



Economic Letter

Global Interfirm Network Reveals Centrality of U.S. and Financial Sector

by Everett Grant and Julieta Yung

ABSTRACT: The global interfirm network indicates the level of integration among firms across industries and regions, which intensified with globalization in recent decades. While there is evidence of direct contagion passing between firms in the network, there are also indications that connectedness plays a role in a reduced likelihood of firm distress and improved performance.

Integration across firms—including greater international connectivity—has increased over the past three decades.

While the unprecedented worldwide global financial crisis highlighted the extent of connectedness, its implications beyond crises and recessions have fostered a renewed interest in understanding the transmission of shocks across countries and industries.

The global interfirm network reveals that firms are most connected with those in the same industry and country, and the U.S. and the financial sector are at the network's core. Further, the level of international connectedness has been especially high over the past decade.

These features are important considerations for policymakers and investors when evaluating possible global economic spillovers and the potentially reduced scope for international risk sharing and portfolio diversification.

Interfirm Connectedness

The exact level of integration between two firms is difficult to quantify because there are often simultaneous linkages across many different dimensions. Not only are interfirm connections difficult to aggregate into a single connectedness measure, but the task of collecting such granular data on even a

handful of firms is insurmountable, let alone doing it in real time.

In an attempt to overcome this challenge, an interfirm network is constructed based on daily equity returns data. The procedure exploits equity market efficiency and the idea that large, actively traded and broadly followed firms' equity prices reflect all available information about them, including proximity via various channels.

For example, consider a firm that outsources work to another. A negative shock to the client firm is passed on to the service provider and is ultimately reflected by declining equity prices for both entities.

These connections can be local or span the globe. Following the March 11, 2011, earthquake and tsunami in Japan, the local Hitachi engine factory that manufactured 60 percent of global car engine airflow sensors shut down. With most major automobile manufacturers utilizing just-in-time global supply chains, this single closure amplified the disruption caused by the natural disaster. Not only did many Japanese automotive factories close, but several German, Spanish and American plants did as well.¹

The challenges of estimating the global interfirm network stem from complications due to the large number of

firms that need to be included to have a representative depiction. In this exercise, equity returns data for hundreds of firms around the world are collected. State-of-the-art machine learning techniques—in particular, methods applicable with very large data sets—are used to systematically select significant bilateral firm connections and estimate the degree of integration among firms.²

In these networks, connections are based on estimates of the degree to which the daily equity return of one firm predicts the next day's equity return for another firm. The connections run in each direction between two firms and need not be symmetric. This methodology only relies on the equity returns, so it can be performed in real time and avoids the need to make assumptions on how each particular firm relates to the hundreds of other firms in the network.

Centrality of U.S. Firms

Spring plots, a graphic technique borrowed from physics for picturing large systems of interacting agents, help visualize the network. In these plots, each firm is represented by a node, or dot. Its proximity to other nodes indicates how connected firms are with one another. Highly connected firms are pulled toward each other by the larger connec-

tion weights between them, as well as potentially being attracted by their connections with shared neighboring firms.

For example, two petroleum refiners might not be closely connected with one another in the network by their direct linkages; however, if they are both strongly connected with a single oil extraction firm, they would end up near each other on the map.

Chart 1 depicts the distribution of 382 large firms that were continuously traded from 1991 through 2016 and in the top 1 percent of all global firms by market capitalization for at least one year—an interfirm global network. A node's color indicates the currency of issuance for its primary equity, a proxy for the firm's geographic region.

Regional groupings are clearly organized in concentric circles, with a central cluster consisting of the U.S., followed by the eurozone, the U.K., other advanced European countries and Canada. The proximity of firms across these regions suggests that geographic borders are not a strong delimiting factor when it comes to interfirm connectedness.³ Shocks that affect any of these highly integrated firms are likely to be reflected in equity return responses of all of the nearby firms in the figure, regardless of where a company's headquarters is located.

