HSSEDI
Homeland Security Systems Engineering & Development Institute

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Financial System Mapping

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Authors:

Brian Tivnan

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HSSEDI
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The Homeland Security Act of 2002 (Section 305 of PL 107-296, as codified in 6 U.S.C. 185), herein referred to as the "Act," authorizes the Secretary of the Department of Homeland Security (DHS), acting through the Under Secretary for Science and Technology, to establish one or more federally funded research and development centers (FFRDCs) to provide independent analysis of homeland security issues. MITRE Corp. operates the Homeland Security Systems Engineering and Development Institute (HSSEDI) as an FFRDC for DHS under contract HSHQDC-14-D-00006.

The HSSEDI FFRDC provides the government with the necessary systems engineering and development expertise to conduct complex acquisition planning and development; concept exploration, experimentation and evaluation; information technology, communications and cyber security processes, standards, methodologies and protocols; systems architecture and integration; quality and performance review, best practices and performance measures and metrics; and, independent test and evaluation activities. The HSSEDI FFRDC also works with and supports other federal, state, local, tribal, public and private sector organizations that make up the homeland security enterprise. The HSSEDI FFRDC's research is undertaken by mutual consent with DHS and is organized as a set of discrete tasks. This report presents the results of research and analysis conducted under:

HSHQDC-16-J-00184
Next Generation Cyber Infrastructure (NGCI) Apex Cyber Risk Metrics and Threat Model Assessment

This HSSEDI task order is to enable DHS Science and Technology Directorate (S&T) to facilitate improvement of cybersecurity within the Financial Services Sector (FSS). To support NGCI Apex use cases and provide a common frame of reference for community interaction to supplement institution-specific threat models, HSSEDI developed an integrated suite of threat models identifying attacker methods from the level of a single FSS institution up to FSS systems of systems, and a corresponding cyber wargaming framework linking technical and business views. HSSEDI assessed risk metrics and risk assessment frameworks, provided recommendations toward development of scalable cybersecurity risk metrics to meet the needs of the NGCI Apex program, and developed representations depicting the interdependencies and data flows within the FSS.

The results presented in this report do not necessarily reflect official DHS opinion or policy.

For more information about this publication contact:

Homeland Security Systems Engineering & Development Institute

The MITRE Corporation
7515 Colshire Drive
McLean, VA 22102

Email: HSSEDI_info@mitre.org

http://www.mitre.org/HSSEDI

Abstract

The Homeland Security Systems Engineering and Development Institute (HSSEDI) assists the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) in the execution of the Next Generation Cyber Infrastructure (NGCI) Apex program. In this report, HSSEDI provides a general definition of interdependence to inform its survey of existing maps of the financial system. This report highlights the usefulness of a cumulative set of maps from Treasury. This set of maps represents the interdependence of the financial system comprehensively while also depicting the various elements emphasized in the Financial Services Sector-Specific Plan. The relevance of this set of maps is reinforced with an illustrative example of Bears Stearns and its series of events in the Financial Crisis of 2007-2008.

HSSEDI concludes this report with four recommendations for the NGCI Apex program. First, HSSEDI recommends that the NGCI Apex program use these maps to illustrate the interdependence of the financial system, thereby reinforcing the value proposition of the Apex program. Second, HSSEDI recommends that the NGCI Apex program use this report to assess the breadth of FSS institutions represented on the CART, and as necessary, use the recommended map to identify potential CART representatives to address any shortfalls. Third, HSSEDI recommends that the NGCI Apex program use the identified maps to assess the impacts of the program. Finally, HSSEDI recommends that the NGCI Apex program undertake a similar mapping exercise for the next Critical Infrastructure to be addressed by the program.

Key Words

1. Next Generation Cyber Infrastructure (NGCI) Apex program
2. Critical Infrastructures
3. Financial Services Sector (FSS)
4. Interdependence
5. Financial System Map

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1 Project Overview

The Next Generation Cyber Infrastructure (NGCI) Apex Program seeks to accelerate the adoption of cyber technologies proven to be effective for mitigating information technology (IT) security risk. Initially, the focal, critical infrastructure for the NGCI Program is the Financial Services Sector (FSS). The FSS is one of the most interdependent of the critical infrastructures, comprised of intensely competing organizations which collectively hold the nation's economic security in their decision-making related to technology implementation. By doing so, the goals of the NGCI program are to 1) increase financial sector-wide situational understanding of evolving IT security risk and the technology associated with mitigating that risk; 2) improve the ability to understand and link compromises in the underlying cyber infrastructure to sub-sector operations; 3) enable greater information flows between sub-sectors as well as across the entire sector; and 4) enable FSS institutions to detect and neutralize adversaries more quickly and effectively than is currently possible.

To achieve these goals, the NGCI program requires a deep understanding of the Financial System, including the many facets of its inter-connectedness and inter-dependence. The intrinsic interdependence of the FSS reinforces the value proposition of the NGCI program: that no one FSS institution alone can mitigate the cybersecurity risks threatening to the sector. To fully realize its value proposition, the NGCI program requires a Cyber Apex Review Team (CART) comprised of representatives from as broad a cross section of the entire FSS as possible to yield the highest impact toward preserving and protecting the U.S. financial system.

Therefore, for this phase of the NGCI program, Homeland Security Systems Engineering and Development Institute (HSSEDI) has developed an FSS map (or maps) to highlight essential aspects of systemic interdependence that may provide pathways for cascading, systemic risk. The specific objective of this report is to identify and depict the intrinsically interdependent nature of the Financial Services Sector. In this way, this report complements the objectives of the companion HSSEDI products for the NGCI program, namely the Cyber Risk Metrics Survey and Assessment, the Threat Models Survey and Assessment, and the Dynamic Data Map. The objective of the Cyber Risk Metrics Survey and Assessment task is to identify risk metrics and assessment frameworks that could be candidates to measure the impact of the NGCI Apex program. The objective of the Threat Models Survey and Assessment is to identify threat models and frameworks that could be candidates to inform testing in the NGCI Apex program. Currently under development, the Dynamic Data Map will provide a representation of authoritative data on a key sub-sector of the FSS.

1.1 Task Overview for the Financial System Mapping

The goal of this task is to describe and to depict the interdependent relationships of the major public, private, or public-private organizations. To accomplish this goal, HSSEDI will:

- Take an ecological perspective to develop a financial systems map of the interconnections across the FSS organizations.
- Apply previous HSSEDI research in support of the DHS Science and Technology Directorate (S&T).
- Develop the map depicting the various actors which comprise the FSS.

- Review relevant MITRE research and engage in discussions with MITRE subject matter experts (SMEs) to develop and inform the map.
- Conduct a literature survey to identify the existing set of maps of the financial system that might have potential relevance to the NGCI Apex program.
- Assess this existing set of maps for their relevance to the NGCI Apex program.
- Develop an integrated map from this existing set of maps, extracting the salient features as necessary as an intermediate step toward attaining the stated goals of this tasking.
- Extend this integrated map as necessary to attain the stated goals of this tasking.
- Develop and provide the following formal deliverable: A *Financial Systems Mapping Technical Report* in both draft and final form.

