Information Access and Innovation: Evidence from Open Banking

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Abstract

Open banking is a global trend giving customers the right to have banks share their data with both fintechs and other banks. National governments have taken a variety of steps to spur open banking uptake, ranging from mandating data sharing to detailing technical standards. These policies aim to increase innovation, competition, and inclusion. We compile a novel, hand-collected dataset of open banking policies across 168 countries. Governments in 80 countries have adopted or are in the process of adopting open banking frameworks, with policies varying in terms of implementation stage, policy objectives, the strictness of compliance, and the broadness of services covered. We show that open banking policies have already led to dramatic increases in bank data sharing and argue that this has increased innovation: venture capital investment in fintechs increases by 50% following the passage of open banking policies. Stricter open banking implementations, where banks must share customer data upon customer request, drive particularly large effects on innovative activity. Our paper speaks to how customer-directed data sharing can spur innovation in the financial sector and broader economy.

Keywords: Open banking, entrepreneurship, fintech, financial innovation, data access, data right, data portability, Big Data, financial regulation, financial sector, banks

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The increasing ease of data collection, storage, analysis, and application to decision making has made data an important economic asset. As the value of data has become increasingly apparent, there has been an active discussion about who controls the data being generated through economic activity: a firm or its customer. The value of data and the importance of who controls it is particularly salient in the financial services sector. Banks' provision of financial products, such as deposits, loans, and transaction services inherently generates large volumes of customer data. Periodic direct deposits reveal the customer's income. Overdrafts or late payments illuminate her riskiness as a borrower. Debit and credit card transactions provide information on her spending patterns. Responses to rate changes show her financial sophistication and price sensitivity. Thus, this customer information forms an integral part in the provision and pricing of financial services.

This paper studies a global shift of changes in the ownership and control of financial transaction data from financial institutions to consumers. Historically, the bank providing the financial product retained sole rights to use this valuable data, both generating ex-post market power and creating complex incentives to form relationships ex-ante. However, major changes are afoot. In nearly 80 countries, regulators have taken steps—some major and others still tentative—to give the customers the rights to their data and to open this data to competitors with customer consent. Collectively, these reforms are known as open banking.

Open banking describes a broad trend where, upon a customer's request, financial intermediaries share—willingly or by regulatory fiat—access to that customer's data with other financial service providers. Observing how important customer data is to financial intermediaries in providing financial products, policymakers reason that by empowering consumers to share their financial data and making privately controlled customer data more widely available, these efforts will increase financial innovation, competition, and inclusion.

The secure and verifiable democratization of previously closely held bank customer information has the potential—at least in open banking proponents' minds—to fundamentally transform the provision of financial services and redraw the industrial organization of the financial services sector. Banks, which before now combined many economic roles into one—screening, monitoring, maturity transformation, and so on—may lose certain comparative advantages that being the sole owner of borrower and lender data affords them. Eliminating these advantages may open the door to further entry, competition, and disintermediation from fintech startups. These increases in competition or innovation may lead to cheaper or even completely novel financial products and services. At the very least, the advent and wide adoption of open banking promises to lay bare issues around what aspects of banks make them special and highlight the barriers to increased innovation, competition, and inclusion in the financial sector.

In this paper, we explore the causes and consequences of government policies to promote open banking adoption. As a preliminary descriptive matter, we ask where open banking is

adopted and how open banking policy choices vary across countries. We then ask what differences across countries, be they economic, innovative, or political, explain this heterogeneity. We then put policymakers' stated objectives to the test and ask whether the adoption of open banking policies has indeed increased data sharing by banks and spurred financial innovation. In doing so, we examine which policy choices by open banking regulators are most important in effecting those goals. The answers to these questions provide a starting point for academics to examine the role of data ownership in financial intermediation more broadly and for policymakers to evaluate the design of open banking policies going forward.

Our paper makes three key contributions to the literature on entrepreneurship, banking, and the economics of data. First, we contribute by assembling the first comprehensive, standardized data set of government-led open banking policies around the world. Our hand-collected data set paves the way for further research on open banking, and is instrumental in our own empirical findings. Second, we document and explain the rich heterogeneity in open banking government approaches and examine the political and economic forces that might be causing open banking policies. Third, we examine the effects that open banking adoption has had on incumbent banks, the creation of new fintech startups, and real economic outcomes, particularly in reference to regulators' stated policy motivations for open banking.

We begin with a careful data collection on worldwide open banking approaches, with a particular emphasis on government policies to promote open banking. Each country's approach is unique: open banking efforts begin at different times and progress at different speeds, they are motivated by different policy goals, and they are drafted by regulators with different policy mandates—sometimes by a consumer protection agency, sometimes by a financial regulator, and sometimes by a competition or antitrust authority. Some approaches require mandatory data sharing by financial institutions, while some are voluntary; some regulators set detailed technical standards while others leave the implementation to market participants. Some open banking regimes narrowly cover transaction accounts, while others encompass consumer finance more broadly or even include small business lending. Many countries have no open banking government policies at all or are in the early stages of looking into implementing open banking policies. We standardize open banking government policies along several key dimensions and assemble a comprehensive data set covering the 168 largest countries—covering more than 99% of world GDP and 98% of world population.

The first part of our paper describes this data collection process and provides key summary statistics. The results from our data collection highlight the vast heterogeneity in open banking policies. For example, counties in the European Union have tended to adopt open banking regimes with mandatory data sharing by banks but without regulator-mandated technical standards. In contrast, East Asian countries have tended to favor voluntary participation but have spelled out detailed technical standards with which participants must comply. These differences and others highlight the fact that regulators have many potentially

consequential choices. Moreover, while all governments would like to see increased financial innovation and most want a more competitive financial sector, less developed countries are more likely to adopt open banking with a policy goal of financial inclusion.

With our open banking data set, we ask two empirical questions: what causes open banking, and what does open banking cause? In particular, in a regression framework, we examine if the adoption of open banking government policies can be predicted with ex-ante country characteristics related to economic development, the financial sector, innovation, and the quality of local institutions. We find that none of these ex-ante country characteristics robustly predict the introduction of open banking policies. Within countries that adopt open banking policies, we find that the governments of countries with ex-ante less competitive banking sector, stronger human rights, and more non-fintech VC activity introduce more comprehensive open banking reforms.

Next, we examine the extent to which open banking adoption has had the desired outcomes in encouraging banks to invest in technology to be able to share customer data and look for direct evidence of the creation of new open Application Programming Interface (APIs) by banks—the technology used to access and share customer bank data that accompany open banking adoption. We show a large effect: the number of banks that provide APIs doubles in countries that implemented open banking policies.

Regarding the impact on financial innovation, we examine whether the adoption of open banking policies has led to increased venture capital (VC) funding for fintech startups. We examine changes in fintech investment around the adoption of open banking by exploiting the staggered timing in the adoption of open banking government policies in difference-in-difference and event-study frameworks, while controlling for country and region-by-time fixed effects. While open banking is relatively new, our results show that the adoption of open banking policies is already having a significant impact on innovation as measured through fintech investment. We find that, despite similar pretends in VC funding of fintechs, fintech investment increases by 50% in countries after the adoption of open banking policies. We also exploit the heterogeneity in policy choices by open banking regulators documented in our data collection to highlight the effectiveness of various approaches. Open banking policies, where banks or fintechs must share data, seem to be a particularly important policy dimension for increased innovative activity. Overall, more comprehensive open banking government policies appear to lead to larger impacts on the funding of financial innovation.

Finally, we look for evidence of increased financial inclusion and access to financial services from a consumer perspective. Our results on real economic outcomes around financial inclusion are less conclusive: at least as measured, we find little effect on remittance costs, bank account uptake, or the measures of bank competition. We caveat that these so-far null results are limited for two reasons: First, because many countries passed or implemented open banking laws in 2020 and 2021, many of these IMF real outcomes data are not yet

available. Thus, analysis is undertaken with a significantly limited sample and an impaired dataset which will be more complete as time passes. Second, even when data is available, open banking is a new phenomenon and its real outcomes may take years to materialize in a macroeconomically measurable way.

To summarize our results, we find that the adoption of open banking government policies leads incumbent banks to invest in technology to share customer data and spur VC investment in fintechs. The specifics of open banking implementation matter, with policies where banks or fintechs must share data upon customer request appearing to play a crucial role in these effects. The potential implications of open banking for academics, policymakers, and industry are large. By giving the customers the right to share their financial data and opening banks' consumer data to potential competitors, open banking promises to upend the organization of the financial sector while increasing competition and financial innovation.

Our paper proceeds as follows. Section 1 situates our contribution in the literature. Section 2 details our data collection and provides comprehensive, high-level summary statistics regarding open banking approaches around the world. Section 3 documents the factors that give rise to open banking policies and their cross-country heterogeneity. Section 4 examines the effects that open banking has had so far, and Section 5 concludes.

1 Related Literature

This paper contributes to several strands of literature. Our results offer new insights relevant to several themes within the entrepreneurship literature. The first relates to the debate on whether policy makers are able to promote high-growth entrepreneurship (e.g., Acs et al. 2016; Bai et al. 2021). The entrepreneurship literature has shown that important innovations often come from new firms,[1] and these findings motivate regulators around the world to promote open banking to achieve greater financial innovation from new entrants. However, prior research finds mixed results on whether policy makers are able to promote high-growth entrepreneurship—the type that economists have in mind. On the one hand, Acs et al. (2016) question the general effectiveness of public policies to encourage entrepreneurship. On the other hand, specific government policies have been found to be effective. For example, federal funding leads university researchers to commercialize their inventions into high-tech startups (e.g., Babina et al. 2020).[2] Therefore, it is not obvious that government efforts to promote

[1] Entrepreneurs play a crucial role in prominent theoretical explanations for economic growth, including Schumpeter (1911), Lucas (1978), and Baumol (1990). Relative to incumbent firms, new firms have faster productivity and employment growth. This literature includes Kortum and Lerner (2000), Foster et al. (2008), Gennaioli et al. (2012), Haltiwanger et al. (2013), Decker et al. (2014), Glaeser et al. (2015), and Akcigit and Kerr (2018).

[2] More generally, government policies can have either positive or negative effects on entrepreneurship. Recent evidence suggests that the US angel investor protection laws reduced eligibility for many angel investors and hurt new firm entry (e.g., Lindsey and Stein 2019), while evidence on angel tax credits suggests they are

open banking would be successful at spurring innovation. One of our contributions is to show that the recent government efforts to promote open banking appear to have been successful in fostering VC-backed fintechs.

Second, while technological advances are often thought of as important drivers of startup growth, surprisingly, direct evidence on this is scarce. Ewens et al. (2018) provide probably the best recent evidence on the role of technology for startup growth: they show that the advent of Amazon Web Services dramatically lowered the cost of starting new businesses and led the venture capital model to change in important ways. Recent work by Ahnert and Doerr (2021) also show that bank use of information technologies increased employment in new firms. Our contribution here is to show that access to customer data and the technologies that facilitate this access play an important role in fostering innovative entrepreneurship.

Finally, our findings speak to the stream of entrepreneurship literature that builds off theories of the firm (e.g., Coase 1937; Hart 1988) to examine why innovation is produced within the boundaries of large firms or at new startups. Most studies in finance examine innovation by incumbents and startups separately, including the subset focusing on financial services specifically.[3] However, open banking could transform the financial services industry structure from the current environment, where banks and fintechs operate in silos, to one where both operate in an ecosystem inter-connected via customer data sharing with banks or neobanks being at the center of this ecosystem and fintechs building their services on top of the banking system. Many governments explicitly state a desire to transition to such an ecosystem-centric equilibrium. Our preliminary findings suggest that data ownership can re-draw firm boundaries, and help integrate banks and fintech in an interconnected ecosystem.

Our paper also connects to and broadens the literature around the industrial organization of the financial sector and its interaction with emerging financial technology. A large literature has studied the role of banks and the increased competition they face from non-depository institutions, e.g., Buchak et al. (2018b), Buchak et al. (2018a), Jiang et al. (2020), Fuster et al. (2019) (residential mortgages in the US), Gopal and Schnabl (2020), Erel and Liebersohn (2020) (small business lending in the US), and Buchak et al. (2021) (deposits in China). The literature in this space typically highlights a complex interplay between technology, regulation, and how they interact with the comparative advantages of depository and non-depository institutions. The literature reviews on the impact of technology in finance can be

largely ineffective (e.g., Denes et al. 2020). On the other hand, the government subsidies of corporate R&D (not designed specifically to stimulate entry) are also effective in increasing new firms started by former employees of the R&D investing firms (e.g., Babina and Howell 2018).

[3] The recent evidence in Babina et al. (2020) suggests that, to truly understand the consequences of economic shocks on innovation, it is important to examine the response of the entire innovation ecosystem. For example, while they find that the Great Depression severely impaired innovation by technological entrepreneurs, large firms increased their innovation precisely in the areas where entrepreneurs receded. For this reason, in a companion paper, we also examine the response by incumbent banks to changes in open banking regimes.

found in Stulz (2019), Vives (2019), Allen et al. (2020), Berg et al. (2021), and Boot et al. (2021).

Our paper lies on fertile new ground at the confluence of these literatures. Depository institutions, by their wide scope, naturally obtain a large amount of consumer data. While this data might be valuable for fintech startups, banks' data ownership prevents their use of it. In our setting, regulation is passed with the purported goal of *facilitating* innovation. Thus, our paper speaks to how banking regulation itself can cause financial innovation. Importantly, however, this banking regulation is itself the result of a complicated political economy setting. Our data speaks to the creation of these rules, and like Kroszner and Strahan (1999), we explore what appears to *cause* the adoption of financial regulation.

Lurking behind this literature is a deeper fundamental question with origins in Diamond and Dybvig (1983) and Diamond (1984) over whether banks are special relative to other financial intermediaries and what makes them special. While non-depository institutions have gained significant market share relative to banks in functions like loan origination and servicing, it is not clear that they have replaced banks in deeper intermediation roles like underwriting, monitoring, and balance sheet lending. Banks appear to derive significant value from combining these functions, as in Egan et al. (2017), Benetton et al. (2021), and Aguirregabiria et al. (2019).

