



DTCC

MAY 2022

INTERCONNECTEDNESS REVISITED

A WHITE PAPER TO THE INDUSTRY

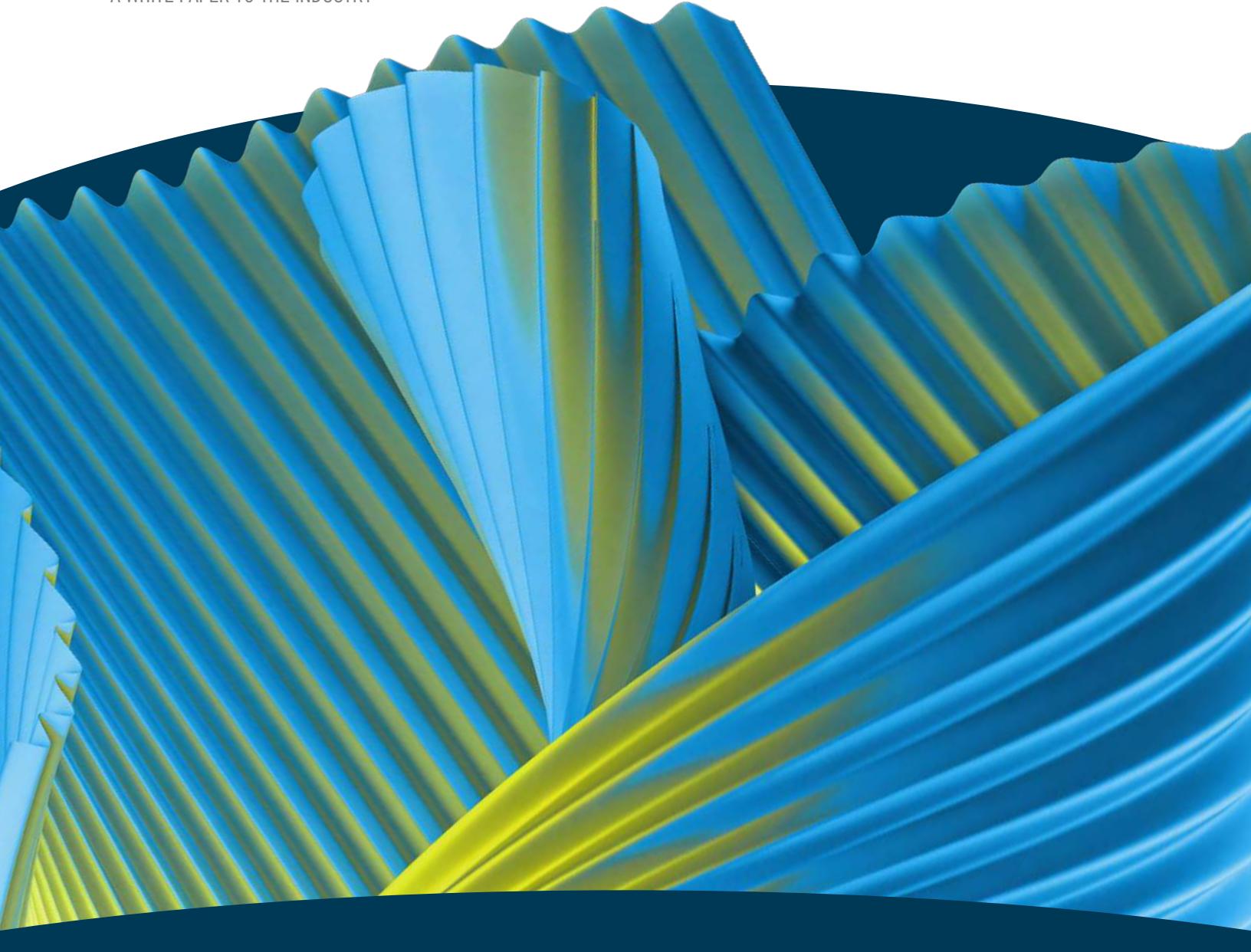


TABLE OF CONTENTS

INTRODUCTION	1
CROSS-BORDER INTERCONNECTEDNESS	3
INTERCONNECTEDNESS OF THE NON-BANK FINANCIAL INTERMEDIATION (NBFI) SECTOR	8
OPERATIONAL INTERCONNECTEDNESS	13
FINTECH AND INTERCONNECTEDNESS	18
INTERCONNECTEDNESS OF FINANCIAL MARKET INFRASTRUCTURES	22
RECOMMENDATIONS	28
CONCLUSION	30
BIBLIOGRAPHY	31

INTRODUCTION

DTCC's 2015 white paper, [Understanding Interconnectedness Risks](#), underscored the importance of looking at the global financial system as a complex network of interdependent components. Building on efforts by academics and researchers to apply network theory and other insights to financial risk management, the paper highlighted how the failure of a large and highly interconnected entity can impact the financial system and the real economy to the point where it can cause worldwide financial instability.

Our initial definition of interconnectedness was limited to relationships that are created through financial transactions and supporting arrangements among economic agents, more specifically between and across: (i) financial institutions (banks and non-banks); (ii) providers of financial market infrastructure services; and (iii) vendors and third parties supporting these entities.¹

We feel now is an appropriate time to revisit this important topic. Whereas the 2015 white paper focused on general insights and principles related to interconnectedness, this follow-up paper is designed to highlight emerging systemic risks that are associated with recent changes in how the global financial system is interconnected.

In line with the expanded scope of this new paper, we have decided to broaden our initial definition of interconnectedness to refer to direct and indirect linkages that exist between and across: (i) national and regional economies; (ii) financial markets and market participants; (iii) providers of financial market infrastructure services and their clients; (vi) financial institutions (banks and non-banks) and their clients; and (v) third and fourth parties supporting these entities.

These direct and indirect linkages are the result of a wide variety of factors, including but not limited to: trade patterns, financial transactions, macroeconomic trends, economic variables, statistical correlations between the prices of financial assets, market structures, operational processes and dependencies, business arrangements (contractual or not), external events and other developments.

It should be emphasized that interconnectedness is not bad per se – on the contrary, it provides a wide range of operational efficiencies and other benefits. Many of the operational and other linkages that exist between financial services firms and other agents today are necessary building blocks for a well-functioning infrastructure that supports a wealth of financial products and services.

However, it should also be recognized that these interconnections can pose certain risks. Broadly speaking, analyzing interconnectedness risks is important for at least three key reasons:

1. The identification of connections and linkages uncovers dependencies that may not be immediately apparent otherwise. This, in turn, helps us better understand how risks can be transferred between entities and how they can spread across the global financial system.
2. Interconnectedness analysis provides greater insight into critical thresholds and tipping points, given that networks are capable of absorbing shocks up to a certain level, while they tend to spread (or amplify) losses beyond a critical threshold.
3. The analysis of interconnections and networks highlights the importance of concentration risk and substitutability as two key factors in assessing potential system-wide vulnerabilities.

¹ DTCC, *Understanding Interconnectedness Risks to Build a More Resilient Financial System*, October 2015.

The global interconnectedness landscape has changed considerably since the publication of DTCC's 2015 paper:

- **Cross-border financial exposures have increased significantly**, facilitating international capital flows and providing many countries with access to new markets and cheaper funding. Even though greater cross-border interconnectedness has provided substantial benefits, it has also increased vulnerabilities in countries that rely heavily on foreign capital inflows for their growth, making them more susceptible to systemic shocks.
- **The growing role of Non-Bank Financial Intermediation (NBFI) in credit intermediation has led to more interconnections.** While these linkages provide additional sources of financing for households and corporates, they also create additional channels that can transmit shocks through different parts of the financial system in ways that are not always readily apparent.
- **Various types of operational interconnectedness risk have come into focus** as a result of the increased use of third-party vendors, the rapid adoption of cloud computing and the continued proliferation and ever-increasing sophistication of cyber-attacks.
- **Cryptocurrencies and other Distributed Ledger Technology (DLT) applications are becoming more interconnected with the global financial system.** New challenges to financial stability are starting to emerge as these and other fast-growing fintech-related developments are becoming an integral part of the financial ecosystem.

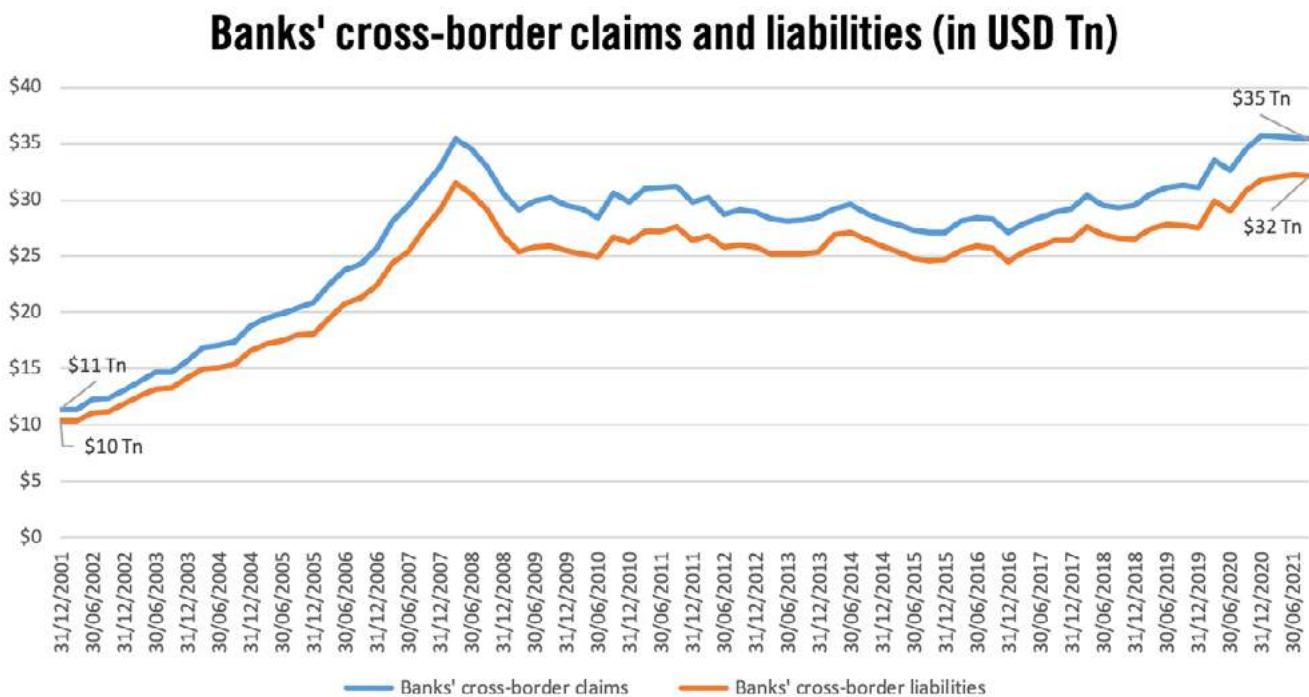
In light of these structural changes, we feel it is more important than ever to recognize the importance of risks related to interconnectedness.

The final chapter of this paper highlights interconnections of Financial Market Infrastructures (FMIs) and provides a few examples of initiatives that DTCC has undertaken to mitigate associated risks.

As we've done in the past, we intend to engage with our clients, policymakers, market supervisors and other key stakeholders in the coming months to raise awareness of this topic, solicit feedback and guidance, and foster collaboration and information sharing. We hope you take time to read this paper, and we look forward to your feedback.

CROSS-BORDER INTERCONNECTEDNESS

Banks' cross-border claims and liabilities tripled from December 2001 to December 2007. While the subsequent global financial crisis (GFC) marked a trend reversal that lasted almost a decade, the last five years show a renewed upward trend to the point where these metrics are again at record levels. As of September 2021, banks' cross-border claims and liabilities stood at \$35 trillion and \$32 trillion, respectively. The graph below, which is based on locational banking statistics (LBS) that are published by the Bank for International Settlements (BIS), illustrates this evolution.²



The interconnectedness created by these positions, while beneficial in many ways, also provides a transmission mechanism that can propagate shocks across the global financial system. A growing body of research uses network analysis to better understand how the size and composition of international financial positions can lead to spillover effects that create cross-border contagion risk.

The International Monetary Fund (IMF) published an innovative analysis that uses network metrics to assess the relative importance of a country in the global financial network, based on the size of its financial activity (total claims or liabilities), as well as the number and importance of its financial partners.³ The analysis uses a multilayer network framework that considers multiple transmission channels simultaneously to better capture multiple cross-border interconnectedness mechanisms. This approach provides a closer estimate of interconnectedness risk, given that more traditional approaches that simply aggregate liabilities tend to underestimate the extent and effects of financial contagion.

² Bank for International Settlements, *Statistical release: BIS international banking statistics and global liquidity indicators at end-September 2021*, January 28, 2022.

³ Yevgeniya Korniyenko et al., "Evolution of the Global Financial Network and Contagion: A New Approach," *International Monetary Fund Working Paper*, No. 18/113, May 2018.

The IMF analysis, which investigates how the structure of the global financial network has changed since the GFC, highlights three major observations:

1) The relative importance of China in the global financial network has increased significantly since the GFC⁴

Since 2007, China's financial institutions have seen significant increases in their levels of interconnectedness across the global financial system. China constitutes the largest banking system in the world in terms of total assets.⁵

Chinese banks have become the largest cross-border creditors for almost half of all emerging market and developing economies (EMDEs). They lend to 135 out of 143 EMDEs and to 30 out of 31 advanced economies, thus establishing a global reach that resembles that of banks from advanced economies.