In the following sections, HSSEDI provides a general definition of interdependence. We focus the survey of existing maps to those with the intended purpose of explicating the intrinsic interdependence of the FSS, and then focus further still with an emphasis on maps that can make significant contributions to the NGCI Apex program. We conclude this report with a discussion of recommendations for next steps for the NGCI Apex program.

2 Interdependence

While the NGCI Apex program is initially focused on the FSS, the overall objective of the program is to mitigate cybersecurity risk across the interdependent set of the nation's critical infrastructures. Therefore, we draw upon previous HSSEDI research, namely the Interdependence of Cyber-Physical Systems (iCAPS) program (HSSEDI, 2016). In that effort, HSSEDI adopted a prevailing definition of *interdependent infrastructures*: "A bidirectional relationship between two infrastructures through which the state of each infrastructure influences or is correlated to the state of the other" (Rinaldi et al., 2001, p. 14). More generally, we consider two infrastructures to be interdependent when each infrastructure has a fundamental dependence on the other. In their groundbreaking study, Buldyrev et al. (2010) found that interdependent infrastructures exhibit vastly different risks of cascades than single infrastructures.

2.1 Interdependence for the Financial Services Sector

Here, we adopt the definition of cascade from Buldyrev et al. (2010). A *cascade* is a sequence of failure events that results from an initial failure and its propagation via iterative and subsequent failures. Buldyrev et al. (2010) highlight the correlation between cascades and the degree to which components of the underlying infrastructure are coupled. They then use this correlation to determine cascading risk – the probability that an initial failure can propagate to create a sweeping disruption (e.g., market crash of 1987, financial contagion of 2007-2008 crisis).

As previously observed by many leading researchers, while members of the FSS are only too familiar with the interdependent nature of the financial system and the intrinsic risks arising from such interdependence, FSS member institutions face potential conflicts of interest when undertaking collaborative partnerships (for example, see Bisias, Flood, Lo and Valavanis, 2012). Therefore, some of the burden of measuring cybersecurity risk facing the FSS must rest with federal agencies since such a task is beyond the reach of any one FSS institution.

3 Ecology of Participants in the Financial System

Before reviewing a set of existing maps of the financial system, it is important to determine which entities comprise the financial system. Colloquially, the NGCI Apex programs has referred to this as "Who is who in the zoo?" To answer that overarching question, this section provides a brief overview of subsectors of the FSS, the prevailing public-private partnerships, trade organizations and the regulators.

3.1 Subsectors

According to the FSS Sector-Specific Plan (Financial Services Sector Coordinating Council, 2015) the FSS is best described by the four categories of services that it offers rather than by some characterization at the level of the FSS institution. Since many FSS institutions provide an array of products and services, the set of regulators overseeing any one FSS institution aligns to the product and services rather than the type (or "species") of institution. The Sector Specific Plan characterizes the sector according to these four sets of products and services: (1) deposit, consumer credit, and payment systems products; (2) credit and liquidity products; (3) investment products; and (4) risk transfer products (including insurance).

3.1.1 Deposit, consumer credit, and payment systems products

For many individual customers, these products comprise the essential set of retail services required from the FSS. Depository institutions (i.e., banks) of all types are the primary providers of wholesale and retail payments services, such as wire transfers, checking accounts, and credit and debit cards. In addition, banks provide customers with various forms of credit (e.g., mortgages, home equity loans, lines of credit and credit cards).

3.1.2 Credit and liquidity products

Customers differ in their requirements for liquidity and credit. While retail customers might seek a mortgage to purchase a home, businesses might obtain a line of credit to expand their operations, and governments might issue sovereign debt obligations to fund operations or manage monetary and economic policy. Many financial institutions meet customers' long-term and short-term requirements for credit and liquidity via a variety of financial products. Some of these entities provide credit directly to the end customer, while others do so indirectly by serving as an intermediary (e.g., by providing credit and liquidity to those financial services firms that provide these services on a retail basis).

3.1.3 Investment products

The global competitiveness of U.S. financial markets arises from the diversity of investment service providers and products. These products provide opportunities for both short-term and long-term investments and include debt securities (e.g., bonds and bond mutual funds), equities (e.g., stocks and stock mutual funds), exchange-traded funds, and derivatives (e.g., options and futures). Securities firms, banks, and pension funds all offer investment products, which are issued and traded in various organized markets, from physical trading floors to electronic markets. The Securities and Exchange Commission (SEC), the Commodity Futures Trading Commission (CFTC), banking regulators, and insurance regulators all provide financial regulation for certain investment products, along with self-regulatory organizations.

3.1.4 Risk transfer products (including insurance)

The transfer of financial risks is an important tool for financial sustainability, from businesses to households. Financial risks range from losses due to theft or the destruction of physical property, from a fire or a cybersecurity incident, or the loss of income due to a death or disability in a family.

Measuring in the trillions of dollars, the U.S. market for financial risk transfer products is among the largest in the world. These products range from the simple (e.g., life insurance) to the complex (e.g., financial derivatives). Market participants often engage in both financial investments as well as in financial risk transfers that enable risk hedging.

3.2 Classes of Organizations

Both domestic and international regulators have identified different classes of institutions across the FSS. Each of these classes relates to the "systemic importance" of a particular institution; namely, that the institution serves a particularly significant role reflective of the inherent interdependence of the FSS. We describe the three major classes below.

3.2.1 Systemically Important Financial Institutions (SIFIs)

Since the Financial Crisis of 2007, any bank with assets of $50 B or more is designated as a Systemically Important Financial Institution (SIFI). As of June 2017, there were 38 banks deemed as SIFIs, from JPMorgan Chase at $2.5 T to CIT Group at $50 B of assets. These banks must adhere to stricter requirements on capital and liquidity than other banks. They must also go through yearly stress tests and have a plan for orderly liquidation.

Four of these SIFI banks, Bank of America, Goldman Sachs, U.S. Bank, and Comerica, currently serve on the CART in direct support of the NGCI Apex program.

3.2.2 Global, Systemically Important Banks (G-SIBs)

In addition to the SIFI designation, a panel of international regulators (i.e., the Basel Committee on Banking Supervision) created a special class of SIFIs, the Global, Systemically Important Banks (G-SIBs). The Basel Committee uses the following five factors to determine the set of G-SIBs: size, interconnectedness, cross-jurisdictional activity, complexity and non-substitutability.

Two of these G-SIBs, Bank of America and Goldman Sachs, currently serve on the CART in direct support of the NGCI Apex program.

3.2.3 Systemically Important Financial Market Utilities (SIFMU)

A Systemically Important Financial Market Utility (SIFMU) designates a key organization within the FSS, such that a disruption to any SIFMU could increase the risk of significant problems spreading among financial institutions and thereby threatening the stability of the FSS.

As of January 2015, the Financial Stability Oversight Council has designated eight companies as SIFMUs. Though these SIFMUs are not banks, these eight companies are SIFIs.

The first two are regulated by the Federal Reserve Board, the next two by the Commodity Futures Trading Commission, and the remaining four by the SEC. The last three SIFMUs are all

subsidiaries of the Depository Trust & Clearing Corporation (DTCC), a U.S. post-trade financial services company providing clearing and settlement services.

