameters (or factors) is collected to construct the model. According to the statistical results, the correlations and significance of the factors can be estimated to explain how regulation impacts the model`s parameters. In addition to modelling, comparisons and counterfactual analyses between factors, models, or groups can be conducted to estimate the quantitative impact.

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[666] ibid.

[667] James Bailey and Diana Thomas, 'Regulating Away Competition: The Effect of Regulation on Entrepreneurship and Employment' (2017) 52 Journal of Regulatory Economics 1.

[668] Robert L Ohsfeldt and Pengxiang Li, 'State Entry Regulation and Home Health Agency Quality Ratings' (2018) 53 Journal of Regulatory Economics 1.

[669] ibid.

3.3 Conclusion

In summary, the examination of underlying theoretical approaches can be concluded as follows:

- According to its objective, the regulatory impact assessment can be evaluated across four dimensions: economic efficiency, welfare, freedom of competition, and justice distribution.

- The differences in competition law and policy`s objectives by schools of thought lead to different weights of the factors and interpretation of competition issues such as vertical restraint or predatory pricing.

- The development of methods and factors has an accumulative effect on the application of other fields. Despite the differences in theoretical approaches, the weight of factors can differ. However, the list of factors accumulates.

In addition, the examination of the application by academia, courts and regulators can be concluded as follows:

- The assessment by the court, in comparison with regulators, has different objectives and is limited in resources, whereas the purpose of academic research is flexible and broad, and courts and regulators are specific.
- Regarding resources, factors and methods applied by the court are limited compared to regulators and academics. Regulators can access big data, construct the pipeline, and develop AI assessment software, but scholars are constrained in dataset size and access.

There are three steps in the regulatory assessment of the competitive level. In the first step, the market characteristics are examined. These include the positions of firms, the nature of the products, the

customer base, and the nature of competition. Possible firm strategies should be considered to create the assessment framework. These include the following features of the market dynamics:

- Dynamic market or not?
- Traditional or digital product.
- Stable or expanding market.
- Overall, is it a traditional or new market?

In the second step, the assessment factors will be selected from the following two lists:

1. Entry and expansion barrier factors:

- Initial set-up costs.
- Economies of scale.
- Technological barrier.
- Network effect.
- Switching costs from reputation, brand loyalty, data access or service quality factors.
- Combination of the above barriers as a first mover advantage.

2 . Market power factors:

- Concentration.
- Price.
- Cost variation.
- Profit variation.
- Market power index.

The selection of factors should be "the more factors, the better interpretation of result", as an individual factor analysis cannot illustrate the whole picture. For instance, the high concentration

assessed individually cannot indicate high market power. Additionally, profit can relate to cyclical factors or specific market characteristics. All factors should be examined in conjunction with each other.

The last step involves constructing a model based on the factors alongside assessment methods and tools. These tools may be traditional or incorporate new techniques. The latest tools utilised by CMA include big data pipelines or data scraping combined with AI big data analysis. Methods can be either qualitative or quantitative. There are behavioural factors on the consumer and supplier sides[670] , which can be captured better through surveys and interviews.[671] It is possible to apply a mixture of methods in market competition assessment. Finally, the interpretation of factors, assessed separately, can be compared or applied with counterfactual assumptions to generate a broad understanding of results.

[670] 'Unlocking Digital Competition, Report of the Digital Competition Expert Panel' (n 236).

[671] Alexa (n 619); 'Digital Comparison Tools: Summary of Final Report' (n 621); 'Investigation into Apple AppStore' (n 644); 'Payday Lending Market Investigation' (n 612).

4. Chapter Four. Empirical Analyses

Introduction

In this Chapter, the empirical data is collected to test the assumptions. The chapter aims to provide a normative model of how open OB regulations impact the competitive market environment.

The impact factor groups in the previous Chapters are entry and expansion barrier factors and market power factors. The entry barrier factors are set-up costs, reputation, network effect with economy of scale, switching costs, service quality, and loyalty. The market power factors are concentration and market power index based on price, cost or profit variation.

Accordingly, the empirical data are collected to model the OB regulatory impact on public sentiment toward OB (reputation factor), service quality and quantity, switching costs, network effect and market power factors. Therefore, the Chapter is divided into four parts corresponding to five groups of analyses. The fifth is the general impact model with all factors:

- Part one. Factor selection of the impact model.
- Part two. The analysis of the Open banking regulatory impact on public sentiment.
- Part three. Open Banking service quantity and quality analysis.
- Part four. The analysis of Open banking regulations on switching costs and network effects in the UK banking market.
- Part five. The analysis of the OB regulatory impact on banks' operations and market power.
- Part six. General OB regulatory impact model. It is where all factors are put together to model the regulatory impact.

The analysis reveals several insights. Firstly, the sentiment analysis shows that OB regulation could impact the sentiment toward OB by increasing the mean sentiment score by 11%. In addition, the topic extraction shows that some topics which existed during the uncertainty period were not discussed after the uncertainty resolution. After the OB regulatory enforcement, the topics now focus on enforcement deadlines and the issues regarding the least advantageous groups, such as small firms and indigent people. Secondly, the regulatory impact on service quality and quantity shows a substantial quantitative increase in service demand and a possible shift in the competitive environment caused by uneven regulatory impact on service quality between banking groups. The topic extraction shows that the OB regulatory enforcement has closed the discussions about security issues; however, the discussion about issues with app updates, freezing and stopping the apps remains. Thirdly, the measurement of the network effect indicates a high probability of the impact after OB regulatory enforcement. Fourthly, the analysis of market power and bank operations shows an insignificant regulatory impact on costs and income. However, the competitive environment is weakening despite the declining market concentration. Lastly, the general impact model predicts a further weakening competitive environment with the following statistically significant impact factors: public sentiment, account switching number, network effect and number of reviews.

4.1 Regulatory impact model factor selection

In this section, the regulatory impact model is constructed based on the assumptions and assessment of factors by courts, regulators and academia. To summarise the findings in the Theoretical Chapter and the Application of impact factors by other actors, there are several steps in constructing the assessment model.

In the first step, the market characteristics are examined. These include the positions of firms, the nature of the products, the customer base, and the nature of competition. Possible firm strategies should be considered to create the assessment framework. In the second step, the assessment factors will be selected from the following two lists: entry barrier and market power factors. These steps will be conducted in the following sections to define the model.

4.1.1 Market Characteristic Assessment

4.1.1.1 The product of the market

OB market is an ecosystem with the banks as the core, surrounded by the TPP. The ecosystem has two types of markets: the traditional core market and various mixed traditional and multisided markets created by TPP.

The core system consists of banks in the traditional market. It possesses some elements of innovative competition, yet remains as fierce as other emerging markets, such as digital advertising or search engines. The small markets created by TPP are mostly multisided platforms. For example, crowdfunding TPP can be a platform that connects lenders and borrowers or issuers of debt or equity with borrowers.

The invoice management TPP can be a side platform. It provides services to clients, not facilitating services between two or more parties.

The products of the market can be divided into two types. First is the core traditional deposit/loan market, and the second is the services derived from the core product. The development of the second product is likely to be significantly impacted by the OB regulations, as the regulations open up the TPP`s market.

4.1.1.2 Dynamics of market competition

The deposit/loan market is not dynamic. It is a well-established traditional market with deposit/loan quality and interest rate competition. However, the financial service market, primarily targeted by OB regulation, is dynamic. Access to bank clients' data would allow service providers to develop new AI systems and incorporate innovative technologies to expand the market; therefore, the competition in this market is dynamic.

4.1.1.3 Market Expansion Factor

For the core deposit-loan market, according to the money supply-demand theory, the market size is relatively stable and is regulated by the BOE to achieve stability. TPP has established a new service market that is expanding.

In summary, the core deposit loan market is a traditional, stable, non-dynamic market, whereas the derivative financial service market is a new, dynamic, expanding market.

4.1.2 Factor selection

In combination with market characteristics, the following factors can be selected. Market barriers factors:

- The OB compliance costs are unevenly distributed, so they can be an entry barrier in the service market. However, it is likely insignificant in the deposit/loan market.

- The economy of scale. There is no economy of scale in either market as the product is financial services. The additional costs of the production service unit are relatively low.

- Network effect. There is likely a network effect as the OB regulations transform banking into a data-driven ecosystem.

- Switching costs are a significant factor, as one of the primary targets of OB regulation is to reduce switching costs. Switching costs may reduce the power of incumbent banks to deter the newcomer`s entry or to influence the post-entry newcomer`s cost

function. As the learning and switching costs are low, the AI development costs or new service provision costs will be reduced, and the incumbent will not over-invest in pre-entry capacity to expand the customer base to deter newcomers from entering or gaining post-entry advantage positions.

- Service quality and loyalty factors, such as service quality ratings, consumer sentiments or complaints, are derived from OB regulations and constitute an entry barrier.

- Market power factors such as concentration, price, profit variation, and index variation should be included when examining a competitive market. The cost variation may be insignificant because the market product is a service with a non-significant marginal cost, and the market is in an expanding cycle.

4.1.3 The regulatory impact models

To summarise the assumptions, the OB regulations impact revenue, costs, learning and switching costs. This may reduce the power of incumbent banks to deter the newcomer`s entry or to influence the post-entry newcomer`s cost function. As the learning and switching costs are low, the AI development costs or new service provision costs will be reduced, and the incumbent will not over-invest in pre-entry capacity to expand the customer base to deter newcomers from entering or gaining post-entry advantage positions.

Ultimately, it will lead to the reduction of barriers and an increase in competition, expanding the market with additional services. Both conditions can increase total welfare. However, it is possible that, in the long run, the market concentration will increase again if there is a network effect.

In addition, the analysis of the practical application of economics and competition theories by the courts, regulators, and academia identifies key impact factors. The findings update the assumptions for the OB impact model. It includes two groups: entry and expansion barriers and market power.

Market power = barrier factors.

The model indicates which factor significantly influences the market power, where the factors are five groups from the factor selection section.

The regulatory impact factors can be separated into four tests for each factor and one general test with all factors. The first one is the OB regulatory impact on public sentiment. DiD methods for impact assessment and topic extraction of tweets will be applied in the analysis. The second is the regulatory impact on service quality and quantity. The DiD method and topic extractions of the app`s reviews are

also applied in the examination. The third analysis is the existence of network effects. The current method and a new method are proposed to detect the effects. In the fourth test, the models for calculating concentration ratio, HHI, Lerner, and Boone indexes are conducted. In the last group of general regulatory impact model tests, linear regression and SVM methods are applied to model the impact of all the factors from the previous tests.

To sum up, from the general OB regulatory impact assumptions, the impact analysis is separated into five empirical tests:

- First. Impact on public sentiment as a reputation factor. The first test is about sentiment. Tweets about OB in English are collected through X (former Twitter) API.[672] A tweet sample consists of user ID, date, tweet`s text, number of likes and replies, geopositioned and other attributes.

- Second. Impact in service quality and quantity factors through decreased learning costs and open access to data. The second test is about service quantity and quality. Reviews of service providers' apps in Google Play are collected through the Google API. A data sample consists of the user`s ID, date, review text, rating score, app version and other attributes.

- Third. Decrease switching costs as a switching factor and the existing network effects. The third test is about switching costs and network effects. The bank`s financial reports

[672] 'Twitter Developers' <https://developer.twitter.com/en/portal/dashboard>.

are collected from the BankFocus database.[673] Data on the number of account switching number will be collected from the CASS website.[674] Those are quarterly switching data of the 20 biggest banks.

- Fourth. Impact on operational factors such as costs and revenue by OB regulations, concentration, and market power indices. The fourth test is about market power. Data is collected from financial reports in the BankFocus database. A data sample consists of the bank`s cost, revenue, total assets, deposits and other financial indicators from eight countries, including the UK, the US and China.

- Fifth. The impact model of the competitive environment through the above factors. Data is collected from all the above sources.

The application of the methods of each test, such as linear regression and Support Vector Machine ("SVM"), is described in the methodology section of each test.

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[673] 'BankFocus | | BvD' <https://bankfocus-r1.bvdinfo.com/version-20230119-3417-1/bankfocus/1/Companies/dashboard/Index?refreshTopPos=0&format=_standard&BookSection=PROFILE&uniqueId=True> accessed 27 February 2023.

[674] 'Current Account Switch Service Statistics' <https://newseventsinsights.wearepay.uk/data-and-insights/current-account-switch-service-statistics/>.

4.2 The analysis of OB regulatory impact on public sentiments

Introduction

Competition theories indicate that open banking ("OB") regulations impact service providers and consumers through costs, service quality, and entry barriers. With the further examination of regulatory and economic theories and the application of theories by the courts, academia, and regulators, the impact factors can be grouped into market power and market barriers. Consumer sentiment is an important factor in the impact model. It is classified under the market entry group.

The current literature establishes the links between regulatory enforcement and consumer surplus, as well as the link between sentiment and consumer behaviour. Under the theoretical assumptions in the theoretical chapter, regulatory enforcement can impact consumer surplus. The OB regulation can produce a better service with a higher consumer surplus. In addition, a branch of literature studies the correlation between consumer sentiment and behaviour. The foundation is based on the loss aversion theory by Kahneman and Tversky in 1973,[675] which was further converted into good and bad news (sentiment) theories explaining consumer behaviour correlated with sentiment. Furthermore, social

[675] Daniel Kahneman and Amos Tversky, 'On the Psychology of Prediction' (1973) 80 Psychological Review 237.

finance studies the transmission of information and ideas between market participants.[676] The study describes the sentimental bubbles which result in crashes in certain markets.

From the above theories, there is a link between regulation and consumer surplus and a link between sentiment and consumer behaviour/surplus. However, there is no connection between regulation and sentiment. The finding of regulatory impact on sentiment would provide a clearer picture and create a bridge between regulatory enforcement and consumer surplus through the sentiment factor.

In the overall thesis, the regulatory impact is studied. The impact model includes factors such as market power, network effect, service quality and sentiment. Regulatory impact on sentiment is one of the main factors. This section will conduct a separate analysis of the regulatory impact on sentiment. Then, the sentiment data will be fed to the total impact model, which includes other impact factors such as market power, provider`s income, costs, service quality, and switching costs.

This section argues that by drafting OB regulation or any other regulation reducing the learning, switching costs, or the market barrier, the regulatory impact on the sentiment can be positive. Once the regulatory impact on sentiment is established, connecting the positive regulatory impact on sentiment with the preposition about the correlation between consumer sentiment and behaviour, there will be a connection between regulatory impact and consumer behaviour through the sentiment factor.

Possible findings are important because they can provide a general prediction of regulatory enforcement and its public impact. As public sentiment can indirectly indicate public adoption of the

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[676] 'Social Finance as Cultural Evolution, Transmission Bias, and Market Dynamics' <https://www.pnas.org/doi/10.1073/pnas.2015568118> accessed 8 June 2023.

specific regulation, a highly negative sentiment regulation is difficult to enforce. On the contrary, positive sentiment can assist regulatory enforcement and service adoption.

The analysis will be divided into six parts. The first part is the introduction. The second part is the theoretical framework. In this part, the theoretical discussion is conducted to shape sentiment research. Next, the data collection, sentiment analysis method, and topic extraction are explained in the methodology section. The empirical section is divided into two parts. The results of topic extraction and sentiment analysis are outlined in part four, and the interpretation of the DiD method`s result on the impact is under part five. Lastly, the conclusion is drawn in part six.

4.2.1 The theoretical framework of sentiment analysis

Tversky and Kahneman's theory suggests an asymmetry in people's risk evaluation or consumption.[677] People's perception of the weight of losses is higher relative to the weight of gains. Therefore, people are risk-averse in gains and risk-loving in losses. In other words, people tend to secure the gains and hold the losses. This combination of behaviour is defined as loss aversion. In addition, the notion of representativeness heuristic is defined. It is where people`s expectations are based on previous similar circumstances, [678] and the emotions are extended to unrelated situations.[679]

The study of investors by Goetzmann, Kim and Shiller shows that the assessment of stock market risk is often exaggerated by the news stories they read.[680] Moreover, the news of local earthquakes, which have no impact on the stock market, can affect investors through negative sentiment.[681] The study of US consumers in 2020 related to the historic stock market crash also finds that people who know the historical crashes are more pessimistic,[682] which can be explained by their more negative starting point (representativeness heuristic). In addition, the study of Easaw and Ghoshray suggests that households

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[677] Kahneman and Tversky (n 676).

[678] ibid.

[679] Paul Slovic and others, 'The Affect Heuristic' (2007) 177 European Journal of Operational Research 1333.

[680] William N Goetzmann, Dasol Kim and Robert J Shiller, 'Crash Beliefs from Investor Surveys' (19 March 2016) <https://papers.ssrn.com/abstract=2750638>.

[681] ibid.

[682] Tobin Hanspal, Annika Weber and Johannes Wohlfart, 'Exposure to the COVID-19 Stock Market Crash and Its Effect on Household Expectations' (2021) 103 The Review of Economics and Statistics 994.

form the belief in the government`s competence first and then use it to form consumer sentiment.[683] Therefore, the based point of sentiment is critical in future sentiment expectations.

The loss aversion theory was further developed in behavioural economics to explain consumer behaviour and surplus concerning good and bad news (or consumer sentiment). In a model by Bowman et al., there are two time periods where the consumer utility function is defined as dependent on the consumption level and the change from the reference point.[684] In the second period, the consumer spends time under uncertainty of sentiments, good and bad news. The study illustrates the result of consumer behaviour when income is uncertain. The result shows an asymmetry in the response to sentiments related to the adverse loss behaviour.[685] When people receive favourable news about the future expectation, they may increase their consumption immediately. However, when people receive bad news, he is reluctant to adjust their consumption immediately. The drop in consumption can be slow relative to the increase in good news.[686] Moreover, the consumer decrease in consumption will be above the reference point of consumption when expected income falls until the realisation of the bad news.

Further studies in the laboratory environment show that the weight of good news and bad news is changing. Some studies show that good news is weighted stronger[687] than bad news, and some

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[683] Joshy Z Easaw and Atanu Ghoshray, 'Confidence or Competence: Do Presidencies Matter for Households' Subjective Preferences?' (2007) 23 European Journal of Political Economy 1025.

[684] 'Loss Aversion in a Consumption–Savings Model' (1999) 38 Journal of Economic Behavior & Organization 155.

[685] ibid.

[686] ibid.

[687] David Eil and Justin M Rao, 'The Good News-Bad News Effect: Asymmetric Processing of Objective Information about Yourself' (2011) 3 American Economic Journal: Microeconomics 114; Camelia M Kuhnen, 'Asymmetric Learning from Financial Information' (2015) 70 The Journal of Finance 2029.

conclude that no such effect exists.[688] For instance, the test on the effect of good and bad news on a person`s belief shows an asymmetry in the news processing. Test subjects incorporate the good news into their belief according to the strength close to the benchmark. However, they tend to discount or ignore the bad news compared to the benchmark.[689] Another example can be that investors are likely to trade more often when there is good news rather than selling during bad news.[690]

Lastly, some studies show a correlation between good and bad news and consumption. Hall and Blanchard show that consumer sentiment can be a significant factor in the drop in consumption during 1990-191.[691] However, despite the high correlation between sentiment and consumption, some economists are sceptical of the causation. They argued that the correlation can be the cause of common independent factors such as the change in income.[692]

In summary, there is an asymmetry in good or bad news processing. This leads to the asymmetry in the sentiment and consumption correlation. However, it is difficult to determine the causal relationship between sentiment and consumption. The correlation can be through the common independent factor or the casual relationship.

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[688] Alexander Coutts, 'Good News and Bad News Are Still News: Experimental Evidence on Belief Updating' (2019) 22 Experimental Economics 369; Kai Barron, 'Belief Updating: Does the "Good-News, Bad-News" Asymmetry Extend to Purely Financial Domains?' (2021) 24 Experimental Economics 31.

[689] The Good News-Bad News Effect Asymmetric Processing of Objective Information about Yourself

[690] Malcolm Baker and Jeffrey Wurgler, 'Investor Sentiment in the Stock Market' (2007) 21 Journal of Economic Perspectives 129.

[691] Robert Hall, 'Macro Theory and the Recession of 1990-1991' (1993) 83 American Economic Review 275.

[692] Christian Gillitzer and Nalini Prasad, 'The Effect of Consumer Sentiment on Consumption: Cross-Sectional Evidence from Elections' (2018) 10 American Economic Journal: Macroeconomics 234.

Social finance

Social finance provides the model to explain the construction of sentiment waves. The discipline proposes a model to describe the behaviour of participants in the market through transmission, adaptation and evolution of cultural traits.[693] Cultural traits are information or ideas that can be information signals, beliefs, strategies, or folk economic models. Understanding how participants possess the belief can explain the behaviour. Social finance proposes to study the transmission of information between participants rather than treating the transmission of information as given in classical economics or treating the biases as given in behavioural economics.[694]

The study of narrative, or how ideas are transmitted in society, is incorporated into economics. Robert J.Shillier called for more attention to *social dynamics* and *popular model* studies, citing the increase of narrative studies in other disciplines.[695] An example is the spread of the narrative about the oil shock or deflation during the US Great Depression, which could postpone buying or borrowing decisions. The topic of peak oil production in years was based on the argument of the explosive demand for combustion engines, and deflation topics were covered by newspapers, arguing that when the war was over, the price would return to the previous level.[696] This behaviour, formed by the narrative, made the economy difficult to recover as it reduced the circulation of funds and economic activities. Consequently, narrative transmission could be a significant factor in the Great Depression, along with

[693] 'Social Finance as Cultural Evolution, Transmission Bias, and Market Dynamics' (n 677).

[694] ibid.

[695] Robert J Shiller, 'Narrative Economics' (2017) 107 The American Economic Review 967.

[696] ibid.

others. Furthermore, the transmission of cultural traits can be explained through peer-to-peer impact on the customer`s decision and the persuasion of participants by others' ideas.[697]

The transmission model

In transmission studies, the Kermack-McKendrick SIR mathematical model of infectious diseases can be applied to explain the construction of infection waves. In this model, there are three compartment groups: S- the number of susceptible people who have not had the infection and are vulnerable, I – the number of infected people, R – the number of recovered people who have obtained immunity to catching or spreading the infection. And the constant N = S+I+R is the total population. In the model, those compartment groups meet and infect with the rate of increase of infectives c >0, and the recovery rate *r >0.* Therefore, if c and r are known, the model can predict the infection with the equations:

$$\frac{dS}{dt} = -cSI$$
$$\frac{dI}{dt} = cSI - rI$$
$$\frac{dR}{dt} = rI$$

The equations describe the changes in population types and the relationship between recovered, susceptible, and infected types. Based on these equations, the model can predict the transmission pattern. It suggests that the infection graph follows a bell-shaped curve or a wave, characterised by an initial rise followed by a decline. Moreover, the speed of infection can be controlled by the ratio c/r.

[697] Esther Duflo and Emmanuel Saez, 'Participation and Investment Decisions in a Retirement Plan: The Influence of Colleagues' Choices' (2002) 85 Journal of Public Economics 121.

In the application of the SIRS model in sentiment analysis, the compartment groups are positive, negative, and susceptible. The interaction between these groups leads to the transmission of sentiment. The nature of sentiment transmission is wave-like, similar to its application in infectious disease modelling.

4.2.3 Conclusion of the theoretical framework

There are three implications of sentiment wave transmission. The first is the sentiment bubble, the second is the continuous fluctuation of the sentiment wave over time, and lastly, the third is related to sentiment impact measurement.

The bubble represents the phenomenon of sentiment transmission. Applying the Kermack-McKendrick SIR model to sentiment analysis reveals that sentiment rises and then collapses, much like an infection wave. In the sentiment variant model, the compartment groups are optimistic, sceptical, and susceptible. The optimists anticipate improvement, while the sceptics and the susceptible do not. After interacting or exchanging sentiments, each group can transition to another group with a certain probability, with the susceptible showing the highest likelihood of conversion. The study by Burnside et al. indicates that in the absence of significant news or the resolution of uncertainty, the population will be influenced by the most contagious group. Therefore, if the second most contagious group is positive, positive sentiment will grow by persuading others and subsequently collapse after being swayed by sceptics. This behaviour will create a bubble.

The second implication of the SIRs model is that the propagation of aggregate sentiment over time will be a continuous wave. This follows from the bell-shaped nature of the sentiment function without uncertainty resolution. Because there will be continuous periods of certainty and uncertainty, the

sentiment will be the sum of these bell-shaped periods as a continuous wave. In other words, a continuously changing information environment will create aggregate sentiment waves.

Lastly, there are two conditions for the measurement of impact on sentiment. The first is that there should be a control group. As the sentiment function has a natural phenomenon of rises (falls) and falls (rises) without any impact, according to the transmission of sentiment in the SIRs model, it is not possible to understand whether the causes of sentiment change by the impact or by the transmission of initial sentiment. Therefore, another sentiment wave should be used as a baseline to subtract the impact of the natural sentiment transmission.

Furthermore, the baseline wave function, or the control group, should have the same wavelength and initial position as the treatment function. Otherwise, the impact calculation will not be possible. For example, in the formula of one-dimensional wave function $f(x,t) = f(x+vt)$, where t is the propagation at the time t, v is the propagation velocity. If the control wave before the impact has a different wavelength, it means that the control and treatment waves have different infection r/c ratios. As two infections with different infection ratios can be caused by various impacts, they are not comparable. Otherwise, if the wavelength and the amplitude are the same, it can be explained as having the same infection ratio and the same factor`s impacts before the regulatory impact. Therefore, the new impacts could be the differences in the waves.

4.2.4 Methodology

The theoretical section proposed the transmission model of sentiments among positive, sceptic and susceptive compartment groups and the correlation of aggregate sentiment to consumer behaviours. The spread of sentiment can be separated into two periods: uncertainty and certainty. During the

uncertainty, the shape of sentiment is bell-shaped, where the group with the lowest entropy will prevail over others. During the certainty, the new information spread, as in the case of narrative analysis.

Consequently, to understand the sentiment toward OB and the regulatory impact on the sentiment, the aggregate sentiment will be separated into positive, negative (sceptics) and neutral (susceptible) groups. In addition, the topic of these positive and negative sentiments will be extracted to analyse the changes during the regulatory enforcement. Lastly, the sentiment between the UK, EU, US, and all others will be examined to select the control group. The criteria for choosing a control group will be defined in the theoretical section as having the same wavelength and amplitude. The selection of treatment and control groups can be applied to measure the OB regulation's impact on the sentiment toward OB.

There are two methods to apply in this analysis. The first group is the DiD method, which examines the sentiment impact based on the selection of the control and treatment groups. The second group consists of the topic extraction methods. These methods are explained below.

4.2.4.1 The first method (Difference-in-difference)

The primary task of the method is to quantify the regulatory impact. After quantification, it is possible to sum and compare the impact of the groups on interpretation under the just distribution framework. According to Pareto, Kaldor - Hicks efficiencies or Rawls's justice definition, the regulatory impact on different groups need to be compared with each other and defined as negative, positive or the minimum impact (for the least affected group).

By applying the DiD method and comparing a control group and a treatment group, the difference between the groups before and after regulatory enforcement is calculated as regulatory impact. The regulations also affect the costs of the different groups in various ways, and the benefits received from regulatory implementation vary among the control groups. The regulatory impacts should differ among the control groups.

Difference-in-Difference method ("DiD") application

DiD is a calculation method commonly used in an impact or causal evaluation.[698] The approach compares two groups before and after a treatment to measure the impact. The method is applied to two groups: the treatment group was treated at some point, and the control group was never treated.[699] The before-after ("BA") treatment is used to find the effect by evaluating the group before and after the treatment (see Figure below). The treatment effect can be defined by calculating the difference between the groups that were treated before and after treatment. However, there may be several other treatment effects occurring simultaneously; therefore, it is not clear which impact is involved. The effect on the untreated group can serve as a baseline to eliminate other impacts. This is determined by calculating the difference between the control group before and after the treatment

[698] Anders Fredriksson and Gustavo Magalhães de Oliveira, 'Impact Evaluation Using Difference-In-Differences' (2019) 54 RAUSP Management Journal.

[699] Myoung-jae Lee, 'Difference in Differences', *Matching, Regression Discontinuity, Difference in Differences, and Beyond* (Oxford University Press 2016) <https://oxford.universitypressscholarship.com/10.1093/acprof:oso/9780190258733.001.0001/acprof-9780190258733-chapter-5> accessed 9 June 2022.

period. The effect of the treatment can be determined by subtracting the difference between the BA treatment group and the BA control group.[700]

In summary, there are two groups (treatment and control) at two time points, before and after ("BA") the treatment. The assumption is that if several factors impact the groups, and these factors have an equal impact on both the treatment and control groups before the treatment, which is the assumption of parallelism, then the impact of the treatment can be defined as the difference between the groups after the treatment.

The method is used in studies to estimate the causal effects of treatment. Nowadays, it has become increasingly used in social science to study policy interventions and the implementation of regulations.[701]

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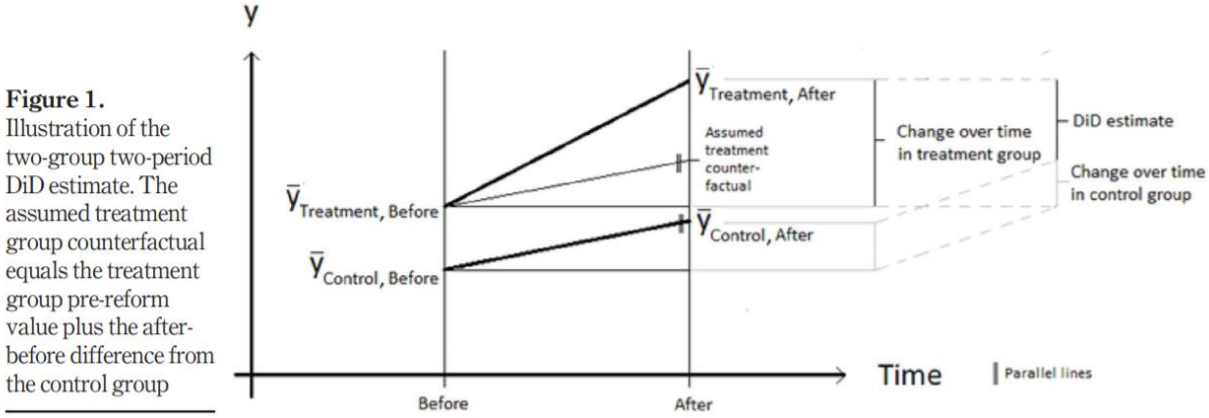
[700] Myoung-jae Lee, *Matching, Regression Discontinuity, Difference In Differences, And Beyond* (Oxford University Press 2016),p132

[701] ibid

Figure 7: DID method illustration. The Figure illustrates the impact of the difference between two groups, control and treatment, in two periods.



Source: Anders Fredriksson and Gustavo Magalhães de Oliveira, 'Impact Evaluation Using Difference-In-Differences' (2019) 54 RAUSP Management Journal 4

Examples of the DiD method in regulation impact studies

In the impact study of the "three-strikes law" in California, the DID method was applied.[702] According to the law, life imprisonment will be imposed if a person commits crimes three times. The method was conducted by assessing the crime rate of California in one year since the regulatory enforcement.[703] Then, the crime rate in Washington state, which has a similar economic pattern to California but without a "three-strikes law," was chosen as a control state.

In Card and Krueger's study on the impact of the minimum wage requirement in New Jersey, DID was applied. The authors examined the impact of the requirements on employment in the fast-food

[702] Eric Helland and Alexander Tabarrok, 'Does Three Strikes Deter? A Nonparametric Estimation' (2007) 42 The Journal of Human Resources 309.

[703] ibid.

industry in New Jersey.[704] As the change in employment from the date of the minimum wage requirement can reflect the impact of that requirement and other factors, such as economic situations, they applied the DiD method to single out the impact of the minimum wage requirement. Assuming that the state of Pennsylvania has the same parallel trend of employment as New Jersey, Pennsylvania was chosen as a control state. The impact of the minimum wage requirement is that by raising 80 cents on minimum wage, the full-time workload equivalents increased by 2.75.

In the study of Reiner, Horst, and others, the impact of company law reform on the EU was examined.[705] Notably, the impact of the reduction of minimum capital requirement on the competitiveness of entrepreneurship was assessed. The treatment group was chosen as the private LLC companies where the law was applied, and the control groups were public companies in Hungary and Poland, where the law was applied to private and public LLCs.[706]

Limitations of the DID method

The method requires a counterfactual assumption (Parallel Trends). From the studies above, the selection of a control group is important. The change in control groups is used as the proxy for the counterfactual change in untreated potential outcomes in the treated group.[707] Therefore, if the

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[704] Card, D., & Krueger, A. B. (1994). Wages and employment: A case study of the fast-food industry in New Jersey and Pennsylvania. American Economic Review, 84, 772–793.

[705] Reiner Braun and others, 'Does Charter Competition Foster Entrepreneurship: A Difference-in-Difference Approach to European Company Law Reforms' (2013) 51 Journal of Common Market Studies 399, 408.

[706] ibid 409.

[707] Andrew M Ryan, James F Burgess Jr. and Justin B Dimick, 'Why We Should Not Be Indifferent to Specification Choices for Difference-in-Differences' (2015) 50 Health Services Research 1211.

potential outcome of the control group does not have a parallel trend to the treatment group, the impact measurement can include the impacts of factors.[708]

In real situations, there can be several situations with parallel trends.[709] The matching method of groups during pre-treatment and post-treatment can be applied to measure the effect more accurately.[710] The method selects groups with parallel trends before and after the treatment. However, matching groups can reduce the sample size, leading to a lower model fit. The method is a statistical method to estimate the impact by applying approximate functions to the real-world relationship. Therefore, it can be used only as an estimation, not as the exact real-world impact.

In OB regulations, the possible issue is related to the control group. To uphold the counterfactual assumption, the control group should have a parallel trend with the treatment group before or after the treatment period. Thus, selecting a control group is very important. In the banking industry, the control group can be banks that have not implemented OB regulations. However, it is unclear how the control group will resemble the treatment group before the OB implementation. As a result, the group matching method may be applied.

4.2.4.2 The second method group (topic extraction)

The topic extraction methods are applied in the first and second tests on tweets and service quality reviews to understand the discussion of negative and positive topics. The mechanism of topic

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[708] ibid.

[709] Justin B Dimick and Andrew M Ryan, 'Methods for Evaluating Changes in Health Care Policy: The Difference-in-Differences Approach' (2014) 312 JAMA 2401.

[710] ibid.

extraction is to classify a corpus of vectorised words into clusters representing different topics. The vectorisation is as follows.

Vectorisation

A common approach to assigning value to words is vectorisation. Term Frequency ("TF") and Inverse Document Frequency ("IDF") are often applied in word vectorisation.[711] Term Frequency refers to the frequency of a word in a sentence or paragraph (in our tests, a tweet or review) divided by the total number of words in the sentence. IDF is the logarithm of the inverse frequency of sentences containing the word, relative to the total number of sentences in the entire text.

TF-IDF provides insight into how important a word is within a sentence (via TF) and how important it is within the broader text (via IDF).

Classification models

There are various classification models with sub-models. Currently, the topic extraction is commonly conducted with Latent Dirichlet allocation ("LDA"), non-negative matrix factorization ("NMF"), Top2Vec, and BERTopic models.[712] The LDA is the most common model, whereas NMF, Top2Vec, and BERTopic are currently attracting more attention.[713] This study applies the topic extraction with the probabilistic

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[711] P Karthika, R Murugeswari and R Manoranjithem, 'Sentiment Analysis of Social Media Network Using Random Forest Algorithm' [2019] 2019 IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS) 1; Christos Troussas and others, 'Sentiment Analysis of Facebook Statuses Using Naive Bayes Classifier for Language Learning' [2013] IISA 2013 1; Anuj Sharma and Shubhamoy Dey, 'A Comparative Study of Selection and Machine Learning Techniques for Sentiment Analysis' (2012).

[712] Roman Egger and Joanne Yu, 'A Topic Modeling Comparison Between LDA, NMF, Top2Vec, and BERTopic to Demystify Twitter Posts' (2022) 7 Frontiers in Sociology 886498.

[713] ibid.

algorithm model LDA and another non-probabilistic algorithm model NMF to provide comparative results.

LDA

LDA is a generative probabilistic model based on the Bayesian model developed in 2001.[714] It is often applied to extract topics from discrete data with a three-level hierarchical Bayesian model.[715] The combination of topic probabilities defines the topic as prior and likelihood distributions of words.[716] The assumption is that documents are collected from random latent topics, and the topic itself is presented as a distribution over words.[717] It is assumed that the K latent topics are distributed in N documents of the corpus, and the relationship between each topic and word is a multinormal distribution over M words. The generative algorithm is as follows:

For each document w in corpus D of N documents:

- Choose *N* - Poisson(x)
- Choose θ_n - Dir(a)
- For each word w_{nm} in the document w:

(a) Choose a topic assignment $z_{nm} \sim$ Multinomial(θ_n);

(b) Find the corresponding topic distribution $\phi_{z_{nm}} \sim$

Dirichlet(β);

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[714] DM Blei, AY Ng and MI Jordan, 'Latent Dirichlet Allocation' (2003) 3 Journal of Machine Learning Research 993.

[715] The Bayesian theorem states that knowing prior distribution and likelihood of observed data, the posterior prediction can be defined.

[716] Stuart J Blair, Yaxin Bi and Maurice D Mulvenna, 'Aggregated Topic Models for Increasing Social Media Topic Coherence' (2020) 50 Applied Intelligence 138.

[717] Blei, Ng and Jordan (n 715).

- (c) Sample a word $w_{nm} \sim$ Multinomial($\phi_{z_{nm}}$).

Assuming the Dirichlet distribution for θ, we know the probability density of $p(\theta|\alpha)$. Given the α and β, the joint distribution of topic mixture θ, a set of topics z and N words can be formalised. Based on the formula of join distribution, the margin distribution of the document and then the corpus probability are obtained as follows:[718]

$$P(D|\alpha,\beta) = \prod_{d=1}^{M} \int P(\theta_d|\alpha) \left(\prod_{n=1}^{N_d} \sum_{z_{dn}} P(z_{dn}|\theta_d) P(w_{dn}|z_{dn},\beta)\right) d\theta_d \quad (1)$$

There are three levels of presentation. The first is at the corpus level. When the corpus is constructed, hyperparameters α and β are applied. Then, in the next level of documents, the θ_d-parameter is applied per each document, and the w_{dn} and z_{dn} parameters are constructed per each word. [719]

The above process is generalised in the Diagram 1. For each document, there are words w_{nm} in the document, the topic is distributed per document by θ_n. The plate describes it with N documents. Then there is K topics with $\phi_{z_{nm}}$ which is the topic distribution over words. These K topics have the topic distribution and the per-word topic assignment z_{nm}. The hyperparameters α and β are for the prior distribution for θ_n and $\phi_{z_{nm}}$. The maximisation task of the algorithm is max P(D|α, β). It is often conducted by selecting α and β with Gibb sampling and variation EM algorithm.[720]

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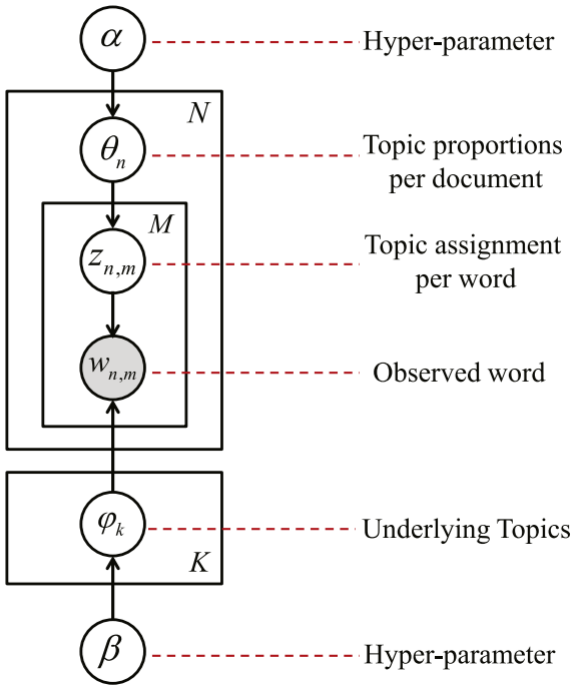
[718] ibid.

[719] ibid.

[720] Yong Chen and others, 'Experimental Explorations on Short Text Topic Mining between LDA and NMF Based Schemes' (2019) 163 Knowledge-Based Systems 1.

There are some specificities of the LDA model. As the model is probabilistic and the choice of topic is randomised, there are no predefined topics. The algorithm can generate different topics each time the model is run. In addition, LDA may work better with longer text documents as more words in documents define the probability more accurately.

Diagram 1: LDA model scheme. The scheme shows the algorithm for choosing K topics from a corpus of N documents with M words per document



Source: Yong Chen and others, 'Experimental Explorations on Short Text Topic Mining between LDA and NMF Based Schemes' (2019) 163 Knowledge-Based Systems 1.

NMF

NMF is a non-probabilistic algorithm that decomposes a matrix into two lower-ranking matrices.[721] The idea is to break down a matrix with word frequencies or words' weight importance (TF-IDF) into a multiplication of matrices containing the topic and another matrix of unimportant words. It is assumed

[721] Adewale Obadimu, Esther Mead and Nitin Agarwal, 'Identifying Latent Toxic Features on YouTube Using Non-Negative Matrix Factorization' (2019).

that the word data matrix is a weighted combination of topic distributions.[722] The task of MNF is to separate the matrix with a unique matrix factor. This leads to the assumption of the anchor word, which means every topic has a unique presentation word. The MNF algorithm is as follows:[723]

N is the number of documents, K is the number of topics, and M is the number of words in the vocabulary. $d_{n,m}$ is the frequency of the mth word in the vocabulary that appears in the nth document. In our case is the frequency of the word in the tweet. The task of the algorithm is to find two matrices U and V from word-document matrix D = [$d_{m,n}$], where the topic-document matrix is V =[$v_{k,n}$], word-topic matrix U =[$u_{m,k}$]. The $v_{k,n}$ is the topic label indicating the probability of an n-document in the k-topic, and $u_{m,k}$ is the probability of the m-word in the k-topic. In addition, there is an assumption that each d_n of N documents of corpus D is a linear combination of u_k with coefficient $v_{k,n}$, where k-1 to K, n=1 to N. It is also the multiplication of matrices D=U*V with the matrix components d_n, u_k, v_{kn}that can be written as follows:

$$d_n = \sum_{k=1}^{K} u_k v_{kn}$$

The objective of MNF is to minimise the squared loss between the original term-document corpus matrix and the multiplication of matrices U and V:

$$\min \sum_{n=1}^{N} ||d_n - \sum_{k=1}^{K} u_k v_{kn} ||^2$$

[722] Yong Ren, Yining Wang and Jun Zhu, 'Spectral Learning for Supervised Topic Models' (2018) 40 IEEE Transactions on Pattern Analysis and Machine Intelligence 726.

[723] Jianyu Wang and Xiao-Lei Zhang, 'Deep NMF Topic Modeling' (2023) 515 Neurocomputing 157.

s.t $u_{mk} \geq 0$ and $v_{kn} \geq 0$

Limitation and further development of topic extraction methods

Inferred from algorithms, the basic methods of LDA or MNF have limitations. They are both based on prior assumptions, which can be biased in some situations. For example, LDA assumptions are the relation of words and topics, and topics are uncorrelated. However, when there are correlated topics or noises in word-topic distributions, the algorithm can have problems. In addition, there is a problem with the intractability of the posterior inference. As the posterior inference is calculated with approximations such as Gibbs sampling, it is impossible to predict all words.[724] The NMF is based on the assumption that each topic has a unique anchor word. However, this assumption cannot be valid in all situations.[725] Besides, the word can have several meanings according to the context. There can be a situation in which the algorithm anchored the wrong word as it does not understand the context. Moreover, as the assumption of factorisation is linear, the MNF model cannot capture the nonlinearity of documents.

To overcome those limitations, sophisticated versions or combinations of models were developed. For LDA, a geometric Dirichlet mean algorithm was developed with k-means clustering with geometric correction to overcome the approximation inefficiency.[726] Another method is to preprocess words with an N-gram to capture similar context words.[727] The deep neural network can also be applied to LDA

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[724] ibid.

[725] ibid.

[726] Mikhail Yurochkin and XuanLong Nguyen, 'Geometric Dirichlet Means Algorithm for Topic Inference' [2016] Advances in Neural Information Processing Systems 2505.

[727] Ashwini Zadgaonkar and Avinash J Agrawal, 'An Approach for Analyzing Unstructured Text Data Using Topic Modeling Techniques for Efficient Information Extraction' [2023] New Generation Computing <https://doi.org/10.1007/s00354-023-00230-5>.

and MNF. In the case of LDA, it can be used as a prior probability base instead of the Dirichlet distribution, and the integration of the deep model can make LDA more powerful and interpretable.[728] For the NMF model, the deep learning MNF can apply word embeddings[729] while keeping low-frequency words.[730]

4.2.5 Data

There are several sources of data for textual narrative sentiment analysis. These sources of data have advantages and disadvantages. The data sources are surveys,[731] newspapers,[732] publications, proxies[733] and data from social networks.[734] There are also sentiment indexes that combine the above sources.[735]

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[728] Wang and Zhang (n 724).

[729] Adji B Dieng, Francisco JR Ruiz and David M Blei, 'Topic Modeling in Embedding Spaces' (2020) 8 Transactions of the Association for Computational Linguistics 439.

[730] Wang and Zhang (n 724).

[731] Carola Binder and Christos Makridis, 'Stuck in the Seventies: Gas Prices and Consumer Sentiment' (2022) 104 The Review of Economics and Statistics 293.

[732] Cindy K Soo, 'Quantifying Sentiment with News Media across Local Housing Markets' (2018) 31 The Review of Financial Studies 3689.

[733] Zuochao Zhang and others, 'The Cross-Correlations between Online Sentiment Proxies: Evidence from Google Trends and Twitter' (2018) 508 Physica A: Statistical Mechanics and its Applications 67.

[734] Juan C Reboredo and Andrea Ugolini, 'The Impact of Twitter Sentiment on Renewable Energy Stocks' (2018) 76 Energy Economics 153.

[735] Zhang and others (n 734).

The surveys can provide more insight.[736] However, information quality depends on how carefully the surveyors answer the questions. In some situations, the number of answers can be limited to present the whole population. [737] The advantage of a survey is the flexibility of design, which allows the examiner to capture the exact research question.

Regarding the proxies, different market or participant behavioural activities can be used as a proxy measurement. These proxies can be the trade volume, fund flow, dividend premium or any other sentiment indicators.[738] These proxies are based on the assumption that these customers' behaviour is strictly correlated with their sentiments. However, the behavioural responses are asymmetric between good and bad news, and the proxies bear some probability of error. Therefore, sentiment proxy measurement can be inaccurate.

Lastly, regarding the data sources from social networks, the regular interaction between individuals on social networks provides a vast potential to capture various topics circulating in the public. In addition, the development of statistical techniques can assist in measuring sentiments even at the individual conversation level and extracting topics at the general public level. However, the accuracy of topic extraction and sentiment scoring depends on the data and the type of algorithm, which is less accurate than human scoring or analysis.

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[736] Baker and Wurgler (n 691).

[737] Soo (n 733).

[738] Malcolm Baker and Jeffrey Wurgler, 'Investor Sentiment and the Cross-Section of Stock Returns' (2006) 61 The Journal of Finance 1645; Malcolm Baker and Jeremy C Stein, 'Market Liquidity as a Sentiment Indicator' (2004) 7 Journal of Financial Markets 271.

In conclusion, the social network data source will be applied in this analysis. Particularly, tweets about OB in English are collected through X (former Twitter) API.[739] A tweet sample consists of user ID, date, tweet`s text, number of likes and replies, geopositioned and other attributes.

Data collection and processing

The examination method is quantitative and is done through the collection of tweets. Tweets related to the word "Open Banking" on Twitter from 2017 to March 2023 are collected. In the first step, the data is cleaned by removing the null data and filtered by tweet location. In the second step, the tweets are cleaned with links and unnecessary symbols and processed with the TextBlob application. The Texblob is the natural language processing library in the programming language Python. It processes the text and outputs the sentiment score of the text. In the final step, the sentiment score of each tweet is aggregated as the monthly and annual mean to provide a broad picture of sentiment changes. The data is stored in file "Vo_207055762_First testtweet.csv", and Python code is in the Appendix E (Tweet Sentiment Analysis- Python Code).

Data description

From January 2017 to March 2023, a total of 369,749 tweets related to the word ' Open Banking' were collected.

The attributes of collected data are user ID, tweet ID, user location, tweet time of creation, tweet geolocation, and the tweet and its properties, which are the number of likes, replies, and retweets.

[739] 'Twitter Developers' (n 673).

Unnecessary columns were removed: user, tweet`s ID, geolocation, number of replies, and retweets. Only creation time, location and tweet text will be used to measure the sentiment score.

Comparison

Three leading jurisdictions—the UK, the US, and the EU—were selected to compare the sentiment score. The reason is that the approach to OB regulations differs among them. The UK's approach is regulatory, applying strict requirements, whereas the US adopts an organic approach, allowing the market more room for self-regulation. The EU's approach lies somewhere in between; it adopts the PSD 2, but the API standard is not compulsory in some member countries. Comparing these jurisdictions can provide insight into the changes in sentiment over time and location. Therefore, regulatory impacts on sentiment can be concluded.

4.2.6 Data cleaning and sentiment scoring

4.2.6.1 Locating the tweet

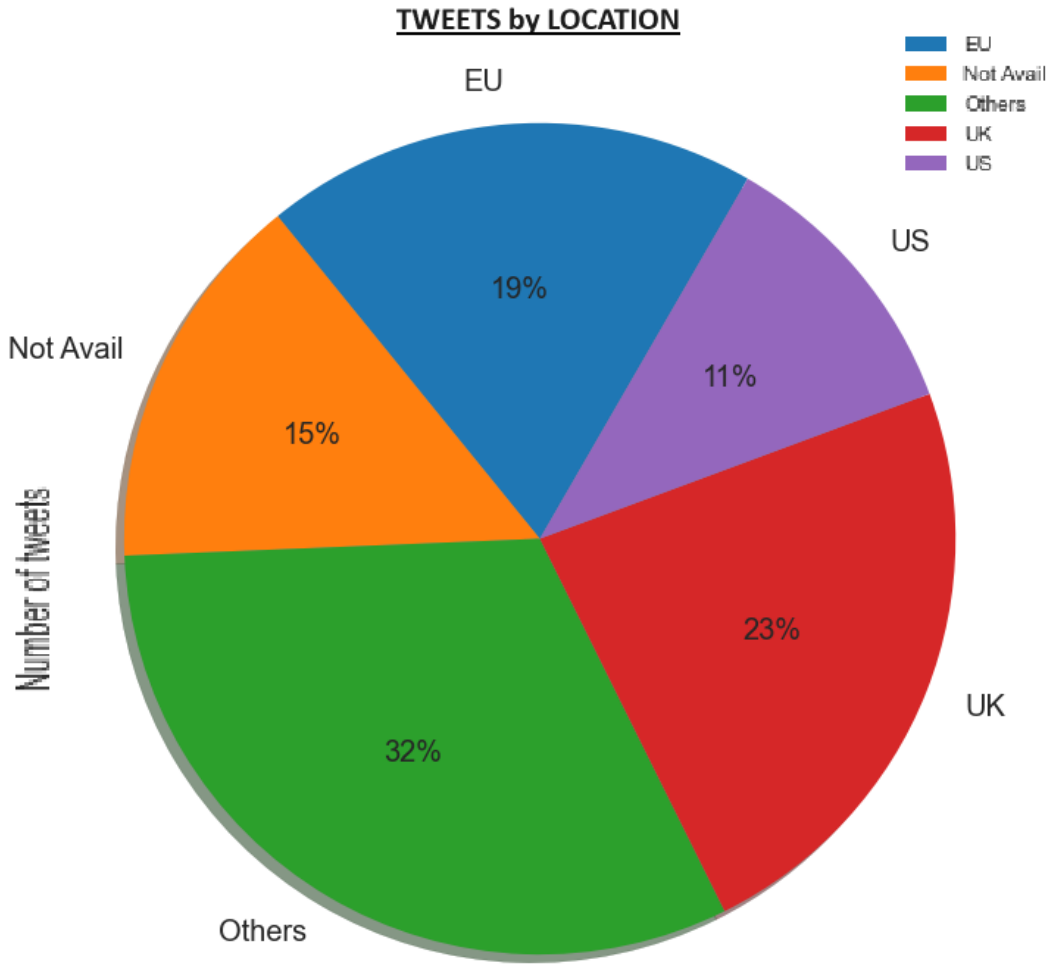
There is a problem with the tweet location. Most tweets do not have geolocation, as users do not identify the tweet's location. Therefore, the location is defined as the user`s location. The location filtering codes were applied as the users input their locations without any standard. Not all of the locations were converted, as there is a possibility that the users input an unrecognisable location or language. An example of the result of the location filtering is shown below.

Table 2: Example from the data source. The original location (column Original) from X (Twitter) was converted to standardised locations (column Converted).

Original	**Converted**
Swansea	UK
Madrid, Comunidad de Madrid	EU
Phoenix, AZ	US
Worldwide	['worldwide']
ðŸ‡ªðŸ‡¸ ðŸ‡ºðŸ‡¸ ðŸ‡¬ðŸ‡§ ðŸ‡©ðŸ‡ª ðŸ‡»ðŸ‡³†' ?	Not Avail

After filtering the UK, US and EU locations, all other locations were converted to 'Others', and the locations with unrecognisable languages were filtered as 'Not Avail'. The results of tweets by location are shown in the following figure. In summary, 23 per cent of tweets are from the UK, 19 per cent from the EU and 11 per cent from the US. Tweets from other countries constitute 32 per cent. The number of tweets with unidentified locations is 15 per cent.

Figure 8: Number of tweets filtered by location. The location groups are EU, UK, US, Others and Not Available.



4.2.6.2 Cleaning tweet and sentiment scoring

Before processing sentiment analysis, links, RT, #, and other symbols were removed. However, not all emojis could be removed. Next, the tweet was input into TextBlob natural language processing

analyser.[740] The TextBlob outputs the subjectivity and polarity score. The subjective score of the tweet indicates how personal it is, ranging from 0 to 1. A score of 1 suggests that the tweet is more a personal opinion than a fact. The polarity ranges from -1 to 1,1, where -1 refers to negative sentiment and +1 indicates positive sentiment.[741] The table below presents the sample results after text cleaning.

Table 3: Sample of tweet text (column Tweet Text) and the subjectivity and polarity scores (columns Subjectivity and Polarity) of the tweet assigned by TextBlob sentiment algorithm.

Tweet text	**Subjectivity**	**Polarity**
With Open Banking, consent relating to data sharing and choice is placed squarely in the hands of consumers... efforts underway to increase privacy, security and fraud prevention.	0.25	0
Open banking could be very positive for financial advice business .	0.403	0.098
Banking customer expectations are sky high, while innovative digital services enter the.	0.498	0.199
Speaking of Open Banking, we are currently looking for a senior product manager	0.53	0.375
... to announce the first Open Banking data recipients - ...	0.41	0.125
Open banking fails to get consumer buy in	0.4	-0.25
... buys stake in a fintech company months after major restructuring	0.5	0.06

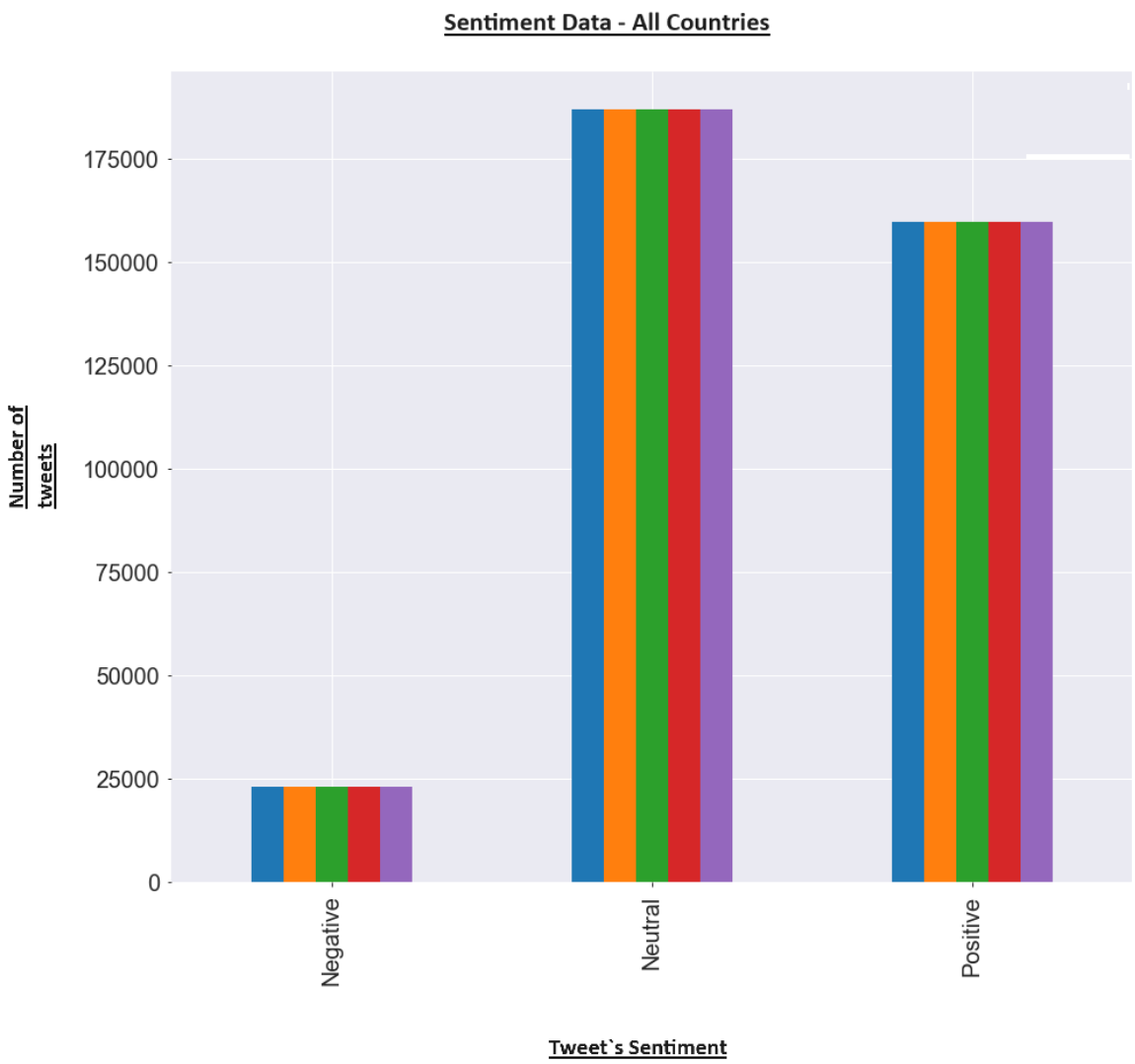
[740] It is a library in the Python programming language for coding sentiment analysis

[741] 'Tutorial: Quickstart — TextBlob 0.16.0 Documentation' <https://textblob.readthedocs.io/en/dev/quickstart.html>.

4.2.6.3 Sentiment Data Description

After the tweets are scored, the data description is provided in Appendix A (Data description), Table 24. The number of tweets by sentiment is shown in the figure below.