China's strong growth since the GFC has been credit-fueled and investment-focused, which has led to the development of several financial vulnerabilities:

- » China's nonfinancial private credit has doubled since the GFC to more than 200% of GDP.⁶
- » China's household debt growth also accelerated since the GFC due to the sharp increase in mortgage borrowing.
- » Some vulnerabilities in China's financial sector stem from devaluations of the renminbi, capital outflows, and the subsequent large movements in Chinese equity prices.
- » Chinese banks also have deep connections to shadow-banking institutions. The Chinese shadow-banking sector is focused on credit intermediation through non-traditional products, such as wealth management products (WMPs).
- » Potential examples of events that could trigger a sharp slowdown in the Chinese economy and threaten financial stability include: a series of local government and corporate bond defaults that dent consumer and investor confidence; a large property sector bust hurting consumer investment and spending; and a further escalation of trade tensions that could impact corporate profits and spending.⁷

Financial shocks originating in China and Hong Kong, as well as other Asian countries such as Singapore and South Korea, are more likely to have a global impact as these countries have moved closer to the center of the cross-border financial network.

China's macroeconomic and financial developments increasingly influence global financial markets through various channels, such as trade flows and commodities demand. Additionally, general market sentiment in China can have international spill-over effects as well, as illustrated by the reaction of global markets and U.S. equities to volatility in China's stock market in 2015 and 2016.

⁴ See, among other sources: Stacey Schreft, "Updated Bank Data Show Rising Systemic Importance of Asian Banks," *The OFR Blog*, December 21, 2017.

⁵ Eugenio Cerutti et al., "Banking Across Borders: Are Chinese Banks Different?" *Bank for International Settlements Working Papers*, No. 892, October 2020. The four largest banks (measured by total assets) in the 2022 edition of S&P Global Market Intelligence's annual global bank ranking are all based in China as well.

⁶ Shaghil Ahmed et al., "Global Spillovers of a China Hard Landing," *International Finance Discussion Papers*, No. 1260, October 2019.

⁷ The rise in bond default rates is in no small measure due to a shift in government policy which withdrew implicit guarantees to bond issuances in 2017.

Moreover, the Chinese government is the second largest foreign holder of U.S. government debt after Japan; each country holds about 5% of total debt outstanding.⁸ If China decided to disinvest, it could impact borrowing costs.

In light of the current geopolitical context and the sanctions that have been issued against Russia following its invasion of Ukraine, it is also interesting to note that China is Russia's largest export market after the European Union.

2) The U.S. remains the most influential country in the global financial network in terms of the size of its gross assets/liabilities and close links to other influential countries

The global financial network remains highly susceptible to shocks from the U.S. The 2020 IMF Financial System Stability Assessment paper on the U.S. notes that shocks within U.S. banks are a larger source of systemic risk globally than shocks that originate in non-U.S. banks.⁹

Contagion from the U.S. to foreign banking systems is partially driven by the fact that nearly half of global cross-border claims are denominated in U.S. dollars (USD). Even though USD funding activity remains below its peak a decade ago relative to the size of the global economy, it clearly remains the dominant international funding currency.¹⁰

The structure of the USD funding landscape has undergone two major changes since the GFC:¹¹

- » **First, there has been a shift in USD funding activity from Europe to emerging market economies.** As such, these economies are becoming more susceptible to changes in the cost and availability of USD financing, which can shift because of changes in U.S. interest rates, fluctuations in global risk sentiment or periods of market stress (e.g., the COVID-19-related stress). Emerging market economies are also particularly vulnerable to faster-than-expected tightening of financial conditions as the recovery gathers momentum in advanced economies. Such sudden tightening of financial conditions could have adverse spillover effects on emerging market and developing economies, particularly among those with high debt and large financing needs.
- » **Second, non-banks have become more important providers and users of USD funding.** While some non-bank institutions (such as pension funds and insurers) tend to have more stable regular funding sources and operate with less leverage than banks, this does create additional vulnerabilities as they may have less recourse to a range of USD funding sources that are only accessible to banks (including central bank facilities).

Several papers highlight that, while post-crisis regulation has improved banking systems' resilience, USD funding remains a global vulnerability.¹² This was evidenced by shocks to USD funding costs that materialized in March 2020 as the COVID-19 pandemic started to spread. Even so, funding stresses for banks in jurisdictions with standing swap lines with the Federal Reserve eased quickly, illustrating the effectiveness of central bank swap line facilities. As a result, while the severity of USD funding strains varied substantially across financial institutions, banks have not been a major source of vulnerabilities during the COVID-19 pandemic, in contrast to what occurred during the GFC.

⁸ Congressional Research Service, *Foreign Holdings of Federal Debt*, July 9, 2021.

⁹ International Monetary Fund, *United States Financial System Stability Assessment*, IMF Country Report No. 20/242, August 2020.

¹⁰ Bank for International Settlements – Committee on the Global Financial System, *US dollar funding: an international perspective*, CGFS Papers No. 65, June 2020.

¹¹ Ibid.

¹² See: (i) Adolfo Barajas et al., "Global Banks' Dollar Funding: A Source of Financial Vulnerability," *International Monetary Fund Working Paper*, No. 20/113, July 2020; and (ii) Egemen Eren et al., "US dollar funding markets during the Covid-19 crisis – the international dimension," *BIS Bulletin*, No. 15, May 12, 2020.

3) While the impact of individual European countries (excluding the UK) on shock propagation is relatively low, the global financial network is highly susceptible to shocks from the entire euro area

While the post-pandemic recovery in the euro area is ongoing, certain concerns with respect to financial stability remain, specifically with respect to increasing levels of public debt and a potential rise in bankruptcies once fiscal support is withdrawn and monetary policies start to normalize. To support the economic recovery, the European Union (EU) agreed on a €1.074 Tn long-term EU budget and a €750 Bn Coronavirus recovery fund.

The European Central Bank's (ECB) Financial Stability Review published in May 2021 found increasing signs of asset quality deterioration on the balance sheets of EU banks:

- » The ECB has forecasted that in an “extreme but plausible” scenario non-performing loans across EU banks could top €1.4 Tn (which would exceed the 2008 financial crisis and the European sovereign debt crisis).¹³
- » The ECB reiterated that a weak economic recovery in the EU along with growing vulnerabilities in the corporate sector may require higher loan loss provisions.
- » The ECB also warned that insolvencies could rise substantially if public support would be withdrawn prematurely, which could impact banks’ balance sheets.

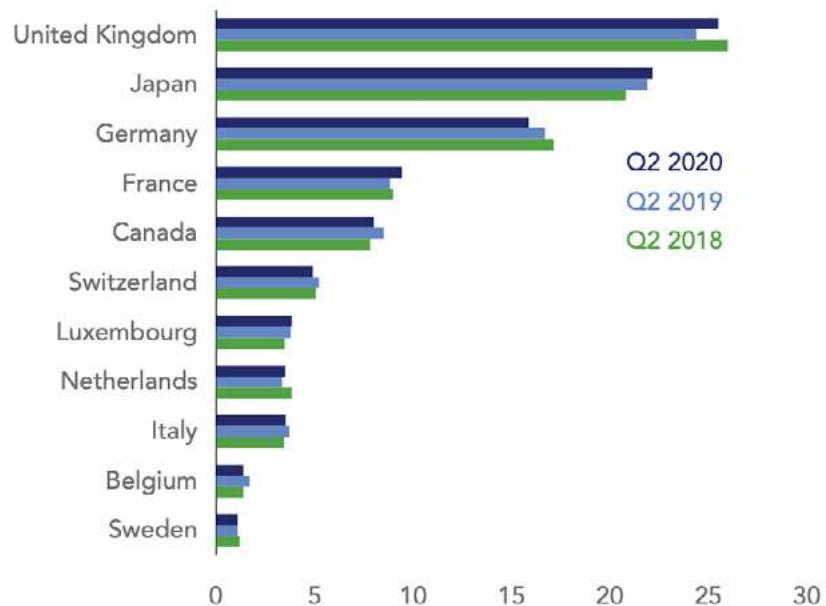
The 2020 Annual Report of the Office of Financial Research (OFR) notes that foreign global systemically important banks (G-SIBs) with cross-border claims on U.S. banks can also be a potential source of contagion risks.¹⁴ Four of the five largest European G-SIBs reported a 7% to 96% decline in earnings in Q2 2020, increasing the risks of potential spillovers to the U.S. banking system arising from European bank defaults.

¹³ Laurence Norman, “European Union Leaders Agree on Spending Plan for Recovery,” *The Wall Street Journal*, July 21, 2020.

¹⁴ Office of Financial Research, 2020 Annual Report to Congress, November 18, 2020.

U.S. banks' risk of loss through financial claims on residents of G-10 countries and Luxembourg represent 12 to 13% of total U.S. commercial banking assets from 1Q 2018 through 1Q 2020, as illustrated in the figure below:

U.S. Banks' Financial Claims on G-10 Countries (Percent of Total for Group)



Note: Claims on Luxembourg (not a G-10 country) also shown. Total exposures equal 12-13 percent of total U.S. commercial banking assets in each quarter.

Sources: Federal Deposit Insurance Corporation, Federal Financial Institutions Examination Council, Haver Analytics, Office of Financial Research

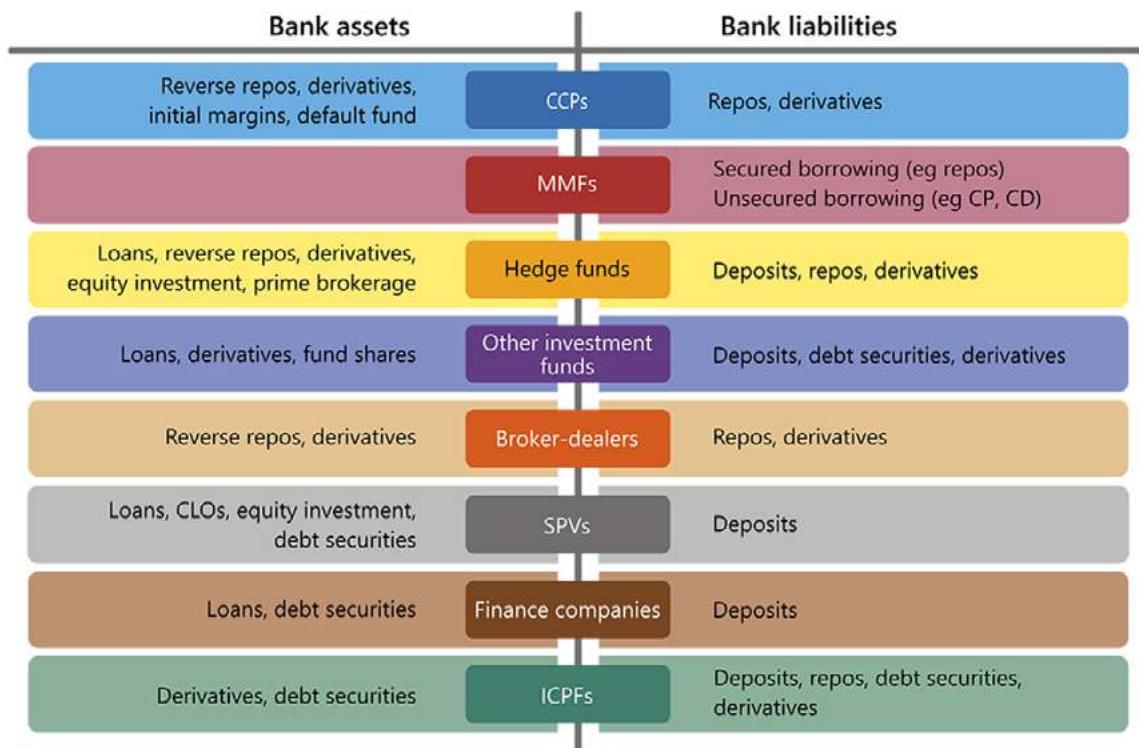
Graph above copied from Figure 77 of the Office of Financial Research's Annual Report to Congress 2020 (<https://www.financialresearch.gov/annual-reports/files/OFR-Annual-Report-2020.pdf>)

INTERCONNECTEDNESS OF THE NON-BANK FINANCIAL INTERMEDIATION (NIFI) SECTOR

Banks and non-bank financial institutions are interconnected through a series of direct and indirect links:¹⁵

- Examples of indirect links include those arising from being part of the same conglomerate (including implicit or explicit support from banks to affiliated funds), or from having exposures to the same counterparty (e.g., overlapping portfolios).
- Examples of direct links include banks' direct claims and liabilities vis-à-vis non-bank financial institutions, which are captured by the BIS international banking statistics (IBS) and which could enter banks' balance sheets, as illustrated in the graph below:

Asset and Liability Links Between Banks and NBFIs: Illustrative Examples



CCPs = central counterparties; CD = certificates of deposit; CLOs = collateralised loan obligations; CP = commercial paper; ICPFs = insurance companies and pension funds; MMFs = money market funds; SPVs = special purpose vehicles.

The diagram does not aim to be comprehensive but to give a high-level overview of the main types of connections to NBFIs on bank balance sheets. Note that credit lines, if not drawn, do not appear on balance sheets.

Source: Authors' elaboration.

