

Buch, Claudia M.; Goldberg, Linda S.

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Complexity and Riskiness of Banking Organizations: Evidence from the International Banking Research Network

Claudia M. Buch | Linda Goldberg

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Evidence from the International Banking Research Network**

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Abstract

Complexity of banks can have important ramifications for the performance and the risks of the banking system. Financial sector reforms that were implemented in the past decade have thus aimed to reduce and to better manage the risk implications of bank complexity. Yet, surprisingly little is known about changes in complexity across countries, its drivers, and its effects. The International Banking Research Network (IBRN) used data and analytical advances to generate rich cross-country insights on the complexity and riskiness of banking organizations. The initiative has yielded four key findings. First, the largest banks in countries tend to be the more complex ones. Even controlling for size, there is substantial diversity across banking organizations in terms of complexity choices. Second, over the past decade, banking organizations have tended to reduce complexity by limiting the number of affiliates in domestic and foreign locations. Generally, however, complexity patterns are fairly persistent. Third, regulatory changes can alter both banking organization complexity and the associated risk profiles. Fourth, the link between complexity and risks involves trade-offs: diversification benefits and reductions in liquidity risk may weigh against agency problems, monitoring costs, and systemic risk contributions arising from higher complexity.

Key words: bank complexity, financial regulation, international banking, risks in banking

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This paper presents preliminary findings and is being distributed to economists and other interested readers solely to stimulate discussion and elicit comments. The views expressed in this paper are those of the author(s) and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System. Any errors or omissions are the responsibility of the author(s).

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I. Motivation

Banking organizations are quite heterogeneous: they can be simple – comprised of traditional banks that mainly provide basic banking functions of taking deposits and extending loans – or can be complex in their organizational structures, types of businesses conducted, and their geographic span. Many banking organizations are corporate conglomerates that contain banks, but also can contain dozens, hundreds, or even thousands of nonbank legal entities. Their business scope can span financial and non-financial activities, and their geography can span multiple countries.

Despite the clear relevance, the complexity patterns and their implications for the activities and the risks of banking organizations are under-researched. Understanding these patterns and the implications for banking organization risks are the focus of this paper. While complexity often has a negative connotation, we find that it entails tradeoffs. Complexity can reduce exposure to some risks as it allows banks to exploit synergies across activities. It can yield benefits in terms of risk diversification and reduced liquidity risk. However, complexity can also increase risks due to the stronger challenges that occur around risk containment and management, and it can increase the costs and feasibility of resolution when the organization fails.

The global financial crisis of 2007/08 demonstrated the dark side of bank complexity. The balance sheet frailties of large and complex financial institutions had been underestimated, as were the negative externalities that were imposed on other institutions, governments, and the real economy. Particularly relevant are costs that arise in times of stress, with recovery and resolution of gone concern banking organizations impeded by a high degree of complexity, including in cross-border contexts.

Far-reaching post crisis reforms have thus aimed at making financial institutions more resilient and at reducing their systemic risk externalities. The regulatory community agreed to a common approach to measure complexity using then available data (BIS 2013). This measure uses specific balance sheet categories associated with informational opacity and illiquidity in assessing the need for additional liquidity and capital requirements, as well as proxies for complexity.² However, the crisis and subsequent policy responses revealed the need for a better understanding of the complexity of banking organizations, both in terms of determinants and implications for risk.

² The Basel Committee on Banking Supervision adopted an assessment methodology for global systemically important banks, and higher loss absorbency requirements, with the updated methodology is at BIS (2013).

Today, we are in a much better position to assess the determinants and patterns of bank complexity than prior to the global financial crisis. This includes assessing relationships with organizational incentives and risk outcomes, and the effects of the regulatory reforms that have been implemented post crisis. One simple reason is the passage of time. More than ten additional years of data enable meaningful analytics, comparing developments over time and around significant policy actions that occurred during this period. In addition, the data infrastructure has improved significantly: more granular bank-level data allows creation of complexity measures and studying trends across different banking organizations. Another factor is that the research community has developed tools to analyze the efficiencies and incentive issues within banking organizations, including on how moral hazard, organizational design, and corporate cultures influence risk outcomes.

The International Banking Research Network (IBRN) advanced this agenda by generating rich cross-country insights on the complexity and riskiness of banking organizations. Researchers from thirteen central banks and the Bank for International Settlements (BIS) worked with confidential data collected by their regulators to provide comprehensive new evidence on banking organization complexity. Research papers written span perspectives of home and host countries of complex banking organizations. Studies consider the mechanisms through which the complexity of banking organizations affects risks associated with these institutions, as well as drivers of such complexity.

This comprehensive new evidence on banking complexity from the vantage point of organizational, business, and geographic dimensions yields four key contributions:

First, structural features of bank complexity are quite persistent over time. High complexity tends to be concentrated in a relatively limited number of institutions, with the largest asset size tier of banking organizations also having the greatest degree of complexity. The relationship between (asset) size and complexity strongest amongst larger banking organizations. However, even controlling for size, there is considerable diversity across organizations in their complexity choices so that size is not a sufficient proxy for banking organization complexity.

Second, over time, banks have tended to reduce organizational complexity by limiting the number of affiliates located in domestic and foreign locations. Aggregate indicators of business complexity exhibited more modest changes over time, with specific changes arising in the composition of businesses rather than complexity across businesses. Geographic complexity increased for banking organizations from some countries while declining for others.

Third, regulatory changes can alter both complexity and the risk profiles of complex banking organizations. Several studies measure the response of complexity and risk to the Basel III

regulatory framework, including its criteria for the designation of G-SIBs. German banks affected by a tightening of regulations reduced geographic and business complexity, but at the same time managed to increase their diversification and thereby reduce their risk (Martynova and Vogel 2021). Foreign banking affiliates of G-SIBs hosted by Hong Kong saw a larger decline in risks than their counterparts as a result of the reduced business complexity of G-SIBs (Ho, Wong and Tan 2021). Implementation of Basel III regulations has been associated with a change in equity portfolios and divested financial holdings in Austrian banking organizations (Ehrlich, Elsinger, Lindner, Segalla and Sigmund 2020). Meanwhile, Norwegian bank balance sheet opacity declined in response to Basel III (Cao and Juelsrud 2021). US regulatory changes specifically targeted at organizational complexity, such as the Living Will provisions of the Dodd Frank Act, significantly changed complexity and risk outcomes. Organizational complexity declines were associated with reduced systemic risk, but increased liquidity risk exposures (Correa and Goldberg 2021). In Spain, the introduction of Institutional Protection Schemes (IPS) as a consolidation mechanism allowed increases in organizational complexity without affecting idiosyncratic risk (Argimón and Rodríguez-Moreno 2021).

Fourth, specific tests of the mechanisms through which complexity influences risk outcomes reinforce the focus on trade-offs: Diversification benefits tend to reduce idiosyncratic risk, while agency problems and monitoring costs in complex institutions might increase risk. For US banks, trade-offs differ by type of complexity considered: higher organizational, business, and geographic complexity generated diversification benefits. Geographic complexity also reduces liquidity risk exposure. All three types of complexity contribute to increased systemic risk. Idiosyncratic risk also declines with complexity, in particular geographic complexity, for Spanish banks and also for business complexity, for Polish and Portuguese banking organizations. Such diversification benefits appear to be outweighed by higher agency costs of complex organizations: Results for banking organizations in Colombia, France, and Hong Kong show that idiosyncratic risks tend to increase with complexity. German systemically important banks managed to increase their diversification benefits while also reducing complexity in response to regulatory tightenings. Italian banking organizations active in more markets were found to be more selective, with reduced exposure to riskier borrowers; the opposite holds for intermediaries with a higher degree of diversification of fee income. This is consistent with mixed idiosyncratic risk outcomes. Various studies point to better risk frontier outcomes when banking organizations are ex ante better capitalized or better governed. In a cross-country setting, the geographic complexity of foreign banking affiliates of the largest international banks tended to mitigate the effects of local shocks on bank risk (z-score) while weakening the positive effects of prudential regulation on capitalization (Aldasoro, Hardy and Jager 2021).

The remainder of the paper is organized as follows. In Part two, we compile new evidence on the patterns and determinants of bank complexity. Part three focuses on the drivers of bank complexity. Part four presents evidence on the link between complexity and risk. Part five concludes with policy insights and research suggestions.

II. Evidence on Bank Complexity

While the simple, stand-alone commercial bank has traditionally been the perspective embedded in research and policy, the banking landscape has changed. Many banks are complex combinations of different businesses, sometimes in many locations around the world, and conducted through a host of legal entities. Countries can also serve as hosts to foreign banking organizations, with subsidiaries or branches of complex global bank holding companies (BHCs) being important providers of local credit and financial services. Below, we describe recent analytical advances that provide lenses on these forms of complexity, and then we turn to new cross-country evidence.