Figure 10: Number of tweets filtered by sentiment score (Negative, Neutral and Positive). The y-axis represents the number of tweets. The x-axis is the groups of negative, neutral and positive tweets.



There is a total of 369,749 tweet scores. The polarity score mean is 0.116891. The most considerable number of sentiments is a Neutral rating with 186,936 frequency. Next, the subjectivity and polarity score distribution will be examined with and without Neural polarity scoring.

4.2.6.4 Subjectivity and Polarity Distribution

The distribution of the subjectivity score with a neutral polarity score (green colour) has two distribution peaks (see Figure 11). These are around the points of 0 and 0.5 scores. However, without neutral sentiment scores, the distribution (red) is normal, with the centre at 0.5. The distribution indicates that the subjectivity of negative and positive tweets is primarily neutral, whereas the subjectivity of neutral sentiment tweets is mostly not personal.

The distribution of the polarity score indicates that most tweets are neutral or positive, with a score above 0. Excluding the neutral tweets, tweets are primarily positive and distributed in the score range of 0 to 0.6 (see Figure 12).

To sum up, the distribution of the subjectivity score is normal, which makes the prediction model stable. In contrast, the distribution of the polarity score has some defects, with a second peak of around 0.5 scores.

igure 11: The distribution of subjectivity scoring. The y-axis represents the frequency. The x-axis represents the subjectivity score. (Green line- with Neural subjectivity scoring, Redl- without Neural subjectivity scoring)

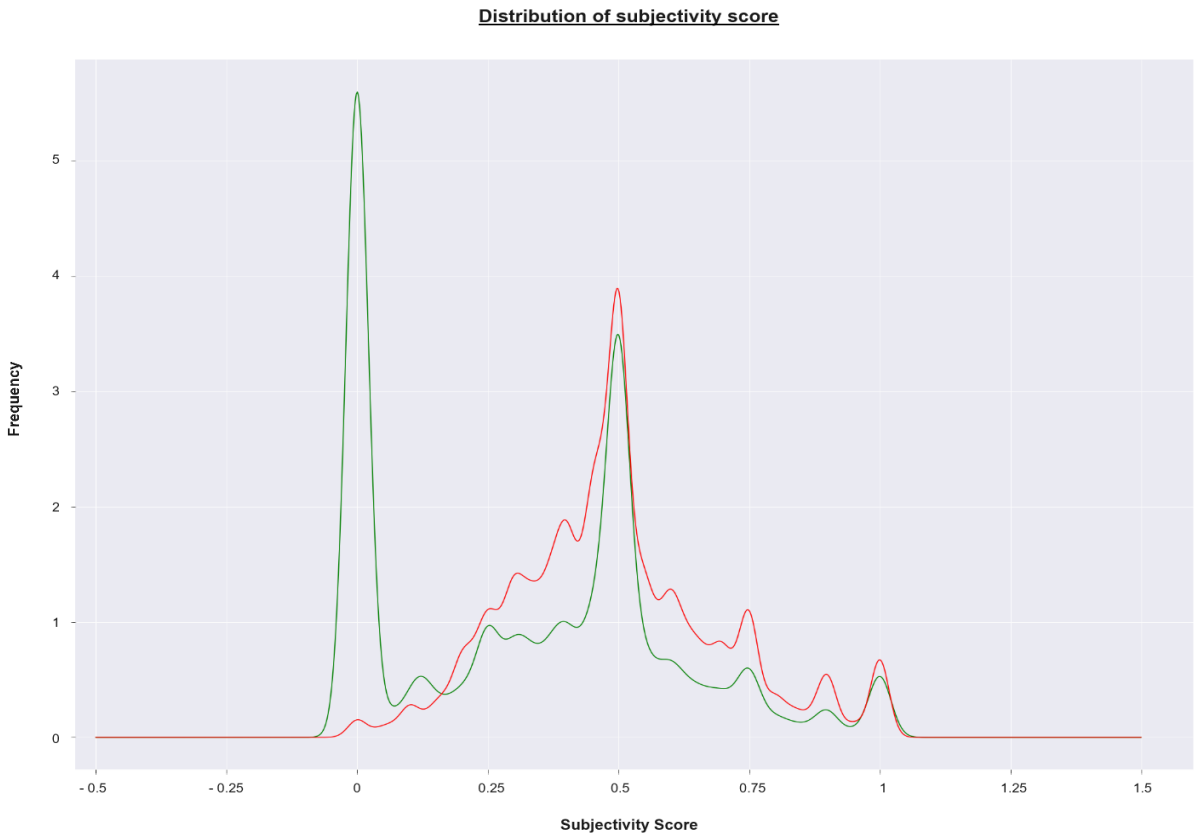
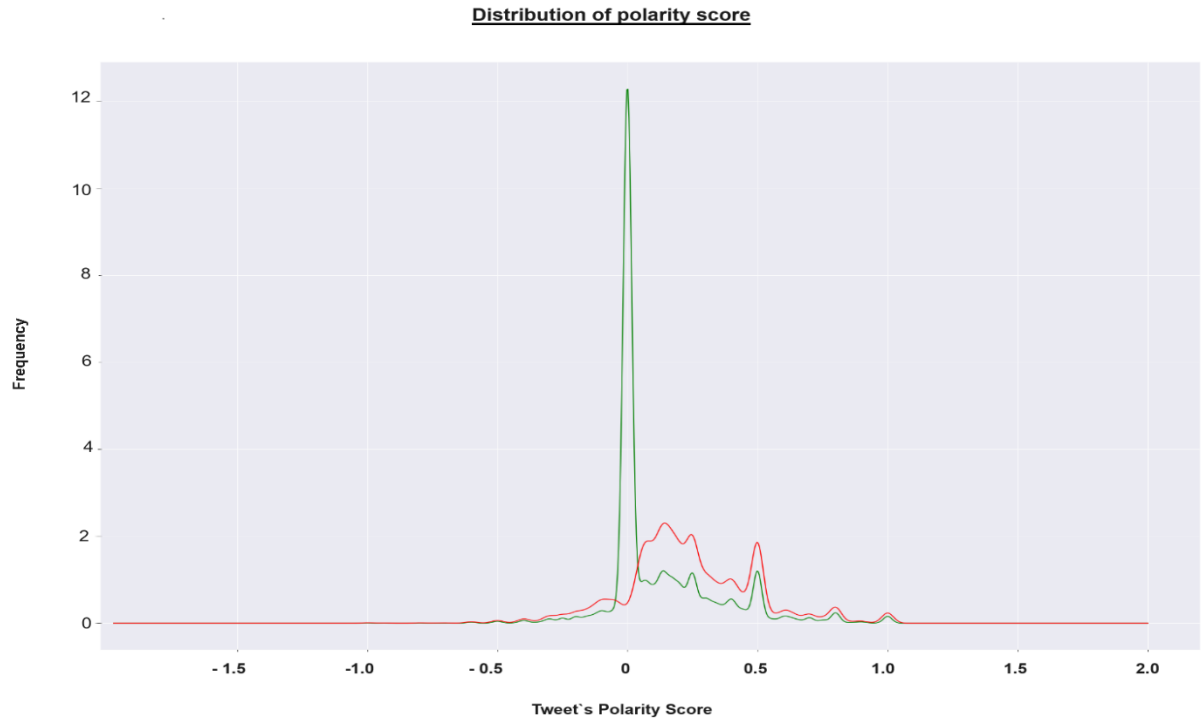


Figure 12: The distribution of polarity scoring. The y-axis represents the frequency. The x-axis represents the polarity score. (Green line - with Neural polarity scoring, Redline - without Neural polarity scoring)



4.2.6.5 Tweet`s text analysis

This section applies the LDA and NMF methods to extract the discussion behind the negative or positive sentiment toward OB.

The data preprocessing and feeding of the LDA and NMF models were conducted with the 'sklearn' library in Python. First, the punctuation and stop words were removed from the text. Next, all text was tokenised and vectorised with TF and TF-IDF vectorizers for NMF and LDA models.

The model parameters are set to their defaults. The trial-and-error procedure for defining the number of topics was not utilised due to limitations in computational power. The number of topics was established as 10, along with the top 10 words. The loss minimisation for MNF employs the Frobenius norm method, while learning for LDA uses the Online Variational Bayes method.

4.2.6.6 Model results

In the models, all tweets about open banking, followed by tweets with negative and positive sentiments, were vectorised with TF and TF-IDF frequencies and fitted to the NMF and LDA models to extract topics. The output will illustrate the general topics from tweets about OB. The negative and positive topics can provide insight into why the public is positive or negative about OB. The tweets are separated into negative and positive, and all tweets are together. The most frequent words in those groups are "new", "data", and "financial" (see Table 4).

Table 4: Most frequent meaningful words in the tweet's dataset in three groups: positive tweets about OB, Negative and All tweets.

Positive tweets		Negative tweets		All Tweets	
Word	**Freq**	**Word**	**Freq**	**Word**	**Freq**
new	*27280*	*via*	*1960*	*new*	*28367*
financial	*11751*	*data*	*1507*	*fintech*	*28057*
great	*10188*	*financial*	*1443*	*financial*	*26004*
latest	*10066*	*mean*	*1365*	*via*	*22024*
data	*9803*	*customer*	*1278*	*bank*	*19546*
read	*8905*	*small*	*1242*	*data*	*18874*
services	*8013*	*behind*	*1039*	*digital*	*16799*
digital	*7399*	*new*	*1021*	*services*	*16580*
fintech	*7080*	*services*	*973*	*future*	*15806*

Topic result interpretation

The general topics illustrate a positive sentiment toward open banking (see Table 5). For example, topic 1 generated by NMF shows that 'open' 'banking' is 'finance', 'data' through 'APIs' with 'PSD2' 'launches' 'business' 'global', 'revolution' with 'consumer' 'adoption' in 'news'.

The topics in the negative tweets illustrate that there is discussion about ‘closed’ ‘opportunities’ with ‘consumers’, ‘slow’, ‘struggle’, ’partnership’(topic 1, negative topics with NMF model) or in topic 3 with NMF model: ‘fails’, ‘consumer’, ‘expectation’, ‘longer’, ‘meet’ and ‘democratise’ (see Table 7).

To sum up, the topics, in general, are positive. The negative topics concern failed expectations, trust issues, and slow adoption. There is also an interesting topic about the winners and losers during the transformation of OB (negative topic 9, NMF model or negative topic 8, LDA model) and the future of small businesses (negative topic 10, NMF model)

.

Table 5: Topics with all tweets. The table displays the top 10 topics in the corpus. Each topic displays the twenty words with the most substantial weights in a bar chart. The weight is its TF-IDF value for MNF and TF (term-frequency) value in the LDA method.

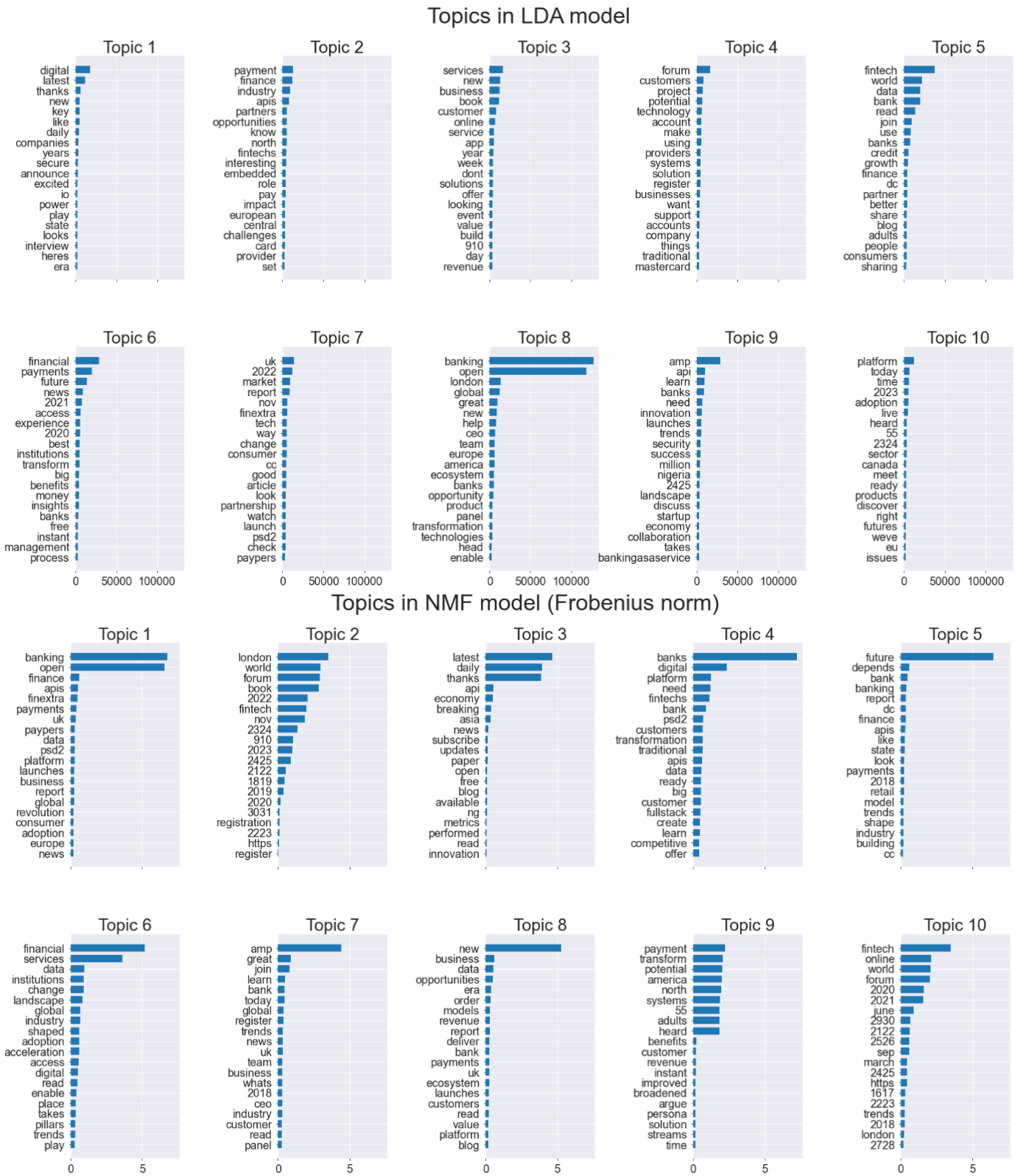


Table 6: Topics with positive tweets. The table displays the top 10 topics in the corpus. Each topic displays the twenty words with the most substantial weights in a bar chart. The weight is its TF-IDF value for MNF and TF (term-frequency) value in the LDA method

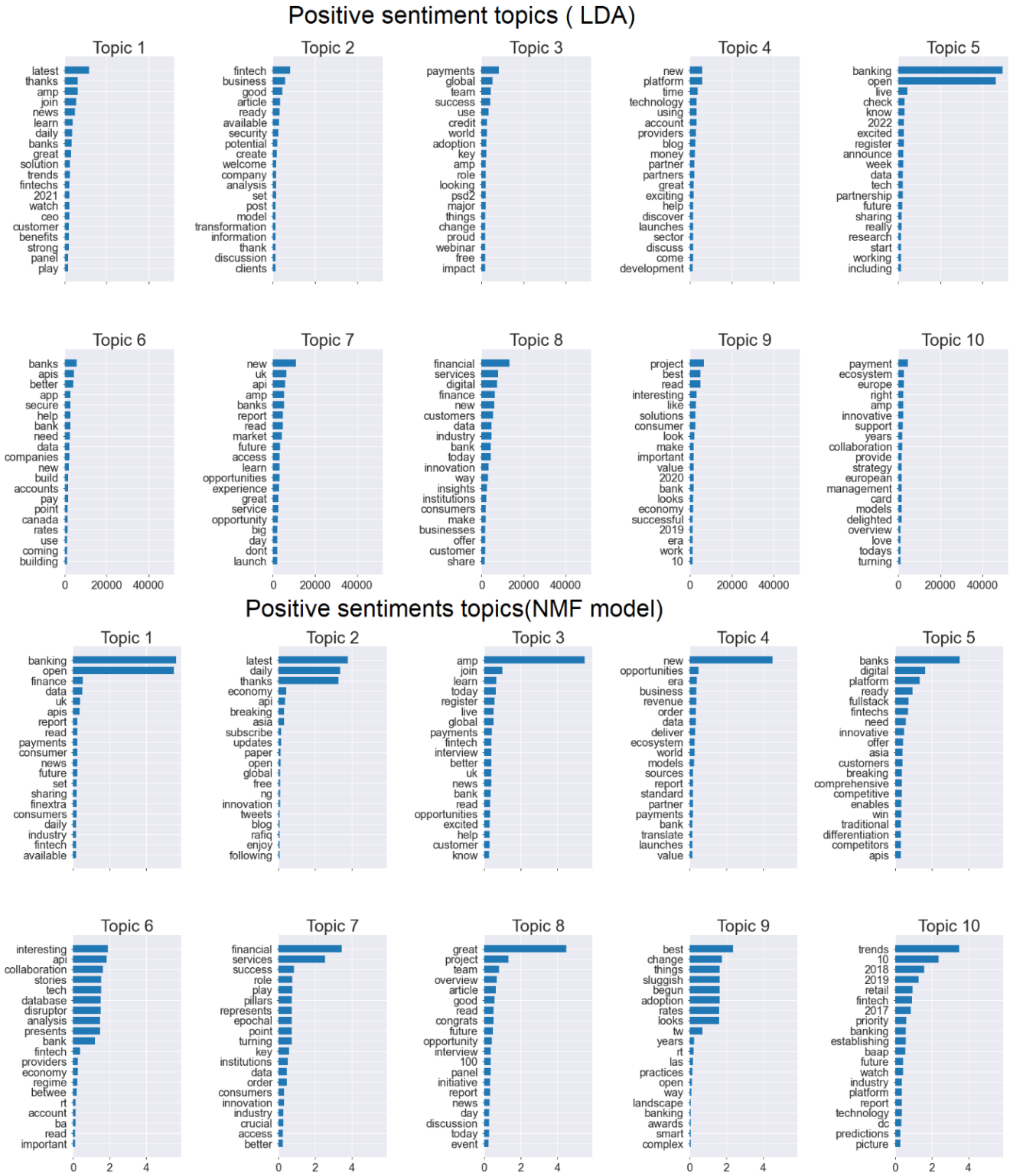
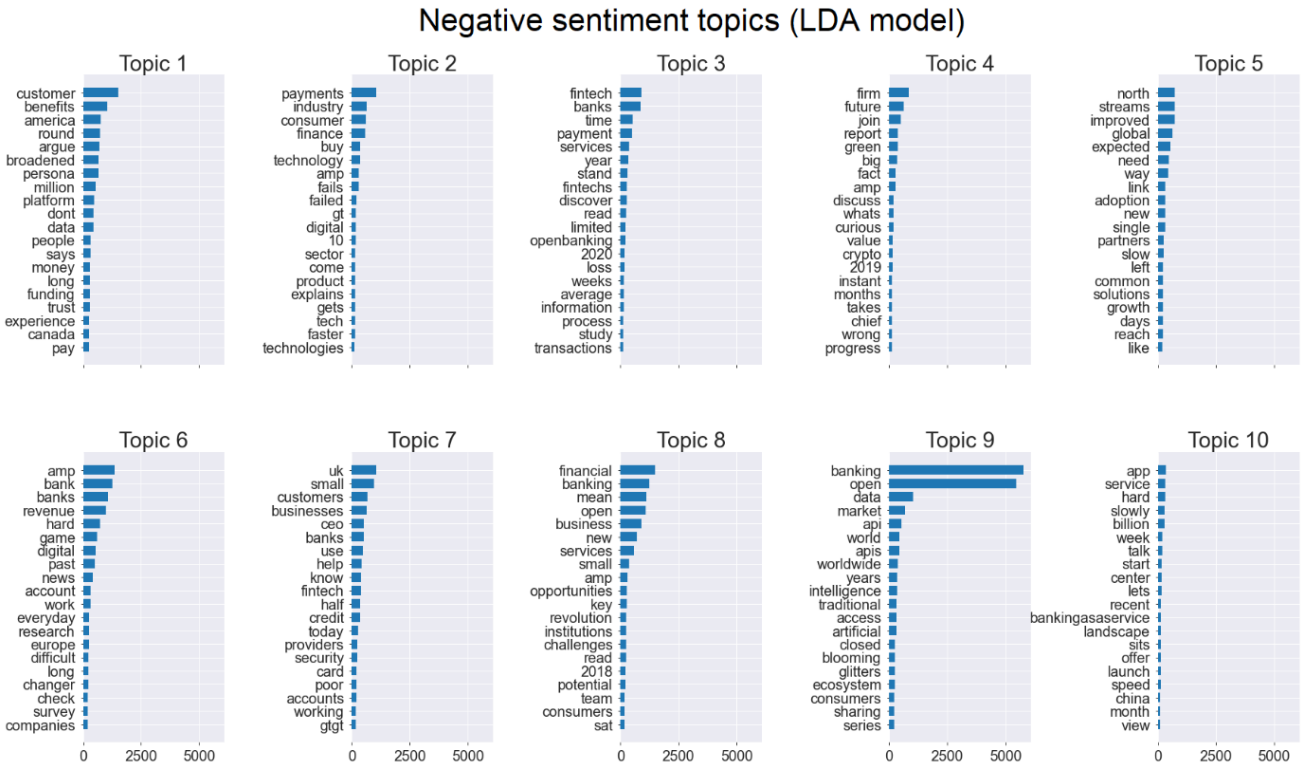
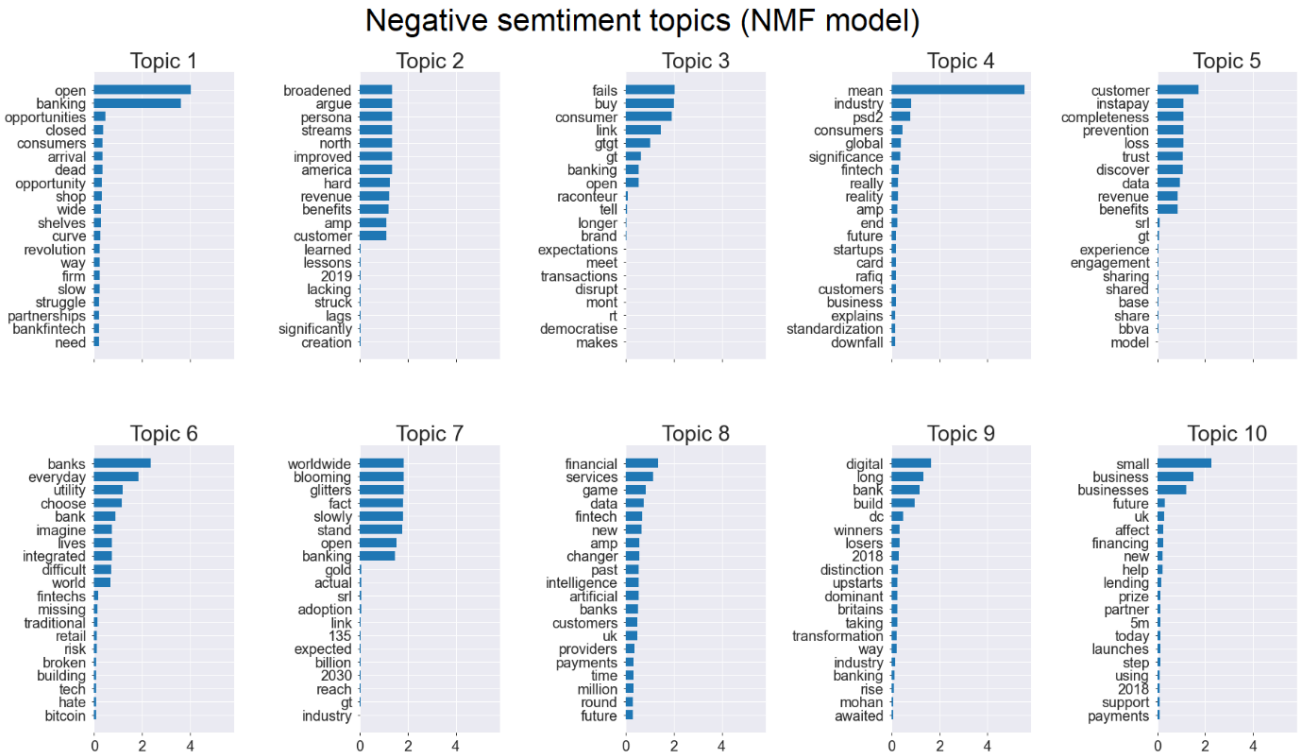


Table 7: Topics with negative tweets. Topics with positive tweets. The table displays the top 10 topics in the corpus. Each topic displays the twenty words with the most substantial weights in a bar chart. The weight is its TF-IDF value for MNF and TF (term-frequency) value in the LDA method





Topics Before and After the OB Regulation Enforcement

Topics from positive and negative tweets are extracted before and after 2018. All topics are generated by the MNF rather than the LDA algorithm because MNF is non-probabilistic, providing more consistency. For ease of interpretation, the topics before and after regulatory implementation are filtered (see the table below). More detailed results of topic extraction are in Appendix B (Topic extraction on tweets).

Table 8: Comparison between topics before and after OB regulation enforcement (MNF model). The positive and negative topics generated by the MNF algorithm before and after the OB regulatory enforcement are summarised in a 2x2 table.

	Before OB enforcement	**After OB enforcement**
Positive	*Industrial Revolution opportunity*	*PSD2 digital platform success*
	A new era with financial innovation	*Better consumer use, access to money and services*
	Better financial services, secure data sharing through API	*Great global panel discussion*
	SMEs and consumers have new opportunities to access	*Instant payment, secure account*
	Network economy with platforms	*Reports and articles about interest in the future of fintech*
	Regulated fintech marketplace	
Negative	*The democratisation will close opportunities and obstacles for fintech*	*Slow enforcement, missed deadline*
	Challenges and cutting of small businesses	*The future of credit unions*
	Not understand how to ask and how to access the service	*Benefits for new firms*
	The struggle between banks and fintech Needs new regulations to moderate the relationship.	*Poor people matter, budget problem.*
	Vulnerable customer apps	*App issues, hard to make payment*
	Customers fail to trust fintech.	
	Data risks from SMEs and fraud	

Before OB regulation enforcement, the positive topics are summarised as the opportunity with revolution, a new era for financial regulations, and opportunities for SMEs and customers. After the regulatory enforcement, the topics discussed included the success of PSD2, better access, products, instant payment, and secure accounts. These topics are consistent with pre-implementation discussions about the OB revolution, focusing on improved products and opportunities.

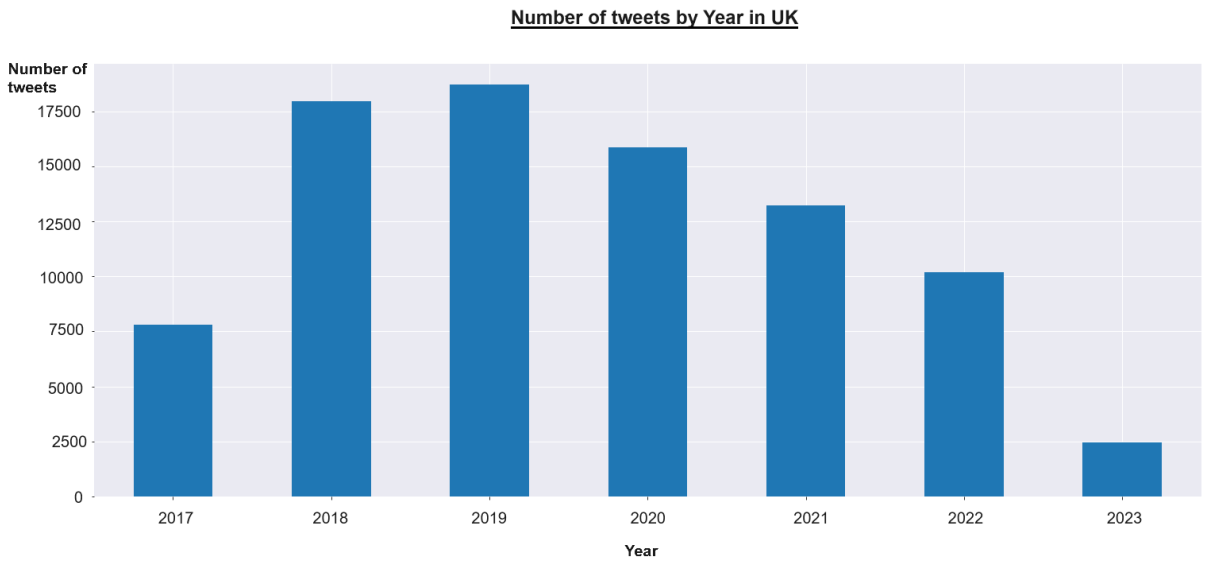
The negative topics before regulatory enforcement are concerns with closed opportunities, challenges for small businesses, and not understanding the product and access to services. In addition, the trust, adoption of new services, the problem with securities, fraud, slow implementation and monetisation were discussed. After the regulatory enforcement, the negative topics mostly revolved around the issues of slow implementation and deadlines, as well as the benefits of small firms, credit unions, and poor people.

In summary, there is a shift in concern from broad issues to specific matters regarding deadline implementation and the benefits for the least advantaged groups, such as small firms and indigent people.

4.2.7 Comparison of sentiment between jurisdictions

In this section, the total number of tweets per year is examined. Next, the monthly and annual mean polarity (sentiment) scores in the UK, US and EU are calculated to understand the trend of sentiments in these jurisdictions. After that, they will be compared to conclude the possible impact of OB regulations.

Figure 13: Total number of tweets about OB in the UK by year. The vertical axis represents the number of tweets. The horizontal axis represents the year. The graph shows a bubble of tweets about OB from 2017 to 2022.



The total number of tweets about OB increased significantly in the year OB regulations were implemented (see Figure 13). The number of tweets rose from around 75 thousand to 175 thousand and continued to rise until 2020. However, attention towards OB decreased from its peak in 2019. Still, the number of tweets in 2022 is higher than in 2017, the year before OB regulations were put into effect.

The boom in the number of tweets can be evidence of increasing discussion about OB. However, the sentiment of the discussion remains unclear. Therefore, in the next step, the monthly and annual average polarity scores will be calculated to understand the change in sentiment toward OB during the years of OB regulations.

Figure 14: The monthly mean polarity score between the UK and EU (the green area where UK>, red where UK<). The y-axis represents the mean polarity score, and the x-axis the year.

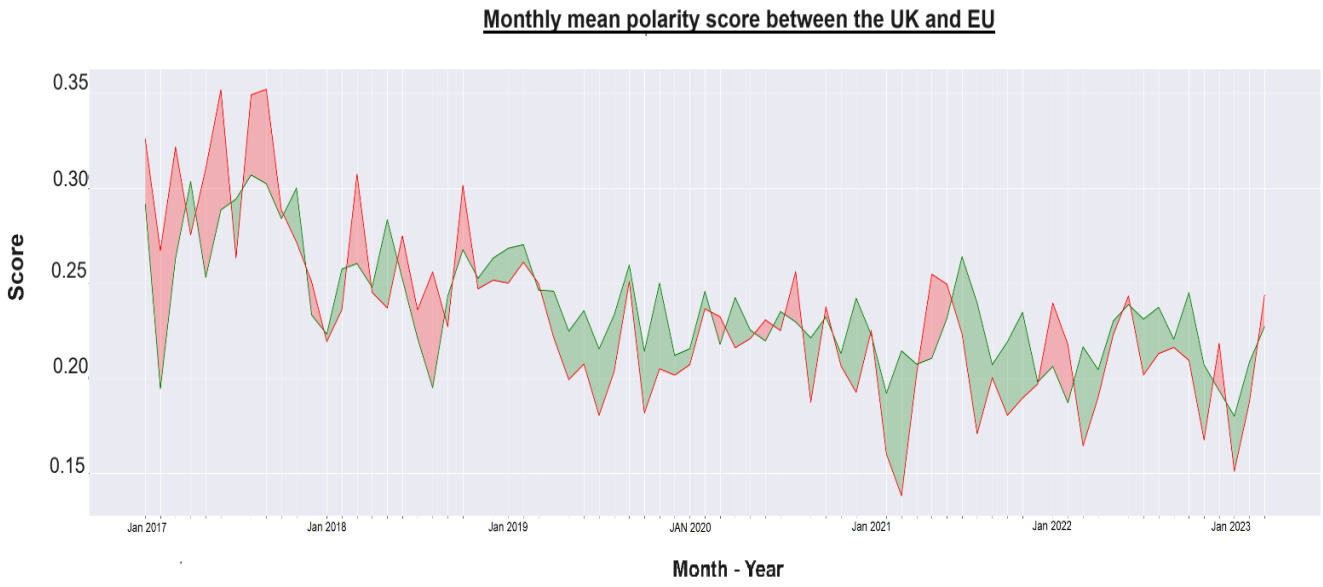
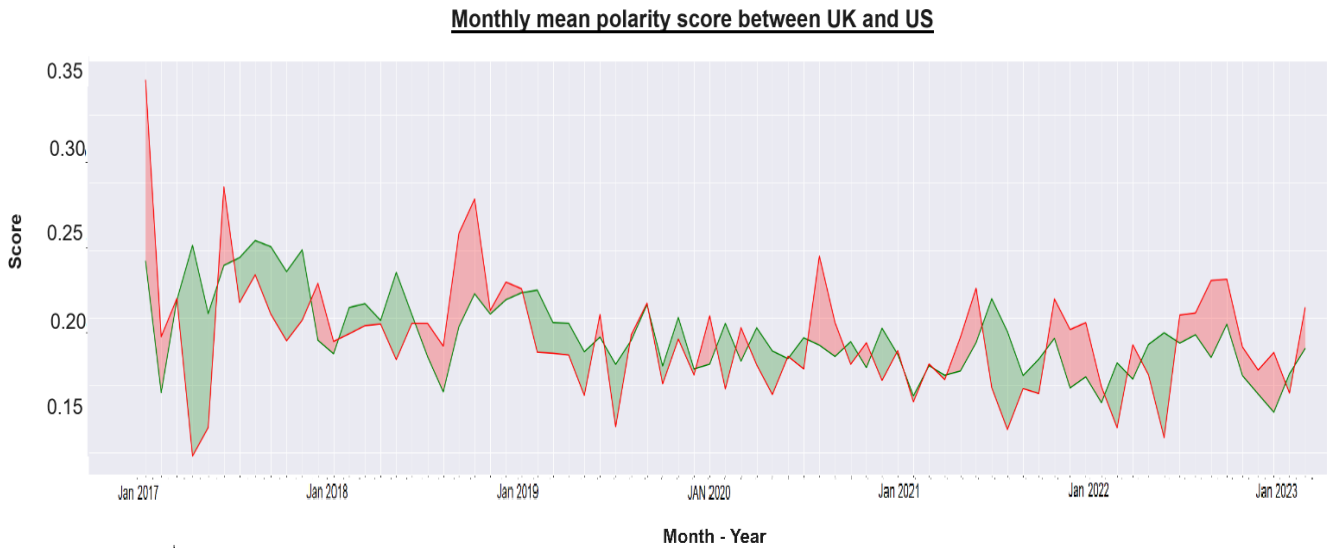


Figure 15: The monthly mean polarity score between the UK and US (green area where UK>, red where UK<). The y-axis represents the mean polarity score, and the x-axis the year.



The data indicates that the UK sentiment was lower than that of the EU and the US before the implementation of the OB regulation. However, from 2018 until 2022, UK sentiment toward OB was

higher than that of the US and significantly higher than that of the EU. In the first quarter of 2023, the sentiment in the US has risen significantly. For better visualisation, the annual mean score is calculated.

Figure 16: Mean Polarity Score by Year (Green-UK, Blue-EU, Red-US). The y-axis represents the mean polarity score, and the x-axis the year.

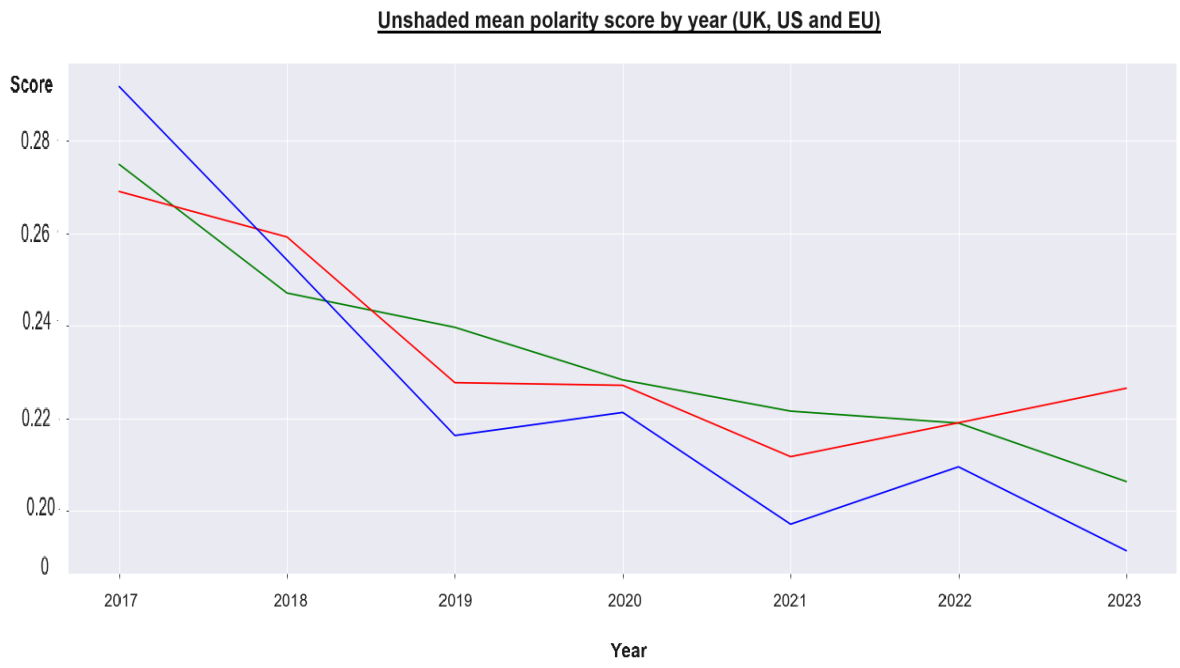
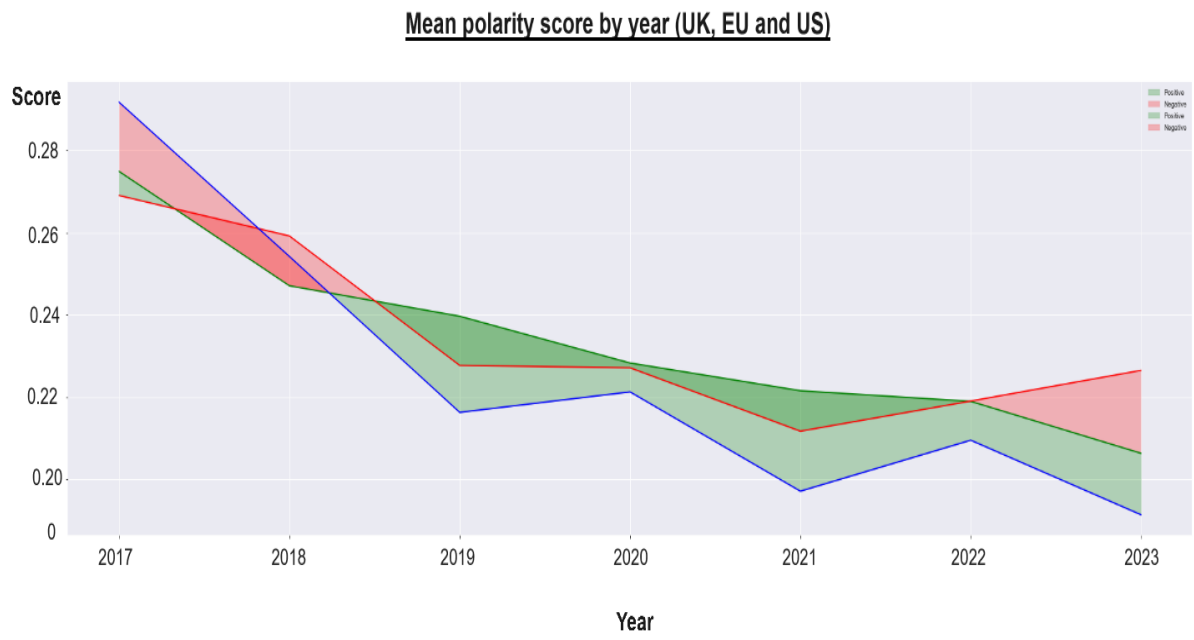


Figure 17: Mean Polarity Score by Year (Green area where UK score is higher, Red area where UK score is lower) (Green line - UK, Blue line - EU, Red line - US). The y-axis represents the mean polarity score. The x-axis represents the year.



4.2.7.1 Comparison with EU Jurisdiction

The EU`s approach to OB is regulated through PSD 2. However, there is no requirement to standardise the API. This makes the EU`s approach less standardised than the UK's.

Before the OB regulatory enforcement, the sentiment trend in the UK was parallel to that of the EU, with a lower sentiment score (see Figures 16,17). The UK score was also lower than that of the US before the implementation. However, from 2018 until 2022, during the UK OB regulation implementation, the UK`s OB sentiment score started to rise above the EU and the US. By 2023, the sentiment trend between the UK and EU returned to the pre-implementation pattern of 2017. However, the UK score is now higher than the EU, potentially reflecting the impact of UK OB regulation implementation. This parallel trend between the UK and EU fits the parallel assumption for the DiD method. In conclusion, the DiD method can effectively quantify the impact of OB regulations on public sentiment.

4.2.7.2 Comparison with US Jurisdiction

The US approach to OB is organic, adopting a wait-and-see stance. There are discussions about the implementation of OB regulation in the US.

Data shows that from the beginning of 2023 to March 2023, the US public opinion toward OB rose significantly, surpassing the UK in 2023 (see Figures 16,17). In contrast, the sentiment in the US was higher than that of the UK before the implementation of OB in the UK. This suggests a possible public incentive to end the wait-and-see approach and enforce the regulation in the US.

From 2018 to 2022, the UK's average sentiment score consistently surpassed that of the US. The steady trend of UK sentiment after implementing regulations, outpacing both the US and EU, further suggests that OB regulations positively influence public sentiment.

4.2.8 DiD Regulatory Impact

4.2.8.1 Counterfactual (parallel) condition

The method assumes that average factors' impacts on sentiment about OB in the UK and EU are proportionate, meaning they influence both jurisdictions equally, and the sentiment trends in both jurisdictions should be parallel. For example, the trade war in 2017 impacted OB sentiments differently across the UK, EU and US. It shifts the trend in the US but not the UK. These factors could shift the OB sentiment again when the OB regulations were later implemented. If factors such as war caused a non-parallel shift in sentiment, calculating OB regulatory impact would be difficult because the factor`s impact would interfere with the regulatory impact. Measuring the exact proportion of the factor's impact on sentiment is difficult. However, if the trade war equally impacts sentiment in both

jurisdictions, their trends are parallel. The OB regulatory impact can be measured by subtracting it from the control group`s base impact.

The visual comparison of sentiment score trends between jurisdictions shows that the EU and UK had parallel trends before regulatory enforcement from 2017 to 2018. In contrast, the trends between the US and UK fluctuated and were not parallel before the enforcement. This can be attributed to the harmonisation between the UK and EU jurisdictions, which are more similar in economic and other social factors than the US. Therefore, the assumption of parallel trends is satisfied for the UK as the treatment group and the EU as the control group.

4.2.8.2 DiD model

An OSL regression was conducted in the test to calculate the OB regulatory impact. The regression model is defined below:

$$polarity = b_0 contr_treatment + b_1 before_after + b_2 contr_treatment * before_after + b_3 Year$$

Where:

polarity- is the sentiment score of the tweet in the UK or EU

contr_treatment – dummy variable (0 if the tweet is in the EU, 1 if the tweet is in the UK)

before_after - dummy variable (0 if the tweet is before the OB regulatory enforcement, 1 if it is after)

*contr_treatment*before_after* - the DiD impact dummy, multiplication of before-after and control-treatment variables.

Year - the year of the tweet`s score.

Data description

The total number of tweets for the DiD method with the EU as the control group is 75073. The mean positive sentiment score is 0.2333 (see Table 9).

Table 9: Data description of tweets in two location groups, the UK and EU. The total number of tweets is 75073, with a mean positive sentiment score of 0.2333.

	Subjectivity	Polarity	Before_after Contr_treatment Dummy
Count	*75073*	*75073*	*75073*
Mean	*0.493*	*0.233*	*0.568*
Std	*0.200*	*0.252*	*0.495*
Min	*0*	*-1*	*0*
25%	*0.366*	*0.090*	*0*
50%	*0.484*	*0.200*	*1*
75%	*0.6*	*0.378*	*1*
max	*1*	*1*	*1*

4.2.8.3 DiD impact model results

In this section, the summary of regression results with different control groups is illustrated in the table below. The control groups comprise tweets from the EU, the US, and other jurisdictions, while the treatment group is the UK.

Table 10: Summary of DiD impact results against the control group. The control group name is in column "Control group"; The impact coefficient is in column "DiD coef.". The table shows that the regulatory impact raised the sentiment by 0.027 points (or around 10%) in the case of the EU as the control group and 0.012 points with the US as the control group.

Control group	DID coef.	P>|t|	No. Observ.
EU	0.027	0	75,073
US	0.012	0	63,141
Other jurisdictions	-0.019	0	203,416

The model was conducted with 75073 observations of sentiment scores in the UK and EU. The result is shown in the first column of the EU in Table 10. The impact coefficient model is statistically significant with a P value equal to 0.

The results from the regression show that the implementation of OB regulation has a positive impact on the UK's sentiment about OB. The value of the impact coefficient *"Did coef"* is 0.027. It means that regulatory enforcement has increased the polarity score by 0.027 in the UK compared to the control group.

The regulatory impact quantity is relatively high. As the mean polarity score of all tweets in the UK and EU is 0.233350 points, the increase of 0.027 by the regulatory impact constitutes an 11% increase in mean public sentiment about OB.

The regulatory impact is significant because the common threshold for significance is where the P value< 0.05, and in our case, P is 0.

Applying the US and other jurisdictions as control groups

Both models, when compared with those from the US and other groups, are presented in the second and third columns as the US and Other jurisdictions (see Table 10).

The comparison with the US illustrates a positive impact on the sentiment of a 0.0128 polarity score, or an increase of around 5%. The comparison with Other countries with tweets in English, but not a native language, shows that the impact on sentiment was negative compared to those countries of -0.019, or around -8%. Examining visual trends in sentiment reveals that in other jurisdictions, the

sentiment remains unchanged from 2017. In contrast, in jurisdictions such as the UK, EU, and US, the sentiment trend decreased after the initial surge in sentiment preceding the OB enforcement.

In conclusion, it is possible that the hype surrounding OB remains high in other countries, while in the UK and EU, the excitement has subsided. Therefore, the assumption of parallel trends before and after was only confirmed between UK and EU jurisdictions, but not between UK and Others or UK and US.

4.2.9 Conclusion

The general descriptive analysis shows that aggregate sentiment behaves like a wave. The uncertainty period in the UK and EU spans from 2017 until the enforcement of OB regulation around 2018. The number of tweets about OB in the UK, a possible indicator of the spread of OB topics, rose from 2017 to 2019, falling until 2023. The turning point for the OB topic spread was 2019, which is also a year after the OB regulation enforcement.

The mean aggregate sentiment score in the UK steadily declined from 2017 to 2023. According to the SIRs model, there may have been a sentiment bubble around OB during the uncertainty period before 2018. After the resolution of uncertainty, the sentiment continued to decrease, indicating that the negative sentiment had the highest infection rate.

In summary, the uncertainty about OB, or the organic approach without OB regulations, could have increased the spread of the OB topic and contributed to a possible OB sentiment bubble.

Topic Extraction

The topic extraction shows that some topics discussed during the uncertainty period faded after the uncertainty resolution. This aligns with social finance theory, which focuses on the spread and evolution of traits. The topics spread and evolved; the concerning topics after the OB regulatory enforcement are now focused on issues like enforcement deadlines and concerns about least advantageous groups such as small firms and poor people.

Regulatory impact

The EU jurisdiction was chosen as the control according to the interpretation of the SIRs model. The sentiment shape is wave-like, so comparing the groups requires the same wavelengths. Therefore, by comparing sentiment waves, the EU is more suitable. This is likely because EU and UK regulations are more harmonised. The key distinction between UK and EU OB regulations is that the UK mandates a unified API standard, whereas it is not mandatory in the EU.

Applying the EU jurisdiction as the control group, the results show that the OB regulatory enforcement in the UK could have increased the mean sentiment score toward OB by 11%.

4.2.10 Limitation and possible further research

Social finance provides a possible explanation for social phenomena through the transmission of information among participants in society. The topic extraction algorithm can help identify the topics discussed within large volumes of public data. This facilitates understanding the transmission of ideas and their impact on sentiment or behaviour.

However, the method`s accuracy depends on the algorithm and manual interpretation of extractions. The algorithm classifies important related words into clusters and presents them as topics. The presentation of word clusters is still raw and requires human interpretation to derive meaning. This means there can be human error in understanding the word`s clusters.

Further development can focus on the accuracy of the topic extraction algorithm. Moreover, by linking topic extraction to a timeline, where the discussion score is assigned to each topic, the development of such an algorithm can provide a dynamic picture of topic transmission to test social theories.

A limitation of regulatory impact results arises from the DiD method. It cannot capture the exact amount of impact, and it operates under the counterfactual assumption that the control group behaves in parallel with treatment groups while other impacts are equally distributed. However, unobservable factors may affect the control and treatment groups differently.

4.3 Open Banking service quantity and quality analysis

Introduction

The examination of regulatory and competition theories suggests that regulations can improve the competitive environment and social welfare by removing barriers to entry and expansion, including factors such as set-up costs, economies of scale, service quality, technological and data barriers, switching costs and network effects. The regulatory objective in the Open Banking ("OB") ecosystem is to reduce technological and data barriers, lowering switching costs and improving service quantity and quality. One of the regulatory consequences should be better access to big data to develop more artificial intelligence application services. This effect should produce higher social welfare through the increase in service numbers and their quality.

In this analysis, we argue that the enforcement of OB regulations should create more surplus in terms of service quantity and quality. Moreover, the benefit of regulatory enforcement can be uneven among the market participants.

The assessment of the OB regulatory impact is measured through the reviews and scores data of the OB provider applications in Google Play. The service providers are separated into four groups for the detailed analysis: the biggest CMA9 banks or challenger banks to access the most and least impacted groups.

The analysis consists of six parts: introduction, methodology, data description, impact on the quantity and quality of services, findings from topic extraction, and conclusion.

The finding shows a substantial quantitative increase in service demand and a possible shift in the competitive environment caused by uneven regulatory impact on service quality between banking groups. Notably, the number of reviews was used as a proxy for service quantity. The assumption is that the more customers use the app, the more reviews they post. It is based on the finding of OSL regression of app downloads as a dependent parameter and the number of reviews as an independent parameter, which demonstrated the significant value of the number of reviews to the number of app downloads.[742] To retrieve the number of app downloads requires a change in the API request, and the number of app downloads is significantly correlated to the number of reviews; therefore, the use of a number of reviews as a proxy can save the workload and memory resources. Since the OB enforcement, there has been around a 100% increase in annual reviews for the CMA9 group and a 200% increase for the challenger banks group and OB third-party provider ("TPP") group. Moreover, the impact on service quality relative to the CMA9 group for challenger banks increased by 0.2834 points (or around 6%), TPP by 0.4633 rating points (or around 10%). However, there is a negative impact for the NoCMA9 group by -1.2446 rating points (or a decrease of almost 30%).

The reason can be speculated from the topic extraction results. The OB regulatory enforcement has closed the discussions about security issues; however, the discussion about issues with app updates, freezing and stopping the apps remains. The finding suggests that the relatively small increase in service quality can be due to remaining technical issues. Moreover, the group-based topic extraction shows that each bank group provide different values for customers. Customers value security in the CMA9

[742] Oyekunle, Rafiat and others, '(PDF) Online Customer Reviews and Their Effect on the Download of Mobile Applications' (2023) 4 Journal of Information Technology and Computing 39, 49–50.

bank`s services and the cards and rates in the challenger bank`s services. App update and login time for small banks ("NoCMA9"). For the TPP group, the exchange and fee rates and the money transfer service are distinctive discussion features.

4.3.1 Methodology and Data

In this analysis, DiD method is applied to determine the OB regulatory impact on providers' service quality. In addition, topic extraction methods, which include LDA, NMF, and Bertopic models, will be applied to app reviews to provide more insight from the customer`s point of view. Those methods are explained in the methodology section of the first analysis of OB sentiment.

Data collection and description

The application`s reviews and ratings of 35 service providers in Google Play were collected. The list of providers is in Appendix C (List of service providers). The providers are grouped into four groups. The first group is the CMA9, the nine biggest banks under the scope of PSR 2017. The second group includes Challenger Banks, such as Monzo or Starlink, which rely heavily on digitalisation. The third group includes other banks. Third-party providers under OB regulations are in the fourth group. The data is stored in the file "Vo_207055762_Second test Reviews.csv", and the Python code is in Appendix F(Service quantity and quality- Python code).

The collection is conducted by the 'google_play_scraper' library in the programming language Python. The total number of data collected is 1,152,499 review samples. The columns in a sample are user name, review (under column 'content'), rating by user(under column 'score'), date of review, and app version. The example of the collected data is in Appendix A (Data description), Table 25A.

4.3.2 Data description analysis

In this section, the distribution of collected data is examined. The relationship of variables is reviewed by visualising pairwise variables within the dataset.

The Pairplot is illustrated in Figure 18. The variable sample distribution provides several observations. Firstly, the pair plot shows that the app rating score is distributed unevenly. The data shows that most ratings fall under the value 1 (very bad) or 5 (excellent) score, which means users' sentiment is extreme, either overwhelmingly satisfied or very upset about the app. Secondly, the number of reviews is concentrated in the first group, CMA's nine biggest banks. The data distribution is reasonable as the market share of those banks is the biggest; therefore, the number of app downloads and reviews is the highest. Moreover, under the year variable, which indicates the year that the review is posted, the overall trend of the annual number of reviews has increased since 2013. This can indicate quantitative expansion as more reviews and ratings can correlate with more downloads or use of the app.

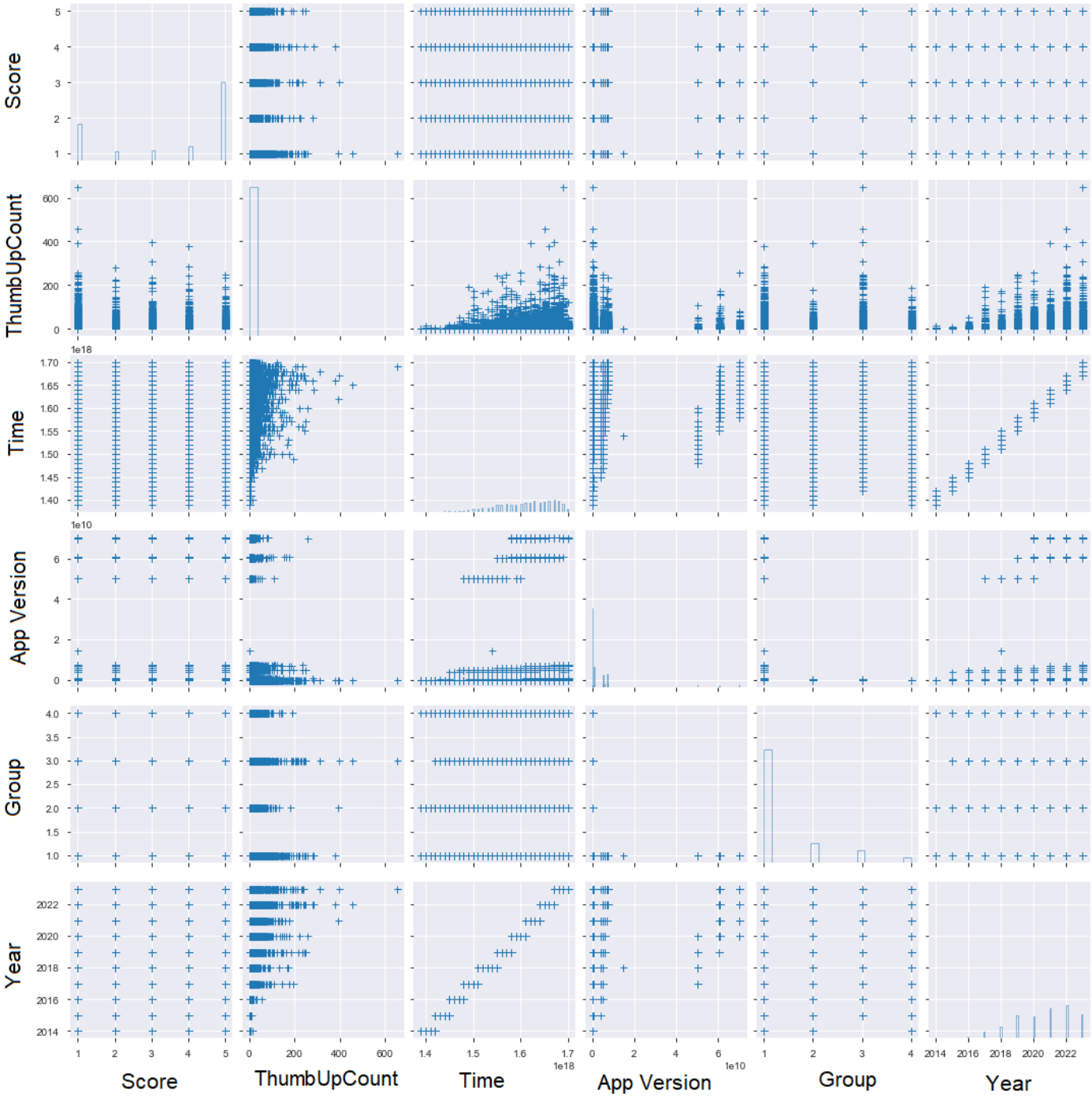
The pairwise visualisation between two variables illustrates the following observation. The relationship between the score rating and the count of thumbs up shows outliers above 200. Most of the count is under 200. The highest thumb count is around 600 for score one (a very bad score). The concentration is at scores 1 and 5. The score rating is not distributed evenly among the groups, indicating that customers rate a certain group's app better than others.

In addition, the thumbs-up count is not distributed evenly among the groups; the CMA9 and Challenger bank groups exhibit a higher concentration of thumbs-up. The thumbs-up count and the posting time show a bell-shaped distribution. Posting times are measured throughout the day and appear random, as the data indicate that users do not have a habit of posting during specific hours. Therefore, the

distribution is normally bell-shaped. The visualisation between the Year and App version shows that from 2018, the year of OB enforcement, a sudden introduction of a new app version occurred. Moreover, the total count of thumbs up for the new app version is less than that of the old type of app, according to the pairwise relationship between the app version and Thumbs-Up-Count variables. For the group and appVersion pairwise relationship, the highest concentration of the app version is under CMA9's nine biggest bank groups, and the lowest concentration is under the TPP group.

