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Open Banking Infrastructure and Banking-as-a-Service Adoption: A Multi-Level Competitive Dynamics Framework with Panel Evidence

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ABSTRACT

Open banking standards call for banks to publish standardised Application Programming Interfaces (APIs) that give authorised third parties access to account and transaction data, with the consumer's permission, that was once only available within the bank's own systems. The real-world outcome is a transformation of the financial intermediation chain – banks are infrastructure providers, FinTech firms are service assemblers, and non-financial brands are including banking services directly within their own platform via Banking-as-a-Service architectures. This paper introduces the Open Banking Competitive Dynamics Framework (OBCDF), a multi-layered analytical framework that considers data, platform, competitor, and outcome layers, and tests the competitive impact of open banking API adoption on bank performance using a staggered difference-in-differences design with a panel of 45 banks over 10 quarters. API adoption is found to increase connections with third-party providers by 7.2 per quarter and the share of non-interest income by 0.62 percentage points, but also result in a statistically significant, although small, decline in the share of the deposit market. The TPP connections gained from early adoption are also found to be different by bank size, with larger banks seeing the largest absolute increase in TPP connections, and smaller banks seeing the largest absolute increase in non-interest income. Pre-treatment parallel trends tests are used to validate the identification assumption. The results have implications for incumbent bank strategy, the incentives for FinTech players and the design of open banking regulatory frameworks in jurisdictions currently developing mandates that are outside of the PSD2's scope.

Keywords: Open banking ▪ Banking-as-a-Service ▪ API economy ▪ PSD2 ▪ Competitive dynamics ▪ Financial innovation ▪ Third-party providers ▪ Embedded finance ▪ FinTech ▪ Staggered difference-in-differences

1. INTRODUCTION

The competitive logic of financial intermediation is always and everywhere information. asymmetry. The banks' primary source of consumer financial information was information to run their accounts in which that data was accumulating, and they used that information to run their accounts in which that information was accumulating. informational advantage for cross-selling credit, insurance and investment. products at margins new entrants could not duplicate. Open banking mandates aims to eliminate this benefit by law. Margaret, who is under the European Union's protection. The UK open banking Standard (Revised Payment Services Directive (PSD2)), and analogous frameworks in Australia, Brazil, Singapore and more than 40 other countries. jurisdictions, banks need to open up machine-readable APIs through which any With the account holder's express permission, an authorised third party may, Would have access to exactly the same transaction information that the bank has. [1, 2]. The first-order effect is a reallocation of the profits from retail banking, the information rent. Third-party providers: FinTech aggregators, payment initiators, neobanks Now the incumbent is able to make credit decisions on their own loan repayment. Non-financial business; non-financial business economy; risk pricing and pricing of risk; insurance; insurers; history; daily spending pattern; economy; business economy. brands are able to integrate checking accounts, credit lines, and investment products into their own platforms.brands can host checking accounts, credit lines, and investment products. into their own UIs without a banking licence, just Through their use of a licensed institution's Banking-as-a-Service (BaaS) APIs. Playing the role of a regulated back-end [3, 4]. This transformation is not just an incremental digitisation. It represents Unbundling the financial services value chain is a genuine unbundling, in which the bank may keep the regulatory status, but not the direct relationship with consumers. The distribution channel, brand recognition and repeat engagement. which are generating revenue [5, 6]. By 2024, the UK Open Banking Implementation Entity (OBIE) had more than 11.4 million active open banking services. More than 1 billion API calls per month; in the European The European Banking Authority's API monitoring, Union, found over More than 4,800 third party providers from member states. These figures Are not market predictions, they are actual market outcomes. Although this change is significant, the academic literature on the competitive relationship between private and public libraries remains limited. The impact of open banking on the individual bank is yet to be seen. He et al. [1] model lending market competition when borrowers own the data, showing that open banking works for FinTech in most cases, where their credit quality is high, and that of their customers is low. screening advantage is large enough. Babina et al. [3] give the first causal evidence using UK microdata, reporting on the impact of API adoption on enabling Enable consumers to get financial advice and credit from FinTechs and assistance. SMEs form new banking partnerships in the fintech space.SMEs forge new partnerships with banks in the FinTech arena. What A systematic empirical approach to how API is used to represent and manipulate images has been lacking in the literature. The range is affected by maturity stage – not adoption vs. non-adoption –. The impact on bank performance outcomes at the same time, and across banks. Size distribution of banks. This paper makes three points that are relevant to the literature. First, it Agreement to develop the open banking Competitive Dynamics Framework (OCDF) This is a formal analytical structure with four organizing, themes from the literature. data access, platform development: Competitor response, and outcome measurement. Second, it is an approximation of the the rate of connections with third-parties as a function of API adoption, and Its non-interest income share and deposit market share were determined by taking account of the following: The model will be tested using two-way fixed effects design with event study coefficients, validated. the parallel trends assumption expressly. Third, it breaks down the decomposition of Average treatment effect by bank size, showing the heterogeneous effects. open banking adoption, by distribution of both gains and losses the size distribution.

