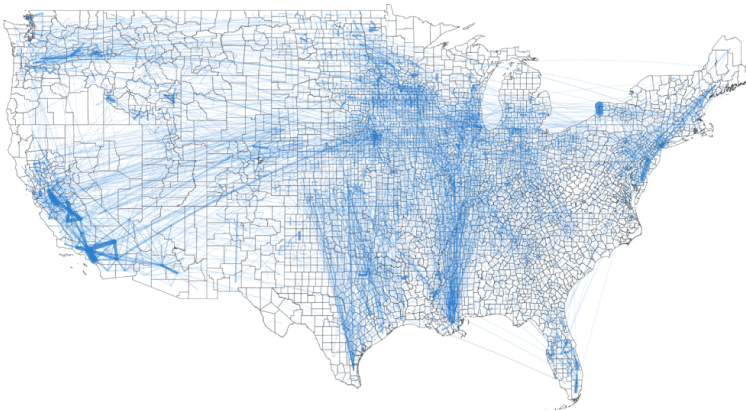


# U.S. FOOD SUPPLY CHAIN SECURITY: A NETWORK ANALYSIS

by Bradford Brown, Dr. Paul Garvey, Megan C. Smith, Eric Harley, Monica Mendoza, and Jeff Harrold



The COVID-19 global pandemic has exposed fissures in the U.S. food supply chain that under the right set of circumstances could cause widespread domestic food outages.



U.S. Food Map<sup>1</sup>

Food security, food safety, and the ability to deliver across the U.S. food supply chain is a national security priority that impacts every facet of American life. A prolonged disruption in the food supply chain will anger citizens, frustrate businesses, and erode trust in the U.S. government.

The MITRE Corporation has been conducting a network analysis of the structure of the U.S. food supply chain. We view this as an opportunity to inform policymakers and industry as they seek to assess and reinforce the U.S. food supply chain in the wake of the global pandemic

## Background

In recent months, stress on a number of U.S. supply chains, including food, revealed a number of systemic issues. As a result, President Biden signed an Executive Order (EO) on February 24, 2021, that applies to six supply chains and segments of supply chains. This policy paper focuses on the agriculture and food production supply chain.

Multiple federal agencies oversee and regulate the U.S. food supply chain. Agencies with a policy and regulatory interest include the U.S. Department of Agriculture (USDA), Food and Drug Administration, Department of Homeland Security (DHS), and U.S. Department of Transportation. Generally, the government views the U.S. food supply chain as the responsibility of private industry—farms, production facilities, storage, transportation, wholesale, and retail. Additionally, many activities at the state and local levels are outside the jurisdiction of the federal government. So, although an agency such as USDA is focused on the regulation and safety of meat, the role of federal agencies is generally to “influence,” not control, the U.S. food supply chain.

The EO states “the Secretary of Agriculture, in consultation with the heads of appropriate agencies, shall submit a report on supply chains for the production of agricultural commodities and food products.”<sup>2</sup> The EO points to the risk-reward question that government and industry often face: how much time, effort, and funding is needed to protect this critical infrastructure segment vs. the possibility that it will be negatively impacted by an event like an earthquake, a fire, a cyber incident, a biological or physical attack, or a global pandemic?

When meat supply shortages at local grocery stores appeared around March 2020, MITRE conducted a network analysis of the U.S. food supply. The analysis found that the food supply chain would be significantly impacted if certain key hubs were disrupted. The analysis also identified key transportation routes that connect the hubs within the network.

## The Study

We focused the network analysis on meats and poultry but also considered fruits, vegetables, corn, and grain commodities. Our insights and conclusions from the meat and poultry analysis generally apply to the overall U.S. food supply chain because all food commodity groups have key hubs connected by key transportation routes.