To sum up, the overall market is growing as the thumbs-up counts are increasing each year. In addition, since the OB enforcement in 2018, new app versions have been released. The most versions released are by CMA9, while the least are by TPP. This may indicate that CMA9 banks have more technological resources compared to TPP. Consequently, this can lead to higher satisfaction rates for CMA9 and Challenger apps, resulting in a greater distribution of thumbs-up counts for CMA9 and Challenger apps than for TPP.

Figure 18: Pairplot variable visualisation. The plot shows distributions between two variables in the dataset of six variables. The "Score" variable – rating score of the review, ThumbUpCount – total count of thumb up for the review, "Time" and "Year"- time and year when the review was posted, "AppVersion"- version of the app which the review was posted, "Group"- the app is classified into one of four groups: CMA9, Challenger banks, small Non-CMA9 banks and TPPs



4.3.3 Open banking impact on service quantity and quality

In this section, the quantity of app reviews is used as a proxy for the quantity of service applications, and the app score rating by users is used to evaluate the quality of service for the examination after the OB regulatory enforcement.

4.3.3.1 Service quantity

The chart of reviews over time is displayed as a bar chart in Figure 19 and as a line in Figure 20. The quantity of reviews can be divided into four periods. According to Figure 19, the first period demonstrates a dramatic increase from 2011 to 2016. Following this, the number stagnated from 2016 to 2018, as indicated by red circle 1 (see Figure 19). Next, there was a two-fold increase from 2018 to 2019, coinciding with the start of the OB regulatory enforcement in 2018. After this boom period, the number stagnated again from 2020 to 2023, as indicated by the second red circle (see Figure 19). It seems that the number has likely reached its ceiling.

In summary, the boom period between the two stagnation red circles 1 and 2 corresponds with the duration of OB regulatory enforcement. It is possible that the OB regulation contributed to this increase in the app`s reviews, which serve as a proxy for the app`s downloads.

Figure 19: Annual number of reviews – bar chart. The green bar is CMA group number of reviews, the blue is noCMA9, the black is Challengers, and the red is TPP.

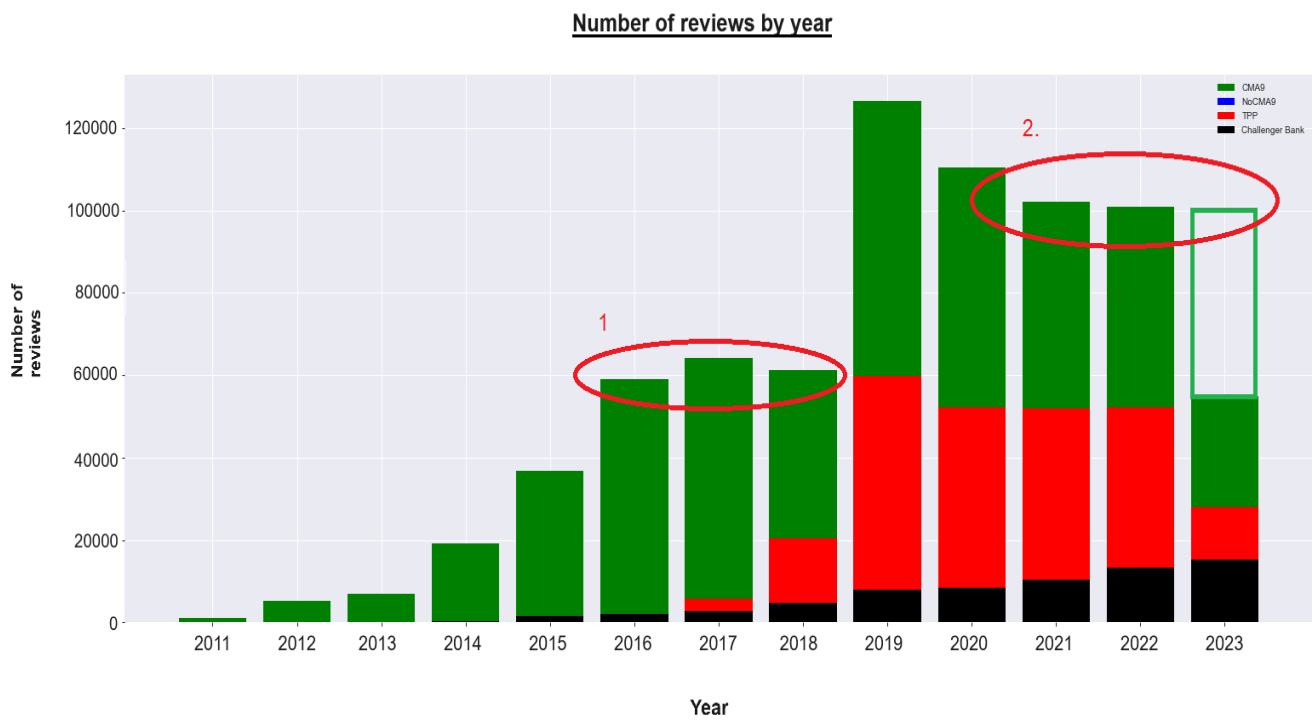
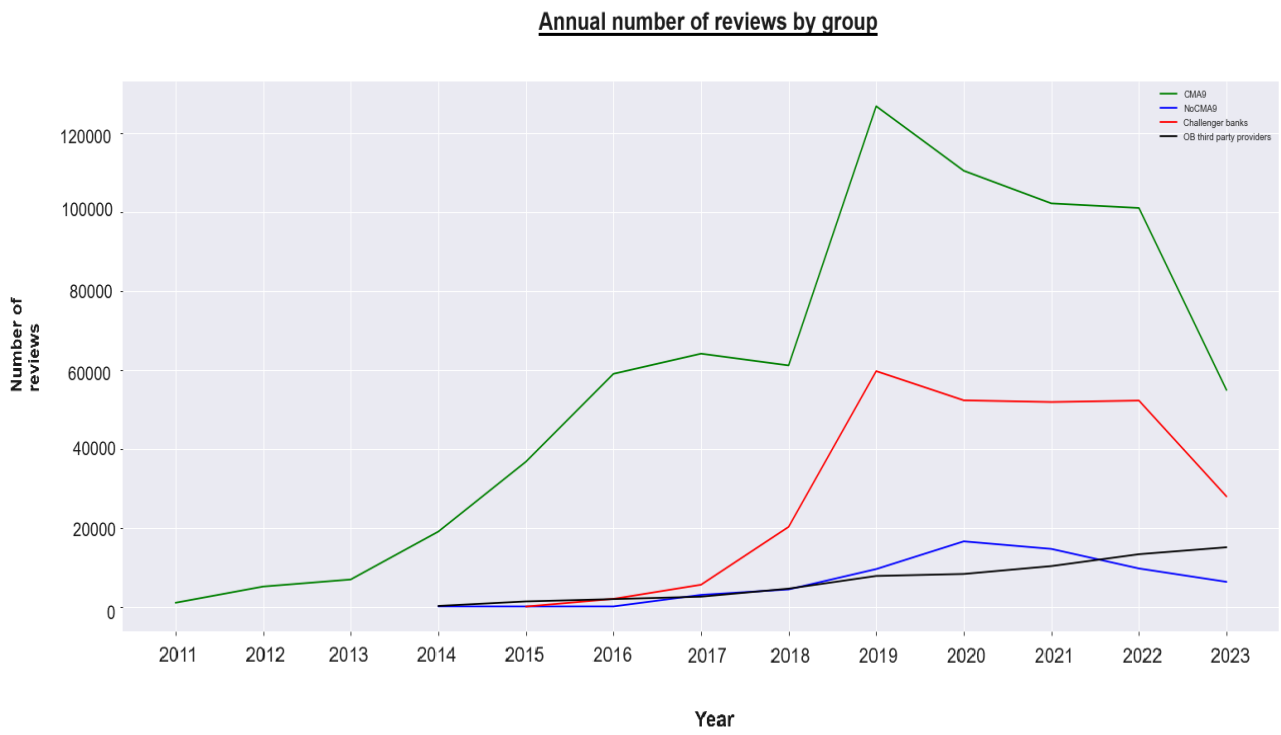


Figure 20: Annual number of reviews by bank group – line. The green line is CMA group, the blue is noCMA9, the red is Challengers, and the black is TPP. The graph shows that all groups benefit from OB enforcement.



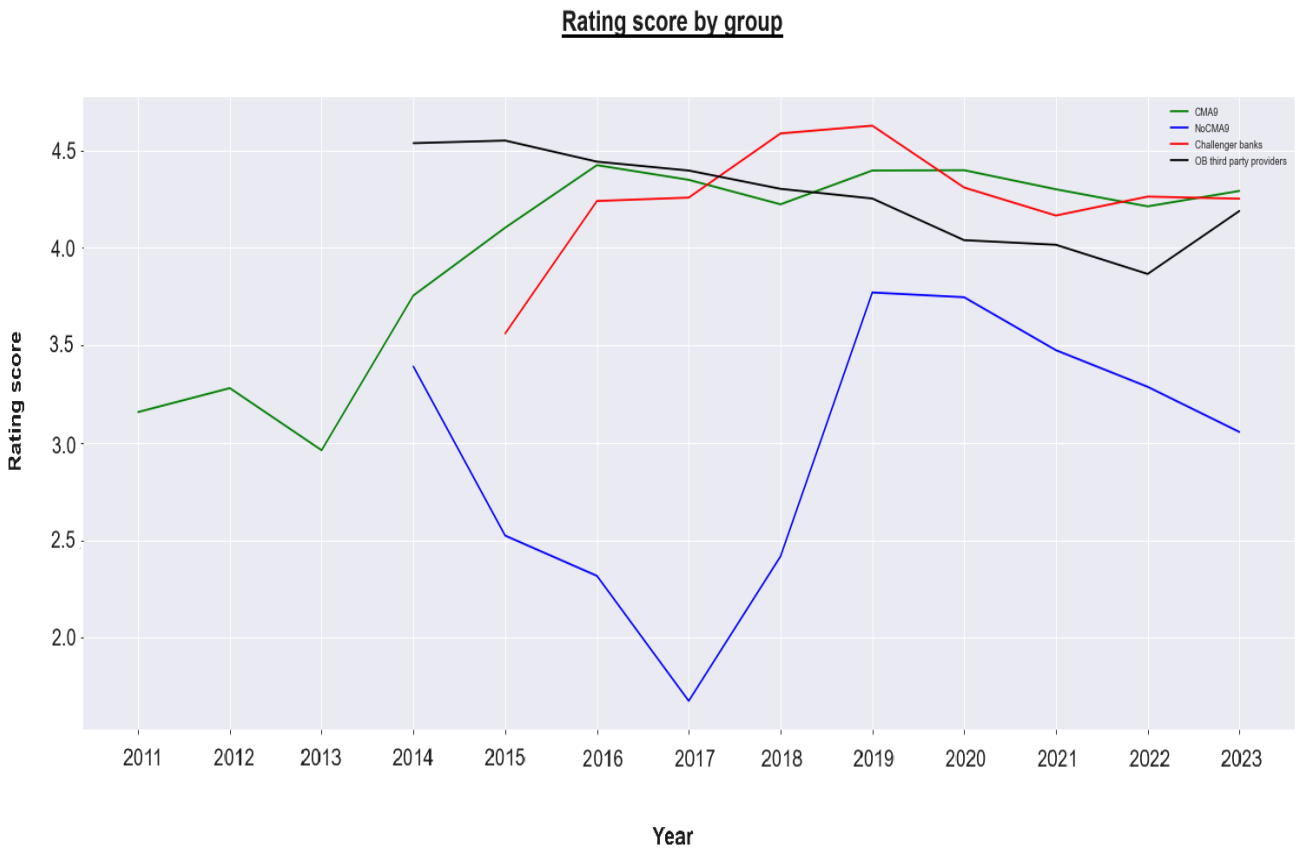
4.3.3.2 Service Quality

The service quality is measured by customer ratings and reviews. The mean rating of the apps grouped by service provider type is calculated with the 'mathplot' library in Python. The result is shown in Figure 21.

The results show different behaviours between groups following the implementation of OB regulation. This indicates that the groups benefit from OB regulation unevenly. The service quality (app score) of the CMA9 group remains steady after the regulatory enforcement. The service quality of the challenger bank group improved until 2019, then declined to the CMA9 level. In the short term, the group received some benefits; however, in the long run, it returned to the CMA9 level. Thus, the CMA9 still has some advantages. The TPP group's service rating steadily decreased until 2022, and it has only improved since 2023. The TPP group may require a longer time to benefit from OB than others. For the NoCMA9 group, which includes other small banks, the service rating fluctuates and remains the lowest. This group faces the highest risk of being ousted from the market.

In summary, CMA9 and the challenger bank groups are the most suitable for the DiD impact measurement method, as the trend before the OB enforcement is almost parallel. The OB regulation may enhance the service quality of challenger banks over CMA9 in the short term, but in the long term, they remain equivalent. The TPP service quantity has increased (see Figure 19). However, the TPP service quality has not risen as expected, and there was a delay in improvement until 2023. Only after that will the service quality improve.

Figure 21: The annual mean rating score is grouped by service providers. The green line is the CMA group. The blue is noCMA9, the red is Challengers, and the black is TPP.



4.3.3.3 Conclusion of service quantity and quality after OB regulatory enforcement

The regulation has likely benefited the challenger bank and TPP groups in terms of quantity (see impact coefficients in Figure 20). Their quantity has increased significantly. However, the benefits of improved service quality are not immediately apparent. There is a short-term increase for challenger banks and a possible lag in benefits for the TPP. The most vulnerable group is other small banks that have less efficient technologies.

4.3.4 OB Impact Measurement

The OB regulations were imposed on the CMA9 group of the largest banks. The CMA9 group is required to open access to its clients' data and provide services for other providers. In this case, the CMA9 benefited from intergroup sharing, and the providers that gained access to CMA9 data also benefited from it. Therefore, the impact of OB regulations can affect all groups of providers.

This section will conduct the impact measure using the DiD method with three tests, as all groups can be affected by OB regulations. Therefore, there can be no unaffected control group. However, it is possible to compare the two in a group and outline the relative OB regulatory impact of the two. Three pairs are CMA9 and NoCMA9, CMA9 and TPP, and CMA9 and Challenger banks.

4.3.4.1 Results interpretation

The summary of the results of the DiD method is shown in the table below. All three tests indicate a statistical significance (P>|t| near 0) of the regulatory impact variable "contr_treatment:before_after." The regulatory impact coefficients reveal that the enforcement of OB regulations has increased the quality of challenger banks by 0.2834 points (or around 6%), TPP by 0.4633 rating points (or around 10%), and significantly decreased the rating score of NoCMA9 by -1.2446 (almost 30%).

In summary, the OB regulation has opened up opportunities for participants. It has increased the service quality of all groups of participants. However, the distribution is not equal. The TPP gains the most benefit in service quality relative to the CMA9 group, followed by the challenger banks. Lastly, the NoCMA9 group service quality has been enhanced since the OB regulatory implementation. However, compared to other groups, the gain was negative.

Table 11: Summary of DiD impact results against the control group. The control group name is in column "Control group"; The impact coefficient is in column "DiD coef." The table shows a negative impact on the NoCMA9 group

Control group	DID coef.	P>|t|	No. Observ.
NoCMA9	*-1.2446*	*0*	*813,981*
TPP	*0.4633*	*0*	814,992
Challenger banks	*0.2834*	*0*	*1,020,973*

4.3.5 **Topic analysis**

This section examines the reviews to understand the reasons behind the customer ratings. The results can provide insight into issues related to service quality. Firstly, data is cleaned using filters for stop words, punctuation, and capitalisation (see Table below). Then, the reviews will be vectorised to feed into the MNF or LDA topic extraction algorithm before and after OB regulatory enforcement.

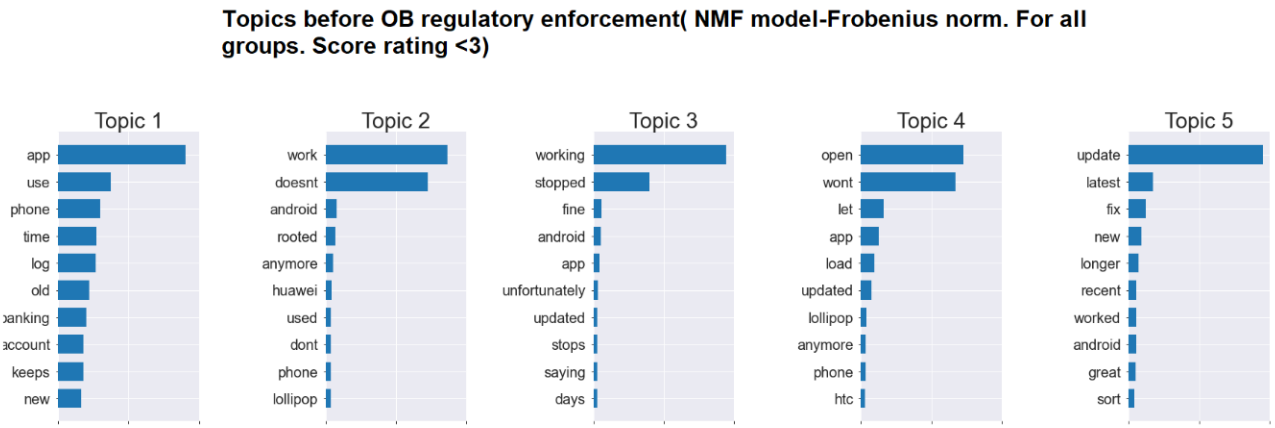
Table 12: Sample of text reviews after cleaning for topic extraction. The review text is in the column "Content"; The "Word count" column represents the number of words in the review.

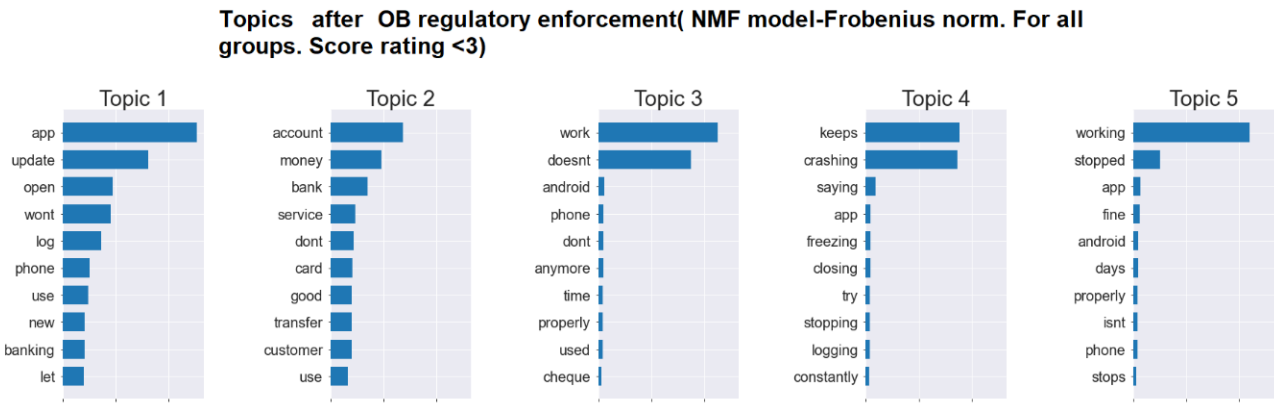
Index	Content	Word count
1	rapid top really bad wait 24h ...	34
2	wont let verify	4
8	cant sign put name says sorry something gone wrong ...	38
13	worst services ever trying the login app ...	32

The result shows that the most discussed issues before the OB enforcement are related to the "use of an app related to an old banking account; the app does not work anymore, the app stops working and updated, cannot open the app, the latest update fixes new longer" (see the table below). After the OB enforcement, the issues were updated, the app won`t open, and issues related to bank service and transfer, kept crashing, freezing, stopping, and logging constantly.

In summary, the technical issues related to app performance before and after the OB enforcement have received the most scrutiny due to poor service ratings. App security issues are not typically categorised as technical.

Table 13: Topics before OB enforcement. NMF model was applied to extract five topics after and before the OB regulatory enforcement. In each topic, the ten words with the strongest weights are displayed in a bar chart. The weight of the word is its TF-IDF value





The topics of reviews grouped by the service provider`s type are illustrated in Table 13. The result for each group is summarised below:

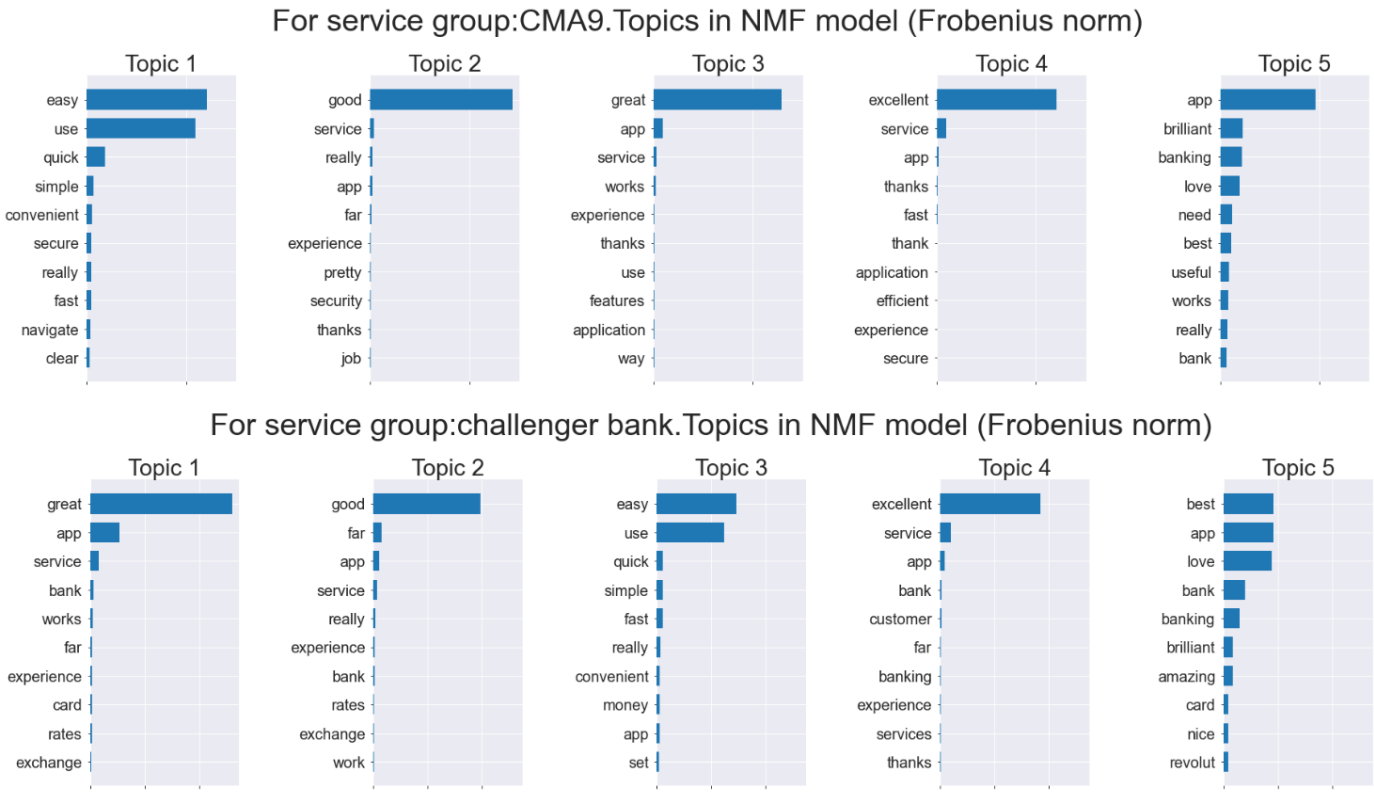
- The quality of the CMA9 group is associated with easy use (CMA9, topic 1), great service (CMA9, topics 2,3), and most significantly secure services (CMA9, topics 1,2,4)

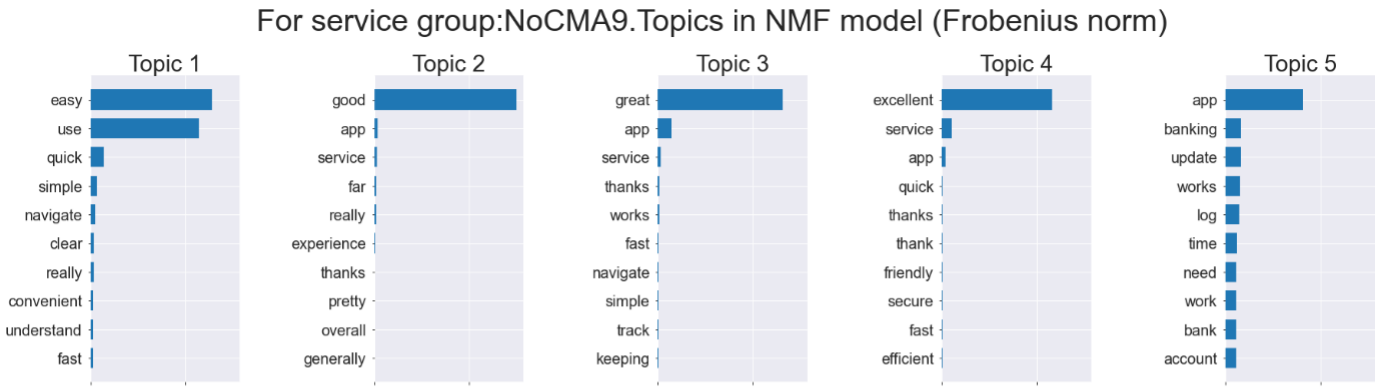
- For the challenger banks, customers discussed good, excellent service (topics 1,2,4), and most significantly about card and exchange rates (topics 1,2,5)

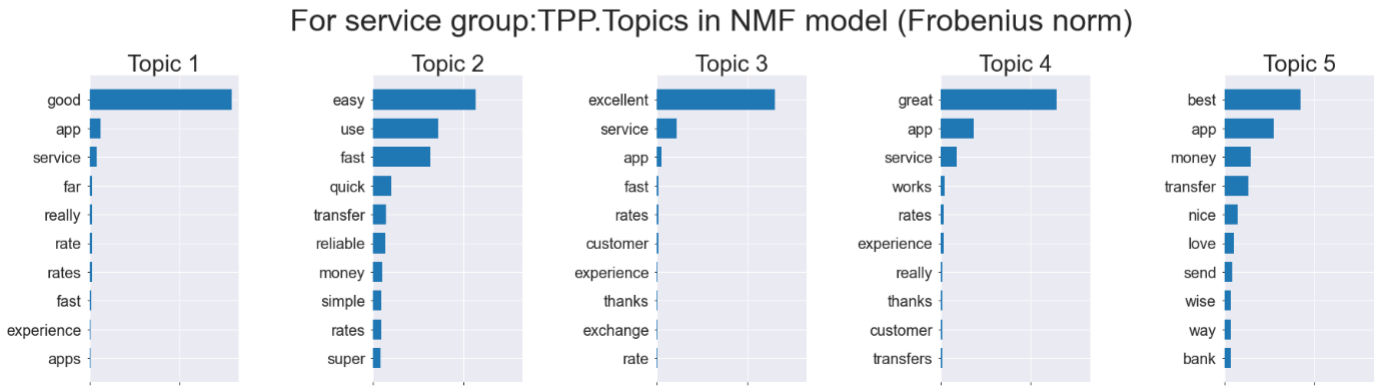
- For NoCMA9, the same holds true for good, excellent, and convenient services (NoCMA9, topics 1, 2, 3, 1,2,3,4). However, there may be an issue regarding updates and login time (NoCMA9, topic 5).

- For the TPP group, the discussions are about easy use, great, excellent apps (TPP, topics 1,2,3,4,5). In addition, those emotions are related to rates, money transfers and exchange rates (TPP, topics 1,2,3,4,5).

Table 14: Topics by group. NMF model was applied to extract five topics from each of the four groups (CMA9, Challenger banks, NoCMA9 and TPP). Each topic displays the ten words with the strongest weights in a bar chart. The weight of the word is its TF-IDF value in the MNF method







4.3.6 Conclusion

In conclusion, the number of reviews examination shows a significant increase in service demand in quantity, as expressed by the twofold increase in the number of reviews since the OB regulatory enforcement. Particularly, there was around a 100% increase in total annual reviews for the CMA9 group and a 200% increase for Challenger banks. For NoCMA9 small banks, the increase in the first year of OB regulation enforcement was offset by the following decrease. Lastly, the TPP group indicates a steady trend of increasing service demand, an increase above 200% from the enforcement date.

The service quality study indicated that not all groups benefit equally from OB regulations. There can be a shift in a group`s competitive advantage. The result of the DID impact statistical tests shows that the regulatory impact variable is statistically significant. The impact on service quality relative to the CMA9 group for challenger banks increased by 0.2834 points (or around 6%), TPP by 0.4633 rating

points (or around 10%). However, there is a negative impact for the NoCMA9 group by -1.2446 rating points (or a decrease of almost 30%).

Furthermore, topic extraction before and after OB regulatory enforcement indicates that the technical issues related to app performance, such as app updates, freezing, and crashes, persist even after the regulatory enforcement. However, security issues are no longer under discussion following the regulatory enforcement. Additionally, the topic extraction for each banking service group shows that customers value different aspects in each group. For the CMA9, customers prioritise security; for Challenger banks, cards and rates; for NoCMA9, app updates and login time; and for the TPP group, exchange and fee rates, along with money transfer services, are significant.

4.4 Analysis of OB regulations on switching costs and network effects in the UK banking market

Introduction

In 2016, the CMA investigation reports triggered the reform in the banking sector. It was concluded that several issues are preventing the operation of the market, such as high barriers and concentration.[743] The Open Banking ("OB") regulations were enforced to lower the switching costs, the entry barriers and open access to data.

In this analysis, it is argued that the OB regulations transforming the traditional banking system into a data-driven OB ecosystem can result in the creation of a network effect. Therefore, contrary to regulatory objectives, the impact can enhance competition only in the short term, but in the long term, the market can be consolidated due to the network effect and might fall under the scope of special sector regulations. The analysis aims to develop a method to measure the network effect and detect possible network effects after OB regulatory implementation. Consequently, an updated method was developed to measure the network effect.

The structure of the analysis consists of five sections. The issue of network effect and the regulatory approaches to regulate the effect are discussed in the first section. In the second section, the literature on existing network effect measure methods is reviewed, and another method to detect network effects is proposed. In the third section, the results of the applied method in the detection of network

[743] CMA, 'Retail Banking Market Investigation' (n 121).

effects are presented. The fourth section examines the robustness of the results by comparing them with another method. Lastly, the conclusion is drawn in the fifth section.

The result of the analysis shows that the effect on switching costs was lagged. The improvement of switching costs, as measured by the account switching number, only started in the last quarter of 2022. The lag may be caused by the COVID-19 pandemic and the delay in OB enforcement. In addition, the network effect was detected with the updated method in the interest income market with a coefficient of 3.5122 (P value = 0) and in the service fee and commission market with a coefficient of 5.07 (P value = 0).

Polynomial regressions and the Metcalfe law method were modelled in the robustness section to check the results. The results are consistent with the assumptions. The updated method is the tangent of a better-fit model, and the Metcalfe law method also found a network effect in the interest income market with U^2 coefficient of 0.00000008 (statistically significant with P value = 0.007), whereas the method could not detect network effects in the service fee and commission market (not significant with too high P value = 0.657). The result is consistent with the assumption of limitation of previous methods.

4.4.1 Network effect and regulatory problems

The network effect describes the phenomenon in a network where the growth of the user base accelerates the growth of network value.[744] The effect provides suppliers with a huge advantage in competition and is classified as an entry barrier.

In the market where the network effect exists, it can create regulatory obstacles. For example, Google dominates the search market with more than 83% market share.[745] In its derivative market of internet browsers, Google's market share constitutes more than 60%, whereas the following two biggest participants have only around 20% market share.[746] Other examples can be the operating systems market, with Microsoft Windows dominating the market, or the social network market, with Facebook capturing more than 60% of the market share.[747] The common issue in these markets is that the network effect creates an undertaking with a dominant position that has the potential of "abuse of dominant position".

Various market investigation reports by regulators and competition cases have been filed to deal with the problem.

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[744] Michael L Katz and Carl Shapiro, 'Network Externalities, Competition, and Compatibility' (1985) 75 The American Economic Review 424; Stephen L Morgan and Aage B Sørensen, 'Theory, Measurement, and Specification Issues in Models of Network Effects on Learning: Reply to Carbonaro and to Hallinan and Kubitschek' (1999) 64 American Sociological Review 694.

[745] 'Global Search Engine Desktop Market Share 2023' (*Statista*) <https://www.statista.com/statistics/216573/worldwide-market-share-of-search-engines/>.

[746] 'Internet Browser Market Share 2012-2023' (*Statista*) <https://www.statista.com/statistics/268254/market-share-of-internet-browsers-worldwide-since-2009/>.

[747] 'Social Networks Website Visit Shares 2023' (*Statista*) <https://www.statista.com/statistics/280295/market-share-held-by-the-leading-social-networks-in-the-united-kingdom-uk/>.

Argument of possible network effect in the OB ecosystem

In the Banking Competition Report 2016, it was stated that the UK banking market is too concentrated.[748] One of the given reasons was the obstacles created by incumbent banks to prevent customers from switching their accounts. The proposal to implement PSD2 was to achieve the goal of reducing the data and account switching barrier. Consequently, these regulations transform the traditional banking market into a possible platform-based market. Traditional banking involves banks operating as service suppliers and customers as server users. In the OB ecosystem, banks can act as a direct service supplier and also a platform (or ASPSP) where the TPP can connect to service customers.[749] The TPP can be PISP or ASP based on the type of service they provide.[750] In addition, an individual TPP provider can also operate as a platform. An example is the crowdfunding platform, which facilitates transactions between creditors and borrowers.[751] The illustration of the OB ecosystem is drawn in diagram below according to the OB requirements.

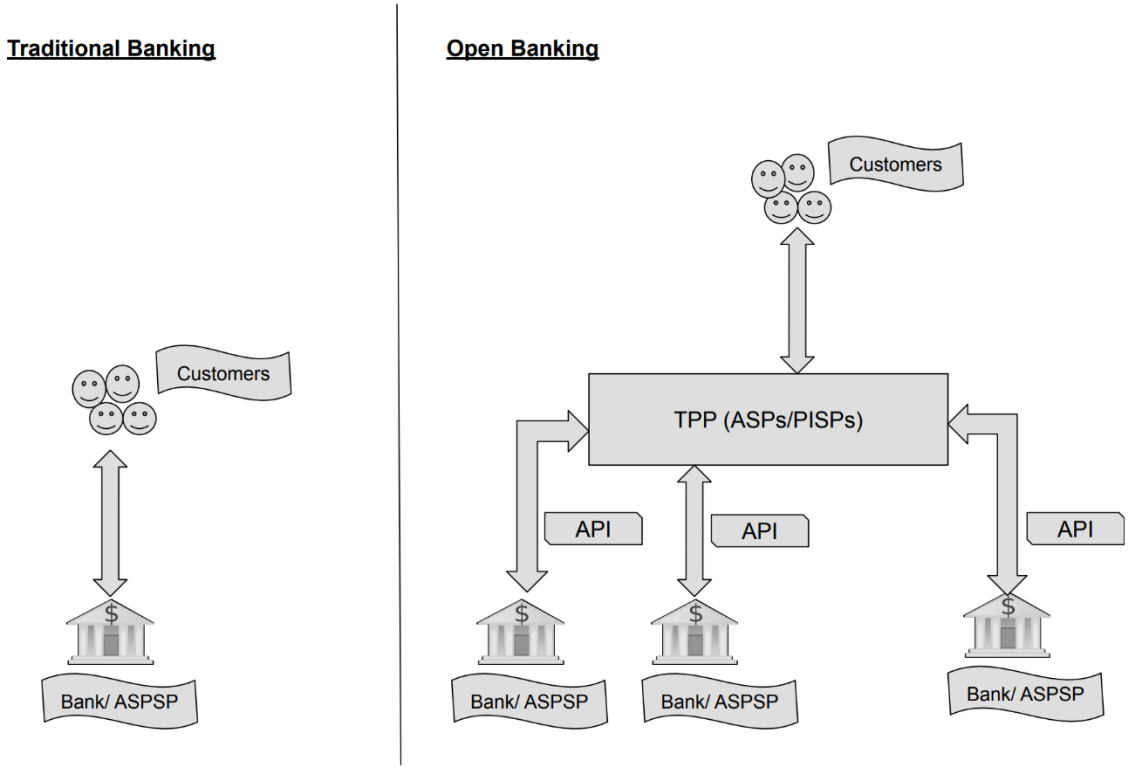
[748] CMA, 'Retail Banking Market Investigation' (n 121).

[749] Payment Services Regulation 2017 (SI 2017/752) arts 102–105.

[750] Payment Services Regulation 2017 (SI 2017/752).

[751] 'Open Banking App Store' (*Open Banking*) <https://www.openbanking.org.uk/app-store/>.

Diagram 2: The transition from traditional banking to OB. The diagram shows the difference in the model between traditional banking on the left and OB on the right. On the left is the workflow in traditional banking, where customers interact with banks directly. Distinctively, on the right, customers can interact with banks directly or through TPPs as service aggregators.



This analysis argues that the transformation of the traditional banking market by OB regulation can create a network effect. The existing method of network effect measurement will be examined to measure the effect in the OB ecosystem.

The measurement is based on the assumption that before OB regulatory transformation, there should not be a network effect in the banking industry as the market type is a traditional one without the platform. The existence of network effect in the current ecosystem should be a strong indicator of OB regulatory causation.

4.4.2 Methodology and data

In this section, the common methods of detecting network effects will be discussed, and a new detection method will be proposed. All measurement methods are based on the definition of network effects, which states that it is the effect when the growth of network value V exceeds the growth of the user base U. Consequently, the measurement can be approximated by any function U that has that property.

For instance, one of the popular methods is Metcalfe's law, which defines the effect if the value of a network value V grows at a rate proportional to the square of the number of users U ($V \sim U^2$). The function V (U^2)has the property that fits the definition of network effects, the growth of V is always faster than the growth of userbase U. Several works measure the growth of a network by applying Metcalfe's law as the reference framework.[752]

The application of Metcalfe`s law to detect network effects is utilised in various markets. In 2015, Zhang and others used data from Facebook as a worldwide example and the Chinese Tencent social network data as a Chinese example to illustrate the Metcalfe law.[753] They found the function of Facebook value V= $5.7*10^{-9}*U^2$ and the value of Tencent social network V= $7.39*10^{-9}*U^2$. The result is consistent

[752] K Stylianou and others, 'Cryptocurrency Competition and Market Concentration in the Presence of Network Effects' (2021) 6 Ledger 81.

[753] Xing-Zhou Zhang, Jing-Jie Liu and Zhi-Wei Xu, 'Tencent and Facebook Data Validate Metcalfe's Law' (2015) 30 Journal of Computer Science and Technology 246.

with the law. Another example is Peterson and van Vliet's analysis of the network effect on Bitcoin size.[754] The Metcalfe law explains about 70% of the variance in Bitcoin value.[755]

Another method is the inverse correlation measurement, based on the causation of the network effect. Due to the existence of a network effect in the market, the winner takes all. Therefore, based on this assumption of winner takes all, calculating the correlation between the parties' values can define the network causation. If there is an inverse value correlation, it means one winner takes the value of other participants. This effect can be described as the inverse (negative) correlation between the parties values.[756]

Furthermore, network effect detection can be done by comparing the changes in value V and the changes in U according to the network effect definition. In Konstantinos et al., the effect is defined as 'Network effects occur where the value of the network V grows supra-proportionately to the number of users U that participate in the network'.[757] Consequently, the change in value (ΔV) is more than the change in number of users (ΔU). To formulise the network effect, the following equation system is established:

1. Network effects occur if: [758]

Equation 1: $\Delta V > \Delta U > 0$ or $\Delta V < \Delta U < 0$

[754] Timothy Peterson, 'Metcalfe's Law as a Model for Bitcoin's Value' (2018) 7 Alternative Investment Analyst Review 9.

[755] ibid.

[756] Stylianou and others (n 753).

[757] ibid.

[758] ibid.

2. The changes Δ are harmonised through the logarithm 'ln' function, so the change at time *t is*: [759]

$$\Delta V = \ln(Vt+1/Vt)$$

$$\Delta U = \ln(Ut+1/Ut)$$

This method compares the changes in value Δ*V* and changes in customer base ΔU. If the probability of samples that fit equation 1 from the overall data samples reach a threshold, the existence of a network effect can be concluded with a certain probability.

4.4.2.1 The limitations of the methods

According to Metcalfe's law, the growth of U should accelerate the growth of value V ~ U^2. Moreover, the definition requires a faster increase in value than the increase in userbase. Therefore, the second derivative of the parabolic function U^2 needs to be found:

$$V(U) = U^2$$

$$\frac{d\ \ V}{d\ \ U} = 2U$$

$$\frac{d^2V}{d^2U} = 2$$

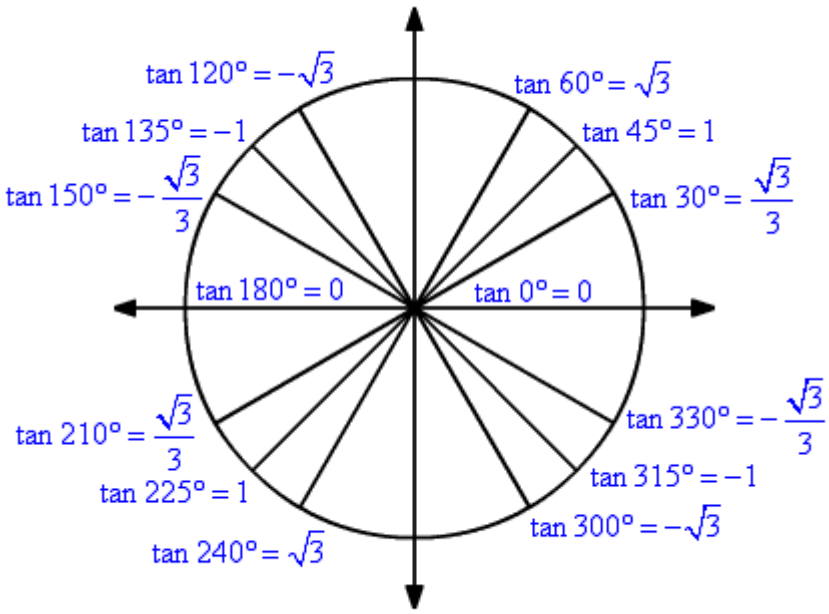
The first derivative shows whether the function is increasing or decreasing, and the second derivative shows whether the first derivative is increasing or decreasing. Therefore, if the second derivative is positive, it means the first derivative is increasing. As the first derivative is the change of function

[759] ibid.

relative to its input, the positive second derivative implies the increase of the increase of the function. It also means the acceleration. For example, there is a function distance S(t), and t is time. The first derivative, the change of distance related to time, is the speed, and the second derivative is the acceleration.

In addition, the derivative of the function is also the slope of the tangent line to the function. If the first derivative of the function is positive, the function is increasing, and the slope of the tangent line should be positive. From the Figure below, which shows the tangent value according to its slope, to show the change in V is faster than the change in U, the tangent angle should be more than 45 degrees, or the tangent value (which is also the second derivative) is more than 1 when U > 0.

Figure 22: Tangent function value. The figure shows that the value of tangent at 45 ° angle is 1, and the function value is more than 1 at the angle interval (45 °, 90 °)



Consequently, as the second derivative of Metcalf law equals two, it is always positive. So the function V ~ U^2 is accelerating and ΔV > ΔU> 0 or ΔV < ΔU < 0. Metcalfe`s law approximation fits the definition of network effect.

There is a limitation of the method. The functions that satisfy the law will fit the definition of network effect. However, not all functions that fit the effect definition are under Metcalfe law. There are other functions which have a tangent slope of more than 45 degrees and a second derivative of more than zero. These functions satisfy the network definition but do not fit the law. The example can be functions of U^3, U^4 or Exponent of U. By accepting Metcalfe law, other possibilities are excluded. The law has the advantage of approximation by saving calculation power. It would have the advantage of calculating a large amount of data, but the application of the law can dismiss other, more detailed actual representation functions of V.

The inverse correlation method has the same limitation as correlation: correlation does not imply causation. For instance, if the existence of network effects is measured by the inverse correlation method, it only indicates that the concentration of market share or market power inversely correlates with network effects. However, the market concentration toward a monopoly state does not necessarily result from network effects; it can arise from other factors such as first-mover advantage, entry barriers related to capacities and technologies, natural monopoly, or other elements.

Therefore, the existence of an inverse correlation suggests a tendency toward monopoly, and one of several reasons could be the network effect; however, there is no certainty regarding the presence of the effect.

4.4.2.2 Proposed method

Another method is proposed in this analysis, which is also derived from the definition of network effect. As the network effect occurs when the change in value (ΔV) is faster than the change in user base (ΔU), the method to define $\Delta V > \Delta U$ will be explored.

To find function $\Delta V(\Delta U)$, where $\Delta V > \Delta U$, function $\Delta V(\Delta U)$ can be divided into three possibilities. These are:

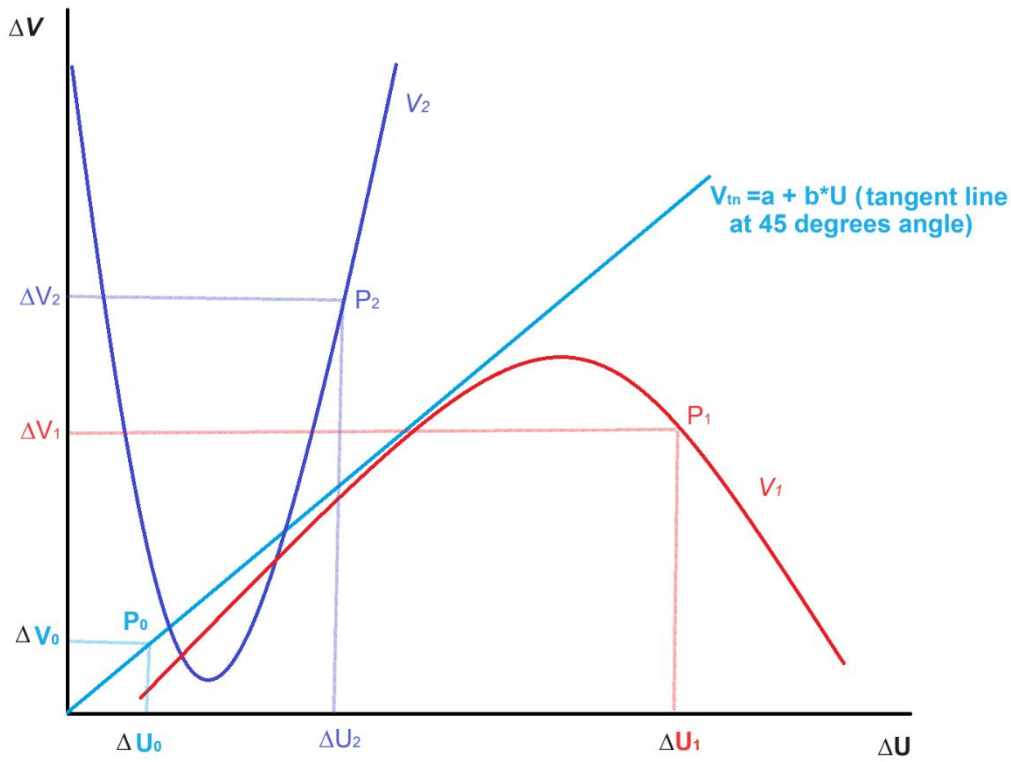
1) $\Delta V = \Delta U$

2) $\Delta V > \Delta U$

3) $\Delta V < \Delta U$.

The functions according to the possibilities are shown in the Figure 23. For the function Vtn, the tangent line at 45 degrees angle, for any points on the line P0, $\Delta V0 = \Delta U0$ as shown in the Figure. Respectively, any functions V2 above Vtn at point P2, $\Delta V2 > \Delta U2$, and function V1 below Vtn at point P1, $\Delta V1 > \Delta U1$.

Figure 23: Possibilities of ΔV(ΔU). Blue function is when ΔV > ΔU, green is when ΔV = ΔU and red for ΔV < ΔU



Let's assume the real-life representation R of changes in network value V according to the changes in userbase V as function ΔV= R(ΔU). Based on the real-life samples, a linear regression ΔV = a + b*ΔU is constructed. There will be two possibilities: the first one is that R is a linear function, and the second is that R is not linear. In the first scenario of linear R, R = a + b*ΔU as R is linear. In the second scenario, R is not equal to a + b*ΔU. However, a + b*ΔU can be constructed as the tangent line of R.

Next, finding the first and second derivatives of a+b*ΔU can provide information about the speed and acceleration of ΔU. The first derivative is b, so if b>0, then ΔV is increasing. The second derivative is 0, which means no conclusion about acceleration. To understand the speed of ΔV relative to ΔU, from Figure 23, ΔV > ΔU if the slope of the tangent line is more than 45 degrees or the tangent is equal to one (see Figure 22 about the tangent value).

In conclusion, if ΔV is linearly dependent on ΔU, the network effect occurs if b>1, where b is the coefficient from linear regression ΔV = a + b*ΔU. This also means that the slope of the regression is more than 45 degrees.

In addition, the method used in this analysis is based on approximating a linear regression between the changes in value (ΔV) and changes in userbase (ΔU). The first coefficient in a regression is calculated as the tangent of the real function. Therefore, regardless of the type of the real V(U) function, whether linear or non-linear, if the slope (the first coefficient) is greater than 45 degrees, this indicates that ΔV > ΔU, which can serve as an indicator of the network effect.

4.4.2.3 Application of the method

In the case of OB, the income data is applied as a proxy for the value as participants in the OB ecosystem compete for the income. Two main components of income will be examined. The interest income represents the money creation market. The fee and commission income represent the derivative financial product market. The user base is the number of clients in the bank. The data on changes of clients (ΔU) is obtained from the account switching number on the CASS website. The regression model for the network effect will be:

$$\Delta V = a + b * \Delta U + \varepsilon,$$

Where:

$$\Delta V = Vt+1/Vt - 1$$

$$\Delta U = Ut+1/Ut - 1$$

and

t – is the period,

V – is the income. Financial data is obtained from the BankFocus database.

U – the approximation of the userbase and data on the account switching number is obtained from CASS.

ε – is the random error

4.4.3 Data

The data on network value are customer deposits, total assets, interest income, fees and commissions, and other incomes. These data were collected from the BankFocus database from 2017 to 2022, with a total of eighteen banks and their subsidiaries. They represent about 90 per cent of market share. Data is stored in the file "Vo_207055762_Third testnetwork effect.csv". The Python is in Appendix H (Network effect analysis- Python Code).

The data on the user base and the account switches is collected from the CASS website. The data represents the number of account switches in the period from the second half of 2018 to 2023 for around eighteen banks and their subsidiaries.

Notes

There are some notes on the financial data and account switch data. The complete list is in Appendix D (Notes on the statements). Firstly, the corporate structure of the banks was different before 2018. Since 2018, the ring-fence regulation has been implemented, requiring banks to separate UK customers' deposits from overseas assets. Therefore, some financial reports from 2017 are not consistent with those from 2018 due to the restructuring mandated by ring-fence regulations.

Secondly, the corporate structure of the bank is not standardised. Some bank holdings separate their brands into subsidiary companies or group them into one entity. Their financial reports include both consolidated and unconsolidated data. Therefore, to address this issue, data collection relies on the consolidated report, and brands are categorised according to this report. However, since the report is consolidated, there may be additional services beyond the core services.

In addition, there was an acquisition of Virgin Money by Clydesdale Bank Plc in 2018. The reports for both brands are under Virgin Money from 2019. More details on the banking group structure and its financial statements are in Appendix D.

Lastly, there are two notes on account switching numbers. Firstly, the data on switches for the first quarter(Q1) of 2019 is missing, so it was replaced by the average of Q4 2018 and Q2 2019. Secondly, the total number of current and savings accounts and the total deposit in 2017 were used as a proxy to calculate the user base (total number of clients in the bank) in the next period.

To address the above problems, the financial reports were first manually filtered by report type-consolidated or unconsolidated. The financial data of affiliated banks and the bank`s acquisition were aggregated to align with the banks' corporate structure for data switching. Additionally, to normalise the switching account data and financial reports, only data from 2018 was selected since the OB was enforced that year; thus, this data can provide insights into OB enforcement. However, no data exists before 2018 for comparison regarding the network effect, which diminishes the test's robustness. Secondly, the missing data for Q1 2019 on account switching was replaced by the average of Q4 2018 and Q2 2019. This method estimates missing data without creating outliers that could distort the regression. Given that there is only one missing data point, observations of the other data in 2019

show no spikes in revenue, costs, or other parameters, indicating a stable environment. Therefore, the average was applied to the missing point for this period; a different method should be employed if a data point is missing in 2020 due to COVID. Lastly, banks do not consistently report the number of clients. For instance, the number is shown in 2018 but not reported in 2020. However, the number of switching accounts detailed from bank to bank is provided, allowing the user base (number of clients) to be calculated from the data in the 2018 financial report, adding or subtracting each period based on the account switching data. The calculation is as follows.

The user base of the individual bank is approximated as the bank`s share of average deposit per account to the bank`s total deposit:

$$U_{i,t} = \frac{Deposit_{i,t}}{Average\ Deposit_t}$$

Where:

$$Average\ Deposit_t = \sum_{n=1}^{n} Deposit_{i,t}/U_t \ ;$$

$$and \quad U_t = U_{t-1} + \Delta U$$

- Number *i* is the index of the individual bank, i is from 1 to n, where n is the total number of banks.
- Number *t* is the time period. The range is from 2017 to 2023.
- $U_{i,t}$ is the user base of ith bank at the period t.
- $Deposit_{i,t}$ is the customer deposit of ith bank at the time t.
- $Average\ Deposit_t$ is the average sum of deposits per customer
- U_t is the user base of all banks in the industry, which is the total number of customers account at period t.

4.4.4 Statistical Results

The data used in the analysis is collected from the bank`s annual financial reports. There are 102 samples of 18 banks from 2017 to 2022 (see the table below). In each sample, the bank name, year of the financial report, customer deposit, interest income, fee and commission income, other total income, and the number of bank switching accounts for that year are stored. In addition, the banks are grouped into CMA9 (the nine biggest banks under OB regulations), Challenger banks and other non-CMA banks.

Table 15: Data description. The table describes the variables collected from annual reports. These variables are company name, group, year of report, deposit at the bank and other financial data.

	Company	***Group***	***Year***	***Customer deposit***	***Interest income***	***Fee inc.***	***Other income***	***Switch/ year***
Count	102	102	102	101	102	101	101	85
Unique	18	3	0	0	0	0	0	0
Top	RBS	CMA9	0	0	0	0	0	0
Freq	6	66	0	0	0	0	0	0
Mean	N/A	N/A	2020	108,421,083	3519880	396,924	750,958	173
Std	N/A	N/A	2	122,844,278	4157863	518,478	1,181,666	33,768
Min	N/A	N/A	2017	0	0	-51,000	-61,000	-69,067
Max	N/A	N/A	2022	449,373,000	16562000	1,762,000	5,000,000	128,167

4.4.4.1 Analysis of switching cost as an entry barrier

One of the objectives of OB regulations is to open data and reduce account switching costs. Theoretically, the opening of data access can enhance competition. Additionally, with a reduction in switching costs, customers will be more likely to switch their accounts to better service providers. The data on switching accounts collected from 2018 shows that, contrary to expectations, the number of

switching accounts dropped significantly after the implementation of the OB regulation (see Figure 24 and 25). The drop has only recovered from the third quarter of 2022 (see Figure 25).

The reason for the account switching number drop is not apparent. To outline the drop in the UK, the account switching data in the UK should be compared to data from other jurisdictions to understand whether the cause stemmed from OB regulations or other factors. We speculate that the drop in switching numbers can be due to the COVID-19 pandemic. The number drops significantly from the second quarter of 2020, which aligns with the beginning of the COVID-19 spread (see Figure 25). The recovery of switching numbers ends in the third quarter of 2022, which is also the end of the pandemic (Figure 25). However, switching data from other jurisdictions needs to be collected to test the hypothesis.

The drop in switching numbers from 2020 to 2022 can be caused by external factors such as the pandemic. Excluding the COVID-19 pandemic, the switching number has increased by around 30% from the end of 2022 compared to the period before OB regulatory enforcement.

Figure 94: The annual number of switching accounts for all banks. The graph shows a massive drop in switching accounts in the years of the pandemic 2020-2021.