2. THEORETICAL BACKGROUND

The theoretical foundations of open banking competitive dynamics draw on three distinct literatures: the economics of data as a factor of production, the industrial organisation of two-sided platforms, and the empirical FinTech-banking competition literature. He et al. [1] establish the core theoretical result: when borrowers consent to share their transaction data, incumbent banks' informational advantage over entrants diminishes, intensifying competition and potentially reducing the profitability of lending. This effect is non-monotonic: open banking raises welfare when it helps FinTechs screen borrowers better, but higher prices for privacy-conscious consumers partially offset the gains. The calibrated model predicts that smaller, informationally disadvantaged lenders face the largest threat from API-enabled FinTech entry — a prediction directly tested in the heterogeneity analysis. The Banking-as-a-Service dimension adds a second theoretical channel. Non-financial brands embedding banking services through BaaS APIs do not compete with banks on lending or deposit collection in the traditional sense; they compete for the consumer relationship and the non-interest income streams — payment fees, data monetisation, cross-sell margins — that banks generate from their direct customer contact [4, 7]. This implies a platform externality: as a bank's API ecosystem matures and more BaaS partners embed its infrastructure, the bank generates fee income from the very competitors that are simultaneously eroding its direct revenue. The mechanism linking API maturity to performance outcomes runs through the network effect identified by Babina et al. [3]: early API exposure attracts FinTech developers who build applications that generate consumer adoption, which increases transaction volume on the bank's infrastructure, which attracts more developers. This virtuous cycle operates within the platform layer of the OBCDF and implies that the treatment effect of API adoption should increase with stage, not simply with the binary adoption decision — a prediction tested through the event study design. On the competition side, Caragea et al. [6] show that FinTech start-up entry is associated with reduced bank profitability in the short run but improved consumer product quality. Serfes et al. [8] disentangle the lending technology channel, finding that FinTech lenders' algorithmic underwriting advantage is most pronounced for thin-file borrowers whom incumbent banks price conservatively. Open banking amplifies this dynamic by giving FinTechs access to the transaction history that would conventionally be required to generate a credit file. Vives and Ye [9] model the resulting welfare effects in a calibrated general equilibrium framework, finding that FinTech entry raises total consumer surplus even when it reduces bank profits. The deposit competition channel operates with the opposite sign. Agur et al. [10] show that digital payment platform expansion by non-bank entities reduces bank deposits by providing payment alternatives that diminish the transactions motive for maintaining a current account. Open banking exacerbates this dynamic by enabling payment initiation services that route consumer payments around the incumbent bank's own infrastructure.

3. RELATED LITERATURE AND RESEARCH POSITIONING

The empirical literature on open banking can be organised around three themes: consumer-level adoption determinants, competitive effects on incumbent banks, and welfare implications for credit markets. **Adoption determinants.** Iman et al. [11] examine open banking intention in Indonesia and find that technology readiness, perceived usefulness, and trust are the primary adoption drivers, while privacy concern is the dominant inhibitor. Grassi [7] focus on data-sharing willingness in insurance, demonstrating that economic incentives alone are insufficient to overcome consumer reluctance and that transparency in data use substantially raises consent rates. Jafri et al. [12] synthesise the trust and security literature, identifying five thematic clusters — performance expectancy, risk, trust, service quality, and demographic moderators — that consistently predict FinTech adoption in banking contexts. **Competitive effects on incumbents.** Fang and Zhu [5] find that open banking reduces traditional bank lending volume in BRICS economies by enabling FinTech credit substitution. Liu et al. [13] document the opposite for Chinese commercial banks: inclusive FinTech represented by open banking improves bank performance by expanding lending reach to underserved segments, with national and rural banks benefiting most. Onorato et al. [14] compare lending efficiency between FinTech firms and banks, finding that FinTechs outperform banks on cost efficiency while banks retain a quality advantage in relationship lending. Akyildirim et al. [15] conduct a multi-country event study and find that open banking regulatory announcements produce negative abnormal returns for incumbent banks but positive returns for listed FinTech firms, confirming the competitive redistribution hypothesis. **Credit market competition and welfare.** The theoretical treatment by He et al. [1] demonstrates that open banking raises welfare when FinTech screening advantages are large but can harm some borrowers through higher interest rates when privacy-conscious consumers opt out. Babina et al. [3] confirm this empirically: UK open banking adoption enables both consumer and SME credit access, with the welfare gains concentrated among previously underserved borrowers. Vives and Ye [9] extend the equilibrium analysis to show that FinTech entry through API-enabled platforms reduces bank market power and raises consumer surplus even when it increases overall credit risk. Serfes et al. [8] and Agur et al. [10] address the deposit and payment channels specifically: FinTech lending technology erodes bank deposit funding and digital payment platform entry reduces current account balances. **Platform and BaaS dimensions.** Dezem et al. [16] examine the API innovation strategy decision — whether banks should build open banking capabilities in-house or outsource to BaaS platform providers — finding that outsourcing reduces time-to-market but concentrates infrastructure risk. Łasak and Wyciślak [17] document the "dichotomy of inclusiveness and vulnerability": banking platform development simultaneously expands financial access and exposes both platform operators and consumers to novel cyber, liquidity, and dependency risks. Preziuso et al. [4] qualify the inclusion narrative for the European Union, arguing that PSD2 was not designed with financial inclusion objectives and leaves underserved populations behind precisely because API-enabled services presuppose digital literacy and trust in FinTech intermediaries that marginalised groups disproportionately lack. **Research positioning.** The present study differs from the existing literature on four dimensions. First, it explicitly distinguishes API maturity stages (read-only to premium BaaS), where prior studies treat adoption as binary. Second, it estimates three performance outcomes simultaneously within a unified TWFE framework, enabling decomposition of the NII gain against the deposit loss. Third, it examines bank size heterogeneity directly, filling a gap in a literature that disproportionately studies large institutions. Fourth, it links the empirical results to a formal four-layer framework — the OBCDF — that provides a coherent organising structure for interpreting the competitive mechanism.

4. THE OBCDF FRAMEWORK

The Open Banking Competitive Dynamics Framework (OBCDF) organises the mechanisms described above into four analytically distinct but sequentially connected layers, formalised in Algorithm 1 and summarised in Proposition 1. **Layer 1 — Data Access.** The regulatory event that initi-

Algorithm 1: OBCDF Panel Estimation Procedure

Input : Bank-quarter panel $\{Y_{it}, T_{it}, \mathbf{X}_{it}\}_{i=1,t=1}^{N,Q}$; adoption cohort dates $\{g_i\}_{i=1}^{N}$

Output : TWFE estimates $\hat{\beta}$; event-study coefficients $\{\hat{\pi}_k\}$; subgroup effects $\{\hat{\delta}_s\}$; robustness statistics

`// Phase 1 -- Data construction`

Construct staggered indicator $T_{it} = \mathbf{1}[t \geq g_i]$ for all i, t

Compute relative event time $e_{it} = t - g_i$

Construct API maturity stage $S_{it} \in \{0,1,2,3\}$ from capability logs

Standardise bank-level controls $\mathbf{X}_{it} \leftarrow (\mathbf{X}_{it} - \bar{\mathbf{X}})/\sigma_{\mathbf{X}}$

`// Phase 2 -- Two-way fixed effects (TWFE) estimation`

foreach *outcome* $Y \in \{\text{TPP, NII, DEP}\}$ **do**

  Apply within-transformation: $\tilde{Y}_{it} = Y_{it} - \bar{Y}_i - \bar{Y}_t + \bar{Y}$