Graph above copied from Graph 2 of "Cross-border links between banks and non-bank financial institutions," BIS Quarterly Review, September 2020 (https://www.bis.org/publ/qtrpdf/r_qt2009e.pdf)

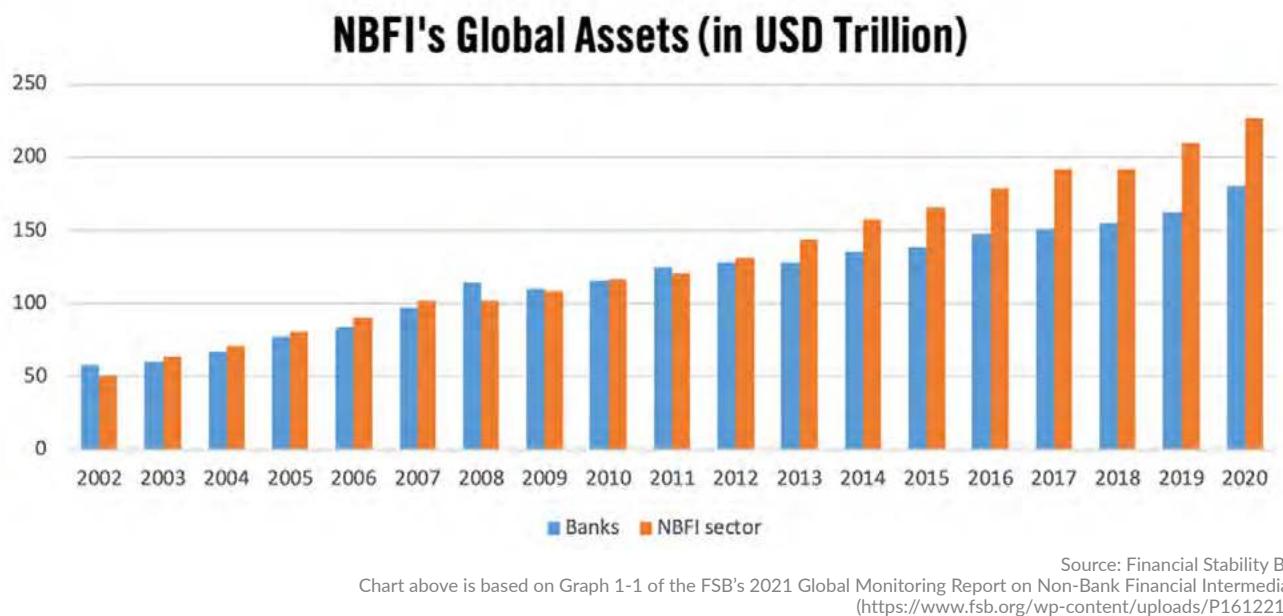
¹⁵ Iñaki Aldasoro et al., "Cross-border links between banks and non-bank financial institutions," BIS Quarterly Review, September 2020: 61-74.

While these links provide additional sources of financing for households and corporates, they can also contribute to systemic risks and they played an important role in transmitting shocks during the GFC.¹⁶

An in-depth report that was recently published by the Financial Stability Board (FSB) describes how the impact of the COVID-19 pandemic has highlighted vulnerabilities in particular activities and mechanisms in the NBFI sector stemming from liquidity mismatches, leverage and interconnectedness.¹⁷

This section highlights the growth of the NBFI sector and its increasing role in providing financing across the financial system. Most of the data included in this section is sourced from the FSB's latest Global Monitoring Reports on Non-Bank Financial Intermediation.¹⁸

- **The NBFI sector has been growing at a faster pace than the banking sector for the past decade.** While the financial assets of the banking sector have grown by 56% from 2010 to 2020, those of the NBFI sector have increased by 94% (to \$226.6 Tn) over the same period.



This growth is largely driven by the expansion of collective investment vehicles (CIVs), such as hedge funds, money market funds, and other investment funds (OIFs).

- » Money Market Funds (MMFs) are mutual funds that hold cash, cash equivalent securities and short-term debt-based securities with a high credit rating to offer investors a high level of liquidity with a very low level of risk. They are key intermediaries in the financial ecosystem (see callout box *Money Market Funds (MMFs) in the U.S. vs. Europe* on the next page).
- » In 2020, MMFs globally saw an annual increase of 17.4% to \$8.5 trillion, the highest increase in assets under management (AUM) since the GFC, and nearly twice the average annual growth observed between 2017 and 2019.

¹⁶ Iñaki Aldasoro et al., "Cross-border links between banks and non-bank financial institutions," *BIS Quarterly Review*, September 2020: 61-74 (which also refers to other sources: Gary Gorton, "Slapped by the invisible hand: the panic of 2007," Oxford University Press, February 2010; and Stijn Claessens et al., "Shadow banking: economics and policy," IMF Staff Discussion Note, No. 12/12, December 2012).

¹⁷ Financial Stability Board, *Lessons Learnt from the COVID-19 Pandemic from a Financial Stability Perspective*, Final report, October 28, 2021.

¹⁸ Financial Stability Board, *Global Monitoring Report on Non-Bank Financial Intermediation* 2020, December 16, 2020 and Financial Stability Board, *Global Monitoring Report on Non-Bank Financial Intermediation* 2021, December 16, 2021.

Money Market Funds (MMFs) in the U.S. vs. Europe

Money Market Funds (MMFs) provide short-term financing to banks, governments and other issuers, and they are used by investors and corporate treasurers to invest excess cash.

Financial companies, including other investment funds, use MMFs to manage their daily liquidity needs for collateral management purposes, margin calls, etc.

Several subcategories exist within U.S. and European MMFs:

U.S. MMFs can be classified into three broad groups:

1. **Government MMFs**, which invest primarily in government debt securities.
2. **Prime MMFs**, which mainly invest in short-term private-sector securities.
A prime MMF may impose liquidity fees or temporarily suspend redemptions if its weekly liquid assets (WLA) decline below 30% of its total assets.
3. **Tax-exempt MMFs**, which primarily hold short-term state and local government and municipal securities.

European MMFs are concentrated in Ireland, Luxembourg and France. They are categorized into three main types:^(*)

1. Public debt constant net asset value (**CNAV**) funds, which must invest a minimum of 99.5% of their assets in public debt.
2. Units/shares in low-volatility net asset value (**LVNAV**) funds, which can be purchased or redeemed at a constant price, as long as the value of the assets in the fund does not deviate by more than 0.2% from par (i.e., the 20 basis point “collar”).
3. Variable net asset value (**VNAV**) funds, which use mark-to-market accounting to value their assets. The NAV of these funds varies with the changing value of the assets and - in the case of an accumulating fund - by the amount of income received.

(*) Information related to European MMFs is sourced from: European Fund and Asset Management Association. *Money Market Funds in Europe – State of Play*. Market Insights – Issue #2, October 2020 (http://www.etha.org.gr/files/pdf/02%20Market%20Insights%20Issue2%20MMFs%20in%20Europe%20final%20October%202020_1615465810.pdf)

Policy changes because of the GFC have made certain product segments unprofitable for banks, thereby driving activity out of the banking sector and towards non-bank financial firms.

Non-banks intermediate twice as much credit to the real economy than depository institutions.

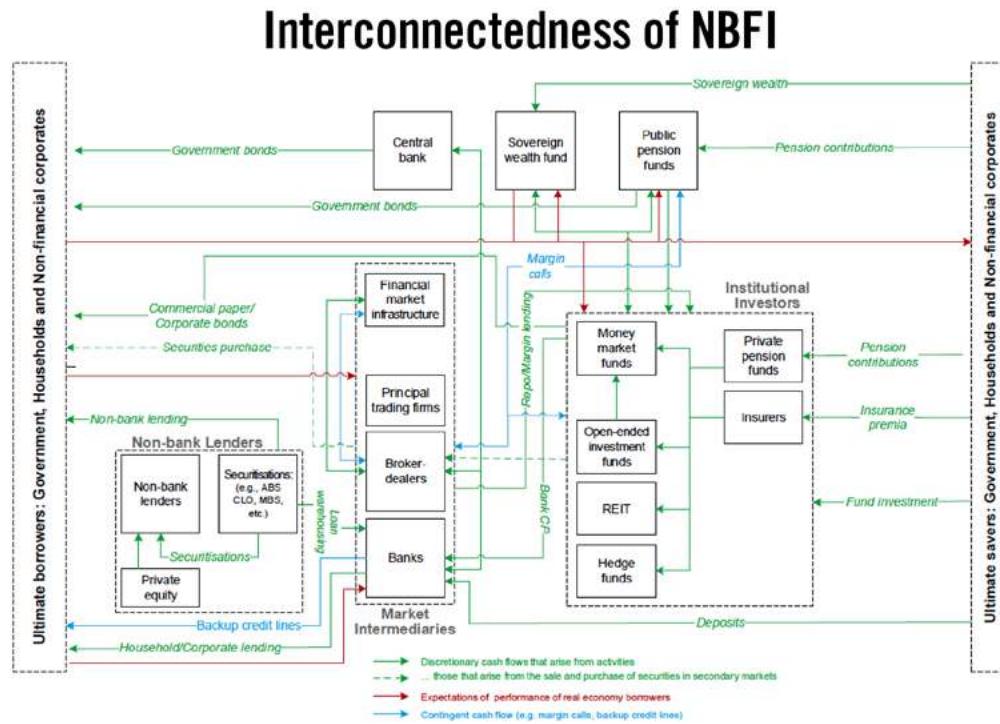
In addition, these sectors are indirectly interconnected through common exposures to asset classes such as corporate bonds, equities, agency, and Treasury securities markets.¹⁹

¹⁹ For example, banks, insurers, pension funds, money market and mutual funds hold about US\$4–7 trillion in debt securities each. See International Monetary Fund, *United States Financial System Stability Assessment*, IMF Country Report No. 20/242, August 2020.

- The growth of the NBFI sector has also led to greater interconnectedness and complexity in credit intermediation chains.

The NBFI sector plays an important role in supporting the supply of credit to the real economy. NBFI entities have increasingly provided diversified financing and investment opportunities, as well as a broad range of risk management and risk sharing services (e.g., through derivatives hedging and treasury management) and efficient delivery (e.g., through payment, clearing, settlement and electronic trading infrastructures).

The increasing role of NBFI in credit provision has led to greater interconnectedness and complexity in credit intermediation chains, as illustrated below:



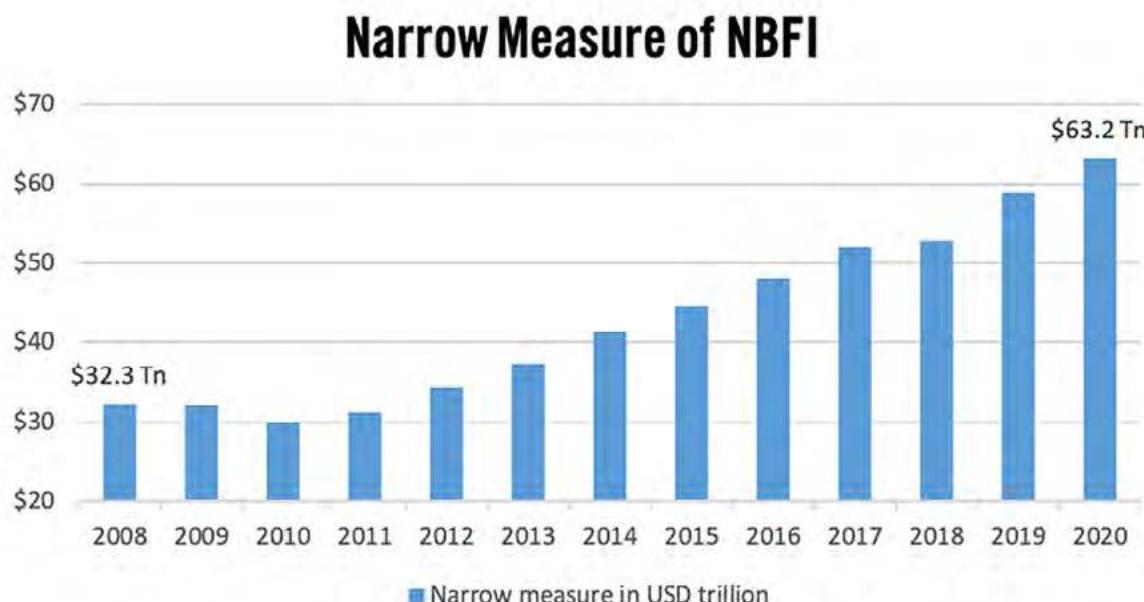
Graph above copied from Graph 3.3 of the FSB's *Holistic Review of the March Market Turmoil* (<https://www.fsb.org/wp-content/uploads/P171102-2.pdf>)

- **Financial links between banks and NBFI are mainly denominated in USD** and concentrated in financial centers and large advanced economies, but have also grown in emerging market economies.

While the NBFI sector tends to be relatively larger in advanced economies, the relative size of the NBFI sector in emerging market economies has increased at a faster pace than in advanced economies.

- Since the GFC there has been a shift of global intermediation from banks to non-bank financial institutions, mainly driven by the significant increase of investment funds in the euro area and several G20 emerging markets.

- The comprehensive monitoring of global trends, risks, and innovations of NBFI is a key part of the FSB's efforts to enhance financial system resilience. The FSB's monitoring of NBFI consists of two steps:
 - First, the monitoring exercise casts the net wide to capture an aggregate measure of the financial assets of entities that engage in NBFI.
 - Second, the exercise focuses on NBFI activities and entities that are involved in certain financial activities to create the "narrow measure of NBFI." This involves data collection on financial activities that may involve bank-like financial stability risks (such as maturity/liquidity transformation and/or leverage) and may warrant policy responses.
- The FSB also noted that the riskiest "narrow measure of NBFI" grew by 7.4% in 2020, in line with the 7.3% average growth rate over the past five years. This narrow measure of NBFI currently represents 13.7% of total global financial assets.
 - Since the 2008 financial crisis, growth of the narrow measure of NBFI has been driven primarily by investment funds, compared to pre-crisis growth, which was largely driven by entity types such as structured finance vehicles (SFVs) and broker-dealers that often received support from banks.