1. *Measuring Bank Complexity*

Regulators use a number of criteria to designate global systemically important financial institutions (G-SIFIs) and to assess systemically important banks on the national level. These criteria include size, cross-jurisdictional activity, inter-connectedness, and complexity. Complexity, in the regulatory context, is related to the opacity of balance sheet and off balance sheet assets of banks. It increases with holdings of assets that are hard to understand and to price, such as notional amounts of over-the-counter (OTC) derivatives, trading and available-for-sale (AFS) securities, and level 3 assets from the classification method of the Basel Committee for Banking Supervision (BCBS) for global systemically important banks (G-SIBs) (BCBS 2013).

Other relevant dimensions of complexity include the extent to which there is broad business scope, wide geographic scope, and more organizational complexity through multiple legal entities. These concepts can be partially informed using information on banks' balance sheets. Some are also informed by using data on the industries and locations of the bank, non-bank financial, and non-financial affiliates of the banking organizations. Recent research links such complexity measures to economic or financial outcomes. Cetorelli and Goldberg (2014), for example, distinguish between organizational complexity, business complexity, and geographic complexity as for 170 foreign banking organizations with US branches, with measures constructed using a cross-country database covering full organizations (Bankscope). Similar

metrics and data sources are used by Carmassi and Herring (2016) for the very largest global banks.³

Yet, publicly available databases reach limits when trying to describe relevant features of bank complexity. Hence, papers in this initiative of the International Banking Research Network (IBRN) draw on complementary supervisory data or other sources of micro-level data available in central banks to document changing patterns in the complexity of banks. The main concepts of complexity that initiative participants created using regulatory data include:⁴

- *Organizational* complexity, which measures the number of entities within the full banking organization.
- *Business* complexity, which captures the span and concentration of affiliates across types of broad business categories (bank, insurance, other financial, real estate, other nonfinancial) or specific types of industries defined using NAICS codes assigned to legal entities in banking organizations (US) or NACE codes for European countries.
- *Geographical* complexity, reflecting the span and concentration of numbers of affiliates across country locations.

These complexity concepts are also relevant for countries that are hosts to complex foreign banking organizations. However, gathering comparable metrics from the regulatory data available to host countries authorities is more challenging, as authorities often do not have full information on the span of all affiliates of the foreign-owned banking organization. Likewise, the compilation of information on the span of foreign branch locations (often not counted as separate legal entities) in addition to banking subsidiaries is challenging. Claessens and van Horen (2014) provide cross-country evidence on these networks, documenting an expansion of complex global banks from 774 in 1995 up to 1,334 by 2009. Most banks come from OECD countries, but also substantially from other high income, emerging market, and developing countries.

2. New Evidence from the IBRN

The *International Banking Research Network* has compiled new evidence on the complexity of global banks, complementing previous work on changes in the structure of banking systems (CGFS 2018). Table 1 summarizes information on participating countries, the number of

³ For conceptual foundations, see Avraham, Selvaggi, and Vickery (2012), Cetorelli and Goldberg (2014), and Goldberg and Meehl (2020).

⁴ See Online Appendix Table 1.

institutions, the share of banking system assets, and types of institutions covered by these complexity metrics. Fourteen countries provide metrics on domestic banking organizations versus foreign-owned but domestically regulated banks, with combined assets of included banking organizations representing most of banking system assets. Some countries exclude smaller, highly specialized, or cooperative banks with a low degree of complexity. Looking across countries, the data includes information on 19 of the 30 global systemically important banks (G-SIBs) designated as of November 2019 by the Financial Stability Board. Complementary work by the BIS adds cross-country evidence on the network and concentration of international branches and subsidiaries of 96 large banks from around the world for 2008 to 2016, including 29 of the 30 GSIBs (Aldasoro, Hardy, and Jager 2021). Over time, global banking organizations as they have become more distinct in their international footprints.

[insert Table 1 here]

Banking organization complexity differs significantly across countries (Table 2). Organizational complexity, reflected in the total affiliate counts within banking organizations, has a mean value under 10 for Austria and Italy, and over 100 for France and the United Kingdom. In all countries, complexity is concentrated in a few organizations: complexity of the upper 25 percentile of banking organizations by size, and especially in the top 10 percentile of banking organizations, is substantially higher than in smaller organizations. Differences across countries are even understated by the reported statistics as some countries have truncated from the included sample many small and non-complex banking organizations. The German and the UK truncations account for nearly 40 percent of banking system assets; US truncations eliminate from the sample all banking organizations under \$10 billion in assets and account for around 10 percent of banking system assets.

[insert Table 2 here]

The bulk of total domestic affiliates is concentrated in the largest banking organizations. The number of affiliates across all banking organizations is higher for larger countries: 2,546 for the UK, 2,676 for France, 3,808 for Germany, and 17,677 for the United States. Within those countries, the affiliates are concentrated in the most complex institutions. Banking organizations in the upper 10 percent of the distribution from the Netherlands and United Kingdom have over 400 affiliates, from France over 600 affiliates, and from the United States over 200 affiliates.⁵ For Germany, the top 10 percent of the 91 largest banks have about 240 affiliates on average, with nearly 1000 foreign affiliates out of 3800 total.

⁵ Detailed data and discussion at the country level are presented in individual papers.

Across countries, foreign affiliates also are concentrated in the largest organizations. The mean number of foreign affiliates across banking organizations from most reporting countries is well below 50. Indeed, most banking organizations have only domestic affiliates or span less than five countries overall, including offshore financial centers. However, the most geographically complex institutions (top 10 percent) from France, the Netherlands, United Kingdom, and United States have affiliates that on average span more than a dozen countries but may span more than 30 countries.

A similar pattern emerges for business complexity across sectors. Business complexity is measured through the number of NAICS or NACE industries spanned by banks' affiliates. The mean number of industries spanned tends to be small and concentrated in banking and just a couple of nonbanking industries. However, the larger organizations have affiliates in a much larger number of industries. The most complex entities in this dimension are active in many types of financial services, management companies, and real estate. They typically have affiliates in more than 20 different industries.

This pattern of different forms of complexity being highly concentrated in a few large organizations partially motivates the enhanced focus on large and complex banking organizations by regulators. In part as a result of tightened regulation on which analytical evidence is presented in Section 2, key complexity metrics have changed over time (Figure 1). In terms of overall size, the European banking organizations tended to become smaller, while organizations from other countries, for example from the US, grew in size (panel a). Meanwhile, the banking systems with the largest organizational complexity tended to reduce this complexity (panel b), including by reducing affiliates held in foreign locations (panel c). Still, the numbers of countries spanned by the largest banking organizations expanded for some countries (France, Spain) and only modestly contracted for others (panel e).

[insert Figure 1 here]

The geographic locations of banking organization affiliates differ considerably across reporting countries, with evidence of regional clustering. 2016 data from the BIS reports that about 30 percent of international bank affiliates are located in the euro area, 13 percent in the United States, 7 percent in the UK, 20 percent across other advanced economies, and the remaining 30 percent across developing economies (Aldasoro, Hardy and Jager2021). Figure 2 shows a breakdown of the geography of these external affiliates, spanning both bank and nonbank affiliates, as reported by specific countries participating in the IBRN initiative. Banking organizations from European area countries tend to have higher shares of affiliates in other euro area countries and tended to reduce shares of affiliates in the UK. Colombian banking

organizations mainly had affiliates in other emerging markets, particularly in Central America. US banking organizations had affiliates distributed across the euro area, the UK, China, Japan, other advanced economies, and over 40 percent in other locations inclusive of offshore locations and emerging markets, also documented in Goldberg and Meehl (2020).

[insert Figure 2]

Business complexity, as captured by the number of industries spanned by banking organizations, changed very little overall over time (Figure 1, panel d). Grouping affiliates into broad categories (bank, insurance, other financial, real estate, and other nonfinancial), the shares of affiliates in these types of businesses spanned by banking organization entities are very mixed across countries (Figure 3). Norwegian banking organizations have at least half of their affiliates classified as primarily engaged in banking. Austrian, German, Polish, Spanish, and US banking organizations have bank affiliates under ten percent of total affiliates. Austria, Spain, Germany, and France have most affiliates' business types categorized as "Other Financial", followed by "Other Non-financial", and then Real Estate.⁶ Denmark's banking organization affiliates are more evenly distributed across banking, real estate, Other Financial, and insurance. Large US banking organizations represented have banks accounting for under 4 percent of the legal entities even while these bank affiliates dominate the larger organization in terms of asset size. Large shares of affiliates are in other financial industries and in real estate categories that contain related management companies. Comparing across countries and over time, while many banking systems have high persistence in indicators of business complexity, other countries (Denmark, Portugal, UK, US) had banking organizations that generated notable shifts in the composition of industries spanned.⁷

[insert Figure 3]

3. *Correlations between Complexity and Size*

Is larger complexity just a by-product of banking organizations getting larger, or conversely, does the desire for complexity by banking organizations lead to expanded size? Individual country studies explore the causality issue more rigorously, using exogenous policy and other effects for identification purposes. Within-country and across-country correlations are nonetheless informative for a broader cross-country perspective on complexity and size.

