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Abstract

Cloud outsourcing may alter competition in banking by allowing smaller competitors to access scalable digital infrastructure. This paper studies the effects of banks' outsourcing agreements with Cloud Service Providers (CSPs) in the UK banking sector using proprietary bank-provider contract data. We find that CSP spending is associated with lower operating costs and higher deposits, with reduced-form effects concentrated among large institutions. We also find that increases in capital requirements are associated with higher CSP spending, consistent with large institutions using CSP adoption to reduce dependence on legacy IT systems, improve operational efficiency, and strengthen long-term franchise value. We then estimate a structural model of competition in the UK deposit market to quantify depositor-demand effects from CSPs. We find that the demand-side benefits of CSP adoption are substantially larger for small and medium banks and building societies. We use the model to conduct two counterfactual analyses. First, we simulate a scenario in which cloud outsourcing was restricted prior to its widespread adoption. The counterfactual implies higher market concentration, lower market shares for smaller institutions, and lower depositor welfare. Second, we analyse a reduction in capital requirements. While lower capital requirements directly increase welfare through funding-cost effects, they also reduce incentives to invest in CSP adoption, offsetting roughly 32% of the direct welfare gain. Our findings suggest that cloud outsourcing has partly reduced technological barriers to competition in banking markets.

Key words: Cloud outsourcing, bank competition, process innovation, financial regulation.

JEL classification: G21, G28, O31, D22.

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1 Introduction

Technology adoption can reshape competition when it changes the cost of entering a market, expanding operations, and improving product quality. Many technologies historically favour large firms because they require large fixed investments, specialised personnel, and organisational capacity. Cloud outsourcing may be different. By allowing firms to access computing infrastructure, software, and data services through scalable contracts, Cloud Service Providers (CSPs) can convert part of fixed IT investment into more flexible operating costs (Biglaiser *et al.* , 2024). In banking, this shift is potentially important because smaller institutions may use outsourced digital infrastructure to compete with large incumbents without replicating their legacy systems or internal technology structures.

This paper explores how cloud outsourcing affects competition in banking. We ask two main questions. First, does cloud outsourcing change banks' cost structures and their ability to compete for deposits in the UK banking industry? Second, how do prudential capital requirements interact with banks' incentives to invest in CSP outsourcing, and what are the implications for depositor welfare? To answer these questions, we use confidential data on outsourcing arrangements between CSPs and UK regulated deposit-taking institutions, combined with regulatory balance-sheet data on banks and building societies.

The UK deposit market provides a useful setting for this analysis. Traditionally, a main barrier to entry and expansion in retail banking has been the stickiness of retail deposits. Large deposit-takers benefit from stable retail deposit funding, while smaller banks must compete by offering better rates, better service quality, or both.[1] Historically, service quality in retail banking depended partly on branch networks and spatial proximity. The transition to digital distribution channels has reduced the importance of physical scale, while outsourcing to CSPs may further reduce technological barriers by allowing banks to shift from costly on-premises IT infrastructure towards more flexible and scalable service-based models.

We study this issue using a proprietary dataset comprising 3,443 material outsourcing contracts from 90 UK domestic banks over the past two decades. Among these, 457 contracts involve cloud service arrangements with external CSPs, covering annual spending of £1.57 billion across 72 banks. We use the start date of each contract to construct a bank-quarter measure of cumulative CSP spending and merge it with the Historical Banking Regulatory Database. This allows us to link CSP adoption to bank-level outcomes such as operating expenses, deposits, deposit rates, lending outcomes, and capital requirements.

We begin by documenting several stylised facts. CSP contracts have become more prevalent over time and are increasingly important in banks' business models. Small and medium banks have increased CSP spending the most relative to staff expenditure and have also experienced stronger improvements in reported service quality and deposit growth. By contrast, small and medium building societies have adopted CSP outsourcing less intensively, report lower service quality, and show slower deposit growth. These patterns suggest that cloud outsourcing is related to dynamic margins of competition, although they do not by themselves identify the causal effect of CSP adoption.

We then estimate reduced-form regressions with bank and quarter fixed effects. We find that CSP spending is associated with lower non-interest expenses and lower staff expenses, with the effect concentrated among large banks and building societies. Similarly, we also find that CSP spending is associated with higher deposit volumes, with stronger results for the larger institutions. These findings suggest

[1] In the UK, this issue is reinforced by the so-called "free-if-in-credit" pricing model, under which customers generally do not pay directly for personal current accounts or common transactions, although they typically receive little or no interest on credit balances. See Competition and Markets Authority (2016) for a discussion of competition in the UK retail banking market and the role of customer inertia in personal current accounts and SME banking.

that large institutions use CSP adoption partly to reorganise legacy infrastructure, reduce operating costs, and improve the value of their deposit franchises.

We also study the relationship between capital requirements and CSP spending. Higher capital requirements could reduce technology investment if they make funding more expensive or constrain resources available for investment. However, they could also increase investment incentives by underpinning charter value: if better-capitalised banks are more likely to remain in operation, they may place greater value on investments that generate future efficiency or service-quality gains. In the data, higher capital requirements are associated with higher CSP spending, especially among large banks and building societies. The reduced form results show that a 1 percentage point increase in capital requirements is associated with about a 4.2% increase in CSP spending, and the relationship is substantially stronger for large institutions. We interpret this result as consistent with a charter-value channel linking prudential regulation, process innovation, and long-term bank franchise value.

To quantify the competitive implications of CSP adoption, we estimate a structural model of competition in the UK deposit market. The model focuses on the national deposit market in which banks compete through deposit rates and service quality. CSP spending enters depositor utility as a demand shifter, capturing the fact that depositors may value the service improvements that CSP adoption facilitates, such as more reliable digital banking, better payment functionality, faster account management, and improved customer interfaces. We allow the demand-side value of CSP adoption to differ across large institutions, small and medium banks, and small and medium building societies.

The structural estimates show that depositors are attracted to higher deposit rates and that the demand-side value of CSP adoption is heterogeneous across institution types. The CSP coefficient for large institutions is small and statistically insignificant. By contrast, the estimated CSP effects for small and medium banks and for small and medium building societies are positive and statistically significant. This distinction reconciles the reduced-form and structural evidence. The reduced-form results indicate that large institutions use CSP adoption mainly on the internal operations margin, where it is associated with lower costs. The structural estimates capture the marginal value of CSP adoption to depositors, which is larger for smaller institutions if cloud outsourcing helps them close service-quality gaps relative to established incumbents.

We use the model to conduct two counterfactual exercises. First, we simulate a scenario in which banks had not expanded their reliance on external CSPs after 2015. This counterfactual is not intended as a realistic policy proposal, but as a way to measure how the observed expansion of CSP adoption affected competition in the deposit market. Freezing CSP spending at 2015 levels reallocates deposits towards large institutions within the modelled banking sector, raises inside-market concentration, and lowers depositor welfare. Average quarter-level depositor welfare falls by £1.13 billion, or 11.2%, while average inside-market HHI rises by 132 points. The losses are proportionally largest for small and medium banks and building societies, suggesting that CSP adoption helped smaller institutions become more attractive to depositors.

Second, we simulate a 1 percentage point reduction in capital requirements. This counterfactual operates through two channels. The direct funding-cost channel increases the recovered marginal benefit of deposit funding and raises depositor welfare. The indirect CSP-response channel works in the opposite direction: because higher capital requirements are associated with higher CSP spending in the reduced form, a decrease in capital requirements lowers predicted CSP adoption and weakens the demand-side benefits of technology investment. The net effect is positive, but smaller than the direct effect alone. The induced decline in CSP spending offsets about 32% of the direct welfare gain from lower capital requirements.

These results have implications for the interaction between prudential regulation, outsourcing, and competition. Capital regulation may affect competition not only through its immediate effect on funding costs, but also through banks' incentives to undertake long-term investments in digital infrastructure. Cloud outsourcing can therefore matter through two related margins: it can help smaller institutions improve digital service quality and gain market share, while also helping established institutions reorganise legacy infrastructure and preserve deposit-franchise value. These issues are likely to become more important as cloud platforms increasingly provide the infrastructure through which banks access advanced data analytics, machine-learning tools, and artificial-intelligence applications. More broadly, our findings suggest that cloud outsourcing has partly reduced technological barriers to competition in banking markets, while also making the competitive effects of regulation depend on how banks adjust their technology choices.

Related Literature

Our paper is directly related to the literature on Information Technology (IT) expenditure in the banking sector and technology adoption more broadly. First, using reported data on IT expenditure, Dadoukis *et al.* (2021) show that banks with higher levels of IT expenditure, based on public accounts, had fewer non-performing loans (NPLs) and more lending during the Covid crisis. Modi *et al.* (2022) develop a measure of IT expenditure based on regulatory filings by US banks and find that bank size and exposure to competition from non-bank fintech lenders are key determinants of IT investment.

A few papers rely on establishment-level survey data from the Aberdeen Technology Data Cloud. Pierri & Timmer (2022) use the number of computers per employee to show that banks with higher technology adoption had fewer NPLs during the Global Financial Crisis. Kwan *et al.* (2024) and Kutzbach & Pogach (2024) find that banks with better IT adoption –particularly in remote work and online communication– experienced higher SME lending and deposit inflows during the Covid crisis, with stronger effects for smaller banks.

He *et al.* (2022) distinguish between communication and software technologies, showing that investment in software is particularly relevant for processing soft information and is driven by SME loan demand. Branzoli *et al.* (2024) corroborate these findings using Italian regulatory filings and survey data, showing that digital adoption improves resilience and lending performance.

Our paper also contributes to recent structural work exploring how technological innovation reshapes competition in banking markets. Koont (2023) and Jiang *et al.* (2026) develop structural models that incorporate digital adoption and service quality into banks' demand and supply decisions. These papers extend earlier discrete choice frameworks –such as those in Dick (2008), Egan *et al.* (2017), Xiao (2020), and Wang *et al.* (2022)– by embedding technology variables into consumer utility and firm investment decisions. Notably, Koont (2023) models endogenous platform adoption and shows that digitalisation reduces market concentration and markups, while Jiang *et al.* (2026) find that perceived digital quality affects surplus distribution across demographic groups. These approaches motivate our own framework, which incorporates cloud outsourcing as a strategic input in banks' cost and demand structures.

In addition, our paper contributes to the literature on prudential regulation and process innovation. Following the Global Financial Crisis, tighter capital requirements and a shift in savers' preferences away from deposits have contributed to the rise of shadow banking and private credit provision (e.g., Buchak *et al.* (2018), Chernenko *et al.* (2022), Davydiuk *et al.* (2024), Avalos *et al.* (2025)). This has raised questions about how regulation affects banks' incentives to invest in operational efficiency. Theoretical work by Diamond & Rajan (2000), Furlong & Keeley (1989), and Rochet (1992) shows that capital requirements can reduce moral hazard and encourage better screening.

Process innovation - such as cloud outsourcing - can be understood as a fixed-cost investment that reduces marginal operating costs, especially when banks expect to scale output (e.g., Dasgupta & Stiglitz (1980), Spence (1986), Vives (2008)). In this context, higher capital buffers may incentivise banks to adopt technologies that improve efficiency and risk management. Empirical evidence from

Laeven *et al.* (2015) and Beck *et al.* (2016) supports this view, showing that financial innovation and stringent capital regulation can jointly improve bank profitability, even if loan growth is constrained. Our findings align with this literature by showing that banks with higher capital ratios invest more in CSPs, and that such investment is associated with higher deposit accumulation.

The relationship between ownership structure and bank efficiency has been extensively studied, yet the evidence remains inconclusive. A large empirical literature evaluates differences between shareholder-owned and mutual institutions using measures of cost and profit efficiency, typically estimated through frontier methods. However, these studies do not find robust evidence that investor-owned banks systematically outperform mutual institutions; in some contexts, efficiency differences are small or even favour mutual and public-sector banks (Altunbas *et al.* (2001)). More generally, the literature highlights that measured efficiency is highly sensitive to both the underlying concept (cost vs. profit efficiency) and the empirical approach, making it difficult to draw definitive conclusions from static performance metrics alone (Berger & Mester (1997)). At the same time, theoretical work emphasises that ownership affects managerial discipline through agency and governance channels: diffuse ownership in mutual institutions weakens monitoring incentives and limits the role of capital market discipline relative to shareholder-owned firms (Fama & Jensen (1983)). Consistent with this view, the expense preference literature shows that, in the presence of weak monitoring and limited competition, managers may deviate from profit-maximising behaviour by favouring non-productive inputs, with evidence from banking and savings institutions pointing to such distortions, particularly in mutual organisations (Hannan & Mavinga (1980); Gropper & Hudson (2003)).

This paper contributes to the literature by studying cloud outsourcing as a specific form of process innovation in banking. First, it complements work on bank technology adoption by using contract-level data on Cloud Service Provider relationships rather than broad measures of IT expenditure or digital capabilities, and by showing how CSP adoption is related to operating costs, deposit growth, and service quality. Second, it contributes to structural work on banking competition by incorporating CSP adoption into a model of deposit demand and rate competition, allowing us to quantify its effects on market shares, concentration, deposit-franchise value, and depositor welfare. Third, it contributes to the literature on prudential regulation and bank investment incentives by showing that capital requirements are associated with CSP spending and by documenting how this technology-investment channel can alter the competitive and welfare effects of regulatory changes.

Roadmap

The rest of the paper is structured as follows. Section 2 describes the data and presents the relevant stylised facts on banks' CSP adoption, service quality and deposit growth. Section 3 presents the reduced-form results on the relationships between CSP adoption and operating costs, the level of deposits and capital requirements. Section 4 presents the structural model of competition in the deposit market, which includes CSP as a demand characteristic. Sections 5 and 6 present, respectively, the structural estimation and the results from the simulated counterfactuals. Section 7 concludes.

2 Data and institutional background

The main dataset includes 3,443 outsourcing contracts from 90 banks with operations in the UK. We only observe agreements that were in place in 2024, so we do not observe contracts that might have been finalised or not renewed before that date. To identify spend on outsourcing to Cloud Service Providers (CSPs), we restrict attention to the 457 contracts which (i) are denoted as Cloud Service contracts and (ii) are made with an external provider (in particular we exclude intra-group contracts). These 457 contracts capture an annual spend of £1.57bn spread across 72 different banks.

We create a measure of annual CSP expenditure across time based on the start date of each of these contracts. Banks differ in the timing and intensity with which they outsource their operations to CSPs, and we exploit this variation in the analysis that follows. We split banks into three categories depending on their size and business model: (i) large banks and building societies (Large B&BS); (ii) small and medium banks (SM Banks); (iii) small and medium building societies (SM BS). Table 1 provides information on the average CSP spending by each of these three types of bank.

Table 1: Institution-type composition and average CSP exposure

Institution type	Banks	Bank-quarters	Mean Assets	Mean Deposits	Mean Total CSP
Large Banks and Building Societies	9	509	512.88	291.06	48.30
Small and Medium Banks	35	1,423	6.03	4.95	3.06
Small and Medium Building Societies	20	1,140	3.01	2.54	0.48

Note: Mean assets and mean deposits are measured in GBP billions. Mean Total CSP is measured in GBP millions. Total CSP refers to cumulative CSP spending. Bank-quarters counts all rows in the full panel.

We merge this measure into the Historical Banking Regulatory Database (HBRD), a regulatory balance sheet of domestic UK banks, for the period 2010Q1 to 2024Q1.[2] This allows us to link the use of CSP with other bank-level variables, such as deposits, average interest rates and operating expenses (OPEX). Table 2 provides some summary statistics for key variables based on the HBRD data.[3] More details of how this dataset was constructed can be found in Appendix A.

Table 2: Summary statistics for core bank-quarter variables

Variable	Unit	N	Mean	SD	P25	Median	P75
Total CSP	GBP millions	3,072	9.60	37.34	0.00	0.12	1.84
Total assets	GBP billions	3,072	88.89	265.56	0.46	1.38	13.42
Capital requirement	Percentage points	3,035	14.15	5.02	11.05	13.04	15.67
Non-interest expenses	GBP millions	3,072	902.08	2,957.29	6.44	23.97	166.08
Staff expenses	GBP millions	3,072	336.52	903.03	3.32	13.50	82.74
Deposits	GBP billions	3,072	51.46	142.18	0.38	1.17	10.51
Interest on deposits	Percentage points	3,072	1.54	0.90	0.84	1.42	2.12

Note: This table reports summary statistics for the full bank-quarter panel. Total CSP, non-interest expenses, and staff expenses are measured in GBP millions. Total assets and deposits are measured in GBP billions. Capital requirement and interest on deposits are measured in percentage points. Total CSP refers to cumulative CSP spending. N is row-specific and counts non-missing bank-quarter observations for each variable.