On the network periphery are Australian and Asian firms. These companies tend to be less sensitive to the types of shocks that would generate large movements in the equity returns of those in the core.

Centrality of Financial Firms

Firms not only differ in their currency of equity issuance but also in the types of goods and services they produce. Therefore, each node of the network is classified by industry instead of region to examine the relationships among them (*Chart 2*). Each firm is in the same location as in Chart 1. The industry-based node colors reveal a very different pattern of how firms cluster in the network.

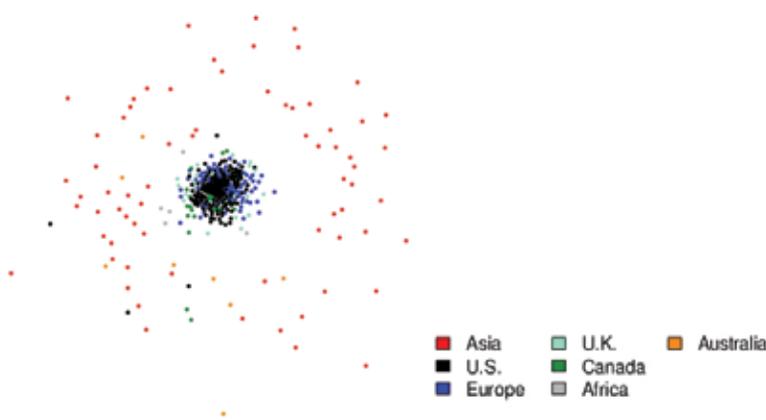
Firms within the same industry tend to group together in a roughly pie-slice-shaped pattern. Financial and industrial diversified firms are at the center of the map, revealing that they are the most integrated firms, not only with one another but also with firms in other industries. Firms in the information, communication and technology sector are at the top right, followed by consumer noncyclical, utility, energy and base materials, and then consumer cyclical firms at the top.

Since the network shows clear (but different) grouping patterns by industry and locality, it is apparent that both dimensions play important roles in establishing the structure of the system. There appear to be both significant region- and industry-level shock propagation channels in the interfirm network.

Top Region-Industry Sectors

From the network plots, a handful of region-industry pairs appears to have outsized network impact. Table 1 sorts region-industry pairings by total connection weights across all firms. For example, the No. 1 pair, U.S.-finance, has a connectedness measure that is more than double the pair five slots down the list (U.S.-energy), which in turn has a connectedness measure that is more than double the pair five slots below it (euro area-consumer noncyclical). This ranking of integration by region and industry provides insight into how shocks affecting specific sectors in the economy may spread.

Chart 1 Companies Arrayed in Regional Concentric Circles



NOTES: Each colored dot represents a firm in a specific region. Plot covers 1991–2016. Firms in the same region tend to cluster together in concentric circles.

SOURCE: "The Double-Edged Sword of Global Integration: Robustness, Fragility & Contagion in the International Firm Network," by Everett Grant and Julieta Yung, Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute Working Paper no. 313, May 2017.

Global Network Evolution

The evolution of the network of 382 firms in Chart 2 can be separately estimated over subperiods (*Chart 3*). A distinct pattern of consolidation emerges over time, indicating that the high integration of firms is a relatively recent phenomenon.

There is evidence of a particularly large increase in agglomeration from 1997 to 2001 and 2002 to 2006, notably with European firms moving into the center, likely reflecting the adoption of the euro and its associated economic and political integration.

The 2007–11 subprime mortgage and eurozone debt crisis period brought together North American and European firms, but many Asian firms were far out on the network periphery and not as affected. Additionally, it is worth highlighting that over this crisis period, energy and base materials were at the center of the network rather than finance. Thus, finance’s positioning at the center of the long-term 1991–2016 network is not merely a result of the global financial crisis.

