Blood, Sweat, and PPEs: Rescuing Perishable Product Supply Chains and Impacting Policy Through Analytics

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Acknowledgments

Many thanks to the INFORMS Practice Section Board and to its Members for this invitation.

Thanks also to INFORMS for assisting with the logistics and the event!

This webinar is dedicated to essential workers, including all the tech workers, healthcare workers, first responders, farmers, food processors, and grocery store workers, and freight service providers, whose selflessness and expertise help to sustain us. Thank you.

Outline of Presentation

Part 1: Background and Motivation

Part 2: Food Supply Chains and Disruptions

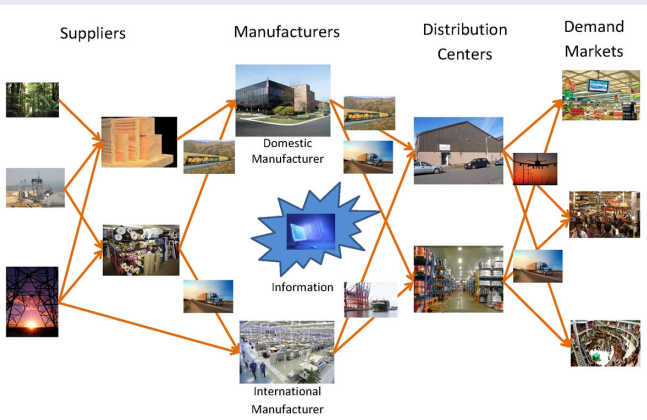
Part 3: Where are the PPEs?

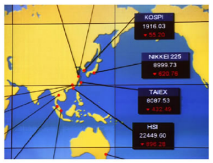
Part 4: Blood Supply Chains in the Pandemic and Convalescent Plasma

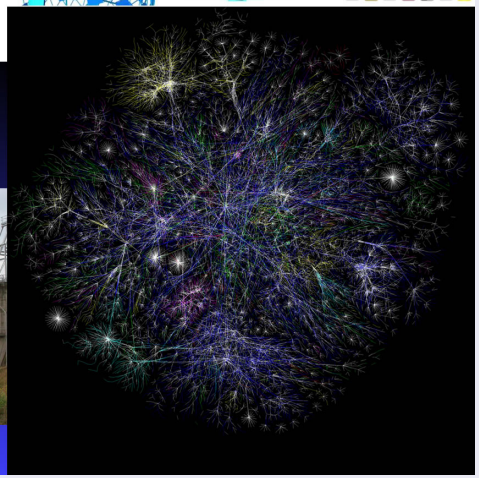
Part 5: Impacting Policy Through Analytics

Background and Motivation

I Work on the Modeling of Network Systems





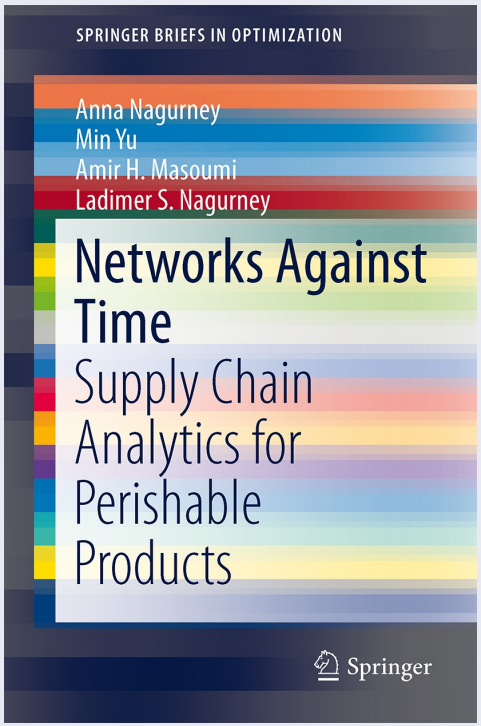


Much of My Recent Research Has Been on Supply Chains

Some of My Books

A Multidisciplinary Approach

In our research on perishable and time-sensitive product supply chains, we utilize results from physics, chemistry, biology, and medicine in order to capture the perishability of various products over time from healthcare products such as blood, medical nucleotides, and pharmaceuticals to food.