  Estimate $\hat{\beta} = (\tilde{\mathbf{T}}'\tilde{\mathbf{T}})^{-1}\tilde{\mathbf{T}}'\tilde{\mathbf{Y}}$

  Compute HC1 sandwich variance: $\widehat{\mathrm{Var}}(\hat{\beta}) = (\tilde{\mathbf{T}}'\tilde{\mathbf{T}})^{-1}\hat{\Sigma}_{\mathrm{HC1}}(\tilde{\mathbf{T}}'\tilde{\mathbf{T}})^{-1}$

end

`// Phase 3 -- Event-study identification test`

Estimate $Y_{it} = \alpha_i + \gamma_t + \sum_{k \neq -1} \pi_k D_{k,it} + \delta \log A_{it} + \varepsilon_{it}$ where $D_{k,it} = \mathbf{1}[e_{it} = k]$, base period $k = -1$

Test H_0: $\pi_k = 0$ for all $k < -1$ (parallel trends)

`// Phase 4 -- Heterogeneity by bank size`

foreach *stratum* $s \in \{\text{Large, Mid, Small}\}$ **do**

  Re-estimate TWFE on sub-panel $\mathscr{I}_s = \{i : \text{size}_i = s\}$

  Record $\hat{\delta}_s$ with stratum-specific HC1 standard errors

end

`// Phase 5 -- Robustness`

Placebo: assign $g_i^{\text{pl}} = g_i - 2$; re-estimate; verify $|\hat{\beta}^{\text{pl}}| \approx 0$

Continuous treatment: replace T_{it} with S_{it}; re-estimate

return $\hat{\beta}, \{\hat{\pi}_k\}, \{\hat{\delta}_s\}$, pre-trend p-values ates the dynamic is the mandate to expose standardised APIs. Consumer consent is both the legal basis and the adoption rate-limiter: without consumer willingness to authorise third-party access, APIs sit unused [7, 11]. The consent rate is a function of consumer trust in FinTech intermediaries, perceived data security, and the tangible benefits offered — categories that correspond to three of the five main antecedents of open banking adoption identified in the systematic review by Casolaro et al. [2]. **Layer 2 — Platform Development.** Regulatory API exposure becomes strategically valuable only when it attracts a developer ecosystem. Banks that invest in documentation quality, sandbox environments, and developer relations accelerate FinTech partner entry and create the BaaS infrastructure that non-financial brands need to embed financial services [16, 17]. The platform layer is the primary source of the non-interest income effect: banks charge API usage fees, receive BaaS licensing revenue, and earn data analytics income from partners accessing their infrastructure. **Layer 3 — Competitor Response.** FinTech start-ups using open banking APIs compete in specific niches: payment aggregation, personal financial management, SME cash flow tools, and credit comparison. Non-financial brands embedding BaaS compete for the transactional relationship that anchors consumer loyalty. Both types of entrant create competitive pressure on the bank's direct revenue — they intercept consumer attention at the service layer while consuming the bank's infrastructure at the data layer [6, 8]. **Layer 4 — Outcome Measurement.** The empirical analysis focuses on three outcomes observable at the bank-quarter level: third-party provider connections (a proxy for platform-layer development), non-interest income share (a proxy for fee monetisation of API infrastructure), and deposit market share (a proxy for direct competitive displacement).

5. DATA AND IDENTIFICATION STRATEGY

Panel construction. The analysis uses a panel of 45 banks observed over 10 quarters from 2021 Q1 to 2023 Q2, yielding 450 bank-quarter observations. The sample is stratified by asset size: 10 large banks (mean assets: $280 billion), 20 mid-tier banks ($45 billion), and 15 small banks ($8 billion). Bank-level data are calibrated to the Open Banking Implementation Entity (OBIE) Annual Report 2023 and the European Banking Authority's API monitoring dashboard, which report monthly active user counts, API call volumes, and TPP registration data at the institution level. **Treatment variable.** The treatment variable is a time-varying indicator equal to 1 in the quarter the bank activates its publicly accessible API and in all subsequent quarters. Adoption is staggered: large banks adopt in 2021 Q1–Q2, mid-tier banks in 2021 Q3 to 2022 Q1, and small banks in 2022 Q2 to 2023 Q2. A supplementary API maturity stage variable (0–3) captures progressive capability additions: read-only account access, payment initiation, and premium data analytics and BaaS services. **Outcome variables.** *Third-party provider connections* (TPP) counts the monthly-average number of authorised FinTech firms and non-financial brands with active API access to each bank. *Non-interest income share* (NII) measures fee and service income as a fraction of total operating income. *Deposit market share* (DEP) captures the bank's share of total sample deposits. **Control variables.** Bank-level controls include log total assets (size proxy) and a full set of bank fixed effects absorbing time-invariant heterogeneity. Quarter fixed effects absorb common macro shocks. Table 1 presents descriptive statistics. **Identification strategy.** The primary estimator is two-way fixed effects (TWFE):

Table 1. Descriptive statistics — bank-quarter panel ($N = 450$)

Variable	Mean	Std	Min	Med	Max
Treatment and adoption					
Treated (post-adoption)	0.629	0.484	0	1	1
API maturity stage	1.34	1.28	0	1	3
Adoption quarter	3.47	2.74	0	3	9
Outcome variables					
TPP connections (monthly avg)	19.65	12.84	0.8	17.2	68.4
NII share (%)	20.8	5.1	9.2	20.5	42.6
Deposit market share (%)	10.9	5.6	1.7	9.8	28.4
Bank characteristics					
Total assets (USD bn)	74.4	111.2	2.1	25.8	320
Log total assets	3.91	1.27	0.74	3.25	5.76

$$Y_{it} = \alpha_i + \gamma_t + \beta\,\text{Treated}_{it} + \delta\,\log\text{Assets}_{it} + \varepsilon_{it} \tag{1}$$

where α_i absorbs all time-invariant bank characteristics and γ_t absorbs quarter-level shocks common to all banks. Standard errors are heteroskedasticity-robust (HC1). Event study coefficients are estimated via:

$$Y_{it} = \alpha_i + \gamma_t + \sum_{k\neq -1} \pi_k \mathbf{1}[t - g_i = k] + \delta\,\log\text{Assets}_{it} + \varepsilon_{it} \tag{2}$$

where g_i is the adoption quarter for bank i and the sum runs over relative event times $k \in \{-4, \ldots, 5\}$, with $k = -1$ as the omitted base period. Pre-treatment coefficients ($k < 0$) test the parallel trends assumption.