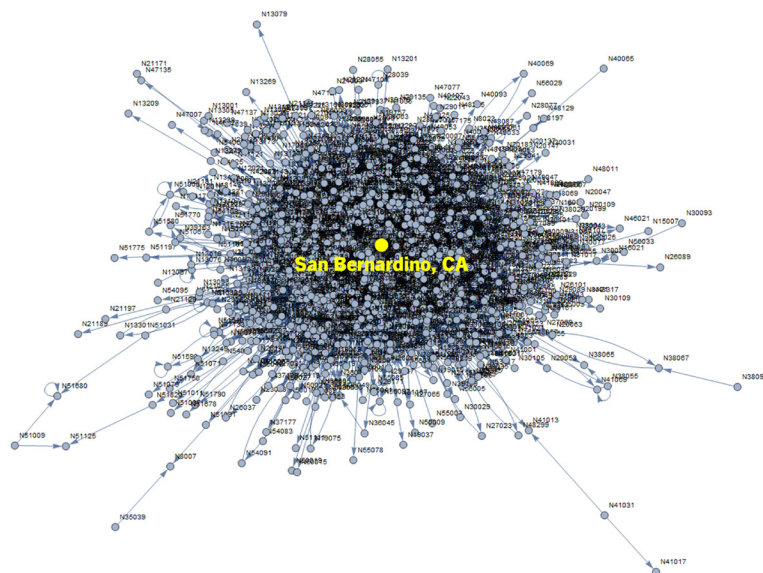
The county-level network analysis was conducted with publicly available data,<sup>1</sup> although many details about the U.S. food supply chain are proprietary and siloed within industry. Even with county-level data, our analysis points to a much larger public policy question: how does the United States ensure food flows under any circumstance? It is impossible to assemble a complete systems view of the U.S. food supply chain without access to industry data. This lack of access is a vulnerability to threats that needs evaluation.

What did MITRE do?

- Evaluated the structure, resilience, and vulnerability of the U.S. food supply chain, focusing on meat commodities.
- Applied network science algorithms and discovered which U.S. counties have the greatest structural influence on the overall food supply chain.
- Investigated how a disruption, such as a pandemic, in one part of the food supply chain affects dependent counties and their pathways across the food supply chain ecosystem.

The U.S. food flow map provides a visualization of the supply chain's breadth and intricacies.

THE U.S. FOOD  
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## THE U.S. WILL HAVE MEAT SHORTAGES IF THE THROUGHPUT OF A KEY HUB IS DIMINISHED

There are approximately 9.8 million origin-to-destination transportation links connecting producers to consumers. During the first peak of the COVID-19 pandemic in March 2020, it was widely reported that food supplies were showing signs of strain. In reality, it was much more than that. Although the federal government made assurances about the security of the U.S. food supply chain, John Tyson, chairman of Tyson Foods, stated in a Washington Post opinion editorial that “the food supply chain is breaking.”<sup>3</sup>