- The Clearing House Payments Company – "on the basis of its role as operator of the Clearing House Interbank Payments System" (CHIPS)
- CLS Bank International – world's largest multicurrency cash settlement system
- Chicago Mercantile Exchange – subsidiary of the CME Group, the world's largest futures exchange
- ICE Clear Credit – subsidiary of Intercontinental Exchange (ICE), the second largest futures exchange after CME
- Options Clearing Corporation
- Depository Trust Company
- Fixed Income Clearing Corporation
- National Securities Clearing Corporation

Previously, two of these SIFMUs, The Clearing House and DTC, served on the CART in direct support of the NGCI Apex program.

3.3 Public-Private Partnerships (PPPs)

Several Public-Private Partnerships (PPPs) exist to serve the needs of the FSS. A set of three PPPs sit at the forefront of organizations serving the FSS; namely, the Financial Services Sector Coordinating Council, the Financial Services – Information Sharing and Analysis Center, and the Financial Systemic Analysis & Resilience Center. In addition to these three PPPs, the Financial and Banking Information Infrastructure Committee also has relevance to the NGCI Apex program.

3.3.1 Financial Services Sector Coordinating Council (FSSCC)

Established in 2002 by the financial sector, the Financial Services Sector Coordinating Council (FSSCC) works collaboratively with key Government agencies to protect the Nation's critical infrastructure from cyber and physical incidents. FSSCC partners with the public sector on policy issues concerning the resilience of the sector. The FSSCC coordinates the development of critical infrastructure strategies and initiatives with its financial services members, trade associations, and other industry sectors.

The FSSCC has built and maintained relationships with the U.S. Treasury and Homeland Security Departments, all the federal financial regulatory agencies (e.g., Federal Deposit Insurance Corporation, Federal Reserve Board of Governors, Office of Comptroller of the Currency, Securities and Exchange Commission), and law enforcement agencies (e.g., Federal Bureau of Investigation, U.S. Secret Service). Through these relationships, the FSSCC directly assists the sector's response to natural disasters, threats from terrorists, and cybersecurity issues of all types.

3.3.2 Financial Services – Information Sharing and Analysis Center (FS-ISAC)

The Financial Services Information Sharing and Analysis Center (FS-ISAC) is a non-profit corporation that was established in 1999 and is funded by its member firms and sponsors. The FS-ISAC has about 7,000 members worldwide representing all types of financial services firms (e.g., banks, credit unions, securities firms, insurance companies, payments companies, exchanges, associations). The FS-ISAC is a member-driven organization whose mission is to help assure the resilience and continuity of the global financial services infrastructure and individual firms against acts that could significantly impact the sector's ability to provide services critical to the orderly function of the global economy. FS-ISAC shares threat and vulnerability information; conducts coordinated contingency planning exercises; manages rapid response communications for both cyber and physical events; conducts education and training programs; and fosters collaborations with and among other key sectors and government agencies.

The FS-ISAC launched the Global Resilience Federation (GRF) in May 2017 as an intelligence provider and cross sector sharing hub for cyber and physical threat information among not-for-profit organizations (i.e., Information Sharing and Analysis Centers [ISACs], Information Sharing and Analysis Organizations [ISAOs], and Computer Emergency Readiness Teams [CERTs]) from many different sectors around the world. Prior to May 2017, the FS-ISAC's Sector Services division supported the creation, operation, and growth of information sharing communities of interest and to provide a foundation of sophisticated cross-sector sharing and collaboration. GRF is an evolution of Sector Services, leveraging 18 years of information sharing expertise to create new efficiencies and intelligence that can be used both within and across sectors. GRF helps to assure the resilience and continuity of vital infrastructure and individual organizations against threats and acts that could significantly impact individual organizations and various sectors' ability to provide services critical to the orderly functioning of the global economy. Members of GRF include FS-ISAC, Legal Services Information Sharing and Analysis Organization (LS-ISAO), Energy Analytic Security Exchange (EASE), National Health ISAC (NH-ISAC), and Oil and Natural Gas ISAC (ONG-ISAC).

The FS-ISAC also has two limited liability companies with independent boards that also play significant roles in enhancing the financial sector's security and resiliency. These two companies are Sheltered Harbor and Financial Systemic Analysis and Resilience Center.

3.3.2.1 Sheltered Harbor

Sheltered Harbor was established in 2016 to enhance the financial services industry's resiliency capability in the event of a major disaster event. The concept for Sheltered Harbor arose during a series of successful cybersecurity simulation exercises between public and private sectors known as the "Hamilton Series" in 2015. Sheltered Harbor is based on standards and the concept of mutual assistance. Should a financial institution be unable to recover from a cyber-attack in a timely fashion, firms that adhere to the Sheltered Harbor standards will enable customers to access their accounts and balances from another service provider or financial institution. Sheltered Harbor members access specifications for common data formats, secure storage ("data vaults") and operating processes to store and restore data, and receive a Sheltered Harbor acknowledgement of adherence to the specification.

3.3.2.2 Financial Systemic Analysis and Resilience Center (FSARC)

The Financial Systemic Analysis and Resilience Center (FSARC) was established in 2016 after the chief executive officers (CEOs) of eight banks – Bank of America, BNY Mellon, Citigroup, Goldman Sachs, JPMorgan Chase, Morgan Stanley, State Street, and Wells Fargo – came together to proactively identify ways to enhance the resilience of the critical infrastructure underpinning much of the U.S. financial system. As of February 2018, the FSARC has expanded to include the eight SIFMUs listed in Section 3.2.3 for a total of 16 member organizations. FSARC membership is limited to those financial institutions designated by the U.S. government as "critical infrastructure" under Section 9 of Executive Order 13636 (February 2013).

The FSARC's mission is to proactively identify, analyze, assess, and coordinate activities to mitigate systemic risk to the U.S. financial system from current and emerging cybersecurity threats through focused operations and enhanced collaboration between participating firms, industry partners, and the U.S. government, including the Department of Treasury, the Department of Homeland Security and the Federal Bureau of Investigation. The FSARC expects its efforts and activities to benefit the broader FS-ISAC membership and the FSS.

3.3.3 Financial and Banking Information Infrastructure Committee (FBIIC)

In the wake of the attacks on September 11, 2001, the Financial and Banking Information Infrastructure Committee (FBIIC) was created to address three focus areas:

- Improving coordination and communication among financial regulators;
- Enhancing the resiliency of the financial sector; and
- Promoting public-private partnership.

Working with appropriate members of financial regulatory agencies, FBIIC coordinates efforts to improve the reliability and security of the financial sector infrastructure.

To fulfill its mission, FBIIC:

- Identifies critical infrastructure assets, along with their locations and potential vulnerabilities, and prioritizes their importance to the financial system of the United States;
- Establishes secure communications capability among the financial regulators and protocols for communicating during an emergency; and
- Ensures that sufficient staff at each member agency has appropriate security clearances to handle classified information and to coordinate in an emergency.

Of particular relevance to the NGCI Apex program, the FBIIC has partnered with the Department of Treasury to develop the Financial Sector Cyber Exercise Template. The Template is designed to aid smaller financial sector companies in strengthening their cybersecurity posture by providing a template for carrying out internal cybersecurity exercises. This exercise template is developed to assist companies who wish to use it in not only considering their own internal processes, but also discussing how they can most effectively engage with the national architecture for coordinating response to significant cybersecurity incidents among government and industry.