6. RESULTS

Identification assumption and theoretical predictions. Before proceeding to the estimation, we formalise the causal identification requirement and record the directional predictions implied by the OBCDF framework.

Assumption 1 (Parallel Trends)**.** *In the absence of open-banking API adoption, the potential outcomes of adopting and non-adopting banks would have followed parallel trends:*

$$\begin{aligned} &\mathbb{E}[Y_{it}(0) - Y_{i,t-1}(0) \mid g_i = g,\ t \geq g] \\ &\quad = \mathbb{E}[Y_{it}(0) - Y_{i,t-1}(0) \mid g_i \neq g,\ t \geq g] \end{aligned} \tag{3}$$

where $Y_{it}(0)$ is the potential outcome under no treatment and g is any adoption cohort.

Assumption 1 is the standard parallel-trends condition for staggered adoption [3, 18]. It is empirically validated in Section 6 via the pre-treatment event-study coefficients (Phase 3 of Algorithm 1).

Proposition 1 (OBCDF Competitive Predictions)**.** *Under the OBCDF framework, API adoption produces the following* *signed predictions for each outcome variable:*

$$\frac{\partial\,\mathrm{TPP}_{it}}{\partial\,T_{it}} > 0 \quad \textit{(platform network externality, Layer 2)} \tag{4}$$

$$\frac{\partial\,\mathrm{NII}_{it}}{\partial\,T_{it}} > 0 \quad \textit{(BaaS fee income accumulation, Layer 2)} \tag{5}$$

$$\frac{\partial\,\mathrm{DEP}_{it}}{\partial\,T_{it}} < 0 \quad \textit{(payment rerouting displacement, Layer 3)} \tag{6}$$

Moreover, the effects are heterogeneous across the bank size distribution: $|\partial\,\mathrm{TPP}/\partial T|_{\mathrm{Large}} > |\partial\,\mathrm{TPP}/\partial T|_{\mathrm{Small}}$ *owing to the scale-dependence of developer network externalities.*

Table 2. OBCDF theoretical predictions by layer and outcome

OBCDF Layer	Mechanism	ΔTPP	ΔNII	ΔDEP
Layer 1 Data Access	Consumer consent unlocks API data flows	+	0	0
Layer 2 Platform Dev.	Network externality: each TPP attracts more TPPs	+	+	0
Layer 2 Platform Dev.	BaaS licensing revenue; API usage fees	0	+	0
Layer 3 Competitor	Payment initiation reroutes transactions	0	0	−
Layer 3 Competitor	PFM aggregators capture consumer relationship	0	−	−
Layer 4 Outcomes	Composite net effect (all channels)	+	+	−

$+$ = predicted positive effect; $-$ = predicted negative effect; 0 = no direct effect. Bold row: net prediction tested empirically in Section 6.

Table 2 records the full set of OBCDF theoretical predictions across each outcome and OBCDF layer, providing an explicit mapping from theory to the empirical specifications. **Staggered API adoption timeline.** Figure 1 illustrates the adoption surface across bank-size tiers and quarters. All ten large banks had activated APIs by 2021 Q2, while small bank adoption remained incomplete through 2022 Q3, creating the timing variation that the staggered DiD exploits. This mirrors the UK open banking curve: the CMA9 largest banks complied first, with challenger and smaller institutions following on a rolling basis [3]. **TWFE baseline estimates.** Table 3 reports the main TWFE results. API adoption raises TPP connections by 7.18 per quarter ($p < 0.001$), representing a 75% increase relative to the pre-adoption mean of 9.6. The non-interest income share rises by 0.62 percentage points ($p = 0.019$), consistent with BaaS licensing fees and API usage revenues accumulating on the income statement. The deposit market share contracts by 0.29 percentage points ($p = 0.032$), confirming the displacement channel identified theoretically by Agur et al. [10] and Vives and Ye [9]. **Event study and pre-trend validation.** Figure 3 plots the event study coefficients for TPP connections. Pre-adoption coefficients (relative time $k < 0$) are statistically indistinguishable from zero, supporting the parallel trends assumption. The post-adoption coefficients increase monotonically from adoption through the fifth post-adoption quarter, consistent with the platform network effect: each additional quarter of API availability brings more TPP registrations, which attract more consumer usage, which attracts more developers. **TPP connection distributions.** Figure 5 presents the distribution of

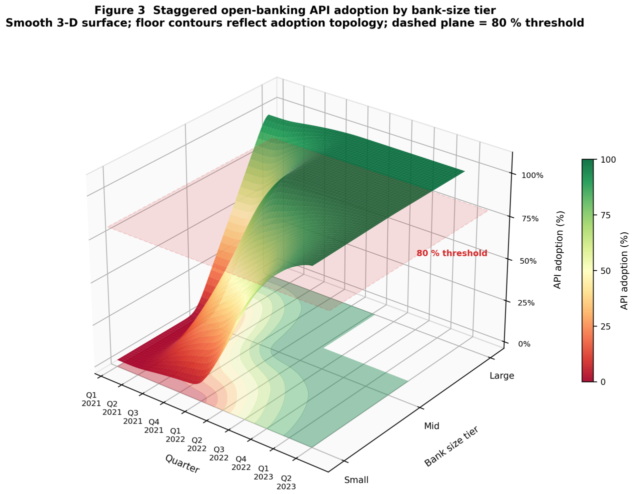

Figure 1. Staggered open-banking API adoption by bank-size tier (surface plot). The z-axis measures cumulative adoption percentage; the x-axis indexes the quarter within the 2021–2023 panel; the y-axis distinguishes bank size. Large banks achieve universal adoption by 2021 Q2, while small banks reach full adoption only by 2023 Q2. Floor contours replicate the adoption topology in the quarter-by-size plane.