Source: Financial Stability Board
 Graph based on Annex 2 of the FSB's 2021 Global Monitoring Report on Non-Bank Financial Intermediation
 (<https://www.fsb.org/wp-content/uploads/P161221.pdf>)

OPERATIONAL INTERCONNECTEDNESS

While financial interconnectedness was prioritized in the aftermath of the 2008 financial crisis, operational interconnectedness has been rising on the regulatory agenda because of the growing use of outsourcing and the increased importance of third and fourth parties. Other noteworthy developments related to operational interconnectedness include the financial services sector's reliance on an increasingly complex and interconnected IT infrastructure, as well as the further proliferation of cyber-attacks and the continued rise of fintech.

- **Regulatory authorities around the world specifically address outsourcing and third parties in their operational risk and resilience guidance:**
 - The International Organization of Securities Commissions (IOSCO) has recently updated its *Principles on Outsourcing*, which set out expectations for regulated entities that use third parties and service providers.²⁰ These updated principles are based on the 2005 *Outsourcing Principles for Market Intermediaries* and the 2009 *Outsourcing Principles for Markets*, but their application is expanded to trading venues, market intermediaries, market participants acting on a proprietary basis, and credit rating agencies. IOSCO notes that their application may also be considered by financial market infrastructures.
 - The Basel Committee on Banking Supervision (BCBS) published its *Principles for Operational Resilience* in March 2021.²¹ This document includes a principle on *Third-party dependency management* as well as a separate principle on *Mapping interconnections and interdependencies*. The BCBS also published *Sound Practices on the Implications of Fintech Developments for Banks and Bank Supervisors* in 2018 specifically to provide guidelines for cloud service outsourcing.²²
 - The Federal Reserve Board (FRB), the Federal Deposit Insurance Corporation (FDIC), and the Office of the Comptroller of the Currency (OCC) jointly released proposed interagency guidance on third-party relationship risk management.²³ The stated objective of this document is to *promote consistency in the agencies' third-party risk management guidance and to clearly articulate risk-based principles on third-party risk management*.
 - The European Commission published draft legislation in the form of a "Digital Operational Resilience Act" (DORA) for the financial sector. This draft legislation introduces an oversight framework for third-party ICT providers.
 - The European Securities and Markets Authority (ESMA) issued guidelines on outsourcing to cloud service providers for entities under its supervision, covering governance, contractual requirements, exit strategies, access and audit rights, among other areas. Additionally, ESMA incorporated into its latest *Framework for CCP Stress Tests* a thorough methodology on assessing operational risk. This methodology includes an interconnectedness analysis of the network of third-party entities that could create a business disruption or potentially systemic failure.

²⁰ International Organization of Securities Commissions, *Principles on Outsourcing - Final Report*, October 2021.

²¹ Bank for International Settlements – Basel Committee on Banking Supervision, *Principles for Operational Resilience*, March 2021.

²² Bank for International Settlements – Basel Committee on Banking Supervision, *Sound Practices – Implications of fintech developments for banks and bank supervisors*, February 2018.

²³ Board of Governors of the Federal Reserve System et al., *Proposed Interagency Guidance on Third-Party Relationships: Risk Management*, July 19, 2021.

- **The Bank of England** introduced a new operational resilience framework²⁴ for firms and FMIs with a three-year implementation period starting March 31, 2022. The framework includes a section that is specifically dedicated to outsourcing and the use of third parties in light of their importance in providing important business services.
- **The Monetary Authority of Singapore (MAS)** revised its *Technology Risk Management Guidelines* in January 2021. These guidelines include a section on the *Management of Third Party Services* given that a system failure or security breach at a third party can adversely impact the operations and the customers of financial institutions.
- **As financial services become more sophisticated and specialized, third-party vendors tend to rely increasingly on subcontractors themselves, thus creating fourth-party risk.**
 - Banks rely on third-party organizations for products and services for core bank processing, IT, accounting, human resources, compliance, or to provide customers access to products and services through third-party platforms. Because these third-party organizations can offer quick and relatively inexpensive access to new innovations, human capital, and other competitive advantages, banking institutions will likely continue to grow these relationships.²⁵
 - Broadly speaking, regulators are primarily concerned about the following risks with respect to third-party relationships: contagion risk; concentration risk; financial risk; legal risk (e.g., contractual terms); data security risk; oversight and access rights; third-party companies' resilience to cyber-attacks, business continuity plans, and disaster recovery. The Russia-Ukraine war illustrates the importance of country risk as another factor that must be taken into account when assessing the risks associated with third-party relationships.
 - Interconnectedness of banks with parties within and external to the financial sector is deepening as large parts of bank IT systems are now provided not only by third-parties, but also by fourth-parties. This type of risk is particularly hard to manage for two reasons:
 - » First, the lack of contractual agreements or direct operational arrangements between a financial institution and its vendors' subcontractors makes it hard to identify, oversee and control fourth-party providers.
 - » Second, the sheer number of fourth-party providers that a financial firm may have makes effective risk management even more difficult.²⁶
- **The financial services sector's reliance on an increasingly complex and interconnected IT infrastructure increases concentration risk.²⁷**
 - Concentration risk emerges as a result of operational interconnectedness when an increasing number of financial services firms rely, either directly or indirectly, on the same third-party service providers or products that have a substantial market share.
 - The rapid adoption of cloud computing and the high degree of concentration among major cloud service providers has raised concerns around *cloud concentration risk*.²⁸

²⁴ Bank of England et al., *Operational resilience: Impact tolerances for important business services*, March 2021.

²⁵ Board of Governors of the Federal Reserve System et al., *Proposed Interagency Guidance on Third-Party Relationships: Risk Management*, July 19, 2021.

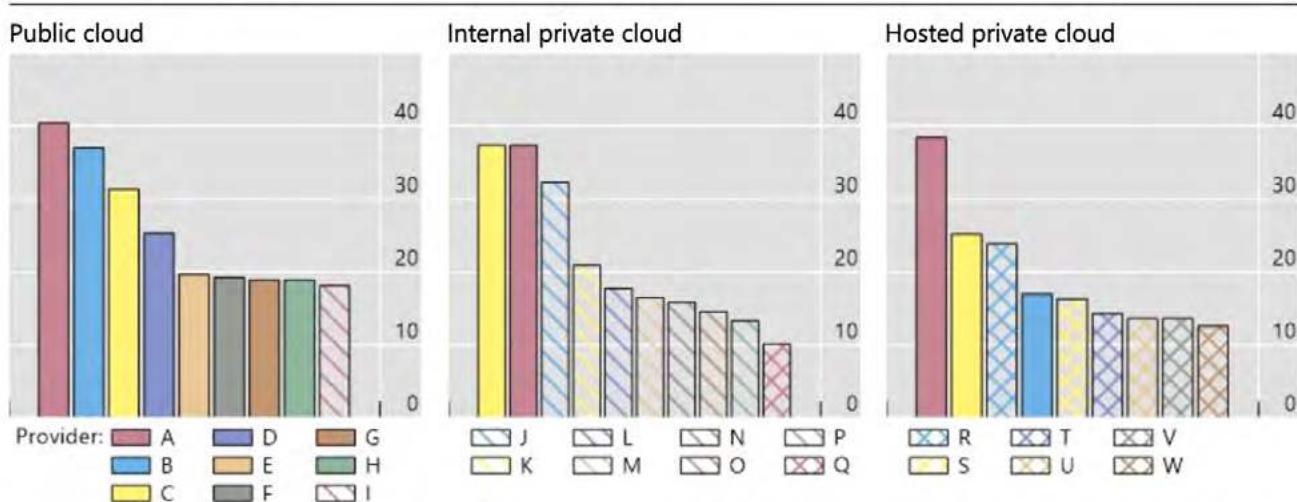
²⁶ See, among other sources: Jill Czerwinski, "Fourth-party risk is daunting – make it manageable in three steps," *Crowe Insights*, March 15, 2021.

²⁷ Office of Financial Research, *2020 Annual Report to Congress*, November 18, 2020.

²⁸ See, among other sources: (i) Financial Stability Board, *Third-party dependencies in cloud services – Considerations on financial stability implications*, December 9,

Share of Financial Institutions Using or Planning to Use Specific Cloud Providers

In % of respondents, all regions



From a sample of 265 financial services firms (public cloud), 158 firms (internal private cloud) and 294 firms (hosted private cloud), respectively. Firms may use multiple providers, such that responses add up to more than 100%.

Source: Forrester's Global Business Technographics® Infrastructure Survey, 2017.

Graph above copied from Graph 1 of *Third-party dependencies in cloud services – Considerations on financial stability implications*, published by the FSB (<https://www.fsb.org/wp-content/uploads/P091219-2.pdf>)

- While cloud computing provides substantial advantages compared to data centers that are located on-premises,²⁹ the concentration of cloud services among a very limited number of major providers presents a growing source of concern.
 - » As the shift from on-premises to cloud computing continues, a single prolonged operational outage within a cloud provider could affect a wide array of financial firms. Without appropriate back-up and recovery plans, this might have far-reaching, if not systemic, ramifications.
 - » Some House Democrats have called on the Treasury to designate U.S. cloud providers “systemically important financial market utilities” under the Dodd-Frank Act.³⁰
- It should be noted that cloud concentration risk affects financial services companies both directly (when they choose to contract directly with a cloud provider) and indirectly (when their third-party or fourth-party providers decide to offer cloud-based services).

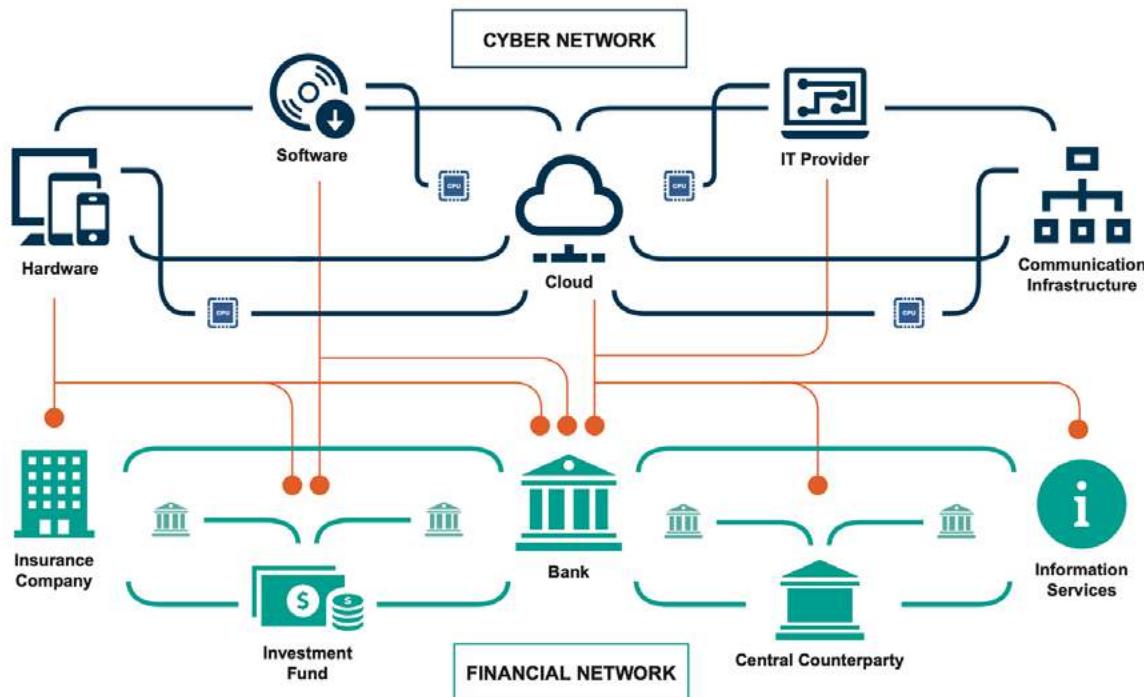
2019; and (ii) Richard Harmon, “Minimizing Cloud Concentration Risk for Financial Services Institutions, Regulators and Cloud Service Providers,” *Cloudera Blog*, July 16, 2020.

²⁹ Advantages may include: enhanced resilience for individual firms; greater operational flexibility and scalability; and lower costs.

³⁰ Agustín Carstens, *Public policy for big techs in finance*, Introductory remarks made at the Asia School of Business Conversations on Central Banking webinar, ‘Finance as information’, January 21, 2021.

- The continued proliferation and the ever-increasing sophistication of cyber-attacks require financial services firms to keep enhancing their cybersecurity programs.
 - Cybersecurity has been a major concern for financial firms for many years and the growing role of state-sponsored cyber actors has increasingly been recognized. The rise in cyber-related concerns following Russia's invasion of Ukraine³¹ illustrates how malicious cyber capabilities and geopolitical tensions – traditionally two of the top risks cited in DTCC's Systemic Risk Barometer surveys – can come together to create a combined threat to financial firms and other organizations.
 - While the considerable and continuous investments that have been made in cybersecurity programs may have protected the financial services industry from a successful large-scale attack so far, the rise of ransomware and other types of cyber-attacks demonstrates the need for continued vigilance.
 - » 45% of large financial services companies experienced a rise in cyber-attack attempts since the onset of the COVID-19 pandemic.³²
 - » Financial services firms are 300 times as likely as other companies to be targeted by a cyber-attack.³³
 - The various touchpoints between cyber and financial networks and some of the complex interdependencies that exist between them, are illustrated in the schematic diagram below:³⁴

Interaction Between Cyber and Financial Networks



This figure was developed by the authors and represents some of the relationships between cyber and financial networks. It is not intended as a complete description of the full network.

