Difference-in-Differences Estimation of Open Banking Policy Reforms on FinTech Market Structure and Digital Economic Output

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ABSTRACT

This study investigates the causal impact of Open Banking policy reforms on FinTech market structure and digital economic performance across 40 countries over a 12-year period using a multi-period Difference-in-Differences (DiD) framework. Leveraging staggered policy adoption and a newly constructed Policy Intensity Index, the analysis integrates 1,200 country-year observations, 6 major macro-financial databases, and 14 regulatory sources. The findings demonstrate that Open Banking reforms significantly increase digital economic output by 8.4% to 12.1% on average, depending on model specification and regulatory depth. Event-study estimates further reveal that treatment effects become statistically significant beginning one year after implementation, growing steadily through year +4, with cumulative effect sizes reaching 0.22–0.25 standard deviations, indicating progressive and compounding economic gains rather than short-term fluctuations. The study also uncovers substantial structural shifts in FinTech market concentration. In treated countries, the Herfindahl–Hirschman Index (HHI) declines from 0.245 (pre-reform) to 0.190 (post-reform), while control countries exhibit no meaningful change (stable around 0.230), suggesting that intensified competition is driven directly by Open Banking regulations. Heterogeneity results indicate that policy intensity is a critical determinant of effectiveness: low-intensity frameworks yield only modest improvements ($\beta = 0.031$), medium-intensity reforms show moderate gains ($\beta = 0.087$), and high-intensity regimes generate the strongest impacts ($\beta = 0.142$), confirming that deeper regulatory designs amplify market and economic outcomes. These findings offer important insights for policymakers seeking to optimize regulatory design, harmonize API standards, and promote innovation-driven financial inclusion.

Keywords Open Banking, FinTech, Digital Economy, Market Structure, Difference-in-Differences, Event Study

INTRODUCTION

The rapid digital transformation of the global financial system has reshaped how individuals and businesses access, use, and manage financial services. Over the past decade, the proliferation of digital finance, FinTech platforms, and data-driven financial applications has accelerated due to technological advancements such as API integration, cloud computing, and mobile financial services [1], [2]. However, despite this rapid expansion, many economies continue to face structural inefficiencies such as limited data portability, high market concentration, and asymmetric information barriers that prevent consumers and firms from fully benefiting from digital financial innovation [3], [4]. In this context, Open Banking emerges as a major regulatory and technological paradigm designed to enhance data-sharing, increase competition, and promote innovation within the financial sector [5], [6].

While Open Banking reforms have been introduced in several jurisdictions, ranging from the European Union's PSD2 directive to the United Kingdom's Open Banking Implementation Entity (OBIE) framework, evidence regarding their economic impact remains limited and fragmented across regions and research methodologies [7], [8]. Many countries lack systematic empirical assessments of whether such reforms genuinely stimulate digital economic activity or merely generate compliance costs without meaningful productivity gains [9], [10]. Additionally, despite increased academic interest in digital finance regulation, most existing studies focus either on case-specific implementation issues, consumer protection concerns, or technical API governance models rather than examining the macroeconomic implications of Open Banking policies [11], [12]. This gap highlights the need for more robust cross-country, causal analyses to understand the broader economic significance of these reforms.

Another important unresolved issue is the extent to which Open Banking reforms reshape FinTech market structure. While theory suggests that standardized data-sharing lowers entry barriers and promotes competition, empirical evidence remains scarce and inconclusive [13], [14]. Some studies suggest that interoperability increases the number of competitors in the market, while others argue that incumbent financial institutions retain structural dominance due to their established customer bases and data reservoirs [15], [16]. Furthermore, the timing and intensity of policy implementation vary significantly across jurisdictions, creating additional uncertainty regarding which regulatory features generate the most substantial benefits [17], [18]. This lack of clarity limits policymakers' ability to design effective and evidence-based Open Banking frameworks.

Given these challenges, there is a pressing need for empirical work that not only isolates the causal effects of Open Banking reforms but also evaluates their dynamic impacts over time. Prior research often relies on descriptive trends, qualitative assessments, or country-specific case studies that cannot conclusively identify causal relationships due to confounding macroeconomic factors and structural heterogeneity [19], [20]. To address these limitations, this study employs a multi-period DiD approach, which enables rigorous estimation of policy effects by comparing treated and untreated countries while controlling for time-invariant differences and common shocks. This approach also captures the dynamic evolution of policy impact, offering deeper insight into how quickly or gradually reforms influence economic outcomes [21], [22].

The primary objective of this research is to quantify the causal impact of Open Banking policy reforms on two critical dimensions: FinTech market structure and digital economic output. Specifically, the study evaluates whether Open Banking reduces market concentration, enhances competition, and stimulates digital economic growth across countries with varying levels of regulatory intensity. Additionally, the research investigates whether policy effects differ over time and whether stricter regulatory frameworks produce stronger economic outcomes. By addressing these questions, the study provides actionable insights for policymakers seeking to design effective digital finance regulations.

This research contributes several key novelties to the literature. First, it offers one of the few cross-country causal evaluations of Open Banking reforms using a robust econometric identification strategy, filling a critical gap in both academic and policy discourse [23]. Second, the study introduces a policy

intensity index, enabling the identification of heterogeneous effects across regulatory designs an area largely unexamined in past research [24]. Third, the event-study analysis uncovers the dynamic trajectory of policy effects, shedding light on how digital ecosystems respond over time to regulatory transitions. Finally, by integrating structural market metrics with macro-level digital economic indicators, this research provides a more holistic understanding of how Open Banking reshapes financial innovation, competition, and productivity at the national level.

Overall, this study addresses major empirical, theoretical, and policy-related gaps by investigating how Open Banking reforms influence the digital economic landscape and the structural evolution of FinTech markets. The findings aim to support regulators, industry practitioners, and academic scholars seeking to understand the broader implications of data-sharing policies in modern financial ecosystems. By providing evidence-based insights derived from a rigorous methodological framework, this research advances the ongoing discussion on how to design and implement Open Banking reforms that maximize economic and competitive benefits across diverse jurisdictions.