3.4 Trade Associations / Industry Organizations

One trade association, namely the Securities Industry and Financial Markets Association, has previously participated in the CART. Other candidate organizations which could provide valuable perspectives to the NGCI Apex program include the American Bankers Association, the Financial Services Roundtable, and Global Association of Risk Professionals.

3.4.1 Securities Industry and Financial Markets Association (SIFMA)

Formed in 2006, the Securities Industry and Financial Markets Association (SIFMA) is an association representing hundreds of U.S. banks, broker-dealers, and asset managers. SIFMA is also the U.S. affiliate of the Global Financial Markets Association. With offices in New York, NY, and Washington, DC, SIFMA provides a forum for the shared interests of financial industry participants and represents the financial industry to policymakers, regulators, and the public. To date, SIFMA is the only financial trade association to engage with the NGCI Apex program.

3.5 Regulators

As a direct result of the complex ecosystem that is the FSS, a wide array of federal regulators exists to provide oversight and supervision of various elements of the FSS. As noted in Section 3.1, the respective regulators align to products and services rather than specific FSS institutions (i.e., any one institution may provide many products and services). Therefore, we present a top-down perspective of the regulatory ecosystem, beginning with the Financial Stability Oversight Council (FSOC) and its components.

3.5.1 Financial Stability Oversight Council (FSOC)

In response to the financial crisis that began in 2007, the FSOC was formed as part of the Dodd-Frank Act of 2010. The council aims to promote market discipline and bring greater efficiency and transparency to the financial services industry. Chaired by the U.S. Treasury Secretary, the FSOC is the overarching body charged with monitoring the financial system, including identifying potential threats to the country's financial stability. The FSOC is composed of 10 voting and five non-voting members.

The 10 voting members of the FSOC are:

- Secretary of the Treasury (chairs the FSOC)
- Chairman of the Federal Reserve
- Comptroller of the Currency
- Director of the Consumer Financial Protection Bureau
- Chairman of the U.S. Securities and Exchange Commission
- Chairman of the Federal Deposit Insurance Corporation
- Chairman of the Commodity Futures Trading Commission
- Director of the Federal Housing Finance Agency
- Chairman of the National Credit Union Administration Board

- Independent member (with insurance expertise), appointed by the President

The five non-voting members of the FSOC are:

- Director of Treasury's Office of Financial Research
- Director of Treasury's Federal Insurance Office
- State insurance commissioner
- State banking supervisor
- State securities commissioner

3.5.2 Treasury

Established in 1789, the Department of the Treasury is an executive department and administered by the Secretary of the Treasury, a member of the cabinet. The many responsibilities of the Treasury include producing currency and coinage, collecting taxes and paying bills of the U.S. government, managing the federal finances, supervising banks and thrifts, and advising on fiscal policy.

3.5.2.1 Treasury's Office of Financial Research (OFR)

Established in 2010, the Office of Financial Research (OFR) is an independent bureau within the U.S. Department of the Treasury. As part of the Dodd–Frank Wall Street Reform and Consumer Protection Act, OFR was chartered in response to the financial crisis of 2007-2008 and the subsequent Great Recession. The OFR is tasked with providing administrative, technical, budget analysis, and other support services to the FSOC and its affiliated agencies.

3.5.2.2 Office of the Comptroller of the Currency (OCC)

Like the OFR, the Office of the Comptroller of the Currency (OCC) is an independent bureau within the Department of Treasury. Its mission is to "ensure that national banks and federal savings associations operate in a safe and sound manner, provide fair access to financial services, treat customers fairly, and comply with applicable laws and regulations." The OCC is the U.S. federal agency that serves to charter, regulate and supervise the national banks and the federal branches and agencies of foreign banks. The OCC is headed by the Comptroller of the Currency, who is appointed by the president and approved by the Senate.

Founded through the National Currency Act of 1863, the OCC monitors banks to ensure they are operating safely and meeting all requirements. In particular, the OCC monitors capital, asset quality, management, earnings, liquidity, sensitivity to market risk, information technology, compliance, and community reinvestment.

3.5.2.3 Treasury's Office of Critical Infrastructure Protection and Compliance Policy

The Office of Critical Infrastructure Protection and Compliance Policy coordinates the Treasury's efforts to enhance the security and resilience of the financial services sector critical infrastructure and reduce operational risk. The Office works closely with financial sector companies, industry groups, and government partners to share information about cybersecurity and physical threats and vulnerabilities, encourage the use of baseline protections and best

practices, and respond to and recover from significant incidents. Of note, the Office has partnered with DHS S&T to serve as the federal sponsor of the NGCI Apex program.

3.5.3 Federal Reserve Board (FRB)

The Board of Governors of the Federal Reserve System, colloquially referred to as the Federal Reserve Board (FRB), is a seven-member body that governs the Federal Reserve System - the U.S. central bank in charge of making the country's monetary policy.

The FRB is considered an independent agency of the federal government. The FRB has a statutory mandate to maximum employment and stable prices at moderate long-term interest rates, and the FRB chair and other officials frequently testify before Congress, but it makes monetary policy independently of the legislative or executive branches and is structured like a private corporation.

3.5.4 Federal Deposit Insurance Corporation (FDIC)

Established in 1933, the Federal Deposit Insurance Corporation (FDIC) is the U.S. corporation insuring deposits in the United States against bank failure. The FDIC was created during the Great Depression to maintain public confidence and encourage stability in the financial system through the promotion of sound banking practices. As of 2016, the FDIC insures deposits of up to $250,000 per institution, if the bank is a member firm.

3.5.5 National Credit Union Administration (NCUA)

The National Credit Union Administration (NCUA) is the independent federal agency created by the U.S. Congress to regulate, charter, and supervise federal credit unions. With the backing of the full faith and credit of the U.S. government, NCUA operates and manages the National Credit Union Share Insurance Fund, insuring the deposits of nearly 105 million account holders in all federal credit unions and most of state-chartered credit unions. As of September 2016, there were 5,844 federally insured credit unions, with assets totaling more than $1.3 trillion, and net loans of $847.1 billion.

3.5.6 Securities and Exchange Commission (SEC)

Established in 1934 as the first federal regulator of securities markets, the U.S. Securities and Exchange Commission (SEC) is an independent, federal government agency responsible for protecting investors, maintaining fair and orderly functioning of securities markets, and facilitating capital formation. The SEC promotes full public disclosure, protects investors against fraudulent and manipulative practices in the market, and monitors corporate takeover actions in the United States.

The SEC's primary function is to oversee organizations and individuals in the securities markets, including securities exchanges, brokerage firms, dealers, investment advisors, and various investment funds. Through established securities rules and regulations, the SEC promotes disclosure and sharing of market-related information, fair dealing, and protection against fraud. It provides investors with access to registration statements, periodic financial reports, and other securities forms through its comprehensive electronic, data gathering, analysis, and retrieval (EDGAR) database.

3.5.7 Commodity Futures Trading Commission (CFTC)

Established in 1974, Commodity Futures Trading Commission (CFTC) is an independent U.S. federal agency. The CFTC regulates the commodity futures and options markets. Its goals include the promotion of competitive and efficient futures markets and the protection of investors against manipulation, abusive trade practices and fraud.