⁶ Data reported for France on "other financial institutions" includes the insurance companies.

⁷ See Cetorelli, Jacobidis, and Stern (2017) for analysis of transformation of business scope in US banking organizations.

Simple within-country correlations between size and complexity generate mixed results. In some countries, the correlation between size and complexity is indeed very strong, but the form of complexity that correlates the most with size can differ. In Denmark, Portugal, and Spain, for example, banking organization asset size does not imply more business types spanned. Asset size of Spanish banking organizations, for example, is strongly correlated with more banking affiliates and foreign locations. The link between geographic complexity and the size of banking organizations is highly non-linear: across countries, geographic complexity is concentrated in a relatively small number of large institutions. Accordingly, strong correlations between size and geographic complexity appear for banking organizations from France, Germany, Italy, the Netherlands, Portugal, Spain, the United Kingdom and United States. The correlations tend to be smaller, weaker, and sometimes even negative across the small and medium sized banking organizations of many countries. Cross-country regressions using country buckets of banking organization size and complexity correlations confirm that complexity and size are not strongly correlated within or even across countries. Using the BIS data on very large banking organizations and taking a cross-country perspective, banking organization size and numbers of banking affiliates have a strong and positive correlation, but exhibits extensive variation.

The steepest relationship is between banking organization size and the numbers of legal entities within these organizations.⁸ Using data provided by countries aggregating banking organizations across different size ranges and showing corresponded aggregates for types of complexity at different dates, we have correlated size and complexity. The cross-country analytics confirm that the link is statistically significant and positive, but also characterized by substantial variation. On average, a 100 percent increase in total assets is associated with about a 50 percent increase in organizational complexity in terms of the numbers of affiliated firms. Correlation between size and countries or industries spanned by affiliates is weaker. The expansion of geographic complexity is particularly a feature of the largest banking organizations. The number of industries spanned by affiliates within banking organizations is positive but heterogeneous across banking organizations. Indeed, the cross-country data show two very different patterns of industries spanned – one quite weak and the other much stronger -- in relation to total asset size as banking organizations grow.⁹

Summing up, evidence shows that patterns of bank complexity are quite different across banks and quite persistent over time. How banks set up their activities – be it across regions, or be it

⁸ See Online Appendix Figure 1.

⁹ While beyond the scope of this current initiative, an interesting issue is the role of organic growth versus merger and acquisition expansion as a complexity driver.

across activities – is part and parcel of the banks’ business models, and may also reflect institutional features of countries. Both do not change quickly.

4. *Nonbank financial intermediaries*

While not a feature of financial systems addressed by the IBRN initiative, other recent efforts have targeted informing the structure and complexity of nonbank financial intermediaries. The Financial Stability Board, for example, produces an annual monitoring report to cover global trends and risks. By 2019 the nonbank financial intermediary (NBFI) sector, mainly comprising pension funds, insurance corporations and other financial intermediaries, grew to represent about half of the global financial system, rising at a faster rate for emerging markets compared with advanced economies (FSB 2020a). While providing extensive detail on the overall size, industries, economic function and risks of types of entities, less information is available on the distributions of these entities and their complexity.

Interconnectedness between banks and shadow banking entities is one of the linkages benefiting from new research. Portes, Abad, D’Errico, Killeen, Peltonen and Urbano (2021) map linkages between bank and nonbank financial institutions – shadow banks – using granular bank and exposure-level information for EU banks from 2015. A complement to the IBRN initiative, the authors construct a measure of European Union banks’ geographical complexity to consider whether this increases geographical exposure to shadow banks. They find that exposures are concentrated by type of shadow banking counterparty, with the majority of exposures toward non-money market investment funds, finance companies and securitization vehicles. Larger and more profitable banks are more likely to have higher exposures, including cross border exposures.

III. New Evidence on the Drivers of Bank Complexity

1. *Drivers of Complexity in Banking Organizations*

What drives managerial decisions to change the complexity of banking organizations? These decisions have to weigh the benefits against costs in terms of managing complex organizations. Generally, complexity arises from firm-level optimization approaches of banking organizations

and their managers. In addition, country-level factors affecting diversification and profitability, regulatory incentives, and possibilities for tax arbitrage matter.¹⁰

As regards geographical complexity of banks, the traditional view has been that banks follow the path of globalization of non-financial multinational enterprises (Buch and Goldberg 2020). Recent literature on global banking emphasized a trade-off between an increase in banks' profits through larger scale and the compression of interest margins because of more intense competition (Faia and Ottaviano 2017). Reduced costs of cross-border banking lead to an increase in banks' foreign market shares and, in equilibrium, multinational, and domestic banks co-exist. Niepmann (2015) argues that more efficient banks are more likely to have assets, liabilities and affiliates abroad, and also to achieve greater scale in these activities. Fillat, Garetto, and Corea-Smith (2018) relate entry into foreign markets via branches or subsidiaries to differences across countries in regulatory environment and in bank management efficiency. Cetorelli, Jacobides, and Stern (2017) explore the consequences of mergers and acquisitions across banking organizations for endogenous productivity: banks that expand into new activities yield worse performance, whereas expanding into activities closely related to the business activities of the modal bank has more positive effects.¹¹

Relatively little work has investigated the drivers of bank complexity. One explanation is that synergies and diversification can be economic drivers of complexity. Complex organizations might exploit synergies in terms of risk allocation across subsidiaries (Ashcraft 2008), traditional versus nontraditional activities (DeYoung and Torna 2013) or across regions (Berger et al. 2017; Rajamani et al. 2017).

Exploiting synergies in managing liquidity across different markets could be important in reducing costs of default and financial economies of scale, but also potentially spurring more risk taking in the context of possible government bailouts (Luciano and Wihlborg 2020). Evidence on liquidity consequences of complexity in banking organizations is emerging from a range of studies. Liquidity management through internal capital markets is supported, for example, by branches of foreign banking organizations hosted by the US having more liquid

¹⁰ Differences in the levels and structure of taxation can be important motivations for the location of globally active firms, including financial institutions. The post-crisis decline in geographic complexity of US bank holding companies was more concentrated in affiliates housed in locations known for financial secrecy, as affiliate numbers in low tax jurisdictions remained more robust (Goldberg and Meehl 2020).

¹¹ US banking organizations changing some financial businesses to move closer to the prevailing "modal bank" with early expanders into particular activities benefiting more, whereas later adopters lose out.

balance sheets available to meet the needs of the nonbank parts of the organization (Cetorelli and Goldberg 2016). Nonbank parts of a banking organization might be exposed to risk events that differ from the exposure of the core banking business. During periods of elevated returns in swap transactions in dollar funding markets, US commercial banks transact to increase dollar flows to their broker-dealer affiliates (Correa, Du, and Liao 2020). During the European sovereign debt crisis, German universal banks shifted risky sovereign holdings from banking units to related mutual funds (Bagattini, Fecht and Weber 2019).

The balance between costs and benefits of increased complexity may differ from a societal perspective, compared with the perspective exclusively from the vantage point of the banking organization. Given the difficulty of resolving large and complex organisations, these institutions may gamble on government support in times of distress. Banking organizations considered too-big- or too-complex-to-fail have benefited from implicit subsidies and funding cost advantages (Balasubramnian and Cyree 2011, 2014; Ueda and Weder di Mauro 2013; Acharya et al. 2016). Low funding costs and lack of market discipline create incentives for these banks to take on more risk or to grow beyond their optimal scale and to increase exposure to tail risk (Arteta et al. 2019; Berger et al. 2019). Consistent with this, divisional rent seeking and inefficient investment are evidenced in non-bank corporate conglomerates (Scharfstein and Stein 2000, Ozbas and Scharfstein 2010). Safety nets and federal assistance have been shown to lead to additional risk taking (Gropp et al. 2010, Dam and Koetter 2012, Duchin and Sosyura 2014). Also, banks may have used a variety of legal entities, such as Asset Backed Commercial Paper vehicles, to arbitrage regulation and increase risk-taking (Gong et al. 2018). One previous study on complexity across 80 stock-listed banks in the euro area, by Krause, Sondershaus, and Tonzer (2017), finds that higher geographic complexity was associated with an increased probability of state aid requests, while higher nonbank subsidiaries' shares reduced this probability. In the US financial sector, Antill and Sarkar (2018) examine sources of systemic risk (threshold size, complexity defined as number of legal entities, and interconnectedness) and find that the market's perception of the sources of systemic risk has changed over time, with implied subsidies due to complexity risk increasing sharply after the bankruptcy of Lehman Brothers in 2008.