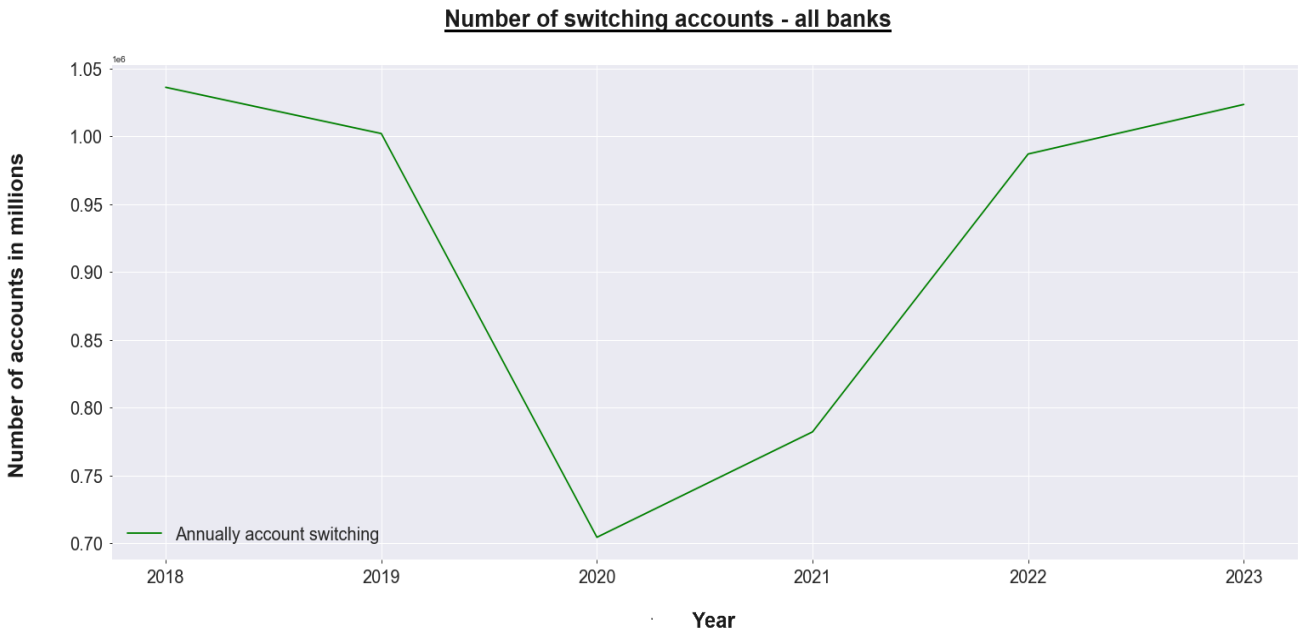
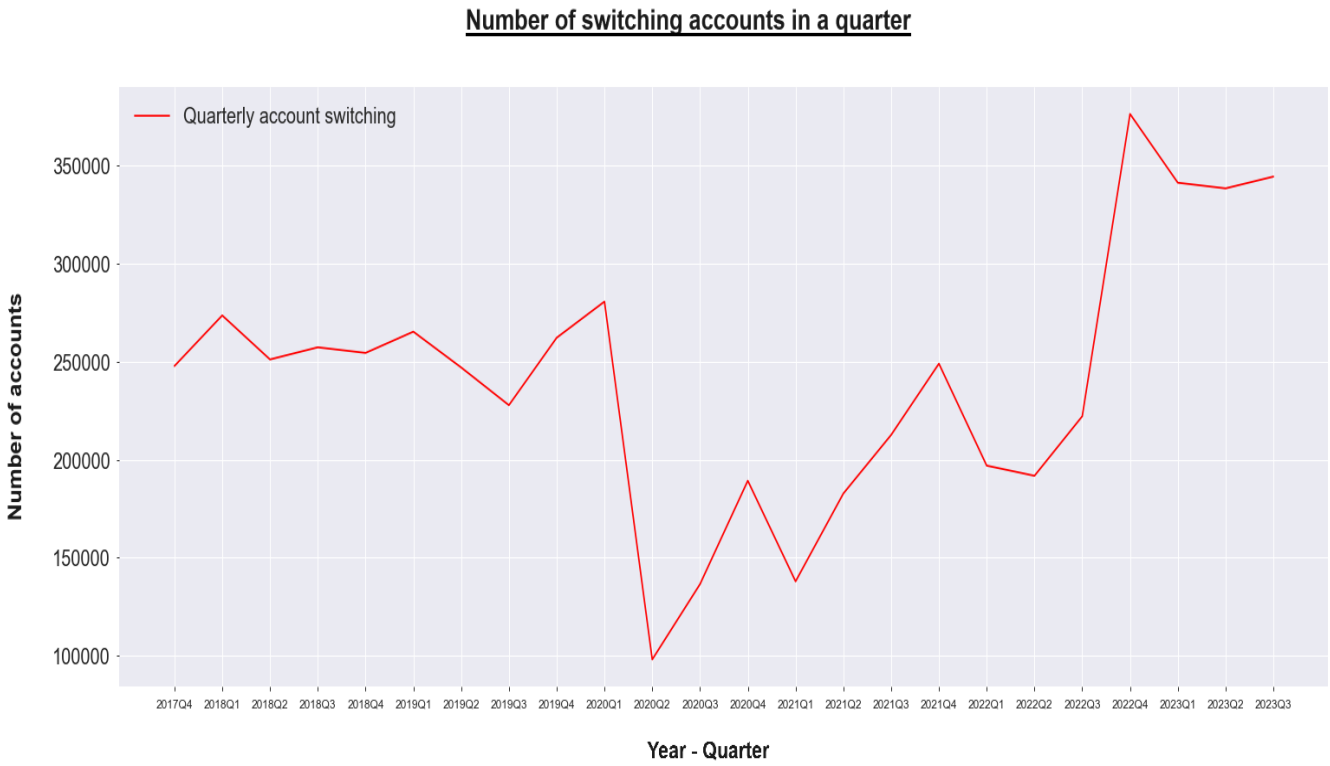


Figure 105: Quarterly number of switching accounts for all banks. The graph shows a massive drop in switching accounts in the years of the pandemic 2020-2021.

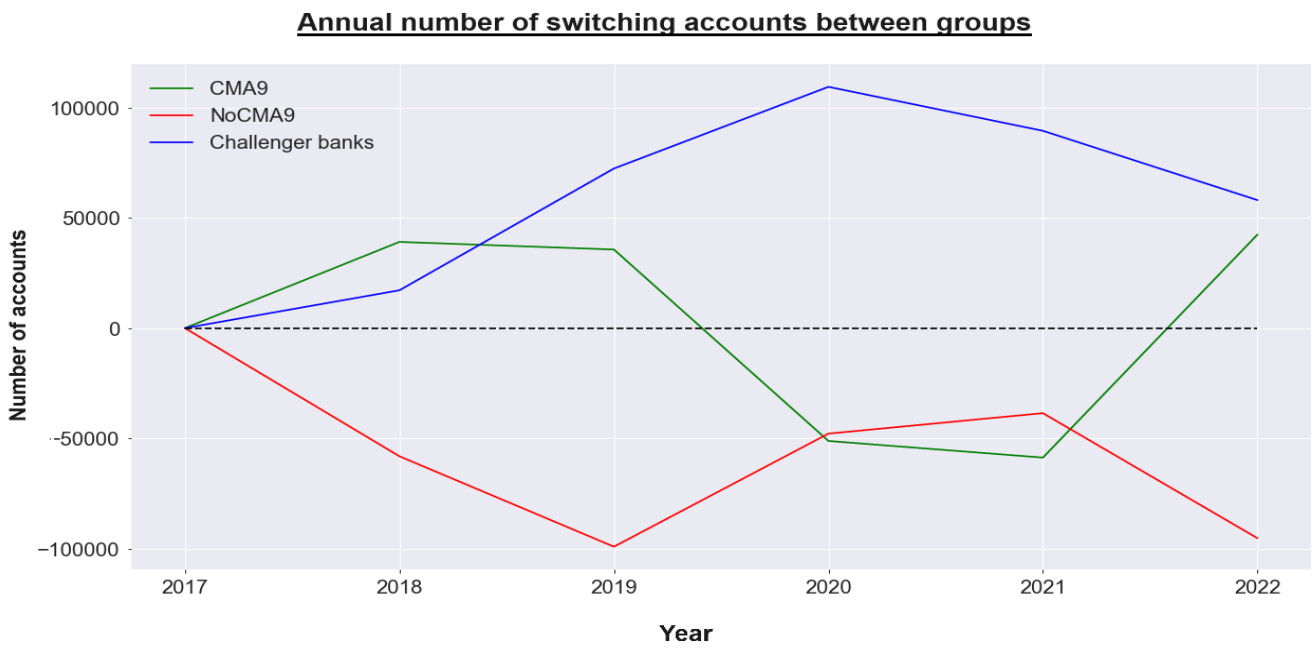


The account switching between banking groups (see Figure 26) illustrates a pessimistic future for small banks with technological disadvantages. Since the implementation of OB, customers from CMA9 and NoCMA9 groups have switched their accounts to challenger banks. For the small banks of the NoCMA9 group, the net customer switching has been negative every year for the last 4 years of OB regulatory implementation. The group's net loss is about 350 thousand accounts over the past four years. These negative trends are increasing and may threaten the viability of the banks. The challenger banks are the most favourable group, enjoying the influx of new accounts. The net account switching is positive; it has around 370 thousand accounts. The last group is the incumbents. Nine of the biggest CMA9 banks suffered net negative account switching in the first few years of OB implementation. However,

it has recovered in 2022. The total net account switching number for CMA9 from the start of OB is marginal, with around 20,000 negative accounts.

In conclusion, the implementation of OB regulation in the last four years has not met the expectations of the regulatory objective. The number of switches did not increase; on the contrary, it dropped significantly. It was not until the end of 2022 that account switching began to improve. This effect may be due to the delay in OB regulatory implementation, its lagging impact, or the potential influence of the COVID-19 pandemic during 2020-2022. The data on group account switching demonstrates that the most advantageous group is challenger banks, with a net positive of 370 thousand switching accounts, while the least advantageous group is the small NoCMA9 banks, with a net negative of 350 thousand switching accounts.

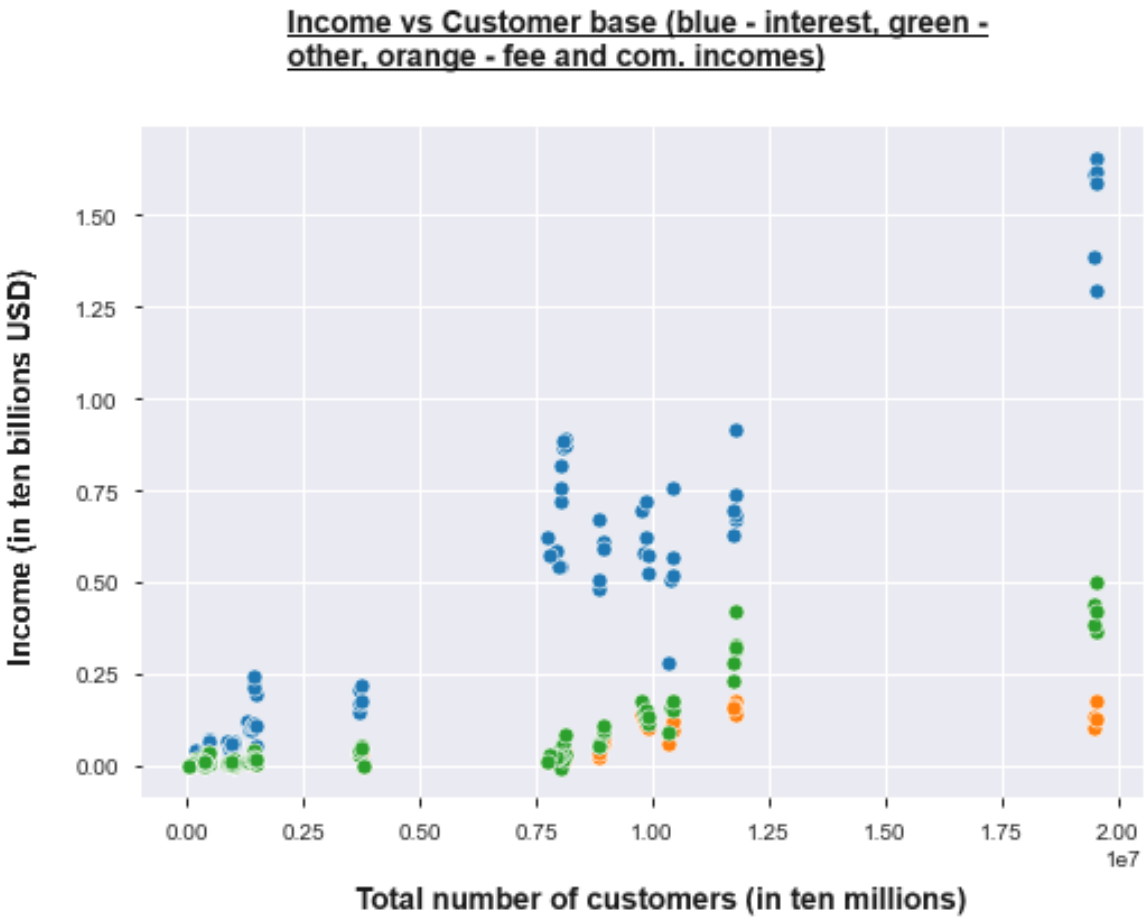
Figure 116: The annual number of switching accounts between bank groups. Note: The annual data in 2017 started with 0 because the data collection starting point is Q4 2017; therefore, the algorithm replaced the beginning of 2017 with 0. For more details, see Figure 26 about quarterly data.



4.4.4.2 Network Value and User-base Data

In this section, the data is examined to detect the existence of the network effect. Firstly, the data distribution will be assessed, and then the correlation between network value V and the user-based U will be defined to outline the possibility of network effect. Lastly, if the correlation is significant, the effects will be measured.

Figure 27: The pair plots income and customer base. The Figure shows a positive correlation between income and the user base.



There is a correlation between the number of customers and the income from the above pair plot. The more customers the bank has, the higher its income. The trend is likely a linear regression with a straight line. The highest increase related to the customer base is the interest income, followed by the total other income, and lastly, the fee and commission income. The Pearson correlation can be calculated to define the strength of the linear correlation between income and customer base.[760] The result shows the high correlations between incomes and customer base (see Figure below). Furthermore, to illustrate that the increase of V is faster than the increase of U, a linear regression will be constructed.

Table 16: Pearson correlation result. The table shows Pearson correlation and p-value for the customer base U and three types of income V (Interest income, Fee, commission income and Other income). The result shows that all incomes are highly correlated to the customer base

	Pearson Correlation	***P-value***
Interest income	*0.941*	*0.000*
Net fee, commission income	*0.826*	*0.000*
Total other income	*0.861*	*0.000*

4.4.4.3 The network effect in interest income and fee, commission markets

In addition to the correlation between user base U and value V, the changes in U should be lower than in V to define the network effect. First, the linear dependency of ΔV on ΔU will be checked by data visualisation. Then, afterwards, the linear regression will be constructed. Lastly, the regression result will be interpreted along with data visualisation to illustrate whether there is a network effect or not.

[760] 'Scipy.Stats.Pearsonr — SciPy v1.11.3 Manual' <https://docs.scipy.org/doc/scipy/reference/generated/scipy.stats.pearsonr.html>.

Furthermore, as the OB regulations require AISPs to open data access to other providers, we assume that OB regulations impact both the interest income and fee and commission markets. It is also possible that the impact will be more significant in the fee and commission market than in the traditional interest income market.

The reason is that the interest income market depends on the amount of money from the credit/loan creation mechanism and the interest rate, whereas the fee and commission market depends on the demand for financial services. In addition, OB regulations regulate the provision of financial services. There are some regulations on capital requirements in addition to additional service provisions; however, OB regulations do not regulate the core credit/loan creation market. Consequently, the two separate markets, interest income and fee commission income, will be examined.

4.4.4.4 Data visualisation

The ΔV and ΔU for all banks show that the percentage changes are concentrated in the area near zero (see Figure 29). Therefore, the regression's upward slope is inconclusive as the data outside the central area is small. Further examination for CMA9 and challenger banks will be conducted. For the CMA9 group, both the interest income and the fee commission markets show a small upward slope (see Figure 30). This indicates an insignificant network effect.

Figure 29: The changes of value V in terms of income for all banks. The changes are presented as a function of changes in customer base U. In the left table, the blue dots represent changes in interest income, and the orange dots represent fees and commission income. The right tables are regression predictions for changes in interest income and fee income.

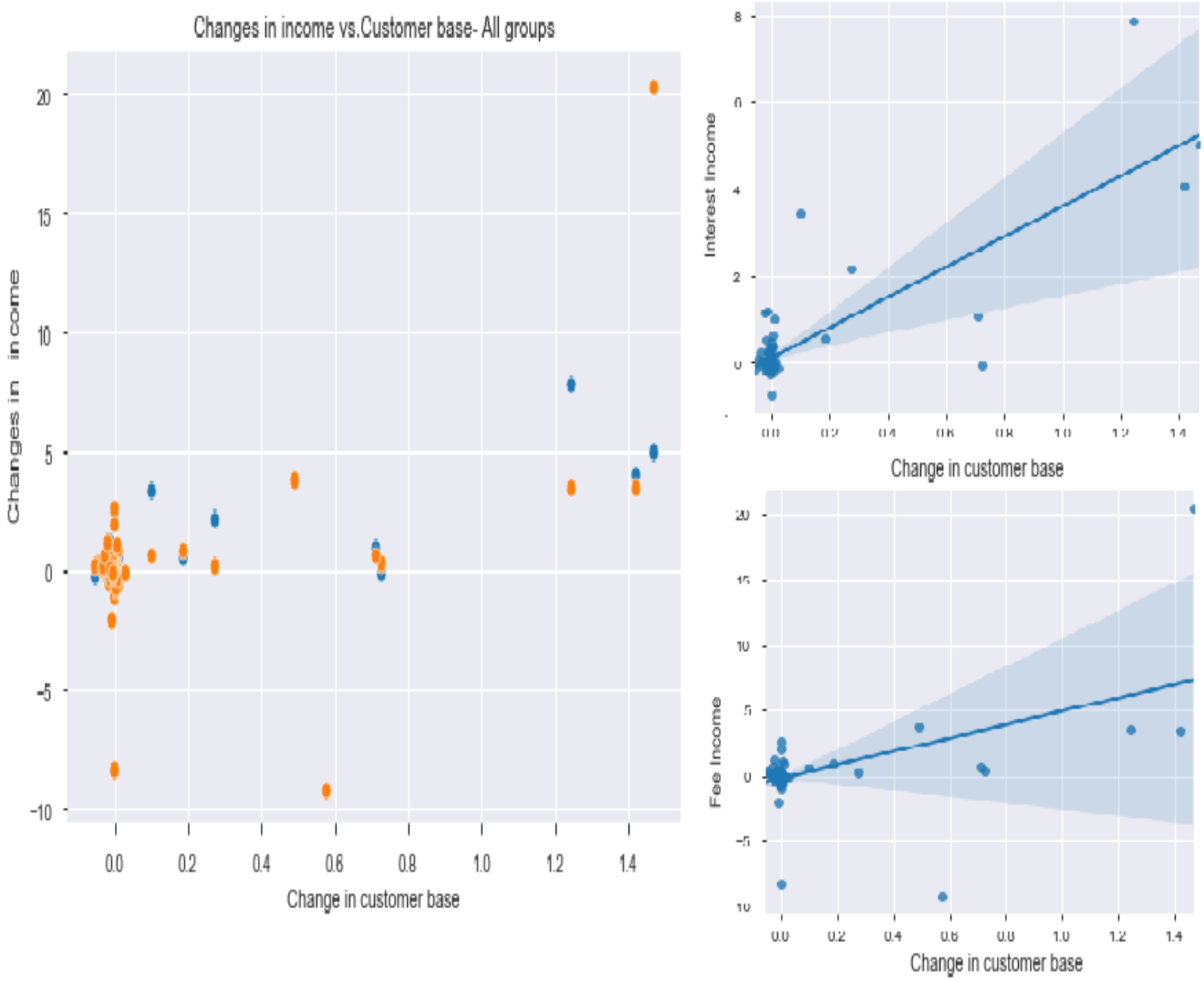
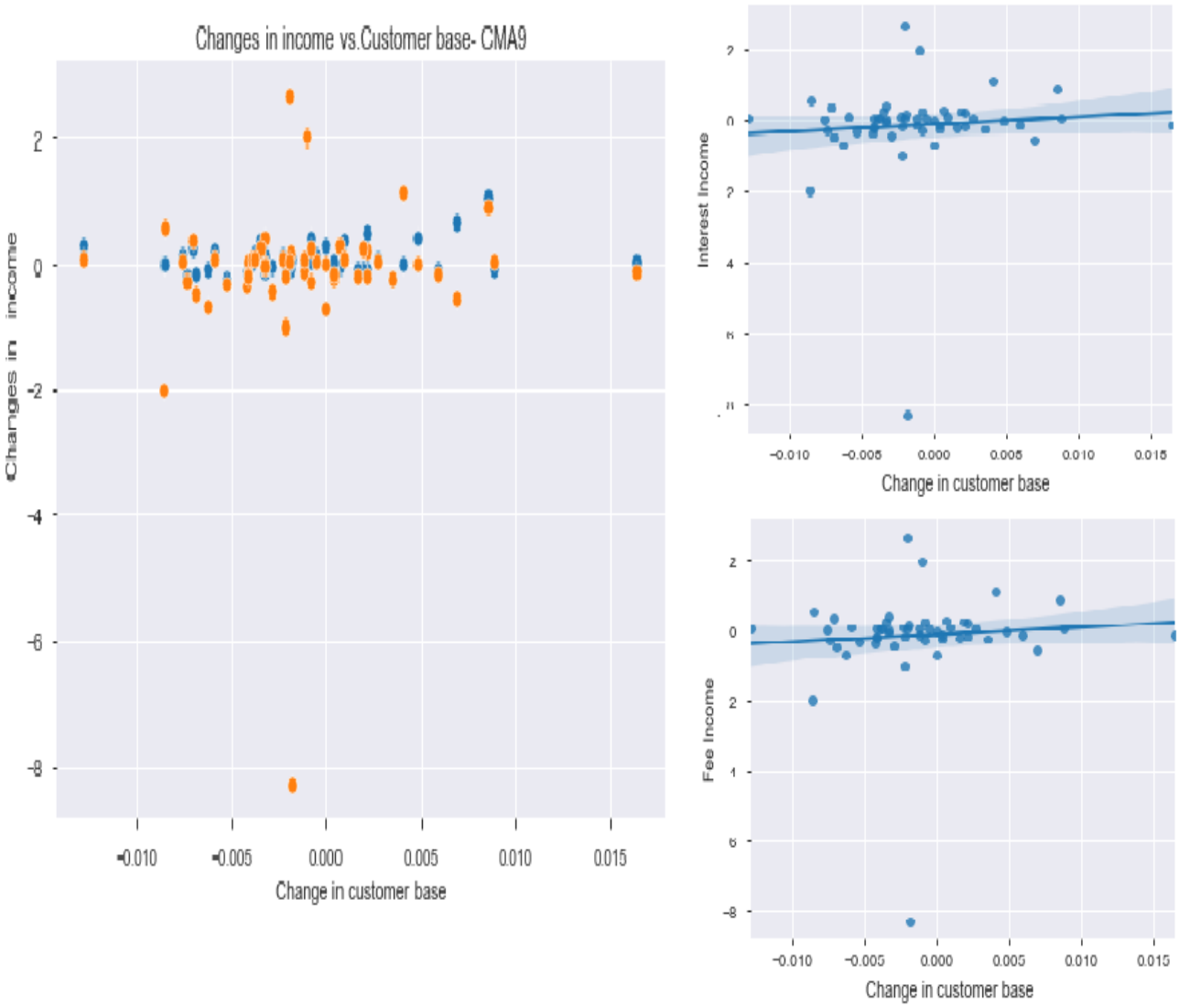


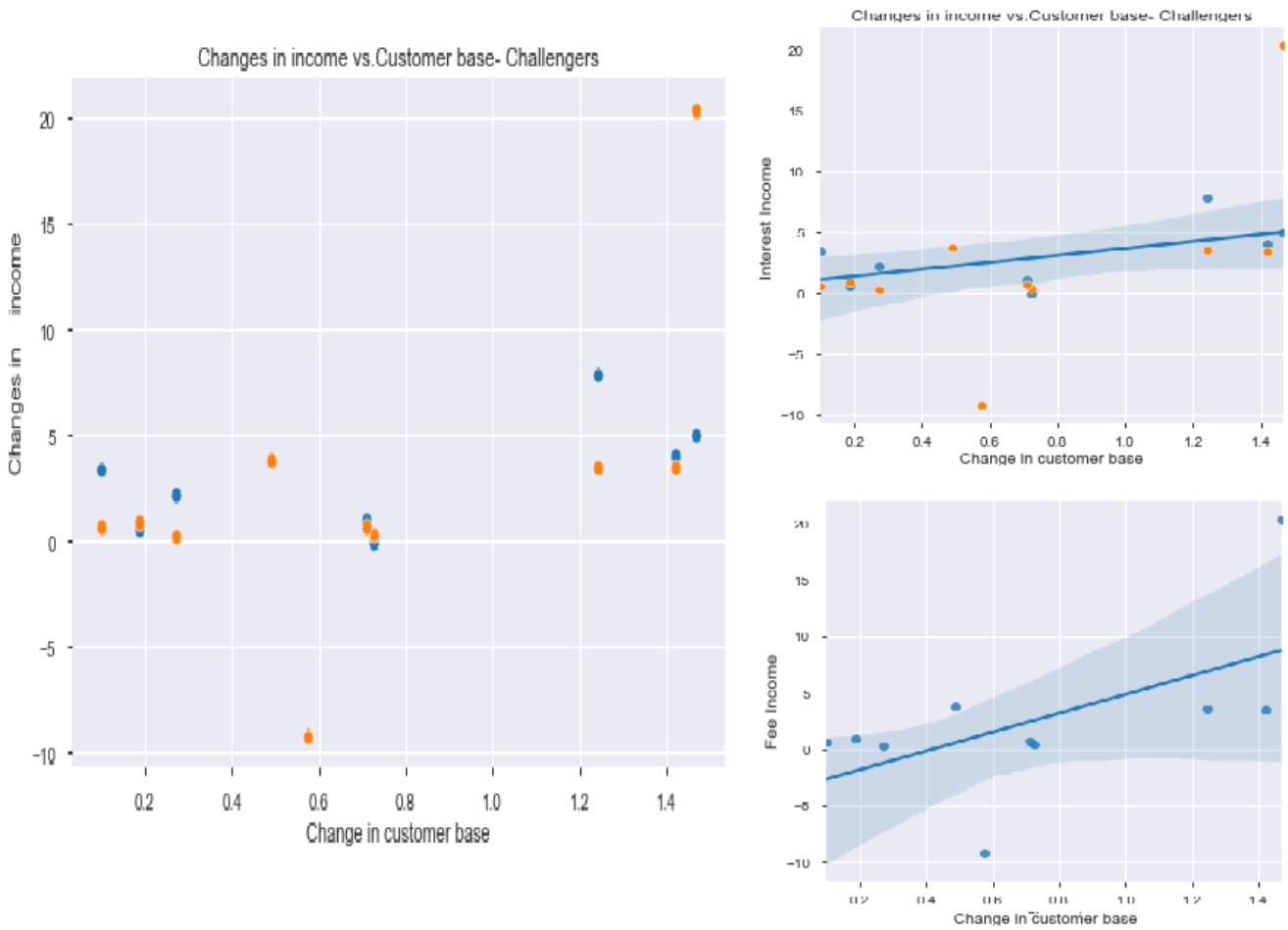
Figure 30: The changes of value V in terms of income for banks in the CMA9 group. In the table, the changes are presented as a function of changes in customer base U. In the left table, the blue dots represent changes in interest income, and the orange dots represent fees and commission income.



The data for challenger banks in the figure below indicates a high network effect, especially for the derivative product market (fee and commission income). The change in user base (ΔU) produces a

significant increase in income (ΔV). However, the number of observations is limited. It is possible that with more observation, the regression will change.

Figure 31: The changes of value V in terms of income for banks in the challenger banks. The changes of value V are presented as a function of changes in customer base U. In the left table, the blue dots represent changes in interest income, and the orange dots represent fees and commission income. The right tables are regression predictions for changes in interest income and fee income.



4.4.4.5 Network Effect Measurement Result

The linear regressions for all groups and the specific groups (CMA, NoCMA and Challengers) are displayed in the table below. The result is analysed in conjunction with data visualisation. It is statistically probable that there is a network effect in the banking industry, in both the interest income and the service fee commission market, as the results show a high probability of network effect for all groups. Both market userbase ("U") coefficients (5.07 and 3.5122) are higher than 1 and statistically significant (P>|t| are near zero).

The network effects are defined as when the growth of V, the value in the network, is faster than the growth of U, the network`s user base. The method for finding the first coefficient of parameter U involves defining the speed of change of U compared to the change of V. There are two markets that we are interested in: the first is the money creation market, where the value is expressed in the interest fee; the second is the service market, which is reflected by commissions and other fees collected. There are a total of four groups of service providers that are the subjects of investigation. We want to know how strong the network effects are for all service providers and for each group.

The linear regressions for all groups and the specific groups (CMA, NoCMA and Challengers) are displayed in the table below. All banks in OB are measured by the group "ALL Banks". The regression shows a strong network effect in the money/loan market (interest income) with userbase ("U") coefficients of 3.51 (higher than 1) and statistically significant (P>|t| are near zero). Moreover, the presence of network effect is the same in the service fee commission market; the market coefficient is 5.0708 and statistically significant (P>|t| are near zero).

For the individual bank`s group, the most substantial network effect is found in the challenger banks, with a User-base coefficient of 10.2 for the service fee and commission market and 8.19 for the interest income market. The effect for the CMA9 and NoCMA9 groups is insignificant (as P>|t| is above 0.05). Notably, the NoCMA9 group can bear adverse effects from the network effect (coefficient for interest income is -7.6689). This can mean that small banks have less advantage in a market with a network effect. However, the network effect coefficient for the NoCMA9 group in the money/loan market has a high value (P = 0.771), indicating statistically insignificant differences in the coefficient.

Table 17: Userbase growth by banks group. The result of the linear regression method indicates a network effect if the user-base coefficient is more than 1. The "Group" column shows which bank group the method was applied to. The "Market" column is the market in which the detection method was used, it can be either the interest income or the service fee and commission market

Group	Market	Userbase Coeff.	Std. err.	P>|t|
All Banks	Fee and commission	5.0708	0.907	0
	Interest income	3.5122	0.279	0
CMA9	Fee and commission	19.3571	36.012	0.59
	Interest income	10.8897	7.052	0.12
NoCMA9	Fee and commission	-7.6689	4.626	0.11
	Interest income	-1.5832	5.359	0.77
Challenger	Fee and commission	10.2142	4.994	0.08
	Interest income	8.1948	3.575	0.07

4.4.4.6 Robustness of the results

A second and third-order polynomial regression of $\Delta V \sim \Delta U$ for the interest income market (Figure 32A) and fee commission market (Figure 32B) shows that those regressions are above the first-order (linear) regression. The linear regression approximates the tangent of the second and third order. In addition, the R-squared for second and third-order regression is higher than the linear, which means they better

explain the model than the linear. The result is consistent with the assumption that the linear regression of ΔV~ΔU is the tangent of a better-fit model.

To illustrate the consistency of the method, a second-order polynomial regression of V ~ U^2, the Metcalfe law, is modelled. The result of Metcalfe law (V ~ U^2) shows a network effect in the interest income market (see the table below). The user coefficient is 1.11E-08 with a high statistically significant P>|t| = 0.007, whereas the network effect in the fee and commission market is not apparent, as the P value is high. The result is consistent with the assumption of the limitations of previous methods.

Table 18: The result summary of V ~ U applied by three methods: linear regression, Metcalfe law method (2nd order polynomial) and 3-rd order polynomial for Interest income and Fee and commission markets.

Model (V ~ U)	**Market**	**User Coefficient**	**P>|t|**
Metcalfe law (2-nd order polynomial)	Fee and commission	-0.000000000387	0.657
	Interest income	0.0000000111	0.007
3-rd order polynomial	Fee and commission	-0.000000000000000529	0
	Interest income	-0.0000000000000287	0

Figure 32A: The result ΔV ~ ΔU applied by three methods: linear regression, 2-nd order polynomial and 3-rd order polynomial for the Interest income market.

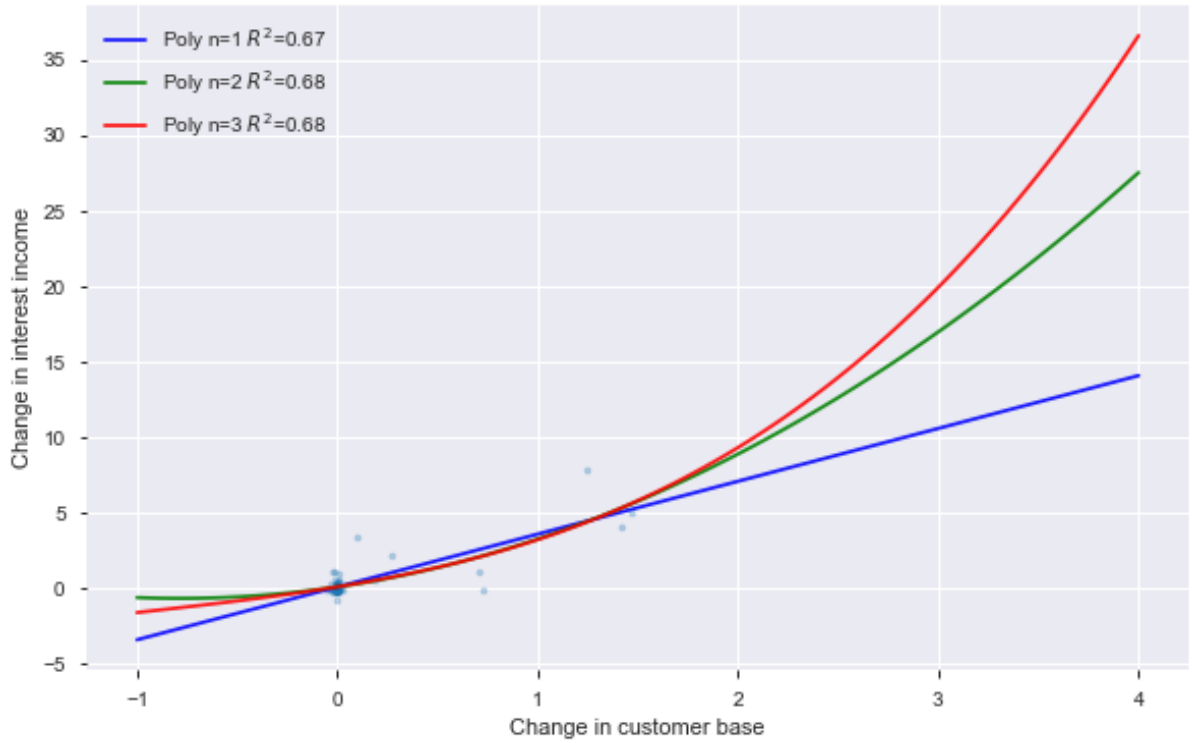
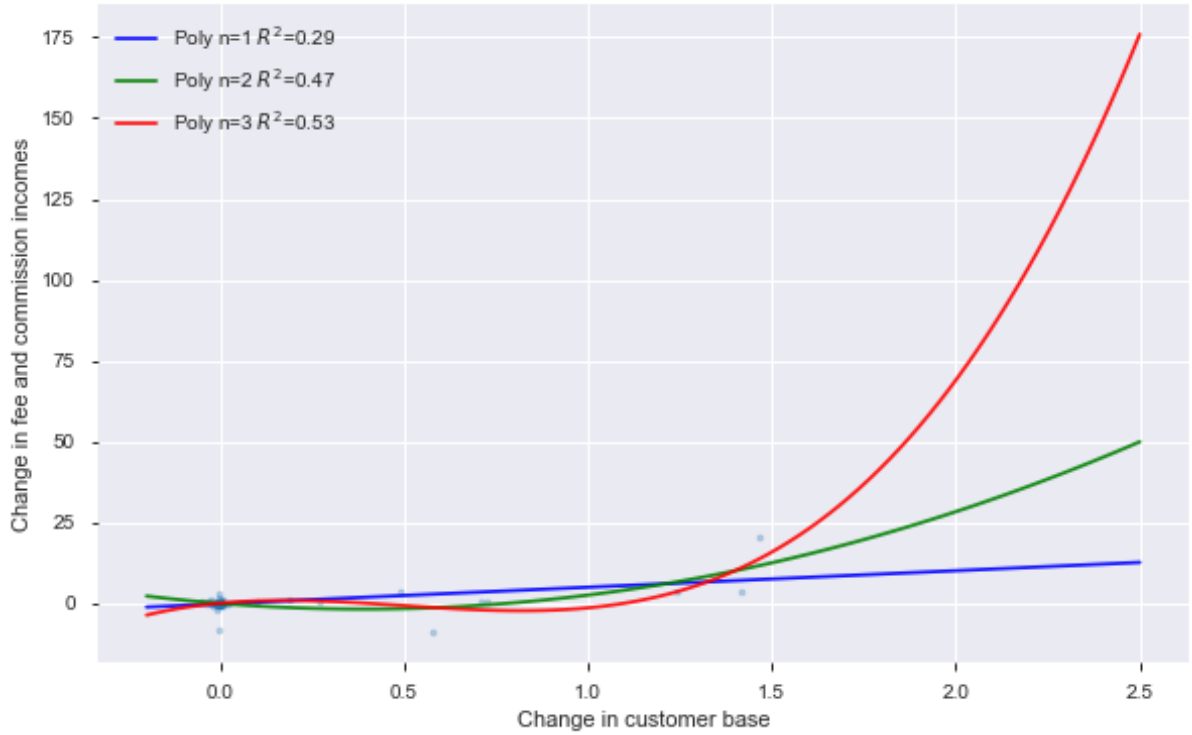


Figure 32B: The result ΔV ~ ΔU applied by three methods: linear regression, 2-nd order polynomial and 3-rd order polynomial for service fee and commission market.



4.4.5 Conclusion

The analysis of switching costs reveals that, in the first four years of OB regulatory enforcement, the objective of reducing switching costs has not been achieved. The account switching number was applied as the proxy for switching costs. The reduction was only achieved in the last quarter of 2022, with around a thirty per cent increase in switching numbers. There was a significant drop in switching numbers from 2020 to the third quarter of 2022. The reason may be the delay of OB implementation and its lagging effect. It is also possible that the drop was caused by the widespread spread of COVID from 2020 to the end of 2022.

For the switching costs between market groups, the analysis illustrates that the most advantageous group is challenger banks with a net positive 370 thousand switching accounts from the date of OB regulatory enforcement, and the least advantageous group is the small NoCMA9 banks with a net negative 350 thousand switching accounts. Therefore, based on the fact that switching account flows from NoCMA9 banks to challenger banks, OB regulation has shifted the competitive environment. It has negative effects on small, less technological banks and benefits technical banks the most.

In addition to switching costs, the linear regression method, which calculates the growth of the network compared to the userbase growth, detected the network effect in the interest income, service fee, and commission markets. In the robustness tests, the Melcafe law and other polynomial methods were applied, showing a consistent result. It shows that the second and third-order polynomial regressions fit better than the linear regression and lie above the linear regression. This means that the V(U) function lies above the tangent line represented by the linear regression. In other words, polynomial and Metcalfe estimations also satisfy the condition $\Delta V > \Delta U$. The application of the Metcalfe law

method also detects network effect in the interest income market (the coefficient is 1.11e-08), whereas in the fee and service market, the effect is not clear as the P value equals 0.657 and the coefficient is negative. As such, the negative coefficient can be rejected; to show the effect, the coefficient should be positive. However, rejecting the negative coefficient does not mean that the coefficient is positive. It can be zero or fall in the situation described in the method limitation section. The Metcalfe law is the approximation of V from U^2, the model can miss the network effects expressed in a function in which the tangent of ΔU is between (1,2).

To sum up, the OB regulations have dramatically changed the competitive environment. The regulations reduced the data barrier and switching costs expressed in switching account patents. As a result, the banking system could transform into a data-driven ecosystem with a network effect. Several methods were applied to measure the growth rate of network value compared to the rate of user base according to the effect definition. The preliminary analysis based on data from 2018 to 2023 indicates a statistically significant coefficient of network effects. The biggest beneficiary group is technologically strong banks; the least advantageous group is small NoCMA9 banks. Network effect provides a considerable advantage for big data-driven platform companies such as Google, Apple or Facebook if they enter the OB ecosystem. The OB ecosystem is only in the early stages of development; however, in the future, there may be consolidation of the market due to this effect. In terms of social welfare, if it is not regulated, there is a potential for abuse of market power to affect consumer surplus and choices because of the network effect.

In the next test, analyses of market concentration and market power will be conducted to examine the results of the network effect. Stronger market power and concentration can support the existence of network effects; conversely, decreasing concentration and market power will contradict the presence of network effects.

4.4.6 Limitation

There are several limitations in this research, stemming from data limitations and method approximations. Firstly, there is no individual bank data on the number of switching accounts before the OB implementation (year 2018). In addition, some approximations were calculated to replace the missing point in 2018. Secondly, no account switching data is available from other jurisdictions that have not enforced OB regulations. Therefore, it is not possible to construct a control group to define a more detailed OB impact on the network effect. Lastly, the number of samples is small, and the regulatory enforcement period may not be long enough. Seventeen UK banks capture more than 90 per cent of the market and report the account switching number, and the duration of OB enforcement is only five years from 2017 to 2022. Therefore, there are only 105 samples of annual reports in the period of OB regulatory enforcement. Network effect measurement can be revised several years later with more data samples.

4.5 Open Banking regulatory impact on banks' operations and market power

Introduction

This section examines the effect of OB regulations on banks' operations, including revenue, costs, profits, and market power in the UK.

The above impact factors are developed from the historical contexts of three schools of thought. The Harvard structure-conduct-performance ("SCP") hypothesis states that the industry structure determines the competitive conduct and performance of firms within that market.[761] Under this hypothesis, more concentrated industries will be less competitive as the opportunities for collusion improve.[762] The further development of competition theories by the Ordoliberal and Chicago schools describes the impact of regulations through several additional factors. The measurement of market power is not merely the concentration but also the combination of the bank`s operations in terms of revenue, costs, and profits. Under economic theories, the combination of factors and the definition of market power led to the construction of market power indexes such as HHI, Lerner and Boone indexes. The assumption of regulatory impact predicts that the OB regulations reduce the data, service barriers and switching costs. As a result, the market can be more competitive, and the impact will be reflected in the market power measurement.

[761] Bain (n 478).

[762] Sebastian J. A. de-Ramon and Michael Straughan (n 575).

Understanding the regulatory impact on a bank`s operations and its market power can assist regulators in drafting regulations that shift the market toward efficiency through the competitive environment or enhance consumer protection if necessary. In addition, businesses can adapt their strategic behaviour according to the competitive environment.

The structure of the analysis comprises four sections. The first section describes the data collection. The methodology is described in Chapter Three. The second section is the analysis of regulatory impact on banks' income, costs and profits. The third section is the examination of the regulatory impact on market power. Lastly, the conclusion is in the fourth section.

The limitation of OB regulatory impact on the above financial factor is that DiD impact coefficients have a low P-value. This is due to the aggregation of financial factors by country, which limits the number of samples in the control group. Nevertheless, the analysis shows that OB regulations might have reduced the operating costs by £5.1 billion and the staff expenses by £1.2 billion. The reduction of the expenses can be explained by the net benefit of the adaptation of new technology developed by the OB regulations over the costs of new investment in OB. The money creation market might have a surplus of £2.2 billion for income. This can be an indirect benefit from opening data and service access. However, the service fee and commission income for banks have a slightly negative or zero surplus. All surplus created by OB regulations may benefit third-party providers ("TPP"). There is an increase in profit, which can be caused by implementing new technologies to increase income and reduce costs.

For the market power, the analysis shows that the competitive environment is weakening. Firstly, the concentration of the UK banking industry is gradually declining, which can be seen as a positive indicator of lower switching costs. Secondly, contrary to the assumptions, the competition environment has not improved. Lastly, there could be short-term improvements, but the long-term competitive trend shows that the competitive environment is weakening.

4.5.1 Methodology

In this test, HHI and market power indices are applied to measure the competitive effects before and after the OB regulatory enforcement. These include concentration and market power indices.

4.5.1.1 Concentration index

The concentration is measured by the Herfindahl-Hirschman index ("HHI"). It reflects the distribution of market shares among the banks. The index is calculated as follows:[763]

$$HHI = \sum_{k=1}^{n} {s_i}^2 \quad (1)$$

Where s_i is the market share of ith bank in the market for a total number of banks. The unit of market share is from 0 to 100. Therefore, the HHI index ranges from close to zero to 10.000.

From the formula of HHI, the index is the weighted average slope of the concentration curve. The maximum number of the index is ten thousand when there is one monopoly firm with 100% market share; the square root of 100 is 10.000. The minimum is zero where the number of firms is indefinite. The value of HHI above 1000 is critical.[764]

The index represents the industry's price-cost margin and is used to measure market competitiveness. The industry price cost margin follows Cournot's quantitative model solution, indicating that it is

[763] Sebastian de-Ramon and Michael Straughan, 'The Evolution of Competition in the UK Deposit-Taking Sector, 1989–2013' (2020) 26 The European Journal of Finance 958, 963.

[764] Viscusi and others (n 94) 160.

correlated to the HHI.[765] The price cost margin is the profit. According to the theory and empirical research, the highly concentrated market is correlated to a firm's high profit because the firms are less competitive.[766] As such, a high value of HHI can be an indication of a less competitive market structure.

4.5.1.2 Lerner Index

The market power indexes are based on the definition of market power and the effect of competition level on the market. The Lerner index measures the price mark-up over the marginal cost ("MC"). The index is calculated as in the formula (2):[767]

$$Lerner_{it} = \frac{P_{it} - MC_{it}}{P_{it}} \qquad (2)$$

The formula shows the power of how far the bank can set the price P over the marginal cost MC. The further the banks manage to set the price, the more power they have over the price; therefore, there is less competition in the market. On the contrary, the lower the index, the less power the bank has over the price and the intense the competition in the market.

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[765] Keith Cowling and Michael Waterson, 'Price-Cost Margins and Market Structure' (1976) 43 Economica 267.

[766] Ian Domowitz, R Glenn Hubbard and Bruce C Petersen, 'Business Cycles and the Relationship between Concentration and Price-Cost Margins' (1986) 17 The RAND Journal of Economics 1; David J Ravenscraft, 'Structure-Profit Relationship at the Line of Business and Industry Level' (1983) 65 The Review of Economics and Statistics 22.

[767] AP Lerner, 'The Concept of Monopoly and the Measurement of Monopoly Power' (1934) 1 The Review of Economic Studies 157, 169.

The MC is calculated from the linear regression of the total cost function in Formula 3, following the approximation method by Berger and others to calculate MC based on financial statement`s data.[768] The total cost includes financial and operating costs; the total asset is used as the proxy for the output. These data are collected from the bank`s financial reports. The regression to estimate total cost based on the output and input prices can be conducted below.[769] Knowing the regression parameters, the changes of output and prices to the change of total cost, the MC can be calculated in Formula 4.

Total cost function:[770]

$$LnCost_{it} = b_0 + b_1 lnQ_{it} + b_2 ln\, Q_{it}{}^2 + \sum_{k=1}^{3}(\lambda_{kt} lnW_{k,it}) + \sum_{k=1}^{3}(\emptyset_{kt} lnQ_{it} lnW_{k,it}) + \sum_{k=1}^{3}\sum_{k=1}^{3}(lnQ_{k,it} lnW_{k,it}) \qquad (3)$$

Where the $Cost_{it}$ is the total cost for bank i at the time t, Q_{it} is the output proxied by the total assets.[771] $W_{1,it}$, $W_{2,it}$, $W_{3,it}$ are input prices for labour, funds and fixed capital. Those input prices are proxied by the ratio of staff expenses to total assets, the ratio of interest expenses to total deposits and the ratio of non-interest expenses to total assets.

Marginal cost MC function:[772]

$$MC_{it} = \frac{Cost_{it}}{Q_{it}}[b_1 + b_2 lnQ_{it} + \sum_{k=1}^{3}(\lambda_{kt} lnW_{k,it})] \qquad (4)$$

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[768] Allen Berger, Rima Ariss, and Klapper, Leora, 'Bank Competition and Financial Stability' (2009) 35 Journal of Financial Services Research 99.

[769] ibid.

[770] ibid.

[771] de-Ramon and Straughan (n 764).

[772] Berger, Ariss, and Klapper, Leora (n 769).

Once the MC_{it} is calculated for each bank at the time-t, and the Lerner index is calculated for each bank. As the price is defined as the income divided by output quantity, to align with other banking literature, the price is defined as interest income and non-interest income divided by output in the above formula.[773] Lastly, the Lerner index is calculated as the average of individual bank indexes over time.

4.5.1.3 Boone index

The Boone index is another market power index. It is also based on the definition of market power and the effect of competition. It measures the competition through the efficiency of the firm and its performance. As the competition intensifies, the more efficient firm gains the advantage over the less efficient. Hence, output is relocated from less efficient firms to more efficient firms. The effect of the relocation can be a shift in the firm`s variable profit or market share. The Boone index is calculated as follows:[774]

$$\pi_{it} = b + b_t \ln(c_{it}) + \Phi X_{i,t} + \eta_{i,t} \qquad (5)$$

Where π_{it} is the variable profit for the bank i at time t, c_{it} is the variable cost. The variable profit can be proxied by market share or profit. The Boone indicator is the estimated coefficient βt derived for each period t. The index compares profit over time. The data on profit and the average cost are easy

[773] ibid.

[774] Klaus Schaeck and Martin Cihák, 'Competition, Efficiency, and Stability in Banking' (2014) 43 Financial Management 215.

to obtain. However, it is possible that in the short term, the less efficient supplier`s profit will not decrease, but will decrease in the long term. It is also possible that the less efficient supplier's profit won`t decrease at all if it manages to construct a high entry barrier. Therefore, the index needs to be interpreted in conjunction with other factors for a robustness test.

In this analysis, the proxy of variable profit is proxied by the ratio of operating profit to total assets developed by Shaeck and Cihak in 2014.[775] The variable costs are proxied by the efficiency ratio of costs to income. The coefficient b_t describes the relationship between variable profit and cost. It is also the Boone index value.

The index value range

As the cost has a negative correlation with profit, the higher the cost, the lower the profit. Therefore, the Boone index value ranges from - ∞ to 0. The lower index value indicates more profit for a more efficient firm. This means the intensity of competition is increasing. On the contrary, the higher the index, the less competition in the market.

In addition, the regression in formula (5) includes a time dummy variable for each year, bank fixed effects and bank-control variables such as customer loans and advances to total assets and return on risk-weighted assets.

[775] ibid.

Table 19: Measurement framework of concentration and market power indexes. The table shows the direction of indices in column "INDEX" toward perfect competition and its range value in column "VALUE RANGE".

INDEX	VALUE RANGE	VALUE AT PERFECT COMPETITION	DIRECTION TOWARD PERFECT COMPETITION
HHI	0- 10000	0	↓
LERNER	0 - 1	0	↓
BOONE	-∞ - 0	-∞	↓

4.5.2 Data

Financial data from 4933 banks across 42 countries are collected from the BankFocus database, spanning the period from 2015 to 2022. Banks outside of UK jurisdictions are categorised into commercial banks and fintech banks. In the UK, banks are classified into CMA9's nine largest banks, challenger banks, NoCMA9 small banks, and building societies, as shown in Table 20 below. The total number of annual bank observations is 40408.

Data selection

Data is collected from the Moody's Analytics BankFocus database and grouped by country. Moody's Analytics is a renowned company providing services in credit ratings. The country`s name is selected according to the countries in the Open Banking index to create a sample representing countries with different approaches to OB.[776] The index illustrates the regulatory score of OB grouped by jurisdictions.

[776] 'EY Open Banking Opportunity Index: Where Open Banking Is Set to Thrive' <https://www.ey.com/en_es/banking-capital-markets/ey-open-banking-opportunity-index-where-open-banking-is-set-to-thrive>.

The more regulated the OB, the higher the score that jurisdiction has. A total of eight jurisdictions with different OB regulatory regimes were selected: the UK, Germany, France, Japan, Australia, Spain, the US, and China. Data is stored in the file "Vo_207055762_Fourthtestmarket power.csv". The Python code is in Appendix I (Market power analysis - Python Code).

After selecting financial institutions that match the OB index, the number of jurisdictions has been reduced to eight. There are a total of 4591 banks in eight countries with 37656 samples. Notably, the data shows that 88% of the banks are from the US because it has several thousand small community and regional banks (see Figure 34). In addition, most of the banks are commercial, illustrating that the number of banks providing traditional retail services is dominant compared to fintech or corporate banks (see Figure 35).

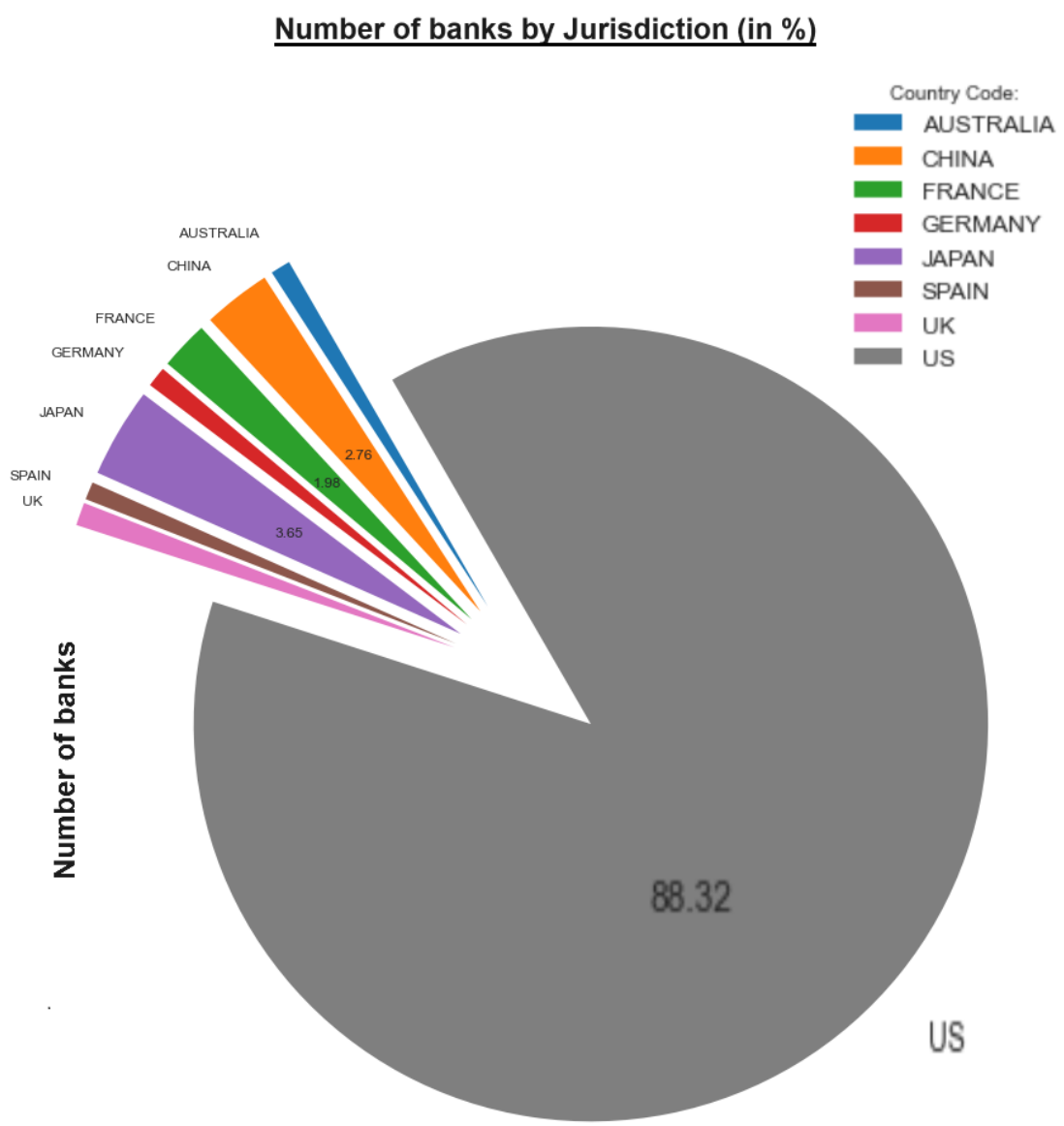
The top frequency observation is the US with 33256 observations (see the table below). Other variables show the mean and standard deviations of banks in 8 countries. The mean bank's asset is USD 18 billion, with a huge deviation of USD 166 billion; the mean interest income is USD 493 million, with a 4.8 billion deviation. The same large ratio of mean/deviation for costs and profits. A high standard deviation value from the mean indicates that the data fluctuates highly (see table below).

Table 20: Description of Banks' data. The following variables on the bank`s operations are collected. Variables Company name, Group and Country are structured, whereas other variables are integers.

Variables	Count	Unique	Top	Freq	Mean	Std
Company name	*37656*	*4591*	*PEOPLES BANK*	*80*		
Group	*37656*	*7*	*Commercial bank*	*35520*		
Country	*37656*	*8*	*US*	*33256*		
Year	*37656*				*2,019*	*2*
Total operating expenses	*37656*				*236,463*	*2,077,152*
Total interest expense	*37656*				*196,515*	*2,066,851*
Non-interest expenses/Average total assets	*37656*				*4*	*11*
Fee & commission expense	*37656*				*17,861*	*203,371*
Staff expenses	*37656*				*103,896*	*995,078*
Other administrative expenses	*37656*				*56,825*	*556,079*
Customer_loans_advance_Total_assets	*37656*				*60*	*19*
Fixed assets (property, plant and equipment)	*37656*				*132,168*	*1,437,965*
Total customer deposits	*37656*				*11,731,957*	*111,931,239*
Total assets	*37656*				*18,729,403*	*166,302,434*
Interest Income	*37656*				*493,334*	*4,827,536*
Fee & and commission income	*37656*				*89,688*	*860,046*
Total other operating income	*37656*				*155,643*	*1,515,975*
Cost-to-income_(Efficiency)_ratio	*37656*				*68*	*74*
Operating profit	*37656*				*155,310*	*1,717,401*
RoRWA_Operating_profit_RWAs	*37656*				*2*	*17*

The percentage of banks among the jurisdictions is shown in Figure 34, and the number of banks by group is presented in Figure 35.

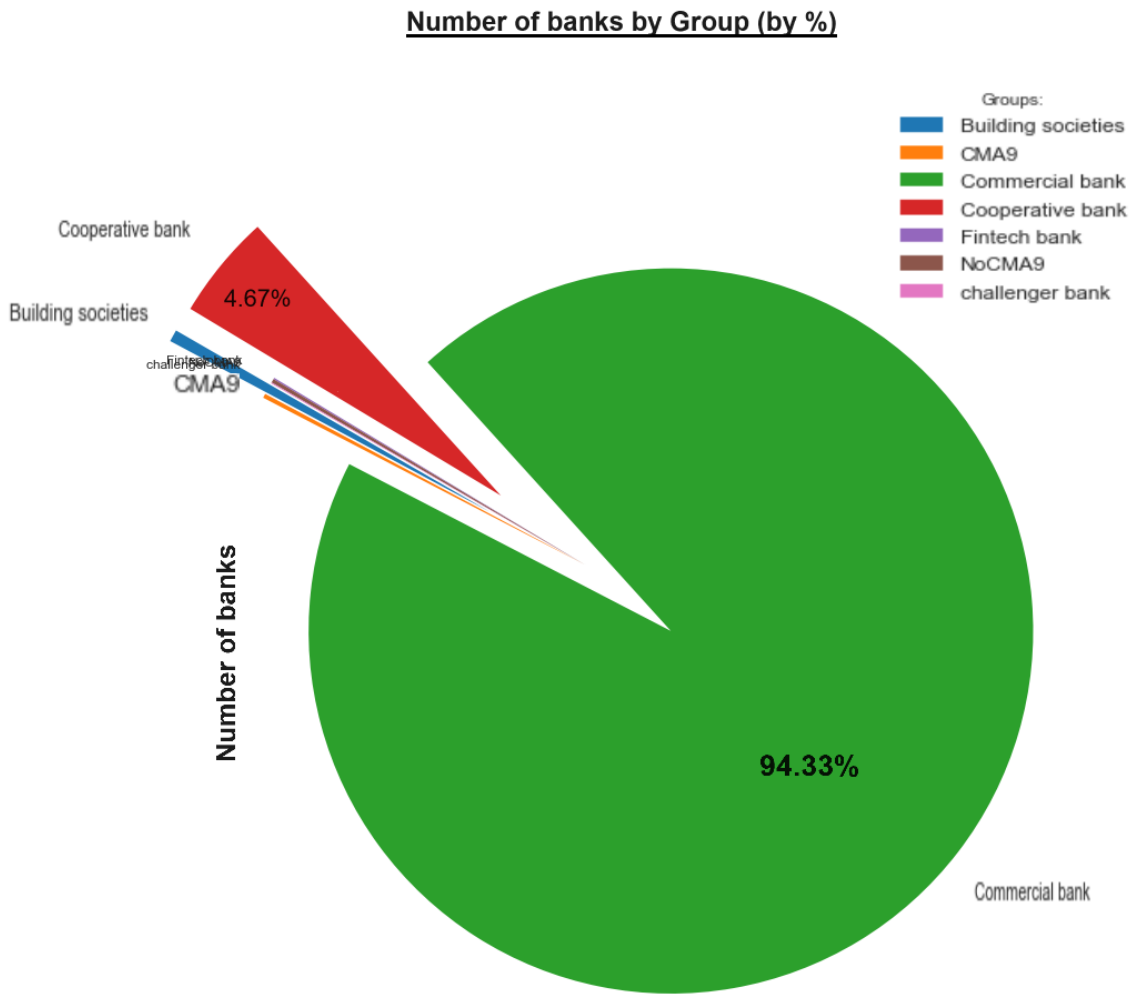
Figure 124: Number of banks by country. The figure shows the number of bank observations per jurisdiction, displayed by percentage. The US observations consist of most of the total observations (88%), followed by the Japanese (3.6%) and then the Chinese (2.76%)



There are eight countries. The US observations account for most of the total observations (88%), followed by Japan (3.6%) and China (2.76%) (see Figure 34). Note that small community banks with assets below USD 1 billion may not be included in the samples; therefore, the number of German banks has decreased. Those jurisdictions are chosen according to the Open Banking ('OB') Index in Chapter One. The OB Index measures how strongly the OB is regulated.[777] By comparing those jurisdictions, the OB regulatory impact can be measured through a control group.