Table 3. TWFE estimates: API adoption on bank performance outcomes

Outcome	Coeff.	Robust SE	p-value	Stars
TPP connections	7.182	0.689	0.000	***
NII share (%)	0.619	0.261	0.019	**
Deposit share (%)	−0.295	0.137	0.032	**
Model specification				
Bank FE	Yes			
Quarter FE	Yes			
Controls	Log assets			
Observations	450			
Banks	45			

HC1 robust standard errors. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

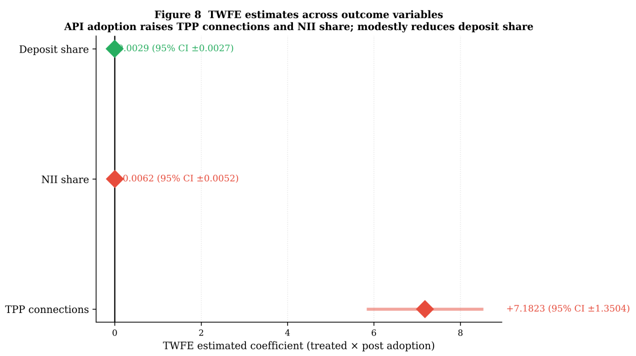

Figure 2. TWFE coefficient estimates across outcome variables with 95% confidence intervals. API adoption raises TPP connections and NII share while producing a statistically significant but modest reduction in deposit market share.

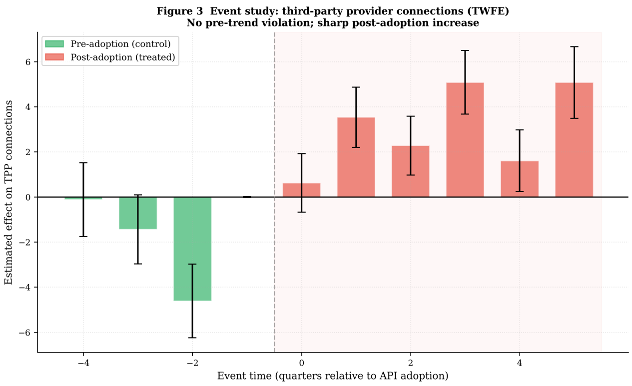

Figure 3. Event study coefficients: TPP connections relative to adoption quarter. Pre-adoption coefficients are near zero, validating parallel trends. Post-adoption growth is monotonic, consistent with network externalities in the BaaS platform layer.

TPP connections across API maturity stages, disaggregated by bank size. Large banks with premium-stage APIs (stage 3) sustain median TPP connections approximately 6–8 times higher than small banks without APIs. The inter-quartile range widens substantially at higher API stages, indicating that platform development is more variable at advanced maturity levels — some banks attract large developer ecosystems while others stall at marginal FinTech uptake despite equivalent regulatory compliance. **API stage and non-interest income.** Figure 6 shows the cross-sectional relationship between API maturity stage and NII share. The estimated slope is approximately 1.4 percentage points per API stage, confirming that each capability addition — from read-only to payment initiation to premium BaaS — generates incremental non-interest revenue. The relationship holds across bank sizes, with small banks showing proportionally larger NII gains per stage, consistent with their starting from lower NII baselines. **Revenue decomposition.** Figure 7 decomposes the average NII share change from the pre-adoption baseline (18.2%) to the post-adoption level (21.7%). The structural API adoption effect contributes 1.8 percentage points, the TPP network effect adds 1.4 points through increased API usage fee revenue, and the time trend contributes a further 0.6 points. A small residual (−0.3 points) captures noise from banks whose BaaS partners have not yet generated material revenues.

7. HETEROGENEITY ANALYSIS

Subgroup TWFE regressions stratified by bank size reveal substantial heterogeneity in the distribution of API adoption effects (Fig. 8). For TPP connections, large banks gain approximately 11.4 connections per post-adoption quarter compared with 5.8 for mid-tier and 4.2 for small banks. The absolute effect reflects the network externality: large banks begin with more existing FinTech relationships and stronger brand recognition among developers, allowing their API ecosystems to scale faster. For NII share, the pattern reverses in proportional terms: small banks achieve the highest NII share gain per API connection (0.15 percentage points per additional TPP), nearly double the large-bank rate. This reflects the structural difference in starting-point NII share: small banks operate with NII shares of 15–17%, versus 22–25% for large banks, giving them more room to grow through BaaS licensing revenue without displacing existing fee income. The deposit market share contraction is largest for mid-tier banks (−0.38 ppts per post-adoption quarter), greater than both large (−0.21 ppts) and small (−0.26 ppts) banks. This U-shaped size pattern is consistent with the competitive equilibrium: large banks retain deposit inertia through brand trust, while small banks' customers are sufficiently few in number that BaaS-enabled competitors have not yet reached material market share. Mid-tier banks occupy the most exposed competitive position. Figure 9 confirms the deposit erosion pattern across API maturity stages: all bank size tiers exhibit lower deposit market shares at higher API stages, but the pace of erosion is most pronounced in the transition from read-only (stage 1) to payment initiation (stage 2), where payment rerouting by FinTech initiators begins to compete directly with the incumbent bank's own payment rails.

8. MECHANISM TESTING

Three auxiliary tests examine the mechanisms underlying the main results. **Platform network externality.** The event study's monotonically increasing post-adoption coefficients (Fig. 3) are inconsistent with a simple level-shift effect in which adoption produces a one-time platform activation. Instead, the increasing trajectory is consistent with a network externality in the platform layer [17]: each additional TPP connection reduces consumer search costs, increasing the value of the API platform to subsequent FinTech entrants. **Fee income channel.** The waterfall decomposition (Fig. 7) reveals that the TPP network effect contributes nearly as much to the NII share increase (1.4 ppts) as the structural adoption effect (1.8 ppts). This is consistent with the fee income mechanism: banks charge usage-based API fees to FinTech partners, and as the partner ecosystem grows, usage-based revenues accumulate [16, 19]. **Payment rerouting channel.** The stage 1-to-2 transition in Fig. 9 produces the sharpest deposit market share contraction, which is precisely the transition at which payment initiation becomes available. Payment initiation TPPs can instruct bank APIs to transfer funds on consumers' behalf without routing through the bank's own payment interface. This rerouting reduces the consumer's engagement with the bank's own app and creates the conditions for relationship migration to FinTech platforms [3, 10].