Food Supply Chains and Disruptions

Food Supply Chains

Food is essential to our health and well-being. During the Covid-19 pandemic, declared on March 11, 2020 by the World Health Organization, the associated supply chains have suffered major disruptions.

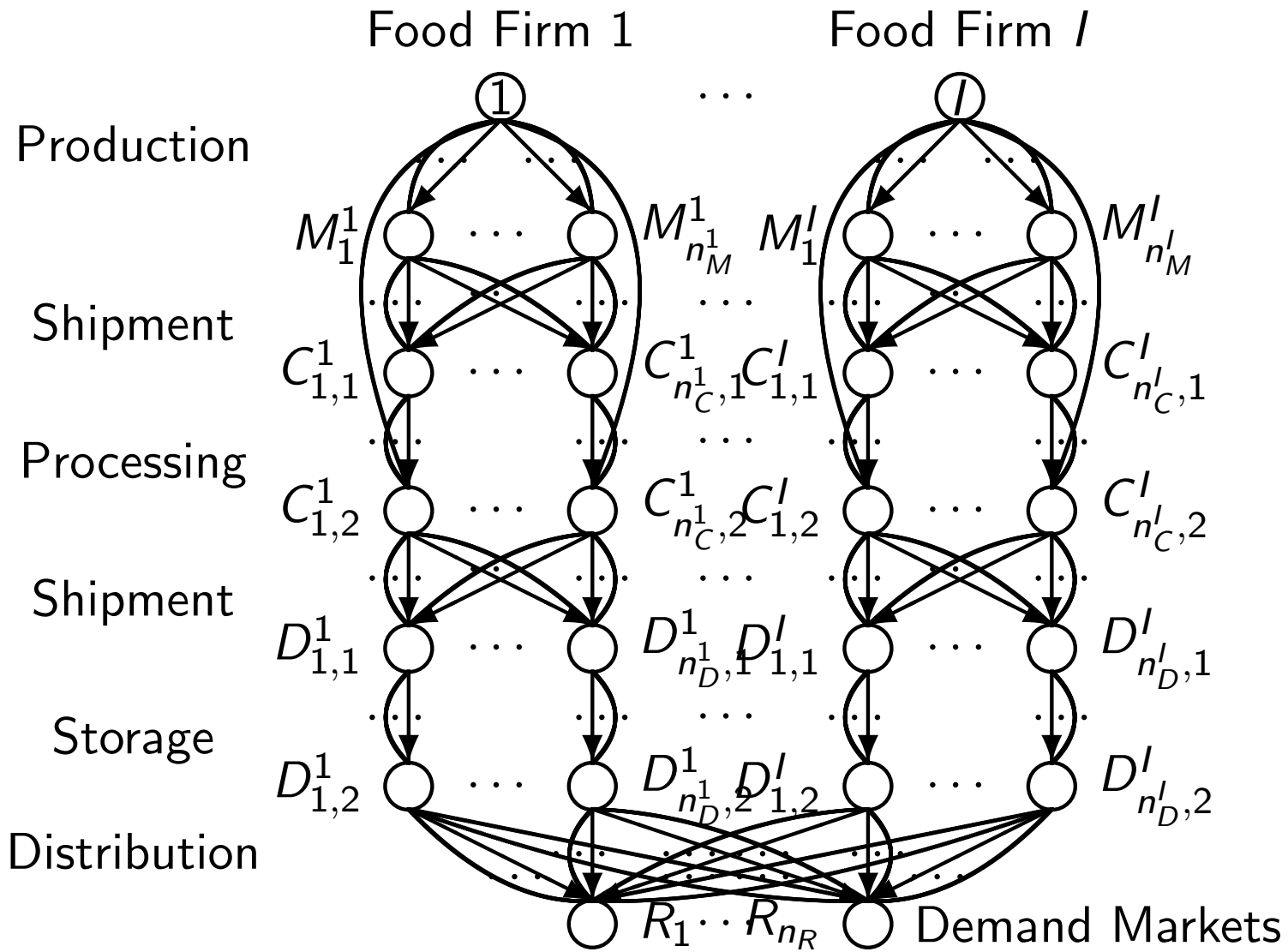
Fresh Produce Food Supply Chains

Our fresh produce supply chain network oligopoly model:

1. captures the deterioration of fresh food along the entire supply chain from a network perspective;
2. handles the time decay through the introduction of arc multipliers;
3. formulates oligopolistic competition with product differentiation;
4. includes the disposal of the spoiled food products, along with the associated costs;
5. allows for the assessment of alternative technologies involved in each supply chain activity.

M. Yu and A. Nagurney, "Competitive Food Supply Chain Networks with Application to Fresh Produce," *European Journal of Operational Research* **224(2) (2013), pp 273-282.**

Fresh Produce Food Supply Chains



The Fresh Produce Supply Chain Network Topology

Pharmaceutical Supply Chains

The supply chain generalized network oligopoly model has the following novel features:

1. it handles the perishability of the pharmaceutical product through the introduction of arc multipliers;
2. it allows each firm to minimize the discarding cost of waste / perished medicine;
3. it captures product differentiation under oligopolistic competition through the branding of drugs, which can also include generics as distinct brands.

A.H. Masoumi, M. Yu, and A. Nagurney, "A Supply Chain Generalized Network Oligopoly Model for Pharmaceuticals Under Brand Differentiation and Perishability," *Transportation Research E* **48 (2012), pp 762-780.**

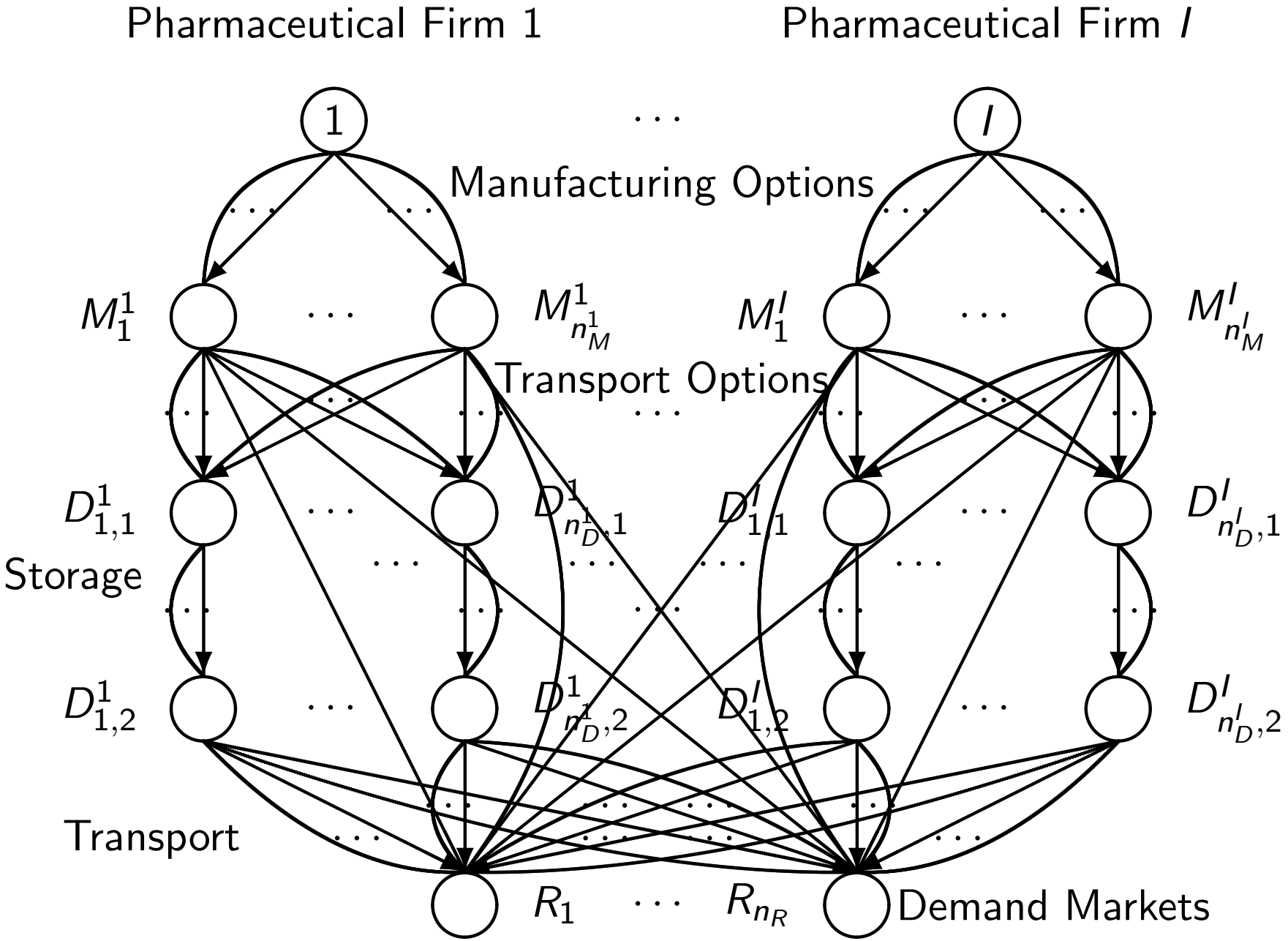
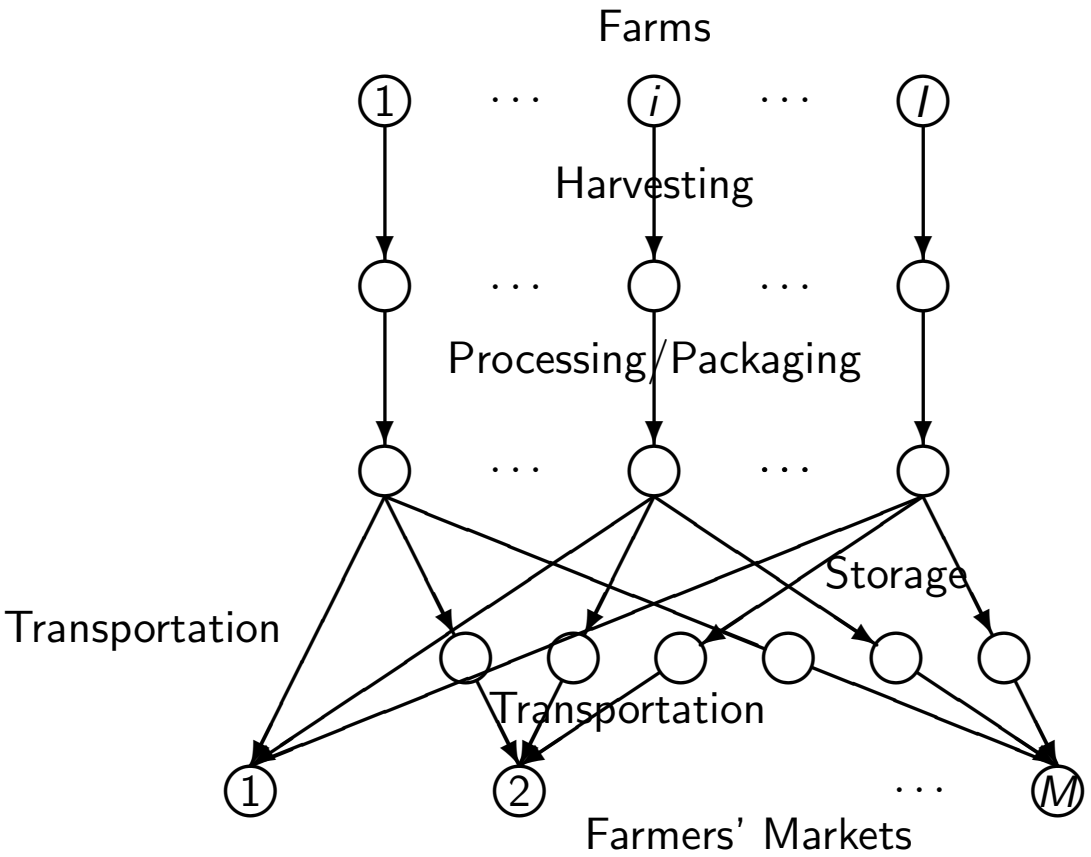