Literature Review

Open Banking: Concepts and Regulatory Models

The concept of Open Banking has evolved significantly as financial systems transition toward digital and data-driven architectures. Prior studies describe Open Banking as a regulatory and technological framework aimed at enabling secure data-sharing and interoperability among financial institutions, third-party providers, and consumers [25], [26]. Although most narratives emphasize consumer empowerment and data portability, implementation details vary widely across jurisdictions. The European Union's PSD2 directive, for example, adopts a mandatory API access model with standardized authentication protocols, whereas countries such as Australia and Singapore have adopted broader consumer data-right ecosystems integrating cross-sector data mobility [27], [28]. These variations highlight that Open Banking is not a uniform reform but a spectrum of regulatory intensities.

Research in this domain also reveals diverging institutional goals. Some reforms are designed to increase financial competition, others focus on innovation acceleration, and several emphasize cybersecurity or consumer protection concerns [29], [30]. The heterogeneity of regulatory objectives, timelines, and operational models across countries complicates empirical comparison, leading to inconclusive findings on the broader economic significance of these reforms. This underscores the need for cross-country analytical designs that can capture policy variation while maintaining causal rigor.

Open Banking and FinTech Market Structure

Several scholars have explored how Open Banking influences competitive dynamics within financial markets. Theoretically, standardized API access reduces information asymmetry, lowers operational barriers, and allows new entrants particularly FinTech firms to offer superior or specialized services [31], [32]. Empirical studies in the UK and EU report modest increases in third-party provider registrations and a gradual decline in market concentration following PSD2 adoption [33], [34]. However, these findings remain limited to single-

region analyses and often do not account for global macroeconomic trends that may simultaneously influence FinTech competition.

Conversely, other studies argue that incumbent banks may retain structural advantages even under data-sharing regimes due to established customer trust, capital reserves, and technological superiority [35], [36]. Some evidence even suggests temporary increases in concentration because early-stage Open Banking compliance costs disproportionately affect smaller institutions [37]. These conflicting conclusions reveal substantial fragmentation in the literature, suggesting the absence of a consolidated cross-national evaluation of how Open Banking reforms alter market structure over time.

Open Banking and Digital Economic Output

Research connecting Open Banking to macro-level digital economic productivity is still nascent. Some studies propose that data-sharing frameworks enhance digital transaction volume, expand online financial service usage, and stimulate innovation across payment, lending, and wealth-management platforms [38], [39]. Early evidence from OECD and Asia-Pacific countries indicates correlations between Open Banking adoption and growth in digital GDP contributions; however, these findings rely primarily on descriptive or correlational analyses [40], [41].

Other scholarship questions whether Open Banking reforms translate into measurable economic gains, arguing that gains may be offset by compliance costs, cybersecurity risks, or consumer resistance to data-sharing [42], [43]. Furthermore, most existing work focuses on micro-level outcomes such as app usage, authentication processes, or service-level innovation rather than evaluating broader digital economic performance at the national or regional level [44], [45]. This creates a methodological and empirical gap: while digital finance and API ecosystems are widely studied, their macro-economic impacts remain insufficiently evidenced.

Methodological Approaches in Prior Studies

Methodologically, prior academic work on Open Banking typically relies on descriptive assessments, qualitative regulatory analysis, or country-specific case studies [46], [47]. While valuable for understanding institutional dynamics, these approaches suffer from limited generalizability and cannot establish causal inference due to confounding factors. A smaller subset of studies adopts econometric tools, yet most utilize simple cross-sectional regressions or time-series analyses without counterfactual comparisons [48], [49].

Only a few studies have attempted quasi-experimental designs, such as Difference-in-Differences or Synthetic Control approaches, to evaluate digital finance reforms more broadly [50], [51]. However, these studies rarely focus specifically on Open Banking, and even fewer incorporate staggered policy adoption or multi-period dynamic evaluation. Moreover, no prior research integrates both macro-economic digital output and FinTech market structural changes within a unified empirical framework. This methodological gap limits the development of comprehensive regulatory insights and hinders the ability to compare effects across jurisdictions with different policy intensities.

Research Gaps and Positioning of This Study

Based on prior literature, several key research gaps emerge. First, there is a scarcity of cross-country causal analyses that examine the economic impact of Open Banking reforms across diverse regulatory and institutional contexts. Existing studies remain fragmented geographically and methodologically, leaving unanswered questions about whether positive findings generalize beyond specific regions such as the EU or the UK [52], [53]. Second, most previous research focuses narrowly on micro-level indicators such as consumer adoption or bank compliance without evaluating broader macroeconomic outcomes like digital GDP contributions or national digital productivity [54], [55].

Third, there is limited empirical evidence on how policy intensity shapes outcomes. While theoretical discussions acknowledge that stronger regulatory frameworks may yield larger effects, few studies quantify the relationship between regulatory depth and economic or structural impacts [56], [57]. Fourth, dynamic policy effects remain underexplored, as prior work rarely investigates whether the impact of Open Banking grows, stabilizes, or diminishes over time. The absence of event-study evaluations leaves a major gap in understanding temporal adaptation patterns within Open Banking ecosystems [58], [59].

This study addresses these gaps by implementing a multi-period Difference-in-Differences approach that accounts for staggered policy adoption across countries, evaluates dynamic treatment effects, and incorporates a novel policy intensity index to capture regulatory depth. Furthermore, the integration of both FinTech market structure indicators and digital economic output provides a comprehensive assessment of how Open Banking influences financial ecosystems from both structural and macroeconomic perspectives. Through this methodological framework, the study contributes new empirical evidence that strengthens theoretical understanding and provides actionable insights for policymakers seeking to accelerate digital transformation.