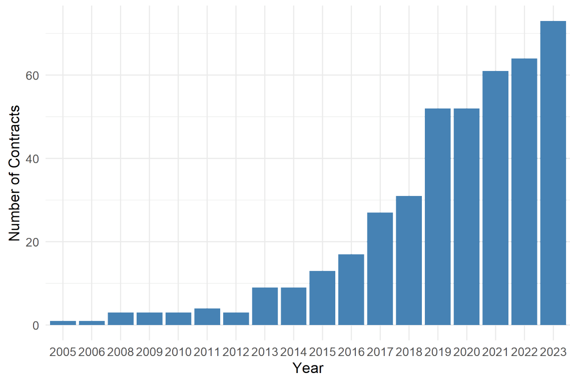
Figure 1 shows that CSP contracts have become steadily more prevalent over time, and are an increasingly important component of UK banks' business models.

For most CSP contracts we observe whether the purchasing bank requires developers to build the final product (i.e. an IaaS or PaaS contract type) or whether the product is directly supplied with a user-interface that end users can use immediately (i.e. a SaaS contract type). Table 3 provides a breakdown of the different contract types.[4]

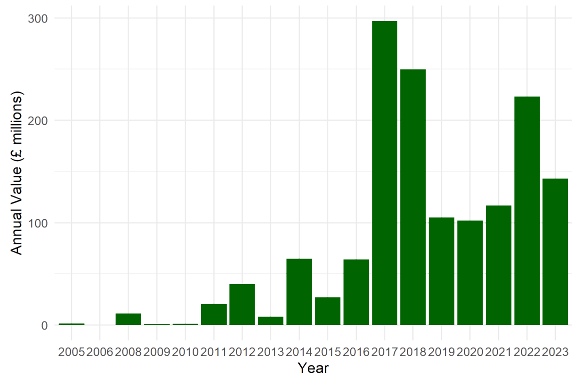
[2]For more detail about the Historical Banking Regulatory Database (HBRD) see De-Ramon *et al.* (2017), De-Ramon *et al.* (2018), and De-Ramon & Straughan (2020).

[3]After merging the outsourcing-contract data with the HBRD, restricting to domestic institutions with non-missing balance-sheet variables, and consolidating banking groups, the main bank-quarter panel contains 64 institutions.

[4]Note 438/457 contracts are uniquely defined as IaaS/PaaS or SaaS; 9 contracts have both components (since developers are required we classify as IaaS/PaaS); 10 contracts do not specify a component (since no evidence of a developer requirement, we classify as SaaS).



(a) Number of new CSP Contracts



(b) Total Value of new CSP Contracts

Figure 1: New CSP contracts and contract value over time

Note: This figure reports the annual number and total value of new external Cloud Service Provider contracts observed in the outsourcing-contract dataset (sample of contracts active in 2024). Contract timing is assigned using the contract start date. The sample is restricted to contracts denoted as Cloud Service contracts with external providers, excluding intra-group arrangements. Contract values are reported in GBP millions.

Table 3: CSP contracts by service model

Contract Type	Number of contracts	Total amount (£m)	Average contract size (£m)
SaaS	323	735.67	2.28
IaaS/PaaS	134	834.33	6.23

Note: This table reports the number, total value, and average size of external Cloud Service Provider contracts by contract type. The sample includes contracts that were active in 2024. SaaS refers to contracts in which the product is supplied with a user interface that can be used directly by end users. IaaS/PaaS refers to contracts requiring developers to build or deploy the final product.

Table 3 shows that the SaaS contract type is more common ($323/457 = 71\%$ of contracts), but that these contracts are typically smaller, with an average size of £2.3m (compared with £6.2m for IaaS/PaaS contracts). These factors ensure that total spend on each contract type is roughly the same, with £736m/£1570m spent on SaaS contracts and the remainder spent on IaaS/PaaS contracts.

For some CSP contracts we additionally observe the area of business that the outsourcing is targeting.[5] Figure 2 shows the different areas targeted and suggests that outsourcing parts of the payment function is the most popular choice for banks. There is also a significant amount of outsourcing in deposits and lending, particularly related to SaaS contracts. Overall, the areas targeted by IaaS/PaaS contracts are broadly similar to those targeted by SaaS contracts, suggesting that banks are taking a diverse range of approaches to tackling the same issues. [6] [7]

The left-hand panel of Figure 3 uses confidential regulatory data and displays the total amount of CSP spending as a proportion of total staff expenditure. It shows that SM banks have increased their CSP spending the most, while SM BS have increased their CSP spending the least. The right-hand panel of Figure 3 uses publicly available survey data: this panel displays how the average overall service quality of each type of bank has evolved over time.[8] It shows that SM banks have improved their

[5] We observe this additional information for 193/457 contracts, with value £899m/£1,570m

[6] Some contracts target more than one category. In this case, we split the total amount of the contract evenly between categories.

[7] The Other category comprises Insurance, Capital Markets and Wholesale. These three categories account for £65m/£899m (i.e. 7.2%) of the categorised contracts.

[8] Customers were asked *how likely they would be to recommend their personal current account provider to friends and*

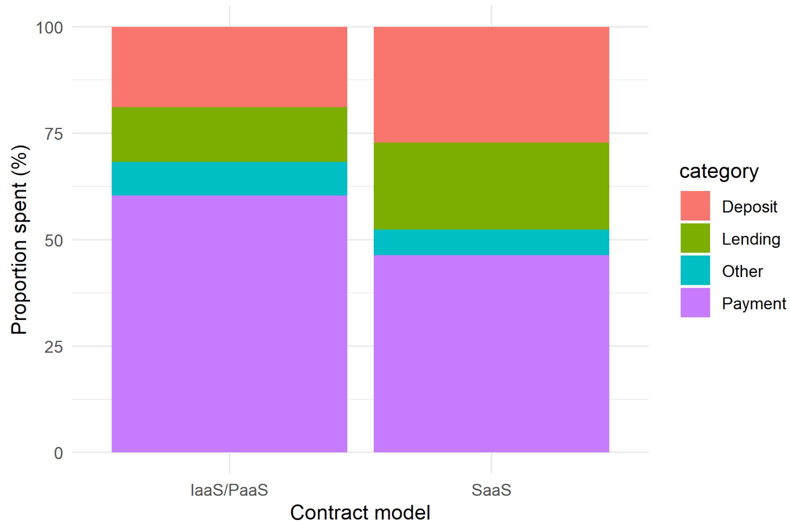


Figure 2: CSP contract spending by service model and business function

Note: This figure reports the distribution of contract spending across business areas for the subset of CSP contracts for which the targeted business area is observed. The categorised sample includes 193 of the 457 external CSP contracts. When a contract targets more than one business area, the contract amount is split evenly across the relevant categories. The "Other" category includes Insurance, Capital Markets, and Wholesale activities.

service quality the most, whereas the service quality of SM BS has deteriorated. Putting these findings together provides motivating evidence that increased CSP spending is associated with improved service quality.

Figure 4 provides evidence that SM banks were able to grow their business particularly quickly over the sample period. This pattern may reflect broader strategic changes among these institutions, coinciding with the period in which CSP investment became more intensive and with improvements in reported service quality. In the analysis that follows we study this relationship between CSP and deposits in more detail.

3 Reduced-form results

3.1 Capital requirements and CSP spending

In this section we investigate the relationship between capital requirements and spend on CSP outsourcing. It is not initially clear whether one should expect a positive or negative relationship between these variables. On the one hand there is a *cost channel*, whereby higher capital requirements force banks to hold more capital, decreasing the amount available for investment in outsourcing relationships. On the other hand there is the *charter-value channel* whereby higher capital requirements encourage banks to take a more long-term view and increase their investment in outsourcing relationships and other long-term projects. The regression results in Table 4 explore the impact of higher capital requirements on CSP spend.

The results in column (1) of Table 4 show that higher capital requirements are associated with more CSP spending, which is more consistent with the *charter-value channel* than with a pure *cost channel* over the period covered by the data. Interpreting the coefficient in column (1), a 1 percentage point

family. Overall service quality was then constructed from these answers (for details see Ipsos Personal Banking Service Quality survey).

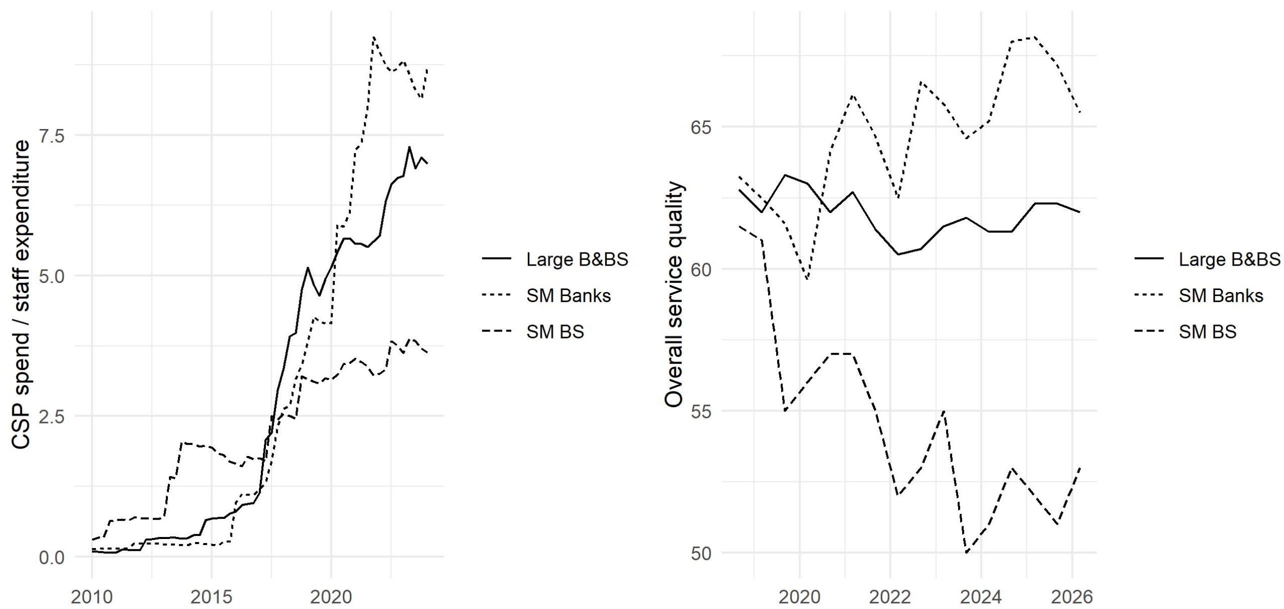


Figure 3: CSP intensity and customer service quality by institution type

Note: The left-hand panel uses administrative data and reports CSP spending as a proportion of staff expenditure by institution type. The right-hand panel uses publicly available Ipsos personal current account service-quality survey data and reports the average overall service-quality score by institution type. Institution types are defined as large banks and building societies, small and medium banks, and small and medium building societies. The service-quality measure is based on customers' reported likelihood of recommending their personal current account provider to friends and family.

increase in capital requirements is associated with about a 4.2% increase in CSP spending. Columns (2) to (4) show that this relationship is concentrated in large banks and building societies: the large-institution slope is positive and highly significant, whereas the slopes for small and medium banks and for small and medium building societies are small and statistically insignificant. The same conclusion holds once additional controls that capture banks' business models are added.

Appendix C shows that the positive relationship between capital requirements and technological investment is also present when we use reported software-related intangible assets as an alternative innovation measure.

3.2 CSP spending and operating expenses

By outsourcing some operations to CSPs, banks may reduce the amount they need to spend on in-house personnel and related infrastructure. It follows that banks that sharply increase their spend on CSPs might be expected to reduce their spend on salaries and other non-interest expenses. To test this hypothesis we use a regression to look for a relationship between these variables. We control for firm and time fixed effects, and regression results are reported in Table 5.

The first and third columns show that additional CSP spending is associated with lower non-interest expenses and lower staff expenses once size has been controlled for. A 10% increase in CSP spending is associated with about a 1.2% decrease in non-interest expenses and about a 1.0% decrease in staff expenses in the pooled specifications. The interacted specifications show that these cost effects are concentrated in large banks and building societies: the large-institution slopes are negative and statistically significant in both expense measures, while the slopes for small and medium banks and for small and medium building societies are close to zero and imprecisely estimated. These results provide

Table 4: Capital requirements and CSP spending

Dependent Variable:	Log CSP spend			
Model:	(1)	(2)	(3)	(4)
Variables				
Capital requirement	0.0416*			
	(0.0218)			
Log assets	0.0205	0.0934	0.1002	0.0694
	(0.0927)	(0.0825)	(0.0825)	(0.0853)
Capital requirement × Large B&BS		0.2879***	0.2888***	0.2813***
		(0.0668)	(0.0670)	(0.0669)
Capital requirement × SM Banks		0.0148	0.0149	0.0158
		(0.0121)	(0.0122)	(0.0110)
Capital requirement × SM BS		0.0155	0.0187	0.0188
		(0.0167)	(0.0167)	(0.0168)
Average risk weight			0.0032	0.0032
			(0.0045)	(0.0042)
Deposits/assets				0.7124*
				(0.4159)
Fixed-effects				
FRN	Yes	Yes	Yes	Yes
quarter_date	Yes	Yes	Yes	Yes
Fit statistics				
Observations	3,035	3,035	3,035	3,035
R^2	0.75758	0.81702	0.81726	0.81912
Within R^2	0.04168	0.27664	0.27760	0.28494

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 5: CSP spending and operating expenses

Dependent Variables:	Log non-interest expenses		Log staff expenses	
Model:	(1)	(2)	(3)	(4)
Variables				
Log CSP spend	-0.1173***		-0.1035***	
	(0.0288)		(0.0346)	
Log assets	0.6131***	0.5939***	0.6186***	0.5910***
	(0.0399)	(0.0419)	(0.0527)	(0.0571)
Log CSP spend × Large B&BS		-0.1490***		-0.1435***
		(0.0337)		(0.0308)
Log CSP spend × SM Banks		-0.0438		-0.0090
		(0.0480)		(0.0684)
Log CSP spend × SM BS		0.0284		-0.0212
		(0.0751)		(0.0751)
Fixed-effects				
FRN	Yes	Yes	Yes	Yes
quarter_date	Yes	Yes	Yes	Yes
Fit statistics				
Observations	3,042	3,042	3,068	3,068
R^2	0.98359	0.98392	0.98302	0.98347
Within R^2	0.53610	0.54529	0.54018	0.55233

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

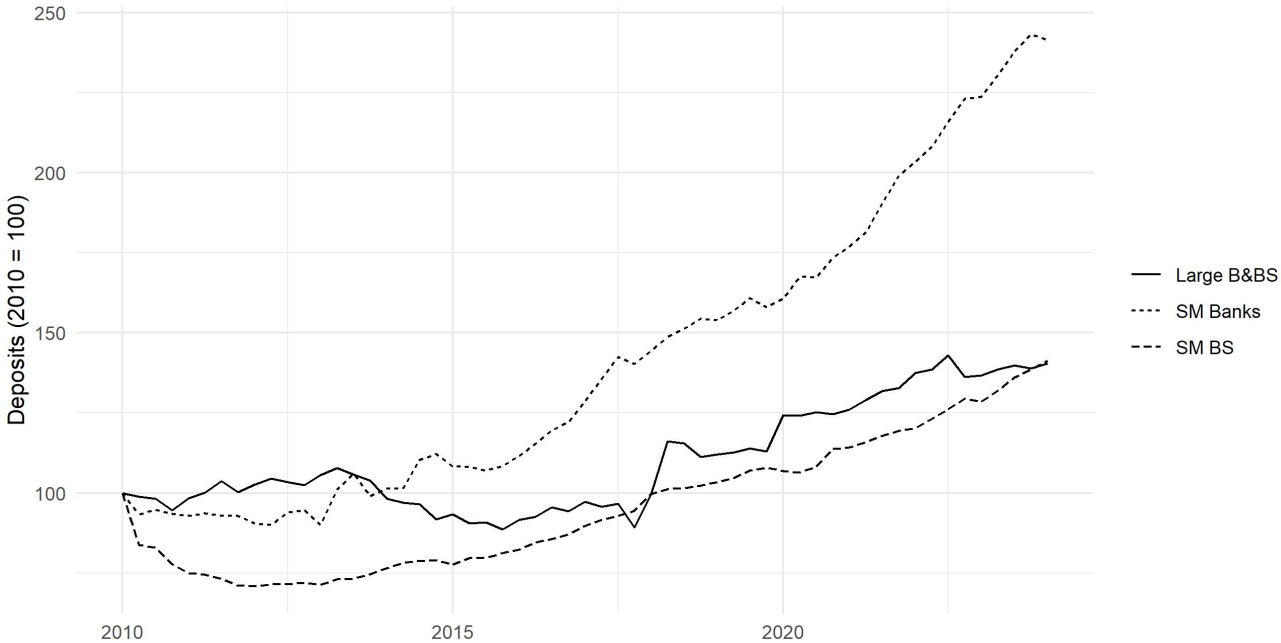


Figure 4: Deposit growth by institution type

Note: This figure reports the evolution of deposits by institution type using the regulatory bank-quarter panel. Deposits are aggregated within each institution type and indexed to 100 in 2010 to compare growth rates across groups with different initial deposit levels. Institution types are defined as large banks and building societies, small and medium banks, and small and medium building societies.

evidence that CSP spending is negatively correlated with ongoing operating costs, especially for the largest institutions.