Summing up, the past decades of global banking have been a powerful – and costly – reminder that banking organizations do not just follow in the footsteps of non-financial multinationals. Instead, the patterns of global banking follow their own drivers that include organizational incentives. We next turn to the roles of the regulatory environment, how the trade-off between bank complexity and risk has evolved over time, and whether regulation has succeeded in making complexity safer.

2. *The Role of Banking Regulation*

The regulatory environment in which banks operate affects their incentives to become or remain complex and to manage their risks. Regulatory arbitrage can lead banks to shift business to less regulated markets (Houston et al. 2012), show more risky behavior in comparatively less regulated countries (Ongena et al. 2013), or shift activities to less regulated entities (Demyanyk and Loutskina 2016), with differences in risk taking and regulation at bank holding company and subsidiary levels (Ly et al. 2018). A number of regulatory reforms that have been implemented following the global financial crisis aim at mitigating these negative externalities.

A first set of policies increases the loss absorbing capacity (going-concern) of systemically important financial institutions (SIFIs) through add-ons to the capital requirements. Bank Capital Regulation under Basel II was widely seen to incentivize banks to adjust organizational structures and to dilute reported risks. The Basel III reforms take into account the complexity of banking organizations, with the most visible tool being the GSIB capital surcharge. Higher capital surcharges apply to systemically important banks at the global (GSIBs) and domestic (DSIBs) level as compared to banks not considered to be of systemic relevance. Classification of banks, in turn, is related to complexity, thus creating incentives to reduce complexity. Some of the externalities generated by complexity are intended to be internalized by the new capital surcharges or the introduction of additional capital regulations aimed at pricing the cost of risks due to complex structures. Banks transformed their organizational structure to minimize the impact of regulatory costs (Flood et al. 2020).

A second set of policies improves authorities' ability to resolve such complex institutions if default is unavoidable (gone-concern), including through living wills and improved resolution frameworks. By targeting the organizational structure of banks to facilitate their recovery and resolvability, the new resolution frameworks incentivize banks to reduce complexity and, ultimately, risk taking. Complying with new resolution frameworks, including "living wills," may force banks to rationalize their organizational structure, including their cross-border activities and affiliates, making structural interlinkages more transparent to regulators and shareholders. Thus, we should observe a potential effect on risk taking if these resolution regimes are effective.

Results from the IBRN initiative on complexity and riskiness of banking organizations indicate that bank capital regulation and the extent to which capital requirements bind have been consequential. The Basel III regulatory framework is used in four studies to understand changes in complexity and risk. **Austrian** banks engaged in portfolio adjustments after Basel III risk weights changed, with higher risk weights on financial sector equity leading to a divestment in

the number and volume of such holdings, and an increase in the relative attractiveness of other business units, including lending (Erich, Elsinger, Lindner, Segalla, and Sigmund 2020). Among **Norwegian** banks, balance sheet opaqueness is positively correlated with bank risk (more available-for-sale securities have lower realized risks, more off-balance sheet items have higher realized risks). This correlation is weaker for better capitalized banks and banks subject to more market discipline, and higher capital requirements under Basel III reduced bank opacity (Cao and Juelsrud 2021). Systemically important **German** banking organizations reduced their complexity after the introduction of the Basel III framework and the various regulations that were activated in the post-crisis period, but at the same time managed to increase their organizational and income diversification and thereby reduce their risk (Martynova and Vogel 2021).¹² In addition, foreign banking affiliates of G-SIBs hosted by **Hong Kong** saw a larger decline in risks than their non-GSIB counterparts. This can be linked to a larger reduction in the business complexity of GSIBs after the introduction of the GSIB regulatory framework under the Basel III (Ho, Wong and Tan 2021).

Resolution reforms, based on descriptive statistics, have a gradual effect on complexity patterns, with correlations that differ across countries. We use an index of resolution reforms compiled by the Financial Stability Board (FSB)¹³ and correlate these reforms with changes in complexity measures constructed by the IBRN teams, comparing the complexity averages of 2010 to 2014 with those for the period 2015 to 2018. The first finding is that, across countries, resolution reforms have made noticeable progress while changes in the complexity of banking organizations have been much more gradual. Both observations are not surprising: resolution reforms agreed at the international level set the clear expectation that national implementation would follow. At the same time, complexity is a deep structural feature of banking organizations, which would be expected to move more slowly than progress in resolution reforms.

The US contribution to the IBRN initiative identifies the effects of resolution reforms. The living will provisions of the Dodd-Frank Act in the **United States**, addressing recovery and resolution planning, are associated with reduced organizational complexity in large US bank holding

¹² As the vast majority of German banks are rather small, regional, and non-complex cooperative and savings banks, the study for Germany focusses on the largest 100 banks as of end-2017. As for some of these banks data availability is limited, or banks are subsidiaries of larger banks in the sample, the study ends up with a sample of 84 banks.

¹³ See FSB (2020a) and Aquilina et al. (2020).

companies (Correa and Goldberg 2021). These changes altered risk frontiers, as further discussed in Section IV.

IV. New Evidence on Bank Complexity and Risks

The studies within the IBRN initiative use micro-data from within different countries to consider different channels through which complexity affect risk. The studies recognize that complexity can manifest itself in opacity of assets and liabilities, or in organizational, business, or geographic spans, leading to inefficiency and more costly resolution in the event of banking organization failure. Excessive organizational expansions could generate larger and more correlated risks, higher probabilities of failure and enhanced systemic externalities. Some empirical identification is achieved by considering specific regulatory events that can alter the incentives for complexity.

This work provides more rigorous perspectives on outcomes. Some studies also differentiate between implications for risk at the bank-level versus implications for systemic risk that matter from a societal viewpoint.

1. *Testing Hypotheses on Risk and Complexity*

Alternative mechanisms can be at play for complexity to alter the risk profiles of banking organizations. A first and direct channel is diversification. More complex banks can have activities that span a larger set of markets or countries. Simple portfolio theory would suggest that, *ceteris paribus*, diversification should imply a favourable risk-return trade-off and thus reduce risk (Markowitz 1952). More diversified banks may have a higher share of non-financial income and benefit from a diversification of their sources of income (Laeven and Levine 2007), including geographically (Goetz et al. 2016). More complex institutions with more diversified sources of income, spanning a larger set of business areas or countries, should thus exhibit lower idiosyncratic risk. If more complex institutions also manage liquidity across the organization, as posited in Luciano and Wihlborg (2020), business or geographic complexity can reduce organizational exposure to liquidity risk through internal capital markets. In this case, complex conglomerates can be formed when synergies and complementarities across affiliates exist.

Diversification at the organizational level could enrich the internal financing available to their affiliates and increase the ability of the parent to share risk among affiliates by relocating resources (Cetorelli and Goldberg 2012a, 2012b). Given the internal capital market channel, parent complexity may contribute to a lower risk for the specific affiliates in response to a shock

to these affiliates. Alternatively, parent complexity could be associated with more risk across affiliates that are not priority locations for the parent, at the time of strains to the parent. Hence, higher geographic complexity with liquidity risk management at the parent level strengthens the internal capital market among affiliates, reduces organizational exposure to liquidity risks, but may increase or decrease the risk outcomes across banking affiliates outside of the host country. Indeed, liquidity risk sharing could occur between the commercial bank and nonbank affiliates too, regardless of location. Correa, Du, and Liao (2020) document such liquidity risk management between banks and broker dealers in a sample of US GSIBs in response to dollar funding market shocks. Baggatini, Fecht, and Weber (2018) show that German banks moved stressed sovereign assets to their affiliated mutual funds during the European sovereign debt crisis.

A second class of consequences from complexity evolve around agency problems and monitoring costs. Complexity implies that the parent may have more difficulties to maintain regular communications across all affiliates. Reduced quality and quantity of management's communication intensifies the agency problems between managers of the parent and its affiliates. As a consequence, increased agency problems and moral hazard imply that affiliates have incentives to take on more risks (Rajan et al. 2001, Scharfstein and Stein 2000, Ly et al. 2018, Penas and Unal 2004, Dam and Koetter 2012, Duchin and Sosyura 2014). Agency problems might be particularly severe in an international context where banks in particular are confronted with information costs related to operating in different jurisdictions and cultures (Scharfstein and Stein 2000, Laeven and Levine 2009, Buch et al. 2013, Carmassi and Herring 2016). International banks in particular are confronted with information costs related to operating in different jurisdictions and cultures (Buch et al. 2013). Agency problems may also be more severe in financial firms with weaker governance, as in nonfinancial firms (Xuan 2009). In sum, if more complex institutions are weakly governed, organizational, business or geographic complexity lead to higher levels of idiosyncratic risk, market risk exposures, and systemic risk contributions.