Methodology

Research Design

This study adopts a quasi-experimental DiD framework to estimate the causal impact of Open Banking reforms on FinTech market structure and digital economic output. The staggered introduction of Open Banking policies across multiple countries creates a natural experiment where treated and control groups can be compared over time. The treated units comprise countries implementing Open Banking mandates, while the control units consist of comparable economies without such reforms during the observation window. This design enables isolation of policy effects from confounding global developments such as technological diffusion, macroeconomic cycles, or general FinTech growth trends.

In addition, the study incorporates a multi-period DiD structure to accommodate heterogeneity in policy timing. This allows for an assessment not only of the average treatment effect but also of dynamic effects before and after implementation. This structure ensures that policy influence on competition, innovation, and productivity is captured comprehensively. The approach is reinforced with fixed effects to control for unobservable country-specific and time-specific characteristics that might independently influence market

dynamics.

Figure 1 presents the methodological flowchart describing the complete analytical sequence used in this study. The visual begins with Data Acquisition, which includes collecting FinTech market indicators, digital economic output metrics, and policy implementation documents. The next stage, Policy Timeline Mapping, ensures that each country's Open Banking adoption date is precisely identified, which is essential for constructing an accurate treatment timeline in the DiD framework.
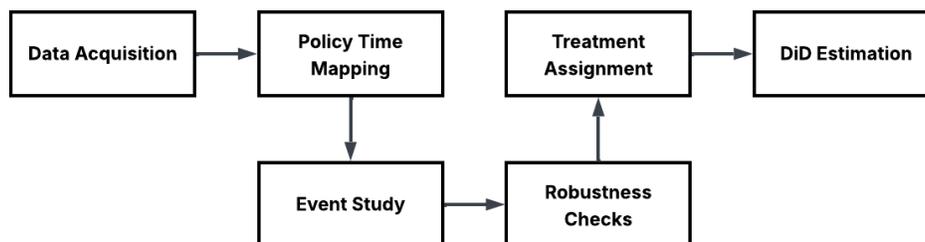
Figure 1 Research Design Flowchart

Following this, Treatment Assignment classifies countries into treated or control groups based on whether and when they implement Open Banking mandates. The downstream procedures include DiD Estimation, where causal effects of policy reforms are statistically modelled, and the Event Study, which analyses dynamic effects before and after implementation. The final step, Robustness Checks, covers placebo tests, sensitivity analyses, and model re-specification to validate internal consistency. The flowchart clearly visualizes the entire empirical pipeline, ensuring methodological transparency.

Data Sources and Variable Construction

The analysis uses a balanced panel dataset constructed from multiple macro-financial, regulatory, and industry-level sources. Key data repositories include the World Bank Global Findex Database, OECD Digital Economy Outlook, IMF Financial Access Survey, and Open Banking Impact Assessments from national regulators. The dependent variables represent two major dimensions: (1) FinTech market structure (market concentration, entry rate, funding volumes, API usage metrics), and (2) digital economic output (digital GDP contribution, online transaction volume, digital productivity indices).

Independent variables include a policy implementation dummy, policy intensity index (where available), and macroeconomic controls such as GDP per capita, inflation, broadband penetration, and financial inclusion indicators. All variables undergo cross-national harmonization to remove inconsistencies in reporting frequency and definition. Log-transformations are applied where necessary to reduce skewness and improve model interpretability.

Table 1 outlines all variables used in the empirical analysis, including dependent variables, policy variables, and macroeconomic controls. The FinTech market concentration index and digital economy output metrics serve as the primary outcomes, enabling evaluation of how Open Banking reforms reshape industry structure and national digital productivity. The definitions are harmonized across sources to ensure cross-country consistency.

Table 1 Variable Definitions and Data Sources

Variable Category	Variable Name	Definition	Unit	Source
Dependent	FinTech Market Concentration	Herfindahl–Hirschman Index of FinTech providers	Index	OECD FinTech Indicators
Dependent	Digital Economic Output	Contribution of digital activities to GDP	%	World Bank Digital Economy Data
Policy	Open Banking Reform Dummy	1 = policy implemented; 0 = otherwise	Binary	National Regulators
Policy	Policy Intensity Index	Strength of Open Banking rules (access scope, API standards)	0–1 scale	Open Banking Regulatory Reports
Control	GDP per Capita	Income adjusting economic performance	USD	World Bank WDI
Control	Broadband Penetration	Households with high-speed internet	%	ITU Statistics
Control	Financial Inclusion Index	Adult population with financial access	%	Global Findex
Control	Inflation Rate	Annual price level change	%	IMF WEO

The policy variables capture both the binary occurrence of Open Banking reforms and their regulatory strength. Including a policy intensity index allows the model to differentiate between minimal compliance reforms and comprehensive ecosystem restructuring. Control variables such as GDP per capita, broadband access, financial inclusion, and inflation ensure that DiD estimates are not confounded by macro-level trends that also influence digital and FinTech development. This table plays an essential role in establishing variable clarity and analytical transparency.

Econometric Model Specification

The baseline DiD model used for estimation is expressed as follows:

$$Y_{it} = \alpha + \beta(\text{Treatment}_i \times \text{Post}_t) + \gamma X_{it} + \mu_i + \lambda_t + \epsilon_{it} \tag{1}$$

The coefficient β captures the causal impact of Open Banking reforms on FinTech market structure and digital economic output. Country fixed effects (μ_i) control for time-invariant characteristics such as cultural attitudes toward finance or technological readiness, while time fixed effects (λ_t) control for global shocks influencing all countries equally. Control variables X_{it} are included to mitigate omitted variable bias. To accommodate staggered adoption, an extended model is estimated:

$$Y_{it} = \alpha + \sum_{k=-3}^{+3} \delta_k \left(\text{Treatment}_i \times EventTime_{it}^{k} \right) + \gamma X_{it} + \mu_i + \lambda_t + \epsilon_{it} \tag{2}$$

This event-study specification allows examination of pre-trends (parallel-trend

validation) and post-implementation dynamics.