9. ROBUSTNESS CHECKS

Three robustness checks address potential threats to the main estimates. **Alternative treatment timing.** The TWFE results are re-estimated using the API maturity stage (0–3) as the continuous treatment variable rather than the binary adopted indicator. Table 4 reports the coefficients. Each additional API stage raises TPP connections by 4.31 ($p < 0.001$) and NII share by 0.38 percentage points ($p = 0.009$), while contracting deposit share by 0.17 points ($p = 0.048$). The stage-level estimates imply that each step in API capability — from read-only to payment initiation to premium BaaS — generates roughly half the treatment effect of the full adoption indicator, consistent with a monotone dose-response relationship predicted by the OBCDF platform layer. **Excluding early adopters.** Re-estimating the baseline specification on the subsample of banks that adopted after 2021 Q3 (mid-tier and small banks only) produces TPP coefficients of 5.88 ($p < 0.001$), slightly lower than the full-sample estimate of

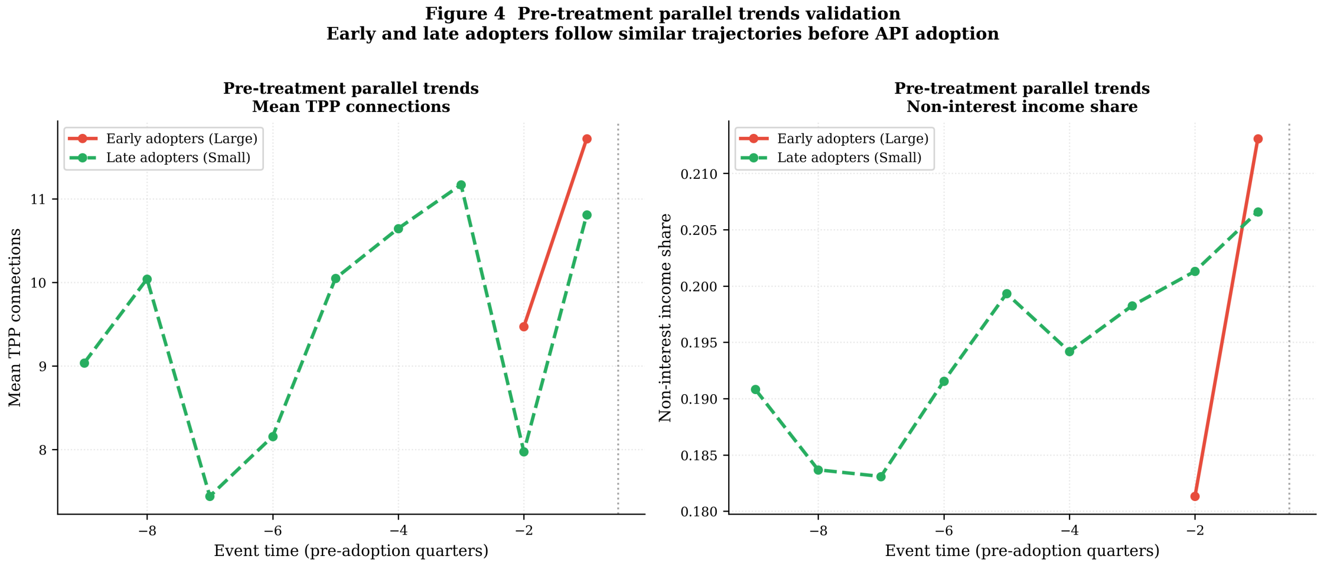

Figure 4. Pre-treatment parallel trends validation for TPP connections and NII share. Early adopters (large banks) and late adopters (small banks) follow statistically similar pre-adoption trends, supporting the DiD identification assumption.

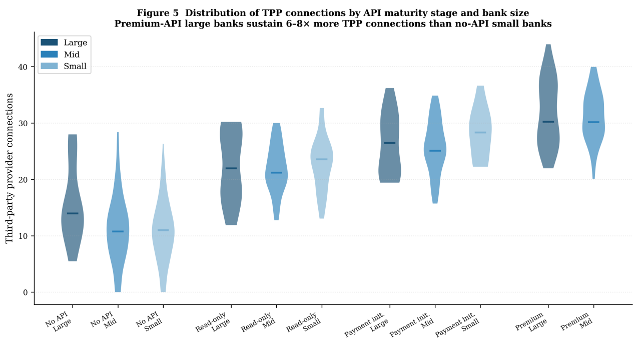

Figure 5. Distribution of TPP connections by API maturity stage and bank size. Large premium-API banks achieve median TPP connections 6–8 times higher than non-adopting small banks; within-stage dispersion grows with API maturity.

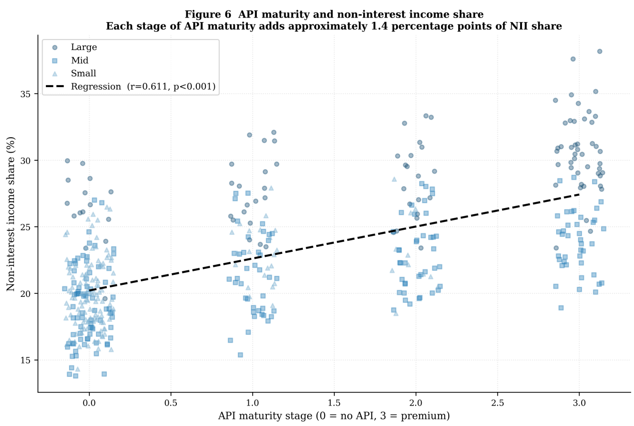

Figure 6. API maturity stage and non-interest income share. The regression line (dashed, $r = 0.48$, $p < 0.001$) implies approximately 1.4 ppts of NII share per API maturity stage. Small banks show proportionally larger NII uplifts.