3.3 CSP spending and deposit volumes

In addition to cost reduction, CSP spending may also be associated with a larger deposit base. In particular, CSP spending can help banks attract additional deposits by making payment services or depositor experience more streamlined. Table 6 presents the relationship between CSP spending on the one hand and volume of deposits on the other.

The first column shows that additional CSP spending has a positive association with deposits once size has been controlled for: a 10% increase in CSP spending is associated with about a 0.3% increase in the deposit base. The interacted specification shows that this reduced-form deposit relationship is concentrated in large institutions. The large-institution slope is positive and becomes weakly significant once the deposit rate is included, while the slopes for small and medium banks and for small and medium building societies are not statistically distinguishable from zero.

Finally, columns (3) and (4) consider how these results change when the interest rate on deposits is included as a control. The qualitative pattern is unchanged, which remains consistent with CSP spending improving depositor experience in reduced form, especially for large institutions.

3.4 A charter-value mechanism interpretation

The reduced-form evidence captures three empirical patterns. First, CSP spending is associated with lower operating expenses, with the effect concentrated among large institutions. This pattern is consistent with cloud outsourcing being used to replace or reorganise legacy IT systems and internal payment

Table 6: CSP spending and deposit volumes

Dependent Variable:	Log deposits			
Model:	(1)	(2)	(3)	(4)
Variables				
Log CSP spend	0.0272*		0.0310**	
	(0.0147)		(0.0147)	
Log assets	1.118***	1.116***	1.147***	1.148***
	(0.0622)	(0.0531)	(0.0720)	(0.0646)
Log CSP spend × Large B&BS		0.0280		0.0346*
		(0.0180)		(0.0196)
Log CSP spend × SM Banks		0.0226		0.0199
		(0.0400)		(0.0363)
Log CSP spend × SM BS		-0.0744		-0.0742
		(0.0637)		(0.0628)
Interest on deposits			-0.1589	-0.1600
			(0.1038)	(0.1035)
Fixed-effects				
FRN	Yes	Yes	Yes	Yes
quarter_date	Yes	Yes	Yes	Yes
Fit statistics				
Observations	3,072	3,072	3,072	3,072
R^2	0.96849	0.96853	0.96905	0.96909
Within R^2	0.61824	0.61874	0.62496	0.62553

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

infrastructure. Second, CSP spending is associated with higher deposit volumes, suggesting that process innovation may also improve the attractiveness of banks' deposit and payment services. Third, higher capital requirements are associated with higher CSP spending, especially among large banks and building societies. As a whole, these facts point to a broader charter-value mechanism linking prudential regulation, process innovation, operating efficiency, and the value of banks' deposit franchises.

Figure 5 illustrates this interpretation conceptually. CSP adoption may affect bank value through two broad margins. On the internal operations margin, outsourcing to CSPs can reduce ongoing operating costs by allowing banks to substitute away from legacy IT systems, internal data infrastructure, and some in-house technology functions. This channel is most visible in the reduced-form cost regressions, where the estimated effects are concentrated among large institutions. On the product-quality margin, CSP adoption may improve the services that depositors and borrowers interact with directly, including digital banking, payment functionality, account management, and loan-origination processes. These improvements can make a bank's products more attractive, expand its customer base, and raise the value of its franchise.

Capital requirements can reinforce these mechanisms through a charter-value channel. Higher capital requirements may reduce the probability that a bank exits or becomes financially constrained, increasing the value of future profits relative to short-run adjustment costs. When process innovation requires upfront organisational costs but generates future efficiency or service-quality gains, better-capitalised banks may therefore have stronger incentives to invest. This mechanism does not imply that capital requirements always increase technology investment, nor that all banks respond in the same way. Rather, it provides an interpretation for the positive association between capital requirements and CSP spending documented above. Appendix D formalises this intuition in a simple dynamic model and shows the conditions under which higher capital requirements can increase investment in innovation.

The evidence in this section therefore motivates the structural analysis that follows, focusing on the implications for competition. In the model, we study competition in the deposit market and quantify

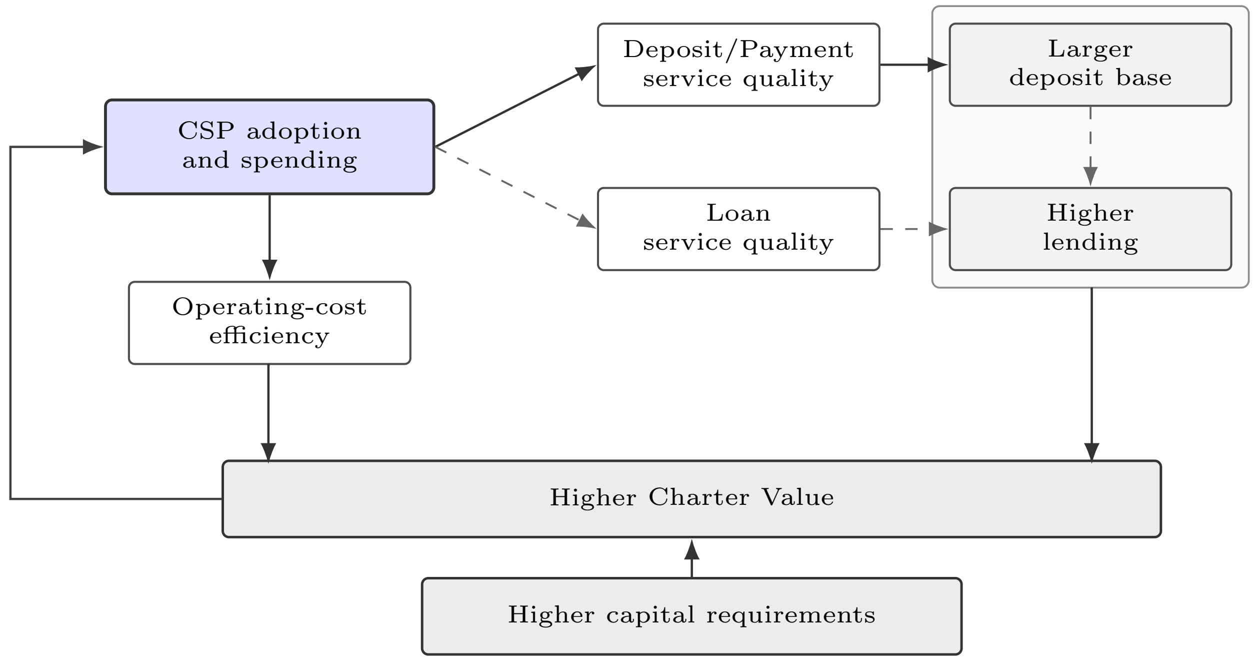


Figure 5: Conceptual mechanism linking capital requirements, CSP adoption, and charter value.

Note: Solid arrows denote the main mechanism linking CSP adoption, deposit services, operating efficiency, charter value, and capital requirements. Dashed arrows denote the secondary lending channel.

the demand-side role of CSP adoption: CSP spending shifts the perceived quality and attractiveness of deposit services. This distinction is important for interpreting the heterogeneity across institution types. The reduced-form evidence suggests that large institutions use CSP adoption mainly to reorganise legacy infrastructure and reduce operating costs. By contrast, the structural demand estimates in the next section capture the marginal value of CSP adoption to depositors, which can be larger for smaller institutions if cloud outsourcing helps them close service-quality gaps relative to established incumbents.

Using this framework, we quantify the effect of capital requirements on the value of deposit funding and the potential response of CSP spending separately.[9]

Finally, although the main structural analysis focuses on deposits, the broader mechanism may also operate through lending. Some CSP contracts target lending and credit processes, and improvements in deposit relationships may also affect lending relationships indirectly. Appendix B reports additional reduced-form evidence on lending volumes, loan rates, and credit-risk outcomes.

4 Structural model of bank competition

4.1 Framework description

The model is based on a discrete-choice framework for banking-service choice, where depositors (households and firms) observe bank characteristics and choose their main deposit institution. The theory allows us to link market shares to the aggregation of individual choice probabilities using a Logit model. Deposit institutions compete through deposit rates and service quality by adjusting their product char-

[9] We do not attempt to structurally model the full dynamic investment problem behind CSP adoption, nor do we embed internal cost synergies from legacy-IT replacement directly into the static operating profit of the deposit franchise. Instead, the reduced-form cost results document that such synergies are present, while the structural model quantifies how the deposit-demand channel affects market shares, concentration, deposit-franchise value, and depositor welfare.

acteristics. Other papers that use this methodology to estimate demand based on national market shares include Egan *et al.* (2017), Xiao (2020), and Wang *et al.* (2022).

4.2 Model setting

Time is discrete: $t = 1, ..., T$. In this model, a set of banks and building societies indexed by $b = 1, ..., B$ compete nationally to offer deposit services (D).[10] We treat each quarter as a separate market, where institution b offers a single deposit service. The market sizes M_t^D are given. Deposit quantities are given by:

$$q_{bt}^D = M_t^D s_{bt}^D, \tag{1}$$

where s_{bt}^D is the market share of bank b in time t, which satisfies $s_{bt}^D \in (0, 1)$. We define the market size M_t^D as all liquid savings in UK financial institutions, which includes cash, deposits, and money market instruments.[11] This definition includes the deposit market and captures substitution into liquid assets outside the modelled deposit sector. It treats deposits at modelled banks as the inside market and the remaining liquid assets as the outside option. The outside-option market share satisfies $s_{0t}^D = 1 - \sum_b s_{bt}^D$.

4.3 Depositors

Every bank $b \in B$ offers deposit products, which are bundles that capture the main subproducts in the deposit market (mainly sight deposits, time deposits, and CDs). Consumer j derives utility from choosing bank b at time t as:

$$u_{jbt}^D = \delta_{bt}^D + \varepsilon_{jbt}^D, \tag{2}$$

where:

$$\begin{aligned} \delta_{bt}^D =& \alpha^D r_{bt}^D + \beta_L^D \text{Tech}_{bt} \times \text{Large}_b + \\ & \beta_{SMB}^D \text{Tech}_{bt} \times \text{SM Bank}_b + \beta_{SMBS}^D \text{Tech}_{bt} \times \text{SM BS}_b + \\ & \psi_t^D + \phi_b^D + \xi_{bt}^D. \end{aligned} \tag{3}$$

In this equation, r_{bt}^D represents the average interest rate for deposits, which is obtained by dividing interest rate expenses by total deposits in the period. The bank-level innovation measure is represented by Tech_{bt}, our measure of cumulative CSP spending over time. The three group dummies partition institutions into large institutions, small and medium banks, and small and medium building societies, so the CSP terms allow the slope on technology to differ directly across the three groups. Additionally, we control for bank fixed effects and quarter fixed effects.

In the empirical implementation, Tech_{bt} is measured as $\log(1+CSPStock_{bt})$, where $CSPStock_{bt}$ denotes the cumulative stock of CSP contract value associated with institution b in quarter t. Thus, β_L^D, β_{SMB}^D, and β_{SMBS}^D denote the direct CSP slopes for large institutions, small and medium banks, and small and medium building societies, respectively.

The idiosyncratic error term ε_{jbt}^D is i.i.d. and follows a Type I Extreme Value distribution. This implies that market shares are linked to the aggregation of choices in a Logit model:

$$s_{bt}^D = \frac{\exp\left(\delta_{bt}^D\right)}{\exp\left(\delta_{0t}\right) + \sum_{i=1}^B \exp\left(\delta_{it}^D\right)}, \tag{4}$$

[10] For simplicity, in the model we refer to all financial institutions in the deposit market as banks, except where relevant.

[11] We use the series B2.5 currency, deposits, and money-market instruments from the Bank of England Bankstats to define the market of liquid savings (private and public sector).

The outside option δ_{0t} is normalized to 0. Therefore, we can write the outside-option share as:

$$s_{0t}^{D} = \frac{1}{1 + \sum_{i=1}^{B} \exp\left(\delta_{it}^{D}\right)}. \tag{5}$$

Taking logs and subtracting the last two equations, we obtain the following linear equation:

$$\ln\left(s_{bt}^{D}\right) - \ln\left(s_{0t}^{D}\right) = \delta_{bt}^{D}, \tag{6}$$

which can be estimated via Generalized Method of Moments (GMM). This equation is estimated using Instrumental Variables to address the endogeneity of interest rates, CSP technology investment, and unobserved bank characteristics included in the error term, as explained in more detail below.

4.4 Banks

4.4.1 Deposit Franchise Value

Banks offer deposit rates r^D in exchange for receiving deposit funds from the public. They use these funds to obtain revenue from their lending operations. The operating profits of bank b for the deposit franchise are defined as:

$$\Pi_{bt}^{\text{oper}}\left(r_{bt}^{D}\right) = \left(mb_{bt}^{D} - r_{bt}^{D}\right) q_{bt}^{D}, \tag{7}$$

where mb_{bt}^{D} is the marginal benefit of the bank from offering deposit services. This term captures the perceived value that one unit of deposits generates within bank operations (loans, liquidity services, cross-selling opportunities, relationship value, and the non-rate cost of servicing deposit accounts).[12] We allow the marginal benefit to have the following reduced form:

$$mb_{bt}^{D} = w_{bt}^{D}\gamma^{D} + \mu_{b}^{D} + \tau_{t}^{D} + \omega_{bt}^{D}, \tag{8}$$

where w_{bt}^{D} includes cost shifters such as effective capital requirements CR_{bt} and the log of Non-interest Expenses.

4.4.2 Static rate competition

In this stage, banks choose interest rates $\left(r_{bt}^{D}\right)$ to maximise Π_{bt}^{oper} (Nash equilibrium in prices). As a result, we obtain the following static equilibrium condition:

$$q_{bt}^{D} - \left(mb_{bt}^{D} - r_{bt}^{D}\right) \frac{\partial q_{bt}^{D}}{\partial r_{bt}^{D}} = 0. \tag{9}$$

Under the Logit, the derivative has a closed form solution. We obtain the following equation:

$$mb_{bt}^{D} = \underbrace{\frac{1}{\alpha^{D}(1 - s_{bt}^{D})}}_{\text{deposit markdown}} + r_{bt}^{D}. \tag{10}$$

Because the bank chooses a deposit rate paid to depositors rather than an output price charged to consumers, the relevant wedge is a deposit markdown, $(mb^{D} - r^{D})$, which differs from a conventional output-price markup.

[12] This term can also be interpreted as the *net marginal value of deposit funding*, since it can represent other non-rate cost variables related to deposit-franchise operations.

4.5 Model equilibrium

The financial regulator chooses the level of capital requirements CR_{bt} exogenously. For given values of CSP spending, non-interest expenses, and capital requirements, banks choose their deposit rates r^D_{bt}. Finally, depositors choose their optimal demand q^D_{bt} such that the deposit market clears.

5 Structural estimation

In this section, we estimate the model by taking it to the data. The estimated structural parameters will serve as primitives to be used in the model under different counterfactuals.

5.1 Parametrization

To capture the role of technological innovations in the model, we proxy the term Tech_{bt} with $\log(1 + CSPStock_{bt})$, our measure of cumulative CSP contract value in logs.