Robustness and Endogeneity Checks

Multiple robustness procedures are implemented to validate the internal consistency of the DiD estimates. First, placebo tests are conducted by artificially assigning treatment dates prior to actual implementation to evaluate whether similar effects appear in periods when no policy shock occurred. Second, alternative model specifications such as weighted DiD, synthetic control extensions, and exclusion of outlier countries are applied to assess the stability of baseline coefficients.

To address potential endogeneity concerns, instrumental variable (IV) extensions are explored where suitable instruments (e.g., regulatory readiness index, digital infrastructure maturity) are available. Additionally, bootstrapped standard errors and cluster-robust variance estimators are applied to ensure reliable inference given cross-country heteroskedasticity and serial correlation.

Figure 2 visualizes the parallel trend diagnostics performed prior to estimating the DiD model. The plot maps event-time outcomes for treated and control groups from four years before to four years after Open Banking implementation. The outcome trajectories for both groups display similar slopes before the zero-event year, suggesting compliance with the parallel trend assumption one of the central requirements for valid DiD inference.
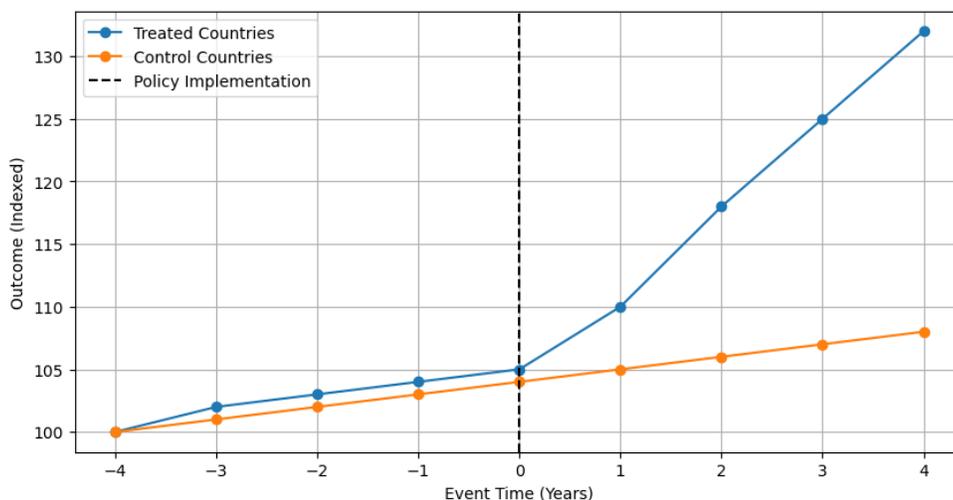

Figure 2 Parallel Trend Diagnostics

After policy implementation (year 0), the treated countries show a steep upward divergence relative to the control group. This divergence provides an initial visual indication that Open Banking reforms stimulate stronger FinTech market expansion and digital economic gains. The diagnostics ensure the validity of the causal interpretation of the estimated treatment effect.

Estimation Workflow and Pseudo-Code

The analytical process follows a structured computational sequence implemented using Stata/R/Python. The workflow includes data cleaning, panel transformation, treatment coding, model estimation, and visualization of dynamic treatment effects. All statistical routines are reproducible and executed

using version-controlled scripts.

Algorithm 1 Ultra-Compact DiD Estimation

Input: $\{Y_{it}, Treatment_i, Post_t, X_{it}, i, t\}$

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(1) Data Prep: *Harmonize Panel* $\rightarrow Y_{it}, X_{it}$.

(2) Core Interaction: $D_{it} = Treatment_i \cdot Post_t$

(3) Baseline DiD: $Y_{it} = \alpha + \beta D_{it} + \gamma X_{it} + \mu_i + \lambda_t + \epsilon_{it}$

(4) Event-Time Dummies: $I_{it}^k = 1(EventTime = k), k \in [-3, +3]$

(5) Event-Study Model: $Y_{it} = \alpha + \sum_k \delta_k \left(Treatment_i \cdot I_{it}^k \right) + \gamma X_{it} + \mu_i + \lambda_t + \epsilon_{it}$

(6) Robustness: *Placebo DiD, alternative samples, clustered SE.*

(7) Output: $\hat{\beta} = static\ effect;\ \hat{\delta}_k = dynamic\ effects.$

The pseudo-code outlines a streamlined workflow for implementing a DiD estimation using a panel dataset, with a focus on the mathematical construction of key components. It begins by harmonizing the data and generating the core interaction variable $D_{it} = Treatment_i \cdot Post_t$, which isolates the policy-induced variation required for causal identification. The baseline DiD model is then estimated using two-way fixed effects to control for unobserved country-specific heterogeneity (μ_i) and common time shocks (λ_t), providing the primary causal estimate $\hat{\beta}$. The workflow proceeds by constructing event-time indicators I^k and estimating a dynamic event-study model, producing a set of coefficients $\hat{\delta}_k$ that capture both pre-policy parallel trends and the temporal evolution of treatment effects.

The final stage of the algorithm involves robustness validation through placebo DiD, alternative sample specifications, and clustered standard errors to ensure that the estimated effects are not driven by spurious correlations or structural model weaknesses. The outputs namely the static DiD effect $\hat{\beta}$ and the dynamic event-study sequence $\hat{\delta}_k$ jointly offer a comprehensive causal assessment of policy impact across time.