A commonly proffered explanation is the natural informational advantages banks derive from engaging in these multiple activities, dating to Petersen and Rajan (1994) and Petersen and Rajan (1995), and more recently Granja et al. (2018). Open banking provides an empirical setting in which banks potentially lose the informational advantage that their wide scope provides to them, and paves the way for an analysis of how important these informational advantages are to banks and bank customers. In particular, we examine the ex-post changes to bank openness to outside providers—if they invest in technology that allow third parties to access banks' customer data—and new funding of bank competitors, as well as opening the door to exploring how ex-ante contracting changes after the informational ownership structure is changed. In a companion paper Babina et al. (2021a), we examine how bank valuation respond to the introduction of open banking regimes, and whether banks change their competitive strategy and adjust business models.

Our work also builds on nascent literature examining the implications of data ownership rights on economic outcomes. Jones and Tonetti (2020) show that, theoretically, a firm might hoard data fearing that entrants can displace it if they have access to its data, and that giving data property rights to consumers can generate allocations that are close to optimal. Farboodi et al. (2019) show that large firms accumulate more data as a byproduct of economic activity and that—if they own the data—the benefits from these data troves could increase firm inequality; consistent with these theoretical implications, Babina et al. (2020) find that larger firms benefit more from their investments in artificial intelligence. He et al.

(2020) study lending market competition when sharing banks' customer data enables better borrower screening or targeting by fintech lenders: they show that, theoretically, open banking could make the entire financial industry better off yet leave all borrowers worse off—whether they agree to share their data or not. Garratt et al. (2020) show that the introduction of a privacy-preserving central bank digital currency preserves the market structure and improves consumers' welfare by enabling them to monetize their private information. To the best of our knowledge, we provide the first empirical study on the economic impact of access to customer financial data. While, so far, we find no changes in consumer benefits from open banking, in the companion paper, Babina et al. (2021b), we revisit this question with more comprehensive consumer data.

2 Institutional Background and Data

This section describes the institutional background of open banking, describes the data collection process, and provides high-level summary statistics.

2.1 Institutional Background on Open Banking

Open banking describes a broad trend where upon customer request financial intermediaries share—willingly or by regulatory fiat—access to their customers' data with other financial service providers. There are two main non-mutually exclusive ways in which open banking is spreading around the world: industry-led, where banks and fintechs adopt open banking without government intervention, and government-led, where regulators institute government policies to promote the adoption of open banking by the financial sector. In this paper, we focus on the efforts of governments around the world to promote open banking. We also collect information on whether a country has some industry-led open banking initiatives. As we document in detail, the specifics of government open banking efforts vary dramatically: some countries mandate banks to share data while others merely encourage data sharing, for example, by introducing technical standards for data sharing.

The United Kingdom's Open Banking Initiative provides an instructive introduction: in 2017, the UK Competition and Markets Authority (CMA) introduced one of the first open banking initiatives, with the aim of increasing innovation and competition in the retail banking sector.[4] The initiative required that by 2018, the six largest banks in Great Britain and three largest banks in Northern Ireland "*give their personal and business customers the ability to access and share their account data on an ongoing basis with authorized [by the government] third parties.*"[5] Here, third parties refers to third-party providers (TPPs), a

[4] Link to official document, also the "Open Banking, Preparing for Lift off" document.
[5] Page 11 of "Open Banking, Preparing for Lift off" document.

category that includes both fintechs and other banks. Additionally, these banks were required to allow TPPs to make payments authorized by banks' customers from their accounts—a practice called payment initiation. Over time, the UK's policy expanded from the nine large banks to cover most of the banking sector and other countries have joined the UK in implementing open banking.

Data access and payment initiation typically occur through a bank-provided application programming interface (API). APIs are a technology or, simply put, a set of instructions that allows two systems (e.g., that of a bank and that of a fintech) to speak to each other over a network. Open banking APIs are published by a provider, such as a bank, and are a set of standardized, programmatic commands that allow data users (e.g., fintechs) to interact with the provider's customer database. For example, with a user's permission, a lender could use a competing bank's API to query that user's bank account transactions in order to help price a loan to that user. An accounting fintech startup could, with a business customer's permission, initiate payments from that business's bank account to that business's suppliers as part of an accounts payable management application. The particulars are regime-specific, but API functionality in open banking typically allows read access (e.g., querying account data) and sometimes allows write access (e.g., payment initiation).

By opening bank data and creating the tools for TPPs to access it, regulators aim to create an environment whereby financial intermediaries—both incumbents and fintech new entrants—can create new financial services for bank customers and compete with existing services. In the case of the UK's open banking initiative, the CMA envisioned several use cases, with functionality increasing over time as more sophisticated APIs were developed. The prototypical use case, already implemented in the UK, is customer account aggregation. A typical person has financial accounts scattered across several financial intermediaries: her bank account where she is paid and which she uses for checking; one or more credit cards; an investment or brokerage account; a mortgage; a car loan; a student loan; an insurance policy; and so on. Rather than separately monitor each of her accounts, she may find it helpful to have this information collected and displayed in a single place. A number of fintechs have emerged which provide these account aggregations services.

Moreover, she may want to create a budget or engage in financial planning: What are her spending habits? Does she have recurring payments or subscriptions she may have forgotten about? Which credit product should she pay down first? How much should she contribute monthly to her retirement account if she wishes to retire by a certain age and maintain a similar level of consumption? With open banking, fintech startups can access, aggregate, and analyze these separate accounts. To the extent that this data is standardized and easy to process, fintech startups can easily enter and compete to provide the best service.

Open banking use cases go far beyond customer account aggregation. The CMA, for example, envisions open consumer lending where potential lenders can access the myriad,

and otherwise private, information that a consumer's home bank has about her. In this way, open banking can reduce search costs and level the informational playing field between a consumer's home bank and potential competitors. Beyond lending, the CMA is testing features like automatic overdraft borrowing, enhancements to consumer credit files, product comparison using actual customer data and not simply representative quotes, and even SME lending. More speculatively, the CMA expects that by promoting an innovative ecosystem, there will be unanticipated innovations beyond the use cases explicitly mentioned.

In countries without open banking, fintechs achieve similar functionality through what is known as screen scraping. A user gives her login credentials for each of her financial institutions to the fintech deploying the screen scraping, such as Mint.com. That fintech runs software that impersonates a human using a web browser. The software uses the user's credentials to log in to each financial institution and extract the relevant account data from the financial institution's web page. Although screen scraping accomplishes the same purpose as accessing an open banking API, screen scraping has numerous weaknesses. First, screen scraping creates numerous risks because it requires the fintech store the user's full account credentials (which creates a much larger security risk than more limited API tokens), because it trains users in the bad security practice of handing over credentials, because it explicitly violates bank fraud protection rules, and because it is incompatible with many forms of two-factor authentication. Second, screen scraping creates privacy issues because it requires the user to give the scraper access to all the user's information with a financial institution, rather than the specific information they want to share, and that access persists until a password change. Third, screen scraping is inefficient both for the fintech (who must implement separate code for each bank website) and for the bank (whose web servers must generate large amounts web page content irrelevant for the fintech's software). Finally, screen scraping is unreliable and is frequently broken by simple website changes. The open banking approach allows for user-permissioned, secure, and direct access to just the parts of the data that the customer intends to share.

2.2 Data Collection Methodology for Open Banking Around the World

Many regulators around the world have implemented open banking policies. Our objective in this paper is to explore how these various open banking approaches have impacted incumbents and financial innovation, and whether these efforts led to changes in real outcomes of consumers among the countries implementing open banking. We therefore undertake to create a complete and detailed database of open banking government policies around the world. The result is a hand-collected data set detailing open banking government initiatives (or the lack thereof) in 168 countries.

This section describes the broad methodology. In subsequent drafts of the paper, we

will release a detailed Appendix providing detailed variable-level collection approaches and descriptions.

2.2.1 Sample Construction

We base our sample on countries with at least one million people according to the IMF 2018 data or at least 10 VC-backed companies.[6] Our aim is to be as comprehensive as possible while focusing on a sample of countries for which there is reliable data on open banking initiatives, if they exist, as well as the availability of economic and outcomes data, in particular, venture capital deals and funding, and also banking data. In total, we collect data on open banking for 168 countries, representing more than 98% of the global population and more than 99% of global GDP.

2.2.2 Sources and Methodology

Our data collection methodology centers on hand-collecting data about each country's open banking policies. For each country, we manually search for official open banking policy documents using Google and, when those are not available, for information from law firms, research papers, journalists, and industry participants which describes the government-led open banking initiative.[7] After finding evidence of open banking, we use, where available, official policy documents (laws, regulations, policy papers, and official statements) to classify the various dimensions of open banking policies into standardized categorical variables. Where official policy documents are not available, we use other sources to codify various dimensions of open banking government policies. The authors independently classify each country's regime and jointly reconcile any discrepancies.

We cross-check this data using two orthogonal methodologies. First, we use automated news topic searches to uncover any material missed in our manual search. For a given country, a program searches Google for all news articles mentioning ("country name" and "open banking" and ["government" OR "central bank" OR "law" OR "regulation" OR "regulatory framework" OR "supervision")]. This search provides a list of sources of potentially relevant information on government open banking interventions to compare to our manual collection. A research assistant then reads the top 10 resulting articles for any discussion on government open banking–however small—and flags articles for the review by the authors, who cross-check that our hand-collected data on open banking reflects potentially relevant articles.

[6]The IMF data on population by country can be accessed here, the PitchBook data are described later in this section.

[7]We use Google as our primary search engine because it has the lion's share of the world search market (88% in June of 2021; see Statista.com). To ensure that using Google does not bias out findings for countries that rely more on other search engines, we also tried using search engines alternative to Google that are prevalent in some regions (e.g., "Yandex" in Russia, "Baidu" in China). We found that these alternative engines do not provide additional relevant articles that we obtained from Google search results.

Second, we use a database on open banking regulations maintained by Platformable,[8] an open banking advocacy group. This data set provides an orthogonal starting point of sources and some regulatory details, which we reconcile against our classification.

2.3 Summary Statistics on Open Banking Regimes

As of October 2021, 87—or 52%—of the 168 countries in our sample have at least a nascent open banking effort. Some of these are market-led and have no government involvement; many of the government-led pushes have not left the early-discussion phase, while some regulators have fully implemented their policies or even moved on to follow-on regulations. Most regulators pursue open banking with an eye towards increased financial innovation, some regulators include increasing competition as a policy mandate, while others focus on the financial inclusion goal of bringing more people into the formal financial system. In many cases, regulators mandate data sharing, while in others it is purely optional, and the regulation merely sets data protocol standards. Some regimes narrowly cover customer transaction accounts, while others cover an expansive array of financial products including savings, loans, investments, and even insurance.

Although every country's approach is unique, there are certain key regularities.[9] Using our hand-collected data on open banking regimes across the world, this section documents and provides summary statistics across key dimensions of heterogeneity. Table 1 shows summary statistics overall and by region.

2.3.1 Market- versus Government-led Approaches

There are two main non-mutually exclusive ways in which open banking is spreading around the world: government-led, where regulators institute government policies to promote the adoption of open banking by the financial sector, and industry-led, where the financial sector participants coordinate on adopting open banking. While relatively few countries have purely market-driven approaches, government-driven approaches are far more common. We find that 48% of countries—nearly all countries with any open banking whatsoever—have a government-driven approach of some kind. Regulatory approaches are well exemplified by the UK case discussed above, where a regulatory body imposes a set of requirements on incumbent banks and other financial intermediaries to provide public APIs. While the main focus on this paper is on government-led open banking policies, we find that 29% of the countries have market-driven open banking initiatives. New Zealand provides a prototypical example of a market-driven approach: an industry consortium coordinated to create shared,

[8] Platformable's data are described here.

[9] For the purposes of making country-level comparisons here, we treat each European country implementing PSD2 as a separate unit of observation. In subsequent analysis, we weight the PSD2 countries as a single unit.

public APIs with little direct government intervention.[10]

There is significant heterogeneity by region, with Europe and Central Asia having the highest degree of both market-led and government-led open banking regimes at 66% and 80% respectively. East Asia's approach tilts more towards government-led approaches, with only 21% of countries having a market-led approach compared to 63% which have a government-led approach. Other regions have relatively less open banking, although open banking is present in all regions, including Sub-Saharan Africa and Latin America.

For government-led approaches, regulators frequently cite one or more policy justifications or policy mandates for implementing open banking regimes in their official policy documents and interviews. The three most common are to promote innovation, to promote competition, and to promote financial inclusion. Table 1 shows that regulator motivations vary substantially across countries: 97% of regulators cite innovation as a policy mandate; 82% cite competition, and 29% cite financial inclusion.[11] There is significant regional heterogeneity in financial inclusion serving as a policy goal of open banking: only 10% of countries in Europe and Central Asia cite financial inclusion, whereas other regions are much more likely to use financial inclusion as a motivation for open banking.

Finally, we note that the Euro area adopted and implemented a common open banking framework known as the Revised Payment Services Directive (PSD2).[12] PSD2 obligated participating countries to individually implement its provisions in their respective banking sectors, which they have done in accordance with the prescribed timeline. For the purposes of our analyses in Sections 3 and 4, we weight all countries covered by the PSD2 as a single pooled observation. In the country-level summary statistics later in this section, we keep the participating countries separate.

2.3.2 Implementation Status and Key Dates of Government-led Policies

For government-led approaches, there is significant heterogeneity around how far the implementation of open banking regimes has progressed and timeline of when laws have been passed and implemented. Broadly, we categorize a country's open banking implementation status into seven stages: (1) pre-discussion (some government interest is announced buy no actual law or implementation is taking place); (2) discussion (the actual law has been introduced or passed and rulemaking is taking place); (3) pre-implementation (the law is passed but nothing is yet binding); (4) early implementation (some data sharing requirements are binding (e.g., bank-level product information), but not personal account/transactions);

[10] BBVA provides an overview of these markets here

[11] This variable is missing for countries with no regulatory open banking approach. Moreover, countries in very early stages of implementation (e.g., very early stage discussion) frequently have not clearly indicated any policy mandate or objective. These countries are omitted.