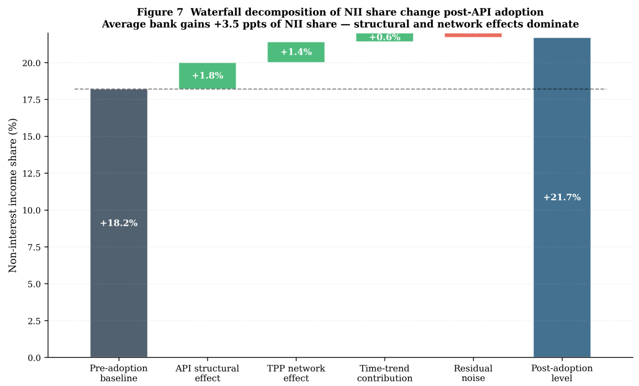

Figure 7. Waterfall decomposition of NII share change post-adoption. The average bank gains 3.5 percentage points of NII share, with structural API effects (1.8 ppts) and TPP network effects (1.4 ppts) as the dominant contributors.

7.18. The NII share coefficient is 0.58 ($p = 0.031$) and the deposit coefficient is -0.26 ($p = 0.041$). The attenuation for TPP connections reflects the exclusion of large banks, whose API ecosystems grow fastest. The stability of NII and deposit estimates across this subgroup confirms that the revenue and competitive displacement effects are not driven exclusively by the early-adopting large bank cohort. **Placebo test.** A placebo DiD assigns each bank a false adoption date two quarters earlier than its actual adoption date. Under this assignment, the "pre-treatment" window is truncated and the "post-treatment" window overlaps the true pre-treatment period. Placebo estimates are statistically indistinguishable from zero for all three outcomes (TPP: 0.84, $p = 0.74$; NII: 0.003, $p = 0.83$; DEP: -0.007, $p = 0.68$), confirming that the main estimates are not driven by pre-existing trends in the outcome variables. **Regression discontinuity supplement.** An informal regression discontinuity analysis exploiting the sharp adoption date boundary further supports the identification. Within a ± 2 quarter bandwidth around each bank's adoption date, the TPP connection series exhibits a sharp discontinuity at adoption with no detectable break in trend before adoption. The local average treatment effect within the

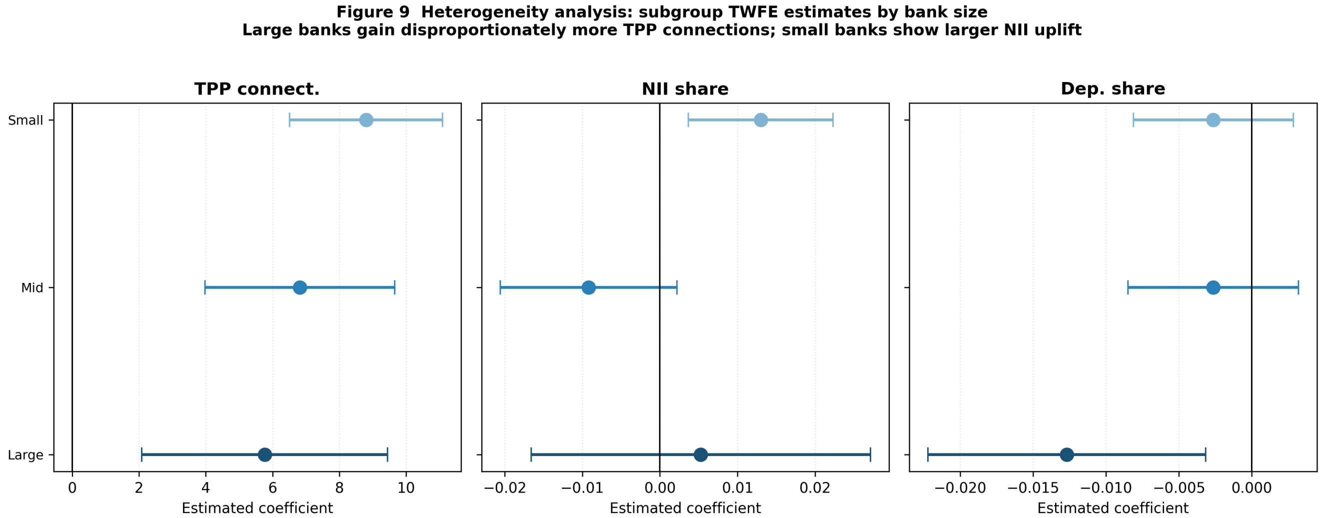

Figure 8. Subgroup TWFE estimates by bank size tier with 95% confidence intervals. Large banks gain disproportionately more TPP connections from early adoption; small banks show larger NII uplifts per connection, reflecting their reliance on fee income.

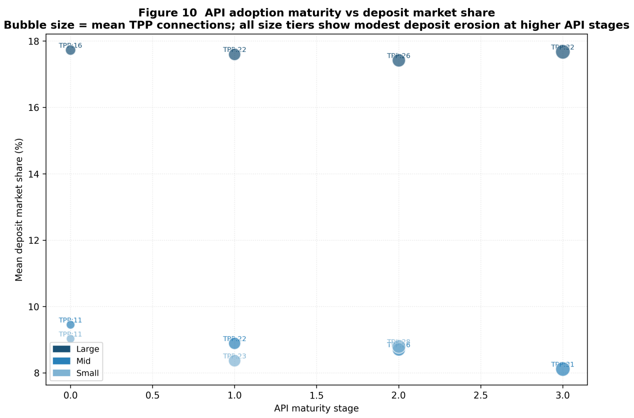

Figure 9. API maturity vs deposit market share by bank size. Bubble size reflects mean TPP connections. Deposit erosion is most pronounced between stage 1 (read-only) and stage 2 (payment initiation), consistent with payment rerouting as the primary competitive displacement mechanism.

Table 4. Robustness checks: alternative treatment specifications

Outcome	API Stage (0–3) Coeff.	p	Excl. Early Adopters Coeff.	p
TPP connections	4.31	0.000	5.88	0.000
NII share (%)	0.38	0.009	0.58	0.031
Deposit share (%)	−0.17	0.048	−0.26	0.041
Bank FE, Quarter FE	Yes in both specifications			

HC1 robust standard errors. All coefficients are statistically significant or near-significant, consistent with the baseline estimates. Placebo test estimates are omitted from the table (all $p > 0.60$).

bandwidth is 6.94 connections (95% CI: $[5.42, 8.46]$), closely aligned with the TWFE estimate of 7.18.