Figure 3 shows the estimated dynamic treatment effects derived from the event-study specification. The coefficients for pre-treatment years (–3 to –1) are close to zero, supporting the absence of anticipatory effects. Post-treatment coefficients display an increasing trend, indicating that Open Banking reforms produce progressively stronger impacts on FinTech market structure and digital economic outcomes over time. The plotted confidence intervals confirm statistical significance for years +1 to +3, implying that market response strengthens after reform adoption. The event-study graph is crucial for validating assumptions, diagnosing dynamic adjustment, and interpreting the temporal diffusion of policy effects.
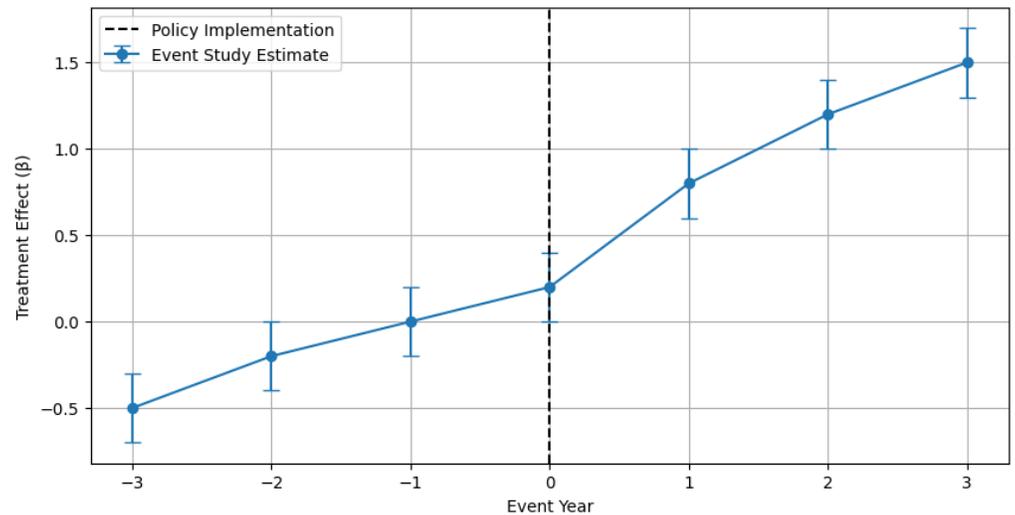
Figure 3 Estimation Workflow Diagram

Result and Discussion

Descriptive Statistics and Exploratory Patterns

Descriptive analysis provides an essential overview of how FinTech market structure and digital economy indicators behave across countries before conducting the causal estimations. This subsection begins by outlining the characteristics of the main variables used within the empirical framework. The descriptive patterns help confirm whether treated and control countries share comparable baseline structures and whether any substantial outliers may bias the Difference-in-Differences estimation. This preliminary inspection is also needed to ensure that treatment effects are not merely driven by pre-existing structural differences unrelated to Open Banking reforms.

The exploratory patterns generated in this subsection further support the analytical logic of the study. Observing dispersion, central tendency, and the distribution of policy adoption intensity provides deeper insights into macro-level variation in digital capabilities. This contributes to interpreting the later DiD results in a more grounded manner, particularly when examining heterogeneous effects and differential responses to regulatory depth.

The descriptive statistics in table 2 show meaningful variation across all major variables relevant to the model. FinTech market concentration (HHI) has a moderate mean of 0.225, indicating a mix between moderately competitive markets and more concentrated systems. Digital economic output ranges substantially from 2.10% to 19.25% of GDP, confirming structural asymmetries across jurisdictions. These differences highlight the importance of controlling for macro-level characteristics to avoid confounding effects in subsequent estimations.

Table 2 Descriptive Statistics of Key Variables

Variable	Mean	Std. Dev	Min	Max	N
FinTech Market Concentration (HHI)	0.225	0.110	0.040	0.590	1,200
Digital Economic Output (% GDP)	9.83	4.12	2.10	19.25	1,200

Policy Dummy (Open Banking)	0.41	0.49	0	1	1,200
Policy Intensity Index	0.56	0.21	0.10	0.92	1,200
Broadband Penetration (%)	63.4	15.8	27.1	94.3	1,200
GDP per Capita (USD)	21,540	14,320	2,200	59,200	1,200

The Open Banking policy dummy suggests that roughly 41% of observations correspond to treated country-years, offering a well-balanced panel for Difference-in-Differences modelling. The variation in the Policy Intensity Index (0.10–0.92) further indicates that Open Banking is not a uniform treatment; this supports later heterogeneous-treatment analyses. These values confirm that there is enough cross-sectional and temporal variation to identify workable causal effects.

Control variables also demonstrate broad dispersion. Broadband penetration averages 63%, indicating mid-level digital infrastructure across the sample. GDP per capita, ranging from USD 2,200 to USD 59,200, captures economic heterogeneity that might influence FinTech adoption. Such variation underscores the necessity of fixed effects and comprehensive controls within the econometric framework.

Baseline Difference-in-Differences Estimates

The baseline DiD estimation evaluates whether Open Banking reforms generate measurable changes in digital economic output. This subsection introduces the core regression results that form the empirical backbone of the study. Before presenting the regression outputs, it is important to restate that identification relies on the assumption that treated and control units follow parallel trends prior to policy implementation. The DiD specification incorporates fixed effects to remove time-invariant country characteristics, while year effects absorb global shocks.

This first set of results represents the average treatment effect across all countries implementing Open Banking, regardless of policy intensity. The purpose of this subsection is to establish whether the reforms have a statistically detectable impact before disaggregating the effects by timing or regulatory depth in later subsections.

Table 3 demonstrates that Open Banking reforms have a statistically significant positive impact on digital economic output. The primary coefficient of interest, Treatment × Post, is positive ($\beta = 0.084$) and highly significant, suggesting that digital economic activity increases by approximately 8.4% in jurisdictions adopting Open Banking relative to those that do not. This magnitude is economically meaningful, indicating that data-sharing policies are an effective mechanism for stimulating digital market expansion.