To characterise the deposit market equilibrium, we need the preference parameters α^D and β^D that explain how depositors value deposit services. Additionally, we need the set of supply parameters γ^D that govern how valuable it is for banks to obtain deposit funds. To find these parameters, we focus on the following equations:

$$\begin{aligned}\delta^D_{bt} =& \alpha^D r^D_{bt} + \beta^D_L \mathrm{Tech}_{bt} \times \mathrm{Large}_b + \\ & \beta^D_{SMB} \mathrm{Tech}_{bt} \times \mathrm{SM\ Bank}_b + \beta^D_{SMBS} \mathrm{Tech}_{bt} \times \mathrm{SM\ BS}_b + \\ & \psi^D_t + \phi^D_b + \xi^D_{bt},\end{aligned} \tag{11}$$

$$mb^D_{bt} = w^D_{bt}\gamma^D + \mu^D_b + \tau^D_t + \omega^D_{bt}, \tag{12}$$

where $\delta^D_{bt} = E\left[u^D_{jbt}\right]$ is the mean utility of bank b across all depositors, and ξ^D_{bt} is an unobservable demand shock that is common to all depositors of bank b.

The optimality conditions of depositors and banks are used to link the unobserved utilities and marginal benefit to observable variables, particularly market shares and interest rates. For the demand, under the logit model, we can express mean utilities as:

$$\ln\left(s^D_{bt}\right) - \ln\left(s^D_{0t}\right) = \delta^D_{bt}. \tag{13}$$

For the supply, we solve for unobservable marginal benefit by measuring the sum between interest rates and markdowns. We have to first obtain the markdowns by estimating the preference parameters α^D and β^D. Then we use:

$$mb^D_{bt} = \underbrace{\frac{1}{\alpha^D(1 - s^D_{bt})}}_{\text{deposit markdown}} + r^D_{bt}. \tag{14}$$

5.2 Identification

We estimate the model sequentially. First, we estimate demand for deposit services using an IV/GMM approach. Given the demand parameters, we then recover marginal benefits and estimate the supply-side coefficients.

The demand equation contains four potentially endogenous variables: the deposit rate, (r^D_{bt}), and the three group-specific CSP terms,

$$Tech_{bt} \times Large_b, \qquad Tech_{bt} \times SMBank_b, \qquad Tech_{bt} \times SMBS_b.$$

Deposit rates may be correlated with unobservable demand shocks, (ξ_{bt}^D), because banks with more attractive unobserved characteristics may choose different rates. CSP adoption may also be endogenous if banks with favourable unobserved demand shocks, stronger digital capabilities, or better growth prospects are more likely to expand their use of CSP outsourcing. Without instruments, OLS estimates of both the interest-rate sensitivity parameter and the demand-side CSP coefficients may therefore be biased.

We collect the excluded instruments in the vector (z_{bt}), which contains two blocks. The first block, (z_{bt}^r), contains balance-sheet cost shifters used to identify the deposit-rate coefficient. We follow the literature and rely on cost shock variables: total capital requirements, leverage ratio, provisions, and non-interest expenses.

We additionally address the endogeneity of CSP adoption using a novel supplier-network instrument constructed from CSP contract data. The concern is that banks with favourable unobserved demand shocks, stronger digital capabilities, or better growth prospects may also be more likely to expand CSP usage, biasing the estimated demand-side effect of technology. This instrument is the basis for the second block (z_{bt}^{Tech}) of excluded instruments.

For each bank-quarter, we construct a measure of the installed customer base of that bank's CSP providers among other banks. Specifically, for every provider used by bank b, we sum the value of that provider's contracts with all other banks, excluding bank b's own contracts. If bank b uses more than one provider, we aggregate these provider-level installed-base measures using contract-value weights. Banks without an active CSP provider are assigned a value of zero.

The economic intuition is that changes in a provider's installed base among other banks proxy for shifts in supplier scale, capabilities, and sector-specific relevance that can affect bank b's own CSP adoption, even when bank b's own demand conditions are unchanged. This makes the instrument analogous in spirit to a BLP-style excluded characteristic constructed from other relationships in the market.

The identifying assumption is that, conditional on bank fixed effects, quarter fixed effects, deposit rates, variation in the installed base of bank b's CSP providers among other banks affects bank b's deposit demand only through bank b's own CSP adoption. Under this restriction, the instrument shifts the attractiveness or feasibility of CSP adoption on the supply side of the technology relationship, rather than directly shifting depositor preferences towards bank b.

The main threat to this exclusion restriction is that banks using the same CSP providers may face correlated unobserved deposit-demand shocks, or that providers may expand among other banks precisely when bank b's own unobserved demand is improving. We mitigate this concern by exploiting within-bank variation over time, absorbing aggregate digital-adoption trends through quarter fixed effects, and constructing the instrument using other banks' relationships with the same providers rather than bank b's own CSP spending. The identifying variation should therefore be interpreted as supplier-side diffusion among providers to which the bank is exposed.

To further identify the three group-specific CSP slopes in β^D, we also interact the Cloud Provider customer base instrument with the same bank group dummies. This provides three instruments, each relevant for the corresponding bank group. These instruments form the second block (z_{bt}^{Tech}) of excluded instruments in (z_{bt}).[13]

5.3 GMM procedure

We specify the moment condition of the mean utility equation by exploiting the orthogonality condition between unobservable demand shocks ξ_{bt}^D and the cost shifters z_{bt}:

[13] Appendix E reports the instrument's distribution, first-stage diagnostics, first-stage coefficients, and the OLS versus IV demand comparison.

$$E\left[\xi_{bt}^{D} z_{bt}\right] = 0. \tag{15}$$

We define θ as the vector of demand parameters, $\theta = \left[\alpha^D, \beta^D\right]$, $Z = [z_{bt}]$ as matrix of instruments, and W as a consistent estimate of $E\left[Z'\xi\xi'Z\right]$. The GMM estimator for demand is:

$$\hat{\theta} = \arg\min_{\theta} \left[\xi(\theta)' Z W^{-1} Z' \xi(\theta)\right]. \tag{16}$$

Because the demand equation is linear in parameters, the demand step can be implemented as a linear IV/GMM estimator. We use a two-step GMM estimator with an identity weight matrix in the first step. We then proceed by backing out marginal benefits. Next, to identify the supply parameters, we use the moment condition given by the orthogonality between the supply shock ω_{bt}^{D} and the cost shifters, w_{bt}^{D}:

$$E\left[\omega_{bt}^{D} w_{bt}^{D}\right] = 0. \tag{17}$$

We estimate the supply parameters γ by an OLS regression of marginal benefits on the supply shifters.

5.4 Parameter estimates

Table 7 shows the estimated demand parameters for the deposits model. Results indicate that depositors are attracted to higher deposit rates. The CSP-stock effect is heterogeneous across institution types: the estimated slope for large institutions is small and statistically insignificant, while the slopes for small and medium banks and for small and medium building societies are positive and statistically significant.[14] The fact that the results indicate heterogeneous effects of CSP on demand validates our choice to allow the Tech_{bt} effect to vary by institution group.

Table 7: Structural Parameters Estimates - Demand Side

Demand Estimation		
		Dep. variable: δ^D
Deposit Rate	α^D	3.8119***
		(0.4018)
Large institutions × Tech	β_L^D	0.0742
		(0.0752)
Small and medium bank × Tech	β_{SMB}^D	0.8346***
		(0.1197)
Small and medium building society × Tech	β_{SMBS}^D	2.1595***
		(0.4944)
Fixed Effects		
Bank		Yes
Quarter		Yes
Observations		3,028
Pseudo R^2		0.0075

Note: Standard errors are reported in parentheses and are heteroskedasticity-robust.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table 8 shows the estimated supply-side coefficients using the recovered mb^D in levels. The specification includes capital requirements and log non-interest expenses as supply shifters. Both coefficients are

[14] Additional details on the instrument's distribution, first-stage strength, and the comparison between the OLS and IV demand estimates are reported in Appendix E.

negative and statistically significant, indicating that tighter capital requirements and higher operating expenses reduce the recovered marginal benefit from deposit funding.

Table 8: Structural supply-side estimates for deposit funding

Supply Estimation		
		Dep. variable: recovered mb^D
Capital Requirement	γ_1	-0.0135***
		(0.0019)
Log Non-interest Expenses	γ_2	-0.1766***
		(0.0319)
Fixed Effects		
Bank		Yes
Quarter		Yes
Observations		3,028
Within R^2		0.0350

Note: Standard errors are reported in parentheses and are heteroskedasticity-robust. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

5.5 Demand elasticities

We construct demand elasticities using the elasticity equations implied by the structural model.[15] The results are shown for deposit rates and CSP, reporting mean and distributional statistics for each bank group.

Table 9: Own-share demand elasticities by institution type

Panel A. Deposit-rate elasticity of demand				
Institution group	*Mean*	*P25*	*Median*	*P75*
Total institutions	5.86	3.20	5.42	8.02
Large banks and building societies	5.93	3.12	5.55	8.21
Medium and small banks	5.73	2.24	5.04	8.54
Medium and small building societies	5.98	3.80	5.64	7.62
Panel B. CSP elasticity of demand				
Institution group	*Mean*	*P25*	*Median*	*P75*
Total institutions	0.29	0.00	0.07	0.52
Large banks and building societies	0.04	0.00	0.06	0.07
Medium and small banks	0.28	0.00	0.07	0.59
Medium and small building societies	0.41	0.00	0.08	0.83

Note: Entries summarise observation-level own-share elasticities over the full structural estimation sample. Panel A reports elasticities with respect to the deposit interest rate, computed as $\alpha \times r^D_{bt} \times (1 - \text{share})$, where r^D_{bt} is the interest rate on deposits and is stored in percentage points. Panel B reports elasticities with respect to the underlying CSP stock when utility includes $\log(1 + \text{CSP stock})$, computed as $\beta_{\text{group}} \times (1 - \text{share}) \times \text{CSP}/(1 + \text{CSP})$. The group-specific CSP slope is the direct coefficient on the relevant type-specific CSP interaction from the IV demand specification. Total institutions pools all inside bank-quarter observations and excludes the outside option.

Table 9 shows that deposit demand is meaningfully sensitive to interest rates across all institution

[15] Appendix F derives the own-share elasticities reported in Table 9 and links them to the implied deposit-markdown formula.

groups: the mean own-share elasticity is 5.86 for the full sample, with similar magnitudes across large and smaller institutions. By contrast, CSP elasticities are much smaller on average, but they are highly heterogeneous. They are close to zero for large institutions, while they are materially larger for small and medium banks and especially for small and medium building societies, which is consistent with the demand estimates indicating that the valuation of CSP adoption is concentrated in the smaller-bank segments. Note that the zero values in the 25th percentile are obtained from the bank-quarter data points in which banks have not adopted CSP.

5.6 Interest rate decomposition

We can decompose the observed deposit interest rate using the structural model to obtain a deposit markdown and a marginal benefit term. Because the model implies high rate elasticity, the implied markdowns are relatively low.

Table 10: Deposit Rate Decomposition

Row	P10	P25	P50	P75	P90
Deposit Rate (r^D)	0.45	0.84	1.41	2.08	2.78
Deposit Markdown	0.26	0.26	0.26	0.26	0.27
Marginal Benefit (mb^D)	0.71	1.10	1.68	2.34	3.04

Note: Entries report percentiles of the baseline estimation sample in percentage-point units over 2010Q1-2023Q4. Recovered (mb^D) is computed as $r + 1/[\alpha \times (1 - \text{share})]$. Markdown is $(mb^D) - r = 1/[\alpha \times (1 - \text{share})]$. Multiply by 100 to express entries in basis points.

Table 10 shows that the demand coefficients imply a positive deposit markdown throughout the sample. The median deposit rate is 1.41 percentage points and the median recovered mb^D is 1.68 percentage points, leaving a median markdown of about 0.26 percentage points. The markdown distribution is also very tight relative to the distribution of rates and recovered marginal benefits, suggesting that most of the cross-bank variation comes from differences in demand conditions and recovered franchise value rather than from large differences in equilibrium markdowns.

5.7 Discussion of the role of Cloud Services

The structural specification implies that CSP adoption affects the deposit-market equilibrium primarily through the demand side. In the model, CSP spending shifts depositor utility by changing the perceived quality and attractiveness of an institution's deposit services. This interpretation is consistent with the idea that depositors do not directly value CSP contracts themselves, but rather the service improvements that CSP adoption may facilitate, such as more reliable digital banking, better payment functionality, faster account management, and improved customer interfaces.

The estimated demand effects are heterogeneous across institution types. The direct CSP slope for large banks and building societies is small and not statistically significant. By contrast, the direct slopes for small and medium banks and small and medium building societies are positive and statistically significant. This implies that the demand-side value of CSP adoption is concentrated among smaller institutions. In economic terms, CSP adoption appears to be more valuable when it allows smaller banks and building societies to close service-quality gaps relative to larger incumbents, rather than when it is adopted by institutions that already have large customer bases and established digital infrastructure.

These estimates should therefore be interpreted as demand-side marginal effects, not as the total effect of CSP adoption on bank performance. They are consistent with the reduced-form evidence once one distinguishes between the internal cost-saving margin, which is more visible among large institutions, and the depositor-quality margin, which appears more valuable for smaller institutions.

This distinction is important for the interpretation of the counterfactuals. The structural model does not require CSP adoption to reduce marginal costs directly in the deposit-franchise supply equation. Instead, the reduced-form evidence documents that CSP spending is associated with lower operating expenses, while the structural model uses CSP variation to estimate its effect on depositor demand. The counterfactual exercises therefore quantify the equilibrium implications of the demand-side channel, while allowing the direct value of deposit funding to depend on capital requirements and operating-cost shifters through the recovered marginal-benefit equation.

5.8 Discussion of the role of capital requirements

Capital requirements affect the model through two conceptually distinct channels. The first is the direct funding-cost channel. In the supply-side equation, higher capital requirements reduce the recovered marginal benefit of deposit funding. This means that, holding CSP adoption fixed, tighter capital requirements lower the net value that banks obtain from an additional unit of deposits. Conversely, a reduction in capital requirements increases the recovered marginal benefit of deposits and can expand the attractiveness of inside deposit products relative to the outside option.

The second channel is an indirect technology-investment channel. The reduced-form results show that higher capital requirements are associated with higher CSP spending, especially among large institutions. We interpret this relationship as consistent with a *charter-value* mechanism: institutions with higher capital buffers may have stronger incentives to make costly long-term investments because they expect to remain in operation and benefit from future efficiency and service-quality gains. In the structural counterfactuals, this relationship is introduced through a reduced-form policy function that maps changes in capital requirements into changes in CSP adoption.

The distinction between these two channels is central for interpreting the capital-requirement counterfactual. A decrease in capital requirements directly raises the marginal benefit of deposits, but it also lowers predicted CSP adoption through the estimated capital-requirement-to-CSP relationship. These forces work in opposite directions. The direct channel improves the deposit-franchise margin, while the indirect channel weakens the demand-side benefits associated with CSP adoption. The net effect therefore depends on the relative strength of the direct funding-cost effect and the indirect technology-response effect. Because the CSP response is not modelled as the solution to a fully dynamic investment problem, we interpret this second channel as a disciplined reduced-form exercise.

5.9 Welfare measurement

To evaluate depositor welfare in the counterfactual exercises, we use the simple-logit expected-utility formula implied by the estimated demand system. For quarter t, expected utility is

$$EU_t = \log\left(1 + \sum_b e^{\delta_{bt}^D}\right), \tag{18}$$

where the sum runs over the inside institutions. Using the IV demand estimate, quarter-level depositor welfare is then

$$W_t = \frac{EU_t}{\hat{\alpha}^D}. \tag{19}$$

For a comparison between a baseline and a counterfactual equilibrium, this is algebraically equivalent to

$$\Delta W_t = \frac{1}{\hat{\alpha}^D}\left[\log(s_{0t}^{\text{base}}) - \log(s_{0t}^{\text{cf}})\right], \tag{20}$$

where s_{0t}^{base} and s_{0t}^{cf} denote the outside-option shares in the baseline and counterfactual equilibria. This expression makes clear that depositor welfare rises when the counterfactual makes inside deposit products more attractive relative to the outside option, and falls when the outside-option share increases.