 = representative of broader network components

³¹ On February 26, 2022, the Cybersecurity and Infrastructure Security Agency (CISA) and the Federal Bureau of Investigation (FBI) issued a joint Cybersecurity Advisory providing an overview of destructive malware that has been used to target organizations in Ukraine as well as guidance on how organizations can detect and protect their networks.

³² James Coker, "Two-Thirds of Financial Services Firms Suffered Cyber-Attack in the Past Year," *Infosecurity Magazine*, November 5, 2020.

³³ Boston Consulting Group, *Global Wealth 2019 – Reigniting Radical Growth*, June 2019.

³⁴ Diagram copied from: Jan-Philipp Brauchle et al., "Cyber Mapping the Financial System," *Cyber Policy Initiative Working Paper Series 'Cybersecurity and the Financial System'*, No. 6, April 2020.

- The 2020 Annual Report of the OFR also identifies cyber risk as a potential threat to financial stability and notes that new vulnerabilities could emerge from increased dependence on remote work.³⁵ The report explains how the increasing reliance of financial firms on highly complex and interconnected IT infrastructure exposes the financial services sector to contagion and concentration risks. It also identifies quantum computing as an emerging technology that could become a new source of longer-term cybersecurity risk.
- According to the ECB's *Assessment of Risks and Vulnerabilities for 2021* report, advancing digitalization exposes institutions to IT deficiencies, cybercrime, and operational disruption.³⁶ During the COVID-19 pandemic, business continuity plans were implemented quickly, but they pose additional challenges to operational risk resilience. Specifically, cyber threats have risen as a result of the heightened level of remote work.
- **The rise of fintech has blurred the lines between IT companies and financial services firms.**
 - An increasing number of large technology companies – big techs – have started to offer financial services, either independently or in partnership with traditional financial firms. As an analysis by the Financial Stability Institute (FSI) of the BIS points out, this has attracted the attention of policymakers and regulators, as illustrated by the following recent initiatives:³⁷
 - » A Subcommittee of the U.S. House of Representatives published a list of recommendations to regulate big techs in October 2020.
 - » In November 2020, China's State Administration for Market Regulation (SAMR) published a draft version of the *Anti-Monopoly Guidelines for the Platform Economy Industries*. The final version of these guidelines was released in February 2021.
 - » The European Commission published proposals for a Digital Services Act and a Digital Markets Act in December 2020.
 - At the same time, a growing list of CEOs and top executives of traditional banks have made public statements indicating that they see their firms as “IT companies with a banking license.”³⁸

“Risks connected with big tech activities in finance may not be fully captured by the regulatory approach up to now, which is geared towards individual entities or specific activities and not the risks that are created by substantive interlinkages within big tech groups and their role as critical service providers for financial institutions.”

Big techs in finance: regulatory approaches and policy options. Financial Stability Institute (FSI) of the Bank for International Settlements (BIS). FSI Briefs No. 12, March 2021

³⁵ Office of Financial Research, 2020 Annual Report to Congress, November 18, 2020.

³⁶ European Central Bank, ECB Banking Supervision: Assessment of Risks and Vulnerabilities for 2021, January 28, 2021.

³⁷ Juan Carlos Crisanto et al., “Big techs in finance: regulatory approaches and policy options,” FSI Briefs, No. 12, March 2021; and Agustín Carstens, *Public policy for big techs in finance*, Introductory remarks made at the Asia School of Business Conversations on Central Banking webinar, ‘Finance as information’, January 21, 2021.

³⁸ SEPA for Corporates, “Technology Companies? What Big Banks Spend & Say About Tech,” November 15, 2018.

FINTECH AND INTERCONNECTEDNESS

The potential impact of emerging fintech-related developments on financial stability was the central theme of a DTCC white paper that was published in 2017.³⁹ Given the further evolution of fintech since the paper's publication, this is a topic that has only become more relevant over the last few years.

The scope of fintech-related applications is extremely broad and encompasses a wide array of innovative technologies, business models and applications, from cloud computing to machine learning and artificial intelligence. As such, the impact of fintech on financial interconnectedness is a multi-faceted topic.

The ever-increasing cybersecurity threats and the risks associated with the growing use of cloud providers, as well as other third and fourth parties, are most often quoted in this context. While these aspects are covered in the previous section of this paper, this section focuses on how cryptocurrencies are starting to become more interconnected with more traditional parts of the financial ecosystem. The total cryptocurrency market capitalization surged from just \$17.7 billion at the start of 2017 to slightly over \$3 trillion in early November 2021, before falling back below the \$2 trillion mark in early 2022.⁴⁰

To be clear, the use of blockchain technology to record and transfer ownership of assets doesn't create additional risk in and of itself and may provide several benefits. However, the pace at which the cryptocurrency market capitalization has grown over the last few years warrants attention, especially given that cryptocurrencies differ from traditional financial instruments in several other respects that are important from a risk management and financial stability perspective:

1. Most cryptocurrencies have no intrinsic value

- Almost 95% of cryptocurrencies (including bitcoin) have no intrinsic value, as they are not backed by any underlying assets; in essence, they are strings of computer code that cannot be replicated and their value is determined solely by the price that buyers are willing to pay at a given point in time.
- The remaining 5% of cryptocurrencies are denominated in fiat money and backed by a pool of assets to stabilize their value relative to the fiat peg. These types of cryptocurrencies, which are primarily designed for payment and settlement purposes, are known as "stablecoins."⁴¹

2. Cryptocurrencies are largely unregulated

- Traditional currencies are supported by extensive regulatory and supervisory frameworks that include deposit guarantees, as well as minimum capital and liquidity requirements for commercial banks. The money issued by a commercial bank in the form of deposit accounts can be exchanged, on demand and at par value, for other commercial bank money or even against central bank money (which is effectively a claim on the state).
- While stablecoins in circulation today are typically backed by a mix of commercial paper, short-dated securities and cash, a similar type of regulatory and supervisory framework currently does not exist for most cryptocurrencies. This raises growing concerns around investor protection, law enforcement and market integrity.

³⁹ DTCC, *Fintech and Financial Stability – Exploring How Technological Innovations Could Impact the Safety & Security of Global Markets*, October 2017.

⁴⁰ Joanna Ossinger, "Crypto World Hits \$3 Trillion Market Cap as Ether, Bitcoin Gain," Bloomberg, November 8, 2021; and Charles Bovaird, "Why The Crypto Market Has Appreciated More Than 1,200% This Year," Forbes, November 17, 2017 (see also: https://www.coingecko.com/en/global_charts).

⁴¹ Jon Cunliffe, *Is 'crypto' a financial stability risk?* Speech delivered at SIBOS, October 13, 2021.

- Even though the majority of the open interest in cryptocurrency derivatives (estimated at more than \$40bn) is positioned on unregulated exchanges, mainstream institutional investors are primarily active on regulated exchanges such as the CME.⁴²

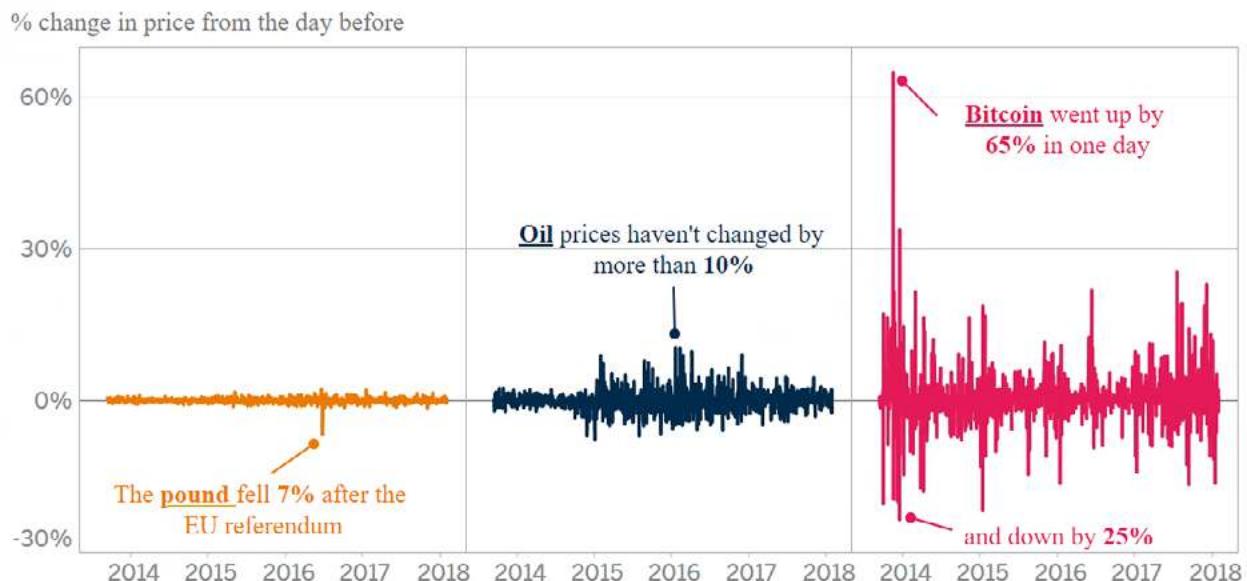
“A massive collapse in crypto asset prices, similar to what we have seen in tech stocks and sub-prime, is certainly a plausible scenario. In such a price correction scenario, the first question that arises is the degree of interconnectedness between crypto and the conventional financial sector. [...] while financial stability risks from the application of crypto technologies are currently limited, there are a number of very good reasons to think that all else equal this might not be the case for very much longer.”

Sir Jon Cunliffe, Deputy Governor for Financial Stability at the Bank of England (Excerpt of speech delivered at SIBOS, October 13, 2021)

3. Unbacked cryptocurrencies can be extremely volatile

- Given that unbacked cryptocurrencies don't have any intrinsic value, they tend to be more volatile than traditional asset classes.
- The graph below illustrates the day-over-day volatility of bitcoin as compared to pound sterling and oil for the period between 2014 and 2018.⁴³

The Bitcoin Rollercoaster



⁴² Ibid.

⁴³ Graph copied from: <https://www.bankofengland.co.uk/knowledgebank/what-are-cryptocurrencies>

More importantly, a growing number of developments suggest that cryptocurrencies are becoming increasingly interconnected with the more traditional financial system:

- Several financial institutions have started offering their customers access to crypto exchanges through their apps and are developing exchange platforms themselves.
- Some payment firms are analyzing how they can use stablecoins for payment and settlement purposes.
- On April 14, 2021, cryptocurrency exchange platform Coinbase went public via a direct listing on the Nasdaq exchange.
- The first bitcoin-linked exchange-traded fund (*ProShares Bitcoin Strategy ETF*) was launched in October 2021.⁴⁴

As direct exposure levels to cryptocurrencies continue to grow (both in terms of the number of cryptocurrency holders and in terms of the size of their holdings), so does the possibility that a sudden price drop might have a systemic impact – especially given the probability of contagion between cryptocurrencies themselves.

- Even though retail investments still dominate the cryptocurrency market, institutional investor interest seems to be growing. A recent report identified 150 to 200 specialist crypto hedge funds.⁴⁵ The same report also includes the results of a survey among hedge funds in which 21% of respondents indicated they were currently investing in digital assets.
- While banks' activities in this area have been largely focused on providing agency services (such as custody and trading platforms), some banks are planning to offer broker-dealer services and may thus become directly exposed to cryptocurrencies. In light of these developments, the BCBS is consulting on the capital treatment for crypto assets on bank balance sheets.⁴⁶

In addition to this direct transmission channel, second round or indirect effects could also affect other asset classes. A steep drop in the value of cryptocurrencies could trigger margin calls on cryptocurrency positions forcing leveraged investors to find liquidity, leading to the sale of other assets, and generating spillovers to other markets. This type of event could even lead to contagion and impact market sentiment more broadly, causing investors to sell other assets that are perceived to be risky and have a similar investor base.⁴⁷

It is worth reiterating that this section primarily focuses on unbacked cryptocurrencies, given their prevalence compared to stablecoins. That said, the increased adoption of stablecoins for payment and settlement purposes may pose specific challenges related to the safety and interoperability of different types of private money that are issued by payment systems with no overarching entity responsible for their operation. To address some of these challenges, CPMI-IOSCO recently published a consultative report that provides guidance on how the Principles for Financial Market Infrastructures (PFMI) should apply to some of the novel features of stablecoin arrangements that distinguish them from existing payment systems.⁴⁸

A key part of CPMI-IOSCO's guidance is the requirement that a stablecoin arrangement needs to be governed by one or more discrete legal entities accountable for managing risks and operational aspects. The guidance further stipulates that any wider interdependent functions within the arrangement must be governed in such a way that the arrangement can meet this governance standard as a whole.

⁴⁴ This ETF tracks CME bitcoin futures, rather than actual bitcoin.

⁴⁵ PwC et al., *3rd Annual Global Crypto Hedge Fund Report 2021*, May 2021.

⁴⁶ Bank for International Settlements – Basel Committee on Banking Supervision, *Prudential treatment of cryptoasset exposures*, Consultative Document, June 2021.

⁴⁷ Jon Cunliffe, *Is 'crypto' a financial stability risk?* Speech delivered at SIBOS, October 13, 2021.

⁴⁸ Committee on Payments and Market Infrastructures et al., *Application of the Principles for Financial Market Infrastructures to stablecoin arrangements*, Consultative report, October 2021.

Even though it will be up to individual jurisdictions to decide how and to which extent they will implement and enforce CPMI-IOSCO's guidance, we feel it contains key principles to help ensure that the benefits of fintech-related innovations can be realized while safeguarding global financial stability.

This is crucially important in light of an emerging set of blockchain applications known as decentralized finance, or "DeFi." DeFi applications refer to decentralized, algorithm-based financial services that rely on smart contracts and that are delivered over DLT platforms without intermediaries. While the degree of decentralization varies across platforms, it is conceivable to create DeFi applications that are completely decentralized, to the point where it would be hard to identify their ownership or any underlying legal entities.