The CFTC has five committees, each headed by a commissioner, who is appointed by the president and approved by the Senate. These five committees focus on agriculture, global markets, energy and environmental markets, technology, and cooperation between the CFTC and SEC. The committees are populated by individuals who represent the interests of specific industries, traders, futures exchanges, commodities exchanges, consumers, and the environment.

3.5.8 Financial Industry Regulatory Authority (FINRA)

Established in 2007, Financial Industry Regulatory Authority (FINRA) is the largest independent, regulatory body for securities firms operating in the United States. While FINRA's overriding task is to protect investors by ensuring that the U.S. securities industry operates in an honest and fair manner, FINRA must deal with thousands of smaller tasks on a regular basis to make this happen.

FINRA operates from headquarters in Washington, D.C. and New York, NY and from 20 regional offices throughout the United States. In addition to overseeing all securities firms, FINRA oversees all firms that offer professional training, testing, and licensing of registered brokers. It also is in charge of monitoring arbitration and market regulation by contract for the New York Stock Exchange (NYSE), the NASDAQ stock market, the American Stock Exchange LLC, and the International Securities Exchange LLC. FINRA provides regulatory oversight to industry utilities, such as trade reporting facilities and over-the-counter (OTC) operations.

4 Representative set of maps of the financial system

Having characterized the various components of the financial system, it becomes imperative to depict how these components interrelate to comprise the financial ecosystem, hence, the purpose of this mapping of the financial system and this report. Below, HSSEDI presents a representative set of three existing maps of the financial system. The three maps represent a "Goldilocks" approach for the NGCI Apex program: the first is simply "Too Big" and detailed, while the second is "Too Dense," while the third likely "Just Right" in its depiction of the interdependent nature of the financial system.

4.1 Federal Reserve Board's map of the banking system

As depicted in Figure 1, this map from the FRB highlights the central role of financial intermediation and its rise over the past 30 years. This map emphasizes a particular type of financial intermediation, namely "shadow banks." Shadow banks are "financial intermediaries that conduct maturity, credit, and liquidity transformation without access to central bank liquidity or public-sector credit guarantees" (Pozsar et al, 2010, p. 1). And in this FRB report, these researchers note that shadow banks became severely strained during the financial crisis. This map relies on the foundational aspects of balance sheets and counter-party risks, thereby depicting aspects of the FSS interdependence of relevance to the NGCI Apex program. But it lacks resolution of other aspects of the FSS, namely the investment products. HSSEDI assessed that it is simply "Too Big" to be of significant relevance to the NGCI Apex program.

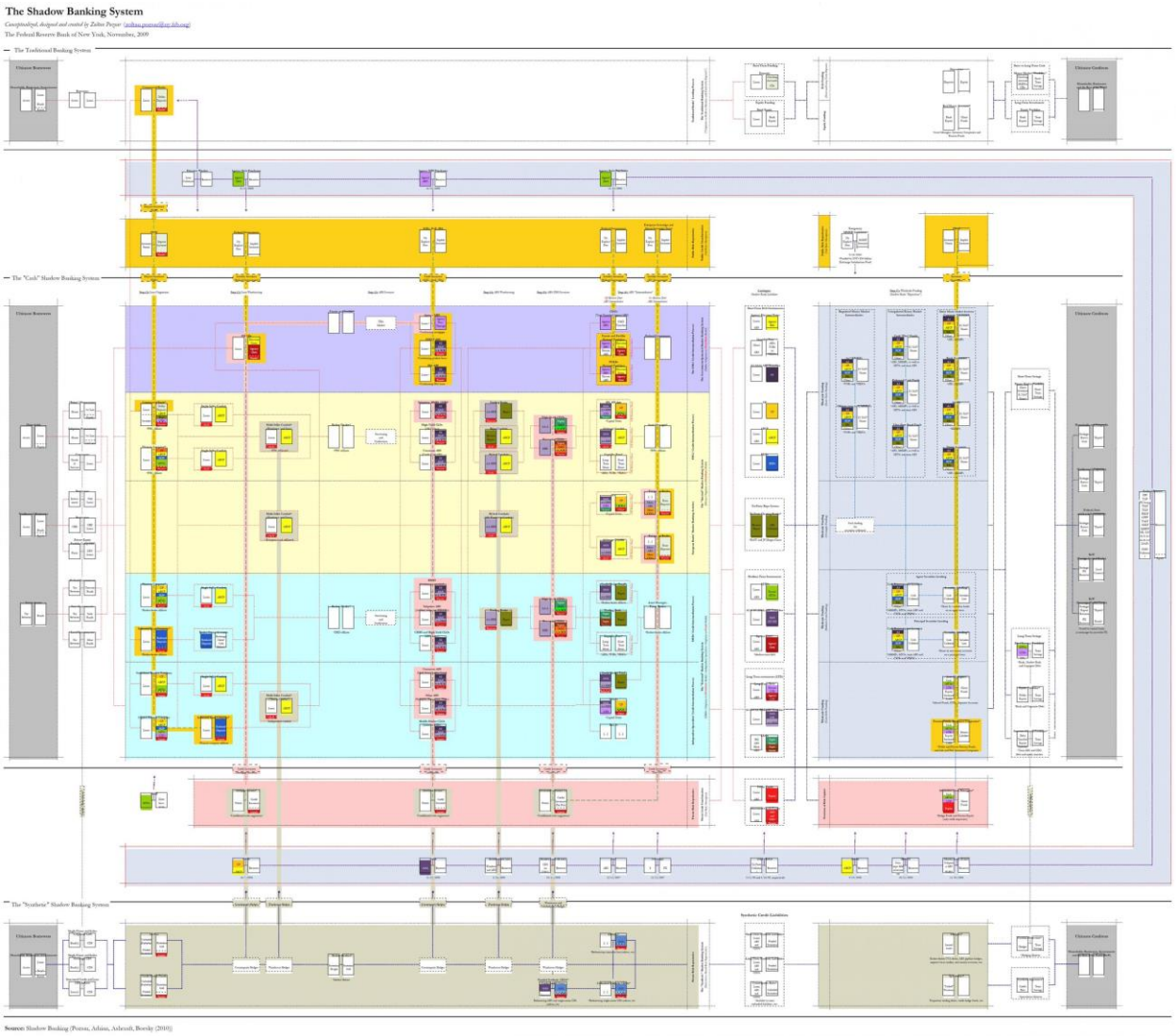

Figure 1. FRB map of the shadow banking system

Source: Pozsar et al (2010, p. 4).

4.2 Bank of England map of United Kingdom's financial system

The Bank of England is analogous to the FRB here in the U.S., and like the FRB, the Bank of England has related interests to understand the structure of its financial system. The Bank of England adopted a similar approach as that of the FRB above, relying on balance sheets to depict interdependence between counterparties across its financial system, as depicted in Figure 2 (Burrows et al, 2015, p. 126).

HSSEDI concurs with this approach. Depicting the financial system as a series of interconnected balance sheets is a useful framework, both for reflecting the interdependence of the financial system as well as informing macroprudential analysis. Despite these advantages, HSSEDI assessed this map as "Too Dense" to be of significant utility to the NGCI Apex program.