Because deposit rates are measured in percentage points in the estimation data, the welfare measure is also expressed in percentage-point units. To express the welfare change in GBP terms, we convert the percentage-point welfare measure into decimal units and multiply it by the relevant deposit-market stock in that quarter. These GBP magnitudes should therefore be interpreted as quarter-level stock-equivalent measures of depositor welfare.

6 Counterfactuals

In this section, we use the estimated results from the structural model described above to study two counterfactual scenarios. First, we consider a counterfactual in which the regulator restricts cloud outsourcing in 2015, just before the sharp growth in CSP spending occurred. Second, we consider a counterfactual in which the regulator decreases capital requirements and explore the implications for deposit-market competition, deposit franchise profit, and depositor welfare.

6.1 Limiting CSP spending to 2015 levels

In the first counterfactual, we study how the deposit-market equilibrium would have evolved if banks had not expanded their reliance on external Cloud Service Providers after 2015. Operationally, we hold each institution's CSP stock fixed at its 2015Q1 level from 2015Q1 onward and recompute the equilibrium using the estimated deposit-demand and supply-side objects. This exercise should be interpreted as a partial-equilibrium counterfactual that removes the observed post-2015 expansion in CSP adoption. It does not allow banks to substitute towards other forms of digital investment, such as in-house IT, fintech partnerships, or alternative outsourcing arrangements. For this reason, the estimates should be read as the effect of constraining the observed CSP channel in isolation.

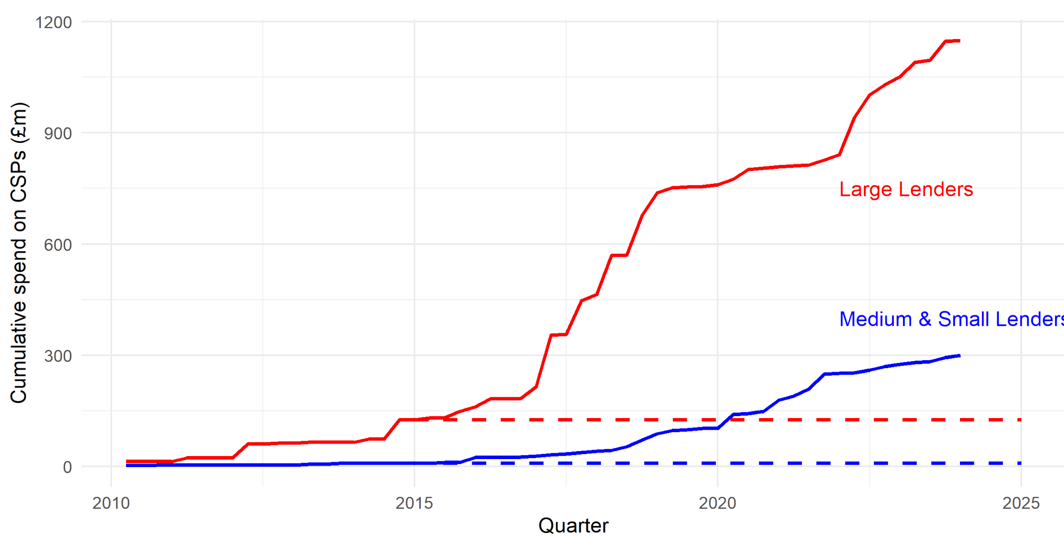


Figure 6: Observed and frozen CSP spending paths under Counterfactual 1

Note: This figure shows the quarterly measure of cumulative spending on Cloud Service Providers, which is a proxy based on the start date of current contracts as of 2024Q1. Dashed lines show the level of spending that each group of banks had in 2015Q1. *Large Lenders* include large banks and building societies. *Medium & Small Lenders* include medium and small banks and building societies that have a CSP contract as of 2024Q1.

Figure 6 illustrates the treatment embedded in the counterfactual. The no-new-CSP path closely tracks observed CSP spending before 2015 and begins to diverge only once cloud adoption accelerates. This timing is useful for interpretation because the counterfactual does not impose an arbitrary gap at the beginning of the sample. Instead, the difference between the observed and counterfactual equilibria grows as CSP spending becomes economically relevant in the data.

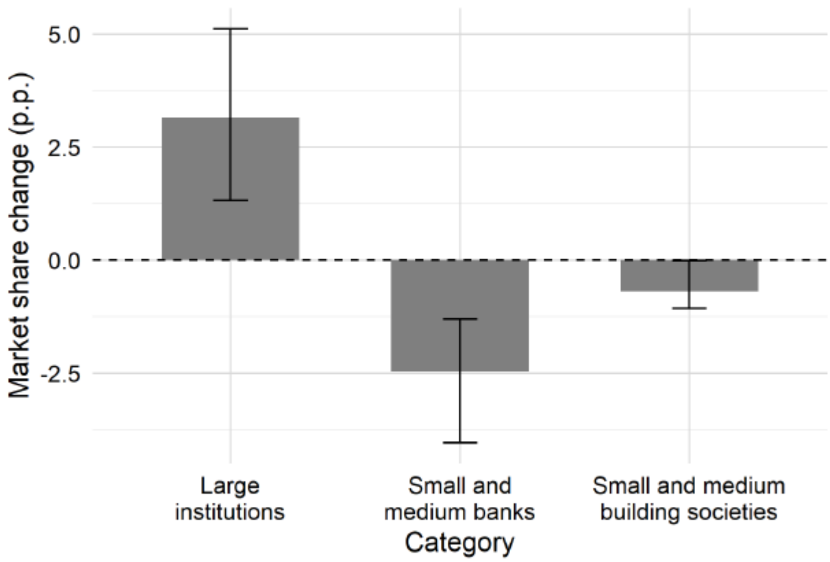
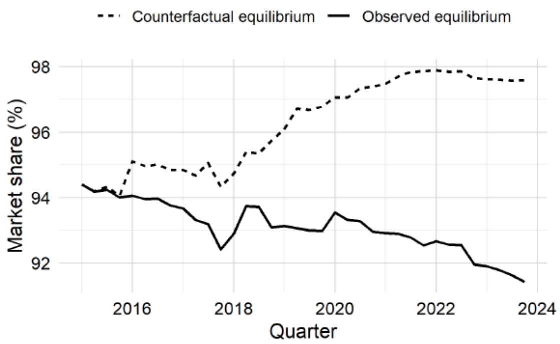


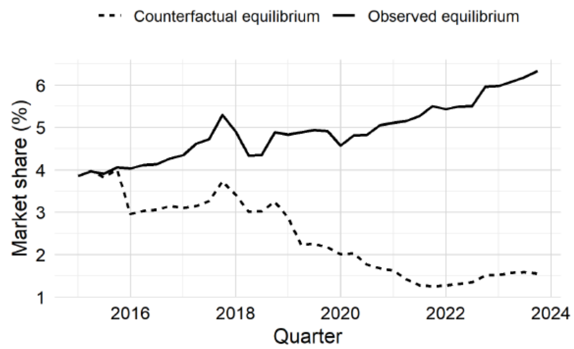
Figure 7: Counterfactual 1: Average inside-market share changes from freezing CSP spending after 2015

Note: This bar plot illustrates the average quarterly change in market share across different categories between the observed equilibrium and the counterfactual with no additional spending on external Cloud Service Providers after 2015. Market shares are recalculated within inside goods only, excluding the outside option. Error bars show the interquartile range of quarter-level changes.

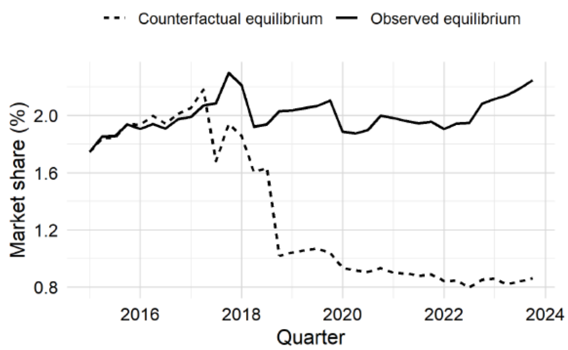
The average inside-market share effects in Figure 7 show that freezing CSP adoption reallocates deposits towards large institutions within the modelled banking sector. Large institutions gain 3.1 percentage points of inside-market share on average, while small and medium banks lose about 2.5 percentage points and small and medium building societies lose about 0.7 percentage points. This pattern is consistent with the estimated demand system: CSP adoption is valued more strongly for smaller institutions, so restricting post-2015 CSP growth removes an important source of differentiation for them.



(a) Large institutions



(b) Small and medium banks



(c) Small and medium building societies

Figure 8: Counterfactual 1: Observed and counterfactual inside-market shares by institution type

Note: Each panel aggregates market shares across the institutions in the stated group. Market shares are recalculated within inside goods only, excluding the outside option. The two lines compare the observed equilibrium with the no-new-CSP counterfactual over 2015Q1-2023Q4.

Figure 8 shows that these market-share effects are not transitory. The gap between the observed and counterfactual paths widens over time, especially for small and medium banks. This is consistent with the gradual accumulation of CSP investment: as CSP stocks rise in the observed equilibrium, smaller institutions become increasingly attractive relative to the no-new-CSP scenario. Although large institutions gain share within the inside banking market in the counterfactual, this does not imply that they gain deposits in absolute terms. Some demand also moves from inside deposit products to the outside option when CSP investment is constrained.[16]

[16] Appendix G shows how the counterfactuals reallocate demand between the inside banking market and the outside option. In Counterfactual 1, the deposit market shrinks relative to the outside option because additional CSP investment does not occur.

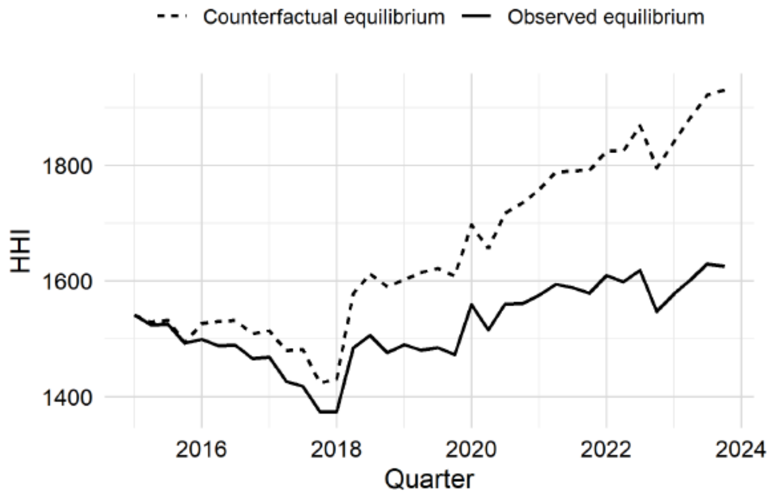


Figure 9: Counterfactual 1: Deposit-market concentration among inside institutions

Note: The figure plots quarter-level HHI values computed across inside institutions only, excluding the outside option, over 2015Q1-2023Q4.

The concentration evidence in Figure 9 points in the same direction. The HHI among inside institutions is persistently higher in the no-new-CSP counterfactual than in the observed equilibrium. Thus, post-2015 CSP adoption appears to have reduced concentration within the modelled deposit market by improving the relative competitive position of smaller institutions.

Table 11: Counterfactual 1: Deposit-franchise profit decomposition

Bank type	**Deposit franchise profit change, %**		
	Due to deposit volume (i)	**Due to markdown (ii)**	**Total profit change (i) + (ii)**
Large banks and building societies	-4.79	-0.22	-5.02
Small and medium banks	-50.33	-0.01	-50.34
Small and medium building societies	-37.89	-0.01	-37.90

Note: Entries are average quarterly percentage changes relative to the baseline over 2015Q1–2023Q4. The volume and markdown columns decompose the percentage change in model-implied deposit franchise profit, defined as deposits multiplied by the deposit markdown. The deposit markdown is given by $(mb^D) - \text{rate}$. Column (i) captures the contribution of changes in deposit volume, column (ii) captures the contribution of changes in the model-implied markdown, and the final column reports the total percentage change in deposit franchise profit.

The deposit-franchise profit decomposition in Table 11 reinforces this interpretation. Deposit franchise profit falls by 50.3% for small and medium banks and by 37.9% for small and medium building societies, compared with a 5.0% decline for large institutions. The decomposition shows that these changes are almost entirely driven by deposit volumes rather than by changes in model-implied markdowns. In other words, the main effect of CSP adoption in this counterfactual operates through market scale and depositor demand, not through large changes in pricing power per unit of deposits.

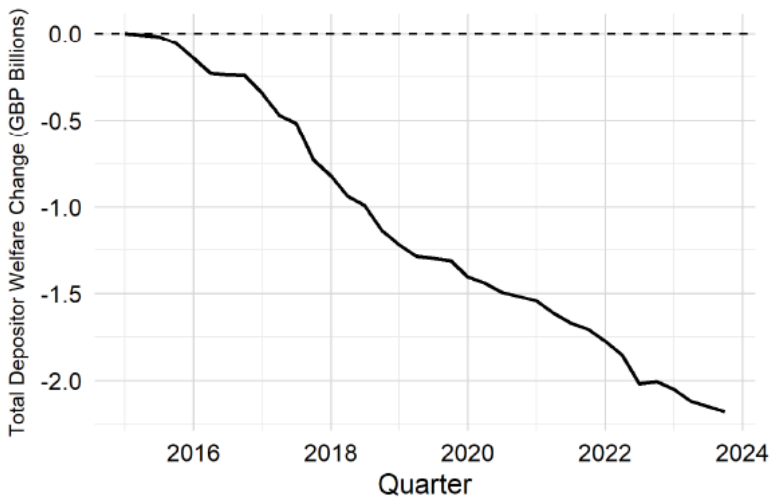


Figure 10: Counterfactual 1: Aggregate depositor-welfare change relative to baseline

Note: The line shows quarter-level changes in aggregate depositor welfare relative to the baseline over 2015Q1-2023Q4. Values are reported in GBP billions per quarter.

Table 12: Counterfactual 1: Depositor welfare by institution type

Institution type	Baseline	Counterfactual	Individual % change	Contr. %
Large institutions	9.31	8.59	-7.76	-7.19
Small and medium banks	0.53	0.22	-58.80	-3.08
Small and medium building societies	0.21	0.12	-44.55	-0.94
Total banking sector	10.05	8.92	-11.21	-11.21

Note: Entries report average quarter-level depositor welfare over 2015Q1-2023Q4. The Baseline and Counterfactual columns are reported in GBP billions per quarter. Because logit welfare is not naturally additive across bank groups, baseline and counterfactual welfare levels are allocated using the Shapley value across large institutions, small-and-medium banks, and small-and-medium building societies in each quarter. Individual % change equals 100 × (counterfactual - baseline) / |baseline group welfare|. Contr. % equals 100 × (counterfactual - baseline) / |baseline total banking-sector welfare|, so the group contributions add up to the total banking-sector percent change in the last row.

Figure 10 shows that the depositor-welfare loss is broad-based over time. The welfare gap is close to zero at the beginning of the counterfactual period and becomes more negative as the observed CSP path moves further away from the frozen 2015 level. Table 12 shows that average quarter-level depositor welfare falls from £10.05 billion in the baseline to £8.92 billion in the counterfactual, a decline of 11.2%. The proportional losses are largest for small and medium banks and building societies, although large institutions account for most of the aggregate welfare contribution because they represent a larger share of baseline depositor welfare. Because the welfare measure is constructed from quarterly deposit stocks, we interpret these magnitudes as average quarter-level stock-equivalent effects.

Table 13: Counterfactual 1: Baseline and no-new-CSP equilibrium comparison

Metric	Baseline	Counterfactual	Counterfactual change	Percent change
Median deposit rate (pct. points)	1.15	1.15	0.00	0.05
Median markdown (pct. points)	0.26	0.26	0.00	-0.01
Average depositor welfare (GBP billions)	10.05	8.92	-1.13	-11.21
Average deposit franchise profit (GBP billions)	8.19	7.49	-0.70	-8.51
Average HHI (inside institutions)	1522.84	1654.94	132.10	8.67

Note: The comparison uses 2015Q1-2023Q4. Deposit rates and margins are medians across bank-quarter observations. Average depositor welfare and average deposit franchise profit are reported in GBP billions per quarter. HHI is the average quarter-level HHI across inside institutions only, excluding the outside option. Counterfactual change equals counterfactual minus baseline and retains its sign. Percent change equals 100 × (counterfactual - baseline) / |baseline|.