2. *New Evidence from the IBRN on Risk and Complexity*

The IBRN studies untangle causal effects of complexity on risk outcomes using a combination of time series and difference-in-difference event study approaches around regulatory changes. The IBRN benchmark testing equations measures risk at the banking organization, bank, or branch level. The risk metrics used across studies include measures of diversification, idiosyncratic risk, liquidity risk exposure, bank failure probabilities, market risk exposure, and systemic risk. While

different studies consider distinct combinations of risk variables, the initiative collectively emphasizes the broader frontier of types of risks as relevant to complexity effects.

This broader frontier is important, as systemic risk has received more attention post crisis. Some studies work with measures of systemic risk through the capital shortfall of each individual bank in case of stress in the whole financial system, as in the SRISK measure of Brownless and Engle (2016) and the Volatility Laboratory (V-Lab) at New York University. Some studies using data on the loan or investment portfolios of the banking organizations include details on the riskiness of the assets or borrowers within these portfolios.

Several IBRN studies find that more complex institutions have more diversified sources of income. The four teams examining this effect (Austria, France, Hong Kong, US) find diversification gains from complexity with statistical significance dependent on the type of complexity considered. Consistent with this, the cross-country perspectives on banking affiliates by large banks using BIS data highlight a positive side of bank geographic complexity as a way to cope with local economic shocks. For Portuguese banks, business complexity is associated with less idiosyncratic risk. However, other country experiences show weaker benefits from higher complexity. Banking organizations in France, Germany, Norway, and Spain have idiosyncratic risk increases across some different aspects of bank complexity, potentially at odds with simple portfolio theory rationales for complexity.

Asset risk and default probabilities also respond to complexity. Several teams analysed this from a **home country** perspective. Among **Italian** banking organizations and using matched bank-borrower data, geographic complexity is associated with lending to less risky firms (and a smaller elasticity of supply to increases in bank capital position), while fee income diversification with lending to riskier firms (Marinelli , Nobili and Palazzo 2021). More geographically complex **Portuguese** banks tended have to riskier balance sheets and more nonperforming loans, but achieve diversification benefits overall (Bonfim and Felix 2020).

The study of **Colombian** banking organizations considers local conditions, modelled through domestic monetary policy, as a factor that can influence the impact of geographical complexity on bank risk. Colombian banks that belong to a more complex banking organization are more sensitive to changes in local monetary policy. During periods of monetary policy tightening, these banks experience higher level of idiosyncratic risks as a result of higher risk taking of these institutions (Cardozo, Morales-Acevedo, Murcia and Rosado 2021).

In **German** banking organizations, the positive correlations between geographic and business complexity and bank idiosyncratic risk decreased in recent years. Banks reduce their complexity in response to regulatory tightenings, as these increase the related regulatory costs.

Surprisingly, for systemically important banks in particular, the reduction of regulatory costs is associated with an increase in diversification benefits. As a result, they are able to lower their idiosyncratic risk more than other banks (Martynova and Vogel 2021).

Results for banking organizations in **Spain** support the hypothesis that in a complex organization, the lower the control, the higher the risk (Argimón and Rodríguez-Moreno 2021). The study exploits differences across banks that have gone through a merger process under traditional rules versus under the Institutional Protection Schemes (IPS) as has been established with the EU regulatory capital reform. Geographic complexity leads to diversification benefits as the activity of affiliates abroad of Spanish banks are in areas where the group has expertise at home and thus higher control. Business complexity is associated with higher risk, as the parent's capacity to influence the different affiliates is weaker. The fact that geographic complexity results in lower risk could also be the result of a low correlation between the home and the host business cycles.

The governance and control issue, directly explored for **US banking organizations**, did not have a very strong effect on the relationship between complexity and risk (Correa and Goldberg 2021). Better governed bank holding companies were those that had the better risk tradeoffs from declines in organizational complexity in the aftermath of the Dodd Frank living will requirements. While systemic risk decreased overall, risk increased in some organizations. Liquidity risk increased in particular in less well-governed organizations.

Using a sample of large banking organizations from **around the world** and complexity based on banking affiliates only, geographic complexity was found to dampen the effects of local economic shocks (Aldasoro , Hardy and Jager 2021). The positive effect of local prudential regulations and of global regulatory initiatives such as the G-SIB framework is weakened as well. This weakened effect is driven by prudential regulation on reserves and risk exposures, which are less coordinated internationally than capital regulation.

For **French banks**, complexity increases risk as priced by the market, but more so for non-systemic banking organizations: complexity implies lower leverage for non-systemic banking organizations than systemic ones, as non-systemic banking organizations are capital constrained due to equity and debt funding costs (Bussiere, Meunier and Pedrono 2020).

Some country teams in the IBRN initiative have taken the **host perspective**, exploring the relationship between the foreign parents' complexity levels and the risk of hosted affiliates. Broadly speaking, results show that structural features of the parent matter in different ways.

Within the **Hong Kong** banking system, idiosyncratic risk of hosted foreign affiliates is higher if parents are more complex in terms of business activities, which is explained by dominating agency problems, even while some diversification benefits accrue when the parent organizations are more geographically complex (Ho, Wong and Tan 2021).

Idiosyncratic risk of affiliates hosted by **Poland** is lower though if the parent organization is more geographically diversified. If the bank affiliates were used exclusively for purposes of return diversification, the complexity of parent organization would be expected to have no influence on the risk of foreign bank affiliates in the host country. These results suggest the opposite as branches and subsidiaries have idiosyncratic risk exposures that *are* influenced by the complexity of their parent organizations. Whether the impact of parent complexity is positive or negative depends on the type of complexity and the country considered (Gajewski and Kurowski 2020).

Overall, there is some evidence in favour of the hypotheses that higher geographical complexity and thus greater potential for diversification lowers risk. However, whether these benefits materialize also depends on country-specific factors, and there are other complexity features which tend to increase rather than lower risk.

V. Lessons for Research and Policy

More than ten years after the outbreak of the global financial crisis and in the midst of the Covid-19 pandemic, global banks are at crossroads. Post-crisis regulatory reforms made the global financial system more resilient. But banks are facing new risks, including the prospect of intensified structural change in the real economy and in finance and strains from the coronavirus pandemic. Key questions include around how banking organizations will position themselves and which business models will succeed. Policy discussions need to be informed by evidence on the drivers and the effects of bank complexity and risk, as has been provided in this summary of an initiative of the International Banking Research Network (IBRN).

The new evidence on banking organization complexity spans multiple countries, years, and different complexity measures. This evidence spans most of the largest banking organizations around the world, and it also highlights differences within and across banking organizations within countries. Key observations are, first, that patterns of organizational complexity have changed as the number of domestic and foreign affiliates within banking organizations tended to decline. Second, the number of industries spanned by businesses affiliated with banks has remained relatively stable, even while the composition of industries has changed. Third, the

global reach of banks according to the number of countries spanned by different global banking organizations has been evolving, expanding for banks while declining for others. Fourth, while the size and complexity of banking organization are positively correlated, these are distinct concepts. This needs to be taken into consideration when discussing regulatory implications of either size or complexity.

Many of the financial regulatory reforms that have been designed and implemented following the global financial crisis aim at reducing the negative externalities of bank complexity. More complex banks face higher capital requirements in order to internalize systemic risk externalities. New regimes for the recovery and resolution of banks aim at improved management of dealing with complex banks operating across borders. Evidence compiled across the cross-country studies shows that regulation matters. Capital-constrained banks tend to reduce lending and increase risk by more than better capitalized banks. Also, increases in risk weights affect portfolios and reduce opacity. The initiative further provides evidence that links bank complexity and risk: Higher complexity is only sometimes associated with greater diversification of revenue and returns or with improvements in liquidity risk improvements. As higher complexity can also give rise to management problems that can increase risks, the effect of complexity on risk may thus entail tradeoffs.

Overall, these insights show that understanding the effects of complexity on risk and the impact of regulations on risk requires detailed micro data. Also, some of the effects become visible only as time evolves. International organizations and central banks have thus pushed the agenda of evidence-based policy-making, conducting regular assessments and evaluations of policies. For example, the Financial Stability Board launched large-scale evaluations of the post-crisis financial sector reforms in 2017, and first evaluations have been completed. In June 2020, results of an evaluation of the too-big-to-fail reforms have been published in an FSB (2020) consultation report, finding only modest changes in the complexity of global banks. Another example of an improved infrastructure for evidence-based policymaking is the repository of evaluation studies developed by the Bank for International Settlements (BIS), which contains studies assessing the effects of regulatory reforms.¹⁴

This collective body of work suggests new directions for research and for policy. A high degree of complexity can impair dealing with failing financial institutions. The evaluation of too-big-to-fail reforms by the FSB finds that resolution has become more feasible and credible, even while obstacles to resolution remain. These obstacles are partly related to the complexity of

¹⁴ See <https://stats.bis.org/frame/>

institutions, such as difficulties to coordinate resolution policies for organizations that span across several jurisdictions.