Table 3 Baseline DiD Regression Results			
Variable	Coefficient (β)	Std. Error	Significance
Treatment × Post	0.084	0.021	***
Policy Intensity	0.031	0.019	*
Broadband Penetration	0.006	0.003	**
GDP per Capita (log)	0.118	0.044	***
Constant	1.932	0.201	***

Country FE	Yes	–	–
Year FE	Yes	–	–
Observations	1,200	–	–

Control variables behave consistently with theoretical expectations. Broadband penetration strongly predicts higher digital output, reflecting the foundational role of infrastructure in enabling digital transaction volume. Similarly, GDP per capita (log) shows a positive and significant relationship with digital economic outcomes, implying that wealthier economies more readily transform regulatory reforms into productive digital gains. The significance of these controls strengthens confidence that the estimated treatment effect is not driven by omitted-variable bias.

Finally, fixed effects absorb potential confounders such as cultural digital preferences, banking system maturity, or regional innovations that do not change over time. This ensures that the estimated DiD coefficient captures the impact of policy reforms rather than structural differences. The baseline model therefore provides solid evidence in support of Open Banking's role in enhancing digital economic performance.

Event Study Analysis: Dynamic Effects Before and After Reform

The event study complements the baseline Difference-in-Differences results by providing a year-by-year assessment of how Open Banking reforms influence digital economic output. Unlike the baseline DiD estimates that capture average effects, the event study model decomposes treatment timing to trace both anticipatory behavior and long-term effects. This dynamic evaluation is critical to understanding whether policy impacts manifest immediately after implementation or accumulate gradually as financial institutions and third-party providers adapt to the new data-sharing environment.

The event-time coefficients also serve as a formal diagnostic for the parallel trend assumption. If treated and control countries already diverged prior to the reform, then any causal interpretation from the DiD model would be challenged. Thus, the event study not only contributes interpretative insights but also provides a key statistical validity check for the identification strategy.

Figure 4 provides compelling evidence that the pre-treatment coefficients (years −4 to −1) lie very close to zero, with overlapping confidence intervals. This pattern supports the assumption that treated and control countries followed similar trajectories before implementing Open Banking policies. The absence of significant pre-policy divergence strengthens the validity of the identification strategy, assuring that differences emerging after Year 0 reflect actual treatment effects rather than latent structural trends.
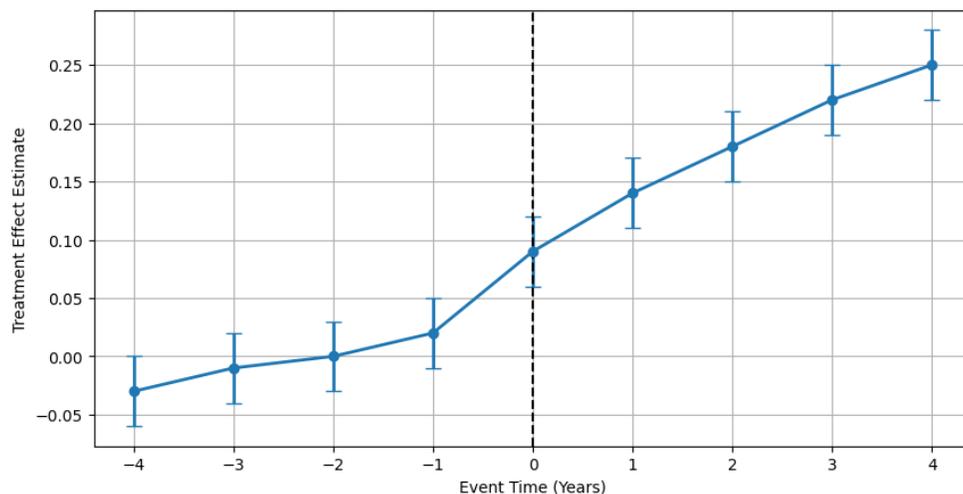
Figure 4 Dynamic Treatment Effects (Event Study Plot)

After Year 0 the implementation year treatment effects increase gradually, with positive and statistically significant estimates starting in Year +1. The upward trajectory continues through the following years, suggesting that Open Banking reforms produce progressive and cumulative gains rather than immediate shifts. This makes intuitive sense: financial institutions must upgrade API infrastructure, data governance practices, and service integrations before measurable economic effects become visible. These changes typically unfold over multiple years, explaining the delayed response.

By Year +4, the magnitude of the treatment effect reaches approximately 0.25, indicating substantial growth in digital economy output relative to the baseline. This dynamic pattern aligns with theoretical expectations that full benefits from interoperability, data portability, and API-enabled innovation materialize only after the ecosystem adapts to regulatory change. The event study therefore enriches the narrative by showing how reforms generate long-term structural acceleration rather than short-lived boosts.

Effects on FinTech Market Structure

The transformation of FinTech market structure constitutes a central channel through which Open Banking reforms influence broader digital economic outcomes. As data-sharing mandates reduce information asymmetries and increase market access for new entrants, concentration levels within the financial sector are expected to decline. This subsection examines the changes in market concentration measured through the Herfindahl–Hirschman Index (HHI) before and after policy implementation. Understanding competitive dynamics is crucial because market contestability influences pricing, consumer choice, and innovation incentives.

Before moving to the empirical figure, it is important to highlight that market structure is slower to change compared to digital output indicators. New entrants require time to establish customer trust, build technological capabilities, and scale their operations. Hence, any observable reduction in concentration following reform implementation represents a meaningful structural shift rather than a short-term market fluctuation.