Table 13 summarises the main aggregate effects. The no-new-CSP counterfactual lowers average quarter-level depositor welfare by £1.13 billion and average deposit-franchise profit by £0.70 billion. At the same time, the average inside-market HHI rises by 132 points, while median deposit rates and model-implied markdowns remain essentially unchanged. Overall, the counterfactual indicates that post-2015 CSP adoption made inside deposit products more attractive, reduced concentration, and increased depositor welfare. The main channel is not a large change in deposit rates, but rather an improvement in the relative demand and scale of institutions that benefited most from CSP adoption.

6.2 Effective capital requirements decrease by 1 p.p.

The second counterfactual studies how a decrease in capital requirements affects the deposit-market equilibrium. We simulate a 1 percentage-point decrease in effective capital requirements for all deposit market inside institutions. The policy operates through two channels. The first is a direct funding-cost channel: lower capital requirements increase the recovered marginal benefit of deposit funding, which changes equilibrium deposit rates, deposit volumes, and deposit-franchise profits. The second is an indirect CSP-response channel: because the reduced-form evidence indicates that higher capital requirements are associated with higher CSP spending, a decrease in capital requirements is mapped into a lower predicted CSP stock. This second channel is a reduced-form policy-function exercise that illustrates how the equilibrium effects of capital regulation can be altered when technology investment responds to regulation. We interpret this second channel as a proxy for the *Charter Value* channel.[17]

[17] To capture this channel, we use the reduced-form semi-elasticity estimates in Table 4, column 2, to map the 1 percentage point capital-requirement shock into a predicted percentage change in CSP spending.

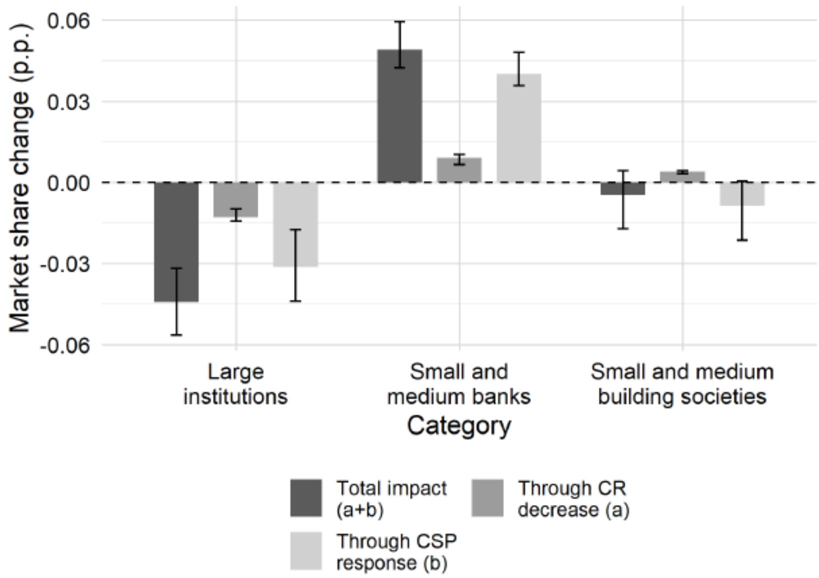


Figure 11: Counterfactual 2: Market-share changes by direct and CSP-response channels

Note: Bars report average market-share changes across quarters over 2010Q1-2023Q4. Market shares are recalculated within inside goods only, excluding the outside option. The three bars for each institution category correspond to the total impact, the direct capital-requirement channel, and the CSP-response channel.

Figure 11 decomposes the market-share effects into the direct capital-requirement channel, the indirect CSP-response channel, and the total effect. The direct channel increases the inside-market share of small and medium banks and building societies, consistent with the idea that lower capital requirements improve the economics of deposit funding. The CSP-response channel partly offsets this effect because lower capital requirements reduce predicted CSP investment, weakening the demand-side benefits associated with technology adoption. The total effect is therefore modest. Large institutions experience a small loss of inside-market share, while small and medium banks gain the most. This decomposition shows that the competitive effects of a capital-requirement change cannot be inferred from the direct funding-cost channel alone.

Table 14: Deposit-franchise profit decomposition after a 1 p.p. capital-requirement decrease

Bank type	**Deposit franchise profit change, %**		
	Due to deposit volume (i)	**Due to markdown (ii)**	**Total profit change (i) + (ii)**
Panel A. Total impact: CR decrease and CSP response			
Large banks and building societies	1.87	0.10	1.97
Small and medium banks	3.10	0.00	3.10
Small and medium building societies	1.70	0.00	1.70
Panel B. Direct impact through the CR decrease			
Large banks and building societies	2.80	0.15	2.95
Small and medium banks	3.03	0.00	3.04
Small and medium building societies	3.04	0.00	3.04
Panel C. Indirect impact through the CSP response			
Large banks and building societies	-0.91	-0.05	-0.95
Small and medium banks	0.07	0.00	0.07
Small and medium building societies	-1.30	0.00	-1.30

Note: Entries are average quarterly percentage changes relative to the baseline over 2010Q1–2023Q4. The table decomposes the percentage change in model-implied deposit franchise profit, defined as deposits multiplied by the deposit markdown. The deposit markdown is given by $mb^D - \text{rate}$. Column (i) captures the contribution of changes in deposit volume, column (ii) captures the contribution of changes in the model-implied markdown, and the final column reports the total percentage change in deposit franchise profit. Panel A reports the total impact of a 1 percentage point decrease in capital requirements, combining the direct capital-requirement channel and the indirect CSP-response channel. Panel B isolates the direct impact through the capital-requirement decrease. Panel C isolates the indirect impact through the induced CSP response.

Table 14 shows how these market-share effects translate into deposit-franchise profits. Under the total effect, deposit-franchise profits rise by 3.1% for small and medium banks, 2.0% for large institutions, and 1.7% for small and medium building societies. The direct capital-requirement channel is positive for all institution types, raising profits by about 3% in each group. The induced CSP response, however, erodes part of these gains, especially for large institutions and small and medium building societies. As in Counterfactual 1, the decomposition shows that the profit effects are driven almost entirely by deposit volumes rather than by changes in the model-implied markdown. This suggests that the main economic adjustment operates through changes in depositor demand and market scale, not through large changes in pricing power per unit of deposits.

Table 15: Counterfactual 2: Depositor-welfare decomposition by channel

Scenario	Quarters	Mean	P25	Median	P75	Min	Max
Total impact (a+b)	56	0.0038	0.0034	0.0036	0.0044	0.0031	0.0048
Impact through CR decrease (a)	56	0.0057	0.0054	0.0058	0.0059	0.0048	0.0062
Impact through CSP response (b)	56	-0.0018	-0.0024	-0.0019	-0.0015	-0.0025	-0.0007

Note: Rows separate the total impact, the direct CR channel, and the CSP-response channel over 2010Q1-2023Q4. Each row reports the distribution of quarter-level depositor welfare changes under the IV demand specification. Because the interest rate on deposits is stored in percentage points in the estimation data, the welfare entries are also in percentage-point units: multiply by 100 for basis points.

The welfare decomposition in Table 15 shows that the net effect remains positive, but materially smaller than the direct effect alone. The direct capital-requirement channel raises welfare by 0.0057 percentage points, or 0.57 basis points, whereas the induced decline in CSP spending subtracts 0.0018 percentage points, or 0.18 basis points. The endogenous technology response therefore offsets about 32% of the direct welfare gain. Thus, even in a counterfactual where lower capital requirements improve the deposit-funding margin, part of the gain is undone when lower capital requirements weaken incentives to invest in CSP adoption.

Table 16: Counterfactual 2: Baseline and total-impact equilibrium comparison

Metric	Baseline	Counterfactual	Counterfactual change	Percent change
Median deposit rate (pct. points)	1.41	1.42	0.01	0.96
Median markdown (pct. points)	0.26	0.26	0.00	0.00
Average depositor welfare (GBP billions)	9.51	9.76	0.24	2.53
Average deposit franchise profit (GBP billions)	7.77	7.93	0.16	2.01
Average HHI (inside institutions)	1553.17	1548.49	-4.67	-0.30

Note: The comparison uses the total-impact Counterfactual 2 equilibrium over 2010Q1-2023Q4. Deposit rates and margins are medians across bank-quarter observations. Average depositor welfare and average deposit franchise profit are reported in GBP billions per quarter. HHI is the average quarter-level HHI across inside institutions only, excluding the outside option. Counterfactual change equals counterfactual minus baseline and retains its sign. Percent change equals 100 × (counterfactual - baseline) / |baseline|.

Table 16 summarises the aggregate total-impact equilibrium. A 1 percentage point decrease in capital requirements raises average quarter-level depositor welfare from £9.51 billion to £9.76 billion, an increase of £0.24 billion, or 2.53%. Average deposit-franchise profit rises from £7.77 billion to £7.93 billion, an increase of £0.16 billion, or 2.01%. The effects on concentration and pricing are small: the average inside-market HHI falls by 4.7 points, the median deposit rate rises by 0.01 percentage points, and the median markdown is essentially unchanged.

The counterfactual highlights an important interaction between prudential regulation and technology adoption. Lower capital requirements directly increase the value of deposit funding and raise depositor welfare, but they may also reduce predicted CSP investment, which partially offsets the direct gains. The results suggest that the welfare and competition effects of capital regulation depend not only on its immediate effect on funding costs, but also on its effect on banks' incentives to invest in digital infrastructure. This indirect channel is quantitatively smaller than the direct channel in this exercise, but it is large enough to matter for the evaluation of regulatory changes.

7 Conclusion

This paper studies how cloud outsourcing affects competition in the UK banking sector. Using proprietary contract-level data on banks' outsourcing relationships with Cloud Service Providers, we document that CSP spending is associated with lower operating costs and a larger deposit base. We also show that banks facing higher capital requirements have higher CSP spending, especially among larger institutions. Taken together, these results suggest that cloud outsourcing is not only a cost-saving technology, but also a form of process innovation that can affect banks' long-term franchise value and their ability to compete for deposits.

To quantify these channels, we estimate a structural model of competition in the UK deposit market. The model separates the role of deposit rates from the role of CSP adoption as a demand shifter and allows the valuation of CSP adoption to differ across institution types. The estimates indicate that the demand-side benefits of CSP adoption are substantially larger for small and medium banks and building societies than for large institutions. The counterfactual exercise restricting new CSP adoption after 2015 shows that cloud outsourcing reduced concentration, increased the relative attractiveness of smaller institutions, and raised depositor welfare. In this sense, CSP adoption appears to have lowered technological barriers to competition.

The results also highlight an important interaction between prudential regulation and technological investment. Lower capital requirements directly increase the value of deposit funding and raise depositor welfare, but they also reduce incentives to invest in CSP adoption, offsetting part of the direct welfare gain. This implies that the competitive effects of regulation cannot be evaluated only through its immediate funding-cost channel: regulation also shapes banks' incentives to undertake long-term investments in digital infrastructure. More broadly, the findings suggest that capital requirements can have consequences for market structure not only through funding costs, but also by influencing the pace and distribution of technological adoption in banking.

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Appendix A: Data construction and variable definitions

The Historical Banking Regulatory Database (HBRD) of the UK is a rich dataset developed by the Bank of England, encompassing financial statements and confidential regulatory data for all authorised UK banks and building societies from 1989 to the present. It offers granular insights at both the consolidated (group) and standalone (bank) levels, enabling a detailed analysis of the UK banking sector, including smaller institutions that are often excluded from aggregate statistics. To prepare this dataset for econometric analysis, we undertake the following steps:

Time Period and Bank Type. Our analysis focuses on the period from Q1 2010 to Q1 2024, which captures the post-Great Financial Crisis environment and the increasing adoption of Cloud Service Providers (CSPs) by banks. We restrict the sample to non-foreign banks operating in the UK, as the financial reporting of foreign institutions may be influenced by their overseas operations, potentially distorting domestic balance sheet data.

Consolidation of Bank Groups. In the UK, several major banking groups are composed of multiple individual institutions, often as a result of mergers or ring-fencing regulations. To accurately capture the market shares of these larger entities, we consolidate their constituent banks into unified economic groups. We aggregate balance sheet variables using simple summation for monetary values (in £) and weighted averages for financial ratios, with Total Assets serving as the weighting factor.

Interest Rates on Deposits. We estimate implicit deposit interest rates at the bank-quarter level by dividing Total Deposit Expenses by Total Deposits for each institution.

The Cloud Service Provider dataset provides information on the network of relationships between Banks and CSPs. The graph below illustrates one aspect of this network, and shows that there are 6 banks that contract with at least 10 different CSPs.

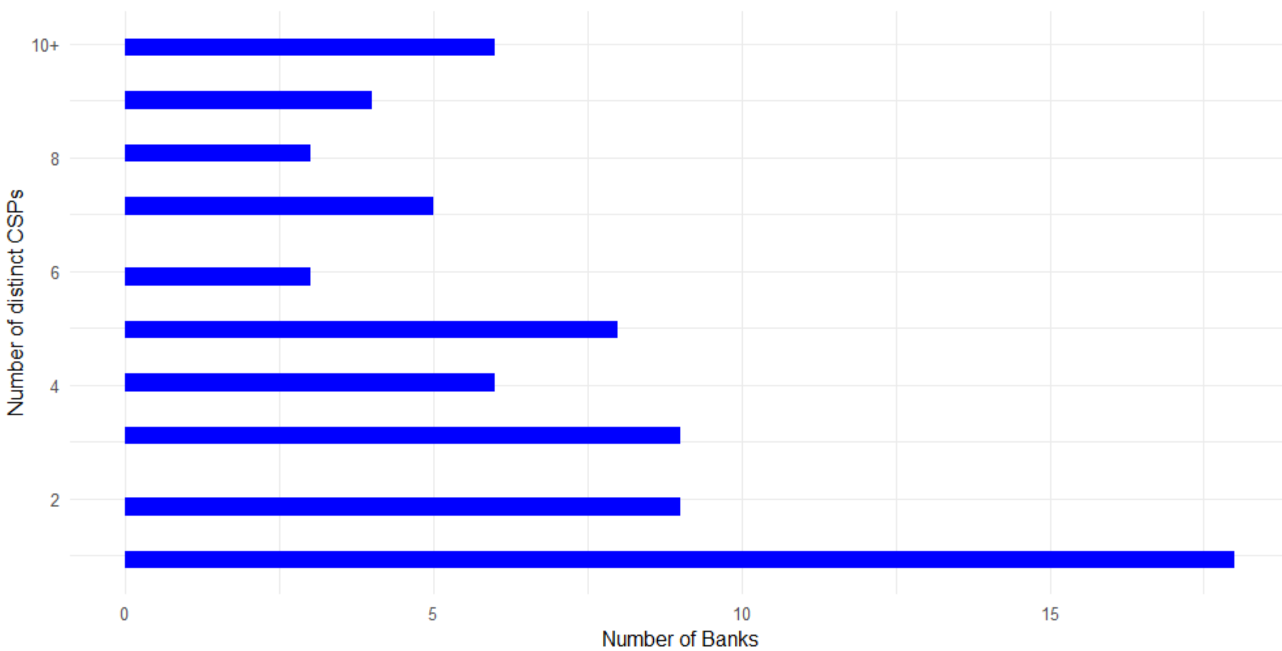

Figure 12: Number of distinct CSP relationships per institution

Appendix B: Additional reduced-form evidence and mechanisms

In this appendix we explore whether CSP spending is associated with (i) lending volumes, (ii) loan rates, and (iii) credit-risk outcomes.