[12] PSD2, Directive (EU) 2015/236

(5) mid-implementation (personal account/transaction data sharing is binding, but not all planned elements are in place); (6) fully implemented (full implementation as described in the law/rulemaking); (7) follow-on regulation or policies (open banking is implemented, and regulators are actively working on related policies such as open finance or open data more broadly).

Panel (a) of Figure 1 shows the geographical distribution of government-led open banking initiatives based on the maturity of open banking policies. Countries marked as "Discussion" in Figure 1 are looking into whether to implement open banking policies and are in policy stages 1 or 2 described above (e.g., USA, see here); countries marked as "Mid-implementation" are in the process of implementing open banking policies and are in policy stages 3, 4, or 5 (e.g, Brazil see here); and countries marked as "Implemented" have fully implemented open banking policies are in policy stages 6 or 7 (e.g., the UK).

As of October 2021, among countries with a government-led approach to open banking, 38% are in pre-discussion or discussion, 18% are in some stage of incomplete implementation, and 44% are fully implemented or already seeing follow-on policies. The UK (with the adoption and implementation of its Open Banking Initiative) and the European Union (fully implemented its pan-EU Payment Services Directive (2) (PSD2)), are the farthest along in terms of implementation, while other countries lag. The UK is considering a follow-on "open finance" regulation, which envisions broadening customer-permissioned data sharing beyond the banking sector (e.g., insurance). Figure 1 Panel (b) tabulates the passage year of countries' major open banking government policies.

2.3.3 Requirements Set by the Regulator

Open banking government policies differ significantly by what they require of market participants, and indeed, whether they require anything at all. The UK, for example, places explicit de jure legal requirements on banks to participate. In contrast, many regimes in East Asia, for example, Hong Kong, South Korea, and Japan, see regulators as facilitators of open banking who mediate industry discussion and set technical standards for APIs. In these cases, the regulator does not explicitly require banks to share data.

Among the countries whose open banking initiatives have advanced sufficiently far for these issues to be decided, in Table 1 we find that 88% have require banks to share data, while the other 12% do not. Additionally—and often —39% of countries' regulators lay out mandatory technical specifications for APIs while the remainder do not. There is significant regional variation in government-led approaches regarding mandatory data sharing and mandated technical specifications. In particular, open banking regimes in Europe tend to have mandatory data sharing (97%) but do not set technical specifications (15%). Conversely, open banking regimes in East Asia tend to be less mandatory (60%) but are significantly

more likely to mandate technical specifications (82%). Figure 2 Panels (a) and (b) show these differences graphically for mandatory data sharing and set technical specifications, respectively.

Finally, open banking regimes, in addition to typically requiring incumbent banks to share data, sometimes also require the data users—new banks and non-bank financial intermediaries (e.g, fintechs) to share data. In other words, is there data sharing reciprocity or does the onus to share fall only on the incumbent banks? Our data show that only 18% of regimes have data sharing reciprocity, where fintechs that use the data must share. There is no data sharing reciprocity in Europe, while other regions, particularly East Asia, tend to require it.

2.3.4 Open Banking Scope: Covered Services and Functions

Open banking government-led regimes differ dramatically in the scope of which financial products and services are covered. Among industry participants and regulators, these differences are frequently described as more narrow "open banking" versus more broad "open finance." Open banking in its narrowest incarnation covers only transaction accounts: checking accounts at banks and the debit cards linked to them, and occasionally credit cards. Some regimes include a broader set of core consumer finance products: savings products, investments, and loans. Still broader regimes, bordering on "open finance" as opposed to merely "open banking" cover financial services like insurance or small business lending.

Our data shows that all open banking regimes cover at least transaction accounts. Fewer—34%—additionally cover non-transaction accounts, while fewer still cover a broader set of products like insurance or small business lending. Regarding regional heterogeneity, European open banking laws tend to be very narrow in scope, with only 3% covering non-transaction accounts. In contrast, open banking laws in East Asia and elsewhere are much broader: 90% of east Asian open banking regimes go beyond transaction accounts and 70% are extremely broad. Like East Asia and unlike Europe, other regions tend to have broad open banking scope.

Regarding functionality, open banking APIs can, in theory, be used both to read data (e.g., pull customer account information) and to write data (e.g., payments). Some open banking regimes focus on data sharing only, and some on both. Our data show that among those countries where this issue has been decided, only 5% focus on data sharing only, none on payments only, and 95% on both.

2.3.5 Related Regulatory Efforts

Finally, open banking efforts do not exist in a regulatory vacuum. These efforts frequently follow, coincide with, or precede a related regulatory effort. We consider two types of related regulatory efforts: (i) regulations around data privacy and data rights, and (ii) regulations

around other types of data sharing (e.g., open data, which). The prominent example of data privacy and data rights regulations is General Data Protection Regulation (GDPR) in the European Union. Data privacy and rights laws generally have two important consequences. First, they give the consumer the ownership right to their data. This aspect is crucial for open banking because if the data ownership is not clearly specified, banks cannot be forced to share their customer data with third-party providers. Second, these laws also give customers the right to privacy: for example, they grant consumers certain rights to anonymity, to not have their data shared without consent, and to be have their data deleted.

Open data laws go a step further and are the more general version of open banking or open finance laws. These laws, like open banking laws, mandate that businesses (that come into possession of consumer data) share that data with the customer's request. A central example of such an effort is the Consumer Data Right in Australia that is designed to give consumers greater access to and control over their data. The Consumer Data Right is being applied to the financial sector first, in the future followed by the energy and the telecommunications sectors. Unlike data privacy laws, open data policies are fairly rare as of October 2021.

2.4 Non-Open Banking Policy Data

2.4.1 Financial Innovation

Financial innovation is one of our key outcome variables and is based on venture capital (VC) investments from PitchBook, widely acknowledged as one of the best venture capital data sources for more recent coverage. Using PitchBook data, we construct a country-by-year panel of VC deals for the past twenty years, from 2000 to the first half of 2021. We measure VC activity using two standard variables: the number of deals and the investment amount in millions of US dollars. Because of the large cross-country variation in VC activity, we normalize both variables by taking the log of one plus the value.

Our interest lies in financial innovation, so we split the deals in each country year into fintech deals and non-fintech deals, with fintech deals being the deals PitchBook places in the "Financial Software" sub-industry or the "Fintech" vertical. We are interested in measuring the impact of open banking on innovation around specific use cases, but Pitchbook lacks more granular industry classifications. We overcome this by using PitchBook's keyword's feature to define six sub-industries of fintech: alternative lending, consumer finance, financial IT, payments, regtech, wealth management, and digital assets. Details of our classification are in Appendix B. Because of the recent cryptocurrency boom and bust cycles and the fact that digital assets are not related to open banking, we reclassify digital assets startups as non-fintech for our main analysis, although this has only a small impact on our results.

Table 2 summarizes our PitchBook data. Although PitchBook has arguably the best international coverage of venture capital deals for recent years, international VC coverage data

is spotty and many countries have either a small number of deals or very limited coverage. Specifically, more than half of our country-year observations have zero VC deals and three quarters have zero fintech deals. Coverage is worse in smaller countries and earlier years. This creates conceptual problems because in many of our tests we wish to look at the increase in fintech innovation (proxied for using fintech VC deals) relative to the increase in overall innovation (proxied for using non-fintech VC deals).

We address the issue of zero-deal countries by restricting our PitchBook analysis to countries that had at least 5 fintech deals in the 2000–2010 period, which we refer to as high-coverage countries. For our main analysis, we consider the 2011–2021 period for these countries, both to prevent contamination due to the filtering and because PitchBook's coverage improves over time. The countries in the high-coverage sample account for 91% of the VC deals and 94% of the VC dollars invested in the 2011–2021 period. While the excluded country-years typically have zero VC deals, the high-coverage sample always has at least one VC deal.

We have 21 countries in our high-coverage sample. This is a significant sample restriction and means our results only speak to countries that already had relatively active VC markets and where we have more confidence in data quality.[13]

2.4.2 Bank API Data

The use of APIs by banks across countries—the technology used by banks to connect, share customer information, and initiate payments to TPPs—comes from Platformable (described above), which is a global leader in data on banks' usage of APIs use over time.[14] To our knowledge, these data provide the best global coverage of banks' APIs, and allow us to examine if government efforts to encourage open banking adoption are actually effective at opening up banks by leading banks to introduce APIs. These data also allow us to differentiate between standard APIs that only allow some basic access to bank data and premium APIs (that allow more rich functionality for fintech providers to access banks' services and build more diverse products on top of banks' systems). Looking at whether banks introduce premium APIs allows for first-hand evidence for whether some banks might be exploring or shifting towards a platform-based business model—similar to an "AppStore of banking", where outside developers can build new products using the banks' platforms.

[13] The results in Table 6 continue to hold for the entire sample of countries with similar coefficients; however, the large number of zeros makes it hard to interpret the results.

[14] Platformable collects industry data on open banking and open finance by systematically identifying API providers and consumers using bank and fintech website sources, fintech registers such as EUCLID (Europe) and FCA (UK), assessing API consumers and providers from fintech association membership lists, and by surfacing new initiatives from newsletters and industry alerts. Data is assessed against Platformable taxonomies that standardize bank types, API products, fintech sub-sectors, business and pricing models, security and authorization technologies, and the adoption of standards, amongst other data fields. Data is collected on a rolling basis, with each entity assessed at least once every three months.

2.4.3 Explanatory Variables

We compile a variety of other country-by-year variables, which are summarized in Table A1. We start with basic country-level data, including per capita GDP in thousands of US dollars and population in millions from the World Bank. We add standard measures of country-level financial sector development, including the quantity of private sector credit to GDP, the number of bank branches per 100k people, and the financial sector Lerner index are also from the World Bank. The Lerner index ranges between zero and one and measures the market power of banks, with higher values denoting less competition. In addition to those measures, we take the percentage of banks that are foreign owned from the Claessens and Van Horen (2013) foreign bank ownership data.

To capture the quality of institutions, we use several indexes. The Human Freedom, Rule of Law, and Business Regulation Indexes are from the Cato Institute are on a zero to ten scale, with higher numbers denoting more favorable conditions. The corruption perception index is from Transparency International and is on a zero to one hundred scale, with higher numbers again denoting more favorable conditions.

3 What Causes Open Banking?

We first examine the determinants of open banking adoption. Similar in spirit to Kroszner and Strahan (1999), we test which ex-ante country-level variables predict whether a government adopts open banking policies. We run the following cross-sectional, country-level regression:

$$OpenBanking_i = X_i'\beta + Region_r + \epsilon_i, \tag{1}$$

where i indexes a country. $OpenBanking_i$ is one of three types of open banking outcomes in a country. First, we use a zero-one indicator for whether the government has implemented open banking policies in a country as of October 2021. Second, we use a number ranging from 0 to 7, indicating how far the implementation of government open banking policy has progressed, with 0 denoting none and 7 denoting fully implemented with follow-on regulation.[15] Third, among the countries implementing or considering the introduction of open banking policies,

[15]The full definitions are: (0)—none; (1)—pre-discussion (some government interest but no law or implementation is taking place); (2)—discussion (the law has been introduced or passed, or rulemaking is taking place); (3)—pre-implementation (the law has passed, but no customer data-sharing mandates or major functionalities are yet binding/in place); (4)—early implementation (some data sharing requirements are binding but no personal accounts/transactions); (5)—mid implementation (personal account/transaction data sharing is in place but not all elements are in place); (6)—fully implemented (full implementation as described in the law/rulemaking/policy documents); (7)—follow-on regulation (open banking is fully implemented and regulators are actively working on open finance or open data more broadly).

we use indicators for whether the regime has various policy characteristics—as described in Section 2.3, such as the obligation by banks to share data or prescribed technical standards.

$Region_r$ is a region fixed effect, which allows us to exploit within-region variation (e.g., comparing Asian countries to one another) to identify the coefficients (regions are based on the World Bank classification; the regions are Europe/Central Asia, East Asia, MENA (Middle East and North Africa), Sub-Sarahan Africa, South Asia, LATAM (Latin America), North America). X_i' is a vector of ex-ante country-level characteristics as of 2013. We choose 2013 both because it is when the first open banking initiatives were starting into motion (2013 was the year of the revised PSD2 proposal) and the final year that comprehensive Lerner index data is available from the World Bank. In addition to basic economic variables (GDP per capita, GDP per capita squared, and log population), we include several categories of variables capturing potential drivers of open banking adoption. First, we capture financial sector development through the ratio of private-sector credit to GDP, the number of bank branches per one-hundred thousand people, and the financial sector Learner index.[16] Second, we include measures of venture capital investment as a proxy for innovation: the number of non-fintech VC deals broadly, as well as the number of VC fintech deals in particular. Third, as a proxy for the political power of incumbent banks, we examine the fraction of foreign-owned banks, with the idea that when the banking sector is dominated by local banks, they will have more political power to resist open banking adoption. Fourth, we examine several measures of the strength of local institutions: the Cato Institute's Human Freedom (where high numbers denote high overall freedom), Rule of Law (where high numbers denote an effective legal environment), and Regulation (where low numbers denote onerous regulation) Indexes, as well as Transparency International's Corruption Perception Index (where high numbers denote less perceived corruption).

Table 3 shows the results for both the binary (columns 1–5) and continuous (column 6) open banking adoption measures. The number of observations fluctuates across columns due to the availability of data on independent variables. Since low overall levels of economic development could be associated with the introduction of open banking policies, in addition to our region fixed effects, in all columns we control for both GDP per capita (and its square) and log population to prevent this association from driving our results. However, across columns 1–6, we find that neither a country's GDP nor its population robustly predicts the introduction of open banking government policies. Column 1 considers three measures of financial development, none of which robustly predict government-led efforts to promote open banking within their country. Column 2 shows that open banking policies are somewhat more likely to be adopted in countries with more non-fintech VC deals, but that fintech VC deals, in particular, are not predictive of adoption. Thus, open banking policies might be

[16]The Lerner index is an index of markups over marginal costs in a financial services sector.

connected to innovation generally but not fintech innovation specifically. In column 3, we find a weak and statistically insignificant association between the fraction of foreign-owned banks and the adoption of open banking policies. This is suggestive evidence that local, politically connected banks may be effective in preventing open banking adoption, but the evidence is weak. In column 4 we consider several rankings of institution quality and see that open banking is more likely to be adopted in countries that are relatively freer, as measured by the "Human freedom" index. In columns 5 and 6, we include the full set of predictor variables, whereas in column 6 we use the continuous variable for the progress of the open banking policies: we find that more "Human freedom" predicts having an open banking policy (column 5) and the "Financial sector Lerner index" has a significant correlation with the progress of implementation of open banking policies.