Figure: The Pharmaceutical Supply Chain Network Topology

The Fresh Produce Supply Chain Network Topology

- The I farms compete **noncooperatively** in an **oligopolistic** manner.
- Products are differentiated based on **quality** at the farmers' markets.



D. Besik and A. Nagurney, "Quality in Competitive Fresh Produce Supply Chains with Application to Farmers' Markets," *Socio-Economic Planning Sciences* **60 (2017), pp 62-76.**

Food Supply Chain Disruptions Due to Covid-19

The Covid-19 pandemic has impacted food supply chains in a dramatic and sustained manner.

1. Infections at three of the nation's largest meat processors have quadrupled over the past month despite new safety measures. At Tysons Foods, the largest meat processor in the US, **the number of Tyson employees with the coronavirus has exploded from less than 1,600 a month ago to more than 7,000 as of May 25, 2020.**
2. **Shortages of many types of meats, even organic chicken, are being experienced, with price increases**, with expectations that these will continue. It is projected that **meat supplies in grocery stores could shrink as much as 35%, prices could rise 20%** with even greater impact later this year.
3. **Fresh produce (oranges, potatoes, strawberries, etc.) on some farms, has had to be discarded** because of lack of timely processing capabilities at plants.

Food Supply Chain Disruptions Due to Covid-19

1. **Many farm animals have had to be culled** because of the shutdown of several big meat processing plants. Enhanced cleaning, redesign, and emphasis on social distancing is slowing down the processing, causing additional delays. **It is estimated that up to 10,069,000 market hogs will need to be euthanized**.
2. **Labor needed to pick ripened produce is less available due to migrant labor restrictions, illnesses, etc.**
3. With the closures of schools, restaurants, businesses, etc., outlets for perishable food have been changed dramatically. **Distribution channels are in dire need of being reinvisioned and redesigned.**
4. **Food insecurity is rising nationally. Massachusetts committed $56 million to fighting food insecurity as local pantries struggle to keep up with demands (May 27).**

Food Supply Chain Disruptions Due to Covid-19

USA TODAY

AMERICA'S FOOD CHAIN

As coronavirus pandemic spikes orange juice sales, a Florida citrus grower gets squeezed

Janine Zeitlin, USA TODAY Network - Florida
Updated 8:07 p.m. EDT May 14, 2020

CNN

An Idaho farm is giving away 2 million potatoes because coronavirus has hurt demand

By Alisha Ebrahimji, CNN
Updated 1:33 PM ET, Thu April 16, 2020

Lacking seasonal workers, Italy elevates its long-shunned migrants

The Christian Science Monitor

THEDENVER CHANNEL.COM

Farms encountering guest worker shortage amid new coronavirus restrictions

REUTERS

Piglets aborted, chickens gassed as pandemic slams meat sector

The Washington Post
Democracy Dies in Darkness

The meat industry is trying to get back to normal. But workers are still getting sick — and shortages may get worse.

There are now more than 11,000 coronavirus cases tied to Tyson Foods, Smithfield Foods and JBS

Germany Struggles To Fill Its Farm Labor Shortage After Closing Its Borders

May 20, 2020 · 10:58 AM ET

ROB SCHMITZ

npr

Perishable Food Supply Chain Network Model with Labor

Our new paper, "Perishable Food Supply Chain Networks with Labor in the Covid-19 Pandemic," A. Nagurney, May 2020.