Even though DeFi is still in a nascent stage, its rapid growth will force regulators and other stakeholders to carefully consider how further fintech innovations should be structured and supervised to make sure that they deliver benefits in a way that does not compromise the safety and soundness of the global financial system.

INTERCONNECTEDNESS OF FINANCIAL MARKET INFRASTRUCTURES

Financial market infrastructures (FMIs) are interconnected with the financial ecosystem in (at least) three ways, which each provide a channel for risk transmission:

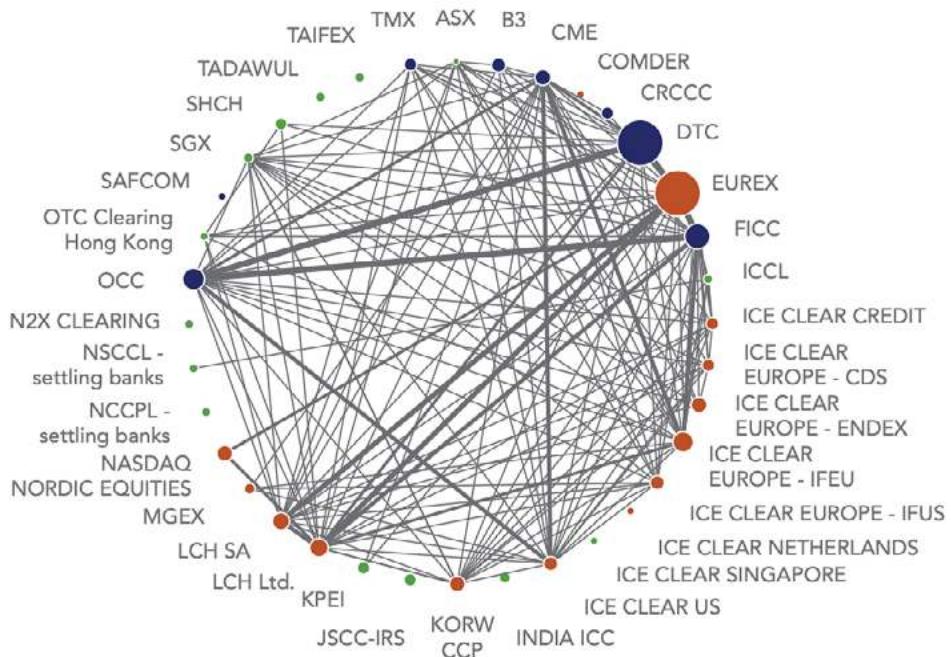
1. FMIs are interconnected to each other through common members

If an FMI member defaults and the margin and default fund contributions collected from the defaulting member are insufficient to cover the associated losses, the FMI itself will typically contribute part of its capital resources (this is the so-called skin-in-the-game) and the FMI's solvent members may be affected as well (through loss mutualization).⁴⁹

The default of an entity that is a common member of multiple FMIs can therefore affect several FMIs simultaneously. As a result, the more members two FMIs have in common, the higher the likelihood that the default of a common member will simultaneously affect them and, possibly, their solvent members as well.

The OFR has included a map that visualizes the interconnectedness between central counterparties (CCPs) in its 2020 Annual Report to Congress.⁵⁰ The thickness of each line in the map below represents the number of members that each pair of CCPs have in common:

Mapping Shows Central Counterparty (CCP) Connections



Note: The thickness of each line represents the number of members each pair of CCPs have in common. The size of each circle represents the number of clearing members a CCP has as of the first quarter of 2020. The color of each circle represents the CCP's location: blue is North and South America, orange is Europe, and green is Asia.

Source: Office of Financial Research

Interconnectedness mapping above copied from Figure 79 of the Office of Financial Research's Annual Report to Congress 2020 (<https://www.financialresearch.gov/annual-reports/files/OFR-Annual-Report-2020.pdf>)

⁴⁹ An FMI's *default waterfall* describes in detail the mechanism that is used to allocate remaining losses (i.e., losses that are not covered by the insolvent member's margin and default fund contributions) to the FMI itself and/or its solvent members.

⁵⁰ Office of Financial Research, 2020 Annual Report to Congress, November 18, 2020.

In order to mitigate the risk that a common member of multiple FMIs could negatively affect several FMIs simultaneously, DTCC's Clearing Agencies have entered into specific agreements with each other and with other FMIs:⁵¹

- **DTCC's National Securities Clearing Corporation ("NSCC") has an Accord with The Options Clearing Corporation ("OCC"), the *Stock Options and Futures Settlement Agreement* (the "Accord"), effective August 7, 2017, which replaced the Third Amended and Restated Options Exercise Settlement Agreement.⁵²** The Accord governs the delivery and receipt of stock resulting from the exercise and assignment of stock options and stock futures.

The Accord is designed to facilitate the settlement of transactions that: (i) arise out of either the exercise or assignment of an option or the maturity of a stock futures contract, (ii) are between two firms that are members of both NSCC and the OCC, and (iii) are in either CNS or Balance Order securities (i.e., eligible for clearance and settlement at NSCC). Members of both clearing agencies, known as "Common Members," rely on this link for seamless processing of underlying security transactions.

The Accord sets the time when the settlement obligations and the CCP trade guaranty shift from the OCC to NSCC with respect to these transactions ("Guaranty Substitution"). After NSCC has received a transaction from the OCC, Guaranty Substitution occurs when NSCC has received all Clearing Fund Required Deposits of the Common Members taking into account that transaction.

The Accord addresses the procedures for the transfer of these obligations (including NSCC's ability to reverse transactions), the delivery of notices between the OCC and NSCC (including notice from NSCC that the Guaranty Substitution has occurred), and other information-sharing agreements between the OCC and NSCC (for example, credit risk information regarding Common Members), and sets a process by which the terms of the Accord are to be reviewed by the OCC and NSCC on a regular basis.

The Accord: (i) reduces market risk by providing consistent treatment for all applicable regular-way transactions, (ii) reduces operational complexities by delineating a single point in time at which the OCC's trade guaranty ceases and NSCC's trade guaranty begins, (iii) reduces market and legal risks by delineating the roles of NSCC and the OCC in the event of a common member default, and (iv) reduces operational, market, credit and legal risks through procedures, information sharing and overall governance of the agreement.

- **DTCC's Fixed Income Clearing Corporation ("FICC") and Chicago Mercantile Exchange Inc. ("CME") have a *Cross-Margining Agreement* (the "Agreement") that is designed to reduce the risk to both FMIs when a cross-margining participant defaults by reducing the exposure to cross-margining participants in the form of cross-margin credit.**

Since 2000, FICC and its predecessor have had a cross-margining arrangement in place with the CME. The Agreement was entered into by FICC and CME in January 2004.

FICC and CME established a cross-margining arrangement in order to cross-margin products whose price volatility is sufficiently closely correlated that long and short positions in such products offset one another to some degree for purposes of determining margin requirements.

CME guarantees certain obligations of a cross-margining participant to FICC (Government Securities Division or "GSD"); likewise, FICC (GSD) guarantees certain obligations of a cross-margining participant to CME.

⁵¹ These three agreements meet the definition of a "link" and, as such, are subject to a comprehensive framework that DTCC has developed to identify, monitor, and manage risks related to any link with one or more other clearing agencies, FMUs, or trading markets (as described in more detail in the section that focuses on how FMIs are interconnected through links).

⁵² The OCC was founded in 1973 and is the world's largest equity derivatives clearing organization. The OCC provides central counterparty ("CCP") clearing and settlement services to 19 exchanges and trading platforms.

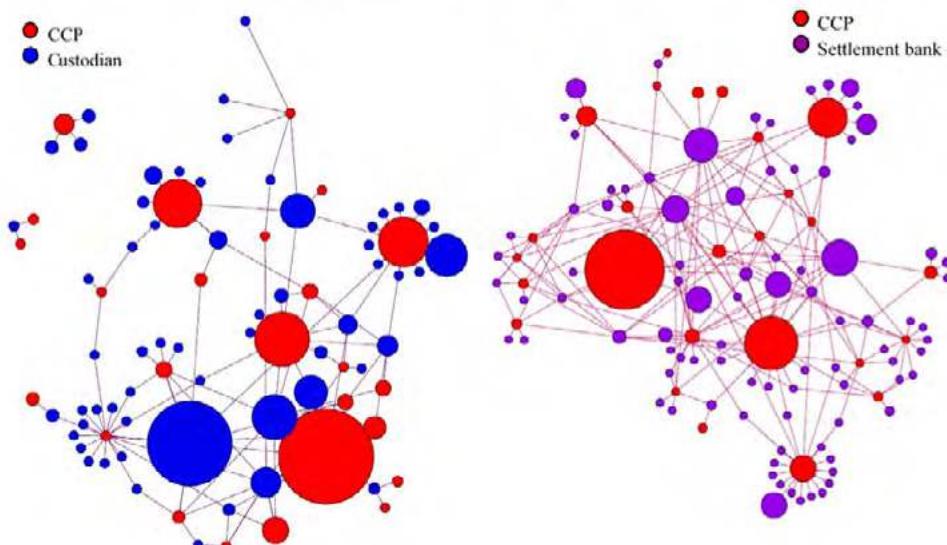
- A Netting Contract and Limited Cross-Guaranty Agreement (“Multilateral Cross-Guaranty Agreement” or “Agreement”) is in place between The Depository Trust Company (DTC), NSCC, FICC and the OCC. Under this Agreement (which has been in place since 2003), the clearing agencies have agreed to make payments to each other for unsatisfied obligations of a common defaulting participant to the extent they have excess resources of the defaulting Member. Under this arrangement, no party ever needs to pay “out of pocket” and no party can receive more than its loss.
- 2. Each FMI in its own right is interconnected with a series of entities that it relies upon for the continued provision of its services

In order for FMIs to provide core clearance and settlement services to their members, they rely on a wide variety of interconnected entities, such as settlement banks, liquidity providers, investment counterparties, and many other types of key service providers.

The two network diagrams below, which are based on a large-scale analysis of interconnections between CCPs and the rest of the financial system,⁵³ visually illustrate:

- the interconnectedness between CCPs and custodians (left half); and
- the interconnectedness between CCPs and settlement banks (right half).

CCP-Custodian and CCP-Settlement Bank Networks



⁵³ Network diagrams are copied from Figure 8 of: Bank for International Settlements – Basel Committee on Banking Supervision et al., *Analysis of Central Clearing Interdependencies*, August 9, 2018.

The failure of an interconnected entity to perform as expected – either as a result of an insolvency, because of a prolonged operational outage or due to other issues – can have a direct impact on the FMI's uninterrupted ability to function.

As such, the failure of an interconnected entity is another potential channel through which risk can be transmitted to FMI members as well as Links (see section (3) below).

Concentration risk as a result of industry consolidation is a key risk in this context:

- The fact that only a limited number of entities are available to provide certain functions creates concentration risk *within* a given area. BNY Mellon's position as the only remaining provider of GCF repo clearing and settlement services is an example of a service that is concentrated within a single entity.
- Concentration risk also exists *across* functionalities, given that a few entities play a major role in several areas (e.g., as settling bank, liquidity provider, investment counterparty) at the same time.

It should be noted that, in recognition of this concentration risk, highly interconnected entities have recovery and resolution plans in place that prescribe how these entities can continue to provide key services in case they become insolvent.

Additionally, FMIs have put in place several mitigants to minimize this type of interconnectedness risk:

- FMIs carefully select interconnected entities based on their creditworthiness and operational robustness, as well as their overall track record.
- To the extent possible, FMIs have back-up procedures in place to address the potential outage of an interconnected entity.
- FMIs perform periodic operational tests with interconnected entities, as well as tabletop exercises designed to enhance the back-up procedures mentioned above.

DTCC has established a cross-functional effort, which was launched in 2013, to address the risk that an entity on which DTCC relies for the provision or support of its services becomes unavailable or fails to operate as expected. This initiative has been instrumental in:

- dimensioning and monitoring the various aspects and the overall level of DTCC's interconnectedness risk;
- creating interconnectedness profiles for member firms to enhance Counterparty Credit Risk reviews and to inform executive management on an ad-hoc basis in times of heightened credit risk; and
- performing multi-year trend analyses with respect to interconnectedness risk.

This initiative has also given rise to changes aimed at enhancing DTCC's resilience to the potential outage of a highly interconnected entity, as illustrated by the two examples below:

- In 2015, DTC submitted a rule filing designed to minimize the risk that a Settling Bank's failure to timely provide its affirmative acknowledgement of its end-of-day net-net settlement balance or notify DTC of its refusal to settle for one or more Participants for which it is the designated Settling Bank might have systemic ramifications. This rule filing, which was approved by the U.S. Securities and Exchange Commission (SEC) in early 2016, established a process known as Settling Banks' passive acknowledgment of net-net settlement balances.⁵⁴ A similar passive acknowledgment process was subsequently implemented for FICC (in 2020) and NSCC (in 2022).

⁵⁴ For additional details, see: DTCC, Rule Filing SR-DTC-2015-011 – Proposed Rule Change Relating to Settling Bank Passive Acknowledgment of Net-Net Settlement Balances, Important Notice, January 20, 2016.

- In 2016, FICC and NSCC substantially decreased their private-sector investment counterparty risk by opening accounts with the Federal Reserve Bank and using those accounts to hold part of the funds that are posted as margin by their respective members.