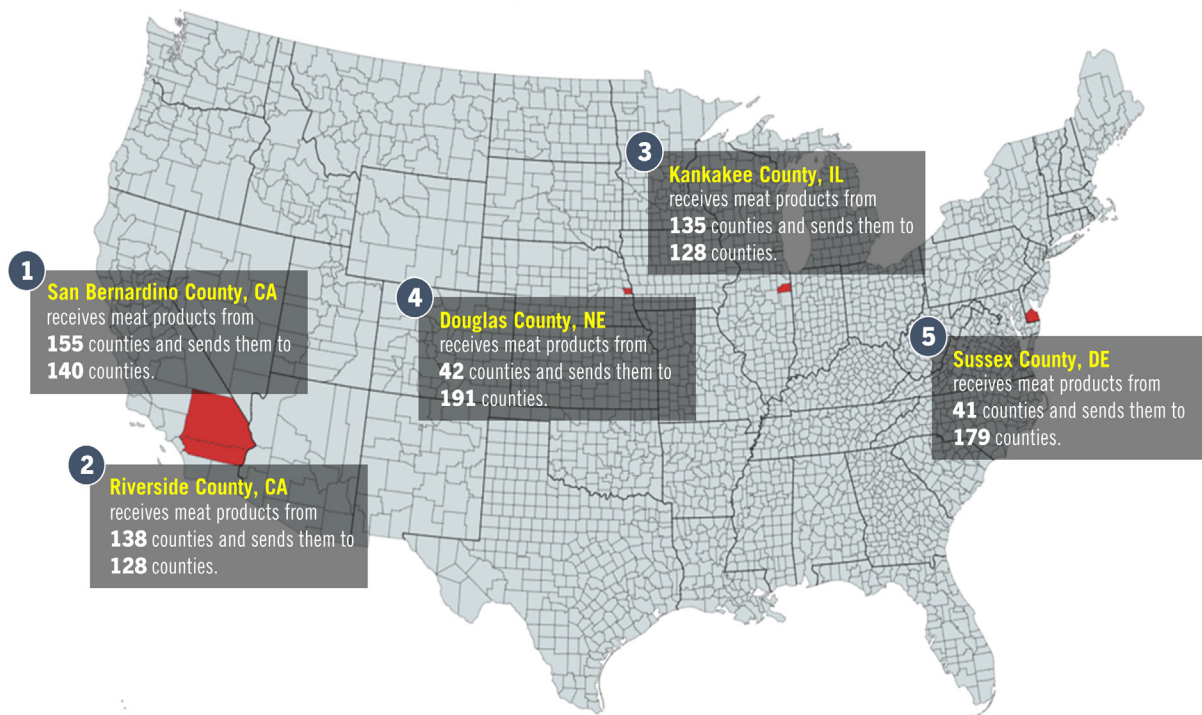
### Analysis

The U.S. food supply chain for meat is a dense and complex network of diverse stakeholders across producers, processors, packagers, distributors, transporters, and consumers.

Transportation is the means for moving product along the links between hub locations. At the county level, the chain consists of thousands of origin-to-destination links that exist between hubs. Some 2,817 U.S. counties constitute the hubs that serve the U.S. food supply chain for meats; 30,670 origin-to-destination transportation links exist between these counties.

A disruption to the network can come in the form of an intentional direct action or an indirect occurrence, such as the pandemic. Most hubs have relatively few links. This means a disruption in one of these hubs would not cause a major breakage. However, there are also some hubs with a substantial number of links where a disruption can cause extensive weakening of the supply chain.

Our analysis identified five key hubs in the U.S. food supply chain for the distribution of meat. These hubs have the greatest number of links to other counties in the U.S. meat supply chain. (See map)



Top Five Meat and Poultry Supply Chain Hubs



These hubs reflect areas of high meat production, cold storage, and transport. As an example, Omaha, which is central to the Douglas County, Nebraska, hub, was once the home to the largest stockyards and related production facilities in the world. Douglas County, Nebraska, has numerous meat packing and cold storage facilities. Overall, it is the fourth-largest U.S. hub and is responsible for the distribution of meat products to 191 U.S. counties. All of this contributes to Nebraska being a large beef exporter to Europe, China, and Japan.

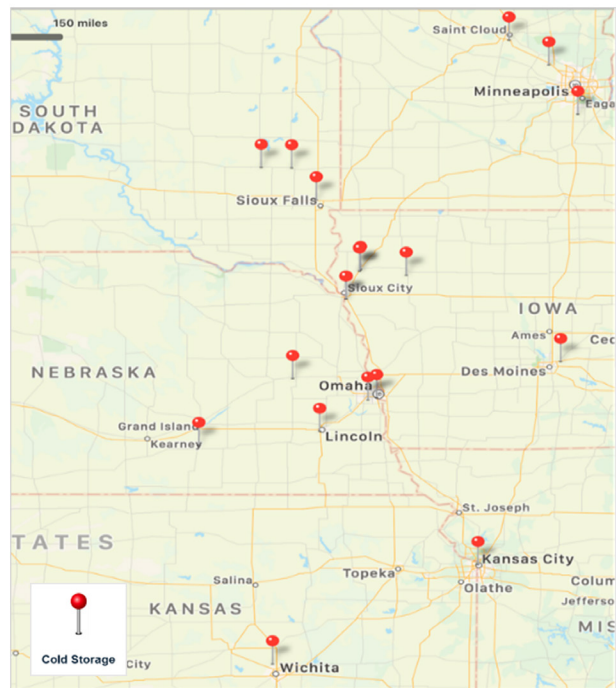
Production facilities in other states, such as Iowa, South Dakota, and Kansas, also use Douglas County as a production, cold storage, and transportation hub due to its access to Route 80—a major east-west transportation link between Chicago and Denver—and Route 29, which runs north-south through Sioux Falls, South Dakota, and Kansas City, Missouri.