In Table 4, we examine how the ex-ante country characteristics predict regulators' policy choices of the Open Banking implementation along several policy dimensions: whether banks must share data (column 1), whether data sharing is reciprocal between banks and non-banking entities accessing bank customers' data (column 2), whether the regulator sets technical specifications for data sharing (column 3), and whether the policy covers non-transaction accounts (column 4). In column 5, we construct an index measuring the strength of open banking policies, by averaging the four policy dimensions used in columns 1 to 4 so that higher values mean more comprehensive open banking policies. We focus on the three explanatory variables that have some predictive power over open banking policies in Table 3: the Lerner Index as a measure of competition, the number of non-fintech deals as a measure of innovation, and the human freedom index as an overall measure of regulatory quality.

Broadly, among countries that adopted open banking, we find that countries with less competitive financial sectors, more innovation, and better quality governments adopt stronger open banking policies, as measured by our "Open Banking Strength Index" index (column 5). However, when each policy dimension is predicted separately (columns 1–4) using these ex-ante country characteristics, none of the characteristics consistently predict stronger open banking policy choices. Having a less competitive financial system—as measured by the Lerner Index, where higher values mean less competition—does not robustly predict any of the individual policy choices: it has a positive, insignificant association with data sharing and technical standards, but a negative, insignificant association with the scope of financial products covered. In conjunction with the previous results showing the less competitive financial systems are more likely to adopt any kind of open banking, this result provides inconclusive evidence that open banking laws may be a reaction by the government to an uncompetitive financial sector. Ex-ante non-fintech VC activity is *negatively* correlated with mandatory data sharing by banks (column 1)—perhaps the most important feature of open banking policies since data sharing is at the heart of the open banking movement. This result suggests that a country's VC community is unlikely to be the main group that lobbies

the government to implement open banking policies. Ex-ante VC activity does significantly predict technical standards (column 3) but is not associated with the breadth of financial services covered by open banking policies (column 4). Countries with higher scores on the "Human freedom" index have open banking policies that are more likely to force sharing by banks and non-banks (column 1 and 2), yet are (insignificantly) less likely to mandate technical standards (column 3) or extend beyond transaction accounts (column 4), potentially suggesting that in these countries, incumbent banks have a more difficult time influencing the political process to their interests.

4 The Economic Effects of Open Banking

4.1 Effect on Incumbent Banks

Open banking policies implemented by regulators have many goals, ranging from spurring innovation to financial inclusion to increased competitiveness. They seek to accomplish these goals by either forcing or encouraging banks to allow access to their customer data to other financial service providers upon the customers' request.

The main technology by which data sharing is implemented is Application Programming Interfaces (APIs), which are the window through which the outside world gets access to a bank's data. They provide programmatic access to the underlying shared consumer data. These APIs are often supplemented by what are known as developer portals, which document the behavior of the APIs and sometimes offer other features such as developer account management, testing sandboxes, support, or tools. These developer portals assist external developers with building products on top of banks' systems using banks' APIs.

We look at whether the implementation of open banking government policies is associated with increased use of APIs by banks using a cross-sectional, cross-country specification. We regress the prevalence of APIs in banks of each country against our measures of that country's open banking implementation:

$$BankAPIs_i = \beta \times OpenBanking_i + X_i'\beta + Region_r + \epsilon_i, \tag{2}$$

where $OpenBanking_i$ is one of two types of open banking outcomes. First, we use a zero-one indicator for whether the government has already implemented open banking policies in a country as of October 2021 (columns 1, 3, and 5). Second, we use a number ranging from 0 to 7, indicating how far the implementation of government open banking policy has progressed, with 0 denoting none and 7 denoting fully implemented with follow-on regulation (columns 2, 4, and 6). $Region_r$ is a region fixed effect (regions are based on the World Bank

classification), and X_i' is a vector of ex-ante basic economic country characteristics as of 2013 (GDP per capita and population).

Table 5 shows the results. The dependent variables are the log-transformed number of banks with APIs (columns 1 and 2); the percentage of the top 10 banks in each country that offer APIs (columns 3 and 4); the log-transformed number of banks in each country offering developer portals (columns 5 and 6). Across the board, we see a strong association between the introduction of open banking policies and banks' APIs. The economic magnitudes are striking—countries with open banking policies have twice as many banks offering APIs and developer portals. Finally, the table shows that a country's population is also associated with increased bank API presence, potentially due to the economies of scale and the fixed costs of setting up this technological capability.

Next, we examine if the presence of bank APIs might be related to different policy choices of open banking regulators. For this test, we use the share of top 10 banks within a country that have technical capabilities for data sharing via APIs as our main dependent variable. We examine whether more banks are capable of sharing customer data when the regulator sets a policy that mandates (i) banks to share data, (ii) financial service providers (such as fintechs) who use the data to share data it in return, (iii) participants to adopt common API standards, and (iv) banks to share data for a wide range of financial products. In Table A2, we estimate the specification from Equation 2, where the open banking being implemented indicator is interacted with one of the above four policy choices (columns 1–4) and with our Open Banking Strength Index, which averages the four policy dimensions used in columns 1–4 with higher values reflecting more comprehensive open banking policies. In terms of specific policy choices, as shown in columns 1 and 2, countries that require banks to share data or require reciprocal data sharing see more banks capable of data sharing. Mandated technical standards (column 3) and the breadth of covered products (column 4) have more muted effects. Finally, stronger overall open banking policies (column 5) are associated with a greater share of top 10 banks within a country that have data-sharing capabilities via APIs.

These results provide the first systematic evidence that government policies to promote open banking might have already had a significant effect on data sharing in the financial service industry, and that counties that have more comprehensive open banking policies are likely to see more data sharing.

4.2 Financial Innovation

Financial innovation is the main policy mandate of open banking regulators, with regulators hoping that giving customers the right to their financial data and allowing them to share their bank data with new entrants will spark the creation of new and improved financial products and services. We use data on venture capital investments in fintechs and a stan-

dard panel event-study design to test whether open banking policies affected investments in innovative fintech startups:

$$FintechVC_{i,t} = \sum_{k \neq 0} \beta_k \times OpenBankingLag(k)_{i,k,t} + Country_i + Region \times Year_{r,t} + \epsilon_{i,t}, \quad (3)$$

where i indexes a country and t indexes time; $FintechVC_{i,t}$ is a measure of fintech VC activity in country i and year t. We measure VC activity both as both the number of deals and the total dollars invested.[17] $Country_i$ and $Region \times Year_{r,t}$ are country and region-by-year fixed effects. $OpenBankingLag(k)_{i,k,t}$ is an event time indicator, equal to 1 if country i's implementation of open banking government policy occurred k years from time t and zero otherwise.[18] We omit the year of the policy's passage so that the coefficient β_k measures changes in fintech VC activity k years before or after open banking's passage relative to the year of its passage. The standard errors are clustered at the country level.

Our VC data has three key issues that we correct for. First, VC activity is very skewed, with the US having far more VC investments than any other country. We correct for this skewness by using a $\log(1+x)$ transformation of our VC activity measures. This transformation implies that our tests measure the relative increases or decreases in VC activity occurring in a country, rather than the absolute changes.

Second, the lack of central VC investment registries in most countries makes VC data challenging to collect. PitchBook, despite being one of the best VC databases, has significant gaps in its international coverage, especially in the early years. Due to a combination of data collection and low VC activity, only one-quarter of our post-2000 country-years have any fintech VC deals and more than half have no VC deals at all. To reduce the bias created by using log-transformed variables in the presence of zeros and the VC data coverage issues, we restrict our consideration to countries with active PitchBook coverage. As our law passages occur in 2016 or later and PitchBook coverage improves over time, we restrict our analysis of VC activity to the 2011–2021 period. In addition, we address a key concern that PitchBook coverage of a country's fintech VC activity might be correlated with the passage of open banking government policies. Specifically, we consider only countries that PitchBook already covered before our regression sample period by focusing on countries with five or more fintech deals in the 2000-2010 pre-period, which we refer to as high-coverage countries. Although only 13% of countries are high-coverage, they include 91% of the VC deals and 94% of the investment value. Thus, our analysis of open banking policies on fintech VC activity uses the sample of high-coverage countries in the 2011-2021 period. 99% of this high-coverage sample

[17] These are the two most common measures of VC activity. The nature of VC staging means that deals will tend to measure earlier stage investment and dollars will tend to measure later stage investment.

[18] For countries in the sample that never implement open banking, $OpenBankingLag(k)_{i,k,t}$ is zero everywhere; these countries help identify region-by-year fixed effects.

has at least one fintech deal, dramatically reducing the econometric issues associated with log-transforming zeros. Because we condition on pre-period deals, our results can best be thought of as speaking to countries that already have developed VC markets.

Third, as Figure 1 Panel (b) shows, 29 countries implemented open banking regulation at approximately the same time due to the January 2018 deadline in the European Union PSD2 open banking mandate. This is about half of the treated countries in the high-coverage sample. These countries not only share a treatment, their close geographic proximity and economic integration means they are likely to be exposed to similar economic shocks. Because of this, our specifications reduce the weight on each of these countries so that together they account for a single observation and adjust standard errors to treat these countries as a single cluster.

Because our filter drops a large number of country-years that *never* had open banking, identification in this specification comes chiefly (though not entirely) through the staggered adoption of open banking within countries. Intuitively, our regression is comparing VC activity in countries at time t to other countries in the region that will adopt open banking but have not adopted it yet. The key identifying assumption is that absent the treatment, countries within a region would have been on parallel trends.

Figure 3 presents the results from the event-study specification in Equation 3 as a check of the parallel trends assumption. The figure shows a relative absence of pre-trends in fintech VC activity, followed by a sharp increase after treatment with an open banking policy. Panel (a) shows this pattern for the number of deals, and Panel (b) shows a similar pattern for the amount invested. In both panels, there is a clear inflection point around the year of the open banking policy passage and a change of large economic magnitude: logged deals increase by about 50% and logged dollars more than double. The absence of pre-trends is consistent with open banking having a causal impact on country-level fintech VC activity. As a robustness check, we include contemporaneous non-fintech VC deals to control for innovation more generally—this addresses a concern that countries that implement open banking policies might be implementing a range of policies that promote innovation more generally, and not necessarily those related to open banking. As a caveat to this test, it is debatable whether it is appropriate to include the contemporaneous control for non-fintech VC deals since open banking innovation may spill over into other, non-financial sectors of the economy. Nonetheless, adding controls for non-fintech VC activity does not change this pattern, as shown in Appendix Figure A1.

Table 6 uses a difference-in-difference design to test the impact of open banking policies on fintech VC activity:

$$FintechVC_{i,t} = \beta \times OpenBanking_{i,t} + Country_i + Region \times Year_{r,t} + \epsilon_{i,t}, \qquad (4)$$

where $FintechVC_{i,t}$ is again the fintech VC activity in a given country-year as measured by the log-transformed number of deals or dollars invested. $OpenBanking_{i,t}$ is a dummy variable equal to one if open banking was implemented in country i before year t. $Country_i$ and $Region \times Year_{r,t}$ are country and region-by-year fixed effects and standard errors are clustered at the country level. We are interested in the coefficient β which measures log change in fintech VC activity following the introduction of government open banking efforts.

Fintech companies receive significantly more VC investment following the implementation of open banking policies, whether measured by the number of deals or the number of dollars invested. Our coefficients are both statistically significant and large in economic magnitude. Using our preferred specification from Equation 4, we find a 0.53 increase in logged fintech VC deals (column 2) and a 1.3 increase in log fintech VC dollars (column 5). As a robustness check, we include contemporaneous non-fintech VC deals and find that the coefficients remain statistically significant and economically large with the inclusion of non-fintech VC activity as a control (columns 3 and 6).

Open banking might have a larger impact on some areas of finance than others. We test this in Table 7 by looking at the impact of open banking on specific product areas within fintech. Our empirical design follows Equation 4, but with a dependent variable based on VC investments only in companies targeting a specific fintech use case. As discussed in Appendix B, we define these fintech categories based on Pitchbook's fintech industry map. Across product areas and specifications, we see economically large increases in logged deal counts, ranging from 0.65 to 0.76. The notable and reassuring exception to this trend is digital assets, where we see insignificant and economically small effects. This is intuitive and serves as a placebo test: digital assets, such as cryptocurrency, are largely unrelated to open banking functionality.

Specifically in Panel (a) of Table 7, we see similar magnitudes and statistically significant results across the categories that are relevant for open banking: alternative lending, which would presumably lever newly available data to make lending decisions; consumer finance, which is the focus of most open banking reforms; financial IT, the backend infrastructure necessary to utilize open banking functionality; regtech, which could follow from either novel open banking applications or increased compliance demands; and wealth management, which is greatly streamlined through open banking account access. Payments, which is one of the key focuses of open banking, shows a similar increase in deals, although it is not statistically significant due to a less precisely estimated parameter. Controlling for the non-fintech VC deal volume in Panel (b) has little impact on these results. Although coefficients decrease slightly across the board, all but wealth management retain statistically significant, while the increase in payments gains statistical significance. Overall, the most statistically robust result is on financial IT fintechs—this is intuitive because the infrastructure to enable bank data sharing between banks and other financial service providers is a necessary stepping stone

for financial service providers utilizing open banking functionality to build their products.