Notwithstanding all of these mitigants, the amount of control that FMIs have over this type of interconnectedness risk is limited by two additional factors:

- First, certain types of interconnections (such as settling bank agreements) are bilateral relationships that are established between an FMI's member and its service provider. While an FMI can require minimum standards for certain types of interconnected entities, it cannot interfere in its members' discretion to select one provider over another.
- Second, interconnections can vary considerably in terms of substitutability, i.e., the speed and ease with which FMIs can switch from one interconnected entity to another. While an FMI can easily switch counterparties when it invests cash posted as margin by its members on an overnight basis, it may be much harder to switch relationships that require custom arrangements (e.g., concentration banks).

3. FMIs are also interconnected through Links, i.e., contractual agreements and other types of arrangements they have established between each other for a variety of purposes (including, but not limited to, cross-margining, loss-sharing and facilitating access to each other's services)

The *Standards for Covered Clearing Agencies* that have been established by the SEC define Links broadly as "*any set of contractual and operational arrangements between a covered clearing agency and one or more other clearing agencies, financial market utilities, or trading venues that connect them directly or indirectly for the purposes of participating in settlement, cross-margining, expanding its services to additional instruments and participants, or for any other purposes material to their business.*"⁵⁵

These Links may represent another channel that can transmit operational failures or financial stress that materializes within one FMI to one or more other FMIs.⁵⁶

As such, SEC Rule 17Ad-22(e)(20) requires covered clearing agencies to establish, implement, maintain and enforce written policies and procedures reasonably designed to identify, monitor, and manage risks related to any link with one or more other clearing agencies, financial market utilities, or trading markets.⁵⁷

In order to help ensure compliance with this SEC Rule, DTCC has developed a comprehensive framework that governs the risks associated with over 100 Links and link-like relationships that its Clearing Agencies have established:

- This framework is based on a series of written Link risk reviews and review meetings that include input and analysis from over a dozen different DTCC functions.
- The frequency and escalation of Link risk reviews is driven by a rating methodology that assesses both inherent risk and the control environment to determine a residual risk rating.
- Inherent risk, control environment, and residual risk levels are assessed across all applicable risk categories, based on over 100 questions per review.

⁵⁵ Securities and Exchange Commission, *Standards for Covered Clearing Agencies*, September 28, 2016.

⁵⁶ While this statement is generally true, it should be pointed out that certain Links are specifically designed to mitigate the risk that a common member of multiple FMIs could negatively affect several FMIs simultaneously (as described in more detail in the section that focuses on how FMIs are interconnected to each other through common members).

⁵⁷ Securities and Exchange Commission, *Standards for Covered Clearing Agencies*, September 28, 2016.

The Study Group on Central Clearing Interdependencies (SGCCI or “Study Group”) published two reports (in 2017 and 2018) that analyzed the interdependencies of 26 CCPs worldwide with their clearing members and financial service providers, as well as the resulting systemic implications.⁵⁸

These reports were the culmination of an effort that had been initiated in 2015 by the Chairs of the FSB Standing Committee on Supervisory and Regulatory Cooperation, the FSB Resolution Steering Group, the Committee on Payments and Market Infrastructure (CPMI), the International Organization of Securities Commissions (IOSCO), and the Basel Committee on Banking Supervision (BCBS). In recognition of DTCC’s focus on interconnectedness risk, SGCCI representatives consulted with DTCC’s Systemic Risk Office as they prepared the surveys that were used to collect data from the participating CCPs.

The SGCCI’s analysis found that prefunded financial resources are concentrated at a small number of CCPs. The key findings of the Study Group’s final report also include a number of observations that highlight various types of concentration risk as it relates to the interconnectedness of CCPs:

- Exposures to CCPs are concentrated among a small number of entities. The largest 11 out of 306 clearing members (as measured by prefunded financial resources contributions to the CCP) are connected to between 16 and 25 CCPs. This indicates that the default of a CCP’s clearing member could result in defaults of the same entity or affiliates in up to 24 other CCPs included in this analysis.
- Among the different types of relationships between CCPs and other financial institutions, a small number of entities tend to dominate each of the critical services required by CCPs. These concentrations suggest that a failure at one of these central elements of a CCP network would likely have significant consequences for the rest of the network.
- Clearing members and clearing member affiliates are also important providers of other critical services required by CCPs and can maintain numerous types of relationships with several CCPs simultaneously.
- The relationships mapped in this report are all characterized, to varying degrees, by: (i) a core of highly connected CCPs and entities; and (ii) a periphery of less highly connected CCPs and entities. At the same time, even these less highly connected CCPs often maintain connections to at least one highly connected entity that indirectly connects the CCP to the central (more interconnected) part of the network structure.

⁵⁸ Bank for International Settlements – Basel Committee on Banking Supervision et al., *Analysis of Central Clearing Interdependencies*, July 5, 2017; and Bank for International Settlements – Basel Committee on Banking Supervision et al., *Analysis of Central Clearing Interdependencies*, August 9, 2018.

RECOMMENDATIONS

Given the increasing complexity and interconnectedness of the global financial system, it is more important than ever to manage risks holistically. In addition to assessing credit, market and liquidity risks, it is crucial to also take into account operational risks, fintech developments, macroeconomic events, cross-border transactions, risks associated with third and fourth parties, as well as the many other factors mentioned in this paper. As such, we strongly recommend organizing cross-functional risk reviews and discussions to identify interconnections and make sure that the associated risks are assessed comprehensively.

We would also like to highlight some additional recommendations specifically with respect to addressing risks related to NBFI.

The rising importance of the NBFI sector in the global financial system has profound implications for financial stability risks. A traditional view that focuses primarily on bank buffers to assess financial stability no longer captures the complexities of a world where risks are increasingly being intermediated and held outside the banking sector or traded in financial markets. As a recent FSB progress report points out, financial stability depends increasingly on the ability of investors to effectively manage market, credit and liquidity risks in times of stress.⁵⁹

In light of the above, we support the FSB's recommendations to adopt a two-pronged approach focused on additional efforts to better understand systemic risk in the NBFI sector, as well as the development of policies that could be considered to enhance NBFI resilience.

1. Efforts to better understand systemic risk in the NBFI sector include the following:

- An assessment of potential vulnerabilities and the resulting liquidity demands under stress across different non-bank financial institutions and markets.
- The identification of the main interconnections that could propagate market stress across the global financial system.
- An assessment of the potential interaction of vulnerabilities and interconnections, and their implications for the liquidity of core markets that underpin the functioning of the global financial system.

The research described above could allow authorities to enhance tools to monitor systemic risk, including:

- Refined indicators of vulnerabilities in individual sectors (including metrics for liquidity imbalances and leverage by non-bank investors).
- Augmented interconnectedness maps for different types of non-bank entities and at various levels of granularity, including for cross-border exposures.
- System-wide risk maps that combine metrics of vulnerabilities associated with particular entity types and activities with interconnections (in addition to potential amplification and feedback loops). Such risk maps could also be used as a basis for scenario analysis.
- Stress tests, where appropriate, to assess the ability of market participants to respond to a shock and analyze common vulnerabilities and major spillovers across markets.

⁵⁹ Financial Stability Board, *Enhancing the Resilience of Non-Bank Financial Intermediation*, Progress report, November 1, 2021.

2. Policies that could be considered to enhance NBFI resilience include:

- Policies to enhance the resilience of liquidity supply in stress (e.g., improve market structure and functioning by reviewing the drivers of dealer behavior in stress, as well as the effectiveness of trading and clearing platforms).
- As we have pointed out in our 2021 white paper *Advancing Together: Leading the Industry to Accelerated Settlement*,⁶⁰ increases in intraday margin calls during periods of high volatility can strain member liquidity as firms draw down credit lines and increase liquidity buffers. We believe that shortening the settlement cycle is the most logical way to reduce the risks that drive margin requirements as well as the associated liquidity strains.
- Measures to enhance risk monitoring and the preparedness of authorities and market participants (e.g., additional reporting and disclosure requirements, stress testing).

⁶⁰ DTCC, *Advancing Together: Leading the Industry to Accelerated Settlement*, February 2021.

CONCLUSION

The interconnectedness risk landscape has changed rapidly and profoundly over the past few years:

- Greater cross-border interconnectedness has made countries that rely heavily on foreign capital inflows more vulnerable to systemic shocks.
- The growing importance of Non-Bank Financial Intermediation has increased the potential role that this sector might play in transmitting stress throughout the financial system.
- The growing reliance on third-party vendors and the ever-increasing proliferation of cyber threats has created yet another channel of risk transmission that may have systemic implications.
- As fintech innovations continue to change financial services and as cryptocurrencies are starting to become more interconnected with the global financial system, a new set of financial stability challenges may be emerging.

While these interconnections offer many benefits, it is also important to recognize that they may pose certain risks as well. Understanding the complexity of these dynamics is a daunting task that requires constant vigilance to identify emerging threats. We must be willing to continuously question ourselves in the face of constant change and new insights.

FMs themselves are interconnected with the financial ecosystem in a myriad of ways, which presents its own set of risk management challenges. DTCC has taken various initiatives to reduce these risks:

- In order to mitigate the risk that a common member of multiple FMs could negatively affect several FMs simultaneously, DTCC's Clearing Agencies have entered into specific agreements with each other and with other FMs.
- DTCC has established a cross-functional effort to address the risk that an entity on which it relies for the provision or support of its services becomes unavailable or fails to operate as expected.
- DTCC has developed a comprehensive framework to identify, monitor, and manage risks related to any link with one or more other clearing agencies, financial market utilities, or trading markets.

Managing risk in such a deeply interconnected and ever-changing environment also requires a multi-disciplinary approach that leverages insights from a wide array of subject matter experts and that is built on close coordination between all stakeholders – in line with DTCC's focus on "Advancing Financial Markets. Together." In that spirit, we encourage you to share your comments and feedback with us.

Andrew Gray

Managing Director, DTCC Group Chief Risk Officer

agray@dtcc.com

001-212-855-1100

Michael Leibrock

Managing Director, DTCC Chief Systemic Risk Officer and Head of Counterparty Credit Risk

mleibrock@dtcc.com

001-212-855-3243

Adrien Vanderlinden

Executive Director, DTCC Systemic Risk Office

avanderlinden@dtcc.com

001-212-855-7615

BIBLIOGRAPHY

Ahmed, Shaghil, et al. "Global Spillovers of a China Hard Landing." *International Finance Discussion Papers*, No. 1260, October 2019. <https://www.federalreserve.gov/econres/ifdp/files/ifdp1260.pdf>

Aldasoro, Iñaki, et al. "Cross-border links between banks and non-bank financial institutions." *BIS Quarterly Review*, September 2020: 61-74. https://www.bis.org/publ/qtrpdf/r_qt2009e.pdf

Avalos, Fernando, et al. "Investor size, liquidity and prime money market fund stress." *BIS Quarterly Review*, March 2021: 17-29. https://www.bis.org/publ/qtrpdf/r_qt2103b.pdf

Bank for International Settlements. *International banking and financial market developments*. BIS Quarterly Review, September 2021. https://www.bis.org/publ/qtrpdf/r_qt2109.pdf

Bank for International Settlements. *Statistical release: BIS international banking statistics and global liquidity indicators at end-September 2021*. January 28, 2022. <https://www.bis.org/statistics/rppb2201.pdf>

Bank for International Settlements – Basel Committee on Banking Supervision. *Principles for Operational Resilience*. March 2021. <https://www.bis.org/bcbs/publ/d516.pdf>

Bank for International Settlements – Basel Committee on Banking Supervision. *Prudential treatment of cryptoasset exposures*. Consultative Document, June 2021. <https://www.bis.org/bcbs/publ/d519.pdf>

Bank for International Settlements – Basel Committee on Banking Supervision. *Sound Practices – Implications of fintech developments for banks and bank supervisors*. February 2018. <https://www.bis.org/bcbs/publ/d431.pdf>

Bank for International Settlements – Basel Committee on Banking Supervision, et al. *Analysis of Central Clearing Interdependencies*. July 5, 2017. <https://www.bis.org/cpmi/publ/d164.pdf>

Bank for International Settlements – Basel Committee on Banking Supervision, et al. *Analysis of Central Clearing Interdependencies*. August 9, 2018. <https://www.bis.org/cpmi/publ/d181.pdf>

Bank for International Settlements – Committee on Payment and Settlement Systems, et al. *Principles for financial market infrastructures*. April 2012. <https://www.bis.org/cpmi/publ/d101a.pdf>

Bank for International Settlements – Committee on the Global Financial System. *US dollar funding: an international perspective*. CGFS Papers No. 65, June 2020. <https://www.bis.org/publ/cgfs65.pdf>

Bank of England. *What are cryptoassets (cryptocurrencies)?* <https://www.bankofengland.co.uk/knowledgebank/what-are-cryptocurrencies>

Bank of England, et al. *Operational resilience: Impact tolerances for important business services*. March 2021. <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/publication/2021/building-operational-resilience-impact-tolerances-for-important-business-services.pdf>

Barajas, Adolfo, et al. "Global Banks' Dollar Funding: A Source of Financial Vulnerability." *International Monetary Fund Working Paper*, No. 20/113, July 2020. <https://www.imf.org/en/Publications/WP/Issues/2020/07/03/Global-Banks-Dollar-Funding-A-Source-of-Financial-Vulnerability-49529>

Board of Governors of the Federal Reserve System, et al. *Proposed Interagency Guidance on Third-Party Relationships: Risk Management*. July 19, 2021. <https://www.govinfo.gov/content/pkg/FR-2021-07-19/pdf/2021-15308.pdf>

Board of Governors of the Federal Reserve System, et al. *Sound Practices to Strengthen Operational Resilience*, October 30, 2020. <https://www.federalreserve.gov/newsevents/pressreleases/files/bcreg20201030a1.pdf>