Yet, there are two broadly accepted pillars of the regulatory approach to large banking organizations following the Global Financial Crisis. These approaches cover both reducing the costs of failure, a key feature of approaches to deal with the resolution of large, complex banks, and reducing the probability of failure. This latter issue has not been adequately considered in discussions around banking organization complexity. In fact, complexity has implications for risk exposures, sometimes yielding diversification benefits and reduced exposures to liquidity risk and local shocks, and other times with more adverse consequences. A better understanding is needed around how organizational structures with strong governance may reduce the probability of adverse outcomes and how this is influenced by institutional and regulatory design.

Research by the IBRN suggests that it is important to be specific about the form of complexity: balance sheet opacity, organizational complexity, business complexity, and geographic complexity have different effects on bank risk. Complexity entails tradeoffs, with some forms of complexity potentially reducing the risk of banking organization failure, even while raising the potential costs of failures when they occur. Identifying these factors requires bank-level data. In terms of future research on the issue, we see scope to further explore the nature of complex banking organizations, including a better understanding the drivers of complexity, management structures, agency conflicts, and effects of complexity on productivity and efficiency. Another research frontier would be to understand the effects of banks' complexity on macroeconomic and market outcomes.

Finally, the evidence collected in this paper pre-dates the coronavirus pandemic. In the longer-term, the crisis may also be a catalyst for structural change which affects bank complexity. The research summarized in this paper cannot inform the likely path of banking organizations and banking systems. It does, however, provide some indication as to how to smooth the transition to a new steady state without creating new risks and fragilities: First, banking organizations change only gradually. Although the shock of the global financial crisis emanated from within the global financial system, it has been less disruptive in terms of structural features of banking organizations such as complexity than one might have expected. Second, structural change requires good policy responses. Policies are needed that enable structural change in the financial system without compromising on financial stability.

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Table 1: Banking Organization Samples by Reporting Countries and BIS

Country	Bank Sample	Foreign Owned	Year	# Orgs	% System Assets	G-SIBs
Austria	Banks with at least one equity holding with ownership share larger than 50 percent	No	2017	147	100	
Colombia	All banks	No	2017	38	100	
Denmark	Banks categorized as SIFI in 2017 (incl. one FBO)	Yes	2018	4	73	
France	All banking groups located in France (incl. 25 percent foreign-owned)	Yes	2017	24	100	BNP Paribas, Groupe BPCE, Groupe Crédit Agricole, Société Générale
Germany	Largest German banks (incl. 11 FBOs)	Yes	2017	91	58	Deutsche Bank
Hong Kong	Domestic-owned banks and local subsidiaries of global banks	Yes	2018	49	58	
Italy	All banks except mutual coop banks	Yes	2016	84	74	Unicredit
Netherlands	All banks	No	2018	18	100	ING Bank
Norway	Entire banking system (incl. 13 FBOs)	Yes	2018	141	100	
Poland	Domestically-owned commercial bank parents and foreign-owned subsidiaries with at least 1 percent of industry assets	Yes	2018	15	80	
Portugal	All Portuguese banking groups (incl. 5 FBOs)	Yes	2018	13	89	
Spain	All Spanish topholders	No	2016	64	100	Santander
United Kingdom	FINREP reporters (incl. 6 FBOs)	Yes	2017	19	61	HSBC, Barclays, Standard Chartered
United States	US topholders above \$25bn USD in assets	No	2018	473	93	JP Morgan Chase, Citigroup, Bank of America, Goldman Sachs, Wells Fargo, Bank of New York Mellon, Morgan Stanley, State Street
Bank of International Settlements (BIS)	Banks contributing to International Banking Statistics (internationally active banks in BIS reporting countries)	Yes	2016	96	100	All except Wells Fargo

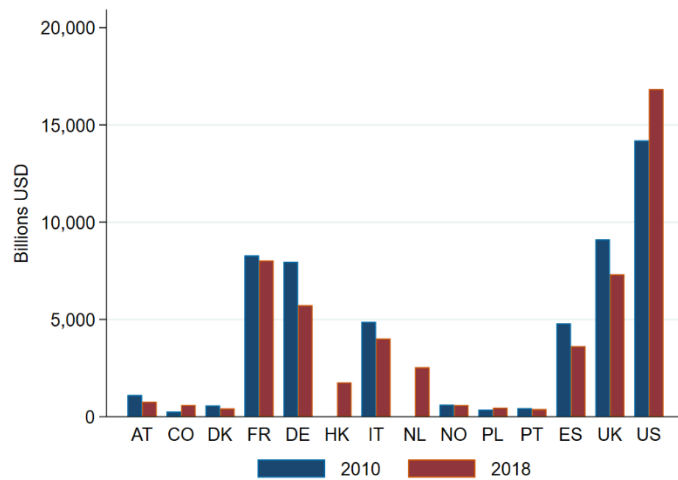
Note: “Foreign Owned” reports the inclusion of foreign owned banks in the sample, “Year” denotes the most recent year of data available, “# Orgs” reports the number of banking organizations, and “% System Assets” reports the percentage of banking system assets for a given country. For countries hosting G-SIBs, no bank-level information is revealed.

Table 2: Summary Statistics of Key Complexity Variables by Reporting Country

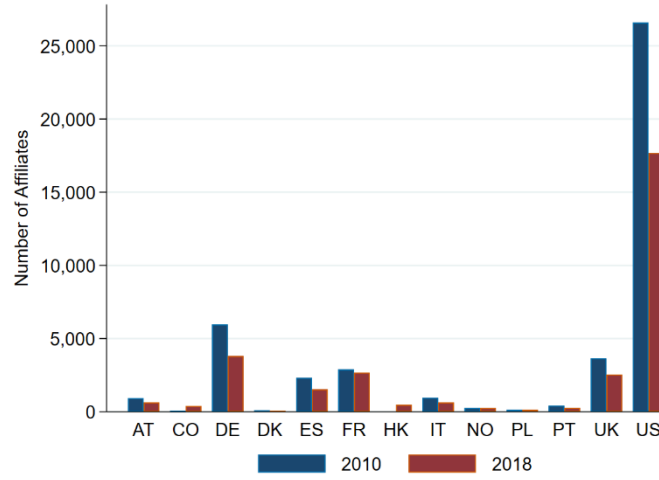
Country	Year	Organizational Complexity				Business Complexity			Geographic Complexity					
		Affiliate Counts				# Industries Spanned			Foreign Affiliate Counts		# Countries Spanned			
		Mean	75-100	90-100	Total	Mean	75-100	90-100	Mean	Total	Banks 75-100	All Types		
												Mean	75-100	90-100
Austria	2017	4	11	18	644	2	4	5	1	133	4	2	4	5
Colombia	2017	78	.	.	400	3	.	.	52	230	.	9	.	.
Denmark	2018	13	26	.	51	4	5	.	5	19	13	6	16	.
France	2017	112	367	600	2676	3	8	10	48	1163	23	12	40	58
Germany	2017	42	128	243	3808	7	17	21	12	1067	2	4	13	18
Hong Kong	2018	10	32	64	476	1	4	5	.	.	.	.	.	.
Italy	2016	8	22	54	640	2	4	7	4	305	2	2	5	10
Netherlands	2018	85	271	416	.	2	4	.	33	.	7	9	26	34
Norway	2018	.	.	.	255	.	.	.	.	114	.	.	.	.
Poland	2018	11	30	.	148	4	9	.	1	.	.	1	.	.
Portugal	2018	20	56	66	265	4	8	9	6	77	8	4	9	9
Spain	2016	24	77	139	1533	6	17	24	9	593	8	3	9	14
United Kingdom	2017	134	440	.	2546	2	4	.	74	1414	18	12	39	.
United States	2018	37	119	216	17677	5	10	12	9	4082	1	2	12	12
BIS	2016	18	40	52	1690	.	.	.	.	.	25	12	25	31

Note: Year denotes the last year of data reported by country. 75-100 and 90-100 respectively refer to the 75-100th percentile mean and 90-100th percentile mean – that is, the average of the top 25 percent and 10 percent of banking organizations by assets respectively.