4.2.1 Open Banking Policy Choices and Financial Innovation

Given the diversity of open banking policy choices described in Section 2.3, it is natural to ask whether the specifics of open banking policies matter. In particular, we examine whether each of the four main open banking policy characteristics is associated with greater fintech VC activity: whether the regime requires that banks share data, whether data sharing is reciprocal between banks and fintechs, whether the regulator sets common technical standards for the APIs, and whether the open banking regime covers a wide or narrow scope of financial products.

We examine these effects by rerunning Equation 4 with open banking implementation interacted with policy choice as the variable of interest:

$$FintechVC_{i,t} = \beta_1 \times OpenBanking_{i,t} + \beta_2 \times PolicyDimension_i \times OpenBanking_{i,t} + Country_i + Region \times Year_{r,t} + \epsilon_{i,t} \quad (5)$$

where, $PolicyDimension_i$ measures a dimension of policy heterogeneity and $PolicyDimension_i \times OpenBanking_{i,t}$ is that policy dimension interacted with open banking being implemented in a country. The country fixed effects absorb level differences between countries with and without these open banking policy characteristics. Countries that do not have open banking or where the policy choice has yet to be decided are coded as zeros. Other variables are as defined above.

The regression tests whether open banking policies with certain characteristics are more successful at promoting fintech VC investment. Table 8 reports our results and shows that stronger open banking policies as measured by our Open Banking Strength Index (column 5) are associated with larger increases in fintech VC deals. In terms of specific policy choices, as shown in column 1, countries that require banks to share data see economically and statistically significantly increased fintech effects of open banking adoption. A similar larger effect is seen for countries that require reciprocal data sharing, where non-bank data users such as fintechs must themselves share their customer data with, say banks, when customers request (column 2). Standardized APIs (column 3) and broader financial product coverage (column 4) have positive and economically large coefficients that fail to reach statistical significance at conventional levels.

Overall, more comprehensive open banking government policies appear to lead to larger impacts on the funding of financial innovation. Open banking policies where banks or data users must share data seem to be a particularly important policy dimension for increased

innovative activity.

4.3 Real Outcomes

Our results suggest a significant increase in innovation following open banking laws. We test for the effects on financial inclusion and competition by looking at a variety of real outcome measures, primarily IMF and World Bank financial inclusion indicators.

Unfortunately, we are not able to effectively test for open banking effects using real outcome measures. The fundamental challenge is that open banking measures have passed recently and generally have only fully taken effect over the past two years.

This creates two hurdles to testing for real effects. First, there are significant time lags involved with cross-country data from the IMF and World Bank. In many cases, 2020 data has not yet been released, which makes it difficult to test the effect of laws that commonly took effect in 2019 or later.

Second, the effect of open banking on inclusion, competition, and innovation is likely to show up over the course of many years. Although measures such as remittance costs or the fraction of the population with bank accounts may be the real outcomes we care most about, they are the result of slow-moving consumer tastes. Our innovation data are from venture capital deals is a forward-looking measure of expected product-market innovation—although we are unable to detect short-term changes in real outcomes, venture capital investment suggests manager's expect long-term changes.

5 Conclusion

Our paper examines the dramatic rise of open banking—now present in some form in roughly 80 countries—and its effects. Using a hand-collected dataset of open banking government policies around the world, we documented significant heterogeneity in their timing, purpose, and implementation details. Open banking adoption leads incumbent banks to set up data-sharing technologies and VC funding into fintechs to increase significantly. Heterogeneity in open banking regimes is of great consequence: regimes that require more entities to participate see much greater increases in fintech investments.

Our results suggest that the large amounts of consumer data that incumbent banks collect are valuable for innovators. By virtue of continued interaction with customers, banks collect data that is potentially useful for budgeting, setting prices, and extending credit. Once this heretofore bank-owned data is opened to the broader community of incumbent and startup financial intermediaries, new opportunities to use it becomes available and venture capitalists make investments in startups that take advantage of these opportunities. Regimes where key players can opt not to share data show much smaller effects, suggesting that widespread

participation is important to the success of an open banking regime.

Open banking is still in its early days. Despite being relatively recent, we can already point to large effects in terms of banks implementing technology for data sharing and VC funding flowing to fintech startups. While we have yet to see clear real effects of open banking in terms of consumer outcomes, it is likely that with more time, some of these effects will materialize. Future research in this area may look at these real outcomes, as well as the other changes such as erosion in bank market value or bank business models to compete with these new fintech entrants.

These limitations notwithstanding, our paper has important implications for academics and policymakers. The role that data ownership and access play in endogenously creating and maintaining market power is a first-order question in an increasingly data-driven economy. Opening data to potential competitors and innovators in order to spur innovation, increase competition, and ultimately, welfare is a natural policy response, and our paper is the first to provide a global comparative analysis around such a set of policy initiatives. As US regulators consider the specifics of open banking, lessons learned in this paper, such as what elements of regulation are key for spurring innovation, could be informative. Finally, our paper illuminates large banks' special ability to aggregate huge amounts of consumer data, and as they lose those special rights, sheds light on how valuable fintech innovators perceive this data.

References

Acs, Z., T. Åstebro, D. Audretsch, and D. T. Robinson (2016). Public policy to promote entrepreneurship: a call to arms. *Small Business Economics 47*(1), 35–51.

Aguirregabiria, V., R. Clark, and H. Wang (2019). The geographic flow of bank funding and access to credit: Branch networks, local synergies, and competition.

Ahnert, T. and S. Doerr (2021). Does it help? information technology in banking and entrepreneurship. *IMF Working Papers 2021*(214).

Akcigit, U. and W. R. Kerr (2018). Growth through heterogeneous innovations. *Journal of Political Economy 126*(4), 1374–1443.

Allen, F., X. Gu, and J. Jagtiani (2020). A survey of fintech research and policy discussion.

Babina, T., A. Bernstein, and F. Mezzanotti (2020). Crisis innovation. Technical report, National Bureau of Economic Research.

Babina, t., G. Buchak, and W. Gornall (2021a). Information access and competition: Evidence from banks after introduction of open banking regulations. Technical report, Columbia Business School.

Babina, T., G. Buchak, and W. Gornall (2021b). The real effects of data sharing: How consumers fare following introduction of open banking. Technical report, Columbia Business School.

Babina, T., A. Fedyk, A. X. He, and J. Hodson (2020). Artificial intelligence, firm growth, and industry concentration. *Firm Growth, and Industry Concentration (July 14, 2020)*.

Babina, T., A. X. He, S. T. Howell, E. R. Perlman, and J. Staudt (2020). The color of money: Federal vs. industry funding of university research. Technical report, National Bureau of Economic Research.

Babina, T. and S. T. Howell (2018). Entrepreneurial spillovers from corporate r&d. Technical report, National bureau of economic research.

Bai, J., S. Bernstein, A. Dev, and J. Lerner (2021). Public entrepreneurial finance around the globe. Technical report, National Bureau of Economic Research.

Baumol, W. J. (1990). Entrepreneurship: Productive, unproductive, and destructive. *Journal of Political Economy 98*(5, Part 1), 893–921.

Benetton, M., G. Buchak, and C. Robles-Garcia (2021). Competition and scope in banking: Synergies and product distortions in business lending. Technical report, Unpublished Working Paper.

Berg, T., A. Fuster, and M. Puri (2021). Fintech lending. Technical report, National Bureau of Economic Research.

Boot, A., P. Hoffmann, L. Laeven, and L. Ratnovski (2021). Fintech: what's old, what's new? *Journal of Financial Stability 53*, 100836.

Buchak, G., J. Hu, and S.-J. Wei (2021). Fintech as a financial liberator.

Buchak, G., G. Matvos, T. Piskorski, and A. Seru (2018a). Beyond the balance sheet model of banking: Implications for bank regulation and monetary policy. Technical report, National Bureau of Economic Research.

Buchak, G., G. Matvos, T. Piskorski, and A. Seru (2018b). Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of Financial Economics 130*(3), 453–483.

Claessens, S. and N. Van Horen (2013). Impact of foreign banks. *Journal of Financial Perspectives 1*(1).

Coase, R. H. (1937). The nature of the firm. *economica 4*(16), 386–405.

Decker, R., J. Haltiwanger, R. Jarmin, and J. Miranda (2014). The role of entrepreneurship in us job creation and economic dynamism. *The Journal of Economic Perspectives 28*(3), 3–24.

Denes, M. R., S. T. Howell, F. Mezzanotti, X. Wang, and T. Xu (2020). Investor tax credits and entrepreneurship: Evidence from us states. Technical report, National Bureau of Economic Research.

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *The review of economic studies 51*(3), 393–414.

Diamond, D. W. and P. H. Dybvig (1983). Bank runs, deposit insurance, and liquidity. *Journal of political economy 91*(3), 401–419.

Egan, M., S. Lewellen, and A. Sunderam (2017). The cross section of bank value. Technical report, National Bureau of Economic Research.

Erel, I. and J. Liebersohn (2020). Does fintech substitute for banks? evidence from the paycheck protection program. Technical report, National Bureau of Economic Research.

Ewens, M., R. Nanda, and M. Rhodes-Kropf (2018). Cost of experimentation and the evolution of venture capital. *Journal of Financial Economics 128*(3), 422–442.

Farboodi, M., R. Mihet, T. Philippon, and L. Veldkamp (2019). Big data and firm dynamics. *AEA Papers and Proceedings 109*, 38–42.

Foster, L., J. Haltiwanger, and C. Syverson (2008). Reallocation, firm turnover, and efficiency: Selection on productivity or profitability? *American Economic Review 98*(1), 394–425.

Fuster, A., M. Plosser, P. Schnabl, and J. Vickery (2019). The role of technology in mortgage lending. *The Review of Financial Studies 32*(5), 1854–1899.

Garratt, R., M. J. Lee, et al. (2020). Monetizing privacy with central bank digital currencies. Technical report, Federal Reserve Bank of New York.

Gennaioli, N., R. La Porta, F. Lopez-de Silanes, and A. Shleifer (2012). Human capital and regional development. *The Quarterly Journal of Economics 128*(1), 105–164.

Glaeser, E. L., S. P. Kerr, and W. R. Kerr (2015). Entrepreneurship and urban growth: An empirical assessment with historical mines. *Review of Economics and Statistics 97*(2), 498–520.

Gopal, M. and P. Schnabl (2020). The rise of finance companies and fintech lenders in small business lending. *Available at SSRN*.

Granja, J., C. Leuz, and R. Rajan (2018). Going the extra mile: Distant lending and credit cycles. Technical report, National Bureau of Economic Research.

Haltiwanger, J., R. S. Jarmin, and J. Miranda (2013). Who creates jobs? small versus large versus young. *Review of Economics and Statistics 95*(2), 347–361.

Hart, O. D. (1988). Incomplete contracts and the theory of the firm. *JL Econ. & Org. 4*, 119.

He, Z., J. Huang, and J. Zhou (2020). Open banking: credit market competition when borrowers own the data. Technical report, National Bureau of Economic Research.

Jiang, E., G. Matvos, T. Piskorski, and A. Seru (2020). Banking without deposits: Evidence from shadow bank call reports. Technical report, National Bureau of Economic Research.

Jones, C. I. and C. Tonetti (2020). Nonrivalry and the economics of data. *American Economic Review 110*(9), 2819–58.

Kortum, S. and J. Lerner (2000). Assessing the contribution of venture capital to innovation. *The Rand Journal of Economics 31*(4), 674.

Kroszner, R. S. and P. E. Strahan (1999). What drives deregulation? economics and politics of the relaxation of bank branching restrictions. *The Quarterly Journal of Economics 114*(4), 1437–1467.

Lindsey, L. A. and L. C. Stein (2019). Angels, entrepreneurship, and employment dynamics: Evidence from investor accreditation rules. In *Sixth Annual Conference on Financial Market Regulation*.

Lucas, R. E. (1978). On the size distribution of business firms. *The Bell Journal of Economics*, 508–523.

Petersen, M. A. and R. G. Rajan (1994). The benefits of lending relationships: Evidence from small business data. *The Journal of Finance 49*(1), 3–37.

Petersen, M. A. and R. G. Rajan (1995). The effect of credit market competition on lending relationships. *The Quarterly Journal of Economics 110*(2), 407–443.

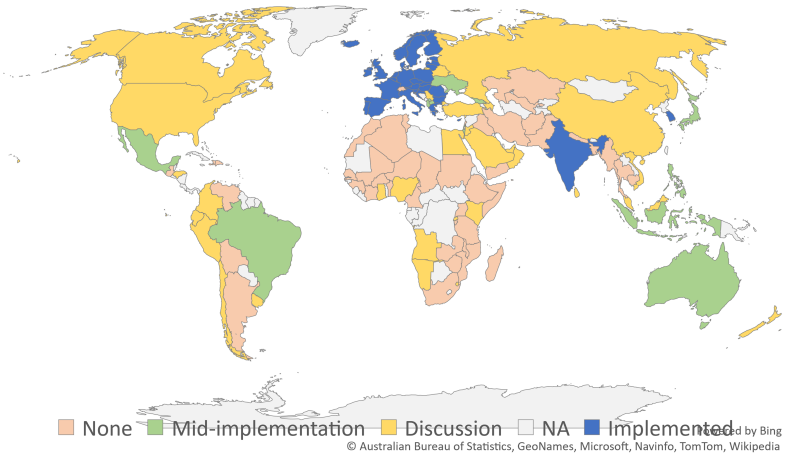
Schumpeter, J. A. (1911). *Theorie Der Wirtschaftlichen Entwicklung*. Leipzig: Duncker & Humblot.

Stulz, R. M. (2019). Fintech, bigtech, and the future of banks. *Journal of Applied Corporate Finance 31*(4), 86–97.

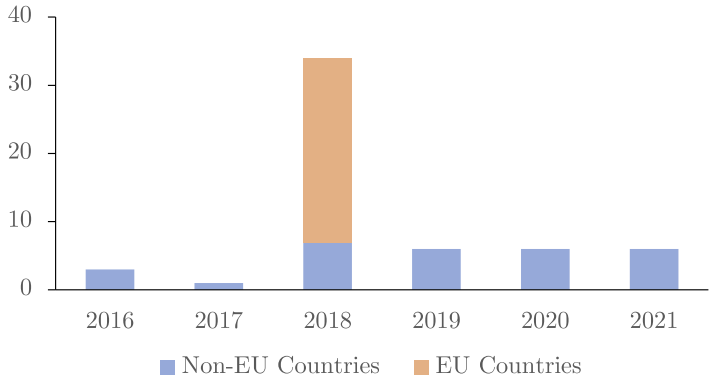
Vives, X. (2019). Digital disruption in banking. *Annual Review of Financial Economics 11*, 243–272.