## DATA SHARING LEADS TO IMPROVED RESILIENCE

With their high connectivity, these five key hubs have significant and extensive influence on the resilience and continuity of the U.S. meat supply chain. A disruption in any one of

these hubs can have a large downstream effect on the rest of the network. The potential for disruption is further exacerbated by the network structure of “super embedded hubs” where each of these five key hubs are tightly interconnected.

For example, at the peak of the first wave of the pandemic, the largest number of COVID-19 cases in Nebraska stemmed from production facilities in Douglas County. The impact of the production slowdown in Douglas County and other key hubs was felt across the country, where meat shortages in grocery stores resulted in public concerns.

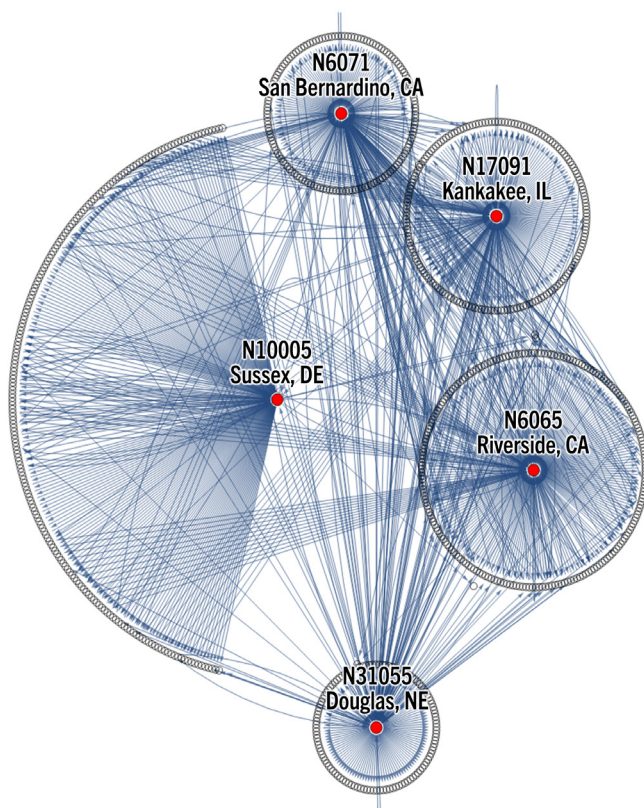


Fourth-Largest Hub – Douglas County, NE

## Insights

**The U.S. food supply chain for meat is vulnerable.** It has some resilience, but, given its high dependence on a few key hubs, it is brittle. The network is built on market need that has evolved into a critical infrastructure with significant hubs embedded within hubs. Given the nature of the threats the country faces, the U.S. food supply chain needs strengthening and increased agility.

**The meat supply chain would be more robust with greater and transparent operational understanding.** The meat ecosystem has a diversity of stakeholders. Sharing data across producers, processors, packagers, distributors, shippers, and consumers is an essential step in the long-term assurance of a safe and secure food flow.



Super Embedded Hubs in Meat Supply Chain<sup>4</sup>

## Additional Study Findings

As MITRE performed deeper analysis into the key hub locations, the surrounding counties, and origin-to-destination links, the following additional information was gleaned from the study.

**The U.S. food supply chain is a massive ecosystem.** There are large datasets at the county level associated with healthcare and related demographics that should be leveraged to add a more integrated systems-oriented view of the U.S. food supply chain. Leveraging these datasets could improve risk analyses on the available work force and potential disruptions due to illness and socio-political challenges.