• With lack of availability of labor being one of the drivers of supply chain disruptions, we developed a new model that considers labor in all the supply chain network economic activities of production, transportation, processing, storage, and distribution.

• The impacts of the reduction of labor (capacities) on supply chain network links can then be quantitatively evaluated on the perishable product flows, the prices that the consumers pay, and profits of the firm.

• The modeling and algorithmic framework enables a variety of sensitivity analysis exercises in terms of the addition of facilities (also their removal) and demand markets as well as redesign of the supply chain network with more direct distribution channels.

Perishable Food Supply Chain Network Model with Labor

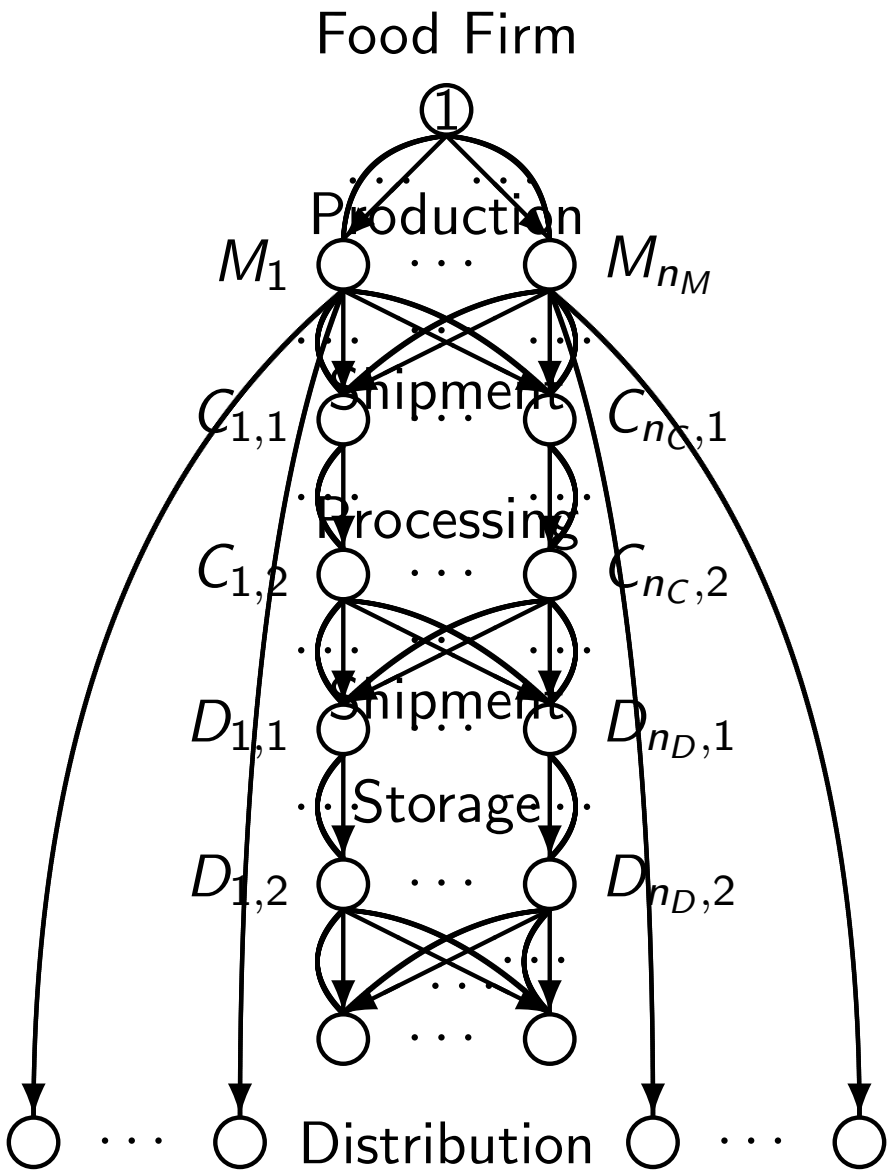
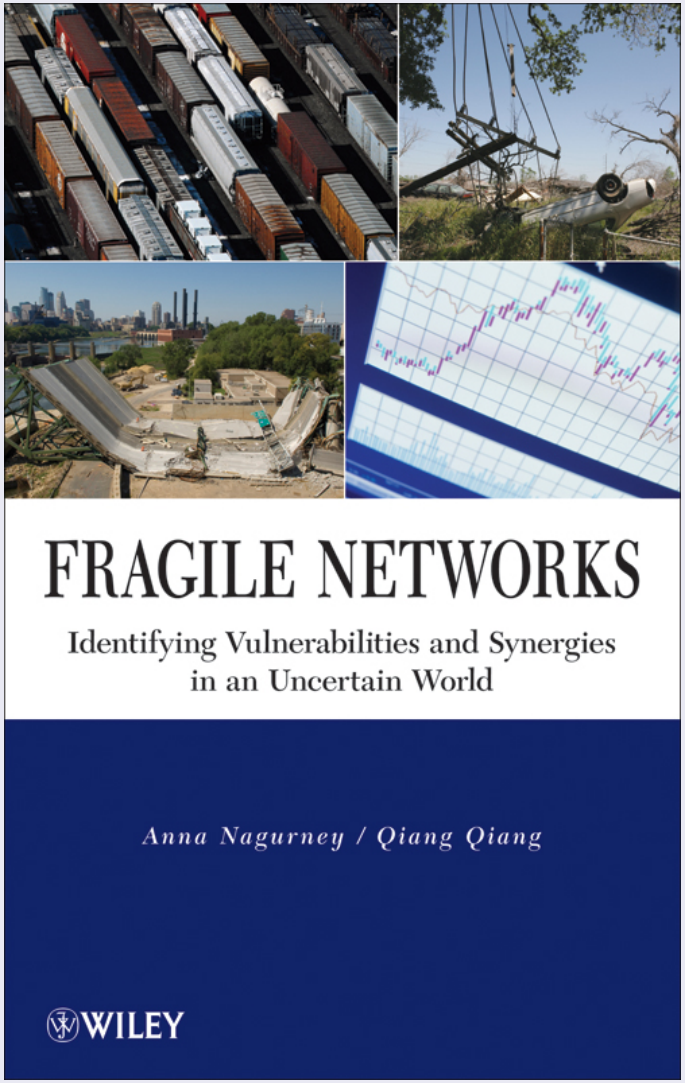