Figure 1: Government-led Open Banking Regimes Around the World

Note: Panel (a) shows a map of countries based on the implementation status of their government-led policies to promote open banking. Countries marked "None" have no government-led open banking approach; "Discussion" have a government either considering implementing open banking policies or is discussing that implementation; "Mid-implementation" have determined the specifics of the open banking approach and are currently implementing it; "Implemented" have implemented open banking government policies; "NA" are countries or regions for which no data were collected. Panel (b) tabulates the passage year of countries' major open banking policies. Data on government-led policies to promote open banking are current as of October 2021.



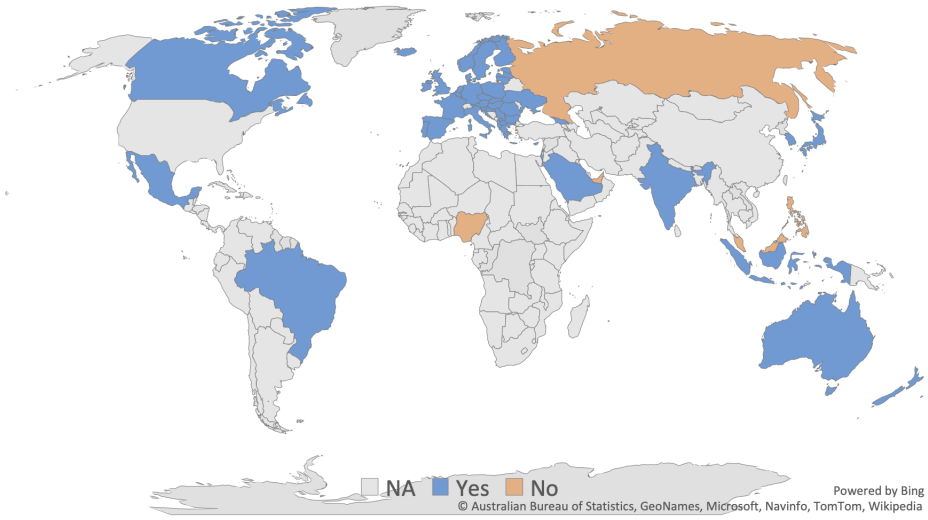
(a) Open banking implementation status among government-led regimes



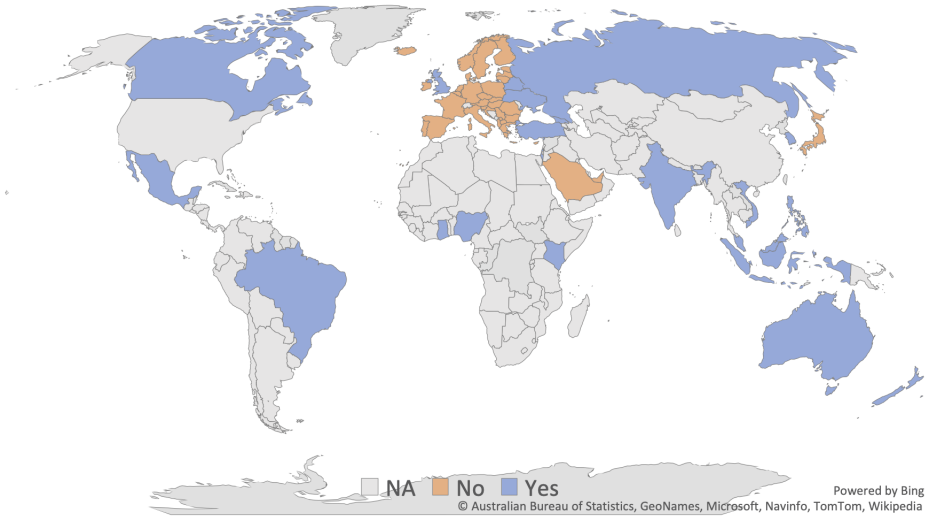
(b) Timeline of open banking adoption

Figure 2: Open Banking Government Policy Dimensions: Mandated Sharing by Banks and Technical Specifications

Note: These maps show mandated data sharing and technical specifications among countries with government-led open banking efforts. Panel (a) shows whether the law requires banks to share data on customer request. Panel (b) shows whether the regulator sets technical standards in the open banking's application programming interface—the technology used in open banking to access and share customer bank data. Countries marked "NA" either have no government-led open banking regime or are too early in discussion for the issue to be decided. Data on government-led policies to promote open banking are current as of October 2021.



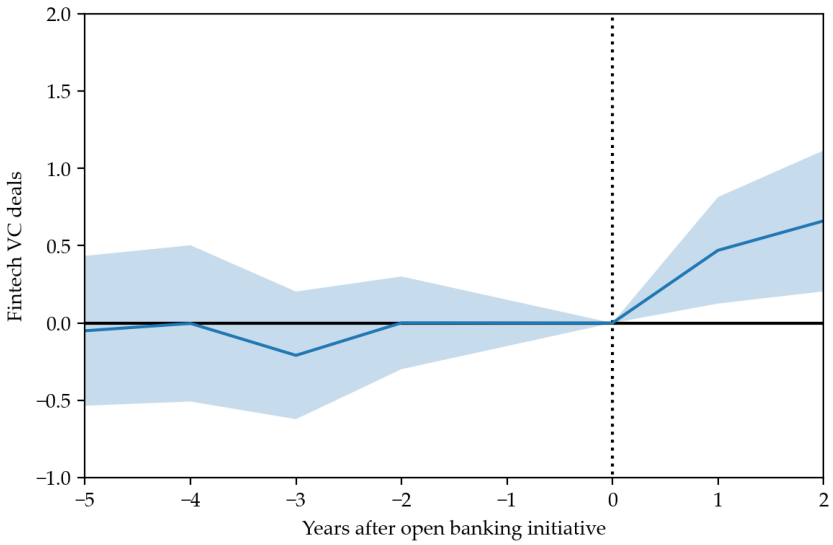
(a) Banks must share data on customer request



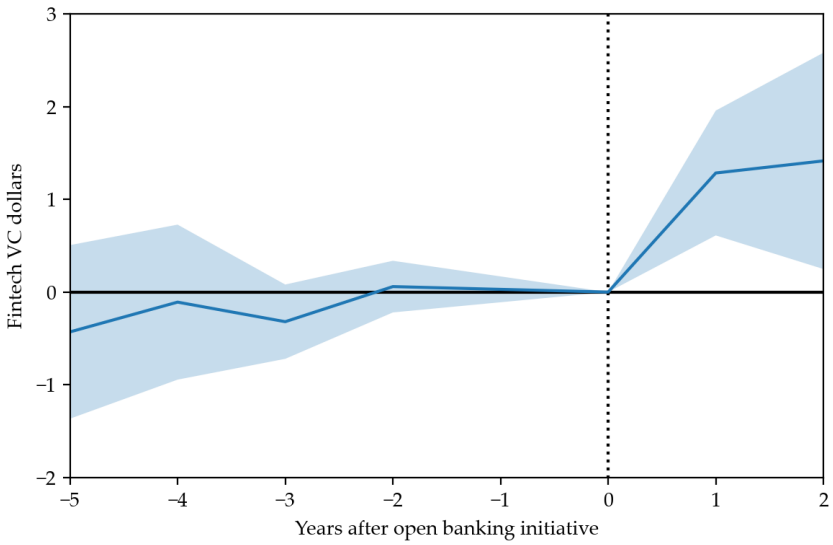
(b) Regulator sets technical standards

Figure 3: Event-study of Fintech Investment After Open Banking Government Policies

Note: This figure shows changes in fintech venture capital (VC) activity around the passage of open banking government policies using a panel event-study analysis. We perform this analysis on our high-coverage Pitchbook panel of 2011-2021 country-year data for the 21 countries with at least five fintech VC deals in the 2000–2010 period. Panel (a) shows an event study on the log of one plus the number of fintech VC deals, and Panel (b) shows an event study on the log of one plus the millions of US dollars invested in fintech VC deals. Year 0 is the passage year of each country's major open banking initiative. The coefficient for year 0 is set to zero and other coefficients are presented net of country and region-by-year fixed effects based on the World Bank regions. European Union member states are weighted to count as a single observation. The shaded regions denote 95% confidence intervals calculated using standard errors clustered at the country level.



(a) Log of number of fintech VC deals



(b) Log of amount of fintech VC investment in millions US dollars

Table 1: Open Banking Regime Summary Statistics

Note: This table shows summary statistics for open banking regimes for 168 countries around the world. The first number is the percentage of countries fitting the given criteria; the number in parentheses is number of countries under consideration. Open banking presence considers all 168 countries for which data were collected. The other categories, policy mandates, status, participation, product scope, and functionality scope, consider only countries with a government-led open banking approach where the reform has advanced far enough such that the issue has been (at least preliminarily) decided.

Variable	Worldwide	Europe/Central Asia	East Asia	MENA	Sub-Sarahan Africa	South Asia	LATAM	North America
Open banking presence								
Any open banking	52% (168)	86% (50)	68% (19)	45% (20)	18% (45)	33% (6)	40% (25)	67% (3)
Market-led	29% (168)	66% (50)	21% (19)	25% (20)	2% (45)	0% (6)	20% (25)	33% (3)
Government-led	48% (168)	80% (50)	63% (19)	40% (20)	18% (45)	33% (6)	32% (25)	67% (3)
Policy justification								
Innovation	97% (65)	97% (39)	100% (11)	100% (5)	100% (4)	50% (2)	100% (3)	100% (1)
Competition	82% (65)	87% (39)	73% (11)	80% (5)	50% (4)	100% (2)	100% (3)	0% (1)
Inclusion	29% (66)	10% (39)	45% (11)	33% (6)	50% (4)	100% (2)	100% (3)	100% (1)
Status								
Discussion	38% (80)	12% (40)	33% (12)	62% (8)	88% (8)	50% (2)	75% (8)	100% (2)
Mid-implementation	18% (80)	12% (40)	50% (12)	12% (8)	0% (8)	0% (2)	25% (8)	0% (2)
Implemented	44% (80)	75% (40)	17% (12)	25% (8)	0% (8)	50% (2)	0% (8)	0% (2)
Participation								
Required data sharing	88% (57)	97% (37)	60% (10)	80% (5)	0% (1)	100% (1)	100% (2)	100% (1)
Mandated tech specs	39% (62)	15% (39)	82% (11)	40% (5)	100% (3)	100% (1)	100% (2)	100% (1)
Data reciprocity	18% (56)	0% (36)	40% (10)	40% (5)	0% (1)	100% (1)	100% (2)	100% (1)
Product scope								
Transaction accts	100% (57)	100% (37)	100% (10)	100% (4)	100% (1)	100% (1)	100% (3)	100% (1)
Non-transactions accts	34% (56)	3% (36)	90% (10)	75% (4)	100% (1)	100% (1)	100% (3)	100% (1)
Very broad	27% (56)	0% (36)	70% (10)	50% (4)	100% (1)	100% (1)	100% (3)	100% (1)
Functionality scope								
Data sharing only	5% (58)	0% (38)	10% (10)	0% (5)	0% (1)	0% (1)	50% (2)	100% (1)
Payments only	0% (58)	0% (38)	0% (10)	0% (5)	0% (1)	0% (1)	0% (2)	0% (1)
Both	95% (58)	100% (38)	90% (10)	100% (5)	100% (1)	100% (1)	50% (2)	0% (1)
Related regulation								
Open data law	25% (160)	65% (48)	28% (18)	11% (18)	0% (45)	0% (4)	8% (24)	0% (3)
Privacy law	61% (110)	94% (36)	93% (14)	58% (12)	17% (30)	25% (4)	45% (11)	67% (3)

Table 2: PitchBook Data Summary Statistics

Note: This table shows summary statistics on our PitchBook venture capital (VC) deal data for 168 countries over 2000–2021. The first column presents statistics on the entire dataset, the next two columns present data for 2000–2010 and 2011–2021 for low coverage countries, and the final two columns present data for 2000-2010 and 2011-2021 for high-coverage countries. High-coverage countries are those with five or more fintech VC deals in the 2000–2010 period, while countries with fewer than five are low-coverage countries. The first set of rows presents the number of countries in each sample, both those with open banking implemented or in the pre-implementation stage as of October 2021 and those that have not reached that stage. The second set of rows presents the number of country-year observations in each sample, both those that are after an open banking policy was passed in that country and other observations. The third set of rows presents statistics on the country-year VC investment: Any VC deals indicates the percentage of country-years with a VC deal, mean and median VC deals (#) present the average number of deals in country-years, and mean and median VC deals ($m) presents the average value of VC deals in a country-year in millions of US dollars. The fourth set of rows presents similar statistics on the country-year fintech VC investment.