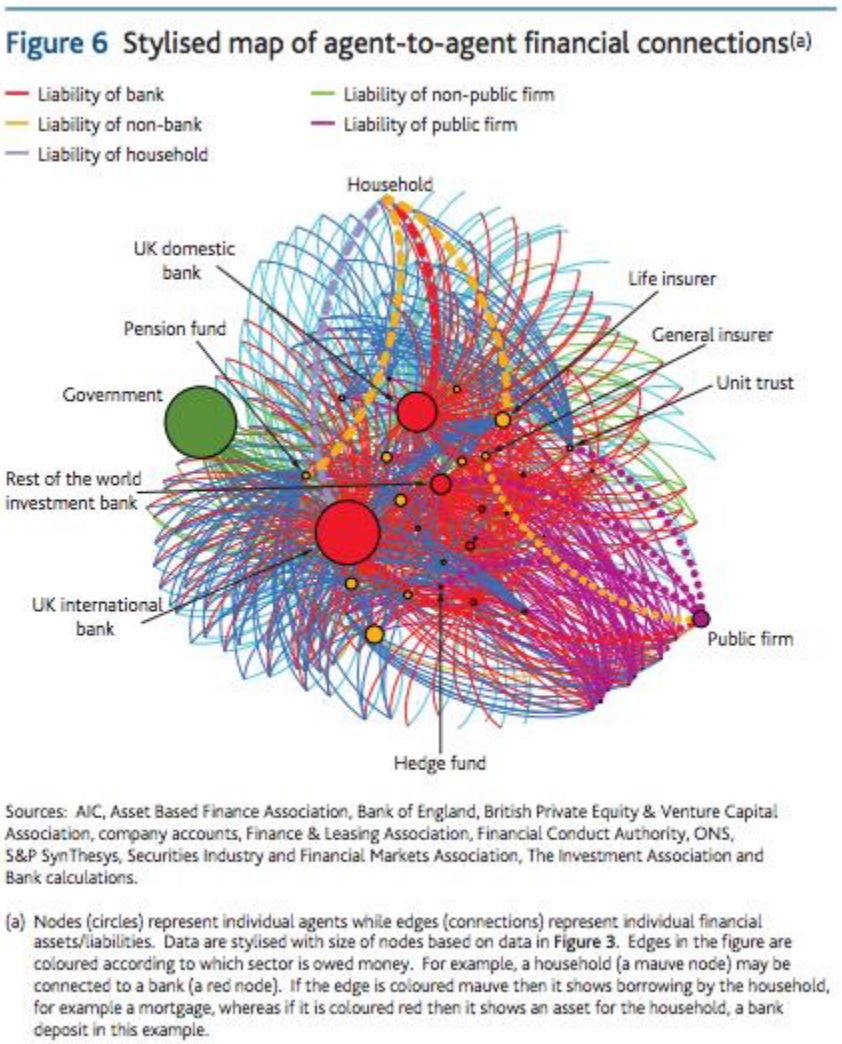

Figure 2. Bank of England map of the United Kingdom's financial system

Source: Burrows, O., et al. (2015, p. 126).

4.3 Series of maps from Treasury's Office of Financial Research

Extending beyond the useful approaches of the FRB and Bank of England to map their respective financial systems, HSSEDI recommends a cumulative approach to mapping the financials system undertaken by researchers from Treasury's OFR. Similar to the FRB map above, this cumulative approach begins with a map of an essential financial intermediary, namely a bank / dealer. The OFR researchers then place the bank / dealer within the interdependent context of the FSS. The bank / dealer is situated in the map, not only based on the products and services that it provides to other FSS institutions, but also due to the flow of products and services upon which the bank / dealer relies. Lastly, the OFR researchers map these products and services to the cognizant regulators.

4.3.1 Map of bank / dealers as financial intermediaries

Similar to the approach undertaken by the FRB researchers, the researchers from Treasury's OFR highlight the importance of financial intermediaries, namely bank / dealers, to reflect the interdependent nature of the financial system. In Figure 3, the bank / dealer serves as the intermediary between asset markets and investors, enabling flows of funds as well as requisite collateral (Bookstaber, Paddrik and Tivnan, 2017, p. 9).

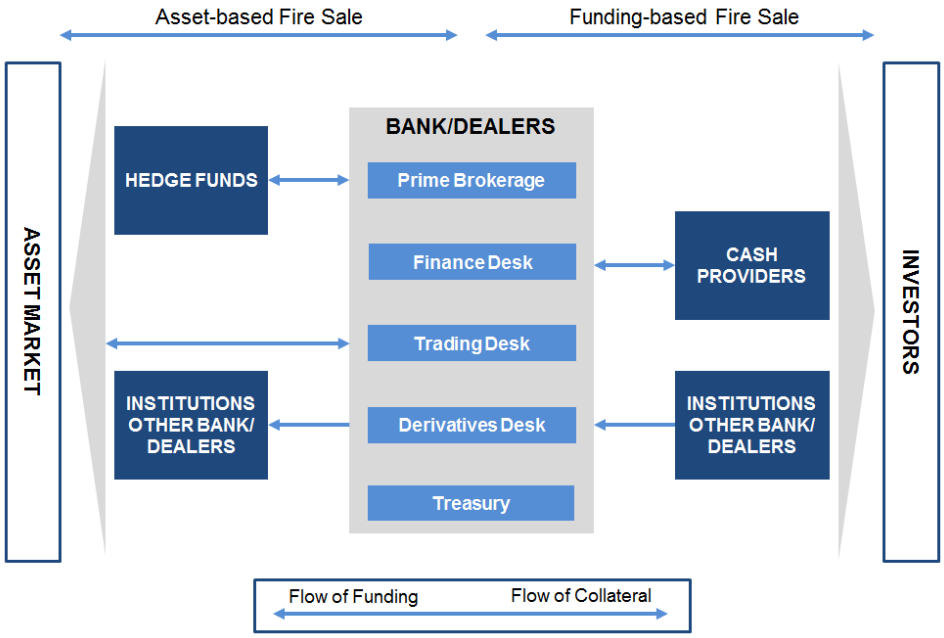

Figure 3. Treasury's map of a bank / dealer

Source: Bookstaber, Paddrik and Tivnan (2017, p. 9)

4.3.2 Multi-layered map of the financial system

Building upon the above map of the bank / dealer, researchers from Treasury's OFR developed Figure 4, a multi-layered map of the financial system (Bookstaber and Kenett, 2016, p. 7). HSSEDI recommends this map of the financial system for the following reasons:

- Map depicts the major sub-sectors and their interactions
- Layered depiction
  - A single institution may participate in more than one financial activity, a graphical reflection of the scenarios described in the Financial Services Sector-Specific Plan as discussed above in Section 3.1
  - Pathways for risk to pass from one financial activity to another (i.e., interdependence)
- While stylized, the map depicts the cyber pathways which provide connectivity between FSS institutions.