[777] Hamish Thomas, 'EY Open Banking Opportunity Index: Where Open Banking Is Set To Thrive' (*Ernst & Young Global Limited*, 2020) <https://www.ey.com/en_gl/banking-capital-markets/ey-open-banking-opportunity-index-where-open-banking-is-set-to-thrive>

Figure 35: Number of banks by service group. There are four groups of UK financial institutions: CMA9, Challenger banks, NoCM9 and the Building societies. Banks in other jurisdictions are grouped into commercial, cooperative and fintech banks. The biggest group in terms of numbers is the commercial banks (94%). In the UK, commercial banks are divided into CMA9 and NoCMA9 groups. The second biggest group is Cooperative banks.



4.5.3 Application of Method

A total of four methods were applied in the analysis. The first method measures the impact of OB regulations on UK financial institutions. The second is to measure the HHI concentration index before and after the OB enforcement. The third is to measure the competition environment before and after

OB with the Lerner index. Lastly, the competition environment is measured with the Boone index to check the robustness of the result.

Impact on banks' operations

The DID is applied to measure the impact on the bank's revenue, costs, and profits. Financial data on the bank's operations from different jurisdictions in the OB index are collected from the BankFocus database. Next, a counterfactual (parallel) analysis is conducted to select the control group for the DiD method. In this step, the trends in income, costs, or profits of banks in different jurisdictions are compared to find the most parallel trend before the OB enforcement. The objective of this analysis is to define the best possible control group. Lastly, the DiD is applied between the UK bank group (treatment) and the control group to measure the impact.

Concentration and market power indexes

The market power measurement is divided into concentration measurement and market power measurement. The HHI index and the Lerner and Boone market power indexes are used in this analysis. These methods are described in the Methodology Chapter Three.

4.5.4 Impact on the bank`s operations

In this section, the OB regulatory impact on a bank`s income, costs and profits will be examined. This follows from Chapter Two of the theoretical analysis, which suggests a shift in costs, including capital, compliance, fixed costs, legal costs, and future integration costs. Firstly, the counterfactual analysis will be conducted by evaluating parallel trends between groups or countries before OB enforcement (the year 2018). Next, the DiD method will be run for the impact measurement.

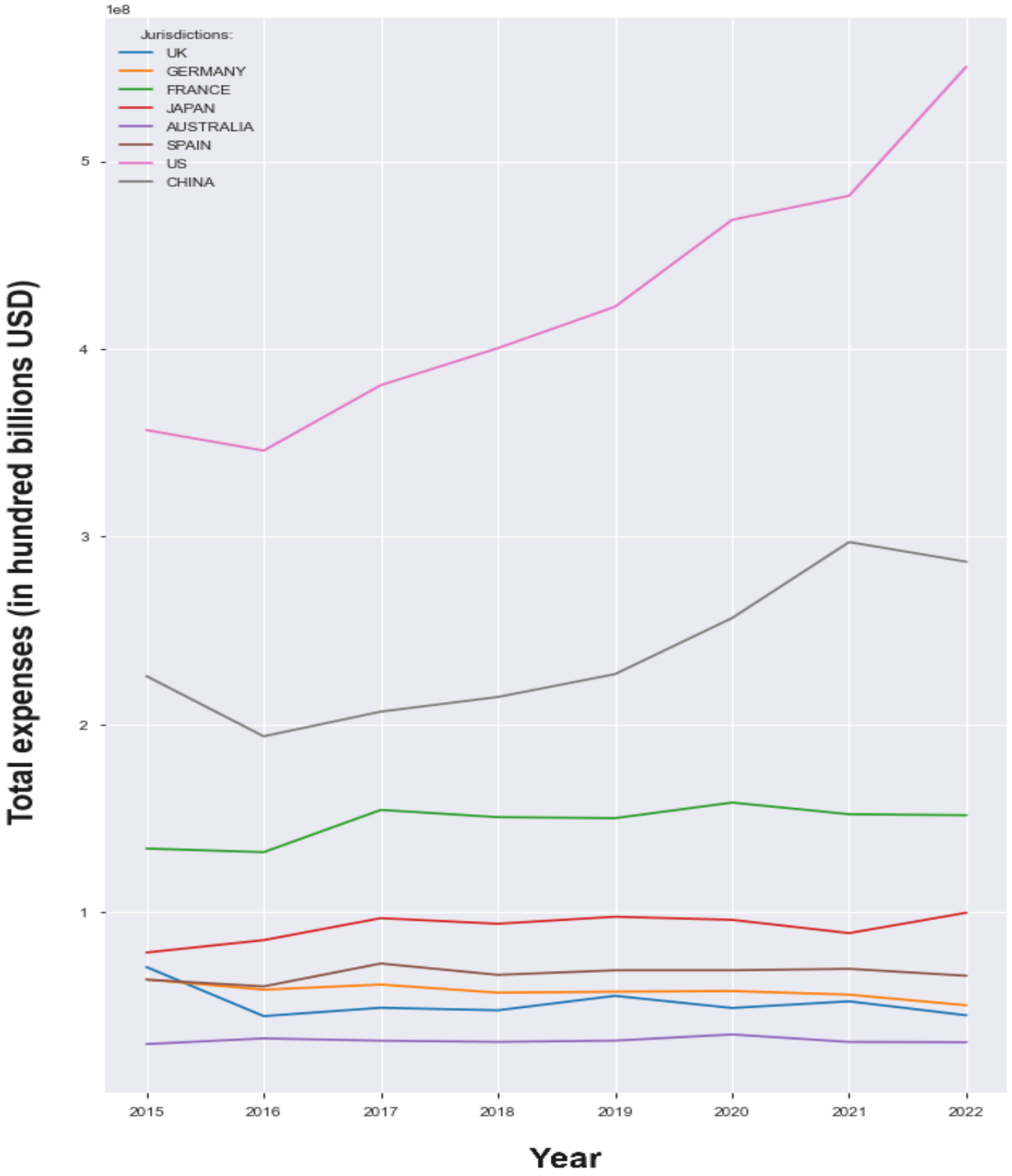
4.5.4.1 Counterfactual analysis.

The summary of financial data trends is explained below, accompanied by the related financial data graph.

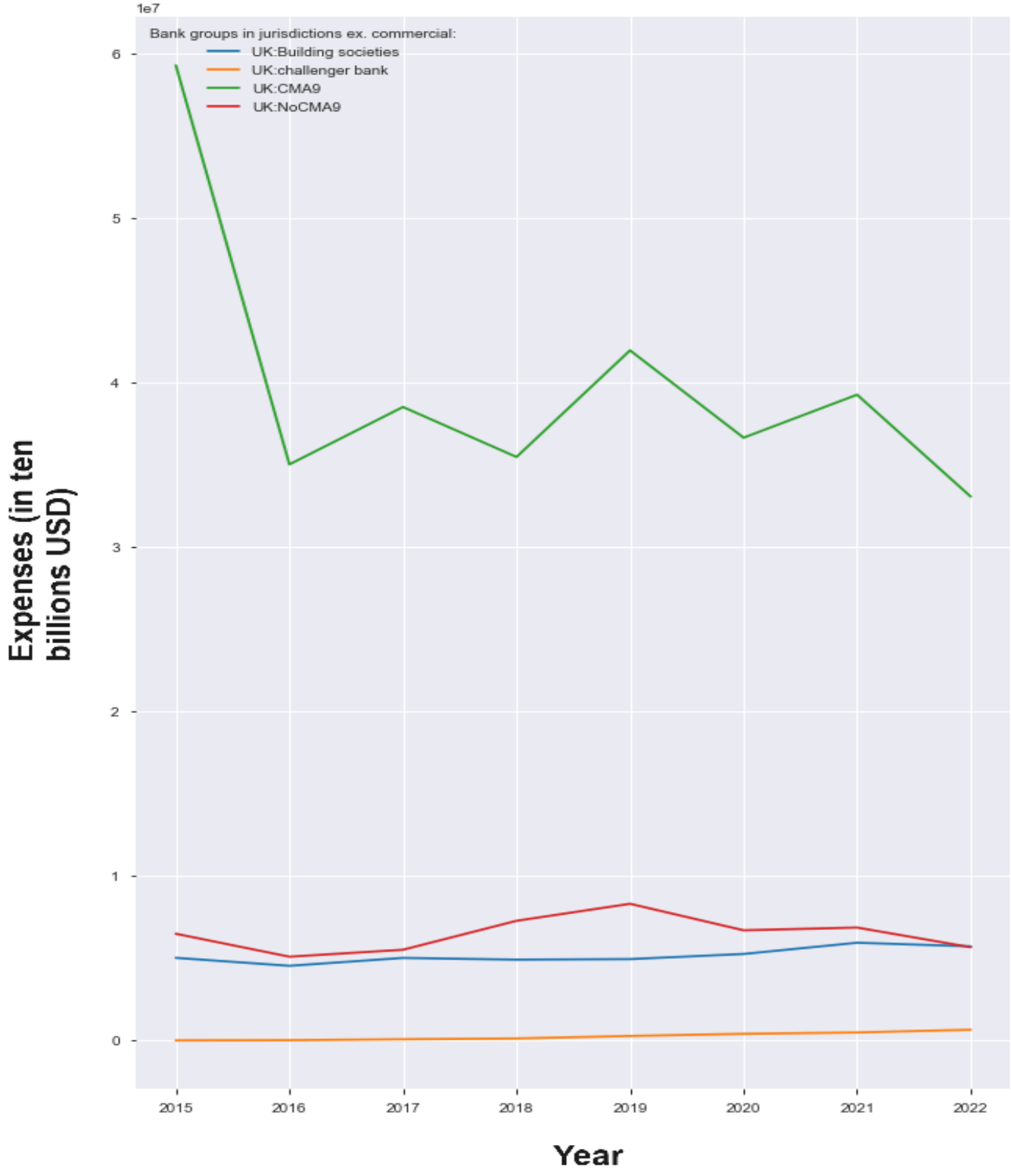
Total operating expenses:

The UK remained at the same level until 2018. There is a marginal increase in 2017 and a reduction in 2018. The graph for Spain (brown) and Germany (orange) shows the same trend as the UK. In the bank group analysis, the CMA9 group shows the same pattern of slight fluctuation before 2018, followed by an increase in 2019. However, since 2019, the trend has been negative. Other bank groups in the UK illustrate the same pattern, except for Challenger banks. The Challenger banks show a steady increase in expenses from 2015. This may be an indicator of increasing investment in technology and expanding customer bases. In comparison with groups in other jurisdictions, the US fintech banks have the most similar pattern to UK CMA9 banks. In conclusion, the most suitable control groups are Spain, Germany and US fintech banks.

Total operating expenses by country.



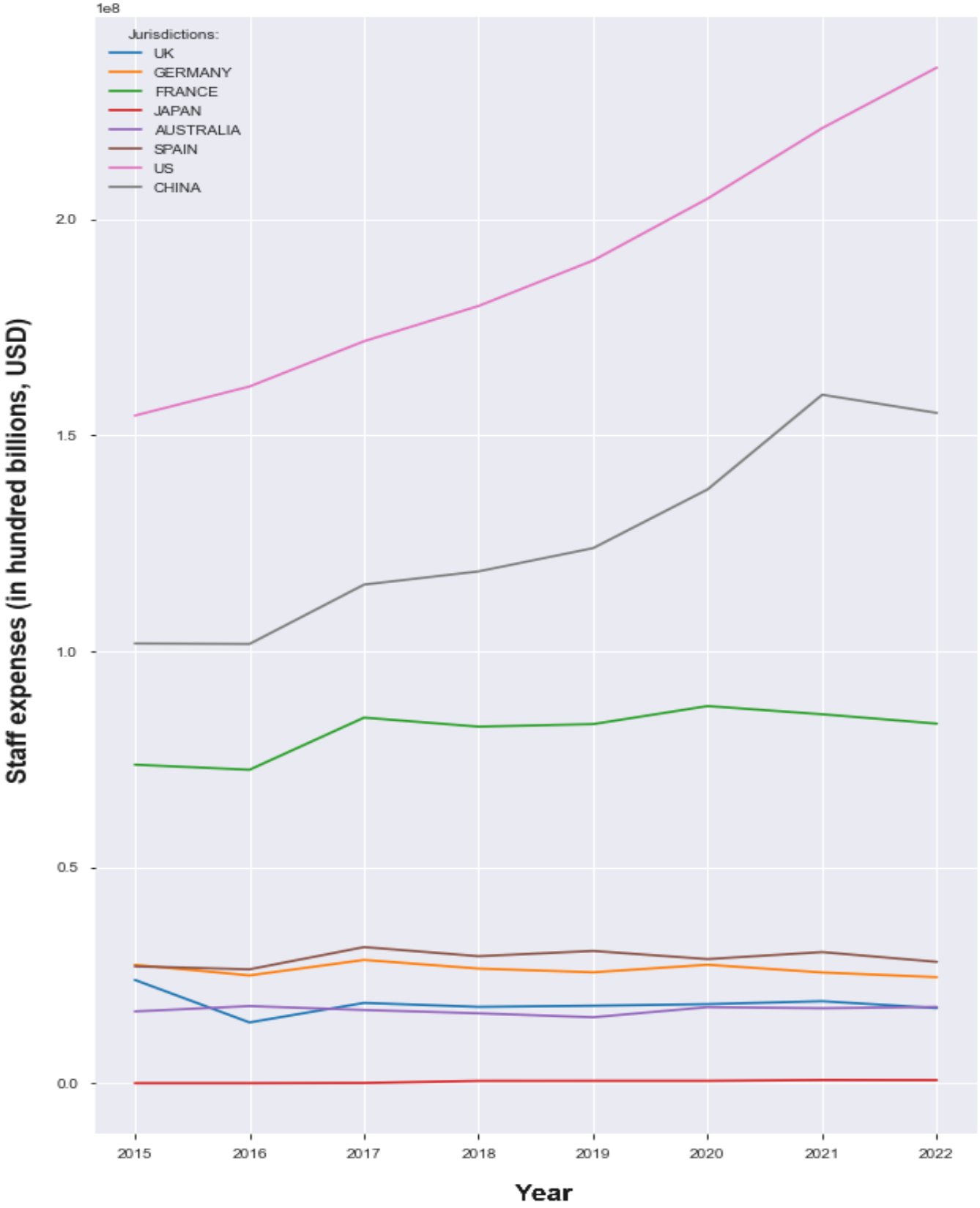
Total operating expenses by group in UK

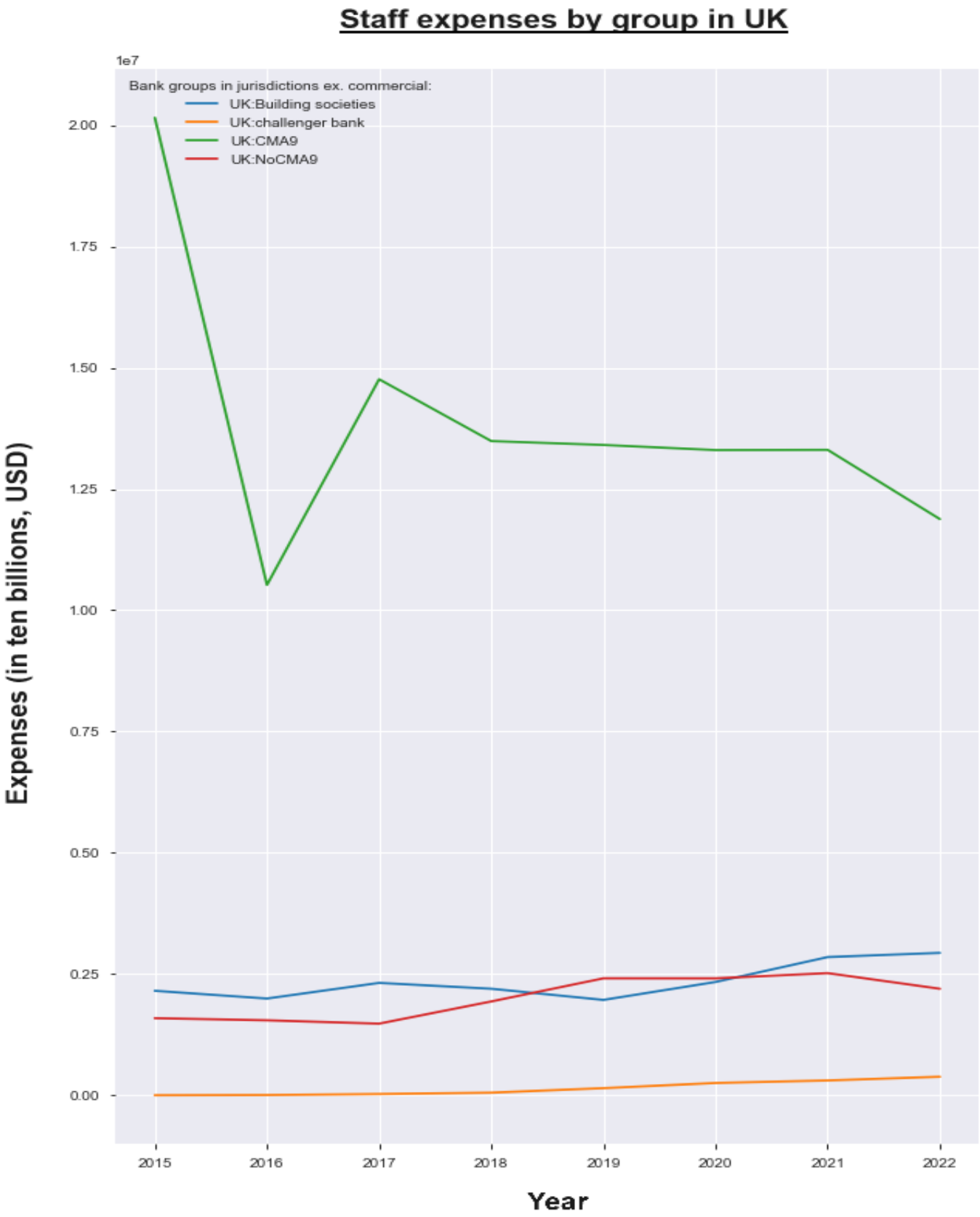


Staff expenses:

The staff expenses of UK banks follow the same pattern as total operating expenses before 2018. However, there has been a gradual decline in staff expenses after 2018, while in countries like the US and China, there has been a significant increase in staff until 2022. The patterns of the German (orange) and Spanish (brown) banks mirror those of UK banks. The group analysis in the UK indicates that only CMA9 banks have reduced staff expenses, whereas all other groups, including building societies, challengers, and NoCMA9, have increased their staff until 2022. In conclusion, the control group for staff expenses can be either German or Spanish banks.

Staff expenses by county

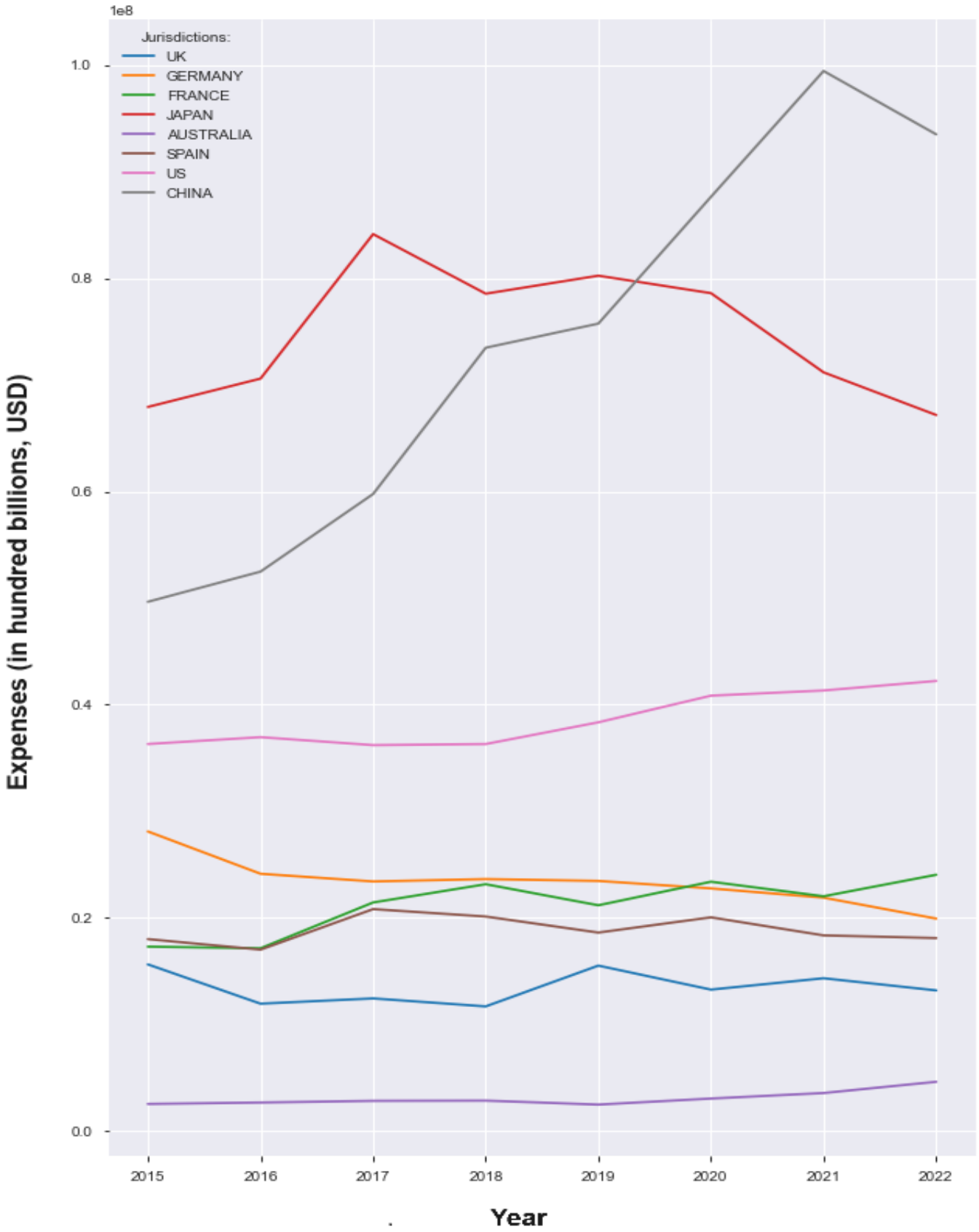



Staff expenses by group in UK
1e7
Bank groups in jurisdictions ex. commercial:
UK:Building societies
UK:challenger bank
UK:CMA9
UK:NoCMA9
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Expenses (in ten billions, USD)
2015
2016
2017
2018
2019
2020
2021
2022
Year

Other administrative expenses:

The other administrative expenses of UK banks remained stable before 2018. There was a sudden increase from 2018 to 2019, after which expenses steadily declined. Among other jurisdictions, only Germany exhibited a similar pattern before 2018. Additionally, the group analysis reveals that no other groups shared the same pattern as the UK CMA9 group prior to 2018; only the US fintech group showed a slight resemblance to the CMA9 group. In conclusion, the control group could be the German banks.

Other administrative expenses by country.

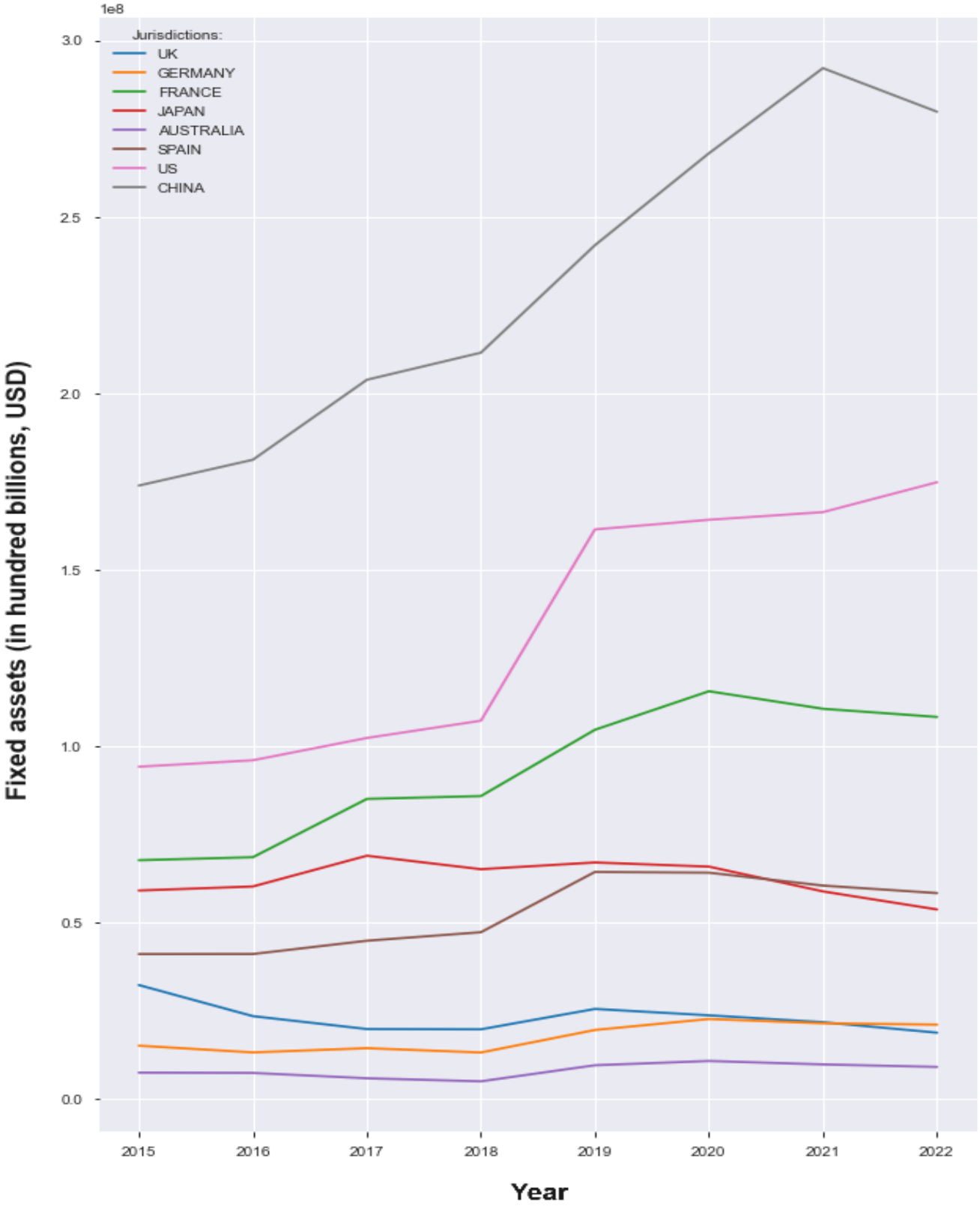


Fixed assets (property, plant and equipment):

The fixed assets of UK banks decreased steadily from 2015 to 2018. This pattern has not been observed in other jurisdictions. The only country exhibiting a similar trend is Australia. The same situation holds true in group analyses; bank groups in different countries significantly increased their fixed assets before 2018. The enforcement of UK ring-fence regulations may have impacted asset levels and customer deposits structure.[778] In UK groups, only CMA9 group fixed assets have decreased, while the building societies, NoCMA9, and challengers' fixed assets have either increased or remained the same. In conclusion, Australian banks can serve as the control group for the impact analysis of fixed assets.

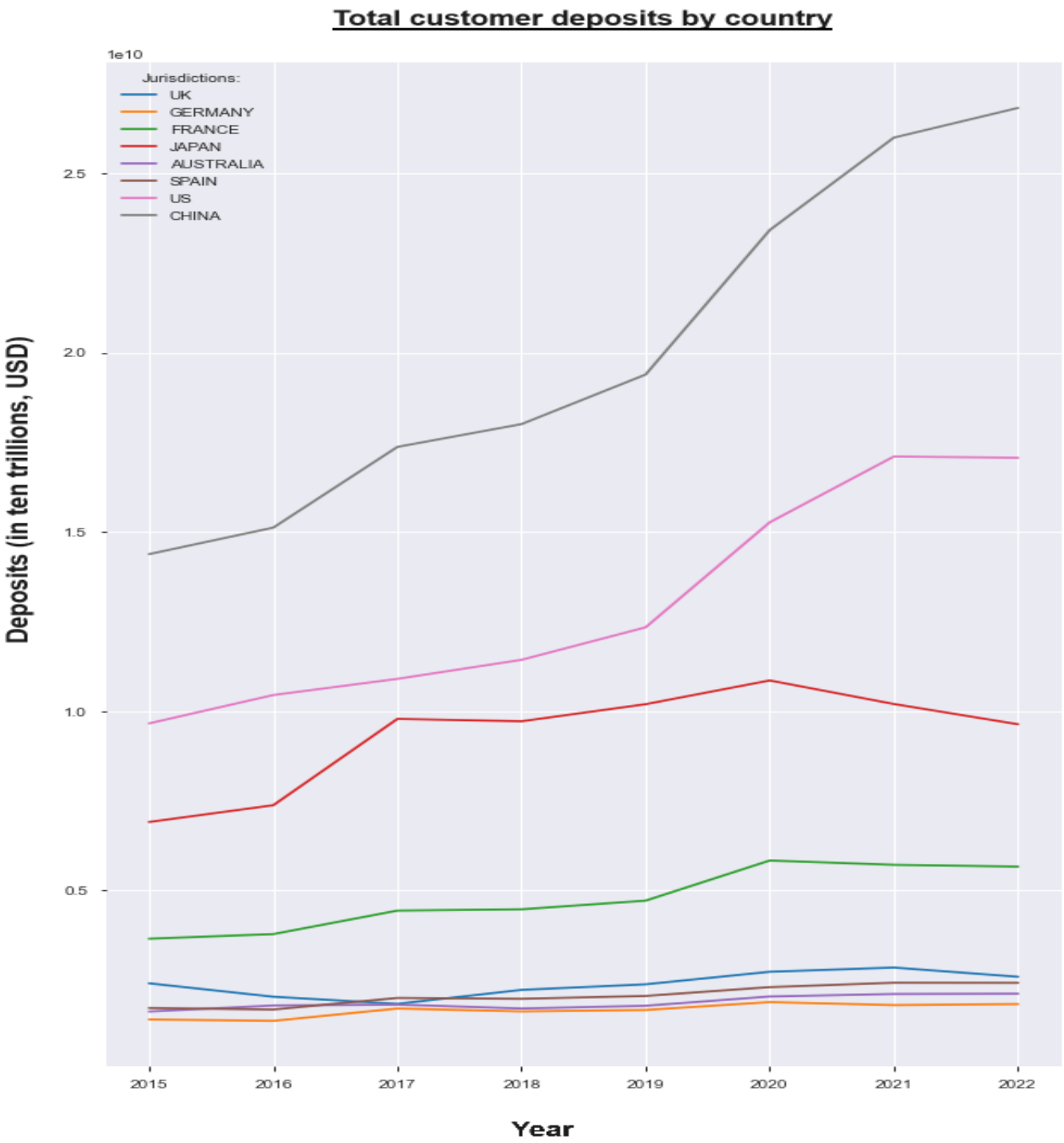
[778] J Cullen, 'Securitisation, Ring-Fencing and Real Estate Bubbles: Financial Stability Implications of UK & EU Bank Reforms' (2018) 4 Journal of Financial Regulation 73.

Fixed assets (property, plant and equipment) by country.



Total customer deposits:

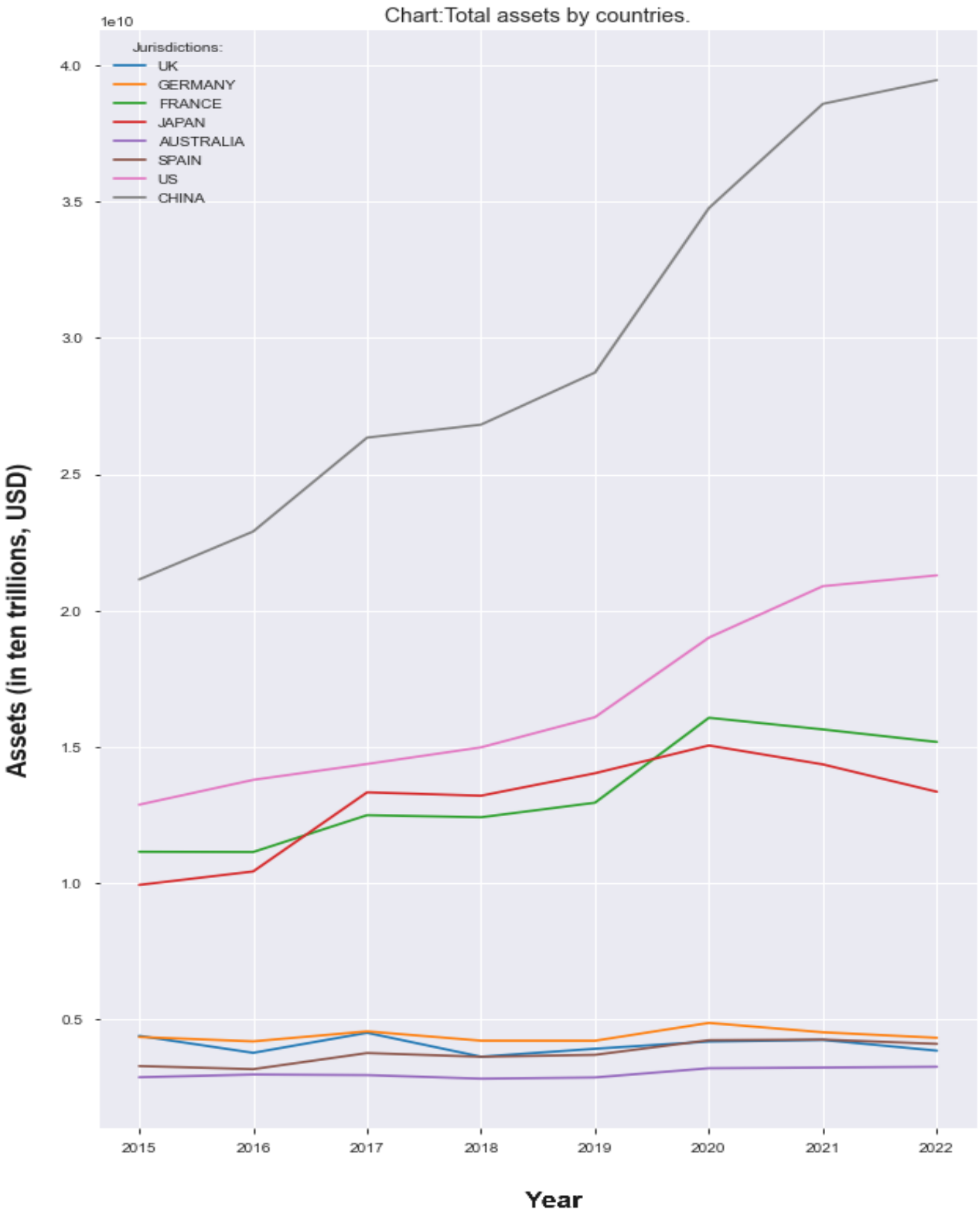
The customer deposits in the UK illustrated the same pattern as the fixed assets. There was a significant decrease during the period from 2015 to 2018, which is contrary to all other jurisdictions. The group analysis shows the same result. In conclusion, there is no counterfactual control group.

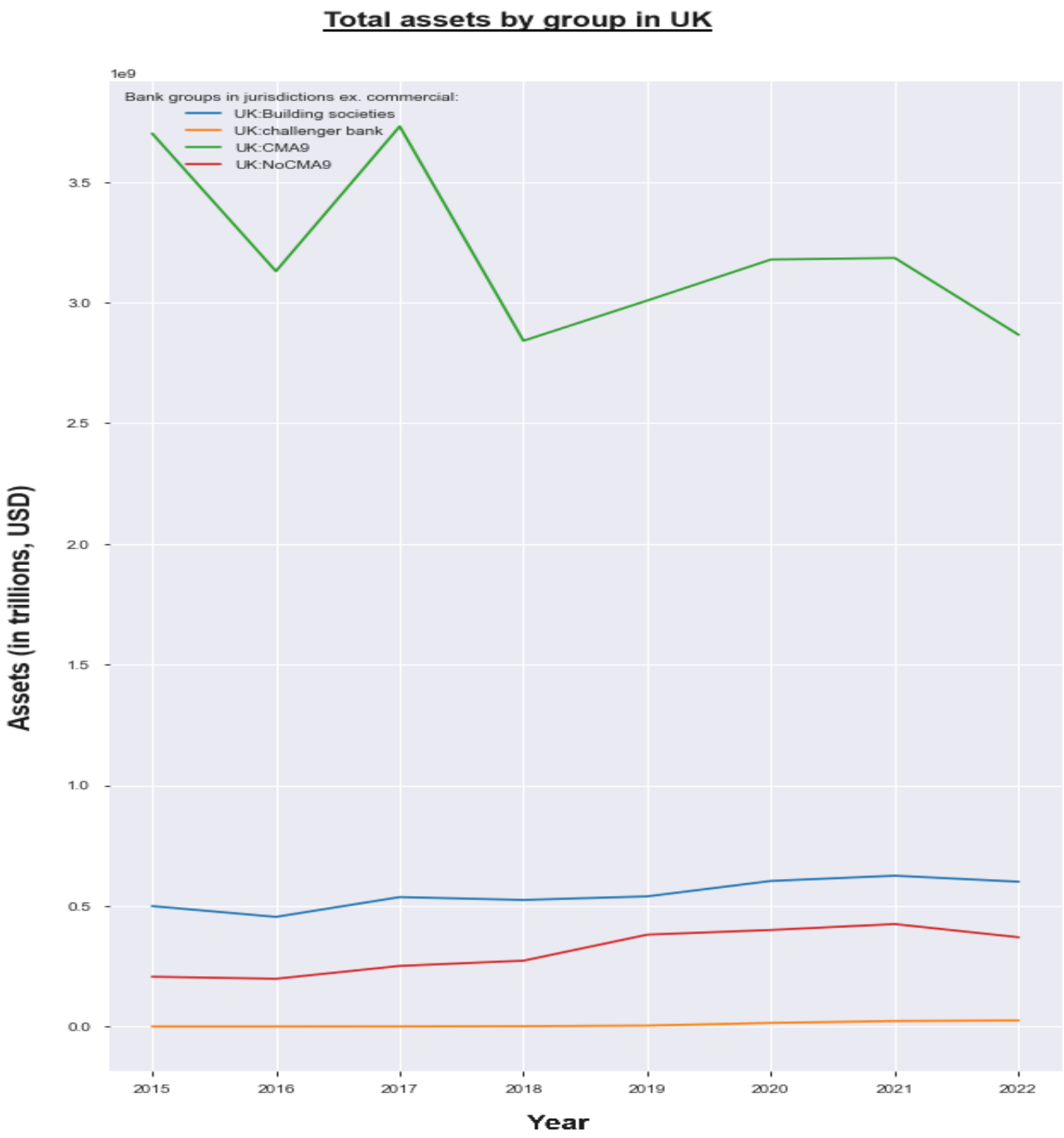


Total assets:

The total assets in the UK remained steady from 2015 to 2022, with an increase in 2017 followed by a drop in 2018. In contrast, assets in the US, China, Japan, and France have steadily increased since 2015. Only German and Spanish banks display similar patterns. The group analysis reveals that only CMA9 has experienced a significant drop in assets, while all other groups have increased. The only exception might be the Japanese cooperative banks, where the increase is marginal. In conclusion, the control group may consist of German or Spanish banks.

Total assets by country

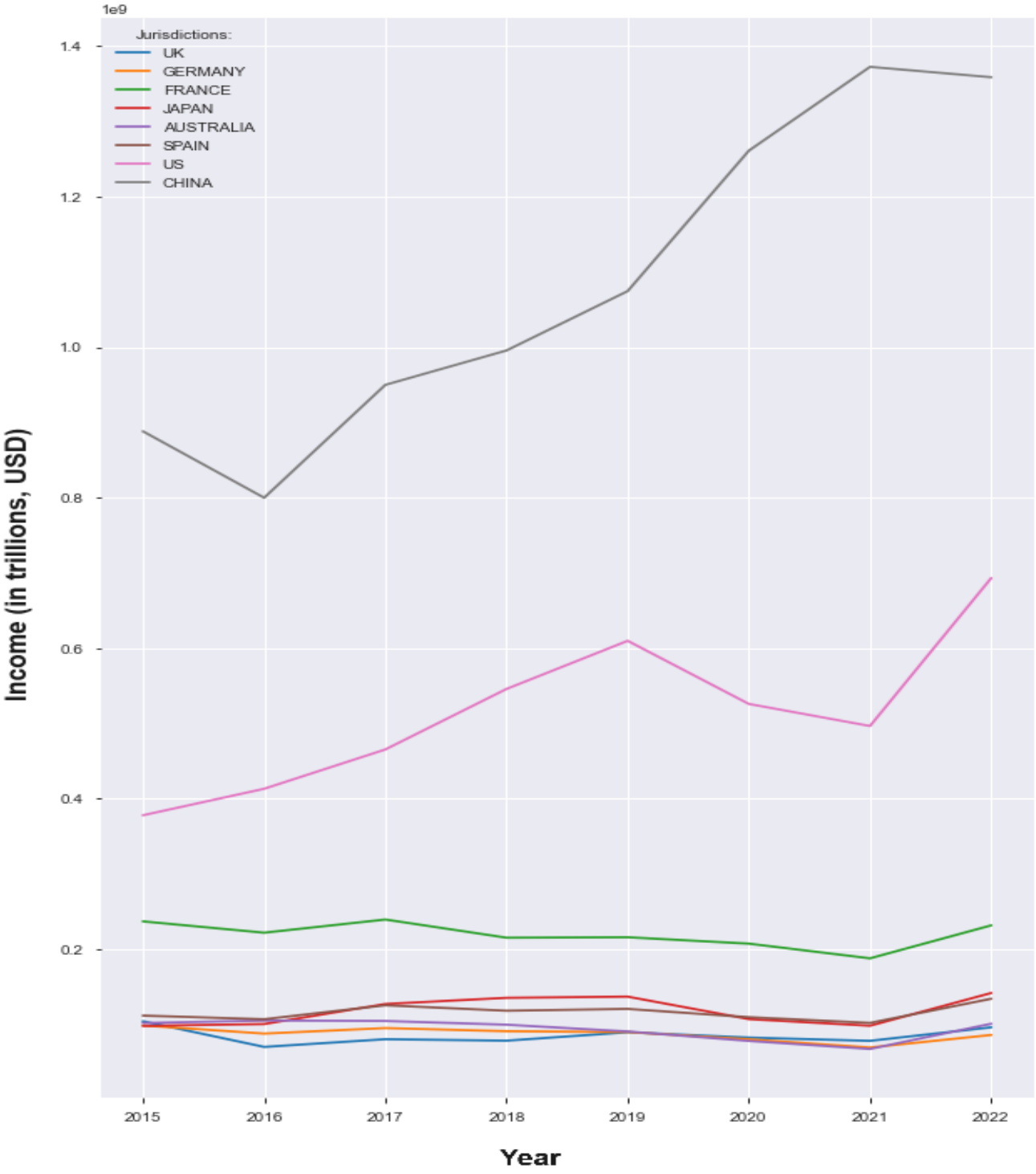



Total assets by group in UK
1e9
Bank groups in jurisdictions ex. commercial:
UK:Building societies
UK:challenger bank
UK:CMA9
UK:NoCMA9
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Assets (in trillions, USD)
2015
2016
2017
2018
2019
2020
2021
2022
Year

Interest Income:

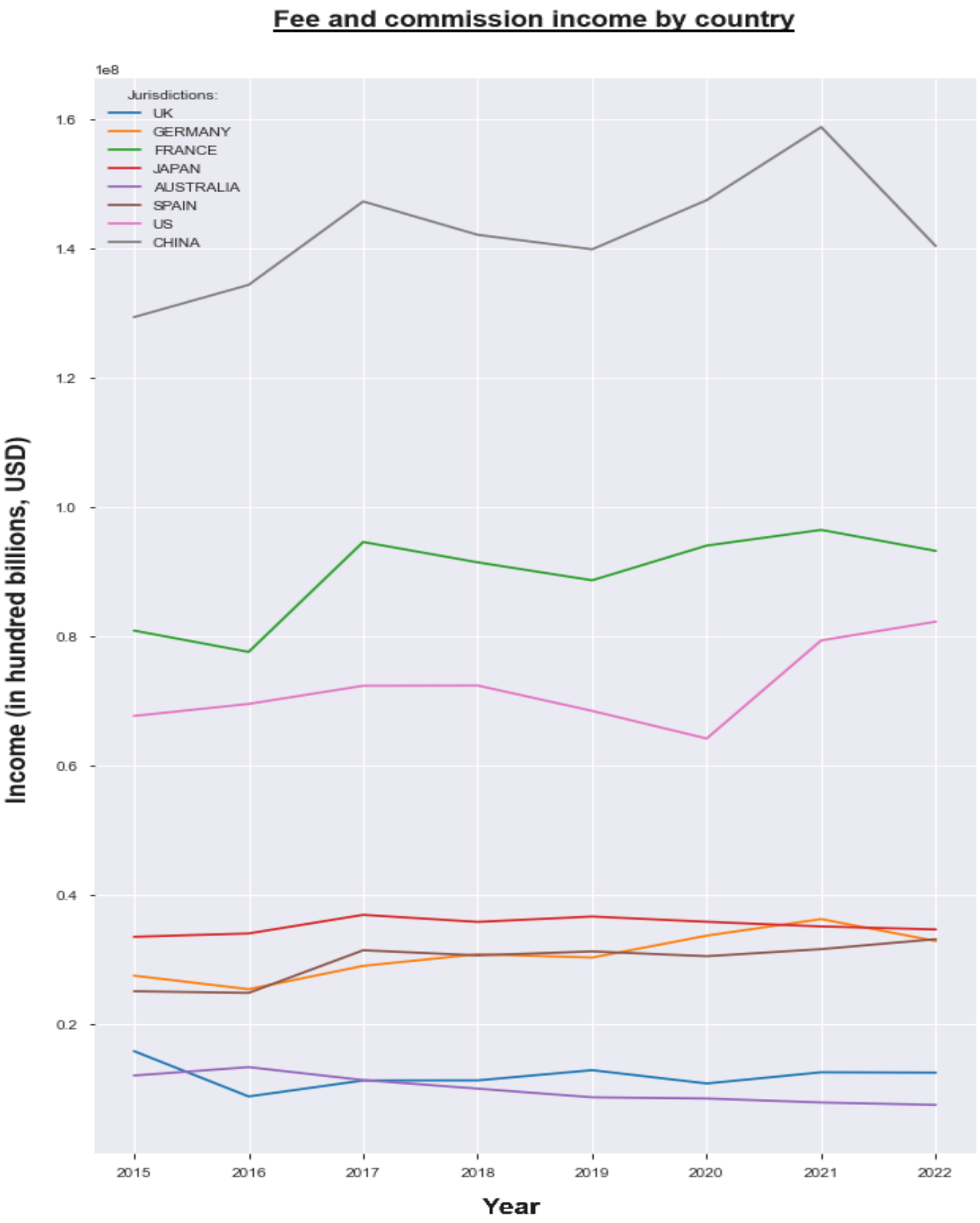
The interest income in the UK decreased in 2016 compared to 2015, but then began to increase until 2018. The rate of increase has accelerated since 2018. Overall, income has consistently grown from 2016 to 2022. A similar trend before 2018 is observed in Spanish banks and possibly in German (orange) and French (green) banks. In the UK, NoCMA9 and building societies have exhibited the same pattern as before 2018. However, the challenger banks' interest income shows a significant increase over the entire period from 2015 to 2022. In conclusion, the control group consists of the Spanish banks.

Interest income by country



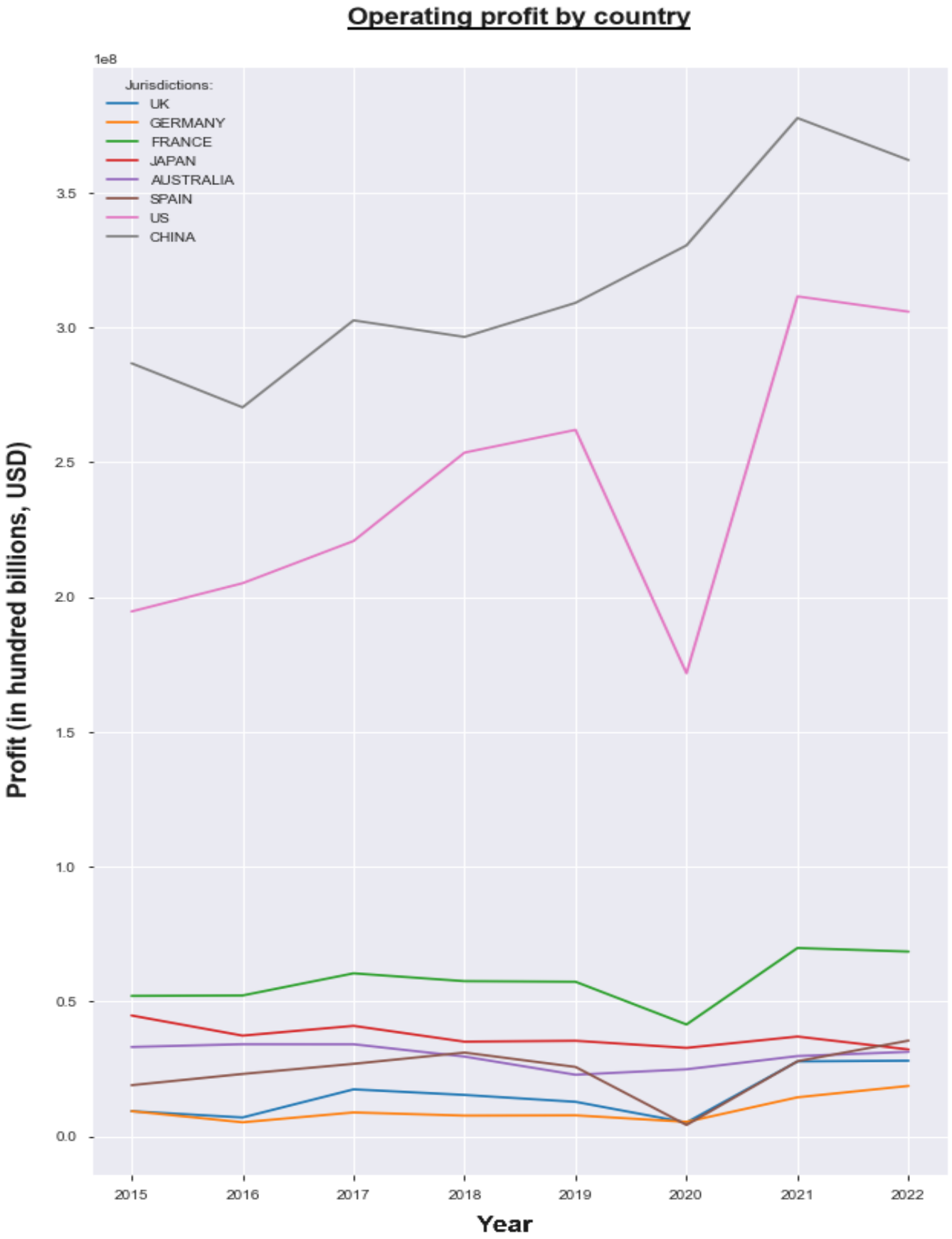
Fee & commission income:

The fee and commission income in UK banks decreased in 2016 but began to recover in 2017. The increase in 2018 was marginal. Throughout the period from 2016 to 2022, income has increased, though not significantly. In all other jurisdictions, including China, the rise in fee and service income was also not substantial. An exception is the income of US banks, which experienced a significant increase. The income patterns of banks in Japan, Germany, and Spain mirrored those of the UK prior to 2018. The analysis of the UK groups reveals that the CMA9 and NoCMA9 groups displayed similar patterns, peaking in growth in 2019, whereas challengers and building societies have steadily increased their income.

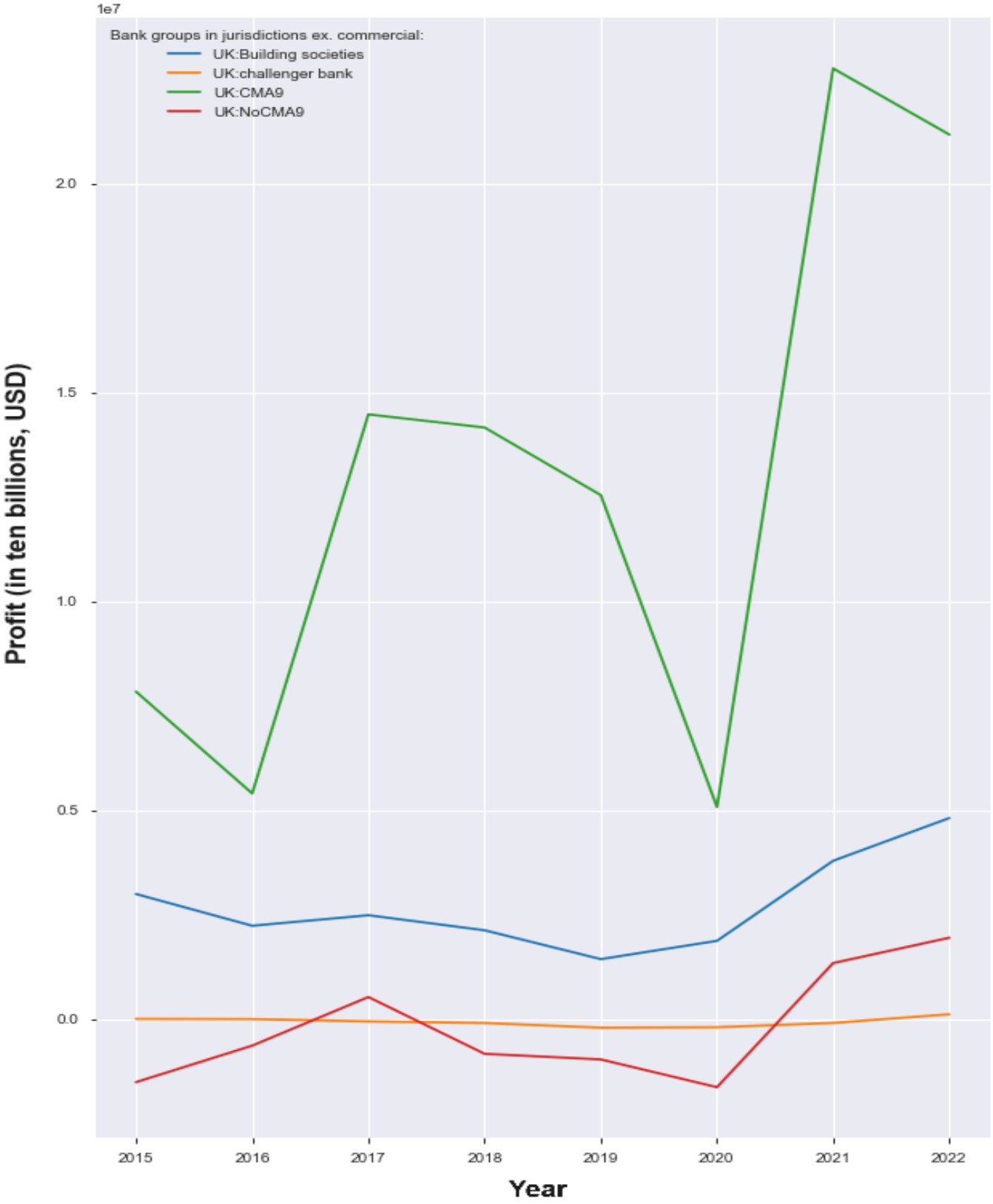

Fee and commission income by country
1e8
Jurisdictions:
UK
GERMANY
FRANCE
JAPAN
AUSTRALIA
SPAIN
US
CHINA
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Income (in hundred billions, USD)
2015
2016
2017
2018
2019
2020
2021
2022
Year

Operating profit:

The banks in the UK experienced a massive increase in operating profit in 2017, followed by a marginal decrease in 2018. The period from 2018 to 2022 shows a significant increase in profit, with a drop in 2020. The COVID-19 pandemic may have caused this drop. The overall picture worldwide demonstrates the same pattern: a steady increase in operating profit with a slump in 2020. Banks in France (green) and Japan (red) illustrated patterns similar to those of UK banks before 2018. The group analysis indicates that building societies, NoCMA9 groups, exhibit the same increase-decrease pattern but are less volatile than the CMA9 group.


Operating profit by country
1e8
Jurisdictions:
UK
GERMANY
FRANCE
JAPAN
AUSTRALIA
SPAIN
US
CHINA
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Profit (in hundred billions, USD)
2015
2016
2017
2018
2019
2020
2021
2022
Year

Operating profit by group in UK



4.5.4.2 Results of possible regulatory impact on the bank`s operations

The counterfactual analysis of trends before the enforcement in 2018 shows that banks in Spain exhibit the most common trends in income, costs, and asset variations, while the second most similar trends were observed in jurisdictions such as Germany and France. In contrast, banks in jurisdictions like China and the US behave differently. These countries have an organic approach to OB. There are no regulated API standards or open data requirements in comparison to the UK approach. The results indicate that even before the enforcement of OB regulations, the macroeconomic conditions, schools of thought, policies, and regulatory enforcement in those jurisdictions were likely different, as evidenced by their behavioural patterns.

Table 21: Impact on the bank`s operations with the DiD method. The table shows the impact with Spain as the most suitable control group.

Impact Factor	Control Group	Impact coef.
Total operating expenses	SPAIN	-5,120,000
Staff expenses	SPAIN	-1,271,000
Other administrative expenses	GERMANY	3,960,000
Fixed assets (property, plant and equipment)	AUSTRALIA	-4,755,000
Interest Income	SPAIN	2,290,000
Fee, commission income	SPAIN	-3,250,000
Operating profit	FRANCE	2,450,000

The potential regulatory impact on costs, income, and profits in Table 21 is interpreted as follows. Regarding the cost, the regulatory impact can indicate technology integration. The OB impact coefficient shows that regulations have decreased operating costs by £5.1 billion and staff expenses by £1.2 billion. This reduction in expenses can be attributed to the net benefit derived from the adaptation

of new technology fostered by the OB regulations, outweighing the costs of new investment in OB. Additionally, it is possible that the regulations accelerate the reduction of staff expenses by integrating new customer service software.