	All countries	Low-coverage countries		High-coverage countries	
	2000-2021	2000-2010	2011-2021	2000-2010	2011-2021
Countries					
Count of countries	168	147	147	21	21
Countries with open banking implemented	49	32	32	17	17
Countries without open banking implemented	119	115	115	4	4
Country-year observations					
Count of country-year observations	3,696	1,617	1,617	231	231
Country-years after open banking passed	139	0	84	0	55
Country-years before open banking passed	3,557	1,617	1,533	231	176
Country-year VC activity					
Any VC deals (%)	44.6	23.4	50.1	99.1	100.0
Mean VC deals (#)	74.5	1.1	13.0	212.7	880.6
Median VC deals (#)	0.0	0.0	1.0	38.0	251.0
Mean VC deals ($m)	718.1	6.3	85.8	1,725.2	9,119.4
Median VC deals ($m)	0.0	0.0	0.0	170.6	1,109.9
Country-year fintech VC activity					
Any fintech VC deals (%)	25.3	3.2	31.4	64.1	98.7
Mean fintech VC deals (#)	6.0	0.0	1.8	8.4	74.8
Median fintech VC deals (#)	0.0	0.0	0.0	1.0	19.0
Mean fintech VC deals ($m)	81.2	0.1	20.9	66.8	1,085.9
Median fintech VC deals ($m)	0.0	0.0	0.0	1.3	88.6

Table 3: Drivers of Open Banking Government Policies

Note: This table shows whether ex-ante country characteristics predict the implementation of open banking government policies. The dependent variable is a dummy variable equal to one if open banking was implemented in the country in question as of October 2021 in columns 1–5, and in column 6 dependent variable is a score between 0 and 7 based on a country's open banking implementation progress as of October 2021, with 0 being no action, 1–2 being increasingly serious levels of discussion, and 3–7 being levels of implementation progress. The open banking implemented dummy corresponds to being in or after the pre-implementation stage or equivalently a level of 3 or above. The independent variables are country characteristics measured as of 2013. Per capita GDP is reported in thousands of US dollars from World Bank data. Population, private sector credit to GDP, bank branches per 100k people, and the financial sector Lerner index are also from the World Bank. The Lerner index ranges between zero and one and measures the market power of banks, with higher values denoting less competition. Fintech VC deals and non-fintech VC deals are from PitchBook and are used after taking the log of one plus the number of deals. Foreign owned banks are from the Claessens and Van Horen (2013) foreign bank ownership data. The Human Freedom, Rule of Law, and Business Regulation Indexes are from the Cato Institute are on a zero to ten scale with higher numbers denoting more favorable conditions. The Corruption Perception Index is from Transparency International and is on a zero to one hundred scale with higher numbers denoting more favorable conditions. The regressions are cross-sectional, where each country in the sample corresponds to a single data point. All specifications include region fixed effects based on the World Bank classification. European Union member states are weighted to count as a single observation. *** denotes p-value < 0.01, ** denotes <0.05, and * denotes <0.1.

	Open banking implemented (0-1)					OB implementation (0-7)
	(1)	(2)	(3)	(4)	(5)	(6)
Private sector credit to GDP	0.000				-0.002	-0.007
	(0.002)				(0.001)	(0.005)
Branches per 100k people	-0.003				-0.007	-0.035
	(0.006)				(0.007)	(0.022)
Financial sector Lerner index	0.149				0.274	3.312**
	(0.463)				(0.415)	(1.536)
Non-fintech VC deals		0.080*			0.055	0.396
		(0.042)			(0.061)	(0.244)
Fintech VC deals		0.070			0.127	0.505
		(0.073)			(0.089)	(0.339)
Foreign owned banks			0.102		0.050	-0.068
			(0.121)		(0.179)	(0.684)
Human Freedom Index				0.152**	0.272**	0.608
				(0.060)	(0.122)	(0.434)
Rule of Law Index				-0.001	-0.050	-0.058
				(0.049)	(0.110)	(0.410)
Business Regulation Index				-0.016	-0.063	-0.177
				(0.045)	(0.063)	(0.226)
Corruption Perception Index				-0.001	0.001	0.035
				(0.005)	(0.007)	(0.026)
Per capita GDP ($k)	0.015	0.004	0.020***	0.016**	-0.001	-0.029
	(0.010)	(0.006)	(0.006)	(0.008)	(0.009)	(0.033)
Per capita GDP ($k) squared	-0.000	-0.000	-0.000**	-0.000*	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population	0.044	-0.032*	0.049*	0.058**	-0.032	-0.065
	(0.049)	(0.019)	(0.027)	(0.025)	(0.058)	(0.173)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	85	162	133	145	82	82
Adjusted R^2	0.308	0.386	0.320	0.359	0.461	0.622

Table 4: Determinants of Open Banking Government Policy Structure

Note: This table shows whether ex-ante country characteristics predict open banking government policy choices among the countries where those choices have been made. The dependent variables in columns 1 to 4 are dummy variables indicating different open banking policy choices: in column 1 it indicates whether banks are mandated to share the data with other financial service providers upon consumer request; in 2 whether there is data reciprocity between banks and other financial service providers (e.g., if fintechs must share customer data with banks); in 3 whether regulators set technical specification for open banking implementation; in 4 whether, in addition to bank payment accounts, open banking policies cover other financial products and services (e.g., mortgages, insurance). The dependent variable in column 5 is the Open Banking Strength Index that we measure as the average of those four policy dimensions used in columns 1 to 4. The independent variables are country characteristics as of 2013. Per capita GDP in thousands of US dollars, population in millions, and the financial sector Lerner index (between zero and one, with high values denoting less competition) are from the World Bank. Non-fintech VC deals are from PitchBook and is used after taking the log of one plus the number of deals. The Human Freedom Index is from the Cato Institute and is on a zero to ten scale, with higher numbers denoting more favorable conditions. The regressions are cross-sectional, where each country in the sample corresponds to a single data point. All specifications include regions fixed effects based on the World Bank classification. European Union member states are weighted to count as a single observation. *** denotes p-value < 0.01, ** denotes <0.05, and * denotes <0.1.

	Banks share	Users share	Regulated tech. specs	Beyond transactions	OB Strength Index
	(1)	(2)	(3)	(4)	(5)
Financial sector Lerner index	0.274	0.839	0.328	-0.632	0.287*
	(0.628)	(0.541)	(0.673)	(0.732)	(0.151)
Non-fintech VC deals	-0.220***	0.077	0.306***	0.064	0.029***
	(0.076)	(0.059)	(0.088)	(0.080)	(0.010)
Human Freedom Index	0.712***	0.258*	-0.143	-0.267	0.145***
	(0.185)	(0.128)	(0.156)	(0.268)	(0.048)
Per capita GDP ($k)	-0.004	-0.039**	-0.046***	0.012	-0.011***
	(0.014)	(0.014)	(0.013)	(0.021)	(0.003)
Per capita GDP ($k) squared	0.000	0.000**	0.000***	-0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population	0.311**	0.115	-0.213*	-0.153	0.038
	(0.118)	(0.093)	(0.119)	(0.134)	(0.024)
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	42	41	46	41	39
Adjusted R^2	0.492	0.702	0.373	0.539	0.964

Table 5: Effect of Open Banking Government Policy on Bank API Offerings

Note: This table shows the association between the passage of open banking government policy and banks providing Application Programming Interfaces (APIs)—the technology used in open banking to share customer bank data. The dependent variable in columns 1 and 2 is the log of one plus the number of banks offering APIs; in 3 and 4 it is the percentage of the top 10 banks in each country (as ranked by 2020 assets in Bureau van Dijk) that offer APIs; and in 5 and 6 it is the log of one plus the number of banks in each country offering developer portals, which document the behavior of the APIs and offer other developer tools. These developer portals assist external developers with building products on top of banks' systems using banks' APIs. The independent variable of interest in columns 1, 3, and 5 is a dummy variable equal to one if open banking was implemented in the country in question as of October 2021 and in columns 2, 4, and 6 is a 0–7 rating of the extent of open banking government policy implementation progress as of October 2021, with 0 being no action, 1–2 being increasingly serious levels of discussion, and 3–7 being levels of implementation progress. The open banking implemented dummy corresponds to being in or after the pre-implementation stage or equivalently a level of 3 or above. All specifications include GDP per capita in thousands of US dollars and the log of population in millions from World Bank data as controls, as well as region-by-year fixed effects, where regions are based on the World Bank classification. European Union member states are weighted to count as a single observation. *** denotes p-value < 0.01, ** denotes <0.05, and * denotes <0.1.

	Banks with APIs		% of top banks with APIs		Banks with dev. portals	
	(1)	(2)	(3)	(4)	(5)	(6)
Open banking implemented (0/1)	0.648***		0.190***		0.674***	
	(0.226)		(0.071)		(0.226)	
Open banking implementation (0-7)		0.201***		0.052***		0.205***
		(0.043)		(0.013)		(0.043)
Per capita GDP ($k)	0.039***	0.025**	0.005	0.002	0.039***	0.025**
	(0.013)	(0.012)	(0.003)	(0.003)	(0.012)	(0.012)
Per capita GDP ($k) squared	-0.000	-0.000	-0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population	0.291***	0.265***	0.046***	0.040***	0.292***	0.266***
	(0.049)	(0.047)	(0.014)	(0.013)	(0.048)	(0.047)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	157	157	157	157	157	157
Adjusted R^2	0.629	0.672	0.488	0.531	0.632	0.675

Table 6: Effect of Open Banking Government Policy on Fintechs

Note: This table shows changes in fintech venture capital (VC) investment following the implementation of open banking policies by governments around the world. The table uses a difference-in-difference design on our high-coverage Pitchbook panel data of country-year data spanning 2011-2021 for the 21 countries with at least five fintech deals in the 2000–2010 period. The dependent variable in columns 1 to 3 is the log of one plus the number of fintech deals in a country-year, in columns 4 to 6 it is the log of one plus the amount invested in millions of US dollars. The independent variable is a dummy variable equal to one if the year in question is after the year major open banking laws were passed in the country in question. Columns 3 and 6 include a control for non-fintech VC activity using data from Pitchbook, transformed the same way as fintech VC activity. All specifications control for country fixed effects, columns 1 and 4 contain controls for year fixed effects, and columns 2, 3, 5, and 6 control for region-by-year fixed effects where regions are based on the World Bank classification. European Union member states are weighted to count as a single observation. Standard errors are clustered at the country-level. *** denotes p-value < 0.01, ** denotes <0.05, and * denotes <0.1.

	Fintech VC deals			Fintech VC dollars		
	(1)	(2)	(3)	(4)	(5)	(6)
After OB initiative	0.214*	0.532***	0.363**	0.746**	1.305**	1.104**
	(0.111)	(0.160)	(0.156)	(0.267)	(0.474)	(0.432)
Non-fintech VC deals			0.475***			
			(0.135)			
Non-fintech VC dollars						0.292**
						(0.095)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes			Yes		
Region-Year FE		Yes	Yes		Yes	Yes
Observations	231	231	231	231	231	231
Adjusted R^2	0.919	0.929	0.936	0.877	0.895	0.898

Table 7: Effect of Open Banking Government Policy on Fintechs by Product Type

Note: This table shows changes in fintech venture capital (VC) investment following the implementation of open banking policies by governments around the world. The table uses a difference-in-difference design on our high-coverage Pitchbook panel data of country-year data spanning 2011-2021 for the 21 countries with at least five fintech deals in the 2000–2010 period. The dependent variable in each specification is the log of one plus the number of VC deals in a country-year and given subsector of fintech, where subsectors are defined based on Pitchbook keywords as described in Appendix B. The independent variable is a dummy variable equal to one if the year in question is after the year major open banking laws were passed in the country in question. Panel (a) performs a panel regression with country and region-by-year fixed effects where regions are based on the World Bank classification. Panel (b) adds a control for the log of one plus the number of non-fintech VC deals. European Union member states are weighted to count as a single observation. Standard errors are clustered at the country-level. *** denotes p-value < 0.01, ** denotes <0.05, and * denotes <0.1.

Panel (a) Without non-fintech VC activity control

	Alternative lending	Consumer finance	Financial IT	Payments	Regtech	Wealth management	Digital assets
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
After OB initiative	0.737*	0.693**	0.760***	0.654	0.709***	0.624*	0.022
	(0.355)	(0.260)	(0.230)	(0.407)	(0.135)	(0.329)	(0.279)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	231	231	231	231	231	231	231
Adjusted R^2	0.866	0.835	0.877	0.863	0.876	0.875	0.828

Panel (b) With non-fintech VC activity control

	Alternative lending	Consumer finance	Financial IT	Payments	Regtech	Wealth management	Digital assets
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
After OB initiative	0.623*	0.589**	0.644***	0.508*	0.544*	0.424	-0.132
	(0.326)	(0.205)	(0.201)	(0.277)	(0.250)	(0.312)	(0.280)
Non-fintech VC deals	0.323	0.292	0.329	0.409	0.463*	0.562***	0.434
	(0.276)	(0.225)	(0.218)	(0.251)	(0.221)	(0.163)	(0.340)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	231	231	231	231	231	231	231
Adjusted R^2	0.868	0.838	0.880	0.868	0.883	0.883	0.834

Table 8: Effect of Open Banking Government Policy and Its Characteristics on Fintechs

Note: This table shows changes in fintech venture capital (VC) investment activity following the implementation of different types of open banking policies by governments around the world. The table uses a difference-in-difference design on our high-coverage Pitchbook data of country-year data spanning 2011-2021 for the 21 countries with at least five fintech deals in the 2000–2010 period. The dependent variable in each specification is the log of one plus the number of fintech VC deals in each country-year. The independent variables are different characteristics of open banking government policies interacted with a dummy variable equal to one if the year in question is after the year major open banking laws were passed in the country in question. In column 1 we indicate whether banks are mandated to share the data with other financial service providers upon consumer request; in column 2 whether there is data reciprocity between banks and other financial service providers (e.g., if fintechs have to share customer data with banks); in column 3 whether regulators set technical standards for open banking implementation; and in column 4 whether, in addition to bank payment accounts, open banking policies cover other financial products and services (e.g., mortgages, insurance). In column 5, the dependent variable is the Open Banking Strength Index that we measure as the average of those four policy dimensions used in columns 1 to 4. All specifications have country and region-by-year fixed effects where regions are based on the World Bank classification. European Union member states are weighted to count as a single observation. Standard errors are clustered at the country-level. *** denotes p-value < 0.01, ** denotes <0.05, and * denotes <0.1.