Loan volumes

While some CSP spending aims at improving payment experience or depositor experience, other CSP spending aims at improving the lending experience. In addition, customers are more willing to take out loans with the bank where they have their primary deposit account, and so increased deposit volume driven by CSP spending indirectly spurs additional lending. For these reasons we might expect a positive association between CSP spending and lending volumes. Table 17 presents regression results related to mortgage lending:

Table 17: CSP spending and mortgage lending volumes

Dependent Variable:	Log mortgages		
Model:	(1)	(2)	(3)
Variables			
Log CSP spend	0.2109*		
	(0.1087)		
Log assets	1.539***	1.576***	1.646***
	(0.2380)	(0.2752)	(0.3193)
Log CSP spend × Large B&BS		0.3371***	0.3418***
		(0.1186)	(0.1219)
Log CSP spend × SM Banks		-0.1431	-0.1130
		(0.3606)	(0.3587)
Log CSP spend × SM BS		-2.050	-2.034
		(1.483)	(1.482)
NPL/loans			0.0034*
			(0.0020)
Impairments/assets			0.0558
			(0.0345)
Capital surplus			-3.95×10^{-5}*
			(2.17×10^{-5})
Liquid assets ratio			0.0105
			(0.0132)
Fixed-effects			
FRN	Yes	Yes	Yes
quarter_date	Yes	Yes	Yes
Fit statistics			
Observations	3,072	3,072	3,051
R^2	0.80711	0.81820	0.81593
Within R^2	0.19193	0.23838	0.24143

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The first column shows a positive association between CSP spending and mortgage volumes, significant at the 10% level. In the interacted specifications, this positive association is concentrated in Large B&BS, while the estimates for small and medium banks are close to zero and the estimates for small and medium building societies are negative and imprecise. The third column shows that adding business-model controls leaves this pattern broadly unchanged. The mortgage results are suggestive of a positive link between CSP spending and mortgage lending for large institutions, but they are not broad-based across all groups. Table 18 presents regression results related to SME lending:

The first column shows a positive but statistically insignificant association between CSP spending and SME lending volumes. Once interactions are introduced, the estimates for Large B&BS and small and

Table 18: CSP spending and SME lending volumes

Dependent Variable:	Log SME loans		
Model:	(1)	(2)	(3)
Variables			
Log CSP spend	0.2248		
	(0.1552)		
Log assets	1.304***	1.220***	1.109***
	(0.1525)	(0.1427)	(0.1533)
Log CSP spend × Large B&BS		0.1799	0.1716
		(0.1683)	(0.1664)
Log CSP spend × SM Banks		0.2720	0.2914
		(0.2868)	(0.2847)
Log CSP spend × SM BS		-1.797*	-1.849*
		(1.031)	(1.030)
NPL/loans			-0.0031
			(0.0022)
Impairments/assets			0.0848
			(0.0631)
Capital surplus			6.02×10^{-5}**
			(2.95×10^{-5})
Liquid assets ratio			-0.0220*
			(0.0110)
Fixed-effects			
FRN	Yes	Yes	Yes
quarter_date	Yes	Yes	Yes
Fit statistics			
Observations	3,072	3,072	3,051
R^2	0.88776	0.89765	0.89876
Within R^2	0.27202	0.33613	0.35527

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

medium banks are positive but imprecise, while the coefficient for small and medium building societies is negative and weakly significant. The third column is similar after adding business-model controls. The SME results are mixed and do not provide strong broad-based evidence that CSP spending raises SME lending.

Loan rates

Above we have considered the possibility that CSP spending enables banks to attract borrowers and grow lending volumes. We now consider another possibility, whereby CSP allows banks to increase lending rates while still retaining the same lending volumes. To investigate this, Table 19 presents regression results related to loan interest rates:

Table 19: CSP spending and loan interest rates

Dependent Variable:	Loan interest rate			
Model:	(1)	(2)	(3)	(4)
Variables				
Log CSP spend	0.1297			
	(0.1160)			
Log assets	-0.2625	-0.1985	-0.2014	-0.1250
	(0.2569)	(0.2614)	(0.2614)	(0.2494)
Log CSP spend × Large B&BS		0.2139**	0.2114**	0.2122**
		(0.0947)	(0.0941)	(0.0951)
Log CSP spend × SM Banks		-0.0627	-0.0660	-0.0582
		(0.2415)	(0.2409)	(0.2397)
Log CSP spend × SM BS		0.1862	0.1783	0.1824
		(0.2580)	(0.2549)	(0.2552)
SME share			0.0168***	0.0153***
			(0.0038)	(0.0047)
NPL/loans				0.0054
				(0.0056)
Impairments/assets				0.0186
				(0.0575)
Capital surplus				6.75×10^{-5}***
				(2.04×10^{-5})
Liquid assets ratio				0.0093
				(0.0161)
Fixed-effects				
FRN	Yes	Yes	Yes	Yes
quarter_date	Yes	Yes	Yes	Yes
Fit statistics				
Observations	3,072	3,072	3,072	3,051
R^2	0.84570	0.84670	0.84694	0.84820
Within R^2	0.01650	0.02289	0.02439	0.03156

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The first column shows a positive but imprecisely estimated association between CSP spending and loan interest rates. In the interacted specifications, the positive association is concentrated in Large B&BS, where the coefficient is statistically significant, while the estimates for small and medium banks and for small and medium building societies are not statistically significant. The evidence points to at most a limited link between CSP spending and loan rates, concentrated in large institutions.

Credit risk

Finally we consider the impact of CSP spending on credit risk. Part of CSP spending is associated with improving screening, and so we may expect that increased CSP spending may be accompanied by reduced credit risk. To investigate this, Table 20 presents results related to credit risk across three different metrics:

Table 20: CSP spending and credit-risk outcomes

Dependent Variables:	NPL/loans		NPL/assets		Impairments/assets	
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Log CSP spend	-0.3700		-0.3636		-0.0957	
	(0.5989)		(0.3955)		(0.0849)	
Log assets	-4.916**	-4.997**	-1.640*	-1.474	-0.1888**	-0.0904
	(2.225)	(2.348)	(0.9411)	(0.9392)	(0.0906)	(0.0830)
Log CSP spend × Large B&BS		-0.5727		-0.2027		0.0306
		(0.5179)		(0.3186)		(0.0431)
Log CSP spend × SM Banks		0.1743		-0.6836		-0.3820
		(1.209)		(0.7362)		(0.3369)
Log CSP spend × SM BS		2.395		1.463		0.0835
		(2.438)		(1.788)		(0.1337)
Fixed-effects						
FRN	Yes	Yes	Yes	Yes	Yes	Yes
quarter_date	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	3,072	3,072	3,072	3,072	3,072	3,072
R^2	0.13633	0.13726	0.11346	0.11446	0.61189	0.62005
Within R^2	0.02628	0.02732	0.00680	0.00792	0.01138	0.03217

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The pooled specifications display negative but statistically insignificant coefficients for all three credit-risk measures. Once interactions are introduced, none of the CSP coefficients are precisely estimated across the three outcomes. These regressions do not provide robust evidence that CSP spending is systematically associated with lower credit risk in this sample.

Appendix C: Capital requirements and technological innovation

We complement the analysis in the main body of the paper on how prudential standards affect process innovation by focusing on software expenditure which banks choose to capitalise and report as an asset on their balance sheet as part of intangible assets. In particular, we use reported levels of Other Intangible Assets (OIA, excluding Goodwill) for banks reporting in jurisdictions where accounting standards require them to treat software assets as intangible assets. This is the case under both the International Financial Reporting Standards (IFRS) and the national Generally Accepted Accounting Principles (GAAP) standards applied across the EU, UK, Canada, Australia and Japan. Using confidential administrative data for UK banks to match corresponding reported numbers, we can verify that OIA closely track capitalised software assets. There were 26 UK banks (and building societies) that reported a non-zero value for software assets in Q1 2024. In 20/26 cases software assets represented above 80% of other intangible assets.

We focus on UK banks by relying on confidential administrative data to use actual capital requirements (ie, Pillar 1 + Pillar 2A). Our sample includes quarterly observations in which OIA are reported from 2018 to 2023. In Table 21, we find a positive and significant coefficient between total capital requirements and Other Intangible Assets. In particular, a 1 percentage point increase in capital requirements is associated with approximately an 8% increase in Other Intangible Assets. The negative coefficient on the Building Society indicator captures the fact that Building Societies lag behind Banks and hold a lower level of software assets. This suggests that our findings related to CSP spending also hold for broader measures of technological innovation.

Table 21: Capital requirements, building-society status, and other intangible assets

Dependent Variable:		log(OIA)	
Model:	(1)	(2)	(3)
Variables			
BSoc_ind	-1.231***	-0.9770***	-1.133***
	(0.0385)	(0.0633)	(0.0853)
log(total_assets)	0.8171***	0.9157***	0.9294***
	(0.0149)	(0.0194)	(0.0154)
total_capital_requirement		0.0815***	0.0816***
		(0.0115)	(0.0119)
loans/assets			0.9671***
			(0.3301)
Fixed-effects			
quarter	Yes	Yes	Yes
Fit statistics			
Observations	1,910	1,693	1,686
R^2	0.45226	0.48402	0.48795
Within R^2	0.45099	0.48304	0.48699

Clustered (quarter) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The positive coefficient associated with total capital requirements further reinforces our findings regarding the importance of the *Charter Value* channel. This provides additional evidence that effective capital requirements can support rather than hinder investment in process innovation.

Appendix D: A simple model of capital requirements and innovation

In this appendix we introduce a simple theoretical model which illustrates how higher capital requirements can increase investment in innovation.

When capital requirements are low the bank chooses a capital ratio $K \in \{K_L, K_H\}$, whereas when capital requirements are high the bank must choose a capital ratio $K_H > K_L$. If the bank chooses a low capital ratio it is less resilient and remains solvent until the next period with probability p_L; if the bank chooses a high capital ratio it is more resilient and remains solvent until the next period with probability p_H.

After choosing its level of capital, the bank then chooses its level of investment in innovation $I \in \{I_L, I_H\}$. A higher level of investment incurs a cost in the first period, but increases bank profitability Π in every period. In particular when $I = I_L$, then $\Pi = \Pi_L$; when $I = I_H$, then $\Pi = \Pi_H > \Pi_L$. Define (i) $\Delta K = K_H - K_L$, (ii) $\Delta I = I_H - I_L$ and (iii) $\Delta\Pi = \Pi_H - \Pi_L$. Banks maximise their future expected profits V where:

$$V = \underbrace{\Pi - K - I}_{\text{1st period profits}} + \underbrace{\frac{p}{1-p}(\Pi - K)}_{\text{Future profits}} \tag{21}$$

We now introduce an assumption on the capital levels:

Assumption 1

$$\Delta K > \left[\frac{(1-p_L)p_H - (1-p_H)p_L}{1-p_H}\right]\left[\Pi_H - K_H\right] + p_L\Delta\Pi + (1-p_L)\left[\Delta\Pi - \Delta I\right] \tag{22}$$

Assumption 1 requires that the difference between the low capital ratio and the high capital ratio is sufficiently high. It ensures that banks always prefer to choose a low capital ratio (K_L) rather than a higher capital ratio ($K_H = K_L + \Delta K$). Next we introduce an assumption on the cost and benefits of additional investment:

Assumption 2

$$\underbrace{\frac{1-p_L}{p_L}}_{\textit{Charter value channel}} > \underbrace{\frac{\Delta\Pi}{\Delta I - \Delta\Pi}}_{\textit{Return on investment}} > \underbrace{\frac{1-p_H}{p_H}}_{\textit{Charter value channel}} \tag{23}$$

Assumption 2 assumes that the return on investment in period 1 is in an intermediate range. On the one hand if the cost of investing is above the upper bound, then it is always optimal not to invest regardless of the level of capital requirements. On the other hand if the cost of investing is below the lower bound, then it is always optimal to invest regardless of the level of capital requirements. In particular the charter value channel (i.e. additional future profits) dominates the cost channel (i.e. additional cost in period 1) exactly when capital requirements are high. This discussion motivates the following result:

Proposition D.1 *Suppose Assumption 1 and Assumption 2 hold. Then an increase in capital requirements from K_L to K_H increases the level of investment in innovation from I_L to I_H.*

Proof 1 *Assumption 1 guarantees that:*

$$\Delta K > \left[\frac{(1-p_L)p_H - (1-p_H)p_L}{1-p_H}\right]\left[\Pi_H - K_H\right] + p_L\Delta\Pi + (1-p_L)\left[\Delta\Pi - \Delta I\right] \tag{24}$$

Re-arranging gives:

$$(\Pi_L - K_L - I_L) + \frac{p_L}{1-p_L}\Bigg[\Pi_L - K_L\Bigg] > (\Pi_H - K_H - I_H) + \frac{p_H}{1-p_H}\Bigg[\Pi_H - K_H\Bigg] \tag{25}$$

It follows that:

$$V_{K=K_L;I=I_L} > V_{K=K_H;I=I_H} \tag{26}$$

This ensures that when capital requirements are low, banks prefer to choose ($K = K_L$; $I = I_L$) rather than ($K = K_H$; $I = I_H$).

To complete the proof we must show that (i) when capital requirements are low banks prefer to choose $I = I_L$ and (ii) when capital requirements are high banks prefer to choose $I = I_H$. Assumption 2 guarantees that:

$$\frac{1}{1-p_L}\Delta\Pi < \Delta_I < \frac{1}{1-p_H}\Delta\Pi \tag{27}$$

Re-arranging the left-hand side gives:

$$(\Pi_H - I_H - K_L) + \frac{p_L}{1-p_L}(\Pi_H - K_L) < (\Pi_L - I_L - K_L) + \frac{p_L}{1-p_L}(\Pi_L - K_L) \tag{28}$$

Hence:

$$V_{K=K_L;I=I_H} < V_{K=K_L;I=I_L} \tag{29}$$

This shows (i). Re-arranging the right-hand side gives:

$$(\Pi_L - I_L - K_H) + \frac{p_H}{1-p_H}(\Pi_L - K_H) < (\Pi_H - I_H - K_H) + \frac{p_H}{1-p_H}(\Pi_H - K_H) \tag{30}$$

Hence:

$$V_{K=K_H;I=I_L} < V_{K=K_H;I=I_H} \tag{31}$$

This shows (ii) and completes the proof.

Finally we supply a corollary:

Corollary D.2 *Suppose either Assumption 1 or Assumption 2 does not hold. Then an increase in capital requirements from K_L to K_H does not change the level of investment in innovation.*

Corollary D.2 shows that when the change in capital ratio is sufficiently small or the level of investment is outside the intermediate range then changes to capital ratios do not affect the level of investment in innovation. The proof follows similar lines to the proof above and so is omitted. Figure 13 considers example parameter values and shows under what scenarios investment is made:

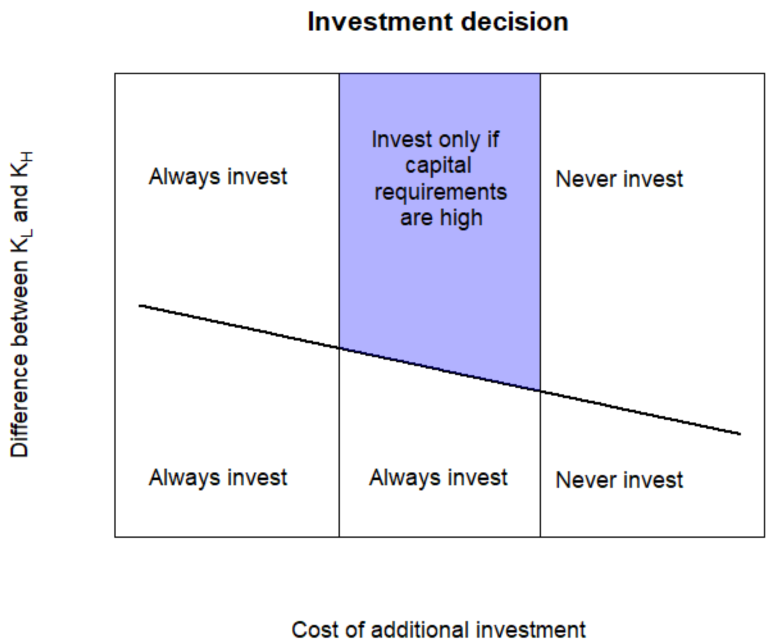

Figure 13: Innovation investment under low and high capital requirements

Appendix E: Structural identification and IV diagnostics

Tables 22–24 report the excluded-instrument variation and first-stage evidence for the deposit-demand IV specification. Table 22 shows that the three type-specific CSP supplier-network instruments are concentrated at zero in the lower tail but have meaningful upper-tail variation, while the balance-sheet instruments also display meaningful dispersion across bank-quarter observations. This mix of variation is useful because the identification strategy relies on both cost shifters for deposit rates and supplier-network exposure for CSP adoption.

Table 22: Summary statistics for instruments used in the deposit-demand GMM specification.