Boston Consulting Group. *Global Wealth 2019 – Reigniting Radical Growth*. June 2019. https://image-src.bcg.com/Images/BCG-Reigniting-Radical-Growth-June-2019_tcm9-222638.pdf

Bovaird, Charles. "Why The Crypto Market Has Appreciated More Than 1,200% This Year." *Forbes*, November 17, 2017. <https://www.forbes.com/sites/cbovaird/2017/11/17/why-the-crypto-market-has-appreciated-more-than-1200-this-year/?sh=9dcac606eed3>

Brauchle, Jan-Philipp, et al. "Cyber Mapping the Financial System." *Cyber Policy Initiative Working Paper Series 'Cybersecurity and the Financial System'*, No. 6, April 2020. https://carnegieendowment.org/files/Brauchle_Cyber_Mapping_the_Financial_System_final.pdf

Bricco, Jana, et al. "Interconnectedness and Contagion Analysis: A Practical Framework." *International Monetary Fund Working Paper*, No. 19/220, October 2019. <https://www.imf.org/en/Publications/WP/Issues/2019/10/11/Interconnectedness-and-Contagion-Analysis-A-Practical-Framework-48717>

Carstens, Agustín. *Public policy for big techs in finance*. Introductory remarks made at the Asia School of Business Conversations on Central Banking webinar, 'Finance as information', January 21, 2021. <https://www.bis.org/speeches/sp210121.pdf>

Cerutti, Eugenio, et al. "Banking Across Borders: Are Chinese Banks Different?" *Bank for International Settlements Working Papers*, No. 892, October 2020. <https://www.bis.org/publ/work892.pdf>

Coker, James. "Two-Thirds of Financial Services Firms Suffered Cyber-Attack in the Past Year." *Infosecurity Magazine*, November 5, 2020. <https://www.infosecurity-magazine.com/news/two-thirds-financial-services>

Committee on Payments and Market Infrastructures, et al. *Application of the Principles for Financial Market Infrastructures to stablecoin arrangements*. Consultative report, October 2021. <https://www.bis.org/cpmi/publ/d198.pdf>

Congressional Research Service. *Foreign Holdings of Federal Debt*. July 9, 2021. <https://sgp.fas.org/crs/misc/RS22331.pdf>

Crisanto, Juan Carlos, et al. "Big techs in finance: regulatory approaches and policy options." *FSI Briefs*, No. 12, March 2021. <https://www.bis.org/fsi/fsibriefs12.pdf>

Cunliffe, Jon. *Is 'crypto' a financial stability risk?* Speech delivered at SIBOS, October 13, 2021. <https://www.bankofengland.co.uk/speech/2021/october/jon-cunliffe-swifts-sibos-2021>

Czerwinski, Jill. "Fourth-party risk is daunting – make it manageable in three steps." *Crowe Insights*, March 15, 2021. <https://www.crowe.com/insights/3-steps-to-handle-fourth-party-risk>

Deutsche Bundesbank. *Global financial interconnectedness and spillovers between the G20 countries*. Monthly Report, September 2020. <https://www.bundesbank.de/resource/blob/844610/190fdecc2dcd67c2381feb9940d38929/mL/2020-09-globale-finanzielle-verflechtung-data.pdf>

DTCC. *Advancing Together: Leading the Industry to Accelerated Settlement*. February 2021. <https://www.dtcc.com/-/media/Files/PDFs/White%20Paper/DTCC-Accelerated-Settle-WP-2021.pdf>

DTCC. *Fintech and Financial Stability – Exploring How Technological Innovations Could Impact the Safety & Security of Global Markets*. October 2017. <https://www.dtcc.com/-/media/Files/PDFs/Fintech-and-Financial-Stability.pdf>

DTCC. *Rule Filing SR-DTC-2015-011 – Proposed Rule Change Relating to Settling Bank Passive Acknowledgment of Net-Net Settlement Balances*. Important Notice, January 20, 2016. <https://www.dtcc.com/-/media/Files/pdf/2016/1/20/B2509-16.pdf>

DTCC. *Understanding Interconnectedness Risks to Build a More Resilient Financial System*. October 2015. <https://www.dtcc.com/-/media/Files/Downloads/WhitePapers/InterconnectednessWP-101815.pdf>

Eisenbach, Thomas, et al. "Cyber Risk and the U.S. Financial System: A Pre-Mortem Analysis." *Federal Reserve Bank of New York Staff Reports*, No. 909, January 2020; revised May 2021. https://www.newyorkfed.org/medialibrary/media/research/staff_reports/sr909.pdf

Eren, Egemen, et al. "US dollar funding markets during the Covid-19 crisis – the international dimension." *BIS Bulletin*, No. 15, May 12, 2020. <https://www.bis.org/publ/bisbull15.pdf>

European Central Bank. *ECB Banking Supervision: Assessment of Risks and Vulnerabilities for 2021*. January 28, 2021. <https://www.bankingsupervision.europa.eu/ecb/pub/ra/pdf/ssm.ra2021~edbbea1f8f.en.pdf>

European Central Bank. *ECB Banking Supervision: Risk assessment for 2020*. October 7, 2019. <https://www.bankingsupervision.europa.eu/ecb/pub/ra/pdf/ssm.ra2020~a9164196cc.en.pdf>

European Central Bank. *Financial Stability Review*. November 2020. <https://www.ecb.europa.eu/pub/pdf/fsr/ecb.fsr202011~b7be9ae1f1.en.pdf>

European Central Bank. *Financial Stability Review*. May 2021. <https://www.ecb.europa.eu/pub/pdf/fsr/ecb.fsr202105~757f727fe4.en.pdf>

European Fund and Asset Management Association. *Money Market Funds in Europe – State of Play*. Market Insights – Issue #2, October 2020. https://www.efama.org/sites/default/files/publications/20%2010%20Market%20Insights%20Issue2%20MMFs%20in%20Europe%20final_0.pdf

European Securities and Markets Authority. *Framework for the 2021 ESMA Stress Test Exercise for Central Counterparties*. Final report, June 7, 2021. https://www.esma.europa.eu/sites/default/files/library/esma91-372-1367_framework_for_the_2021_ccp_st_exercise.pdf

European Securities and Markets Authority. *Guidelines on outsourcing to cloud service providers*. May 10, 2021. https://www.esma.europa.eu/sites/default/files/library/esma_cloud_guidelines.pdf

European Systemic Risk Board. *EU Non-bank Financial Intermediation Risk Monitor 2021*. NBFI Monitor No. 6, August 2021. https://www.esrb.europa.eu/pub/pdf/reports/nbfi_monitor/esrb.202108_eunon-bankfinancialintermediationriskmonitor2021_~88093a4a94.en.pdf

Financial Stability Board. *Enhancing the Resilience of Non-Bank Financial Intermediation*. Progress report, November 1, 2021. <https://www.fsb.org/wp-content/uploads/P011121.pdf>

Financial Stability Board. *Global Monitoring Report on Non-Bank Financial Intermediation 2020*. December 16, 2020. <https://www.fsb.org/wp-content/uploads/P161220.pdf>

Financial Stability Board. *Global Monitoring Report on Non-Bank Financial Intermediation 2021*. December 16, 2021. <https://www.fsb.org/wp-content/uploads/P161221.pdf>

Financial Stability Board. *Holistic Review of the March Market Turmoil*. November 17, 2020. <https://www.fsb.org/wp-content/uploads/P171120-2.pdf>

Financial Stability Board. *Lessons Learnt from the COVID-19 Pandemic from a Financial Stability Perspective*. Final report, October 28, 2021. <https://www.fsb.org/wp-content/uploads/P281021-2.pdf>

Financial Stability Board. *Third-party dependencies in cloud services – Considerations on financial stability implications*. December 9, 2019. <https://www.fsb.org/wp-content/uploads/P091219-2.pdf>

Harmon, Richard. "Minimizing Cloud Concentration Risk for Financial Services Institutions, Regulators and Cloud Service Providers." *Cloudera Blog*, July 16, 2020. <https://blog.cloudera.com/minimizing-cloud-concentration-risk-for-financial-services-institutions-regulators-and-cloud-service-providers>

International Monetary Fund. *United States Financial System Stability Assessment*. IMF Country Report No. 20/242, August 2020. <https://www.imf.org/-/media/Files/Publications/CR/2020/English/1USAEA2020002.ashx>

International Monetary Fund. *World Economic Outlook – Managing Divergent Recoveries*. April 2021. <https://www.imf.org/-/media/Files/Publications/WEO/2021/April/English/text.ashx>

International Organization of Securities Commissions. *Principles on Outsourcing - Final Report*. October 2021. <https://www.iosco.org/library/pubdocs/pdf/IOSCOPD687.pdf>

Ker, Michelle. "U.S. Financial Exposure to China." *U.S.-China Economic and Security Review Commission, Staff Research Report*, May 9, 2017. <https://www.uscc.gov/sites/default/files/Research/U.S.%20Financial%20Exposure%20to%20China.pdf>

Korniyenko, Yevgeniya, et al. "Evolution of the Global Financial Network and Contagion: A New Approach." *International Monetary Fund Working Paper*, No. 18/113, May 2018. <https://www.imf.org/en/Publications/WP/Issues/2018/05/15/Evolution-of-the-Global-Financial-Network-and-Contagion-A-New-Approach-45825>

Kothari, S.P, et al. *U.S. Credit Markets Interconnectedness and the Effects of the COVID-19 Economic Shock*. October 5, 2020. https://www.sec.gov/files/US-Credit-Markets_COVID-19_Report.pdf

Kowsmann, Patricia. "Bitcoin at the Bank: Mainstream Lenders Dabble in Crypto Outside the U.S." *The Wall Street Journal*, January 4, 2022. <https://www.wsj.com/articles/bitcoin-at-the-bank-mainstream-lenders-dabble-in-crypto-outside-the-u-s-11641288824>

Norman, Laurence. "European Union Leaders Agree on Spending Plan for Recovery." *The Wall Street Journal*, July 21, 2020. <https://www.wsj.com/articles/eu-leaders-close-in-on-coronavirus-recovery-plan-deal-11595274568>

Office of Financial Research. *2020 Annual Report to Congress*. November 18, 2020. <https://www.financialresearch.gov/annual-reports/files/OFR-Annual-Report-2020.pdf>

Ossinger, Joanna. "Crypto World Hits \$3 Trillion Market Cap as Ether, Bitcoin Gain." *Bloomberg*, November 8, 2021. <https://www.bloomberg.com/news/articles/2021-11-08/crypto-world-hits-3-trillion-market-cap-as-ether-bitcoin-gain>

Paddrik, Mark, et al. "Central Counterparty Default Waterfalls and Systemic Loss." *OFR Working Paper*, No. 20-04, June 18, 2020. https://www.financialresearch.gov/working-papers/files/OFRwp-20-04_central-counterparty-default-waterfalls-and-systemic-loss.pdf

Patalano, Robert, et al. "Structural developments in global financial intermediation: The rise of debt and non-bank credit intermediation." *OECD Working Papers on Finance, Insurance and Private Pensions*, No. 44, March 30, 2020. https://www.oecd-ilibrary.org/finance-and-investment/structural-developments-in-global-financial-intermediation-the-rise-of-debt-and-non-bank-credit-intermediation_daa87f13-en

PwC, et al. *3rd Annual Global Crypto Hedge Fund Report* 2021. May 2021. [https://www.pwc.com/gx/en/financial-services/pdf/3rd-annual-pwc-elwood-aima-crypto-hedge-fund-report-\(may-2021\).pdf](https://www.pwc.com/gx/en/financial-services/pdf/3rd-annual-pwc-elwood-aima-crypto-hedge-fund-report-(may-2021).pdf)

Quarles, Randal. *The FSB in 2021: Addressing Financial Stability Challenges in an Age of Interconnectedness, Innovation, and Change*. Speech delivered at the Peterson Institute for International Economics, March 30, 2021. <https://www.federalreserve.gov/news/events/speech/quarles20210330a.htm>

Raddant, Matthias, et al. "Interconnectedness in the Global Financial Market." *OFR Working Paper*, No. 16-09, September 27, 2016. https://www.financialresearch.gov/working-papers/files/OFRwp-2016-09_Interconnectedness-in-the-Global-Financial-Market.pdf

Schreft, Stacey. "Updated Bank Data Show Rising Systemic Importance of Asian Banks." *The OFR Blog*, December 21, 2017. <https://www.financialresearch.gov/the-ofr-blog/2017/12/21/updated-bank-data-show-rising-systemic-importance-of-asian-banks/>

Securities and Exchange Commission. *Standards for Covered Clearing Agencies*. September 28, 2016. <https://www.sec.gov/rules/final/2016/34-78961.pdf>

SEPA for Corporates, "Technology Companies? What Big Banks Spend & Say About Tech." November 15, 2018. <https://www.sepacorporates.com/payments-news-2/technology-companies-what-big-banks-spend-say-about-tech/>

U.S. Department of the Treasury. *A Financial System That Creates Economic Opportunities – Nonbank Financials, Fintech, and Innovation*. Report to President Donald J. Trump – Executive Order 13772 on Core Principles for Regulating the United States Financial System, July 2018. <https://home.treasury.gov/sites/default/files/2018-08/A-Financial-System-that-Creates-Economic-Opportunities---Nonbank-Financials-Fintech-and-Innovation.pdf>

Yamaguchi, Yuzo, et al. "The world's 100 largest banks, 2022." S&P Global Market Intelligence, April 11, 2022. <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/the-world-s-100-largest-banks-2022-69651785>

For more information on our products and services, visit [DTCC.com](https://dtcc.com)

For information on careers at DTCC, visit careers.dtcc.com

FOLLOW US ON