For the income, the regulatory impact depends on the market. In the money creation market with interest income, the impact of regulation is a surplus of £2.2 billion. Given the provisions in the regulations, there can be indirect benefits from opening data and service access. Access to client data can provide better credit risk management and loan provision. These improvements can lead to increased interest income.

Contrary to our assumptions, the impact on service fees and commission income is slightly negative or zero. Theoretically, we expect the regulations to reduce entry barriers, allowing third-party providers to compete for financial services. However, the DiD impact measurement does not concur with the assumption. There are two explanations for this result. First, the OB regulations do not impact or have a slightly negative impact on the additional service market. Second, all the surplus created by regulations benefits TPPs and does not impact bank income.

For the profit, the overall OB regulatory impact on the banks and building societies' profits is positive. There is an increase of £2.4 billion in operational profit with France as the control group. This increase can be explained by the assumption that the regulations create a surplus in income and reduce costs. Therefore, profits should increase. The income surplus is caused by enhancing the quality and quantity of services. For example, they are integrating a better credit management system or introducing new services based on client data. Cost reduction can occur by integrating new service applications.

Limitations of the robustness tests

The above possible regulatory impact is based on the DiD method. The idea of the method is to measure an abnormal deviation from the assumed normal trajectory (applied by the control group as a counterfactual assumption of a normal trajectory without the treatment). The prior-treatment counterfactual (parallel) implies that the control and treatment groups behave similarly before the treatment. However, when the treatment occurs, in our case, the OB regulatory enforcement, the impact of treatment can still have deviation as the control group does not behave 100 per cent as the treatment. The cause can be new factors occurring at the same time as the treatment, or the different behaviour between groups that have specific reactions to that particular treatment. Therefore, the interpretation of the impact result should be sceptical when the impact quantity is small relative to the total quantity, as it can be just a deviation of the treatment. Conversely, the higher the number of possible impact factors from the treatment date, the higher the possibility of overlapping the impact and the more sceptical the result. In conclusion, as the ratio of impact quantity to total quantity increases, so does the likelihood of the regulatory impact, since it encompasses possible overlaps and deviations.

A robustness test can be performed to validate the impact results. There are two methods to conduct robustness tests. First, the same DiD method can be applied to different datasets, or an alternative method can be employed to achieve the same result. In our case, data collection is limited to annual reports or surveys. However, due to the project's resource constraints, conducting bank surveys is not feasible. Consequently, only theoretical assumptions and results from tests of other factors can be applied to validate the results. The potential impact will be assessed against our theoretical assumptions.

4.4.5 Regulatory impact on the competitive environment

One of the objectives of regulations is to reduce the data barriers and switching costs. The expectation is that these instruments will affect the concentration and competitive environment of the banking industry. The concentration index and market power index measure the competitive environment. The results of this index are illustrated below.

4.4.5.1 HHI concentration index

In this section, the HHI indexes on the market share of revenue and user base are presented. The bank's revenue is derived from interest income and other commissions and fees, whereas the user base represents the clients' deposits. These HHI index trends for income and deposits should align with each other because the more deposits banks have, the more they can receive higher interest income and other service fees. As such, these three indices can constitute a robustness test.

The results of the HHI index on income are shown in Figures 36 and 37. It shows that the most concentrated jurisdiction is Spain, and the least concentrated is the US. The UK is in the middle of the group.

The HHI index indicates that concentration has decreased in terms of total deposits since 2018 (see Figure 38). Deposits in the banking industry are less concentrated after OB enforcement. The drop was 49 points (from 1127 in 2018 to 1078 in 2022). However, the most significant drop was in 2017, from 1554 to 1127, which was before OB enforcement.

The same can be true for the concentration of income. Concentration in both interest income and fee commission income has gradually decreased since 2018. The interest income concentration was

reduced from 1286 to 1066, whereas the fee and commission income decreased from 1353 to 1217. Thus, all three HHI indicators align with each other, showing a decrease in concentration.

In conclusion, the concentration drop in the money creation market (interest income) is higher than the additional services (fee and commission income), and the concentration in deposits is marginally impacted. The result shows that incumbent banks still hold a strong position in the deposit market with high concentration. However, the income is more equally distributed in terms of generating income from deposits.

Figure 13: HHI index by country in the interest market. The index shows the highest value for Spain and the lowest for the US.

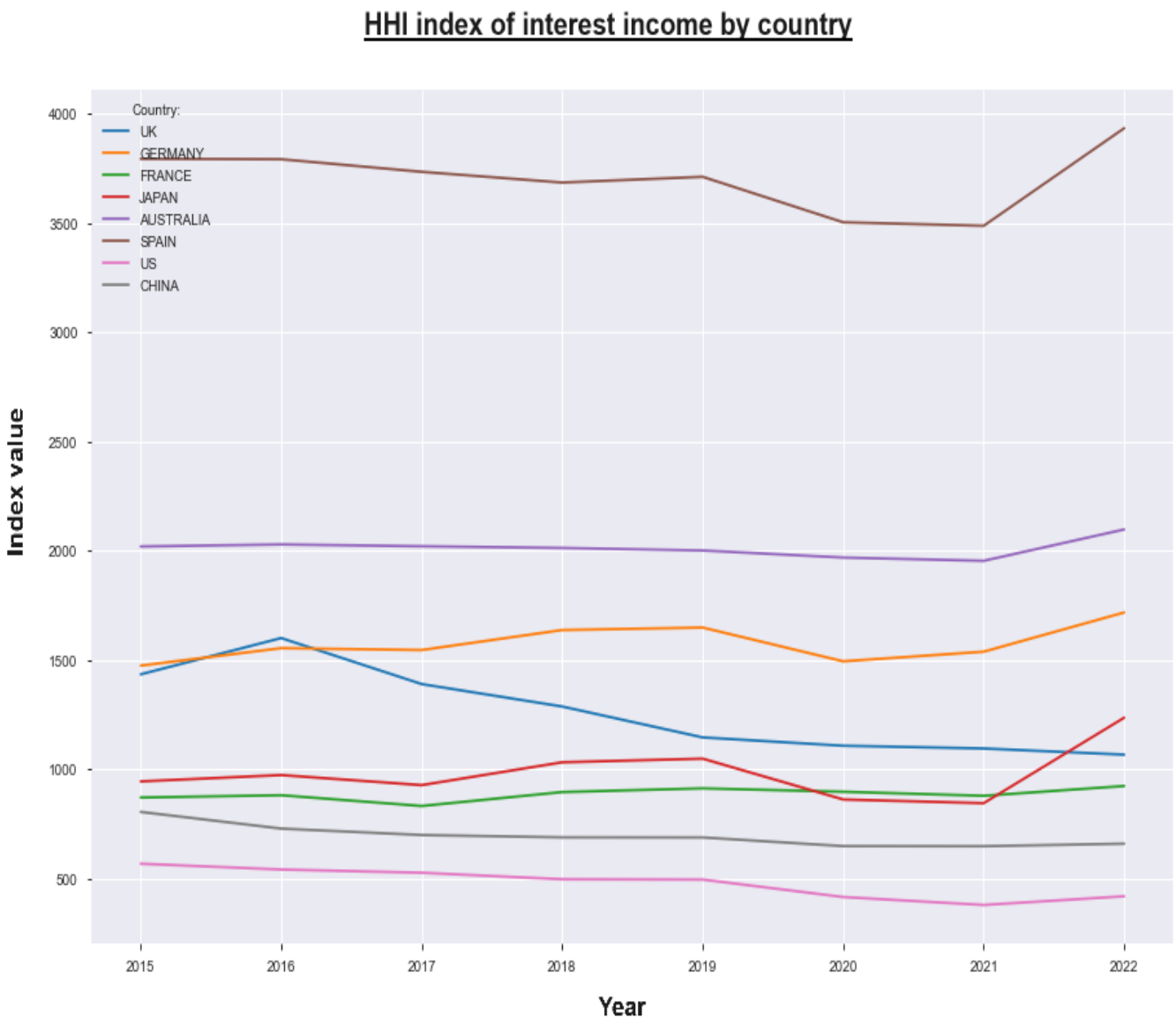


Figure 14: HHI index by country in the fee and commission market. The index shows the highest value for Spain and the lowest for the US.

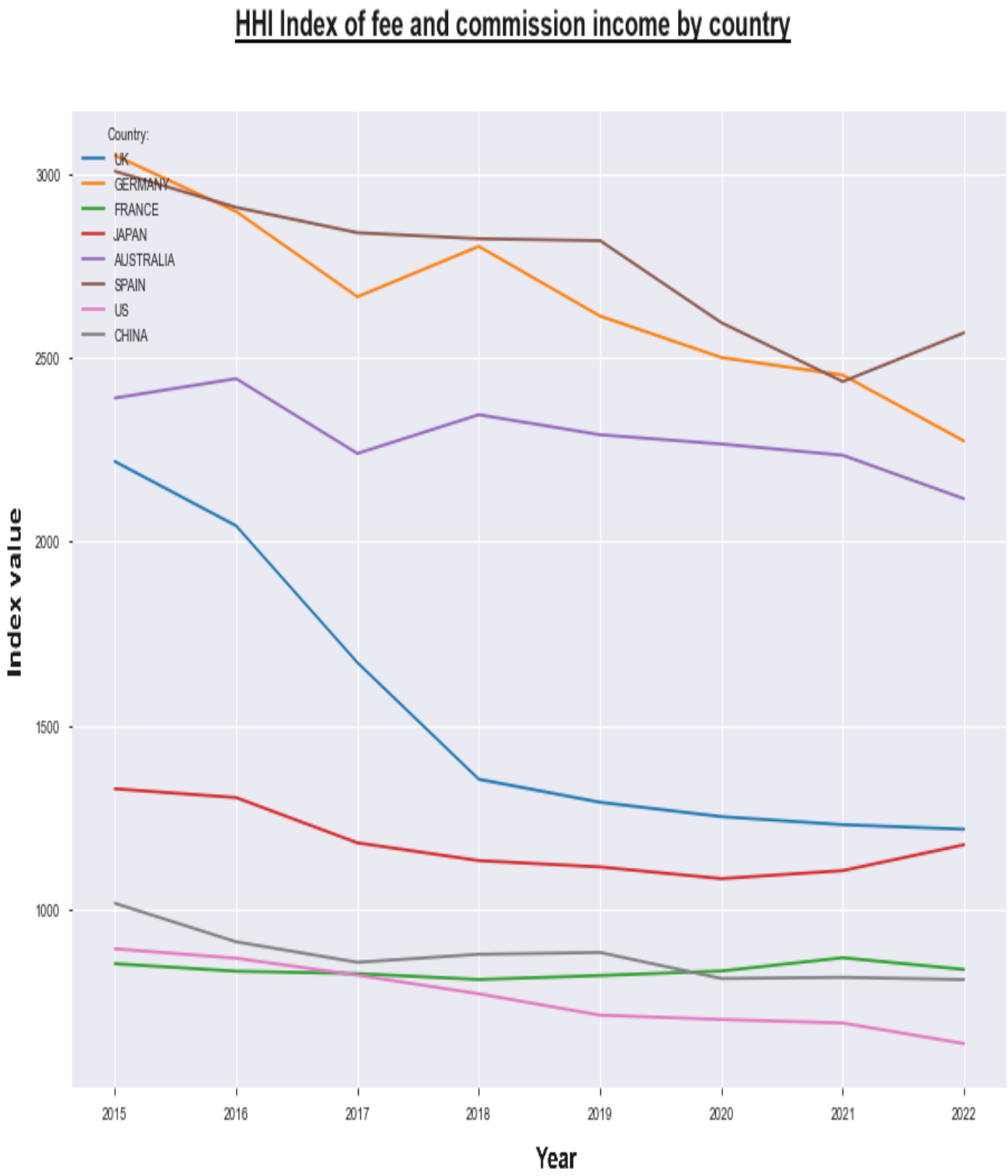
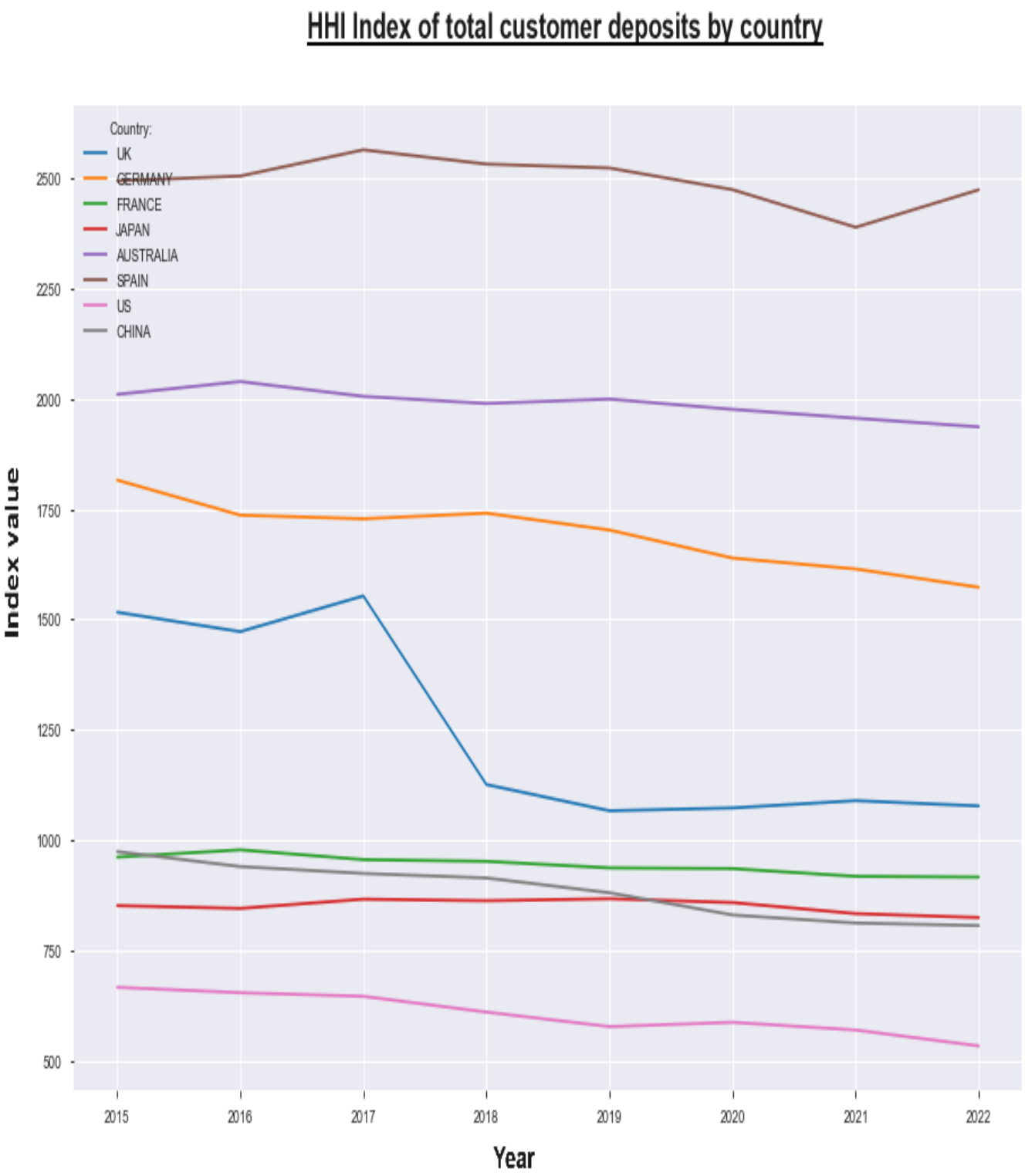


Figure 15: HHI index by country in the deposit market. The index shows the highest concentration value for Spain and the lowest for the US.



4.4.5.2 Lerner Market Power Index

The Lerner index measures the level of competition in the market. The higher the index, the less competition there is in the market. In the list of jurisdictions shown in Figure 39 below, Germany is the most competitive market, whereas China is the least competitive market according to the Lerner index. In the UK, the competition in the banking industry intensified until 2017, then reversed the trend to weakening competition until 2022.

To sum up, some of the country's Lerner index results match the assumptions, and some do not. Firstly, the Chinese competitive environment is the least competitive. It can be explained by the high level of state control in the banking industry.

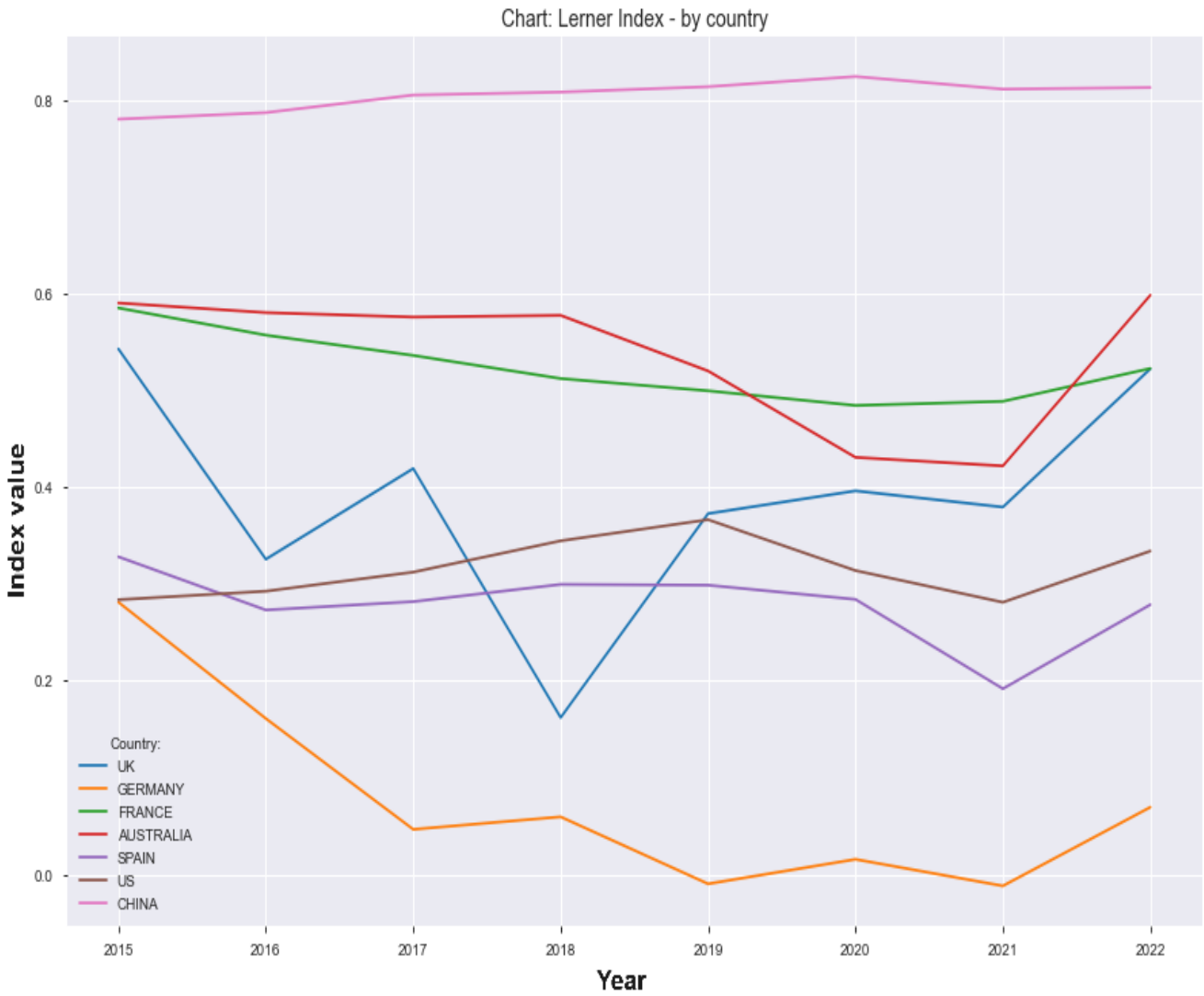
Secondly, it would be expected that the Lerner index in the US is lower than in Germany, but the index shows the opposite. The expectation of intensive competition in the US is based on the lowest concentration level of US banks among jurisdictions and the US organic approach to OB. The expectation of weak competition in Germany is based on the assumption that the community banks in Germany are well separated and protected under German regulations, and the OB market is more regulated than the US. However, the index shows that the German market is the most competitive. In another measurement of market power in the EU, confirming the finding, the German banks are also competitive.[779]

[779] Maria Celia López-Penabad, Ana Iglesias-Casal and José Fernando Silva Neto, 'Competition and Financial Stability in the European Listed Banks' (2021) 11 SAGE Open 21582440211032645.

Therefore, the assumption of a competitive environment based on the concentration presumption is not always accurate. Other factors, such as regulatory restraints, may also play a role. Thirdly, since 2018, there has been an inverse trend between HHI concentration and the Lerner market power index. Before 2018, the reduction of concentration in the UK coincided with an intensification of competition. However, after 2018, concentration in the UK remained stable, while competition became less intense. OB regulation was enforced in 2018, suggesting a possible regulatory impact.

Moreover, in the previous analysis of the network effect, the impact was detected following the OB enforcement. It is possible that the network effect has weakened competition. Lastly, due to contradictions in reversing the trend, another market power index, the Boone Index, will be used to validate the reversal competition trend.

Figure 16: Lerner index value by country. The graph shows that banks in China (pink line) have the most potent market power, and banks in Germany have the least market power.

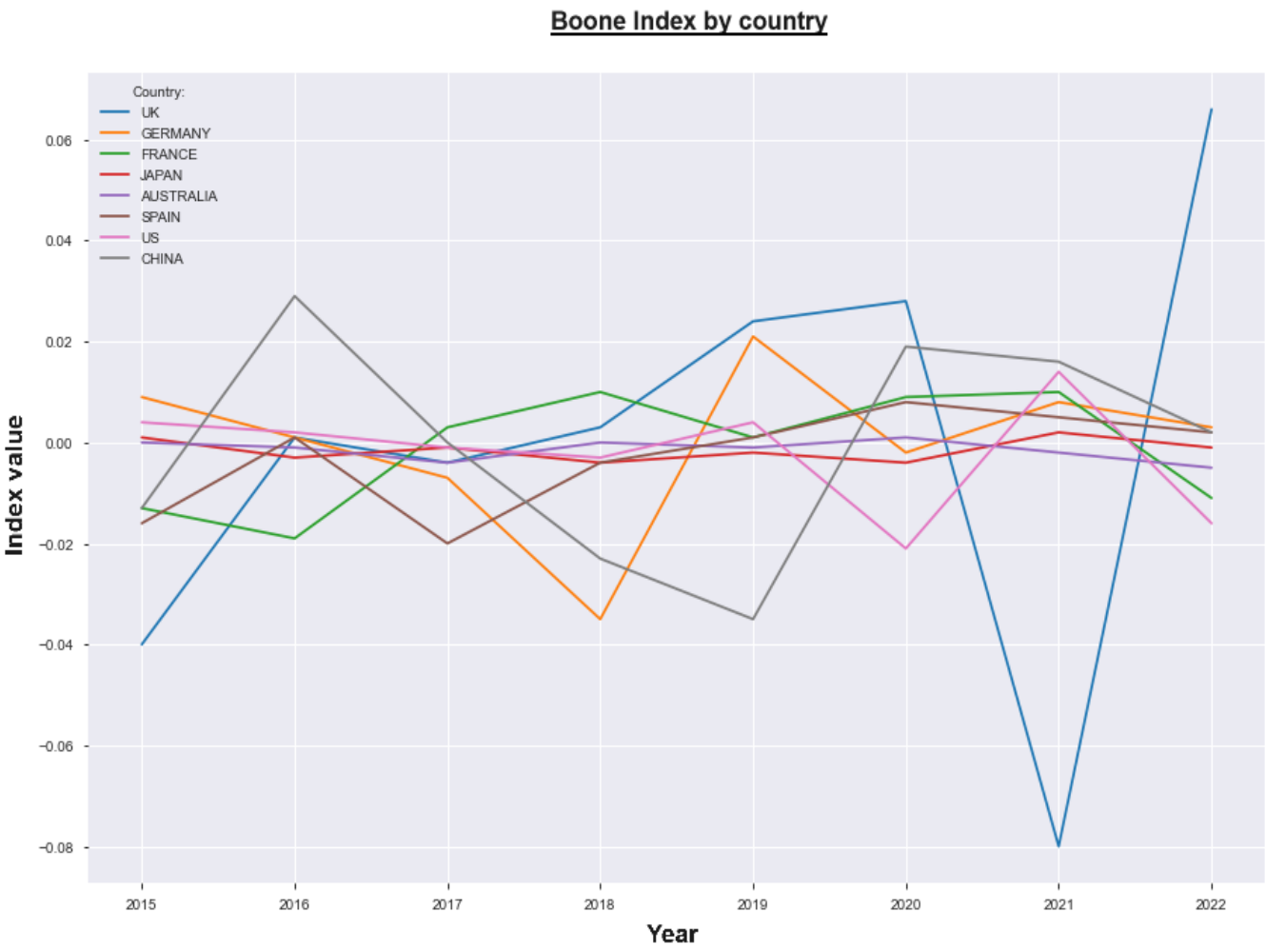


4.5.5.3 Boone Market Power Index

The Boone index indicates that the most intense competition is in the US, whereas Germany has the lowest level of competition (see Figure 40). The index fluctuates significantly, accompanied by a wide range of standard errors. Therefore, the exact competition score should be interpreted with a potential deviation in mind. Analysing the overall long-term trend should help mitigate the short-term fluctuations. Over the entire period from 2015 to 2022, competition in the UK banking market has

diminished. There was a period between 2017 and 2020 when competition was declining, but it began to intensify until 2021. However, the competition level returns to its long-term trend of decreasing competition in 2022. In summary, there was a short period of improvement in competition between 2020 and 2021; however, the long-term trend of competition in the UK remains one of lessening.

Figure 17: Boone index value by country. The Boone index shows a short period of improvement in competition in the UK (the blue line). However, the long-term trend of competition in the UK weakened from 2015 to 2022.



4.5.5.4 Robustness

As the HHI, Lerner, and Boone indices have advantages and limitations, to confirm the changes in the competitive environment after the OB enforcement, all three indices are presented together in Table 22 for the robustness test. According to the conclusion in Chapter Three, their trends are examined collectively regarding the application of factors by courts, regulators, and academia; their examination of factors should be collective, as individual factors cannot reflect all aspects of real-world impact. for instance, the decreasing concentration of income can indicate an improving competitive environment. However, if the concentration is declining alongside increasing market power, several situations may arise. One possibility is that the market can be expanding, leading to a decrease in concentration. Additionally, the decrease in concentration can be temporary, as the increasing market power suggests that, in the long term, the share of the expanding market may be captured by participants with high market power. As a result, the decrease in concentration is likely only temporary.

The changes in concentration and market power are categorised into four periods. These periods are separated because significant events, including OB enforcement and the COVID pandemic, happened during this time. The first period was before the OB enforcement, from 2015 to 2017. The second period is after OB enforcement and before the COVID-19 pandemic, from 2018 to 2019. The third period is during the COVID-19 pandemic, between 2020 and 2021. Therefore, the impacts of these measures can overlap. The last period is after the pandemic, which is the year 2022.

Table 22: Market power and HHI in four periods. There is no correlation between market power and the HHI concentration index.

Year	Boone Average	Lerner	HHI Average
Period 1 (2015-2017)	-0.46	0.54	1723
	-0.04	0.33	1705
	-0.17	0.42	1538
Period 2 (2018-2019)	0.10	0.16	1255
	0.17	0.37	1168
Period 3 (2020-2021)	0.84	0.40	1144
	-1.33	0.38	1138
Period 4 (2022)	0.04	0.52	1120

In the first period, all Lerner and HHI indicators show improvement in the competition environment. The concentration index dropped from 1723 to 1538, the Lerner index lowered from 0.54 to 0.42, and the Boone index is still increasing. However, it should be noted that the Boone index measures competition through efficiency as a proxy of profit and costs. Therefore, the Boone index can be lagged by the Lerner index, which measures the competition through marginal costs. Consequently, it can adapt to the environment faster than the efficiency measurement.

Both market power indexes show a worsened competitive environment in the second period after the OB enforcement. The Boone index gains from 0.10 to 0.17, and the Lerner Index gains from 0.16 to 0.37. However, the HHI index shows a reverse trend of concentration. There is no correlation between concentration and competition in this period.

In the third period during the pandemic, the competition intensified in terms of efficiency as the Boone Index decreased from 0.84 to -1.33. However, the bank's power over the price setting has not been reduced at the same level as the Lerner index, which decreased slightly from 0.40 to 0.38. The concentration during the period is still gradually decreasing.

In the last period after the pandemic, both market power indicators returned to their pre-pandemic levels after the OB enforcement trend. They indicate a weakening competitive environment.

4.5.6 Conclusion

The analysis shows that OB regulations might have reduced the operating costs by £5.1 billion and the staff expenses by £1.2 billion. The reduction of the expenses can be explained by the net benefit of the adaptation of new technology developed by the OB regulations over the costs of new investment in OB. The money creation market has a surplus of £2.2 billion for income. This can be an indirect benefit from opening data and service access. However, banks' service fees and commission income have slightly negative or zero surpluses. All surplus created by OB regulations may benefit TPP. There is an increase in profit, which can be caused by implementing new technologies to increase income and reduce costs. However, the OB regulatory impact on costs and income is not statistically significant compared to service quality and public sentiment results. The impact coefficient p-value for costs and income is higher than 0.2, whereas the results for service and public sentiment are approximately 0.

In addition, the concentration of the UK banking industry is gradually declining. It can be a good indicator of lowering switching costs. However, contrary to the assumptions, the competition environment has not improved. There could be short-term improvements in the first and third periods, but the long-term competitive trend, measured with Boone as an efficiency proxy and Lerner index as

the power to set the price, shows that the competitive environment is weakening. Therefore, despite the expectations of OB regulations to reverse the competition environment in the banking industry, the main objective of the regulations has not been fulfilled.

4.6 General Regulatory Impact Model

Introduction

This section incorporates the datasets from the previous analysis on public sentiment, service quantity and quality, network effects, bank operations and market power to model the general regulatory impact.

The modelling considers how the OB regulations impact the competitive market environment. This enables us to predict the interaction between regulations and the market. Since social welfare is linked to the competitive environment, predicting the regulatory impact on competition has welfare implications.

The analysis consists of five parts. In the first part, a regression model and data are described. The second part modulates a linear regression model with the forward stepwise algorithm. In the third part, the linear model is checked for heteroskedasticity. Since a heteroskedasticity problem exists with the linear model, another non-linear model is constructed using the Support Vector Machines ("SVM") algorithm to cross-check the linear model, thereby enhancing the robustness of the results. In the fourth part, the linear and SVM models are applied to predict the future behaviour of the competitive market. Lastly, the interpretation and conclusions are outlined in the fifth part.

The modelling reveals several insights. Firstly, the linear regression model shows that the statistically significant impact factors are public sentiment, account switching number, network effect and number

of reviews. The findings support the existence of a network effect. Consequently, a proposal to amend the regulation should be drafted. Secondly, all three models show that public sentiment is the most significant impact factor. The implication of these results is interesting. When the public sentiment is reducing or increasing, the public should have an instrument to react to the market power, maybe by influencing the regulators or through a change in consumption behaviour. With the current AI applications, the accessible tracking of public sentiment can provide a powerful prediction indicator. Thirdly, the OB regulatory impact has a duration limitation. The regulatory impact exists for a fixed period. Lastly, the prediction shows the weakening competitive environment when the sentiment is reducing and other factors, such as switching numbers and the number of reviews, are increasing. In summary, by changing the values of those significant factors, a prediction of a proposal to regulate the network effect can be conducted to understand the possible future regulatory impact.

4.6.1 Methodology and data

The impact model is detailed with more factors from previous empirical tests:

$$Market\ Power\ factors = b_o + \sum_{k=1}^{n} b_k * Entry\ barrier\ factors_k \qquad (1)$$

Furthermore, after the factor analysis, the detailed regression form is as follows:

$$\begin{aligned} Lerner_index_{i,t} \\ &= b_o + b_1 * Sentiment_{i,t} + b_2 * Company\ name_{i,t} + b_3 \\ &* Account\ switching\ number_{i,t} + b_4 * Number\ of\ Reviews_{i,t} + b_5 \\ &* OB\ enforcement\ dummy_{i,t} + b_6 * Review\ score_{i,t} + b_7 \\ &* Total_operating_expenses_{i,t} + b_8 * Total_customer_deposits_{i,t} \end{aligned}$$

Where:

- $Lerner_index_i$ is the value of the Lerner index for i^{th} bank at the year t. The variable represents the market power factor.
- $Sentiment_i$ is the public sentiment value for i^{th} bank at the year t. All banks share the same public sentiment.

- $Account\ switching\ number_{i,t}$ is the net number of accounts switching to the ith bank at the period t.
- $Number\ of\ Reviews_{i,t}$ is a number of reviews on the ith bank`s app in Google Play during the t-time period.
- $Review\ score_{i,t}$ is the user review score of the ith bank`s app in Google Play during the t-time period.
- $OB\ enforcement\ dummy_{i,t}$ equals to 1 when the OB regulations are enforced for i^{th} bank at the year t. Otherwise, it equals 0.

The impact model with the above factors can be a linear or non-linear regression. By choosing the model type, such as a linear or non-linear regression model, the modelling can be processed. In this analysis, the two types of models, linear regression and SVM, are applied. In addition, the forward stepwise selection method is applied in modelling. The types of linear and non-linear models and the modelling process are explained below.

4.6.1.1 Linear regression

Linear regression describes the dependent variable Y as a linear regression of independent variable X (input factor or predictor). The relationship between variables is represented in the form of linear regression:

$$Y(X) = b_0 + \sum_{i=1}^{p}\left(b_i(X_i)\right) + \varepsilon\ ;$$ [780]

Where:

p is the number of independent variables (or predictors),

b are the coefficients

ε is the random error term.

[780] Gareth James and others, *An Introduction to Statistical Learning: With Applications in R*, vol 103 (Springer 2013) 21.

The coefficient $b_i$can be calculated by feeding sample data of X_i into the model to minimise the sum of square errors ("SSE")[781].

In addition to typical linear regression, partial least square ("PLS") or principle component regression ("PCR") and their combinations are also the linear regression type of model. Moreover, there are different types of regressions, such as logistic and polynomial.[782] It is often referred to as the classification method when the response is qualitative.[783]

The model`s fit and accuracy can be interpreted based on standard indicators such as residual standard error ("RSE"), R squared, Akaike information criterion("AIC"), F-statistic or p-value.

For example, the residual standard error measures the standard deviation of the error.[784] In other words, if the model is constructed and the coefficients b_i are found, the model's prediction is off by the average value of RSE from the actual output. The higher the RSE, the greater the error of the model. The R-squared is the square of the Pearson correlation coefficient R.[785] The coefficient of determination, R-squared, shows what percentage of the independent variable explains the variation in the dependent variable.[786] The F-test assesses the joint significance of all estimated parameters. The p-values, which replace t-statistics, evaluate the significance of individual

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[781] SSE is the residual sum of squares, the residual is the distance between the best fit and the actual values

[782] Andy P Field, *Discovering Statistics Using R / Andy Field, Jeremy Miles, Zoë Field.* (SAGE 2012).

[783] James and others (n 781) 28.

[784] ibid 68.

[785] Field (n 783) 258.

[786] Field (n 783).

parameters. Together, they indicate whether the model prediction is significantly effective or not.[787]

Other indicators such as standard error, t-statistic and p-value of the coefficient b_i can be used to interpret the confidence in the hypothesis H: $b_i \neq 0$.[788]

4.6.1.2 Non-linear regressions

Besides linear regression models, various non-linear methods were developed. Some of these, such as neural networks, Support Vector Machines (SVM), or Multivariate Adaptive Regression Splines, can be applied.

Neural network

The most famous is the artificial neural network ("ANN"), which is widely applied in machine learning. The method feeds data to a network resembling the human brain's neural network. With an algorithm to compare the network outcome with the actual result, the ANN can correct itself to get a better result. The model consists of a network of neurons, each neuron processing the input data and then sending it to the next neuron until the last neuron for the output.[789] The common types of neurons are sigmoid, piecewise-linear, and logistic functions.[790]

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[787] ibid 259.

[788] Field (n 783).

[789] Hélène Paugam-Moisy and Sander Bohte, 'Computing with Spiking Neuron Networks' in Grzegorz Rozenberg, Thomas Bäck and Joost N Kok (eds), *Handbook of Natural Computing* (Springer Berlin Heidelberg 2012) 337 <http://link.springer.com/10.1007/978-3-540-92910-9_10>.

[790] ibid.

There are various variations of the neurons, the composition of the network and the self-correcting algorithm.[791] These parameters can be tuned to optimise the model. The model is effective with big data.

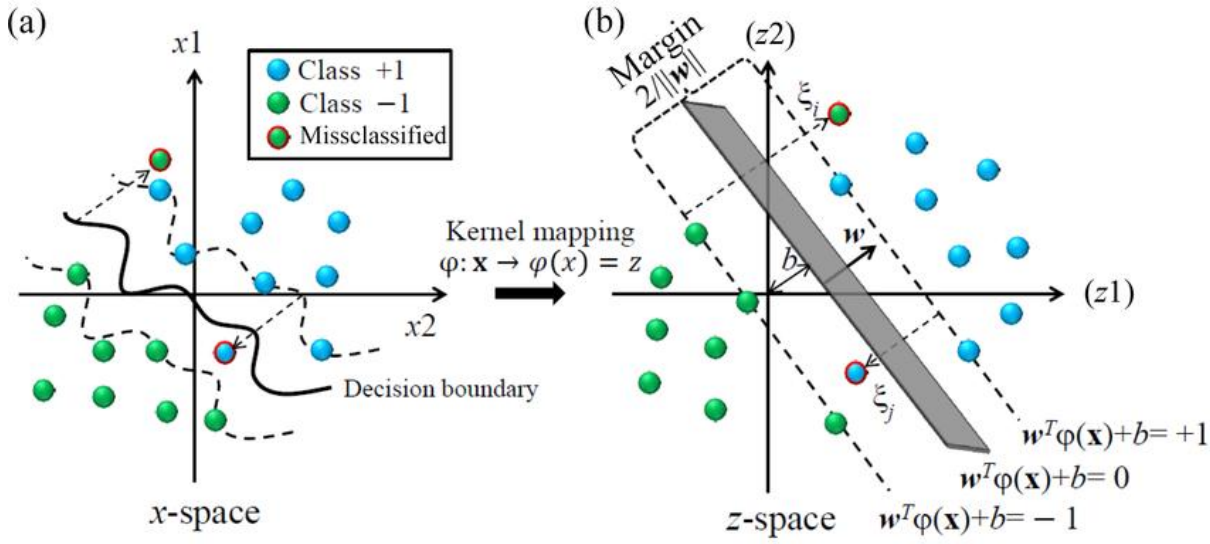
Support Vector Machines

SVM is a supervised non-parametric machine learning algorithm used for classification or regression. The algorithm's objective in classification is to find a hyperplane in high-dimensional feature space that can separate data samples into classes (groups).

For the regression task, the same principle of SVM is applied. The input data (independent variables) is mapped to points in a high-dimensional feature space. The algorithm's objective is to find the hyperplane to maximise the distance between the hyperplane and the points, thereby minimising the prediction error. As visualised in the Picture below, data are fed into the SVM. The green line is the hyperplane, and the red lines are the boundaries.

[791] Max Kuhn and Kjell Johnson, *Applied Predictive Modeling* (Springer 2013) 141–144 <http://link.springer.com/10.1007/978-1-4614-6849-3>.

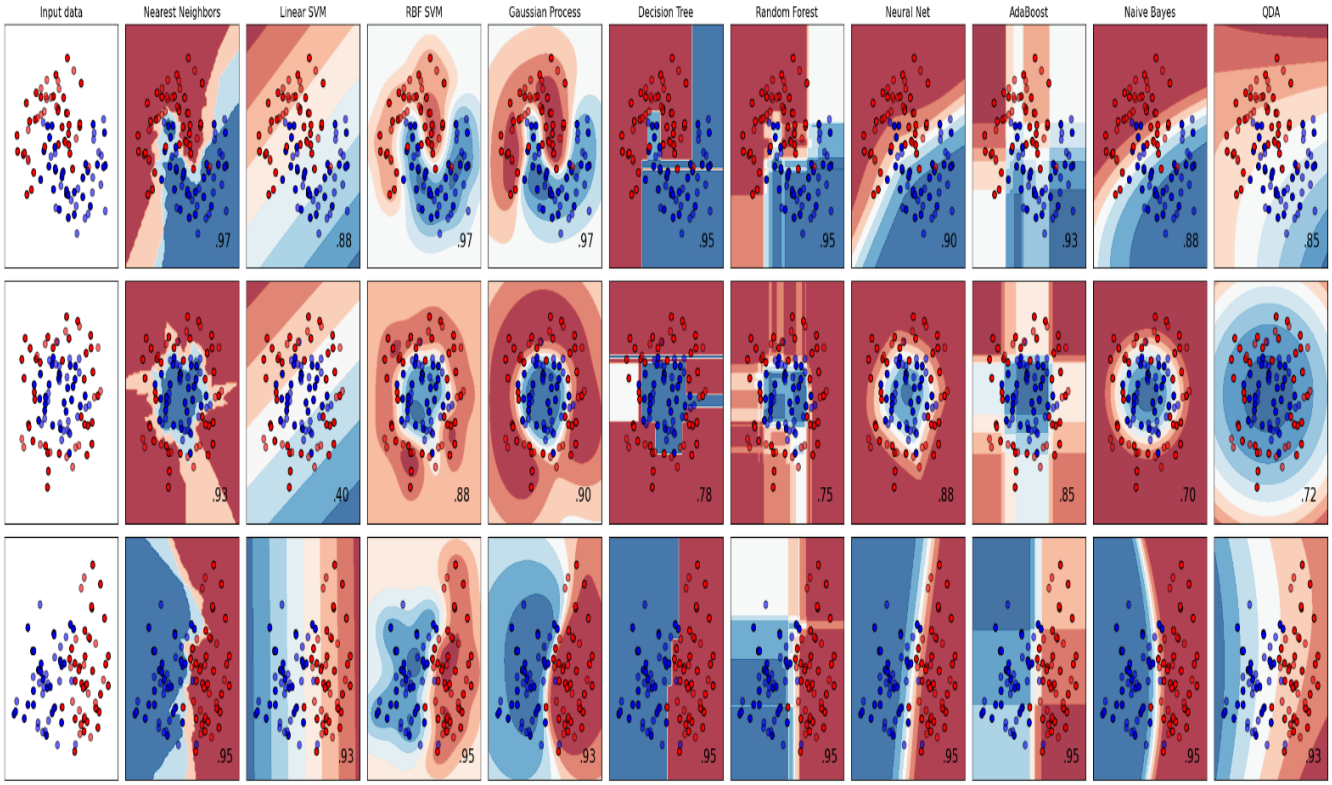
Figure 18: A visualisation of the non-linear kernel with decision boundary b classification. (a) the input x-space with classification problem (b) the non-linear mapping to a high-dimensional feature z-space with the W^T X_k+b hyperplane as a classifier.



Source: Faisal Khan, Frieder Enzmann and Michael Kersten, 'Multi-Phase Classification by a Least-Squares Support Vector Machine Approach in Tomography Images of Geological Samples' (2016) 7 Solid Earth 481.

The objective of the algorithm is to find a hyperplane with specified decision boundaries that contains the largest number of points. Depending on the kernel type, the hyperplane can be linear or in different forms, such as polynomial, sigmoid, Gaussian, and RBF. The form of a linear function is a straight line in two dimensions, a plane in three dimensions, whereas the form of the RBF function is like a curve, and the polynomial function is a sequence of curves based on its degree. The appropriate model can be found by fine-tuning the kernel to the data. The illustration of different kernels is depicted in the picture below.

Figure 41a . A visual comparison of SVM classification with different kernel types using a small training set and other models. The number in the bottom right shows the model's accuracy. SVM has the highest score (RBF SVM - 97%) in the first type of input data with the non-linear classification. It works worse with noise (linear SVM - 40%, RBF SVM-88%) in the second type of input data.



Source: 'Classifier Comparison' (*scikit-learn*) <https://scikit-learn/stable/auto_examples/classification/plot_classifier_comparison.html>.

Mathematically, the objective of the algorithm is to find the hyperplane that separates observations with maximum geometrical margin (the distance from observation to the hyperplane) after a series of calculations is as follows:[792]

$$\text{Max } \sum_{i=1}^{n} \alpha_i \text{ - ½} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_i * \alpha_j * y_i * y_j * < x_i T * x_i > \qquad (2)$$

$$\text{Subject to } \sum_{i=1}^{n} \alpha_i * y_i = 0$$

Where the training set is t $\{X_1, X_2, \ldots, X_n\}$, $X_i \in R_l$, i = 1, 2,..., n. W $\in R^l$ is a linear combination of training vectors with the weight α. W and b ∈ R are linearly separable, satisfying:

$$y_k(W^T X_k + b) > 0 \ \forall k \text{ with } 1 \leq k \leq n.$$

The above formula shows that the classifier $W^T X_k + b$ can be optimised by calculating linear weight α_i, α_j of the support vector.

Advantages and limitations of the method

As shown in the optimisation algorithm in formula (2), to maximise the geometrical margin of the classifier, the main parameters are α and the inner product $< x_i T * x_i >$. Let the transformation of x from the input dimension to the higher feature dimension be the function $\Phi(x)$. It is proved that $< x_i T * x_i >$ can be replaced by kernel function K($x_i T, x_i$)= $\Phi^T(x)\ \Phi(x)$. As shown above, the kernel function can be nonlinear.

[792] MN Murty and Rashmi Raghava, *Support Vector Machines and Perceptrons: Learning, Optimization, Classification, and Application to Social Networks* (Springer International Publishing 2016) 43–52 <http://link.springer.com/10.1007/978-3-319-41063-0>.

Consequently, the SVM algorithm can model linear and nonlinear classifiers or regressions with different kernels and types of input data. Moreover, a transformation to N-dimensional feature space requires the calculation of N^2, but as indicated in formula (2), there are only parameters α and the inner product $< x_i T * \mathrm{x}_i >$ which requires only n calculations. Therefore, the SVM algorithm can deal with large or infinite feature dimensions with low calculation costs.

The limitation of the algorithm is that it is difficult to interpret the model, as there is no understanding of the weight or impact of input variables. The model requires only the calculation of the linear parameter α and kernel. We only know the final model and the prediction results. Therefore, in our case, it is not possible to interpret the sentiment, switching costs, or impact of other variables. In addition, there can be difficulty in tuning the hyperplane as it is impossible to visualise the high dimension.

4.6.2 Modelling the impact regression

The *Foward stepwise selection* is applied to model the regulatory impact. It starts with a model with zero predictors, then adds one more predictor at each step. The selection can improve the modelling process by selecting the best fit model in each step of the predictor`s addition.[793]

The advantage of the forward stepwise selection modelling compared to subset selection is that the number of modelling steps is significantly lower. Therefore, it is more computationally efficient. The limitation is that its search space is smaller than the subset selection; the resulting model can be less fit compared to the subset selection. Therefore, stepwise selection modelling is suitable for the project with limited computational resources. The selection algorithm consists of three steps:

- It starts with a model M_o, a null model with no predictors.
- For k= 0,...p-1
    a) Consider all p-k models in M_k with an additional predictor
    b) Choose the best model according to RSS or R-squared as M_{k+1}
- For all models $M_o, \dots . M_p$. Choose the best model according to cross-validated prediction errors, AIC, BIC or adjusted R-squared.

As it is unclear which type of model fits best, an OSL linear regression model is used to create predictions, followed by the application of another model, Support Vector Machine ("SVM"). As a linear model, a correlation matrix is generated to check the correlation between predictors (independent variables). Next, modelling is conducted using a forward stepwise selection algorithm. The linear regression is performed with a company-fixed effect. During the OSL regression modelling process,

[793] James G and others, An Introduction To Statistical Learning With Application In R (3rd ed., Springer 2017) 207-208

heteroskedasticity was found. Therefore, the non-linear SVM model was run as a robustness test, and the OSL results were validated against the SVM results.

4.6.2.1 Descriptive analysis

After the matching of datasets, there are N/A (not available) values as the collection of banks' account switching numbers only started in 2018, and app review data are collected for 18 major banks (see the table below). The N/A values based on the column number of reviews are dropped from the dataset to maintain the consistency of the model. In total, there are 91 samples of 16 banks from 2017 to 2022. Data is stored in the file "Vo_207055762_Fifth test Impactmodelling.csv". The Python code is in Appendix J (General impact modelling - Python Code).

Table 23: Data description. The table shows some characteristics of bank data in the UK used in the impact model. There are a total of 16 unique banks and 91 observations in the range of 5-6 years. Notably, the data on banks switching numbers is only available from 2018

	Year	OB enforcement dummy	Sentiment	Switch number	Number of reviews	Review score	Total operating expenses	Total customer deposits	Lerner index
count	91	91	91	75	91	91	91	91	91
mean	2019.6	0.87	0.24	1,447	6,493	3.63	2,692,957	128,020,023	0.14
std	1.66	0.32	0.02	35,556	7,831	1.03	3,486,851	158,676,214	0.89
min	2017	0	0.22	-69,067	0	0.00	41,739	98,222	-5.27
25%	2018	1	0.22	-19,388	1,257	2.99	450,550	12,027,534	0.15
50%	2020	1	0.23	-4,323	3,301	4.11	1,300,936	27,331,055	0.41
75%	2021	1	0.25	21,506	8,352	4.41	3,736,426	232,594,691	0.56
max	2022	1	0.27	128,167	39,346	4.73	15,721,987	603,687,635	0.80

The correlation between all variables is not significant (see the table below). There is only a strong correlation between Sentiment and the Year, as well as the OB enforcement dummy variable. This can be explained by the theoretical framework of public sentiment analysis from the first empirical test (see section 4.2). There is a tendency for a bubble to form before the resolution of uncertainty, and once that uncertainty is resolved, the sentiment bubble collapses. In this case, the resolution of uncertainty refers to the OB enforcement. Therefore, a high correlation exists, and sentiment has been decreasing after the year of OB enforcement. As the OB enforcement dummy is crucial for understanding the regulatory impact, it has been decided to retain it. In conclusion, the Year variable will be removed from the modelling.

Table 24: The correlation table. The table shows correlations between pairs of variables. Value 1 indicates the highest correlation, whereas 0 means no correlation. The negative value indicates the reverse correlation. The most correlated pairs are between Sentiment and Year (-0.94) and between Sentiment and OB enforcement dummy (-0.84).

	Year	OB_enforce	Sentiment	Switch_number	NB_Review	Review_score	Total_operating_expenses	lern_index
Year	1	0.64	-0.94	-0.013	0.17	0.077	-0.00078	0.096
OB_enforce	0.64	1	-0.84		0.15	0.1	0.014	0.0037
Sentiment	-0.94	-0.84	1	0.012	-0.19	-0.099	-0.0058	-0.064
Switch_number	-0.013		0.012	1	-0.11	0.14	-0.098	-0.1
NB_Review	0.17	0.15	-0.19	-0.11	1	0.46	0.47	-0.0024
Review_score	0.077	0.1	-0.099	0.14	0.46	1	0.35	-0.22
Total_operating_expenses	-0.00078	0.014	-0.0058	-0.098	0.47	0.35	1	-0.016
lern_index	0.096	0.0037	-0.064	-0.1	-0.0024	-0.22	-0.016	1

Next, the forward stepwise algorithm is applied to model the regression. The description of regression models is in the Methodology Chapter. The regulatory impact model K4-1 is the most suitable multiple linear regression model for describing the OB regulatory impact on the competitive environment, based on the model score in Appendix E. The description of model K4-1 and its coefficients are presented in Table 25.

Table 25: K4-1 model characteristics. In the modelling process, K4-1 demonstrates the most accurate model with four coefficients: sentiment, switching number, number of reviews, and OB dummy.

Model description		**Model accuracy**		**Heteroskedasticity**	
Dep. Variable:	Lern_index	R-squared:	0.59	Lagrange multiplier:	37.63
Model:	OLS	Adj. R-squared:	0.47	P-value:	0.01
Method:	Least Squares	F-statistic:	4.87	F-value:	3.38
No. Observations:	75	AIC:	159.3	F P-value:	0
Df Residuals:	57	BIC:	201		

Variables	**Coef**	**std err**	**P>|t|**	**[0.025**	**0.975]**
Intercept	*1.9534*	*0.842*	*0.02*	*0.268*	*3.639*
Sentiment	*-14.8937*	*7.13*	*0.04*	*-29.171*	*-0.617*
Account switching number	*0.00001*	*0*	*0.08*	*0*	*0.00001*
Number of Reviews	*0.00006*	*0.00003*	*0.03*	*0*	*0*
OB enforcement dummy	*1.9534*	*0.842*	*0.02*	*0.268*	*3.639*

4.6.2.2 Robustness of the statistical model

The statistical impact model K4-1 is checked for heteroskedasticity. Heteroskedasticity problems can occur in linear regression models. When the variance of errors is not constant across observations, the tell-tale of residual errors tends to fan out in the visual examination of data. This tendency violates the assumption of data behaviour in linear models, creating biases in linear regression models. In this analysis, the Breusch-Pagan test is conducted for heteroskedasticity. The test hypothesis is as follows:

- The null hypothesis (H0): Signifies that Homoscedasticity is present.

- The alternative hypothesis (Ha): Signifies that the Homoscedasticity is not present (i.e. heteroscedasticity exists)

The result of the Breusch-Pagan Heteroskedasticity Test shows that the Lagrange statistic is 37.63, and its P value is 0.01 (below 0.05). The null Hypothesis can be rejected (see Table 25). This means that heteroscedasticity is present in the model.

Next, robust standard errors (White-Huber-Eicker standard errors) are used in the regression to deal with an unknown type of heteroscedasticity. The application of robust standard errors has improved the model`s F-statistics (from 4.87 to 13.22). However, heteroscedasticity is still present. Therefore, another method should be applied.

The same coefficient of model K4-1 with the total customer deposit factor instead of the account switching number is applied. The assumption is that when the customer switches to the new bank, the bank`s customer deposits should increase. Therefore, the total deposit factor can be used as a proxy for the account switching number. The substitution can increase the number of samples. The results of the K4-1D model are illustrated in Table 26. All coefficients in K4-1D confirm the signs of the coefficients in K4-1, except the OB enforcement dummy. However, heteroscedasticity remains present. Therefore, another non-linear method will be applied.

Table 26: K4-1D model with total customer deposit. The K4-1D replaces the switching account number variable with a deposit to check the robustness of the result.

Model description		**Model accuracy**	
Dep. Variable:	lern_index	R-squared:	0.56
Model:	OLS	Adj. R-squared:	0.44
Method:	Least Squares	F-statistic:	5.4
No. Observations:	91	AIC:	200.3
Df Residuals:	71	BIC:	251
Variables	**Coefficient**	**P>|t|**	
Intercept	6.0623	0.005	
Sentiment	-20.3744	0.01	
Total customer deposits	-0.000000006	0.01	
Number of Reviews	0.00004	0.33	
OB enforcement dummy	-0.7801	0.07	

Application of Support Vector Machines ("SVM") model

Another solution for heteroscedasticity is to apply non-parametric models instead of linear regression models. These models can be a type of SVM, Decision Tree or Neural Network.[794] A neural network usually works with a big data set, and SVM can work with big data and small data sets with multiple predictors.[795] As our dataset is small, with seven predictors, the sample data is used to train an SVM model in this analysis. A detailed description of the SVM method is in the Methodology Chapter.

[794] James and others (n 781).

[795] ibid; Evgeny Kondratovich, Igor I Baskin and Alexandre Varnek, 'Transductive Support Vector Machines: Promising Approach to Model Small and Unbalanced Datasets' (2013) 32 Molecular informatics 261.

The results of SVM modelling are shown in Table 27. In the first step, the same linear regression model K4-1 with four independent variables is modelled with the SVM algorithm. The data sample is split with a 0.4 test size to train the model. All three types of SVM kernels are considered. The result shows that the SVM model with the RBF kernel has the highest model score (R-squared) of 23%. Next, in the second step, the test size is decreased to 0.25 (or the training size to 0.75), and decision boundary C is set to 500. The gamma and epsilon are set as default to enhance the model score. The model accuracy reaches 92% with a broader training size and decision boundary. Lastly, to check the model's accuracy with other predictors, new predictors (independent variables) are added to the model in the third step. The total is seven predictors, including review score, total deposits, and total operating expenses, in the new SVM-5 model. The model score has increased to 97% without the configuration of gamma and epsilon parameters.

Table 27: Modelling SVM regulatory impact model. The models with the highest score are SVM-4 and SVM-7

First step					
Model number	Kernel type	Number of Predictors	Model R sq. score	Model intercept	Test size
SVM-1	*rbf*	*4*	*0.23*	*0.24130249*	*0.25*
SVM-2	*linear*	*4*	*-0.07*	*0.41841355*	*0.25*
SVM-3	*polynomial*	*4*	*- 0.07*	*0.41411207*	*0.25*
Second step					
Model number	Kernel type	Number of Predictor	Model R sq. score	Model intercept	Test size
SVM-4	*Rbf, C = 500*	*4*	*0.92*	*-0.81264111*	*0.25*
Third step					
Model number	Kernel type	Number of Predictors	Model R sq. score	Model intercept	Test size
SVM-5	*Rbf, C = 500,*	*7*	*0.97*	*0.45691834*	*0.25*

The SVM and the linear regression show that models with four predictors, public sentiment, account switching number, number of app reviews and OB dummy, have the highest accuracy. The linear regression model K4-3 has a 59.3% accuracy score, which is the highest among other linear regression models, and the SVM model SVM-4 has a 92% accuracy score, which is the second highest among SVM models and higher than other linear regression models.

In conclusion, the K4-1 linear regression model is used for interpretation, and the SVM model is used for prediction and cross-checking. The SVM model is similar to other machine learning algorithms. They provide the output, but interpreting the internal learning process is challenging. Therefore, the linear model K4-3 is applied to interpret the impact factor. For the prediction, the SVM-4 model and K4-1 are used to predict the competitive environment and cross-check the results.