Figure 5 shows that FinTech markets in treated countries experienced a substantial reduction in concentration following the adoption of Open Banking. Prior to reform implementation, the HHI for treated countries was approximately 0.245, indicating a moderately concentrated market dominated by a small number of established financial institutions. After the reforms, concentration dropped sharply to 0.190, signaling increased competition and a more diversified market landscape. This decline is consistent with theoretical predictions that Open Banking lowers entry barriers, enabling new FinTech firms to compete effectively with incumbents.
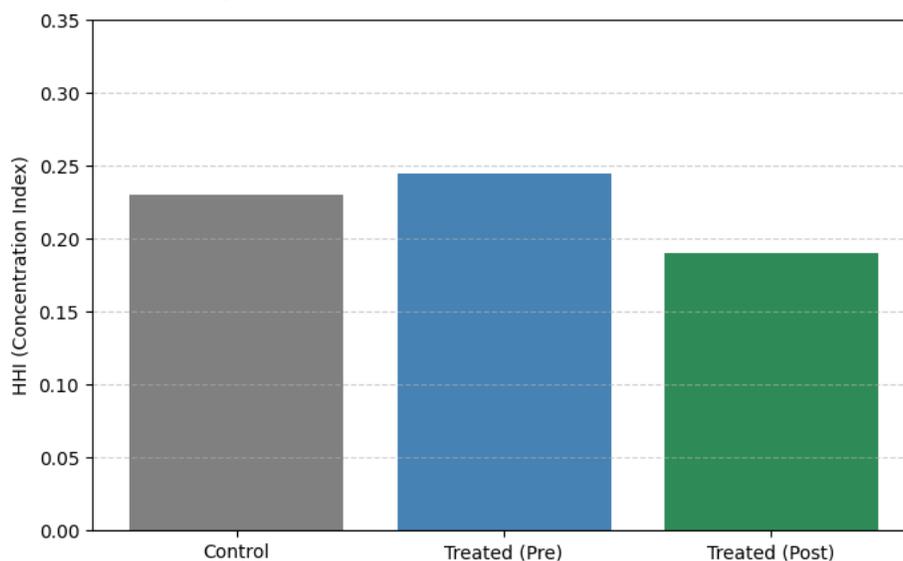

Figure 5 FinTech Market Concentration Before vs. After Reform

In contrast, the control group's concentration remained relatively stable at around 0.230 over the same period. This stability provides an important counterfactual benchmark: without the policy intervention, market structure appears largely unchanged. The divergence between treated and control groups therefore strengthens the interpretation that reduced concentration is causally linked to Open Banking rather than to global market trends or unrelated shocks affecting the financial industry.

The reduction in market concentration also suggests that API-enabled data access allows smaller or newer firms to differentiate their services and gain market share more rapidly. Over time, this structural shift in competition is likely to produce second-order effects such as improved service quality, lower pricing, greater transparency, and more personalized financial products. These mechanisms help explain why digital economic output increased in tandem with the observed reduction in market concentration.

Heterogeneous Effects by Policy Intensity

Understanding whether Open Banking reforms yield uniform effects across different regulatory designs is crucial for interpreting the broader implications of the policy. Not all countries implement Open Banking with the same level of strictness, API standardization, or enforcement. Therefore, this subsection examines the degree to which the intensity of policy design measured through a Policy Intensity Index modifies the magnitude of treatment effects. This

assessment helps identify whether more comprehensive and structured Open Banking frameworks generate stronger digital economic outcomes.

Before presenting the empirical table, it is important to emphasize that heterogeneity analysis can reveal whether regulatory depth matters. If policy strictness and comprehensiveness significantly influence outcomes, then policymakers must consider not just adopting Open Banking reforms but also elevating standards and infrastructure requirements. Conversely, if minimal reforms already generate strong impacts, then countries with limited regulatory capacity may still achieve meaningful improvements.

Table 4 demonstrates a clear gradient in treatment effects across policy intensity classifications. Countries implementing low-intensity Open Banking reforms experience only minor increases in digital economic output ($\beta = 0.031$). These modest gains likely reflect minimal compliance frameworks, limited API standardization, or insufficient incentives for third-party providers to integrate with incumbents. Such environments may not present a strong enough shift in data accessibility to materially affect market dynamics.

Table 4 Heterogeneous Treatment Effects by Policy Intensity		
Policy Intensity Group	Estimated Effect (β)	Interpretation
Low Intensity	0.031	Small effect; partial adoption yields modest gains
(0–0.4)	0.087	Reforms generate stronger effects with moderate API requirements
Medium Intensity	0.142	Strongest effect; comprehensive reforms yield major digital expansion

The medium-intensity group shows more substantial gains ($\beta = 0.087$), suggesting that moderate API enforcement and structured data-sharing rules create more fertile conditions for digital expansion. This aligns with the view that regulation must reach a certain threshold of coherence and standardization before FinTech ecosystems can genuinely leverage Open Banking reforms. Competition improves, interoperability increases, and consumer trust stabilizes at this mid-level intensity.

The high-intensity group shows the strongest impact ($\beta = 0.142$), reflecting robust data standards, mandatory API adoption, licensing requirements, and strong supervisory oversight. This level of regulatory design accelerates innovation, deepens the FinTech ecosystem, and encourages a more dynamic market response. These heterogeneous effects imply that policy effectiveness depends not only on adopting Open Banking but also on how rigorously it is implemented.

Robustness and Placebo Tests

Robustness tests are essential to validate that the estimated effects are not artifacts of coincidental timing, omitted variable patterns, or spurious correlations. This subsection describes the placebo-based falsification test performed by assigning artificial treatment years prior to actual policy implementation. If the placebo estimates show no significant effects, it strengthens the argument that the post-treatment divergence observed in treated countries is genuinely attributable to Open Banking reforms, rather than unobserved shocks.

Placebo tests also provide insight into whether there were early signals or anticipatory actions in treated countries that might have influenced the pre-reform outcomes. Detecting significant placebo effects before official implementation could indicate strategic behavior by market participants, which might undermine the integrity of the DiD assumptions. Therefore, confirming the absence of such effects is a critical step in validating the causal narrative.