## Identification of foreign-owned companies within the U.S. food supply chain is critical.

Our analysis found that some foreign-owned meat companies prioritized sending meat products to their own country over meeting the consumption needs of the United States. During a disruption, this risk should be addressed by making sure fair food allocations among countries is deliberate and coordinated in the food supply chain, regardless of ownership.

**Decentralized trucking companies are critical to U.S. food distribution transportation.** Most U.S. trucking companies are small businesses comprised of many stakeholders with a few trucks. This poses a single-point-of-failure risk. Truckers were frequently frustrated during spikes in the pandemic as various states randomly closed rest stops or restricted access from out-of-state travelers. Transportation consistency across states is important to keeping the food supply chain.

**The U.S. food supply chain is national, but execution is local.** Much of the production work occurs at the local level or within a company's network. When disruptions occur, getting food from producer to consumer becomes a national challenge. *The Emergency Support Function 11—Agriculture and Natural Resources* needs to be revamped to ensure quick and appropriate national coordination to address disruptions.

## Recommendations

The COVID-19 global pandemic has exposed fissures in the U.S. food supply chain that, under the right set of circumstances, could cause widespread domestic food outages. The Office of Management and Budget, USDA, DHS, and the Department of Health & Human Services all have the opportunity to address U.S. food supply chain resiliency by providing leadership in the following areas:

## **Data and Data Sharing**

Formalize a data-sharing capability across federal, state, and local governments that includes industry. The data should include relevant transportation and production data, which could be used to develop a predictive analytics capability to improve resilience as required by the EO.

## **Systems View**

Establish a systems view of the U.S. food supply chain from end-to-end to the local level. This will alleviate the strain of shortages of essential products felt by American households, workers, and companies, as mentioned in the EO, through improved understanding and planning to get products from source to destination.

## **Operational Risk Assessments**

In the near term, conduct operational risk assessments of the U.S. food supply chain at the facilities within key counties. Assessments would consider issues such as the cold weather in Texas that resulted in frozen natural gas pipelines and a lack of electricity. Additional risk scenarios could be informed by the damaged ship that recently blocked the Suez Canal and the backed-up cargo ships at the port of Los Angeles that were unable to unload. Per the EO, these risk assessments will identify critical goods and detailed locations of key processing and production assets.

## **Foreign Ownership**

Identify and document the foreign ownership of key components, especially processing and production assets requested by the EO, within the U.S. food supply chain and analyze the policy implications of non-compliance with U.S. government mandates during an emergency.

## **Scenario Planning**

Establish a formal plan that can be implemented in case of serious disruption vs. leaving it to industry alone. The Food and Agriculture Sector-Specific Plan must move beyond requiring risk assessments and vulnerability identification to using scenario planning to position the country to mitigate disruptions that would improve resilience required by the EO.

## **Decentralize Key Hubs**

Consider incentives to decentralize activity around the key hubs to de-concentrate the U.S. food flow as part of making our supply chains more secure and being a source of well-paid jobs for communities across the country per the EO.

## **Office of Supply Chain Management**

USDA should consider establishing an Office of Supply Chain Management that will focus on the production and distribution issues and coordinate across agencies on security and defense.

## **Conclusion**

The pandemic exposed the fragility of the U.S. food supply chain. Recent events like the cold weather in Texas and backup of cargo ships at the Port of Los Angeles reinforce the evidence of fragility. Strengthening this supply chain will require a systems approach that includes planning strategies and leveraging data to predict and prepare for unexpected disruptions.

## About the Authors

**Bradford Brown**, outcome lead and senior principal in the Government Administration and Judiciary Division, leads the U.S. Food Supply Chain Strategic Initiative within MITRE.

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## References

<sup>1</sup> Xiaowen Lin et al 2019 Environ. Res. Lett (ERL). 14 08401. Research Director: Professor Megan Konar and dataset, <http://mkonar.cce.illinois.edu/>

<sup>2</sup> Executive Order on America's Supply Chains, February 24, 2021

<sup>3</sup> [Tyson ad - The Washington Post](#), April 27, 2020

<sup>4</sup> The depiction merely shows the significant interconnectedness between the key hubs. The size of the rings is not relevant.