Figure 5. Three-dimensional Multilayer Network

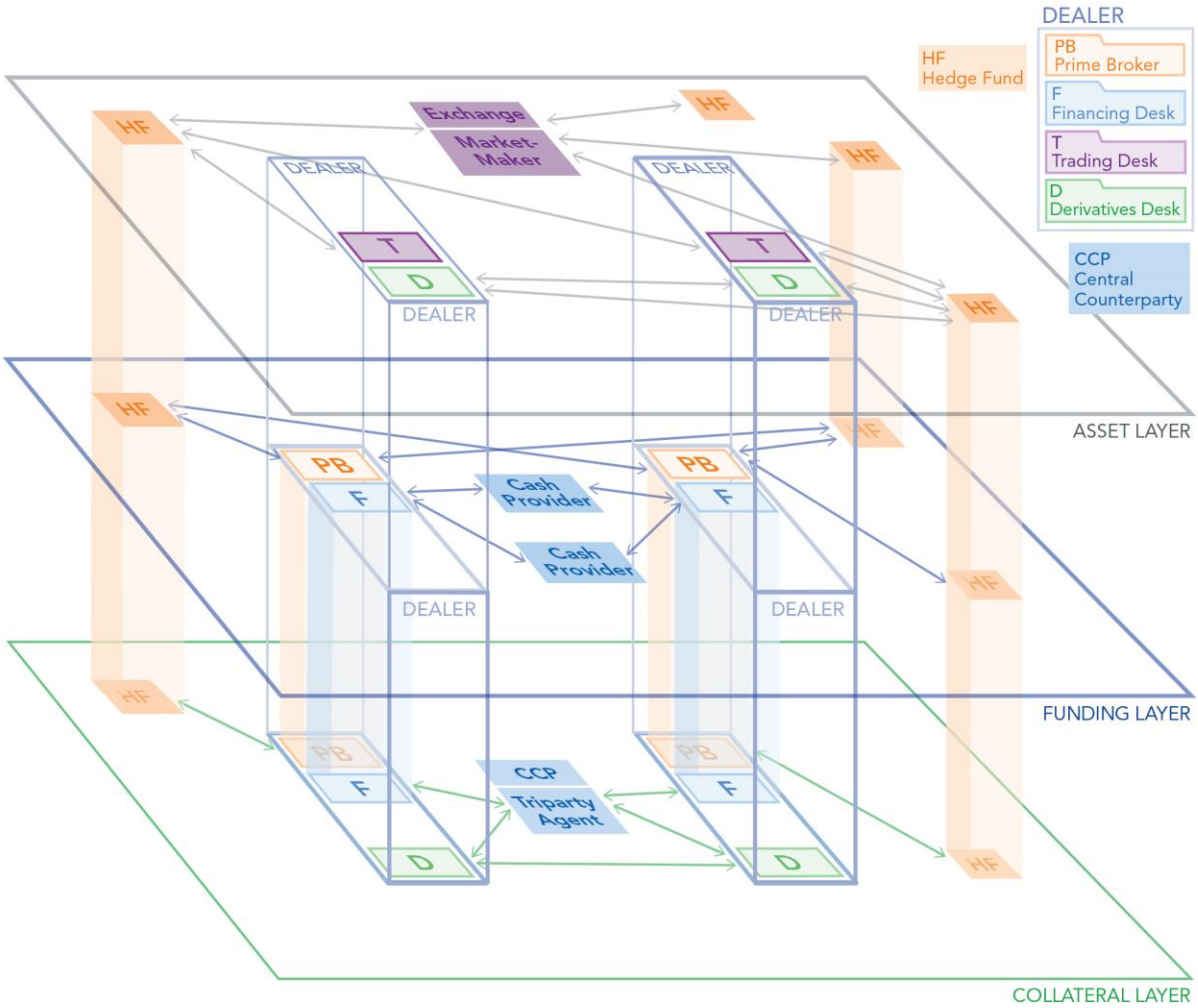

Figure 4. Treasury's multi-layered map of the financial system

Source: Bookstaber and Kennett (2016, p. 7)

4.3.3 Mapping the regulators to their respective products and services

Completing this cumulative approach to mapping the ecosystem of the financial system, in Figure 5, researchers from Treasury's OFR also mapped the regulators to their cognizant products and services (Bookstaber and Kenett, 2016, p. 11). With this third map in the set, Treasury's OFR has provided the NGCI Apex program a useful depiction of the financial ecosystem.

Figure 7. Financial Participants in a Multilayer Network

	Agent	Network Node		Network Function			Primary Regulator
		Core Node	Peripheral Node	Supplier	Intermediary	User	
ASSET LAYER	Hedge Funds		X	X		X	SEC, CFTC
	Bank/Dealer Trading Desk	X			X		OCC, FED, SEC
	Bank/Dealer Derivatives Desk	X			X		OCC, SEC
	Exchanges and Market-Makers	X			X		SEC, CFTC, SRO
FUNDING LAYER	Hedge Funds		X			X	SEC, CFTC
	Cash Providers (pension funds, insurance companies)		X	X			U.S. Department of Labor, state insurance regulators, FIO
	Bank/Dealer Financing Desk	X			X		OCC, FED
	Bank/Dealer Prime Brokerage	X			X		SEC
COLLATERAL LAYER	Hedge Funds		X			X	SEC, CFTC
	Cash Providers (pension funds, insurance companies)		X	X			U.S. Department of Labor, state insurance regulators, FIO
	Bank/Dealer Derivatives Desk		X	X		X	CFTC
	Bank/Dealer Financing Desk	X		X		X	OCC, FED
	Central Counterparties (CCPs)	X			X		SEC, CFTC, FED
	Triparty Repo Agents	X			X		FED

CFTC = Commodity Futures Trading Commission, FED = Federal Reserve, FIO = Federal Insurance Office, OCC = Office of the Comptroller of the Currency, SEC = Securities and Exchange Commission, SRO = self-regulatory organizations

Figure 5. Treasury's mapping of regulators to products and services

Source: Bookstaber and Kennett (2016, p. 11)

5 Illustrative example using Treasury's map

While this cumulative set of maps is informative, an illustrative example will reinforce its relevance and usefulness to the NGCI Apex program. The example relies on Bear Stearns, not only because it was actively involved in all three layers of the map but because Bear Steans played a central role in the Financial Crisis of 2007-2008.

5.1 Overview of Bear Stearns and the Financial Crisis of 2007-2008

In the run up to the crisis, Bear Stearns depended heavily on short-term funding to support its highly leveraged positions. In 2006, Bear Stearns managed two large hedge funds, the High-Grade Structured Credit Strategies Fund and the High-Grade Structured Credit Strategies Enhanced Leverage Fund. Each of these hedge funds was heavily leveraged, therefore relying on significant loans from several large investment banks. Yet, the investment banks lending to the two hedge funds through their prime brokers were often the same banks selling risky securities to the Bear Stearns' hedge funds via their respective trading desks.

While exchanges (e.g., New York Stock Exchange and NASDAQ) exist for trading equities and commodities, other assets (e.g., foreign exchange rates and credit instruments) rely on the trading desks of bank / dealers such as Bear Stearns. So, as Bear Stearns' two hedge funds faced default, they placed added pressure on Bear Stearns, the parent company. But because of the interdependence of the financial system and its central role in the overall system, Bear Stearns served as a conduit for financial contagion throughout much of the financial system.

5.2 Bear Stearns in the Multi-layered Map

In Figure 6, researchers from Treasury's OFR used the map to provide a graphical depiction of the above series of events for Bear Stearns.