Variable	Unit	N	Mean	SD	P25	Median	P75
Large institutions x CSP supplier-network instrument	Log GBP millions	3,028	0.3200	1.1200	0.0000	0.0000	0.0000
Small and medium bank x CSP supplier-network instrument	Log GBP millions	3,028	0.7300	1.7200	0.0000	0.0000	0.0000
Small and medium building society x CSP supplier-network instrument	Log GBP millions	3,028	0.1400	0.6400	0.0000	0.0000	0.0000
Capital requirement	Percentage points	3,028	14.1400	5.0100	11.0500	13.0500	15.6700
Provisions	GBP millions	3,028	0.5400	1.8300	0.0300	0.1300	0.3800
Leverage ratio	Ratio	3,028	7.6400	6.3900	4.8400	6.1400	8.2400
Log non-interest expenses	Log GBP millions	3,028	1.0200	0.5400	0.6800	0.8700	1.2400

Note: This table reports summary statistics over the structural estimation sample. The supplier-network instrument enters the specification only through the three type-specific interactions reported here. N is row-specific and counts non-missing bank-quarter observations for each variable.

Table 23: IV first-stage diagnostics.

Row	Endogenous variable	First-stage F	p-value	df
IV model	Deposit rate	19.97	< 0.001	7, 2,901
IV model	Large institutions x CSP stock	824.98	< 0.001	7, 2,901
IV model	Small and medium bank x CSP stock	469.49	< 0.001	7, 2,901
IV model	Small and medium building society x CSP stock	144.25	< 0.001	7, 2,901

Note: The first-stage F-statistics come from `fixest ivf` diagnostics on two-stage least squares models used as a reference for the IV demand specification. Standard errors are heteroskedasticity-robust.

Table 23 indicates that the excluded instruments are relevant for all four endogenous regressors. The first-stage F-statistic is 19.97 for deposit rates and much larger for the three CSP-related regressors, ranging from 144.25 to 824.98, which suggests that identification is strongest on the technology margins but remains comfortably above conventional weak-instrument thresholds for the rate equation as well.

Table 24: Reference first-stage coefficients.

Row	Rate	Large x CSP	Md&SBank x CSP	Md&SBSoc x CSP
Capital requirement	-0.0159***	0.0111***	0.0110***	0.0053***
	(0.0021)	(0.0022)	(0.0029)	(0.0011)
Provisions	0.0120	0.0076*	-0.0211***	0.0046**
	(0.0075)	(0.0044)	(0.0071)	(0.0022)
Leverage ratio	0.0031	0.0011	-0.0033	-0.0010*
	(0.0025)	(0.0013)	(0.0022)	(0.0005)
Log non-int. expenses	-0.2196***	-0.0346	0.0240	-0.0084
	(0.0508)	(0.0217)	(0.0431)	(0.0072)
Large institutions x log other-bank value	0.0197	0.6695***	-0.0432***	-0.0385***
	(0.0123)	(0.0197)	(0.0038)	(0.0026)
Small and medium bank x log other-bank value	-0.0094	-0.0165***	0.2972***	-0.0300***
	(0.0084)	(0.0028)	(0.0106)	(0.0019)
Small and medium building society x log other-bank value	-0.0586***	-0.0168***	-0.0492***	0.1342***
	(0.0134)	(0.0037)	(0.0050)	(0.0113)
Observations	3028	3028	3028	3028
Banks	64	64	64	64
Bank FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Within R-squared	0.0460	0.6656	0.5311	0.2582
Adjusted within R-squared	0.0437	0.6648	0.5300	0.2564

Note: Each column is a bank- and quarter-fixed-effects first-stage regression for the listed endogenous variable. Standard errors are heteroskedasticity-robust.

Table 24 shows the pattern behind those diagnostics. The type-specific supplier-network instruments load strongly on the corresponding CSP-stock equations, while capital requirements and non-interest expenses also contribute to the deposit-rate first stage. Taken together, the first-stage evidence is consistent with the IV demand results drawing most of their identifying power from the technology-side instruments, supplemented by the balance-sheet cost shifters for interest rates.

For reference, Table 25 reports the within-bank-and-quarter fixed-effects OLS demand specification alongside the IV model. This comparison shows how instrumenting for deposit rates and CSP variables changes the estimated demand slopes that feed into the implied markdown and the counterfactual exercises.

Table 25: Reference deposit demand estimates: OLS versus IV.

Row	OLS	IV model
Deposit rate	0.1249***	3.8119***
	(0.0451)	(0.4018)
Large institutions x CSP stock	-0.1310***	0.0742
	(0.0120)	(0.0752)
Small and medium bank x CSP stock	0.3017***	0.8346***
	(0.0367)	(0.1197)
Small and medium building society x CSP stock	-0.2943***	2.1595***
	(0.0427)	(0.4944)
Observations	3028	3028
Banks	64	64
Bank FE	Yes	Yes
Quarter FE	Yes	Yes
Pseudo-R-squared	0.0547	0.0075
Adjusted pseudo-R-squared	0.0535	0.0062
Price instrumented	No	Yes
Large institutions x CSP instrumented	No	Yes
Small and medium bank x CSP instrumented	No	Yes
Small and medium building society x CSP instrumented	No	Yes

Note: Dependent variable is the Berry log share, $\log(s_{bt}) - \log(s_{0t})$. Column OLS estimates the full interacted demand equation by OLS with bank and quarter fixed effects. The IV model instruments the deposit rate and the three type-specific CSP terms using the excluded IV block plus matched type-specific supplier-network instruments. Pseudo-R-squared is the squared correlation between the within-transformed dependent variable and fitted values from the structural demand equation; the adjusted version applies the standard degrees-of-freedom correction to that measure. Standard errors are heteroskedasticity-robust.

Relative to the OLS benchmark, the IV model implies much stronger sensitivity of deposit demand to offered rates and materially larger positive CSP effects for the smaller-institution groups, while the large-institution CSP slope remains close to zero. This pattern is consistent with endogeneity in both pricing and technology adoption attenuating or distorting the OLS coefficients.

As a robustness check, Table 26 repeats the same OLS and IV demand specifications while clustering standard errors at the bank level. As expected, clustering makes the estimates less precise than in the heteroskedasticity-robust baseline, but the qualitative pattern remains similar. In particular, the deposit-rate coefficient in the IV specification remains positive and statistically significant, and the CSP slope for small and medium banks remains positive and statistically significant, whereas the large-institution and small-and-medium-building-society CSP slopes become more imprecisely estimated.

Table 26: Deposit demand estimates with bank-clustered standard errors.

Row	OLS	IV model
Deposit rate	0.1249	3.8458***
	(0.1536)	(0.9131)
Large institutions x CSP stock	-0.1310***	0.0920
	(0.0426)	(0.3315)
Small and medium bank x CSP stock	0.3017**	0.7032*
	(0.1418)	(0.3648)
Small and medium building society x CSP stock	-0.2943	2.0742
	(0.1772)	(1.5932)
Observations	3028	3028
Banks	64	64
Bank FE	Yes	Yes
Quarter FE	Yes	Yes
Pseudo-R-squared	0.0547	0.0062
Adjusted pseudo-R-squared	0.0535	0.0049
Price instrumented	No	Yes
Large institutions x CSP instrumented	No	Yes
Small and medium bank x CSP instrumented	No	Yes
Small and medium building society x CSP instrumented	No	Yes
J-test p-value		0.125

Note: This table repeats the main demand specification but clusters standard errors by bank. Dependent variable is the Berry log share, $\log(s_{bt}) - \log(s_{0t})$. The first column estimates the full interacted demand equation by OLS with bank and quarter fixed effects. The IV model instruments the deposit rate and the three type-specific CSP terms using the excluded IV block plus matched type-specific supplier-network instruments. Pseudo-R-squared is the squared correlation between the within-transformed dependent variable and fitted values from the structural demand equation; the adjusted version applies the standard degrees-of-freedom correction to that measure. Standard errors are clustered by bank.

Appendix F: Structural elasticity formulas

This appendix collects the formulas used to compute the demand elasticities reported in Table 9. We focus on own-share elasticities because the goal is to quantify how a bank's own deposit rate and own CSP stock affect its own deposit demand in the estimated simple-logit system.

Let the inside-market share of bank b in quarter t be

$$s_{bt}^{D} = \frac{\exp(\delta_{bt}^{D})}{1 + \sum_{k} \exp(\delta_{kt}^{D})}, \tag{32}$$

where the outside option is normalized to have mean utility zero. For the main specification, mean utility can be written as

$$\begin{aligned} \delta_{bt}^{D} = & \alpha^{D} r_{bt}^{D} + \beta_{L}^{D} \mathbf{1}\{\text{Large}_{b}\} \log(1 + \text{CSP}_{bt}) + \\ & \beta_{SMB}^{D} \mathbf{1}\{\text{SM Bank}_{b}\} \log(1 + \text{CSP}_{bt}) + \\ & \beta_{SMBS}^{D} \mathbf{1}\{\text{SM BS}_{b}\} \log(1 + \text{CSP}_{bt}) + \phi_{b}^{D} + \psi_{t}^{D} + \xi_{bt}^{D}, \end{aligned} \tag{33}$$

where β_{g}^{D} is the group-specific CSP slope corresponding to bank b's institution type:

$$\beta_{g}^{D} = \beta_{L}^{D} \mathbf{1}\{\text{Large}_{b}\} + \beta_{SMB}^{D} \mathbf{1}\{\text{SM Bank}_{b}\} + \beta_{SMBS}^{D} \mathbf{1}\{\text{SM BS}_{b}\}. \tag{34}$$

The logit structure implies the standard derivative

$$\frac{\partial s_{bt}^{D}}{\partial x_{bt}} = s_{bt}^{D} \left(1 - s_{bt}^{D}\right) \frac{\partial \delta_{bt}^{D}}{\partial x_{bt}} \tag{35}$$

for any bank-specific characteristic x_{bt} that enters bank b's own utility.

Deposit-rate elasticity. Because deposit rates enter utility linearly, we have

$$\frac{\partial \delta_{bt}^{D}}{\partial r_{bt}^{D}} = \alpha^{D}, \tag{36}$$

so the own-share derivative with respect to the deposit rate is

$$\frac{\partial s_{bt}^{D}}{\partial r_{bt}^{D}} = s_{bt}^{D} \left(1 - s_{bt}^{D}\right) \alpha^{D}. \tag{37}$$

Multiplying by r_{bt}^{D}/s_{bt}^{D} gives the own-share elasticity:

$$\varepsilon_{bt}^{r} = \frac{\partial s_{bt}^{D}}{\partial r_{bt}^{D}} \frac{r_{bt}^{D}}{s_{bt}^{D}} = \alpha^{D} r_{bt}^{D} \left(1 - s_{bt}^{D}\right). \tag{38}$$

This is the formula used in the paper. Because deposit rates are stored in percentage points in the estimation data, the elasticity is evaluated using the percentage-point rate variable directly.

CSP elasticity. For CSP, utility depends on the transformed object $\log(1 + \text{CSP}_{bt})$, so

$$\frac{\partial \delta_{bt}^{D}}{\partial \text{CSP}_{bt}} = \beta_{g}^{D} \frac{1}{1 + \text{CSP}_{bt}}. \tag{39}$$

Applying the logit derivative yields

$$\frac{\partial s_{bt}^{D}}{\partial \mathrm{CSP}_{bt}} = s_{bt}^{D}\left(1 - s_{bt}^{D}\right)\beta_{g}^{D}\frac{1}{1 + \mathrm{CSP}_{bt}}. \tag{40}$$

The elasticity of own share with respect to the underlying CSP stock is therefore

$$\varepsilon_{bt}^{\mathrm{CSP}} = \frac{\partial s_{bt}^{D}}{\partial \mathrm{CSP}_{bt}}\frac{\mathrm{CSP}_{bt}}{s_{bt}^{D}} = \beta_{g}^{D}\left(1 - s_{bt}^{D}\right)\frac{\mathrm{CSP}_{bt}}{1 + \mathrm{CSP}_{bt}}. \tag{41}$$

This expression matches the implementation used for the elasticity table. Intuitively, the CSP elasticity is smaller when a bank already has a large share, because the factor $(1 - s_{bt}^{D})$ shrinks, and it is also dampened when the log transformation implies diminishing marginal effects at high levels of CSP stock.

Appendix G: Outside option in the counterfactuals

This appendix reports how the counterfactuals reallocate demand between the inside banking market and the outside option. Because the demand system is estimated with an explicit outside good, changes in CSP adoption or in capital requirements can shift not only market shares across banks, but also the total size of the deposit market relative to liquid assets outside the modelled banking sector.

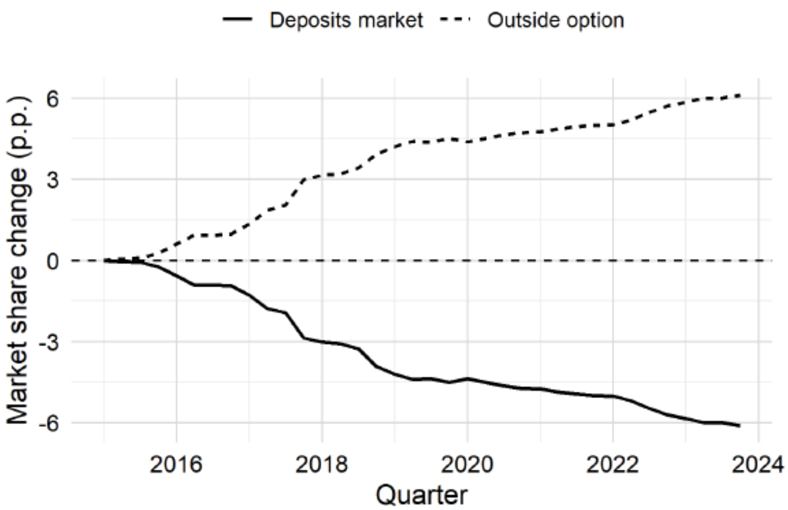

Figure 14: Counterfactual 1: Inside-market and outside-option share changes

Note: Lines report quarter-level changes in aggregate inside-goods share and outside-option share relative to the observed baseline over 2015Q1–2023Q4. The deposits-market line is the aggregate share of all inside goods.

Figure 14 shows that the no-new-CSP counterfactual shrinks the deposit market relative to the outside option. Intuitively, freezing CSP adoption lowers the quality and attractiveness of inside banking products, especially for smaller institutions, so some demand leaves the inside market altogether rather than being reallocated only across banks. This is why the outside-option share rises even though large institutions gain share within the remaining inside market.

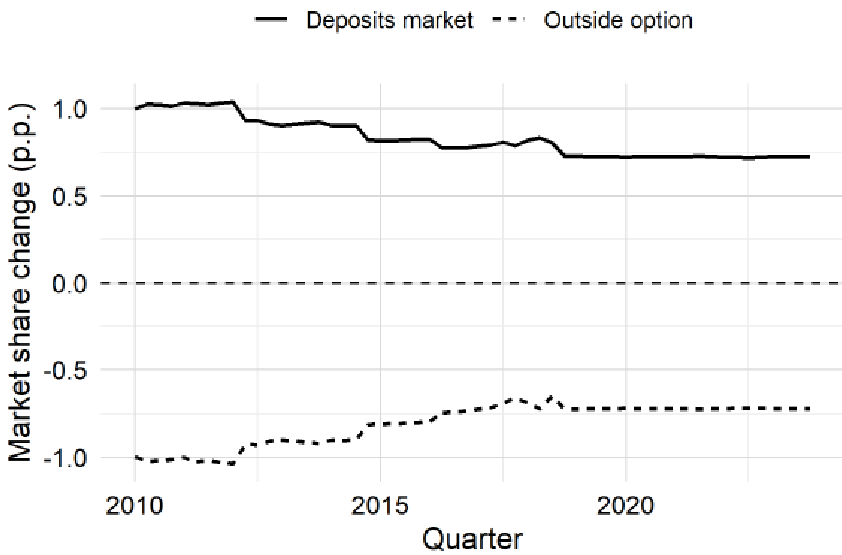

Figure 15: Counterfactual 2: Inside-market and outside-option share changes

Note: Lines report quarter-level changes in aggregate inside-goods share and outside-option share relative to the observed baseline over 2010Q1–2023Q4. The deposits-market line is the aggregate share of all inside goods and uses the total-impact Counterfactual 2 equilibrium.

By contrast, Figure 15 shows that the capital-requirement cut modestly expands the deposit market relative to the outside option under the total-impact equilibrium. Lower capital requirements improve the attractiveness of inside banking products through the direct funding-cost channel, and that positive force dominates the offsetting decline in CSP spending. As a result, some balances move from the outside option into the inside banking market, even though the overall effect is quantitatively small.