4.6.3 Competitive environment prediction

The impact models, SVM-4 and K4-1, are applied to assess the regulatory impact in a future scenario with 23 data points for 23 periods. There are several assumptions in the test scenario:

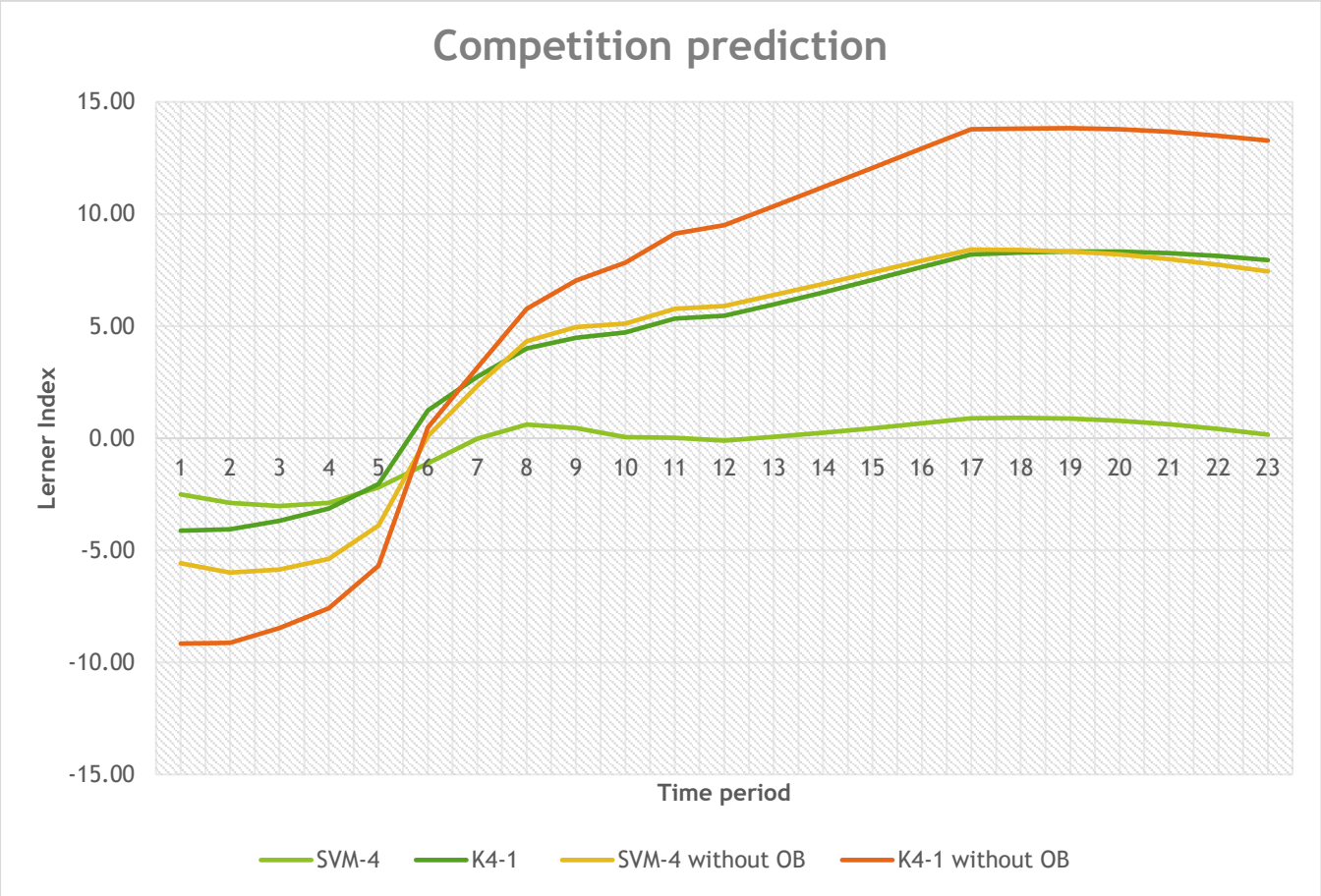
- According to the SARS sentiment model, public sentiment toward OB will decrease further. The model described the bubble in sentiment. Then, at some point, the public sentiment will stabilise after the bubble. The sentiment variable decreases until time t=10, and then the value becomes constant.
- The switching account continues accelerating as more customers want to switch to better services created by open data. The switching account variable is set to increase.
- The number of reviews is still increasing as OB providers are developing new services. The number of reviews variable is set to increase.
- The banking infrastructure has completely switched to the OB ecosystem (the OB dummy is equal to one), or there is no OB enforcement (the OB dummy is zero).

The sample dataset of the above scenario fits the linear regression model K4-1 and the SVM model SVM-4. Figure 42 shows that both models predict a time-fixed OB regulatory impact on the competitive environment, indicating a less competitive environment in the future.

The SVM-4 model shows predictions in two scenarios, one with OB enforcement (OB dummy equals one) and another with no regulatory enforcement (the dummy equals zero). The results of both scenarios, blue and grey lines in Figure 42, show that until time 8, the Lerner index of the grey line is below that of the blue line, then after time 8, they both match each other. The difference between the two scenarios occurs only at the beginning, and then the regulatory impact subsides.

Furthermore, there is a substantial upward trend when sentiment is negative. However, when sentiment is constant at time 10, the linear model shows a slower increase in the Lerner index, whereas the SVM model indicates a stabilisation in the competitive environment. As the acceleration of switching numbers and the number of reviews in scenario test data varies, this implies that in the SVM model, the increase in switching numbers or the number of reviews should reach a breaking point to mitigate the competitive environment. To sum up, both models predict a less competitive environment for certain periods, after which the competitive level stabilises.

Figure 42: Result of predictions for 23 time periods. The vertical is the Lerner index, the horizontal is the period. The input data is the extension of the current predictor`s trends fed to two models, the linear regression model K4-1 and the SVM model SVM-4. The sentiment decreases until T=10, and all other factors, such as the number of switching accounts or reviews, are increasing. The comparison is made with the OB enforcement dummy on and off. All models show that the competition environment is weakening in the long run(until T=23), the enforcement of OB helped to strengthen the competition in the short run by comparing models with and without OB enforcement.



4.6.4 Impact Model interpretation and conclusion

The impact model K4-1 demonstrates that public sentiment (P value = 0.02), the number of switching accounts (P = 0.08), the number of application reviews (P value = 0.03), and the OB regulatory enforcement (P = 0.02) are statistically significant factors influencing the competitive environment. As

the K4-1 has heteroskedasticity, two other models were run to confirm the findings: a linear K-41D and a machine learning non-linear SVM-4. The K4-1D model was employed to confirm that the K4-1 coefficients align in terms of all coefficient signs, except for the OB dummy coefficient. Furthermore, the SVM-4 model, used to cross-verify the K4-1 model, predicts the same trend (see Figure 42).

The OB enforcement dummy indicates whether the OB regulations were enforced in the given year. It is statistically significant, with a coefficient of 1.95, suggesting that the enforcement of OB regulations increased the Lerner index by 1.95 points (see Table 25). As the Lerner index reflects the competitive environment, an increase in the index indicates a less competitive environment. However, both K4-1 and SVM-4 models show that the enforcement of OB regulations, compared to the scenario without enforcement, improves competition (see Figure 42). Nonetheless, the long-run trend, with or without OB enforcement, shows a weakening of competition.

The further comparison of predictions in SVM-4 models in Figure 42 suggests that the OB regulatory impact on competition is temporary. Both models confirm that there is a regulatory impact; it is limited to a fixed period and not powerful enough to reverse the long-term trend of market power consolidation.

The OB dummy coefficient aligns with the previous analysis on market power, indicating that long-term competition decreases after the OB regulatory enforcement. Additionally, the network effect is present when the OB is enforced. Hence, the network effect dummy is equal to the OB enforcement dummy. The significance of the OB dummy also means that the present network effect is statistically significant in influencing market power within the OB ecosystem.

The interpretation of account switching numbers by the K4-1 model deviates from theoretical expectations. In competition theory, more accounts switching between providers indicates lower barriers and a more competitive market. However, in the model, the switching number positively influences the competitive Lerner index. The higher the Lerner index, the less competition there is, so the coefficient suggests that the increased account switching number raises market power, thereby reducing competition in OB. This can be explained by the fact that the increasing switching number is not evenly distributed; rather, the net positive switching number occurs in a certain type of bank. Therefore, a particular type of bank gains an advantage by attracting more users. This result is consistent with the network effect analysis. The existence of the network effect gives some banks an advantage in attracting a user base.

Another positive coefficient is the number of reviews (coef = 0.00006). The coefficient suggests that an increase in the quantity of services, measured by the number of reviews, correlates with decreased competition. This contradicts monopoly theory, which states that reduced competition leads to high deadweight loss and less surplus in terms of service quantity.

It is possible that the surplus from the increase in application reviews created by OB enforcement is greater than the deadweight loss caused by decreased competition. Therefore, the coefficient remains positive. However, in the long run, as competition becomes increasingly monopolised, the deadweight loss may exceed the surplus generated by the improved service quantity resulting from open data, and the coefficient could turn negative, as the theory suggests.

Lastly, public sentiment is the only negative coefficient, indicating that higher public sentiment about OB correlates with increased market competition. The finding across both the K4-1 and SVM-4 models

(see Figure 42) is consistent. In a more competitive market, providers compete to better satisfy customers.

In general, the OB regulatory impact model suggests that regulations impact the provider`s costs, income, profits, public sentiment, service quality and quantity, creating the network effect in the market. In addition, the model shows that costs or total deposit factors alone are not statistically significant to the market power; however, public sentiment, account switching number, network effect and number of reviews are significant. The most significant impact factor is public sentiment. Therefore, by adjusting the values of these significant factors in the K4-1 and SVM-4 models, predictions of market power can be made to anticipate potential future regulatory impacts.

5. Chapter Five: Result Interpretation and Conclusion

In this chapter, the results of the OB regulatory impact discussed in the Empirical Chapter are interpreted within the framework of efficiency and just distribution. In the first section, the outcomes of the OB regulatory impact are translated into utility function value. Furthermore, the stakeholder joint value creation social welfare function ("SWF") and the Pareto efficiency criteria established under Chapter Three, Interpretation Framework, are applied to determine whether the distribution of resources and capacity through regulations is efficient. Finally, the conclusion and limitations of the research will be addressed.

5.1 Result interpretation

Introduction

In this section, the results of the regulatory impact study are interpreted within the framework established in the Interpretation Framework section of Chapter Two. Firstly, the application of alternative states, individuals, and individual utility is examined in the case of the OB ecosystem. Next, the individual utility function under social alternatives $\mathrm{U}_i(\mathrm{X})$ is defined. Lastly, the allocation efficiency Pareto test and the stakeholder framework are applied to assess whether the regulatory distribution is just and efficient or not.

5.1.1 Definition of parameters

To apply the criteria for assessment efficiency and fair distribution, the society (in terms of total groups), individuals, alternative social states, and the utility within the selected society should be defined.

In line with the thesis objective, a regulatory impact study was conducted on the OB ecosystem and its stakeholders. Following the thesis objective, the assessment society is the OB market. The OB market presents two social alternatives: one with OB enforcement and the other without. The stakeholders involved in the OB ecosystem include the CMA9 group of the nine largest banks, challenger banks, non-CMA9 banks, third-party providers, and consumers.

5.1.2 Definition of utility in the study

The utility for individuals in society is defined differently by the supplier group and the demand group (consumers).

In the classical understanding, the supplier's task is profit maximisation, producing more products and obtaining greater profit from sales. This approach is often criticised because the providers lack social responsibility.[796] To fully access the utility of providers in all aspects of social responsibilities, more resources and time are needed. As the study is constrained by resources, the classical terminology of profit maximisation is applied. The utility of providers, such as banks and TPP, is measured directly by their current profit and indirectly by their advantageous positions, as these advantages can increase profit in the long term. Alternatively, the utility of the customer is the surplus in terms of money they receive from acquiring the product.

Similarly, there are critiques regarding this definition of utility since it disregards the aspect of customers' moral satisfaction. In our case, utility is measured by the surplus and sentiment toward the OB ecosystem. The assumption is that the higher the sentiment of customers, the more pleasure they derive from the product. In addition, there is a cap on utility value growth as a diminishing function.[797]

To sum up, the individual utility function represents the total utilities derived from resource and capacity distribution. It can be either better off or worse off in comparison to the base alternative. The base alternative refers to the state without OB, normalised to 100%. The resource or capacity in the

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[796] Mankiw (n 414).

[797] John Rawls, *A Theory of Justice: Original Edition* (Harvard University Press 1971) <https://www.jstor.org/stable/j.ctvjf9z6v>.

alternative with OB is expressed as the percentage ratio of the resource or capacity to the state without OB. The individual utility function value is normalised as follows to facilitate comparison between individuals.

There are two parameters for supplier utility: the market surplus in terms of operating profit and demand, and the capacity in terms of advantage in strategic position (network effect). For consumer utility, consumer satisfaction relates to sentiment toward OB, along with service quality (the review rating on the product); consumer surplus pertains to service demand and total market revenue. The individual utility function assigns a quantitative value to the change in individual resource and capacity from the no-OB alternative to the OB alternative (see Table below).

Figure 19: The individual utility function value. The table assigns utility values to groups against resource and capacity. Each group's utility value can be assigned and compared with the utility values. Individual in column "Individual" is designated by a value in column "Utility value" according to its distribution of resource and capacity in column "Resource/Capacity".

Individuals	Resource/Capacity	Shift in resource/capacity	Utility value
Supplier (CMA9, Challengers, NoCMA9, TPP)	Resource (supplier surplus such as operating profit, demand)	Significantly positive	3 points
		Moderately positive	2 points
		Slightly positive	1 point
		Neutral	no point
		Slightly negative	- 1 point
		Moderately negative	- 2 points
		Significantly negative	- 3 points
	Capacity (strategic advantage position such as network effect)	Significantly positive	3 points
		Moderately positive	2 point
		Slightly positive	1 point
		Neutral	no point
		Slightly negative	- 1 point
		Moderately negative	- 2 points
		Significantly negative	- 3 points
Consumer	Consumer surplus (change in interest, fee and commission income)	Significantly positive	3 points
		Moderately positive	2 points
		Slightly positive	1 point
		Neutral	no point
		Slightly negative	- 1 point
		Moderately negative	- 2 points
		Significantly negative	- 3 points
	Other indirect indicators of satisfaction (sentiment, review rating, switching costs)	Significantly positive	3 points
		Moderately positive	2 points
		Slightly positive	1 point
		Neutral	no point
		Slightly negative	- 1 point
		Moderately negative	- 2 points
		Significantly negative	- 3 points

5.1.3 Utility value of OB ecosystem and its participants

This section discusses the utility value or surplus of the total OB ecosystem and its participants—such as CMA9 banks, challenger banks, Non-CMA9 banks, TPPS, and customers—to measure the value received from two social alternatives: no OB and with OB.

The data from the empirical analysis is illustrated through a spider web. The inner blue circle represents the resource at the social alternative without OB, while the orange circle represents the resource at the alternative with OB. By comparing the two circles (blue and orange) or the resource distribution of the individual, the position can be defined as whether the individual is better off or worse off by the alternative. Following the shift of individual position, the just rule (in our case, stakeholder SWF) can be applied to justify or reject the regulation on the grounds of just distribution.

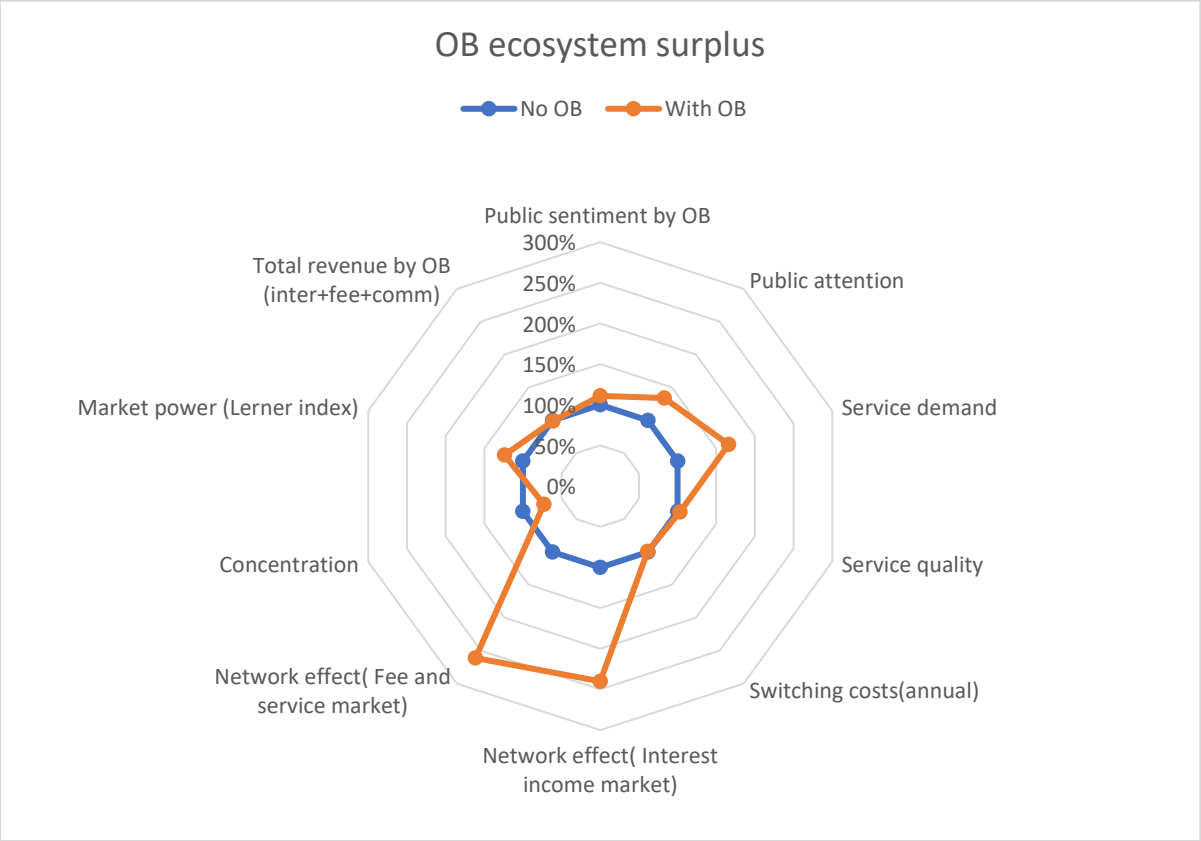
There are several notes regarding the data. The logarithm function normalises values above 200% to display small changes, as some variations reach 500%. Consequently, changes of 10-20% are difficult to represent in the same spider web. Additionally, not all data from the empirical chapter is included. The changes in sentiment, interest, fee, and commission income displayed in the spider web are measured as the regulatory impact. Other variations reflect the total changes in value.

5.1.4 The OB ecosystem alternatives

The comparison of two ecosystem alternatives (No OB—blue circle, With OB—orange) shows that the ecosystem state with OB is better in terms of market surplus but worse in terms of competitiveness. The total revenue, demand, service quality, public sentiment, and attention are greater than those of the alternative without OB.

Although regarding long-term competitiveness, the concentration has reduced, the network effect coefficients and market power have strengthened. Overall, the market is worse off in terms of competitiveness.

Figure 20: Regulatory Impact on OB Ecosystem. There are two social alternatives without OB (blue line) and with OB (orange) and ten parameters indirectly indicate the resource and capacity. Parameters are Total revenue, Market power, Public attention and others.



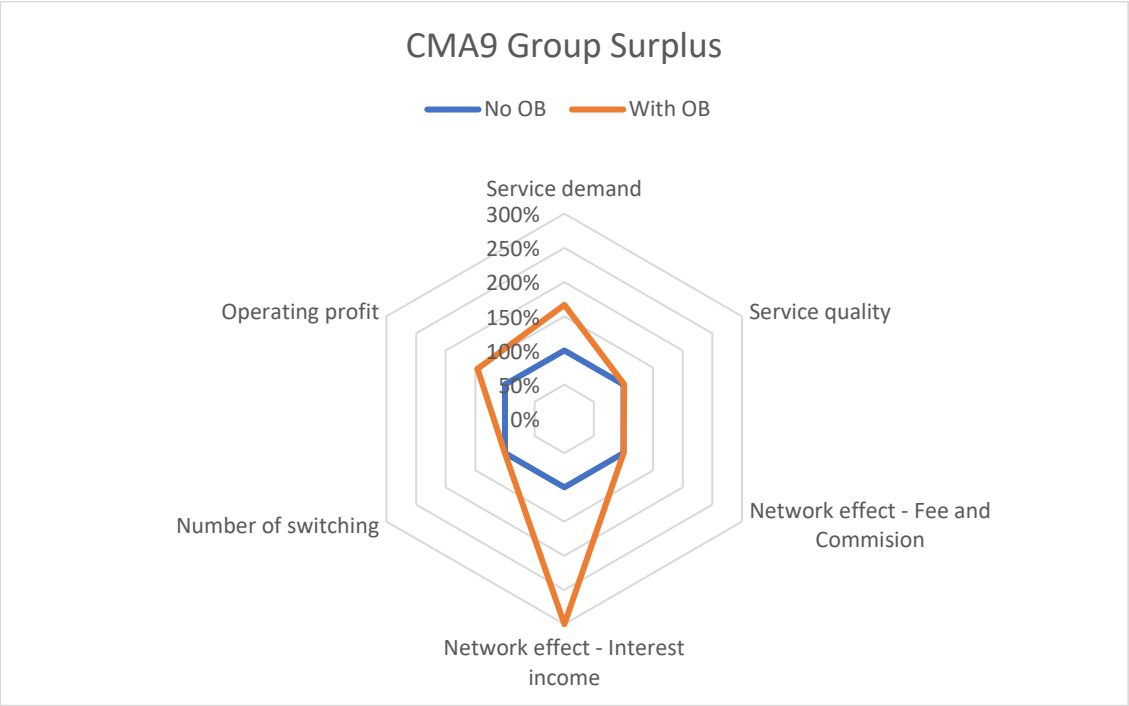
Providers result`s interpretation

The providers, including CMA9 banks, challenger banks, non-CMA9 banks, and TPP, are discussed regarding their utility in the two alternatives.

CMA9 banks

CMA9 banks in total are better off; the orange circle is wider than the blue circle. The service quality, network effects for the fee and commission market, and the switching number have increased slightly (+1). Moreover, the competitive position in the interest income market, due to the network effect, has gained substantially (+3). However, the surplus, which is the operating profit, and the service demand have increased significantly (+3). In total, CMA9 banks are better off by 7 points.

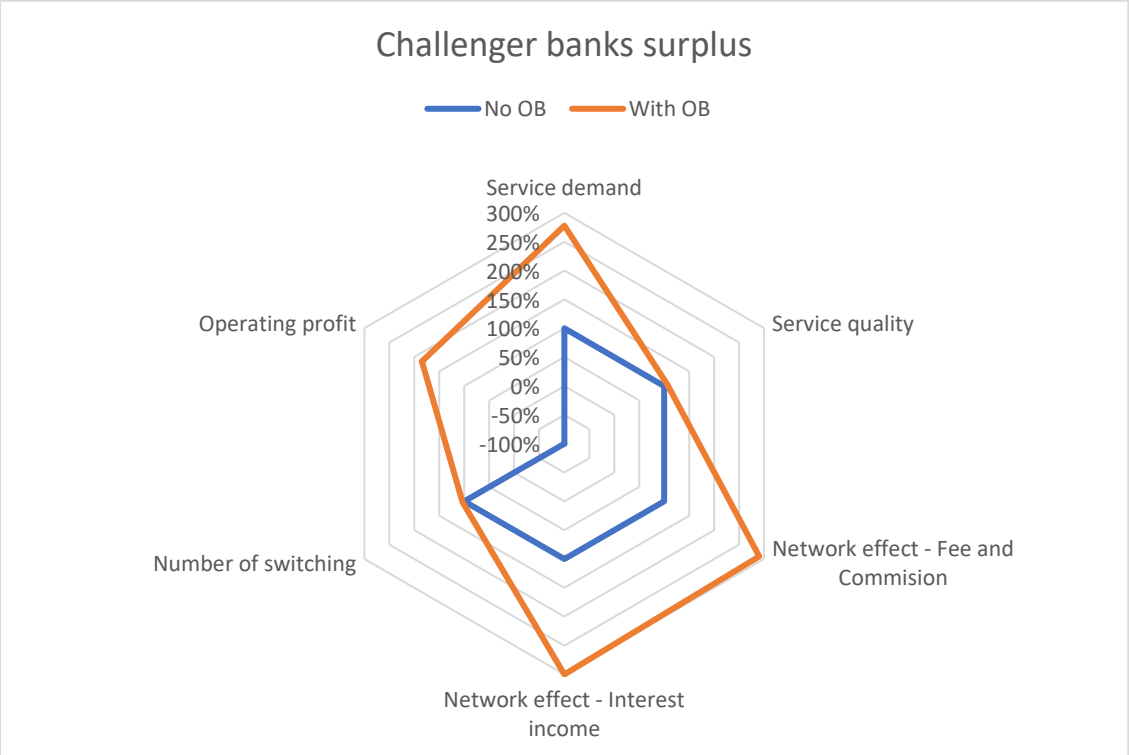
Figure 21: OB Regulatory Impact on CMA9 Surplus. There are two social alternatives without OB (blue line) and with OB (orange) and ten parameters indirectly indicate the resource and capacity. Parameters are Total revenue, Market power, Public attention and others



Challenger banks

The challenger banks might gain the most benefits from OB regulations. The market surplus has increased significantly in terms of operating profit and service demand (+3). Their operating profit has even turned positive from a loss. The switching number and service quality have increased moderately (+2). Moreover, the competitive position has consolidated with a significantly strengthening network effect (+2). The total utility received by challenger banks is 8 points.

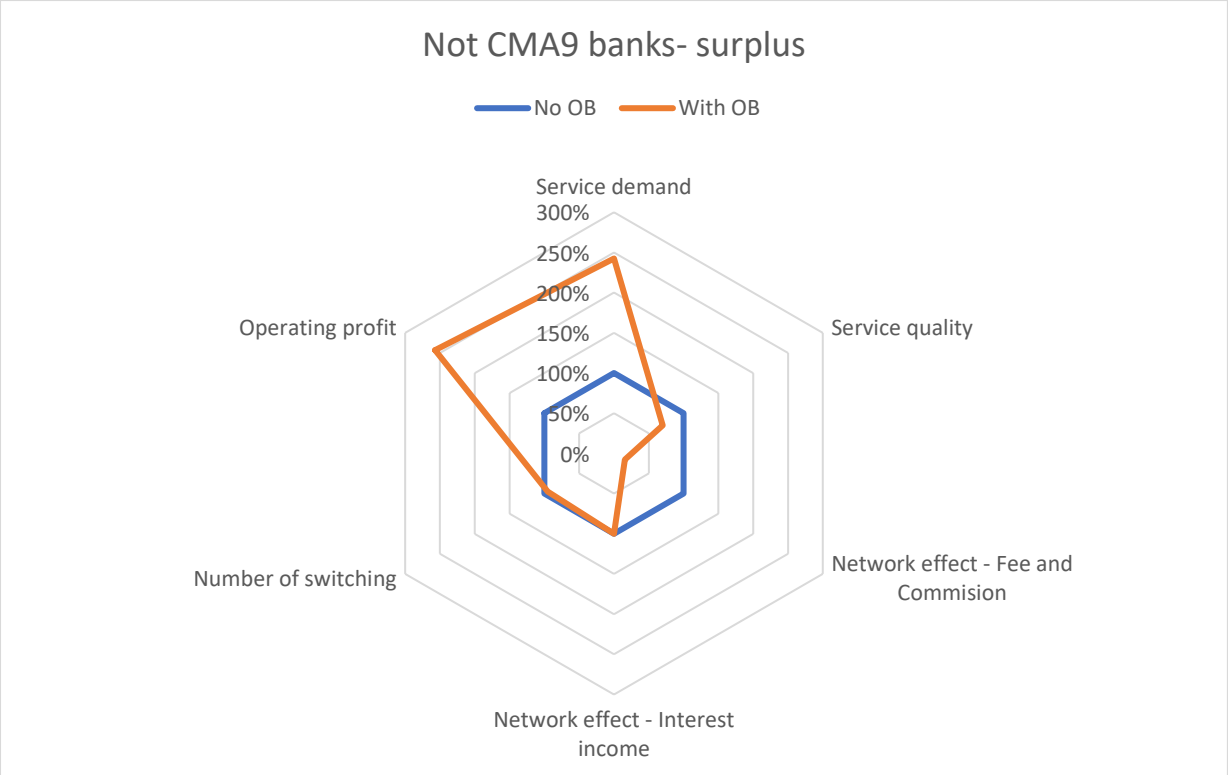
Figure 22: OB Regulatory Impact on Challenger Bank Surplus. There are two social alternatives without OB (blue line) and with OB (orange) and ten parameters indirectly indicate the resource and capacity. Parameters are Total revenue, Market power, Public attention and others



NoCMA9 banks

The NoCMA9 group is worse off. The supplier surplus has increased significantly in terms of operating profit and service demand (+3). However, the service quality and number of account switches have decreased substantially (3). In addition, the strategic position of Non-CMA9 banks has weakened slightly in the interest income market and tremendously in the fee and commission market (-3). As a result, the net number of customers switching to other providers is positive, reducing the bank`s user base. The total utility of the Non-CMA9 group in the OB alternative is -3.

Figure 23: OB Regulatory Impact on No CMA9 Bank Surplus. There are two social alternatives without OB (blue line) and with OB (orange) and ten parameters indirectly indicate the resource and capacity. Parameters are Total revenue, Market power, Public attention

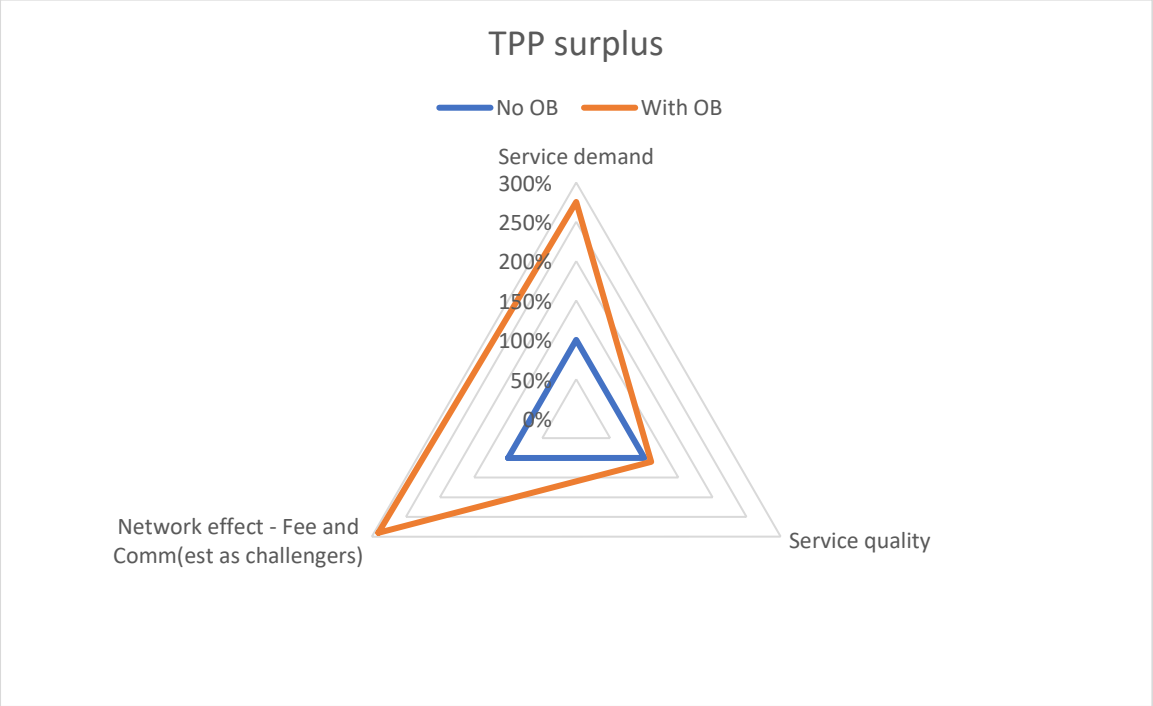


Third-party providers

Limited data exists regarding TPP. Its position is significantly stronger concerning service demand and service quality. Since service demand also indicates income, its revenue and profit have been notably

improved (+3). Regarding service quality, there is a slight increase in value (+1). No data is available on the network effect of TPP. Given that both TPP and its challengers are technology-driven, the network effect coefficient of challenger banks serves as an indirect measure of TPP`s impact. The network effect is notably better (+3). Overall, the utility value totals +7.

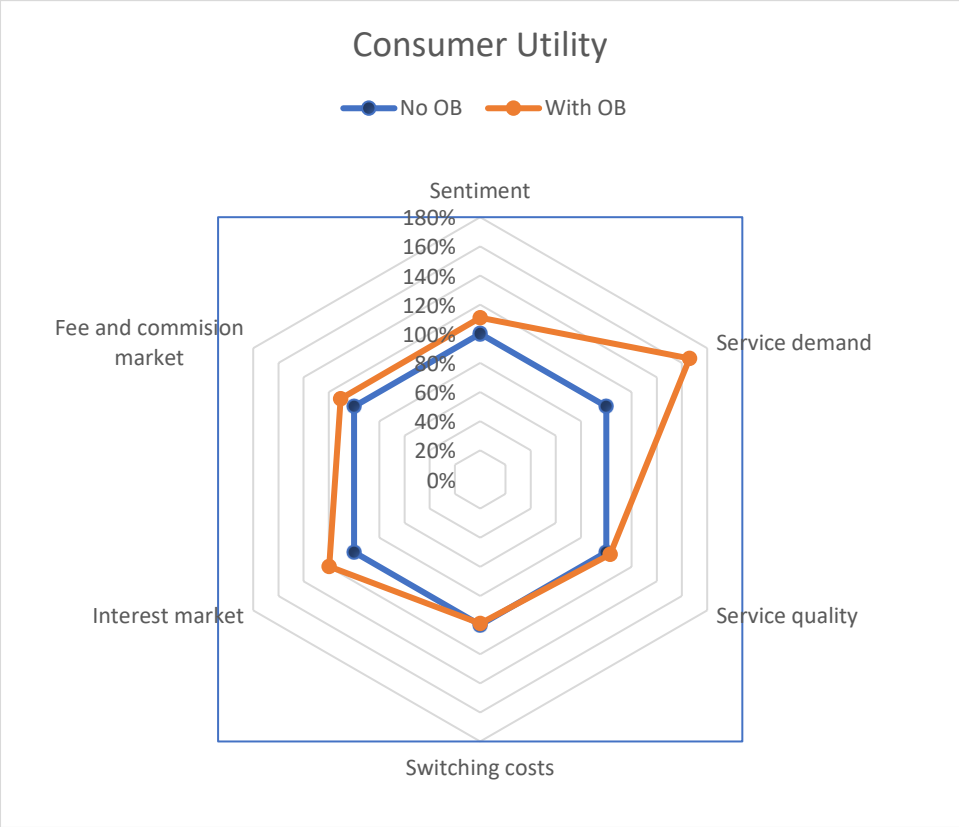
Figure 24: OB Regulatory Impact on TPP Surplus. There are two social alternatives without OB (blue line) and with OB (orange) and ten parameters indirectly indicate the resource and capacity. Parameters are Total revenue, Market power, Public attention and others



Consumer side

Overall, the consumer group benefits more from the social alternative with OB. The blue circle (No OB) is contained within the orange (with OB). Regarding surplus, there was a significant increase in the interest, fee, and commission market. Supporting the rise in surplus, service demand shows a notable increase (+2). Additionally, consumer satisfaction, in terms of sentiment and product review ratings, shows a moderate increase (+2). Finally, the number of switching accounts indicates only a slight positive change (+1). In total, the value of consumer utility is 5.

Figure 25: OB Regulatory Impact on CMA9 Surplus. There are two social alternatives without OB (blue line) and with OB (orange) and ten parameters indirectly indicate the resource and capacity. Parameters are Total revenue, Market power, Public attention and others



5.1.5 Interpretation Conclusion

In summary, there are two social alternatives: one with OB and another without OB. In each social alternative, an individual receives resources and capacity according to the distribution. The utility function value for each individual at the two alternatives is as follows.

Table 28: Utility value of groups. The utility value of groups such as CMA9, Challenger, Non-CMA9, TPP and Consumer are presented in two social alternatives with and without OB. The highest value is the challenger group.

Social alternatives	CMA9	Challengers	Non-CMA9	TPP	Consumer
No OB	0	0	0	0	0
With OB	7	8	-3	7	5

Applying the individual utility values above in the interpretation shows that the OB regulatory effect on joint value production under stakeholder theory is positive. However, it is not efficient under Pareto efficiency; nonetheless, it fits the Kaldor- Hicks criteria.

Within the stakeholder joint value creation framework, the utilitarian SWF represents the sum of all stakeholder utility values; therefore, its value at the alternative with OB is 27 (7+8+7+3-3+5). Consequently, the distribution under the stakeholder framework is positive because the total utility has increased by 27 points. Regarding the Kaldor- Hicks criteria, it requires the sum of members to be better off, and the alternative with OB is 27 points higher than without OB; thus, it also satisfies the criteria.

However, the OB regulatory impact does not achieve Pareto efficiency. Under this framework, no one should be worse off. In this instance, the Non-CMA9 group was worse off by -3 points.

In conclusion, the OB regulation has increased the total surplus. However, it is inefficient according to the just distribution framework. The main issue with the inefficient distribution of capacity may stem from the existence of a network effect in the data-driven platform model. The network effect can create serious problems due to the application of foundational AI models, which require massive training data and computational resources.

5.2 Conclusion

The thesis examines the impact of OB regulations on the competitive environment. The research is normative, aiming to understand how these regulations affect the competitive landscape and how the distribution of resources and capacity according to the regulations is interpreted under the stakeholder framework. The initial intuition was that the transformation of traditional banking into a data-driven market would enhance data-centric software applications and create challenges related to network effects. Consequently, it would shift the advantage to groups utilising data-centric technologies in OB, altering the competitive environment. The main research question was divided into sub-questions:

- How did the OB regulations impact the individual bank's operations?
- How was the bank`s competitive environment impacted? How have account switching barriers, data-centric service quantity, quality and market power changed? Does a network effect exist in the OB market?
- How equitable and efficient was the regulatory impact under the interpretation framework? And how the OB regulatory impact will shape the future competitive environment

For the first and second research sub-questions regarding the regulatory impact mechanism, the modelling indicates that OB regulations influence the competitive environment through several statistically significant factors. These include public sentiment (P value = 0.02), account switching number (P = 0.08), network effect (P = 0.02), and number of reviews (P value = 0.03), which serves as a proxy for service quantity measurement (see Table 25). Other factors, such as costs or total deposits, are not significant. The service quality factor is also significant; however, it was excluded from the model due to its interdependency with other factors.

The factor values indicate that the presence of the network effect is significant in increasing market power. Additionally, the public sentiment factor shows a positive coefficient regarding competition. As the market becomes more competitive, providers compete with one another to satisfy customers, which may result in higher public sentiment.

Moreover, contrary to competition theory, the impact model shows that the number of account switchers negatively affects competition. This can be explained by the potential presence of a network effect. As more customers switch accounts, the network grows stronger in the market, resulting in greater market power.

The number of review factors (a proxy for demand) also negatively influences competition (coef = 0.00006). It is possible that OB regulations mandate open data access, which in turn generates new surplus from new data-centric services. Therefore, at the initial stage, a higher number of reviews is associated with less competition. However, in the long term, less competition can be correlated with a lower number of reviews due to network effects.

Regarding the third set of sub-questions about the resource and capacity stakeholder interpretation framework and predictions concerning the competitive environment, the results indicate that the UK OB regulations create joint value within the stakeholder framework; however, they are not efficient according to the Pareto efficiency framework.

First, the stakeholder salience framework indicates that OB in the UK needs a balanced approach. Regulators with high power and legitimacy must guide CMA9 banks to cooperate with dependent stakeholders, including challengers, NoCMA9, TPP, and consumers with urgent but limited power. OBIE and JROC/future entity serve as bridges to align stakeholders, manage conflicts, and ensure the

initiative delivers value to end-users. Power dynamics are flexible; banks may become more proactive as OB matures, while challenger banks and TPPs may increase their influence. Regulatory pressure can also change. The CS model encourages regulators to build shared infrastructure and foster trust, while AR allows CMA9 banks to mandate client data sharing. EM ensures fair competition for challengers, and MP enhances innovation, quality, and quantity for consumers and service providers. Therefore, the governance framework adapts to these changes, balancing stakeholder interests to create joint value.

The interpretation of the results supports the assumption that OB regulations foster joint value creation. The stakeholder SWF in OB shows a 27-point increase after the implementation of OB. All stakeholders' utility estimations have increased, except for the non-CMA banks. The CMA9 group increased by 7 points, Challenger by 8, TPP by 7, consumers by 5, and Non-CMA9 decreased by 3 (see Table 28). Applying the stakeholder framework, the results show that stakeholder SWF has increased by 27 points, indicating a benefit to stakeholders from OB enforcement. The results satisfy both the stakeholder and Kaldor-Hicks criteria. However, the regulatory implementation does not perform efficiently under the Pareto test, as resource distribution adversely impacts one of the stakeholders, the non-CMA9 group (-3).

Lastly, the prediction model indicates that competition is still weakening (see Figure 42). Potential problems include the presence of the network effect and the increasing market power in the data-driven OB market, considering the significant impact of the quantity and quality of service on the model through the application of data-centric services, such as AI.

5.3 Study Limitations

The study possesses several limitations, primarily related to its scope, resources and findings.

Scope limitation

The OB ecosystem includes banks and other service providers offering financial services, such as credit unions, building societies, fintech companies, and other TPPs. These financial services encompass traditional money, cryptocurrency, and derived services like currency transactions, exchanges, bonds, and more. The deployment of services can be either traditional or AI-based. However, due to resource constraints, data on credit unions and cryptocurrency services were not included in this research. Additionally, the ongoing regulatory proposals addressing cryptocurrency issues were acknowledged but not incorporated into this study.

Resource limitation

There are three types of limitations related to resources: computational, data access, and OB enforcement period. Given the extensive scope of the study, the data sources are diverse. Not all data is available for direct assessment, leading to the use of proxies for measurement. The number of app reviews is interpreted as a proxy for service usage quantity, with more reviews indicating higher customer engagement. Some data sources, such as BankFocus, required payment or access approval; however, limited funding restricted the research to public and university-registered data sources. This also resulted in the absence of account switching data before 2018.

Due to funding limitations, computations were not conducted on a high-performance computer. This presented problems with processing big data, particularly in topic extractions, reviews, and sentiment

analyses. The insufficient computational power prevented the application of the DiD method to evaluate the OB regulatory impact on customer discussions. For instance, review collection was limited to around 1 million samples from the UK Google Play, excluding Apple Store reviews due to processing capabilities.

The OB enforcement period was relatively short, and the final stage was only completed in 2023. In addition, the data sources were various, and the data on account switching numbers were only available from 2018, so the analysis of market power and network effects is constrained to a limited timeframe. The result would have been more accurate if the observation period had been longer.

Model and finding limitations

The modelling process also incorporates the inherent limitations of statistical methods. The DiD method applied to revenue and cost data yielded low p-values due to the small total data samples grouped by year and jurisdiction. Therefore, a small deviation could significantly impact the p-value. Although another version of DiD, which accounts for differences by individual providers, could enhance impact measure accuracy, due to resource constraints, a traditional DiD method based on the average value of control and treatment groups was applied. Furthermore, the network effect calculation could be more accurate with pre-2018 switching account data. A more robust analysis could have been achieved with a dataset before and after the OB enforcement.

While the regulatory impact model identified seven significant factors, the statistical model simplifies reality. In practice, there can be thousands of independent factors, some of which are unobservable. The model's predictions remain valid as long as the significant factors stay stable, but unforeseen future developments could introduce unaccounted possibilities that the model cannot capture.

Finding limitations

The findings have several limitations due to resource and model constraints. Firstly, excluding crypto and credit union parties, they couldn`t provide a complete picture of the OB ecosystem. Assessing these parties would require data on their account switching data, app reviews and tweets, which are unavailable. Moreover, limited time and resources further restricted the data acquisition and processing.

Secondly, the findings are based on the assumptions and results of the statistical models. The quantitative results suggest that OB regulations might generate a surplus. However, the unjust distribution of resources and capacities, along with weakened competition, could diminish the future surplus. Even the most advanced statistical models cannot guarantee precise predictions, as unforeseen factors may arise. For instance, recent advancements in AI, such as foundational architecture, could significantly impact cross-market competition as a handful of Big Tech companies develop foundation models. In addition, future regulations on data-driven markets and data-centric AI applications could interfere with current model predictions.

Lastly, the regulatory proposal addressing the identified problems remains limited to the discussion level. The study primarily focuses on the regulatory impact mechanism and problem identification. Additional research is essential to develop detailed solutions. It may expand into an interdisciplinary study encompassing law, education, and computer science.

Appendix

Appendix A

(Data description)

Table 29A: Data Column Description. There are five columns. The "Location" column contains information about the tweet's user location; "Polarity column" – the polarity score of the tweet; "Sentiment" column – the sentiment of the tweet based on the polarity score; "Year" - the year tweet was posted; "YearMonth" – month and the year when tweet was posted. The "count" row displays total number of observations in the column; "unique" - the number of unique values; "top" is the most common value; "freq" is the most common value's frequency; "NaN" means the value is not available.

	Location	Polarity	Sentiment	Year	YearMonth
count	369749	369749	369749	369749	369749
unique	6996	NaN	3	NaN	NaN
top	UK	NaN	Neutral	NaN	NaN
freq	86272	NaN	186936	NaN	NaN
mean	NaN	0.11	NaN	2019.51	201958.19
std	NaN	0.21	NaN	1.57	157.25
min	NaN	-1	NaN	2017	201701
25%	NaN	0	NaN	2018	201809
50%	NaN	0	NaN	2019	201911

Table 30A: Example of data sample retrieved from Google Play API. Only essential columns are displayed

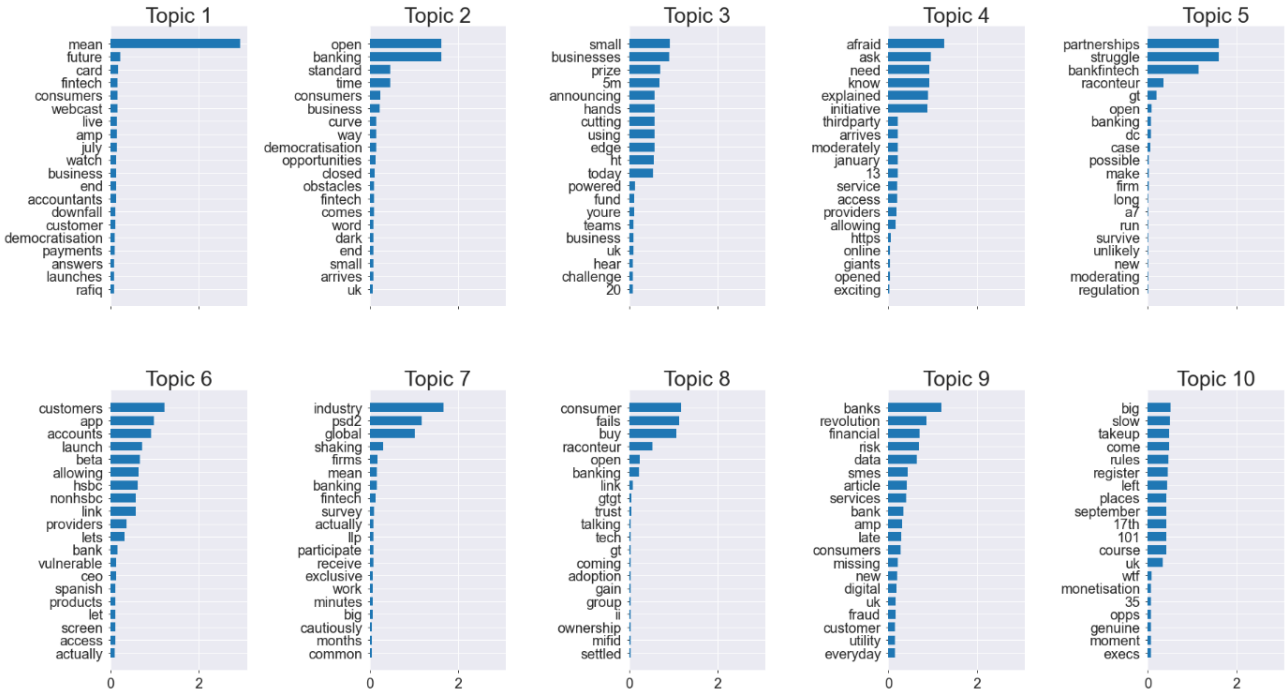
Username	Content	Score	Thumbs Up Count	at	Reply Content	ApVer	Provider	Group
Trace Gibbs	Easy to use great for holidays	5	0	07/08/2023 11:27		9.1 8.2	Revolut	challenger bank
Claudia M.	There is no more rapid top up, this is really bad for me. I have to wait up to 24h for any transfer. I used to like the app but gets worst and worst.	1	0	07/08/2023 11:19	Hi there! Our team will be more than happy to help you with your top-up. Could you drop us a message via in-app chat?	9.1 8.2	Revolut	challenger bank
Heather Jackson	Won't let me verify	2	0	07/08/2023 11:18	Hi! Our team will be more than happy to help you with your identity verification. Could you drop us a message via in-app chat? access it, please e-mail us at support@revolut.com.	9.1 8.2	Revolut	challenger bank

Appendix B

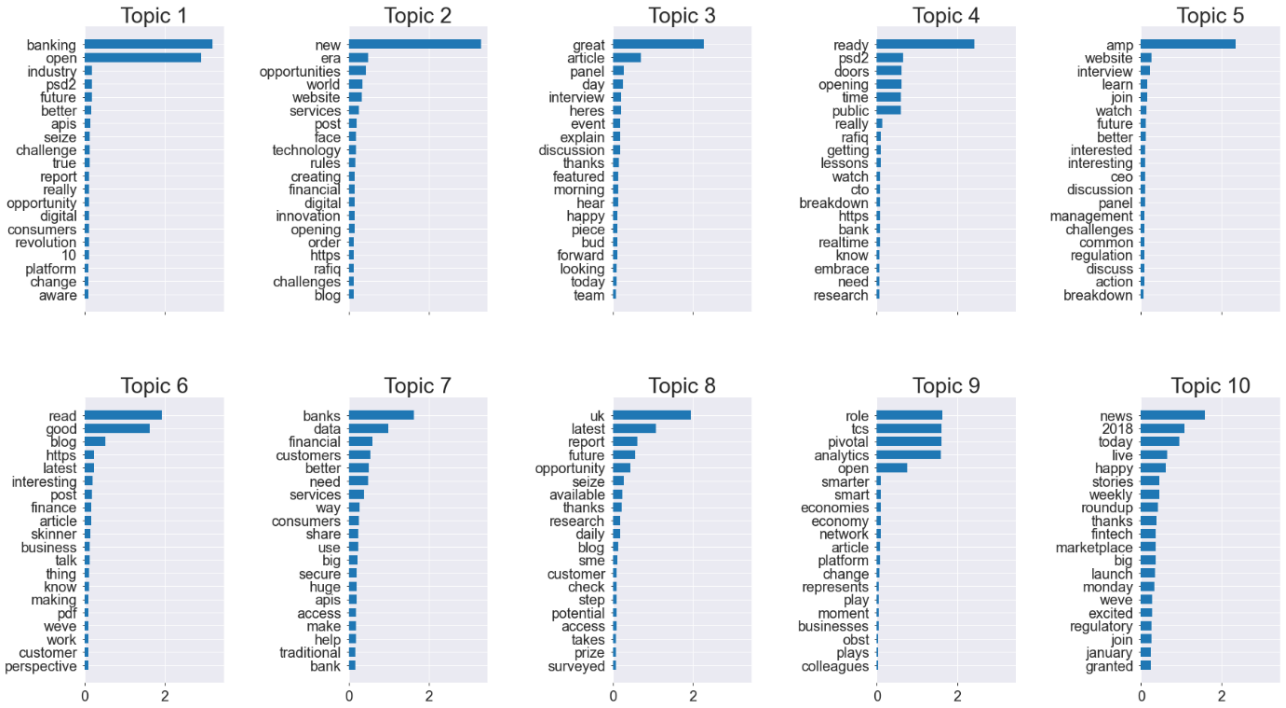
(Topic extraction on tweets)

Table 31A: . NMF topics in the UK before and after OB regulation enforcement. The table displays the top 10 topics in the corpus. In each topic, the twenty words with the strongest weights are displayed in a bar chart. The weight of the word is its TF-IDF value in the MNF method.

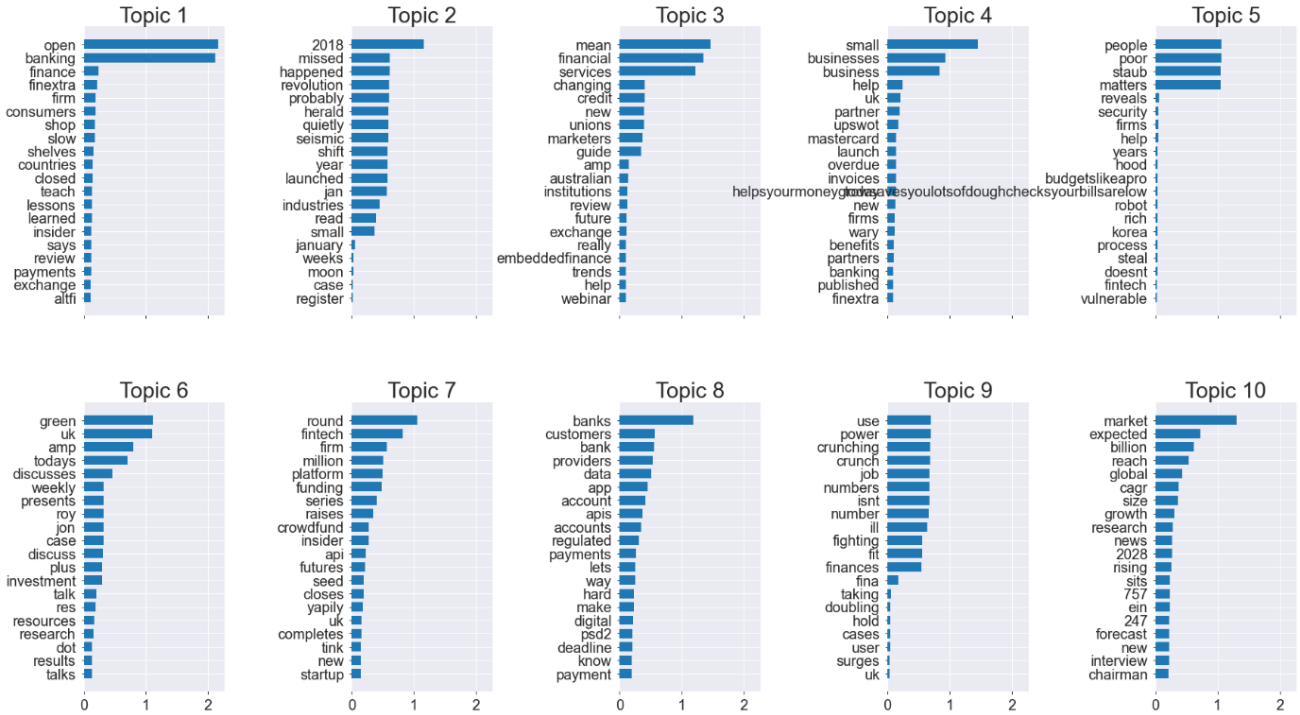
UK before OB enforcement negative tweets (NMF)



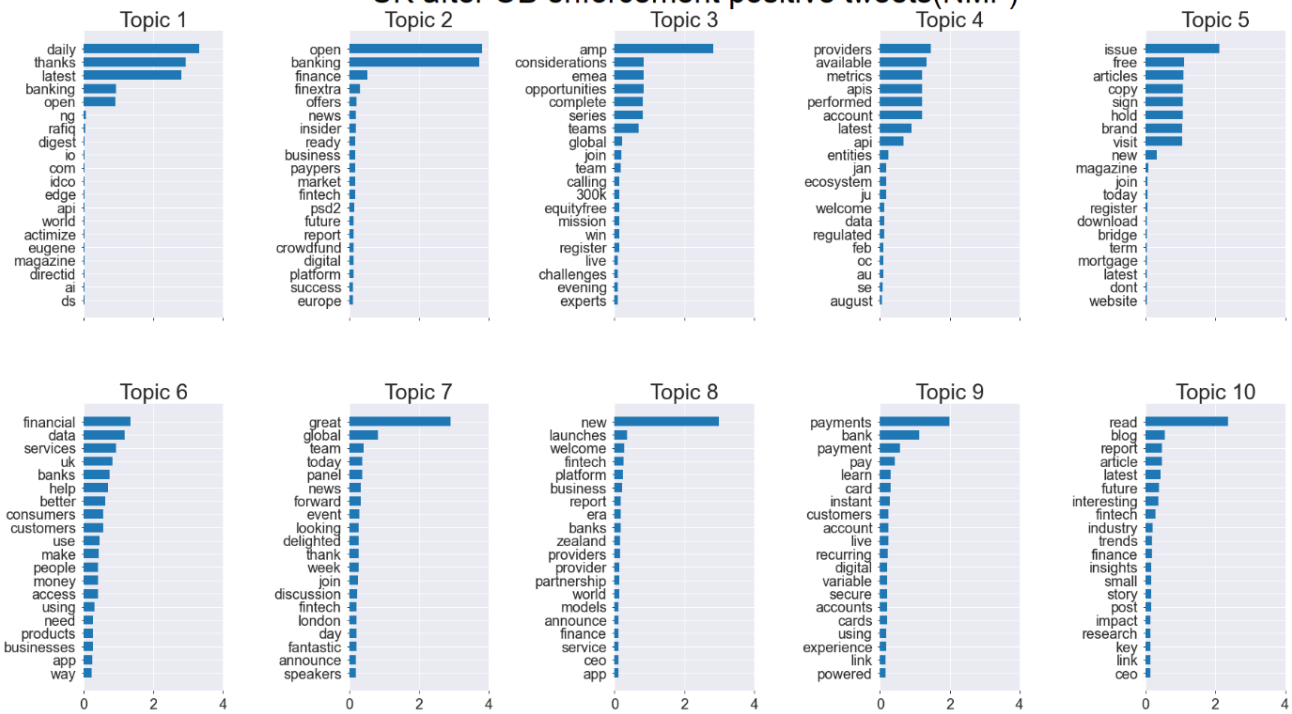
UK before OB enforcement positive tweets (NMF)



UK after OB enfrocement negative tweets (NMF)



UK after OB enforcement positive tweets(NMF)



Appendix C

(List of service providers)

Table 32A: List of service providers. The list consists of providers for whom the data is collected for the analysis.