Figure 6. Bear Stearns: A Case Study of Financial Contagion

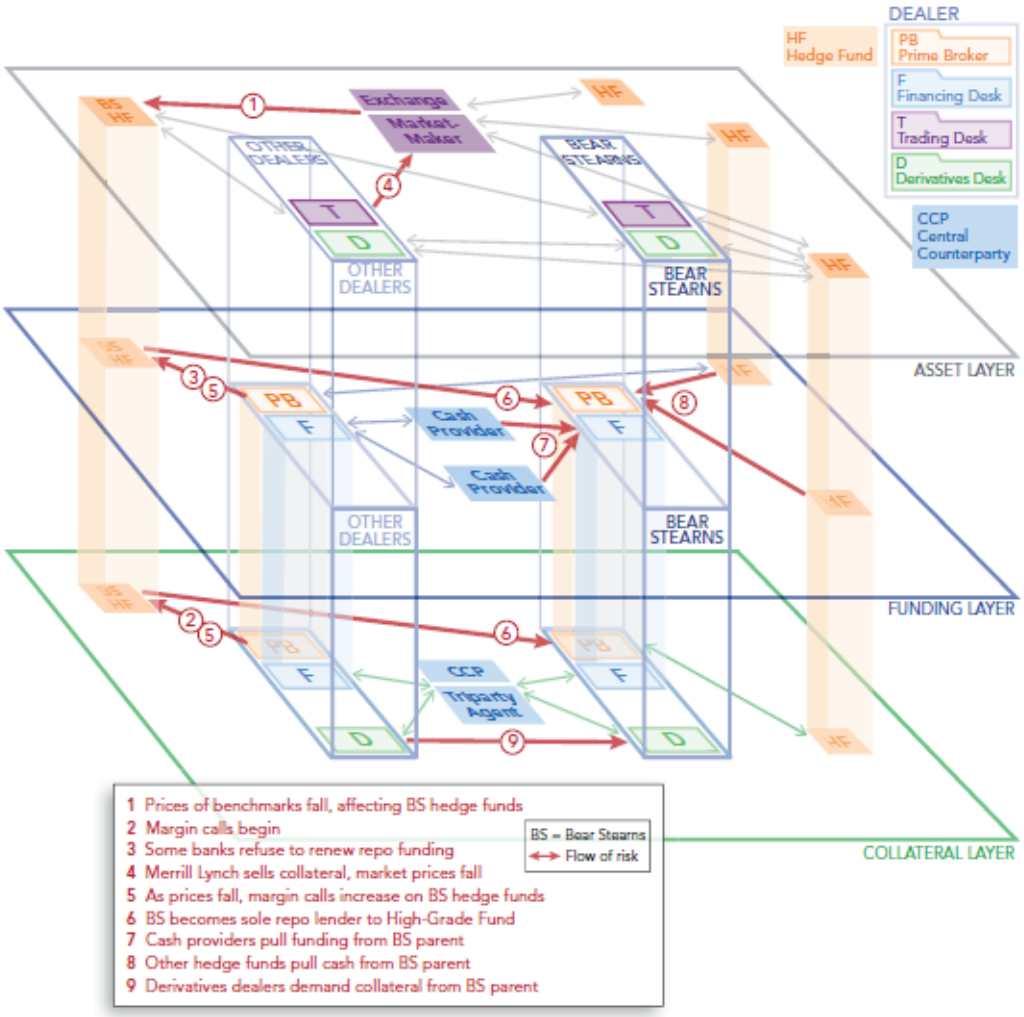

Figure 6. Illustrative example of multi-layered map with Bear Stearns

Source: Bookstaber and Kennett (2016, p. 9)

6 Conclusions

In the preceding sections, HSSEDI provides a general definition of interdependence. We focus the survey of existing maps to those with the intended purpose of explicating the intrinsic interdependence of the FSS, and then focus further still with an emphasis on maps that can make significant contributions to the NGCI Apex program. We complete this analysis of existing maps of the financial system with the identification and assessment of a cumulative set of maps from Treasury's OFR. This set of maps represents the interdependence of the financial system comprehensively while also depicting the various elements emphasized in the Financial Services Sector-Specific Plan. HSSEDI reinforces the relevance of this set of maps with an illustrative example of Bears Stearns and its series of events in the Financial Crisis of 2007-2008.

Finally, HSSEDI concludes this report with a set of four recommendations for the NGCI Apex program.

- HSSEDI recommends that the NGCI Apex program use these maps to illustrate the interdependence of the financial system, thereby reinforcing the value proposition of the Apex program – namely, that cybersecurity risks to the FSS exceed the scope and resources of any one FSS institution to address alone.
- HSSEDI recommends that the NGCI Apex program use this report to assess the breadth of FSS institutions represented on the CART, and as necessary, use Treasury's map to identify potential CART representatives to address any shortfalls.
- HSSEDI recommends that the NGCI Apex program use the identified maps to assess the impacts of the program. The maps can guide the program to ensure that its efforts are comprehensive and reflective of the breadth and complexity of the FSS, from its stakeholder analyses to its test plans to its mitigations of systemic, cybersecurity risk.
- HSSEDI recommends that the NGCI Apex program undertake a similar mapping exercise for the next Critical Infrastructure to be addressed by the program. As identified in a previous HSSEDI study in support of the iCAPS program for DHS S&T, the FSS has significant interdependencies with other Critical Infrastructures, namely the Communications and Energy sectors. Both sectors would serve as logical considerations for extending the NGCI Apex program beyond the FSS.

List of Acronyms

Acronym	Definition
CART	Cyber Apex Review Team
CEO	Chief Executive Officer
CERT	Computer Emergency Readiness Team
CFTC	Commodity Futures Trading Commission
CHIPS	Clearing House Interbank Payments System
DHS	Department of Homeland Security
DTCC	Depository Trust & Clearing Corporation
EASE	Energy Analytic Security Exchange
EDGAR	Electronic, Data Gathering, Analysis and Retrieval
FBIIC	Financial and Banking Information Infrastructure Committee
FDIC	Federal Deposit Insurance Corporation
FFRDC	Federally Funded Research and Development Center
FINRA	Financial Industry Regulatory Authority
FRB	Federal Reserve Board
FSARC	Financial Systemic Analysis & Resilience Center
FS-ISAC	Financial Services – Information Sharing and Analysis Center
FSOC	Financial Stability Oversight Council
FSS	Financial Services Sector
FSSCC	Financial Services Sector Coordinating Council
GRF	Global Resilience Federation
G-SIB	Globally, Systemically Important Bank
HSSEDI	Homeland Security Systems Engineering & Development Institute
iCAPS	Interdependence of Cyber-Physical Systems
ICE	Intercontinental Exchange
ISAC	Information Sharing and Analysis Center

Acronym	Definition
ISAO	Information Sharing and Analysis Organization
LS-ISAO	Legal Services Information Sharing and Analysis Organization
NCUA	National Credit Union Administration
NGCI	Next Generation Cyber Infrastructure
NH-ISAC	National Health – Information Sharing and Analysis Center
NYSE	New York Stock Exchange
OCC	Office of the Comptroller of the Currency
OFR	Office of Financial Research
ONG-ISAC	Oil and Natural Gas - Information Sharing and Analysis Center
OTC	Over-the-Counter
PPP	Public-Private Partnership
S&T	Science and Technology Directorate
SEC	Securities and Exchange Commission
SIFI	Systemically Important Financial Institution
SIFMA	Securities Industry and Financial Markets Association
SIFMU	Systemically Important Financial Market Utility
SME	Subject Matter Expert

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