Measuring Systemic Risk

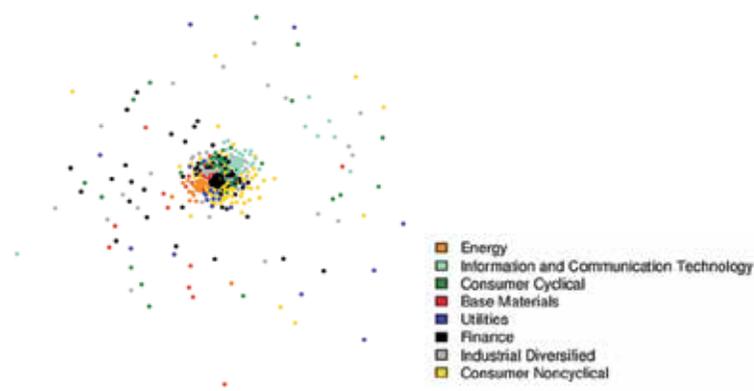
As the research on global networks develops, understanding how firms are connected across industries and countries is the first step toward measuring systemic risk and developing strategies to prevent widespread transmission of shocks.

There is evidence of direct contagion passing between neighboring firms in the network but also evidence that increased network connectedness corresponds with a reduced probability of firm distress and improved stock returns, lower credit spreads on corporate debt, higher profits and greater revenue growth.⁴

The informational content of movements in equity returns is a valuable proxy for investors’ wealth of knowledge about individual firms, which can be exploited as new machine learning and econometric techniques facilitate more rigorous statistical analysis on a large scale. Recent events have emphasized the significance of international developments and contagion, prompting policymakers, regulators and investors to take into account interfirm connections and the implications of global integration.

Chart
2

Classifying by Industry Creates Pie-Shaped Pattern



NOTES: Each colored dot represents a firm in a specific industry. Firms in the same industry tend to cluster together in a pie-slice pattern. Plot covers 1991–2016.

SOURCE: “The Double-Edged Sword of Global Integration: Robustness, Fragility & Contagion in the International Firm Network,” by Everett Grant and Julieta Yung, 2017 Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute Working Paper no. 313, May 2017.

Table
1

Top Region–Industry Pairs in the Global Network Dominated by U.S. and Finance

Rank	Region–Industry	Influence Measure	Rank	Region–Industry	Influence Measure
1	U.S.–finance	760.3	11	Euro area–consumer noncyclical	143.1
2	U.S.–consumer noncyclical	728.1	12	U.K.–finance	118.7
3	U.S.–inform., comm., tech.	622.8	13	Euro area–consumer cyclical	92.0
4	U.S.–industrial diversified	515.0	14	Euro area–industrial diversified	82.6
5	U.S.–consumer cyclical	445.4	15	Euro area–inform., comm., tech.	81.6
6	U.S.–energy	367.0	16	Canada–energy	80.7
7	Euro area–finance.	221.5	17	Switzerland–finance	78.8
8	U.S.–base materials	212.5	18	U.K.–consumer noncyclical	59.9
9	U.S.–utilities	190.0	19	Euro area–utilities	57.4
10	Canada–finance	147.8	20	Japan–consumer noncyclical	54.6

NOTES: The influence measure ranks region and industry pairs by the total sum of their connection weights relative to other firms. U.S. industries are highly connected, as represented by eight of the top 10 pairs. Finance is generally the most integrated industry across countries.

SOURCE: “The Double-Edged Sword of Global Integration: Robustness, Fragility & Contagion in the International Firm Network,” by Everett Grant and Julieta Yung, Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute Working Paper no. 313, May 2017.