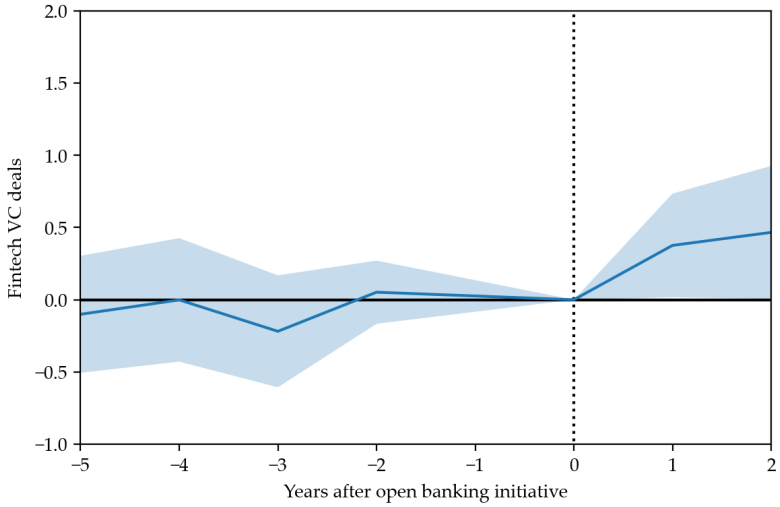
	Fintech VC Deals				
	(1)	(2)	(3)	(4)	(5)
Banks must share X after OB	0.322**				
	(0.132)				
Users must share X after OB		0.394***			
		(0.120)			
Regulated specifications X after OB			0.165		
			(0.135)		
Beyond transactions X after OB				0.361	
				(0.202)	
OB Strength Index X after OB					0.751**
					(0.264)
After OB initiative	0.063	0.300*	0.288	0.257	0.018
	(0.133)	(0.146)	(0.195)	(0.170)	(0.268)
Non-fintech VC deals	0.446***	0.494***	0.500***	0.483***	0.500***
	(0.143)	(0.145)	(0.152)	(0.147)	(0.152)
Country FE	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	231	231	231	231	231
Adjusted R^2	0.935	0.936	0.935	0.936	0.936

Appendix

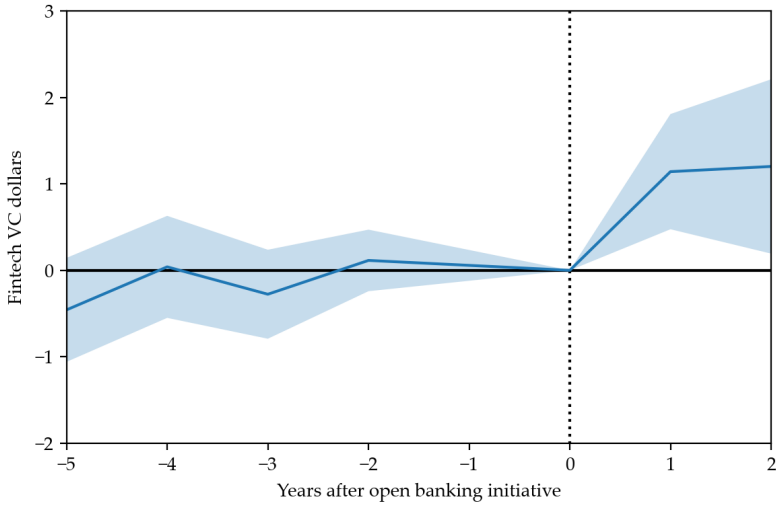
A Additional Tables and Figures

Figure A1: Event-study of Fintech Investment After Open Banking Government Policies After Controlling for Non-Fintech Investment

Note: This figure shows changes in fintech venture capital (VC) activity around the passage of open banking government policies using a panel event-study analysis that includes a control for non-fintech VC activity. We perform this analysis on our high-coverage Pitchbook panel of 2011-2021 country-year data for the 21 countries with at least five fintech VC deals in the 2000–2010 period. Panel (a) shows an event study on the log of one plus the number of fintech VC deals and Panel (b) shows an event study on the log of one plus the millions of US dollars invested in fintech VC deals. Year 0 is the passage year of each country's major open banking initiative. The coefficient for year 0 is set to zero and other coefficients are presented net of a control for non-fintech VC deals or dollars, country fixed effects, and region-by-year fixed effects based on the World Bank regions. European Union member states are weighted to count as a single observation. The shaded regions denote 95% confidence intervals calculated using standard errors clustered at the country level.



(a) Log of number of fintech VC deals



(b) Log of amount of fintech VC investment in millions US dollars

Table A1: Country Data Summary Statistics

Note: This table shows summary statistics on country-year variables. Panel (a) reports values for all countries and the 2013 year, which we use for pre-open banking country characteristics for our cross-country regressions. Panel (b) reports values for 2011–2021 for the high-coverage PitchBook data sample of countries that have at least five fintech venture capital (VC) deals in the 2000–2010 period, which we use for panel regressions of open banking's impact on fintech VC activity. For each variable, we present the number of observations, the average value, the standard deviation, and assorted percentiles. The first set of variables concern the status of open banking: after open banking initiative is equal to one in country-years after a major open banking policy was passed, OB implemented (as of 2021) is equal to one if the open banking policy was implemented or is in the pre-implementation stage as of October 2021, and OB implementation (as of 2021) is a rating of the open banking progress as of October 2021 where higher numbers denote more progress toward regulation. Variables for VC deals, non-fintech VC deals, and fintech VC deals are presented next and are from PitchBook and used after taking the log of one plus the number (and are hence different from Table 2). Per capita GDP is reported in thousands of US dollars from World Bank data. Population (in millions), private sector credit to GDP, bank branches per 100k people, and the financial sector Lerner index are also from the World Bank. The Lerner index ranges between zero and one and measures the market power of banks, with higher values denoting less competition. Foreign owned banks are from the Claessens and Van Horen (2013) foreign bank ownership data. The Human Freedom, Rule of Law, and Business Regulation Indexes are from the Cato Institute are on a zero to ten scale with higher numbers denoting more favorable conditions. The Corruption Perception Index is from Transparency International and is on a zero to one hundred scale with higher numbers denoting more favorable conditions.

Panel (a) 2013 for entire 168 country sample

	Count	Mean	Std. dev.	10th pct.	25th	50th.	75th	90th
Observations	168							
Open banking variables								
After open banking initiative	168	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OB implemented (as of 2021)	168	0.29	0.45	0.00	0.00	0.00	1.00	1.00
OB implementation (as of 2021)	168	1.83	2.46	0.00	0.00	0.00	4.00	6.00
Venture capital variables								
VC deals	168	1.58	1.97	0.00	0.00	0.69	2.79	4.79
Non-fintech VC deals	168	1.54	1.95	0.00	0.00	0.69	2.66	4.67
Fintech VC deals	168	0.58	1.06	0.00	0.00	0.00	1.10	2.11
Other explanatory variables								
Per capita GDP ($k)	162	14.74	20.69	0.76	1.41	5.62	18.75	45.63
Per capita GDP ($k) squared	162	645.46	1,713.83	0.58	1.98	31.59	352.09	2,082.42
Log population	155	2.37	1.50	0.60	1.35	2.31	3.38	4.32
Private sector credit to GDP	149	54.19	47.37	11.08	18.70	39.79	70.53	124.82
Branches per 100k people	155	17.30	15.63	2.72	4.94	12.48	23.54	37.15
Financial sector Lerner index	94	0.31	0.13	0.17	0.23	0.29	0.37	0.47
Foreign owned banks	134	0.43	0.28	0.03	0.20	0.42	0.66	0.80
Human Freedom Index	146	7.00	1.01	5.65	6.38	6.90	7.93	8.35
Rule of Law Index	146	5.18	1.56	3.43	3.94	4.77	6.47	7.56
Business Regulation Index	146	6.39	1.29	4.72	5.72	6.33	7.35	8.09
Corruption Perception Index	160	42.27	19.97	20.90	28.00	37.00	53.25	75.00

Table A1: Country Data Summary Statistics (continued)

Panel (b) 2011–2021 for the 21 country high-coverage sample

	Count	Mean	Std. dev.	10th pct.	25th	50th.	75th	90th
Observations	231							
Open banking variables								
After open banking initiative	231	0.24	0.43	0.00	0.00	0.00	0.00	1.00
OB implemented (as of 2021)	231	0.81	0.39	0.00	1.00	1.00	1.00	1.00
OB implementation (as of 2021)	231	4.81	1.89	1.00	4.00	6.00	6.00	6.00
Venture capital variables								
VC deals	231	5.75	1.22	4.47	4.92	5.53	6.31	7.46
Non-fintech VC deals	231	5.67	1.21	4.36	4.82	5.42	6.21	7.29
Fintech VC deals	231	3.19	1.38	1.61	2.30	3.00	3.88	5.10
Other explanatory variables								
Per capita GDP ($k)	220	42.28	20.57	10.66	32.31	44.82	52.82	63.09
Per capita GDP ($k) squared	220	2,210.32	1,806.40	113.58	1,044.25	2,009.16	2,790.40	3,980.61
Log population	220	3.57	1.52	1.68	2.24	3.64	4.52	5.39
Private sector credit to GDP	199	107.33	44.47	51.88	65.25	105.49	141.13	167.65
Branches per 100k people	197	24.86	13.72	8.92	14.79	21.86	32.93	38.36
Financial sector Lerner index	72	0.27	0.12	0.11	0.18	0.28	0.34	0.41
Foreign owned banks	231	0.27	0.24	0.02	0.08	0.20	0.40	0.58
Human Freedom Index	126	7.96	0.82	6.41	7.99	8.34	8.52	8.59
Rule of Law Index	126	7.08	1.44	4.35	6.78	7.45	8.18	8.61
Business Regulation Index	126	7.28	1.12	6.00	6.79	7.64	8.03	8.18
Corruption Perception Index	168	68.75	17.98	38.00	60.00	74.50	82.00	87.30

Table A2: Effect of Open Banking Government Policy Structure on Bank API Offerings

Note: This table shows the association between the prevalence of banks open banking's application programming interface (APIs) and the implementation of different types of open banking policies by governments around the world. The dependent variable is the percentage of the top 10 banks in each country (as ranked by 2020 assets in Bureau van Dijk) that offer public APIs, which are technological capability that allow outside financial service providers to access banks' customer data upon costumer request. The independent variables are different characteristics of open banking government policies interacted with a dummy variable equal to one if the country has implemented open banking: column 1 indicates if banks are mandated to share data with other financial service providers upon consumer request; column 2 indicates if there is data reciprocity between banks and other financial service providers (e.g., if fintechs have to share customer data with banks); column 3 indicates if regulators set technical specification for open banking implementation; column 4 indicates if, in addition to bank payment accounts, open banking policies cover other financial products and services (e.g., mortgages, insurance). The dependent variable in column 5 is the Open Banking Strength Index that we measure as the average of the four policy dimensions used in columns 1 to 4 with higher values reflecting more comprehensive open banking policies. All specifications include GDP per capita in thousands of US dollars and the log of population in millions from World Bank data as controls, as well as region fixed effects based on the World Bank classification. European Union member states are weighted to count as a single observation. *** denotes p-value < 0.01, ** denotes <0.05, and * denotes <0.1.

	% of top banks with APIs				
	(1)	(2)	(3)	(4)	(5)
Banks must share X OB implemented	0.181				
	(0.145)				
Users must share X OB implemented		0.240*			
		(0.122)			
Regulated specifications X OB implemented			0.015		
			(0.113)		
Beyond transactions X OB implemented				0.046	
				(0.134)	
OB Strength Index X OB implemented					0.233***
					(0.089)
Open banking implemented (0/1)	0.030	0.104	0.180*	0.163	-0.013
	(0.138)	(0.081)	(0.095)	(0.099)	(0.062)
Per capita GDP ($k)	0.005	0.005	0.005	0.005	0.004
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Per capita GDP ($k) squared	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population	0.045***	0.038***	0.046***	0.045***	0.045***
	(0.014)	(0.013)	(0.013)	(0.014)	(0.014)
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	157	157	157	157	157
Adjusted R^2	0.498	0.525	0.484	0.486	0.500

B Classification of Fintech Startups

PitchBook groups tens of thousands of startups into the "Financial Software" subindustry and the "Fintech" vertical, but does not offer a more granular industry definition. We overcome this using PitchBook's keywords feature with categories from PitchBook's 2021Q1 fintech market map and keywords derived from those startups. PitchBook's fintech market map divides recent fintech financing rounds into eight broad categories: alternative lending, capital markets, consumer finance, digital assets, financial services IT, payments, regtech, and wealthtech. Importantly, these categories were designed around use cases and without open banking in mind.

Although innovative startups are by nature often hard to classify, these categories roughly span the current fintech market. Alternative lending includes retail and commercial lending. Capital markets includes institution-focused capital market applications, including trading, data, and capital management. Consumer finance encompasses digital banking, rewards programs, and credit cards. Digital assets covers cryptocurrency and related applications. Financial services IT includes both APIs and enterprise architecture. Regtech includes risk management and compliance startups. Wealth management includes investment advisory and brokerage services.

For each of those categories, we derive a list of keywords used by the startups in that category. These keywords were assigned by PitchBook analysts covering the company, with the typical company having four keywords. Keywords range from general to specific, for example, the most frequently used keywords for companies in the regtech segment of the market map are regtech vertical, fraud detection, fraud detection platform, regulatory compliance, fintech, artificial intelligence, and risk management.

We find the relative frequency of each keyword within each category. For example, the regtech vertical keyword accounts for 3% of the keywords used by startups in the regtech category and less than 1% for all the other categories. A keyword is distinctive to a category if it is in the top 25 keywords for that category and its usage rate in that category is twice the sum of its usage rates in the other categories. Regtech vertical, fraud detection, fraud detection platform, and regulatory compliance are all distinctive keywords for the regtech category. Fintech, artificial intelligence, and risk management are not because they are commonly used across categories. The capital markets category focuses on institutional services and lacks distinctive keywords (its top keywords are financial technology, financial software, financial platform, and financial services) and so we drop it.

We assign fintech startups into categories using the distinctive keywords for each category. A startup is classified as a regtech startup if it is marked with regtech vertical, fraud detection, fraud detection platform, regulatory compliance, or other distinctive keywords for the regtech category. Fintech companies often offer a broad scope of services and can be hard to assign

to a single category. Our keyword-based classification system accommodates this by allowing companies to be in multiple categories. For example, the U.S. company SeedFi offers packages of borrowing and saving to lower-income customers placing it in both the alternative lending and consumer finance categories. The resulting categories are relatively balanced, with the largest categories (wealth management, financial IT) being about two-and-a-half times as large as the smallest category (consumer finance).