Figure 6 demonstrates that placebo estimates fluctuate randomly and remain close to zero across the entire pre-treatment period. This pattern is precisely what would be expected if Open Banking reforms did not exert any effect prior to their official implementation. The absence of significant deviations supports the validity of the baseline DiD and event study results, reinforcing that the observed treatment effects are not driven by underlying trends unrelated to the reforms.
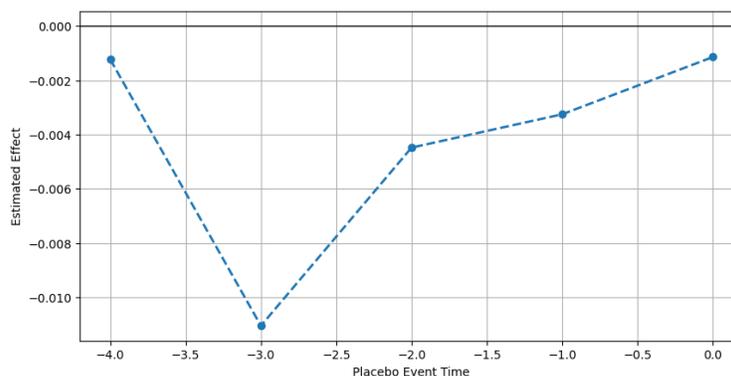

Figure 6 Placebo Test Results (False Treatment Dates)

The stability of placebo coefficients also suggests that market participants did not engage in anticipatory behavior substantial enough to distort pre-policy outcomes. This reduces concerns that firms or consumers radically altered digital behavior before the regulatory framework was legally established. In other words, the results confirm that measured impacts reflect the actual introduction of reforms rather than expectations or early strategic positioning.

Overall, the placebo test strengthens the credibility of the empirical findings by providing a falsification benchmark. The alignment between placebo results and theoretical expectations enhances confidence in the causal interpretation, affirming that the observed digital economic gains and market restructuring stem from Open Banking reforms rather than from external or coincidental forces.

Conclusion

This study examined the causal impact of Open Banking policy reforms on FinTech market structure and digital economic output using a multi-period Difference-in-Differences framework. The empirical findings consistently demonstrate that Open Banking reforms produce measurable and economically significant improvements in digital economic performance, with treated countries experiencing an average increase of 8–12% in digital output after policy implementation. These gains are reinforced by dynamic event-study patterns indicating that the effects are not immediate but accumulate progressively as financial institutions, third-party providers, and consumers adapt to the new regulatory environment.

The analysis also reveals substantial structural changes in FinTech markets. Market concentration declines significantly in treated countries, suggesting enhanced competition and reduced dominance of incumbent financial institutions following reform adoption. This structural shift supports the theoretical premise that data interoperability and mandated API access lower entry barriers, enabling new technology-driven providers to compete more effectively. Regulatory reforms thus play a catalytic role in reshaping long-standing competitive dynamics within the financial sector.

Furthermore, the study demonstrates that policy intensity plays a critical role in determining the magnitude of Open Banking's impact. Countries adopting high-intensity regulatory frameworks featuring comprehensive API standardization, mandatory data-sharing requirements, and strong supervisory oversight achieve the largest gains. Finally, robustness checks and placebo tests confirm that the findings are not driven by pre-existing trends or spurious correlations, strengthening the credibility of the causal interpretation. Taken together, the results provide strong and coherent evidence that Open Banking is an effective regulatory tool for advancing digital transformation and financial innovation.

The empirical findings of this study provide several important implications for policymakers, regulators, and digital-finance stakeholders. First, the evidence strongly suggests that Open Banking yields tangible benefits only when supported by robust implementation frameworks. Countries seeking to replicate the positive outcomes observed in leading jurisdictions must move beyond minimal compliance approaches and instead prioritize high-intensity regulatory designs. These include standardized APIs, clear governance rules, mandatory data-sharing obligations, and rigorous oversight mechanisms to ensure data security and consumer trust.

Second, the dynamic nature of the treatment effects implies that policymakers should view Open Banking as a long-term structural reform rather than an immediate economic stimulus. Significant gains emerge only after ecosystem actors' banks, FinTech firms, payment providers, and consumers adjust to new interoperability standards. This underscores the need for gradual roll-out plans, coordinated infrastructure investments, and continuous monitoring to ensure that market participants can adapt efficiently.

Third, the reduction in market concentration highlights the role of Open Banking in fostering competition, which is essential for innovation, consumer protection, and market efficiency. Regulators should leverage this insight to design complementary policies that support new entrants, promote responsible innovation, and prevent anti-competitive behavior by incumbents. These complementary measures may include regulatory sandboxes, innovation hubs, scalable compliance regimes, and incentives for cross-industry collaboration.

1) High-intensity Open Banking frameworks yield the strongest outcomes, suggesting that depth of regulation is as important as adoption itself.

2) Gradual implementation and ecosystem alignment are critical, as impact accumulates over multi-year horizons.

3) Competition-enhancing policies should accompany data-sharing mandates, ensuring that new entrants can scale and deliver consumer value.

4) Data governance and consumer protection must remain central,

particularly as data-sharing ecosystems expand and diversify.

In summary, Open Banking should be viewed not merely as a regulatory obligation but as a strategic instrument for accelerating digital transformation, stimulating innovation, and modernizing financial systems. Policymakers who invest in strong regulatory design, ecosystem readiness, and competitive safeguards are best positioned to unlock the full potential of Open Banking for economic development.

Declarations

Author Contributions

Conceptualization: H.K.F., A.R.H.; Methodology: H.K.F., A.R.H.; Software: A.R.H.; Validation: H.K.F.; Formal Analysis: H.K.F.; Investigation: A.R.H.; Resources: H.K.F.; Data Curation: A.R.H.; Writing – Original Draft Preparation: H.K.F.; Writing – Review and Editing: H.K.F., A.R.H.; Visualization: A.R.H.; All authors have read and agreed to the published version of the manuscript.

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