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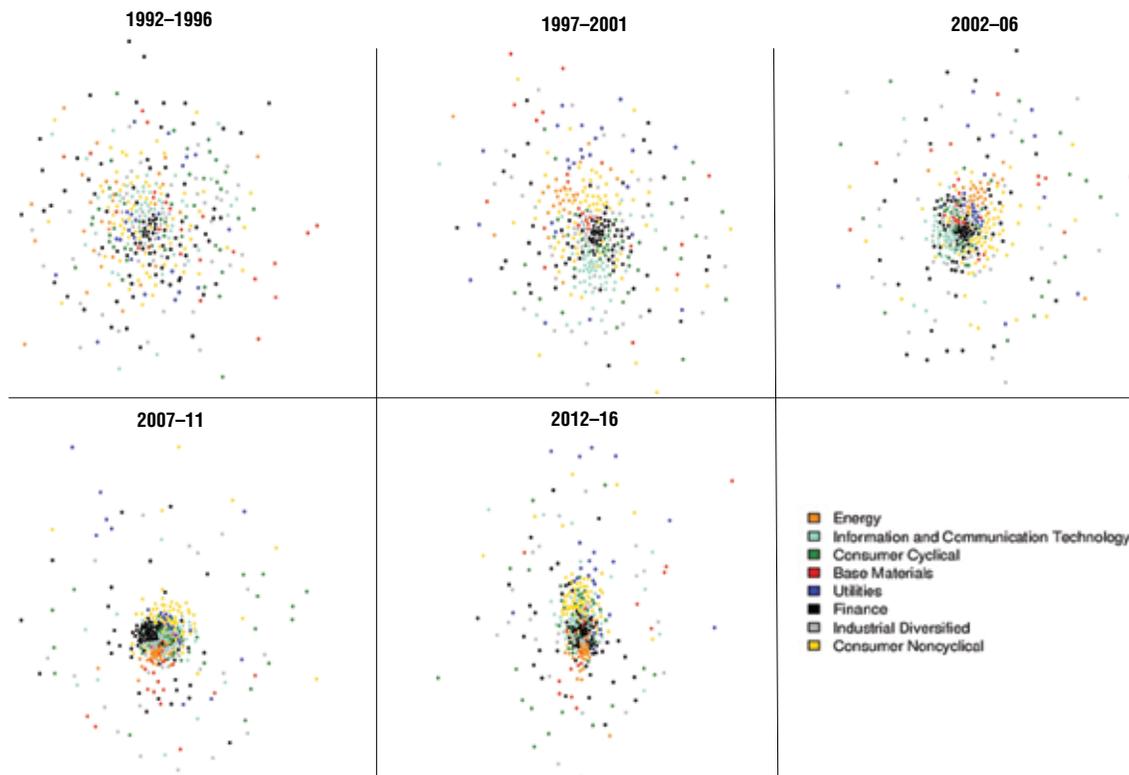
Notes

¹ See, for example, “Stress Test for the Global Supply Chain,” by Steve Lohr, *The New York Times*, March 11, 2011, www.nytimes.com/2011/03/20/business/20supply.html?pagewanted=all&mcubz=0 and “Toyota, Struggling with Part Shortages, to Restart Car Lines,” by Nick Bunkley and David Jolly, *New York Times*, March 24, 2011, www.nytimes.com/2011/03/25/business/global/25auto.html.

² For details on the estimation procedure refer to “The Double-Edged Sword of Global Integration: Robustness, Fragility & Contagion in the International Firm Network,” by Everett Grant and Julieta Yung, Federal Reserve Bank of

Chart 3

Global Network's Concentration Increases



NOTES: Each colored dot represents a firm in a specific industry during a five-year period. Firms have increasingly clustered toward the center over time.

SOURCE: "The Double-Edged Sword of Global Integration: Robustness, Fragility & Contagion in the International Firm Network," by Everett Grant and Julieta Yung, Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute Working Paper no. 313, May 2017.

Dallas Globalization and Monetary Policy Institute Working Paper no. 313, May 2017. This paper includes a summary of the literature on network estimation and a more in-depth investigation of the global interfirm network.

³ The finding that locality is a key factor in structuring interfirm networks is in agreement with the paper "Estimating Global Bank Network Connectedness," by Mert Demirer,

Francis X. Diebold, Laura Liu and Kamil Yilmaz, 2015 Manuscript, Massachusetts Institute of Technology, University of Pennsylvania, and Koc University. This work finds that when looking at the top 150 global banks, location—not bank assets—matters for network structure and proximity.

⁴ See note 2.

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