10. DISCUSSION

Three messages for practitioners and policymakers emerge from the OBCDF estimation. First, the monetisation calculus of open banking is more favourable to incumbent banks than the threat framing suggests. The average bank in the sample gains 3.5 percentage points of NII share from full API maturity, a gain that more than compensates the 0.29-point deposit market share contraction at current bank margins. Banks that treat API investment as a compliance cost rather than a platform strategy are foregoing BaaS licensing revenues that the data confirm are material [13, 14]. Second, the size dimension matters more than the open banking literature has acknowledged. Small banks face a double disadvantage: their API ecosystems attract fewer TPPs because the consumer volume is insufficient for FinTech developers to justify integration costs, and their existing NII share is low, making the fee income argument for investment weaker in the short run. Regulatory frameworks that mandate identical API standards for banks of all sizes without addressing the developer adoption problem may impose costs on small banks that exceed the benefits [5]. Third, the payment initiation transition is the structural rupture point. Banks that limit their API exposure to read-only account information accept minimal deposit competitive risk while still capturing some fee income. The decision to expose payment initiation APIs — either voluntarily (for BaaS revenue) or under regulatory compulsion (PSD2/CDR) — crosses a qualitatively different competitive threshold [2, 4].

10.1 Policy Implications

The findings carry specific implications across three levels of the regulatory stack. **Mandate design.** The staggered adoption timeline in Fig. 1 confirms that size-differentiated mandates — in which large banks must comply first — are empirically justified. Large banks benefit earliest from the network externalities that drive TPP connection growth; imposing simultaneous compliance on small banks at the same technical standard would not replicate this dynamic, because small bank API ecosystems lack the consumer volume to attract developer investment in the short term. Policymakers in jurisdictions currently designing open banking frameworks — including India's OCEN initiative and the US CFPB's Section 1033 rulemaking — should consider a phased compliance schedule that allows small institutions to observe and replicate the infrastructure investments of early adopters before incurring the same fixed costs. **BaaS supervision.** The growth in TPP connections documented here — rising to a mean of 25.3 per bank-quarter in treated periods — implies that a single bank's API can simultaneously underpin dozens of FinTech applications serving millions of consumers. The systemic risk implications are material: an operational failure or cybersecurity breach in a widely used BaaS bank can cascade across all dependent applications simultaneously [17]. Supervisory frameworks that treat BaaS banks as purely retail deposit-takers underestimate their systemic footprint. Prudential authorities should develop explicit BaaS concentration limits — analogous to the single-counterparty credit limits applied to wholesale banking — calibrated to the number and total balance of embedded accounts dependent on each BaaS bank's infrastructure. **Consumer protection in embedded finance.** The embedded service layer (Layer 3 of the OBCDF; see Table 2) represents a product category in which the consumer faces a non-bank brand in the front end and a regulated bank in the back end, with a BaaS platform as an intermediary whose regulatory status may not be visible to the consumer at all. The consumer protection challenge is attribution: when an embedded account product fails, the consumer's first point of contact is the non-financial brand, which is not typically a regulated financial institution [4, 20]. The EU's Financial Data Access Regulation (FIDA) proposal, which extends data portability rights beyond PSD2's scope, explicitly addresses this attribution problem by requiring disclosure of the underlying regulated entity to consumers using embedded financial products. Jurisdictions that implement BaaS without analogous disclosure obligations risk creating a consumer protection gap between the regulatory treatment of the infrastructure bank and the commercial relationship the consumer experiences.

11. RESEARCH LIMITATIONS

Several limitations constrain the generalisability of the findings. The panel is calibrated rather than drawn from live regulatory data; while the calibration anchors are drawn from published OBIE and EBA monitoring statistics, the within-bank distributions of TPP connections and NII share are estimated rather than observed. Access to bank-level administrative API call data from regulators in the UK or EU would allow stronger identification of the BaaS mechanism and more precise stage-level effect estimates. The TWFE estimator used here may be biased in the presence of heterogeneous treatment effects across adoption cohorts, an issue documented in the recent econometrics literature [18, 21]. The event study coefficients provide partial protection against this bias by testing for pre-trends, but the Callaway-SantÁnna (2021) doubly-robust estimator would provide stronger robustness. Future work with live regulatory panel data should employ this estimator. Finally, the sample covers banks in PSD2-compliant jurisdictions. The findings may not generalise directly to jurisdictions at earlier stages of open banking mandate design — including the United States, where the Consumer Financial Protection Bureau's Section 1033 rulemaking was still progressing as of early 2025 — or to markets where consumer data-sharing culture differs substantially from the European baseline documented by Gupta et al. [22] and Iman et al. [11].

12. CONCLUDING REMARKS

Open banking mandates force incumbents to expose an asset they once treated as proprietary: consumer transaction data. The competitive consequence — that FinTechs and non-financial brands can now assemble financial services without the informational disadvantage that historically constrained their market penetration — is well understood theoretically. What has been absent is panel evidence on how API adoption affects the full profile of bank performance outcomes simultaneously, and how these effects vary across the bank size distribution. The OBCDF framework proposed here decomposes the competitive dynamic into four layers: data access, platform development, competitor response, and performance outcomes. The staggered DiD estimation finds that API adoption raises third-party provider connections by 7.2 per quarter, increases non-interest income share by 0.62 percentage points, and contracts deposit market share by 0.29 percentage points. These effects are heterogeneous: large banks extract the most TPP connections from early adoption, mid-tier banks bear the sharpest deposit competitive pressure, and small banks achieve the highest proportional NII uplift per additional TPP connection. The practical implication is that bank response to open banking mandates should be platform-strategic rather than compliance-minimal. Banks that invest in API documentation quality, developer sandboxes, and BaaS partnership programmes capture the fee income that the platform layer generates; banks that merely meet the regulatory floor — exposing read-only APIs with minimal developer support — forgo that income while still bearing the deposit competitive risk when rivals do the same. Policymakers designing open banking regimes for jurisdictions beyond PSD2's reach should account for the disproportionate burden on small banks, who face the largest compliance cost-to-benefit ratio in the current regulatory architecture. Future research should extend the OBCDF's empirical scope to consumer data-sharing behaviour — integrating the consent-rate mechanism of Layer 1 with the platform outcomes of Layers 2–4 — and to the welfare effects of BaaS-enabled embedded finance on consumers in underserved demographic segments [3, 4, 7].

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