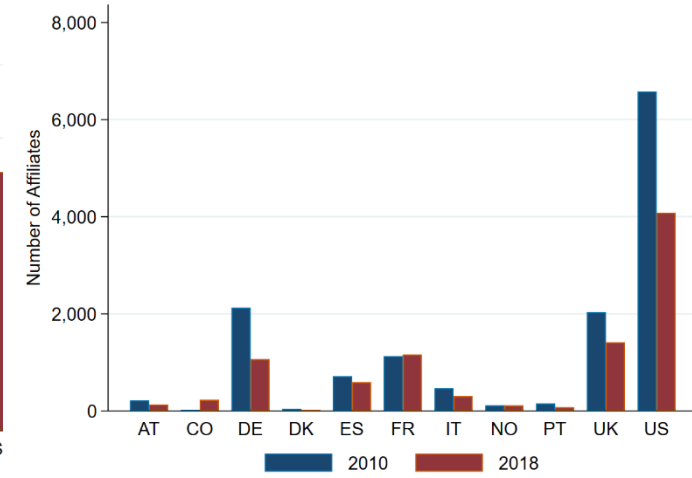
Figure 1: Complexity Changes by Country Over Time



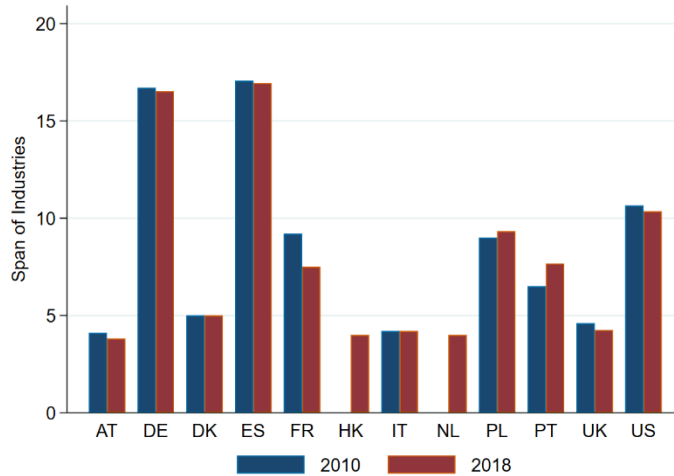
(a) Total Banking System Assets



(b) Total Count of Banking System Affiliates

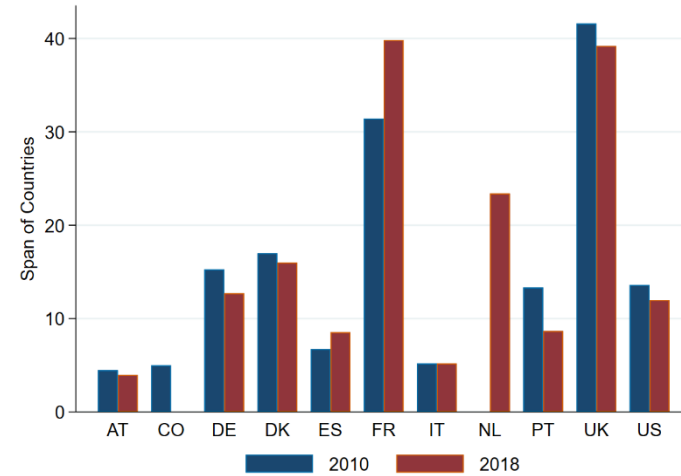


(c) Total Count of Foreign Banking System Affiliates



(d) No. of Industries Spanned:

75-100th %tile Mean

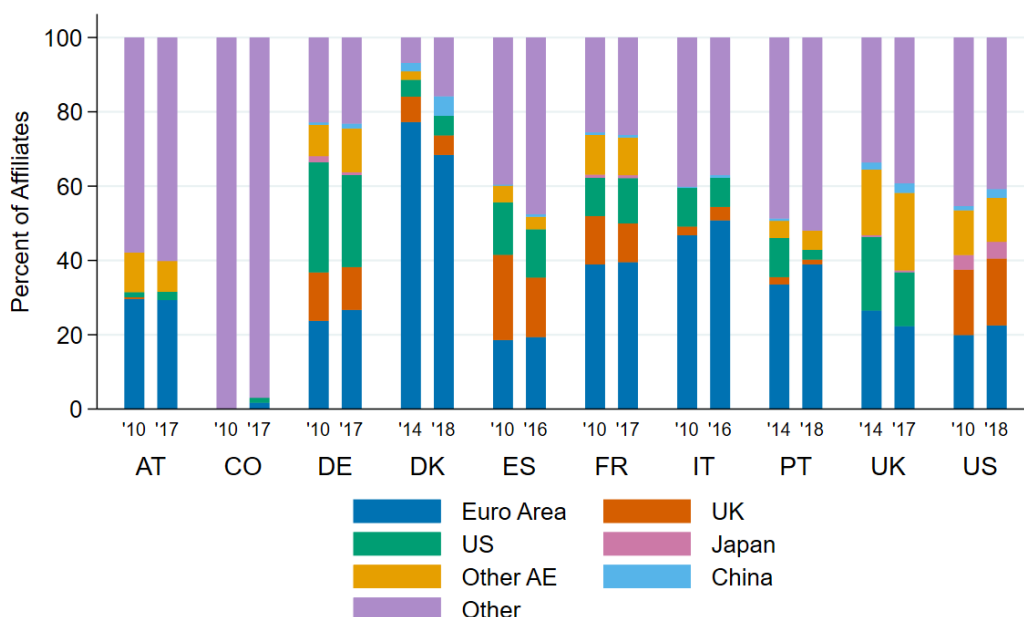


(e) No. of Countries Spanned:

75-100th %tile Mean

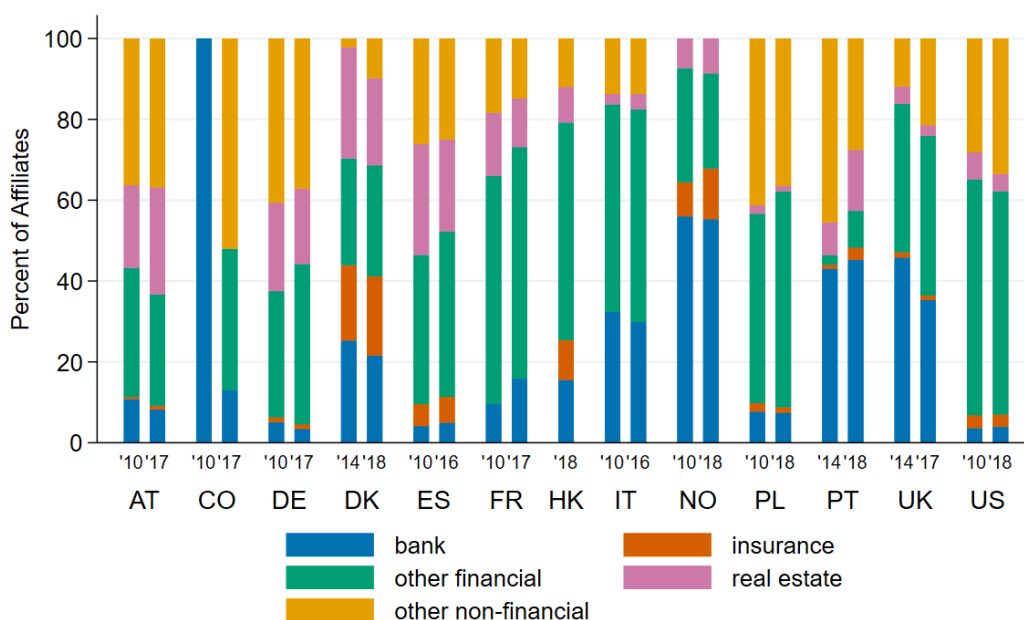
Note: The panel above presents complexity variables in 2010 (2014 for Denmark (DK), Portugal (PT), and United Kingdom (UK)) and 2018 (2017 for Austria (AT), Colombia (CO), Germany (DE), France (FR), Netherlands (NL), and United Kingdom (UK). 2016 for Spain (ES) and Italy (IT)). Industries in Figure 1(d) are reported at the 3-digit NACE level or the 4-digit NAICS level.

Figure 2: Location of Foreign Affiliates



Note: The panel above reports data on total affiliates in reporting countries outside the banking organization's headquarters. Data is reported for 2010 (2014 for Denmark (DK), Portugal (PT), and United Kingdom (UK)) and 2018 (2017 for Austria (AT), Colombia (CO), Germany (DE), France (FR), and United Kingdom (UK). 2016 for Spain (ES) and Italy (IT)). AE corresponds to Advanced Economies.

Figure 3: Business Types of Affiliates



Note: The panel above reports data on the following five business sectors: banking, insurance/pension funds, other financial, real estate, and other non-financial. Reported data for France on "Other Financial" includes the "Insurance" industry category. Data is reported for 2010 (2014 for Denmark (DK), Portugal (PT), and United Kingdom (UK)) and 2018 (2017 for Austria (AT), Colombia (CO), Germany (DK), France (FR), and United Kingdom (UK). 2016 for Spain (ES) and Italy (IT)).