Service Provider	Service Description	Group
MetroBank	Banking services	Challenger bank
Revolut	Banking services	Challenger bank
Starlink	Banking services	Challenger bank
Tide	Banking services	Challenger bank
HSBC UK	Banking services	CMA 9
Bank of Scotland	Banking services	CMA9
Bank of Scotland (Lloyds Banking Group Plc)	Banking services	CMA9
Barclay UK	Banking services	CMA9
Danske UK	Banking services	CMA9
First direct Uk	Banking services	CMA9
Lloyds bank	Banking services	CMA9
Nationwide banking	Banking services	CMA9
Natwest	Banking services	CMA9
Natwest mobile banking(national westminster bank plc)	Banking services	CMA9
Royal Bank of Scotland (under NatWest)	Banking services	CMA9
Royal Bank of Scotland	Banking services	CMA9
Santander UK plc	Banking services	CMA9
Halifax	Banking services	CMA9
Coop bank	Banking services	NoCMA9
Tesco+Clubcard Pay+	Banking services	NoCMA9
TSB	Banking services	NoCMA9
Virgin money uk(Clydesdale bank plc)	Banking services	NoCMA9
Monzo	Banking services	Challenger bank
Aptap	ApTap builds white-labelled financial management API's that allow banks to offer bill management tools to their customers. ApTap is a next-generation	TPP

	affiliate marketplace, housing end-to-end user journeys that allow users to cancel, compare, switch or sign up for services within their banking app.	
Beanstalk	The Beanstalk app is designed to make it really easy to build a nest egg for your children, grandchildren or even yourself. Whether your goal is to save £500 or £50,000 - we've packed it with some great tools and features to help.	TPP
BuildMyCreditScore	Should you really need to have a credit card to build your credit score? And what happens if you don't want a credit card or can't get one in the first place? BuildMyCreditScore was created to solve that problem, simply and transparently.	TPP
Cake	Cake brings together all your existing bank accounts and transactions. It analyses your financial data and habits, with the aim of making your life better. It's the app that rewrites the rules. To make sure you will always get your piece. To use Cake you do not have to change banks or open a new account. It doesn't matter if you have a single bank account or 16 across many. We bring them all together in one app. Piece of Cake!	TPP
Canopy	Canopy's ambition is to build a digital rental market-place, focused primarily on the financial well-being of renters. We streamline the rental process using innovative technology to simplify the rental application process. Our core products are: RentPassportTM a multi-channel renter screening app powered by Open Banking and Experian credit data. Free for estate agents, letting agents, renters and landlords. DepositFreeTM replaces cash deposits with a one-off deposit premium that covers the length of rental. RentTrackingTM helps renters track payments and improve their credit score.	TPP
Chip	Chip is the free app that builds your savings automatically using artificial intelligence and fights to bring you amazing rates. You can also put your savings to work with our investment funds powered by BlackRock, the biggest asset manager in the world.	TPP
CreditLadder	CreditLadder is a UK rent reporting service, helping tenants to strengthen their Experian credit history and improve their Equifax credit score by ensuring their on-time rent payments are verified and reported into their credit report.	TPP

Currensea	Currensea is the layer in front of your current bank account, saving you at least 85% on every transaction, giving you extra security and making your bank work that bit harder.	TPP
Ember	Ember is a new, simpler way for contractors to manage their business finances. Powered by Open Banking and leveraging machine learning, Ember dramatically simplifies the accounting process by only showing you what you need to see; doing all the tracking, management, calculation and submission of tax in the background.	TPP
Emma	Emma is a personal finance and budgeting tool that helps you avoid overdrafts, cancel wasteful subscriptions, track expenses and save money. Our data shows Emma can save you up to £600 every year! Our finance app uses state of the art technology to analyse your accounts and give you the power to make smarter budgeting decisions with your money.	TPP
Nude	Nude is a savings account and financial friend for first-time home buyers. The Nude app will show you how long it'll take to save your deposit; then we'll help you knock time off your goal.	TPP
Wise	Wise Payments makes sending money overseas cheaper, using the real exchange rate, so there's no hidden rate mark-up and you pay a transparent fee. Our borderless account lets you manage money in dozens of currencies, get local bank details in many different countries, and spend your money all over the world without bad exchange rates or bank fees.	TPP
Wollit	Take home the same amount of money every month even if your hours and earnings fluctuate. Wollit offers interest-free Cash Top-ups when you earn less than normal. Wollit takes the stress out of zero-hour contracts, gig work and freelancing by giving you instant access to money in the months when you earn less than normal.	TPP
Loyalbe	Simply link your bank account with loyalBe, and whenever you pay by bank card in any partner store you will earn rewards. - Say goodbye to paper loyalty cards and scanning your phone for every transaction. - View the latest offers from your favourite retailers. - Connect multiple accounts to ensure you're always earning, no matter what card you use.	TPP
Ispent	personal money diary that complements your social interactions.	**TPP**

Appendix D

(Notes on the statements)

Bank name	Notes on the group structure and its financial statement.
HSBC Group	The HSBC Group completed the ring-fencing of its UK retail banking activities on 1 July 2018, transferring 14.5 million qualifying RBWM, CMB, and GPB clients from HSBC Bank Plc to HSBC Bank UK. HSBC Bank Plc has retained the UK global banking, market, and overseas operations business.[798] The products and services of HSBC UK encompass retail banking and wealth management under the following brands: HSBC UK, First Direct, MS Bank, and John Lewis Financial Services.[799]
AIB UK	AIB UK is a bank in the UK that serves retail, SME, and corporate customers in Great Britain and Northern Ireland. In Northern Ireland, services are offered under the First Trust Bank brand. The bank comprises two brands: Allied Irish Bank (GB) and First Trust Bank (FTB).[800]
Bank of Ireland UK plc	The Bank of Ireland UK plc is incorporated in England and domiciled in the UK. The Group comprises four units: GB Consumer Banking, Northern Ireland, which has 300.000 customers; RB Business Banking; and Group Centre- responsible for

[798] 'HSBC UK BANK PLC - Annual Financial Report for Year End December 2018' 2 <https://find-and-update.company-information.service.gov.uk/company/09928412/filing-history>.

[799] ibid 3.

[800] 'AIB GROUP (UK) P.L.C. - Annual Financial Report for Year End December 2018' 2 <https://find-and-update.company-information.service.gov.uk/company/NI018800/filing-history>.

	centralised risk management, funding, liquidity, and capital control for the entire group.[801]
Bank of Scotland plc	The bank provides financial services in the UK and overseas. Following 2018, the bank's overseas business was transferred to Lloyds Bank Corporate Markets plc under Lloyds Banking Group in accordance with ring-fencing legislation. Its subsidiaries include Halifax and Bank of Wales.[802]
Lloyds Bank plc	Lloyds Bank plc provides financial services in the UK and abroad. In 2018, pursuant to ring-fencing regulations, the bank sold its subsidiary, Scottish Widows Groups Limited, and both the bank and its subsidiary, Bank of Scotland plc, sold their overseas and commercial business to Lloyds Bank Corporate Markets plc. The financial data ought to be gathered from an unconsolidated report. However, the data is not available; hence, the consolidated report is utilised instead.
Barclay Bank UK Plc	Barclay Bank UK Plc was incorporated to satisfy the ring-fencing requirements, with employees, businesses, and other entities associated with the UK operations being transferred to the bank. In September 2017, a total of 25000 employees were

[801] 'BANK OF IRELAND (UK) PLC - Annual Financial Report for Year End December 2018' 13 <https://find-and-update.company-information.service.gov.uk/company/07022885/filing-history>.

[802] 'BANK OF SCOTLAND PLC - Annual Financial Report for Year End December 2018' 2 <https://find-and-update.company-information.service.gov.uk/company/SC327000/filing-history>.

	relocated, and 24 million customers were transferred in April 2018. The business encompasses Personal Banking, Barclay Consumer UK, and Business Banking.[803]
Clydesdale Bank Plc	Clydesdale Bank Plc encompasses Clydesdale Bank, Yorkshire Bank, and B brands. The group does not encompass Virgin Money Holdings (UK) plc (Virgin Money) or its subsidiaries.[804] From September 2019, the report includes the October 2018 acquisition of Virgin Money Holdings (UK) plc. Therefore, it should exclude Virgin Money from 2019. The financial year-end is September, unlike that of other banks December.
The Cooperative Bank Holding Ltd	The Holding owns 100% of Cooperative Bank plc, and it has no trading operations. Both the holding and bank accounts are substantially the same.[805]
NatWest group	The group comprises the Royal Bank of Scotland, NatWest Bank, NatWest Market plc and Ulster Bank.[806] The report reflects the activity data for UK personal banking (including NatWest Bank and the Royal Bank of Scotland) and Ulster Bank, as well

[803] 'BARCLAYS BANK UK PLC - Annual Financial Report for Year End December 2018' 3 <https://find-and-update.company-information.service.gov.uk/company/09740322/filing-history>.

[804] 'CLYDESDALE BANK PLC - Annual Financial Report for Year End September 2018' 2 <https://find-and-update.company-information.service.gov.uk/company/SC001111/filing-history>.

[805] 'THE CO-OPERATIVE BANK P.L.C - Annual Financial Report for Year End December 2018' 2 <https://find-and-update.company-information.service.gov.uk/company/00990937/filing-history>.

[806] 'NATWEST GROUP PLC Filing History - Annual Financial Report for Year End December 2018' 5–8 <https://find-and-update.company-information.service.gov.uk/company/SC045551/filing-history>.

	as commercial and private banking for all banks, RBS International, and NatWest Markets.
Santander UK plc	Santander UK plc and its subsidiaries form the Santander UK Group, which is part of the international Banco Santander group. The bank operates in accordance with UK ring-fencing requirements. It serves all personal accounts and the majority of business accounts in the UK.[807]
Starling Bank	Starlin is a branchless digital bank offering retail banking, B2B, and payment services in the UK.[808] All services are accessed through a single app. Only financial data for a group is available in BankFocus. The UK activities are incorporated in the group report.
Tesco Personal Financial Group Plc	Tesco Personal Financial Group Plc's annual report includes a report on the company and its operations subsidiaries.[809] The group operates under the trading name Tesco Bank, which includes the Tesco Pay+ service for shopping customers to collect points.[810] The bank started to integrate the OB regulations in 2018

[807] 'SANTANDER UK PLC Filing History - Financial Report December 2018' 1–3 <https://find-and-update.company-information.service.gov.uk/company/02294747/filing-history>.

[808] 'STARLING BANK LIMITED - Annual Financial Report for Year End November 2021' 5 <https://find-and-update.company-information.service.gov.uk/company/09092149/filing-history>.

[809] 'TESCO PERSONAL FINANCE GROUP LIMITED - Annual Financial Report for Year End February 2019' 2 <https://find-and-update.company-information.service.gov.uk/company/SC173198/filing-history>.

[810] ibid 4.

TSB Bank plc	The bank offers retail and business banking services in the UK.[811] It is a subsidiary of TAB Banking Group, which is part of Banco de Sabadell SA. It is a challenger bank that emphasises the benefits of IT systems.

[811] 'TSB BANK PLC Filing History - Annual Financial Report for Year End December 2018' 1–3 <https://find-and-update.company-information.service.gov.uk/company/SC095237/filing-history>.

Appendix E

(Modelling linear regression regulatory impact)

Table 33A: Modelling process. There are, in total, 7 steps.

Step 1, K=1				
Model no.	**Variables(Predictors)**	**P value**	**Model stats**	
K1-1	OB_enforcement_dummy	0.41	R-squared:	0.498
			Adj. R-squared:	0.39
			F-statistic:	4.597
K1-2	Total_operating_expenses	0.12	R-squared:	0.51
			Adj. R-squared:	0.404
			F-statistic:	4.806
K1-3	Number_of_Reviews	0.03	R-squared:	0.523
			Adj. R-squared:	0.42
			F-statistic:	5.078
K1-4	Review_score	0.88	R-squared:	0.494
			Adj. R-squared:	0.385
			F-statistic:	4.517
K1-5	Total_customer_deposits	0.95	R-squared:	0.494
			Adj. R-squared:	0.385
			F-statistic:	4.515
K1-5	Sentiment	0.03	R-squared:	0.525
			Adj. R-squared:	0.423
			F-statistic:	5.117
Step 2, K=2				
Model no.	**Variables**	**P value**	**Model stats**	
K2-1	Sentiment	0.01	R-squared:	0.541

	OB_enforcement_dummy	0.12	Adj. R-squared:	0.434
			F-statistic:	5.057
K2-2	Sentiment	0.05	R-squared:	0.534
	Total_operating_expenses	0.23	Adj. R-squared:	0.426
			F-statistic:	4.93
K2-3	Sentiment	0.13	R-squared:	0.538
	Number_of_Reviews	0.16	Adj. R-squared:	0.43
			F-statistic:	4.995
K2-4	Sentiment	0.03	R-squared:	0.526
	Review_score	0.77	Adj. R-squared:	0.415
			F-statistic:	4.762
K2-5	Sentiment	0.00	R-squared:	0.558
	Switch_number	0.07	Adj. R-squared:	0.436
			F-statistic:	4.582
K2-6	Sentiment	0.02	R-squared:	0.527
	Total_customer_deposits	0.57	Adj. R-squared:	0.417
			F-statistic:	4.791
Step 3, K=3				
Model no.	**Variables**	**P value**	**Model stats**	
K3-1	Sentiment	0.01	R-squared:	0.558
	Switch_number	0.07	Adj. R-squared:	0.436
	OB_enforcement_dummy	0.01	F-statistic:	4.582
K3-2	Sentiment	0.01	R-squared:	0.558
	Switch_number	0.07	Adj. R-squared:	0.427
	Total_operating_expenses	0.95	F-statistic:	4.239
K3-3	Sentiment	0.04	R-squared:	0.593
	Switch_number	0.07	Adj. R-squared:	0.471
	Number_of_Reviews	0.03	F-statistic:	4.875
K3-4	Sentiment	0.01	R-squared:	0.561
	Switch_number	0.08	Adj. R-squared:	0.429

	Review_score	0.59	F-statistic:	4.276
K3-5	Sentiment	0.01	R-squared:	0.563
	Switch_number	0.10	Adj. R-squared:	0.432
	Total_customer_deposits	0.44	F-statistic:	4.317
Step 4, K=4				
Model no.	**Variables**	**P value**	**Model stats**	
K4-1	*Sentiment*	*0.04*	*R-squared:*	*0.593*
	Switch_number	*0.07*	*Adj. R-squared:*	*0.471*
	Number_of_Reviews	*0.03*	*F-statistic:*	*4.875*
	OB_enforcement_dummy	*0.02*		
K4-2	Sentiment	0.05	R-squared:	0.594
	Switch_number	0.09	Adj. R-squared:	0.463
	Number_of_Reviews	0.03	F-statistic:	4.545
	Total_operating_expenses	0.69		
K4-3	Sentiment	0.02	R-squared:	0.598
	Switch_number	0.11	Adj. R-squared:	0.469
	NB_Review	0.03	F-statistic:	4.636
	Total_customer_deposits	0.36		
K4-4	Sentiment	0.04	R-squared:	0.593
	Switch_number	0.08	Adj. R-squared:	0.462
	Number_of_Reviews	0.03	F-statistic:	4.53
	Review_score	0.83		
Step 5, K=5				
Model no.	**Variables**	**P value**	**Model stats**	
K5-1	Sentiment	0.02	R-squared:	0.598
	Switch_number	0.11	Adj. R-squared:	0.469
	Number_of_Reviews	0.03	F-statistic:	4.636
	Total_customer_deposits	0.36		
	OB_enforcement_dummy	0.01		
K5-2	Sentiment	0.02	R-squared:	0.6

	Switch_number	0.13	Adj. R-squared:	0.461
	Number_of_Reviews	0.03	F-statistic:	4.334
	Total_customer_deposits	0.34		
	Review_score	0.69		
K5-3	Sentiment	0.03	R-squared:	0.599
	Switch_number	0.12	Adj. R-squared:	0.46
	Number_of_Reviews	0.03	F-statistic:	4.32
	Total_customer_deposits	0.40		
	Total_operating_expenses	0.82		
Step 6, K=6				
Model no.	**Variables**	**P value**	**Model stats**	
K6-1	Sentiment	0.03	R-squared:	0.599
	Switch_number	0.12	Adj. R-squared:	0.46
	Number_of_Reviews	0.03	F-statistic:	4.32
	OB_enforcement_dummy	0.02		
	Total_customer_deposits	0.40		

Appendix E

(Tweet Sentiment Analysis- Python Code)

```
#-------------------------------- Download tweets, part of the code is from open source in Github----------------------
# For sending GET requests from the API
import requests
# For saving access tokens and for file management when creating and adding to the dataset
import os
# For dealing with json responses we receive from the API
import json
# For displaying the data after
import pandas as pd
# For saving the response data in CSV format
import csv
# For parsing the dates received from twitter in readable formats
import datetime

import dateutil.parser

import unicodedata
#To add wait time between requests
import time


os.environ['TOKEN'] = ''

def auth():

    return os.getenv('TOKEN')


def create_headers(bearer_token):

    headers = {"Authorization": "Bearer {}".format(bearer_token)}

    return headers


def create_url(keyword, start_date, end_date, max_results = 1):


    search_url = "https://api.twitter.com/2/tweets/search/all" #Change to the endpoint you want to collect data from


    #change params based on the endpoint you are using

    query_params = {'query': keyword,
```

```
                'start_time': start_date,
                'end_time': end_date,
                'max_results': max_results,
                'tweet.fields':'geo',
                'expansions': 'author_id,geo.place_id',
                'tweet.fields':
'id,text,author_id,geo,conversation_id,created_at,lang,public_metrics,referenced_tweets,reply_settings,source',
                'user.fields': 'id,location,name,username,created_at,description,public_metrics,verified',
                'place.fields': 'full_name,id,country,country_code,geo,name,place_type',
                'next_token': {}}
    return (search_url, query_params)
def connect_to_endpoint(url, headers, params, next_token = None):
    params['next_token'] = next_token   #params object received from create_url function
    response = requests.request("GET", url, headers = headers, params = params)
    print("Endpoint Response Code: " + str(response.status_code))
    if response.status_code != 200:
        raise Exception(response.status_code, response.text)
    return response.json()


def append_to_csv(json_response, fileName):


    #A counter variable
    counter = 0


    #Open OR create the target CSV file
    csvFile = open(fileName, "a", newline="", encoding='utf-8')
    csvWriter = csv.writer(csvFile)
    def_lang = 'en'
    #Loop through each tweet
```

```
for tweet in json_response['data']:

    #print(json_response)


    # 1. Author ID

    author_id = tweet['author_id']

    # matching the user location

    for user_location in json_response['includes']['users']:

        #print("user location2", user_location)

        if author_id == user_location['id']:

            #

            print("author id is:", author_id, "user id is", user_location['id'])


            if ('location' in user_location):

                location = user_location['location']

                print("user location is:", user_location['location'])

            else:

                location = "NotAv"

                print("no location")

    # 2. Time created

    created_at = dateutil.parser.parse(tweet['created_at'])


    # 3. Geolocation

    if ('geo' in tweet):

        geo = tweet['geo']['place_id']

    else:

        geo = " "


    # 4. Tweet ID

    tweet_id = tweet['id']
```

```
# 5. Language
lang = tweet['lang']

# 6. Tweet metrics
retweet_count = tweet['public_metrics']['retweet_count']
reply_count = tweet['public_metrics']['reply_count']
like_count = tweet['public_metrics']['like_count']
quote_count = tweet['public_metrics']['quote_count']

# 7. source
source = tweet['reply_settings']

# 9. User Location
#location = tweet['includes']['user']['location']

# 8. Tweet text
text = tweet['text']

# Assemble all data in a list
res = [author_id, created_at, geo, tweet_id, lang, like_count, quote_count, reply_count, retweet_count, source,
location, text]
#print("tweet is:",tweet)
#print("res is:",res)
#print("res type is:",res[0])

# Append the result to the CSV file

if lang in ['en', 'En']:
```

```
            #print(lang)
            csvWriter.writerow(res)
            counter += 1
        else:
            counter += 0
            #print('no')
    # When done, close the CSV file
    csvFile.close()
    #print('The json data from this query[data] is:',json_response['data'])
    #print('The full json includes from this query is:',json_response['includes'])
    # Print the number of tweets for this iteration
    print("# of Tweets added from this response: ", counter)


bearer_token = auth()
headers = create_headers(bearer_token)
keyword = "Open"+"Banking"
start_list =    ['2019-01-01T00:00:00.000Z',
                 '2019-07-01T00:00:00.000Z',
                 ]


end_list =      ['2019-06-30T00:00:00.000Z',
                 '2019-12-31T00:00:00.000Z',
                ]



max_results = 500


#Total number of tweets we collected from the loop
total_tweets = 0
```

```
# Create file
file_name= "data_year2019.csv"
csvFile = open(file_name, "a", newline="", encoding='utf-8')
csvWriter = csv.writer(csvFile)

#Create headers for the data you want to save, in this example, we only want save these columns in our dataset
csvWriter.writerow(['author id', 'created_at', 'geo', 'id','lang', 'like_count', 'quote_count',
'reply_count','retweet_count','source','location','tweet'])
csvFile.close()

for i in range(0,len(start_list)):

    # Inputs
    count = 0 # Counting tweets per time period
    max_count = 500000 # Max tweets per time period
    flag = True
    next_token = None

    # Check if flag is true
    while flag:
        # Check if max_count reached
        if count >= max_count:
            break
        print("--------------------")
        print("Token: ", next_token)
        url = create_url(keyword, start_list[i],end_list[i], max_results)
        json_response = connect_to_endpoint(url[0], headers, url[1], next_token)
        result_count = json_response['meta']['result_count']
```

```
        if 'next_token' in json_response['meta']:
            # Save the token to use for next call
            next_token = json_response['meta']['next_token']
            print("Next Token: ", next_token)
            if result_count is not None and result_count > 0 and next_token is not None:
                print("Start Date: ", start_list[i])
                append_to_csv(json_response, file_name)
                count += result_count
                total_tweets += result_count
                print("Total # of Tweets added: ", total_tweets)
                print("--------------------")
                time.sleep(5)
        # If no next token exists
        else:
            if result_count is not None and result_count > 0:
                print("--------------------")
                print("Start Date: ", start_list[i])
                append_to_csv(json_response, file_name)
                count += result_count
                total_tweets += result_count
                print("Total # of Tweets added: ", total_tweets)
                print("--------------------")
                time.sleep(5)


            #Since this is the final request, turn flag to false to move to the next time period.
            flag = False
            next_token = None
        time.sleep(5)
print("Total number of results: ", total_tweets)
```

```
#-----------------------------------------------------------------------------------------------------------------------------------------

#-------------------------------------Sentiment Analysis-----------------------------------------------

def cleanTxt(text):

    text = re.sub(r'@[A-Za-z0-9]+','',text)#Remove @ sign

    text = re.sub(r'#','',text)

    text = re.sub(r'RT[\s]+','',text)

    text = re.sub(r'https?:\/\/\S+','',text)

    text = re.sub(r'â€¦[A-Za-z0-9]+','',text)


    return text


def getSubjectivity(text):

    return TextBlob(text).sentiment.subjectivity


def getPolarity(text):

    return TextBlob(text).sentiment.polarity


df = pd.read_csv('.csv',

            #index_col='',

            parse_dates=['created_at'],

            header=0,

            names=['created_at', 'location', 'tweet'])

tw_sub = []

tw_pol = []

clean_tweets = []

for tweet in df['tweet']:

     if type(tweet) == np.float:
```

```
        tweet = ""

    #tweet = tweet.lower()

    tweet = re.sub("'", "", tweet) # This is to avoid removing contractions in english

    tweet = re.sub(r'@[A-Za-z0-9]+','',tweet)#Remove @ sign

    tweet = re.sub(r'#[A-Za-z0-9]+','',tweet) #Remove # sign

    tweet = tweet.replace("#", "").replace("_", " ") #Remove hashtag sign but keep the text

    tweet = re.sub(r'RT[\s]+','',tweet)#Remove RT

    tweet = re.sub(r'https?:\/\/\S+','',tweet) #Remove links

    tweet = re.sub('\[.*?\]',' ', tweet) # remove signs

    #tweet = tweet.replace("\n", "").replace("_", " ") #Remove newline "\n" from the tweets

    tweet = re.sub('â€','', tweet)

    tweet = " ".join(tweet.split())

    #tweet = tweet.replace("â€", "").replace("_", " ")

    #tweet = " ".join(w for w in nltk.wordpunct_tokenize(tweet) \

        #if w.lower() in words or not w.isalpha()) #Remove non-english tweets (not 100% success)
# get subjectivity and polarisation from cleaned tweets
    sub = getSubjectivity(tweet)

    pol = getPolarity(tweet)

    clean_tweets.append(tweet)

    res= [sub,pol,tweet]

    tw_sub.append(sub)

    tw_pol.append(pol)

    print ("subject!!!",sub,"polar!!!",pol,"tweet!!!", tweet)

    print ("res!!!",res)

df['tweet'] = clean_tweets

df['subjectivty'] = tw_sub

df['polarity'] = tw_pol

df.to_csv('data_ess_clean_pol_tweet_2019.csv')
```

```
#------------Adding Sentiment Column-------------------

sentiment = []

i=0

for polarity in df['polarity']:

    if polarity > 0:

        sentiment.append('Positive')

    if polarity < 0:

        sentiment.append('Negative')

    if polarity == 0:

        sentiment.append('Neutral')

    i=i+1


df['Sentiment'] = sentiment


#--------------------tokenisation location and time-----------------------------------------------------------------------------------

df['location']= df['location'].apply(lambda x: tokenization(x))

df['created_at']= df['created_at'].apply(lambda x: tokenization(x))

df.to_csv('filter_token_location.csv')


#-----------Sorting the User`s Country-----------------------------------

UK = ['england','uk','london','ireland','wales', 'kingdom','scotland','gb','britain',

      'bristol','newcastle','brighton','edinburgh', 'sheffield', 'swansea',

      'dublin','surrey','newbury','bedford','denver','leeds','reading','nottingham',

      'sunderland','manchester','oxford','leith', 'newcastle',

      'yorkshire','berkshire','leicestershire'

      ]
```

```
US = ['us','usa','new','states','california','washington','boston',
      'nyc','arizona','virginia',
       'miami','seattle','cali','minnesota','angeles'
      'tennessee','pa','colorado','seatle', 'chicago',
      'al','ak','az','as','ar','ca','co','ct','de','dc','fl','ga','gu','hi','id','il',
      'in','in','ia','ks','ky','la','me','md','ma','mi','mn','ms','mo','mt','ne','nv',
      'nh','nj','nm','ny','nc','nd','mp','oh','ok','or','pa','pr','ri','sc','sd','tn',
      'tx','tt','ut','vt','va','vi','wa','wv','wi','wy'
      ]


EU = ['paris','berlin', 'germany','europe','helsinki','finland','italy',
          'oslo','norway','amsterdam','nl','nederland','france','switzerland',
          'zurich','spain','madrid','romania','poland','athens','gr','brussels',
          'piaseczno','roma','milan','austria','prague','stockholm','munich',
          'belgium','milano','luxembourg','schweiz','barcelona','dublin',
          'milan','brussel','hamburg','cologne','berlin','milano','riga'
          'greece','deutschland','denmark','serbia','norge','polska','cyprus',
          'latvia', 'sz', 'bruxelles', 'netherlands', 'italia', 'wien',
          'frankfurt',
          ]


df['unfilt_location']= df['unfilt_location'].apply(lambda x: tokenization(x))# tokenization the location value


loc_posit =0
countr_location = []
for country in df['unfilt_location']:
    print('The country !!!!', country, len(country),type(country))
    loc_posit = loc_posit +1
```

```
    if country == ['', '']:
      df['unfilt_location'][loc_posit-1]= 'Not Avail'


    for UK_country in UK:
       if UK_country in country:
            df['unfilt_location'][loc_posit-1]= 'UK'
            print('the UK_country is', UK_country, 'Country is:', country )
            break

    for US_country in US:
       if US_country in country:
            df['unfilt_location'][loc_posit-1]= 'US'
            print('the US_country is', US_country, 'Country is:', country )
            break

    for EU_country in EU:
       if EU_country in country:
            df['unfilt_location'][loc_posit-1]= 'EU'
            print('the EU_country is', EU_country, 'Country is:', country )
            break


df.to_csv('filter_token_location_creat2017-2023.csv')
#-----------------------Location Pie Chart---------------
df_pie=df.groupby('unfilt_location').count()


ax=df_pie.plot(kind='pie', y='polarity',
                    labels=['EU','Not Avail','Others','UK','US' ],
                    autopct='%1.0f%%',
```

```
                shadow = True,
                startangle=60,
                figsize=(15,13),
                fontsize=20,
                title='Tweet by location ',legend='Country')
#ax.set_xlabel(['Negative','Neural','Positive'], rotation=0)
ax.set_ylabel('Number of tweets', rotation=90)
#ax.subplots(figsize =(95, 85))
#plt.setp(autotexts, size = 8, weight ="bold")
plt.show

#--------------------------------Text analysis-----------------------------

#----------------choosing dataset by jurisdiction or sentiment-------------
df_txt_neg= df[['tweet','Sentiment','Year','YearMonth' ]]
df_txt_neg=df_txt_neg[df_txt_neg['Sentiment'] == "Negative"]

df_All=df[['location','tweet','Sentiment','Year','YearMonth']]


df_DiD_UK_EU['before_after']=0  #create dummy for before and after
df_DiD_UK_EU['before_after']= df_DiD_UK_EU['before_after'].where (df_DiD_UK_EU.Year<2019,1)

df_DiD_UK_EU['contr_treatment']=0  #create dummy for control and treatment group
df_DiD_UK_EU['contr_treatment']= df_DiD_UK_EU['contr_treatment'].where (df_DiD_UK_EU.location =='EU',1)


df_UK_before= df_DiD_UK_EU[df_DiD_UK_EU['location'] == "UK"]
```

```
df_UK_before=df_UK_before[df_UK_before['before_after']== 0]


df_UK_after=df_UK_before[df_UK_before['before_after']== 1]



df_UK_before_neg=df_UK_before[df_UK_before['Sentiment'] == "Negative"]

df_UK_before_pos=df_UK_before[df_UK_before['Sentiment'] == "Positive"]



df_UK_after= df_DiD_UK_EU[df_DiD_UK_EU['location'] == "UK"]

df_UK_after=df_UK_after[df_UK_after['before_after']== 1]



df_UK_after_neg=df_UK_after[df_UK_after['Sentiment'] == "Negative"]

df_UK_after_pos=df_UK_after[df_UK_after['Sentiment'] == "Positive"]



df_txt= df_UK_after_pos

df_txt= df_txt.dropna()# drop null values


df_txt['word_count'] = df_txt['tweet'].apply(lambda x: len(str(x).split(" ")))

df_txt['tweet'] = df_txt['tweet'].apply(lambda x: " ".join(x.lower() for x in x.split()))

df_txt['tweet'] = df_txt['tweet'].str.replace('[^\w\s]','')#remove punctual

df_txt['tweet'] = df_txt['tweet'].apply(lambda x: " ".

                                join(x for x in x.split() if x not in stop))#remove stop words


freq = pd.Series(' '.join(df_txt['tweet']).split()).value_counts()[:30]

print('frequancy top:',freq)
```

```
from time import time
import matplotlib.pyplot as plt


from gensim import corpora, models
from gensim.models.ldamulticore import LdaMulticore
from gensim.models.coherencemodel import CoherenceModel
import pyLDAvis.gensim


--------------------------------------------------Code for NMF and LDA from Github--------------------------
#Plot function
# Author: Olivier Grisel <olivier.grisel@ensta.org>
#         Lars Buitinck
#         Chyi-Kwei Yau <chyikwei.yau@gmail.com>
# License: BSD 3 clause



n_samples = 20000
n_features = 10000
n_components = 10
n_top_words = 20
batch_size = 128
init = "nndsvda"



def plot_top_words(model, feature_names, n_top_words, title):
    fig, axes = plt.subplots(2, 5, figsize=(30, 15), sharex=True)
    axes = axes.flatten()
    for topic_idx, topic in enumerate(model.components_):
```

```
        top_features_ind = topic.argsort()[: -n_top_words - 1 : -1]
        top_features = [feature_names[i] for i in top_features_ind]
        weights = topic[top_features_ind]

        ax = axes[topic_idx]
        ax.barh(top_features, weights, height=0.7)
        ax.set_title(f"Topic {topic_idx +1}", fontdict={"fontsize": 30})
        ax.invert_yaxis()
        ax.tick_params(axis="both", which="major", labelsize=20)
        for i in "top right left".split():
            ax.spines[i].set_visible(False)
        fig.suptitle(title, fontsize=40)

    plt.subplots_adjust(top=0.90, bottom=0.05, wspace=0.90, hspace=0.3)
    plt.show()


# Use tf-idf features for NMF.
print("Extracting tf-idf features for NMF...")
tfidf_vectorizer = TfidfVectorizer(
    max_df=0.95, min_df=2, max_features=n_features, stop_words="english"
)
t0 = time()
tfidf = tfidf_vectorizer.fit_transform(df_txt['tweet'])
print("done in %0.3fs." % (time() - t0))

# Use tf (raw term count) features for LDA.
print("Extracting tf features for LDA...")
```

```
tf_vectorizer = CountVectorizer(
    max_df=0.95, min_df=2, max_features=n_features, stop_words="english"
)
t0 = time()
tf = tf_vectorizer.fit_transform(df_txt['tweet'])
print("done in %0.3fs." % (time() - t0))
print()



print(
    "Fitting the NMF model (Frobenius norm) with tf-idf features, "
    "n_samples=%d and n_features=%d..." % (n_samples, n_features)
)
nmf = NMF(
    n_components=n_components,
    random_state=1,
    init=init,
    beta_loss="frobenius",
).fit(tfidf)


tfidf_feature_names = tfidf_vectorizer.get_feature_names()
plot_top_words(
    nmf, tfidf_feature_names, n_top_words, "Topics in NMF model (Frobenius norm)"
)



print(nmf)
```

```
print(
    "\n" * 2,
    "Fitting LDA models with tf features, n_samples=%d and n_features=%d..."
    % (n_samples, n_features),
)
lda = LatentDirichletAllocation(
    n_components=n_components,
    max_iter=5,
    learning_method="online",
    learning_offset=50.0,
    random_state=0,
)
t0 = time()
lda.fit(tf)
print("done in %0.3fs." % (time() - t0))

tf_feature_names = tf_vectorizer.get_feature_names()
plot_top_words(lda, tf_feature_names, n_top_words, "Topics in LDA model")

print(lda.display())
print(lda.summary())

#------------ Convert time create_at to month of creation------------

def getMonth(s):
    return s.split('\W+', s)[2]
```

```
def getYear(s):
    s= re.split('\W+', s)
    print(type(s))
    return s[1]



def getYearMonth(s):
    s= re.split('\W+', s)
    print(type(s),"for YearMonth",s[1] + s[2])
    return s[1] + s[2]

df['Year']=df['created_at'].apply(lambda x: getYear(x))
df['YearMonth']= df['created_at'].apply(lambda x: getYearMonth(x))

#------------------ Data visualisation-----------------



df_1= df[['created_at','location','subjectivty','polarity','Sentiment','Year','YearMonth' ]]
ax = df_1['polarity'].plot(kind='kde', title='Distribution of data')
ax.set_xlabel(['Tweet Polarity score'], rotation=0)

ax = df_1.plot(kind='scatter',
               x='YearMonth',
               y='polarity',
               title='Polarity and time')
ax.set_ylabel(['Tweet Polarity score'], rotation=0)
```

```
sns.scatterplot(kind='scatter',
            x='year',
            y='polarity',
            #hue='location',
            data=df_1,
            title='Polarity and time')
plt.show


#--------------Difference and Difference regression-----------------------------------------
#----------------DID between UK and EU-------------------------------------------------------
#df_All=df_1[['subjectivty','polarity','Year','location','Sentiment']]
#df_EU=df_1[df_1['location'] == "EU"]


df_DiD_UK_EU=df_All.query("location in ('EU','UK')")
df_DiD_UK_EU['before_after']=0  #create dummy for before and after
df_DiD_UK_EU['before_after']= df_DiD_UK_EU['before_after'].where (df_DiD_UK_EU.Year<2019,1)


df_DiD_UK_EU['contr_treatment']=0  #create dummy for control and treatment group
df_DiD_UK_EU['contr_treatment']= df_DiD_UK_EU['contr_treatment'].where (df_DiD_UK_EU.location =='EU',1)
model= 'polarity ~ contr_treatment + before_after + contr_treatment*before_after + Year'
mod= smf.ols(formula=model, data=df_DiD_UK_EU)
res=mod.fit()
print(res.summary())


#----------------------------Stacked line and bar number of reviews by group annually------------------
df_CMA9= df_1[df_1['Group'] == 'CMA9']
df_NoCMA9= df_1[df_1['Group'] == 'NoCMA9']
df_Ch_bank= df_1[df_1['Group'] == 'challenger bank']
```

```
df_TPP= df_1[df_1['Group'] == 'TPP']


fig, ax = plt.subplots(figsize=(25, 10))


time=df_1.groupby('Year').mean().index.astype(str)

time1=df_NoCMA9.groupby('Year').mean().index.astype(str)

time2=df_Ch_bank.groupby('Year').mean().index.astype(str)

time3=df_TPP.groupby('Year').mean().index.astype(str)

# -----------Plot lines-----------------------------

ax.plot( time, df_CMA9.groupby('Year').count()['score'], color="green",label= 'CMA9')

ax.plot(time1, df_NoCMA9.groupby('Year').count()['score'], color="blue",label= 'NoCMA9')

ax.plot(time2, df_Ch_bank.groupby('Year').count()['score'], color="red",label= 'Challenger banks')

ax.plot(time3, df_TPP.groupby('Year').count()['score'], color="black",label= 'OB third party providers')

plt.legend()

plt.show()

#-----Stacked bar number of reviews by group annually


y1=df_CMA9.groupby('Year').count()['score']

y2=df_NoCMA9.groupby('Year').count()['score']

y3=df_Ch_bank.groupby('Year').count()['score']

y4=df_TPP.groupby('Year').count()['score']


plt.bar(time,y1 , color='green')

plt.bar(time1, y2,

        #bottom=y1,

        color='blue')

plt.bar(time2, y3,

        #bottom=y1+y2,
```

```
        color='red')
plt.bar(time3, y4,
        #bottom=y1+y2+y3,
        color='black')
plt.xlabel("Year")
plt.ylabel("Number of reiews")
plt.legend(["CMA9", "NoCMA9", "TPP", "Challenger Bank"])
plt.title("Number of reviews by year")
plt.show()
#----------------------------Mean app rating by group annually------------------


fig, ax = plt.subplots(figsize=(25, 10))


time=df_CMA9.groupby('Year').mean().index.astype(str)
time1=df_NoCMA9.groupby('Year').mean().index.astype(str)
time2=df_Ch_bank.groupby('Year').mean().index.astype(str)
time3=df_TPP.groupby('Year').mean().index.astype(str)
# Plot lines



ax.plot( time, df_CMA9.groupby('Year').mean()['score'], color="green",label= 'CMA9')
ax.plot(time1, df_NoCMA9.groupby('Year').mean()['score'], color="blue",label= 'NoCMA9')
ax.plot(time2, df_Ch_bank.groupby('Year').mean()['score'], color="red",label= 'Challenger banks')
ax.plot(time3, df_TPP.groupby('Year').mean()['score'], color="black",label= 'OB third party providers')
plt.legend()
plt.show()


#----------------Pair plot--------------
```

```
#----- Convert columns to interger to run pair plot and correlation-

df.loc[(df['Group'] == "CMA9"),['Group']]="1"

df.loc[(df['Group'] == "NoCMA9"),['Group']]="2"

df.loc[(df['Group'] == "challenger bank"),['Group']]="3"

df.loc[(df['Group'] == "TPP"),['Group']]="4"

df = df.astype({'Group':'int'})


df['Year']=df_1['Year']

#df['YearMonth']=df_1['YearMonth']

df = df.astype({'Year':'int'})

#df = df.astype({'YearMonth':'int'})




df['at'] = pd.to_datetime(df['at'],

                    #format='%d%b%Y:%H:%M:%S.%f'

                    )

df = df.astype({'at':'int64'})

df=df.dropna()


df['appVersion'] = df['appVersion'].str.replace('[^\w\s]','')#remove punctual

print('Punctiation',df['appVersion'].head())


df.to_csv('pair plot')

#--------

df = pd.read_csv('pair plot.csv',

          index_col='index',

          header=0,
```

```
        #   parse_dates=['at'],
          names=['index',
                 'content','score', 'thumbsUpCount',
                 'reviewCreatedVersion','at','replyContent',
                 'repliedAt', 'appVersion','Serv_pr', 'Group','Year','YearMonth' ])


df=df[['content','score', 'thumbsUpCount',
                 'reviewCreatedVersion','at','replyContent',
                 'repliedAt', 'appVersion','Serv_pr', 'Group','Year']]
df=df.dropna()
df= df.astype({'appVersion':'int64'})


#-----------------------------------------------------------------


g= sns.pairplot(df,
        #   vars=['score', 'thumbsUpCount',
         #        'reviewCreatedVersion','at',
          #       'repliedAt', 'appVersion', 'Group']
           #hue="Group",
           plot_kws=dict(marker="+", linewidth=1),
   diag_kws=dict(fill=False)


           )



plt.show()


#-------------------------------------correlation table--------------------------------
```

```
df_corr= df.dropna().corr()


print("Corr table!!!:",df_corr)

sns.heatmap(df_corr,annot=Tr
```

Appendix F

(Service quantity and quality- Python code)

```
"""

Created on Mon Jul 24 13:48:43 2023



@author: vlnam

"""

-----------------------------------------------------------Download reviews-----------------------------------

from google_play_scraper import app,Sort,reviews_all

from app_store_scraper import AppStore
import pandas as pd
import numpy as np

import json, os, uuid



G_Serv_providers = [

                    ]



G_Serv_link= [

              ]



service_group='CMA9'



i=25

for i in range(26,28):

   print(G_Serv_providers[i],G_Serv_link[i])

   link= G_Serv_link[i]
```

```
    g_reviews = reviews_all(
         link,
        sleep_milliseconds=0,
        lang='en', # english language
        country='gb', # United Kingdom
        sort=Sort.NEWEST,
        )
#copy reviews from google play to file
    g_df = pd.DataFrame(np.array(g_reviews),columns=['review'])
    g_df2 = g_df.join(pd.DataFrame(g_df.pop('review').tolist()))
    g_df2['Serv_pr']= G_Serv_providers[i]
    g_df2['Group']= service_group

    g_df2.to_csv('google play review TPP'+G_Serv_providers[i]+' bank.csv')

  #--------------Difference and Difference regression-------------------
#----------------DID between UK and EU----------------------------
#df_All=df_1[['subjectivty','polarity','Year','location','Sentiment']]
#df_EU=df_1[df_1['location'] == "EU"]

df_D=df_1[['score','Group','Year']]

#----------Choosing control group-------------------------------------------------------
#--------CMA9-NoCMA9--------
df_CMA9_NoCMA9=df_D.query("Group in ('CMA9','NoCMA9')")

#create dummy for before and after
df_CMA9_NoCMA9['before_after']=0
```

```
df_CMA9_NoCMA9['before_after']= df_CMA9_NoCMA9['before_after'].where (df_CMA9_NoCMA9.Year<2019,1)
#create dummy for control and treatment group
df_CMA9_NoCMA9['contr_treatment']=0


print(df_CMA9_NoCMA9.head())
df_CMA9_NoCMA9['contr_treatment']= df_CMA9_NoCMA9['contr_treatment'].where (df_CMA9_NoCMA9.Group ==
'NoCMA9',1)


#--------CMA9-TPP--------
df_CMA9_TPP=df_D.query("Group in ('CMA9','TPP')")


#create dummy for before and after
df_CMA9_TPP['before_after']=0
df_CMA9_TPP['before_after']= df_CMA9_TPP['before_after'].where (df_CMA9_TPP.Year<2019,1)
#create dummy for control and treatment group
df_CMA9_TPP['contr_treatment']=0
df_CMA9_TPP['contr_treatment']= df_CMA9_TPP['contr_treatment'].where (df_CMA9_TPP.Group =='TPP',1)


#--------CMA9-challenger banks--------
df_CMA9_Chl=df_D.query("Group in ('CMA9','challenger bank')")



#create dummy for before and after
df_CMA9_Chl['before_after']=0
df_CMA9_Chl['before_after']= df_CMA9_Chl['before_after'].where (df_CMA9_Chl.Year<2019,1)
#create dummy for control and treatment group
df_CMA9_Chl['contr_treatment']=0
df_CMA9_Chl['contr_treatment']= df_CMA9_Chl['contr_treatment'].where (df_CMA9_Chl.Group =='challenger bank',1)


#-------------------------DID model result------
```

```
groupDID=df_CMA9_Chl

print(groupDID.describe())

groupDID.to_csv('Test DID.csv')


model= 'score ~ contr_treatment + before_after + contr_treatment*before_after + Year'

mod= smf.ols(formula=model, data=groupDID)

res=mod.fit()


print(res.summary())
```

Appendix H

(Network effect analysis- Python Code)

```
"""

Created on Tue Sep 12 19:41:48 2023



@author: vlnam

"""

import re
import string



import sys
import pandas as pd
from pandas_profiling import ProfileReport

import statsmodels.formula.api as smf


from textblob import TextBlob


import sys

import matplotlib.pyplot as plt

import numpy as np
import seaborn as sns
import csv



df_1= pd.read_csv('data.csv',

        index_col='index',

        header=0,

      #   parse_dates=['at'],

        names=['index','Company','Group','Consol_code',
```

```
                'Year','Total_customer_deposit',
                'Total_asset' ,'Ch_inter_inc','Interest_income',
                'Ch_fee_com_income',
                'Net_fee_comission_income',
                'Total_other_income',
                'Total_switch_per_year',
                'Total_customer_per_year','Ch_cust' ])

#------------All groups scatter plot----------
ax = sns.scatterplot(x="Ch_cust", y="Ch_inter_inc", data=df_1)
ax.set_title("Changes in income vs. Customer base- All groups")
ax.set_xlabel("Change in customer base");
ax.set_ylabel("Changes in interest income")


ax = sns.scatterplot(x="Ch_cust", y="Ch_fee_com_income", data=df_1)
ax.set_title("Changes in income vs.Customer base- All groups")
ax.set_xlabel("Change in customer base");

sns.lmplot(x="Ch_cust", y="Ch_inter_inc", data=df_1);

sns.lmplot(x="Ch_cust", y="Ch_fee_com_income", data=df_1);

#--------------Regression model-network effect-----------------------------------

df_CMA9=df_1.query("Group in ('CMA9')")
df_NoCMA9=df_1.query("Group in ('NoCMA9')")
df_challenger=df_1.query("Group in ('challenger bank')")
```

```
model= 'Ch_inter_inc ~ Ch_cust'# interest income network value

model1= 'Ch_fee_com_income ~ Ch_cust'# fee and commision income network value


#all groups regression
mod= smf.ols(formula=model, data=df_1)# all banks

res=mod.fit()

print(res.summary())

with open('net effect-all groups- Interest-income.csv', 'w') as fh:

    fh.write(res.summary().as_csv())

mod= smf.ols(formula=model1, data=df_1)# all banks

res=mod.fit()

print(res.summary())

with open('net effect-all groups- Fee,commision-income.csv', 'w') as fh:

    fh.write(res.summary().as_csv())


#---- V~U, Fee and commision income - Linear,melcafe law and third order regression-------

plt.figure(figsize=(6 * 1.618, 6))

plt.scatter(df_1[['Total_customer_per_year']], df_1[['Net_fee_comission_income']])

plt.xlabel('Total customer base')

plt.ylabel('Fee and commission incomes')



x = pd.DataFrame({'Total_customer_per_year': np.linspace(-10000, df_1.Total_customer_per_year.max()*2, 100, endpoint=

True)})

#x= df_1[['Ch_cust']]
```

```
print('hchcyc', x.Total_customer_per_year)

poly_1 = smf.ols(formula='Net_fee_comission_income ~ Total_customer_per_year',

                 data=df_1).fit()


print('hchcyc',poly_1.predict(x))

plt.plot(x.Total_customer_per_year, poly_1.predict(x), 'b-', label='Poly n=1 $R^2$=%.2f' % poly_1.rsquared,

         alpha=0.9)


res1=poly_1

print(res1.summary())

with open('V~ U.linear regress- net effect-df_1- fee comm-income.csv', 'w') as fh:

    fh.write(res1.summary().as_csv())


# 2-nd order polynomial

poly_2 = smf.ols(formula='Net_fee_comission_income ~ Total_customer_per_year + I(Total_customer_per_year ** 2.0)',

data=df_1).fit()

plt.plot(x.Total_customer_per_year, poly_2.predict(x), 'g-', label='Poly n=2 $R^2$=%.2f' % poly_2.rsquared,

         alpha=0.9)


res2=poly_2

print(res2.summary())

with open('V~ U.2-nd order polynomial regress- net effect-df_1- fee and commission-income.csv', 'w') as fh:

    fh.write(res2.summary().as_csv())



# 3-rd order polynomial

poly_3 = smf.ols(formula='Net_fee_comission_income ~ Total_customer_per_year + I(Total_customer_per_year ** 2.0) +

I(Total_customer_per_year ** 3.0)', data=df_1).fit()
```

```
plt.plot(x.Total_customer_per_year, poly_3.predict(x), 'r-', alpha=0.9,
        label='Poly n=3 $R^2$=%.2f' % poly_3.rsquared)

res3=poly_3
print(res3.summary())
with open('V~ U.3-nd order polynomial regress- net effect-df_1- Fee and commmision-income.csv', 'w') as fh:
    fh.write(res3.summary().as_csv())

plt.legend()

#---------------- number of switching account chart---------------------------------------------

df_sw_number= pd.read_csv('Raw Data with input missed data- Number of switches per month.csv',
            index_col='index',
            header=0,
        #   parse_dates=['at'],
            names=['index','Year','QYear',
                   'YearMonth', 'Total Switches','Personal_SME'])

#------- Graph monthly, quaterly and annual switch number----

# Plot lines Annual switch--
fig, ax = plt.subplots(figsize=(25, 10))
ax.tick_params(axis='x', labelsize=20)
ax.tick_params(axis='y', labelsize=20)

df_sw_number_1=df_sw_number[df_sw_number['Year'] != 2017]# exclude year 2017, no report data.
```

```
time=df_sw_number_1.groupby('Year').sum().index.astype(str)



ax.plot( time, df_sw_number_1.groupby('Year').sum()['Total Switches'],

        color="green",linestyle = 'dashed',label= 'Annually account switching')


plt.legend(fontsize=20)

plt.show()
```

Appendix I

(Market power analysis - Python Code)

```
# -*- coding: utf-8 -*-

"""

Created on Sun Nov 19 10:05:27 2023



@author: vlnam

"""

import pandas as pd
from pandas_profiling import ProfileReport

import statsmodels.formula.api as smf

import sys

import matplotlib.pyplot as plt

import numpy as np
import seaborn as sns
import csv


def normalise_log(number):

    if number > 0:

        number = np.log(number)

    else:

        number = - np.log(-number)


    return number


df = pd.read_csv('file name',

            index_col='index',

            header=0,

            )
```

```
#-------------HHI index---------------------

time=df.groupby('Year').count().index.astype(str)

factor='Interest Income'
contr_gr='UK'
year=2015
df_HHI_r=df[['Country','Year','Company name',factor]]

df_HHI=df_HHI_r[df_HHI_r['Country'] == "UK"]
print(df_HHI.head(5))

df_HHI_year=df_HHI[df_HHI['Year'] == year]
print(df_HHI_year.head(5))

HHI=pd.DataFrame([['Country','Year','HHI']],columns=['Country','Year','HHI'])

for contr_gr in Countries:
    df_HHI=df_HHI_r[df_HHI_r['Country'] == contr_gr]
    for year in range(2015,2023):
        df_HHI_year=df_HHI[df_HHI['Year'] == year]
        print(df_HHI_year.head(5))

df_HHI_year[factor]=(df_HHI_year[factor]/df_HHI_year[factor].sum())*(df_HHI_year[factor]/df_HHI_year[factor].sum())*10
000

        print(year,df_HHI_year[factor].sum())
        new_row = {'Country': contr_gr, 'Year': year, 'HHI': df_HHI_year[factor].sum()}
        print('new_row',new_row)
```

```
    HHI=HHI.append(new_row,ignore_index=True)


#-------------Boone index calculation---------------------

df['profit']=round((df['Operating profit']/df['Total assets']*100),2)

df['variable_cost_not_norm']=df['Cost-to-income_(Efficiency)_ratio']


df['variable_cost']= round((df['variable_cost_not_norm'].apply(lambda x: normalise_log(x))),2)# normalisation with log



#df['variable_cost']=df['Total operating expenses']/(df['Interest Income']+df['Fee & commission income']+df['Total other

operating income'])*100


#variable costs (ccii,tt in equation (11)) are measured as total costs scaled

# by interest received and income from foreign exchange, investment, fees and other sources.

#df['variable_cost']= (df['Total operating expenses']+df['''])


df_boone= df[['Company

name','Country','Year','profit','variable_cost','Customer_loans_advance_Total_assets','RoRWA_Operating_profit_RWAs']]

df_boone['dummy_year_2015']=1  #create dummy for year

df_boone['dummy_year_2015']= df_boone['dummy_year_2015'].where (df_boone.Year==2015,0)

df_boone['dummy_year_2016']=1  #create dummy for year

df_boone['dummy_year_2016']= df_boone['dummy_year_2016'].where (df_boone.Year==2016,0)

df_boone['dummy_year_2017']=1  #create dummy for year

df_boone['dummy_year_2017']= df_boone['dummy_year_2017'].where (df_boone.Year==2017,0)

df_boone['dummy_year_2018']=1  #create dummy for year

df_boone['dummy_year_2018']= df_boone['dummy_year_2018'].where (df_boone.Year==2018,0)

df_boone['dummy_year_2019']=1  #create dummy for year

df_boone['dummy_year_2019']= df_boone['dummy_year_2019'].where (df_boone.Year==2019,0)
```

```
df_boone['dummy_year_2020']=1  #create dummy for year

df_boone['dummy_year_2020']= df_boone['dummy_year_2020'].where (df_boone.Year==2020,0)


df_boone['dummy_year_2021']=1  #create dummy for year

df_boone['dummy_year_2021']= df_boone['dummy_year_2021'].where (df_boone.Year==2021,0)


df_boone['dummy_year_2022']=1  #create dummy for year

df_boone['dummy_year_2022']= df_boone['dummy_year_2022'].where (df_boone.Year==2022,0)

df_boone = df_boone.rename(columns={'Company name': 'Company_name'})


contr_gr='UK'


df_boone.replace([np.inf, -np.inf], np.nan, inplace=True)

df_boone= df_boone.dropna()

df_boone = df_boone[df_boone['profit'] > -10]

df_boone.to_csv('Boone index.csv')



model= 'profit ~ dummy_year_2015*variable_cost + dummy_year_2016*variable_cost + dummy_year_2017*variable_cost

+ dummy_year_2018*variable_cost + dummy_year_2019*variable_cost + dummy_year_2020*variable_cost +

dummy_year_2021*variable_cost + dummy_year_2022*variable_cost + Customer_loans_advance_Total_assets +

RoRWA_Operating_profit_RWAs'


print(model)

df_boone1=df_boone[df_boone['Country'] == contr_gr]

mod= smf.ols(formula=model, data=df_boone1)
```

```
res=mod.fit()

#-------------Boone index Graph---------------------


jur="UK"


fig, ax = plt.subplots(figsize=(15, 10))

ax.set_title('Chart: Boone Index by country (company fixed effect)',


            fontsize = 14)


time=df_B.groupby('Year').mean().index.astype(str)


for jur in Countries:

    df_test=df_B[df_B['Country'] == jur]

    ax.plot( time, df_test['Boone_ind'],

                        label= jur)



plt.legend(title ="Country:",loc=2)

plt.show()

#-------------HHI index Graph---------------------

jur="UK"


fig, ax = plt.subplots(figsize=(15, 10))

ax.set_title('Chart: HHI Index - by country - '+ factor,


            fontsize = 14)
```

```
time=df_H.groupby('Year').mean().index.astype(str)



for jur in Countries:

    df_test=df_H[df_H['Country'] == jur]

    ax.plot( time, df_test['HHI'],

                        label= jur)


plt.legend(title ="Country:",loc=2)

plt.show()


#----------------------------Lerner index------------------------


import sqlite3
import datetime as dt
import itertools
import linearmodels as lm


from regtabletotext import prettify_result, prettify_results


df['price']=(df['Interest Income']+df['Fee & commission income'])/df['Total assets']*100


df['labour_cost_notnorm']= df['Staff expenses']/df['Total assets']*100

df['labour_cost'] = (df['Staff expenses']/df['Total assets']*100).apply(lambda x: normalise_log(x))


df['fund_cost_notnorm']=df['Total interest expense']/df['Total customer deposits']*100

df['fund_cost']= (df['Total interest expense']/df['Total customer deposits']*100).apply(lambda x: normalise_log(x))


df['oper_cost_notnorm'] = df['Non-interest expenses/Average total assets']

df['oper_cost'] = (df['Non-interest expenses/Average total assets']).apply(lambda x: normalise_log(x))
```

```
df['total_costs_notlog']= df['Total operating expenses']

df['total_costs']= df['Total operating expenses'].apply(lambda x: normalise_log(x))


df['Total_assets_notlog']= df['Total assets']

df['Total_assets']= df['Total assets'].apply(lambda x: normalise_log(x))

df['Total_assets_sq']=df['Total_assets']*df['Total_assets']/2


df.replace([np.inf, -np.inf], np.nan, inplace=True)

df= df.dropna()

#df.to_csv('lerner_mc data not drop.csv')


total_cost_model= 'total_costs ~ Total_assets + Total_assets_sq + fund_cost + labour_cost + oper_cost +

Total_assets*fund_cost + Total_assets*labour_cost + Total_assets*oper_cost + fund_cost*fund_cost +

fund_cost*labour_cost + fund_cost* oper_cost + labour_cost*labour_cost + labour_cost*fund_cost +

labour_cost*oper_cost + oper_cost*labour_cost + oper_cost*fund_cost + oper_cost*oper_cost +Year +

Customer_loans_advance_Total_assets + RoRWA_Operating_profit_RWAs'


mod= smf.ols(formula=total_cost_model, data=df)

res=mod.fit()


with open('Cost coffi - Lerner .csv', 'w') as fh:

        fh.write(res.summary().as_csv())


prettify_result(res)


df['Margin_cost']=df['total_costs_notlog']/df['Total_assets_notlog']*(0.9767 + 0.00002*df['Total_assets']

                                        -0.008*df['fund_cost']
```

```
-0.0158*df['labour_cost']

+ 0.0119*df['labour_cost'])*100


df['lern_index']= (df['price'] - df['Margin_cost'])/df['price']


df.to_csv('lerner index.csv')
```

Appendix J

(General impact modelling - Python Code)

```
"""

Created on Sat Dec 30 07:31:09 2023


@author: vlnam

"""

import numpy as np

import matplotlib.pyplot as plt

import pandas as pd


df = pd.read_csv('data.csv',

        index_col='index',

        header=0,

        )


#------------File check-------------------

df=df[df['Year']>2016]

df=df.dropna(subset=['NB_Review'])

df=df.dropna()

df=df[['Company_name','Group','Year','Sentiment','Switch_number','NB_Review','OB_enforce','Total_customer_deposits','R

eview_score','Total_operating_expenses','lern_index']]

df_test=df[['Sentiment','Switch_number','NB_Review','OB_enforce','Company_name']]


X= df.iloc[:, 3:7].values.astype(float)
```

```
y=df.iloc[:,10].values.astype(float)


from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2, random_state = 0)


from sklearn.preprocessing import StandardScaler

sc = StandardScaler()

X_train = sc.fit_transform(X_train)

print('X_test before transform:',X_test)

X_test = sc.transform(X_test)


#print('X_train:',X_train)

print('X_test:',X_test)


#--------------------fitting model----------------------
from sklearn import svm
from sklearn.svm import SVR

from sklearn.model_selection import train_test_split

from sklearn.svm import SVC

classifier = SVR(kernel="rbf", C=500)

classifier.fit(X_train, y_train)


y_pred = classifier.predict(X_test)

print('prediction:', y_pred)

print('model score :', classifier.score(X_train, y_train))

print('model intercept :', classifier.intercept_)

#------prediction -----

x_test_df= pd.read_csv('prediction_x_test - SVR.csv',
```

```
        index_col='index',
        header=0,
        )

#---------transform X to SVR data----------
x_test_SVR_df= sc.fit_transform(x_test_df)
print('x_test_SVR_df',x_test_SVR_df)
y_predic=classifier.predict(x_test_SVR_df)
print('prediction:', classifier.predict(x_test_SVR_df))
```

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