Online Appendix Table 1: Definitions for Banking Organization Complexity Measures

Organizational Complexity	Count of all subsidiaries, irrespective of their business line and geographical location, of a BHC.
	Count of all subsidiaries of a BHC which are active in commercial banking and/or are classified as credit institution/bank (NACE 641 / NAICS 5221).
	Count of all BHC subsidiaries not classified as credit institution (not NACE 641 / NAICS 5221).
Business Complexity	Count of all subsidiaries of a BHC which are active, respectively, in insurance or pension fund industries (NACE 641 / NAICS 5241, 5242, 5251), in other non-commercial-banking financial industries (NACE 642-649 / NAICS other 52), in real estate (NACE 68 / NAICS 53), or in other non-financial industries (other NACE / NAICS).
	Number of 3-digit NACE or 4-digit NAICS industries in which a BHC is active, irrespective of geographical location.
Geographic Complexity	Number of countries in which a BHC is active, irrespective of business line.
	Number of countries in which bank subsidiaries of a BHC are active.
	Count of all subsidiaries of a BHC which are not located in the country of residence of the BHC.
	Count of all subsidiaries of a BHC which are active, respectively, in the home country, in the USA, in the Euro Area, in Great Britain, in Japan, in other advanced economies, in China, or in other countries.
	Herfindahl-Hirschman index of geographic concentration of foreign affiliates.

Note: Countries that reported host- rather than home-country data reported a subset of these variables for hosted branches and subsidiaries of foreign banks, along with additional measures of complexity that include foreign shares of bank revenue, foreign shares of bank assets, industry HHIs, and nonbank revenue shares. Various countries also reported opacity measures.

Online Appendix Table 2: Complexity Variable Construction by Reporting Country

Country	Year	Organizational Complexity			Business Complexity		Geographic Complexity			
		Affiliate Counts			Industries Spanned	Affiliate Counts	Countries Spanned		Affiliate Counts	
		Total	Bank	Nonbank			By Banks	All	Foreign	By Region
Austria	2004-17	✓	✓	✓	✓	✓	✓	✓	✓	✓
Colombia	2000-17	✓	✓	✓	✓	✓	✓	✓	✓	✓
Denmark	2008-18	✓	✓	✓	✓	✓	✓	✓	✓	✓
France	2010-17	✓	✓	✓	✓	✓	✓	✓	✓	✓
Germany	2005-17	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hong Kong	2018*	✓	✓	✓	✓	✓				
Italy	2000-16	✓	✓	✓	✓	✓	✓	✓	✓	✓
Netherlands	2016-17	✓	✓	✓	✓	✓	✓	✓	✓	
Norway	2000-17									✓
Poland	2008-18	✓	✓	✓	✓	✓		✓	✓	
Portugal	2014-18	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spain	2005-16	✓	✓	✓	✓	✓	✓	✓	✓	✓
United Kingdom	2014-17	✓	✓	✓	✓	✓	✓	✓	✓	✓
United States	2000-18	✓	✓	✓	✓	✓	✓	✓	✓	✓
BIS**	2008-16		✓				✓		✓	✓

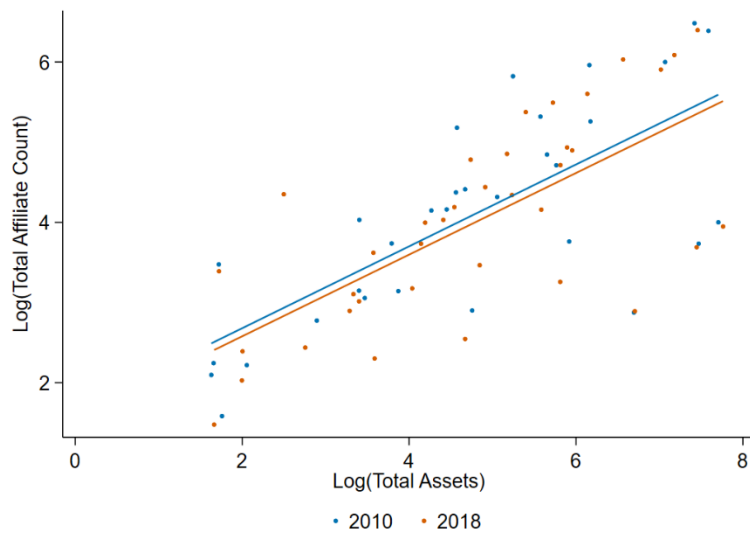
Note: This table presents the data availability by reporting country. Year denotes the time period where complexity variables are reported. The ✓ shows reported complexity variables by each country.

Netherlands and Norway provide data on opacity measures, including the ratio of OTC derivatives, AFS-securities, and Level 3 assets to the banking organization's total assets.

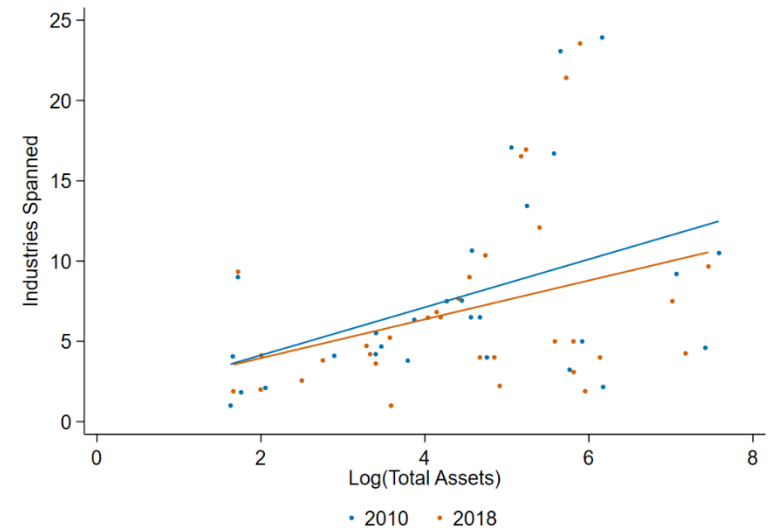
* Hong Kong also reports foreign revenue share, foreign asset share, NAICS industry HHI, and nonbank revenue share from 2004-2017 for hosted foreign banking organizations.

** For the BIS, data only includes foreign banking affiliates, distinguishing branches and subsidiaries. Reported variables accordingly exclude e.g. home country affiliates and business complexity.

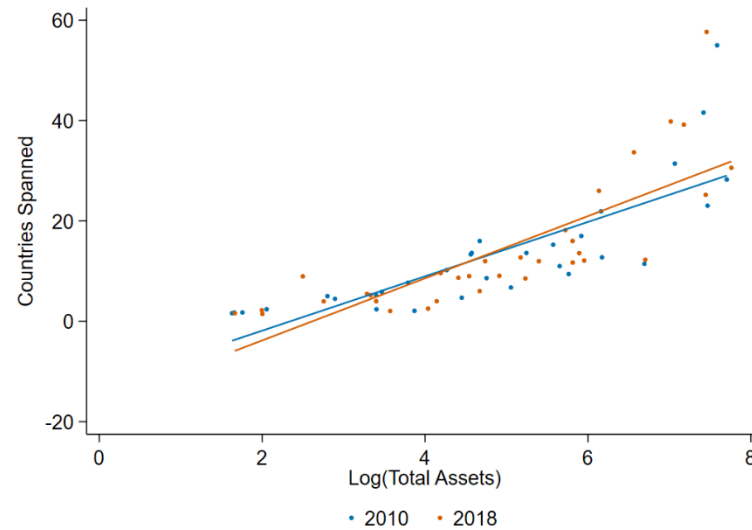
Online Appendix Figure 1: Cross-Country Evidence on Size and Complexity



(a) Logarithm of Total Affiliate Count



(b) Number of Industries Spanned



(c) Number of Countries Spanned

Note: Total Affiliate Count reflects the total number of affiliates in the banking sector, by reporting country and year. Industries Spanned reports the number of industries spanned by banking organization affiliates (reported at the 3-digit NACE level or 4-digit NAICS level) at the mean, 75-100th percentile mean, and 90-100th percentile mean. Countries Spanned reports the number of countries spanned by banking organization affiliates at the mean, 75-100th percentile mean, and 90-100th percentile mean. Log(Total Assets) is measured in billion of USD and reflects the corresponding mean, 75-100th percentile mean, and 90-100th percentile mean by reporting country and year. Data is reported for 2010 (2014 for Denmark, Portugal, and UK) and 2018 (2017 for Austria, Colombia, France, Germany, Netherlands, and UK. 2016 for Italy and Spain.)