Figure: The Perishable Food Supply Chain Network Topology

Our findings include:

1. **The lack of labor on a single link, even a freight one, may significantly negatively impact a food firm.**
2. **Preserving productivity in all utilized supply chain network economic activities is critical** since the impact of a drastic reduction can severely reduce profits.
3. **Adding more direct sales, whether at farmers' markets or nearby farm stands, may help a food firm in a pandemic.**
4. Also, if a firm **enhances its marketing** so as to have consumers be willing to pay a higher price for its fresh produce, **major profit increases can occur**.

Identifying the Most Important Nodes and Links



Where are the PPEs?

Time and Perishable Products

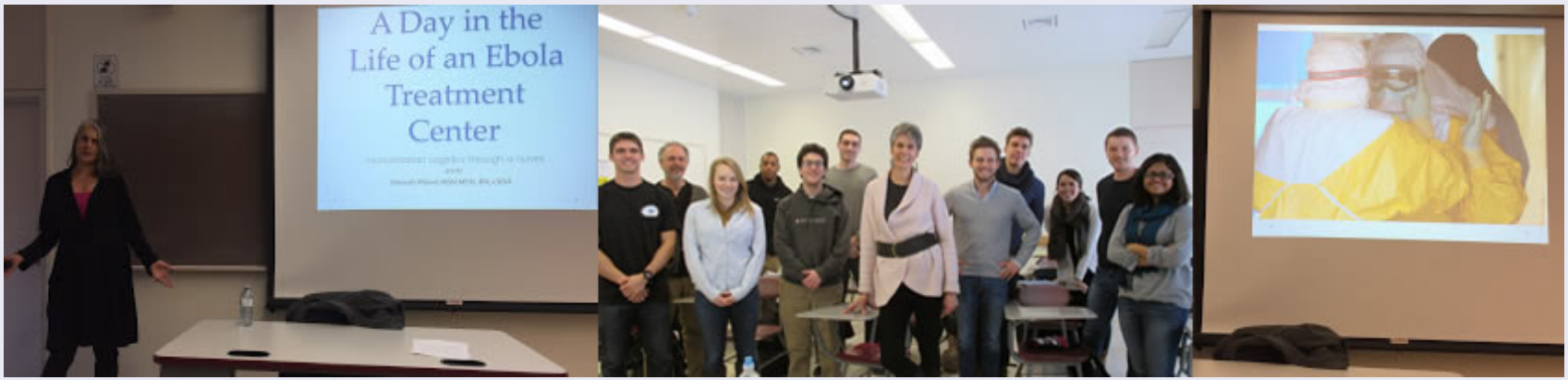
Classical examples of perishable goods include fresh produce in the form of fruits and vegetables, meat and dairy products, medicines and vaccines, radioisotopes, cut flowers, and even human blood.

We take **the broader perspective of products being perishable** not only in terms of their characteristics (such as their chemistry and the underlying physics) and **supply** (that is, the manner of procurement/production/processing, storage, transportation, etc.) aspects, but also in terms of the **demand** for the products.

We include, under the **perishable product umbrella**, products that are *discarded* (or replaced) relatively quickly after purchase, because of changing consumer tastes, such as **fast fashion apparel**, or those that become obsolete (as in **certain high technology products**) and **PPEs**.

Battling Ebola and PPEs

I teach a class on Humanitarian Logistics and Healthcare, which includes guest lectures by practitioners.

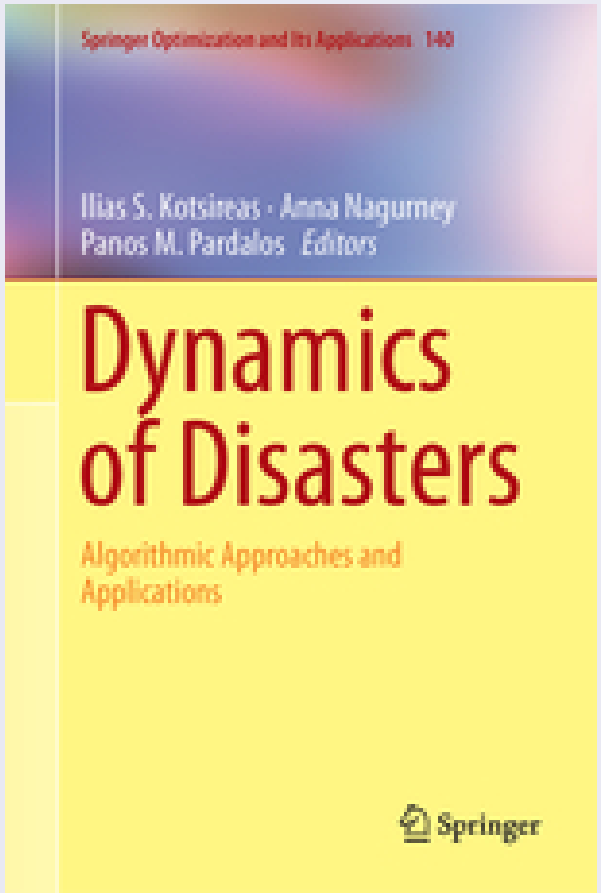


In 2014, Debbie Wilson, a nurse working for Doctors Without Borders, spent 6 weeks battling Ebola in Liberia. Wilson managed a 120-bed Ebola Treatment Unit (ETU) at the height of the Ebola epidemic.

She spoke to my class in 2015 and in 2018.

Battling Ebola and PPEs

Ms. Wilson's chapter in our book, "Ode to the Humanitarian Logistician: Humanistic Logistics Through a Nurse's Eye."



Battling Ebola and PPEs

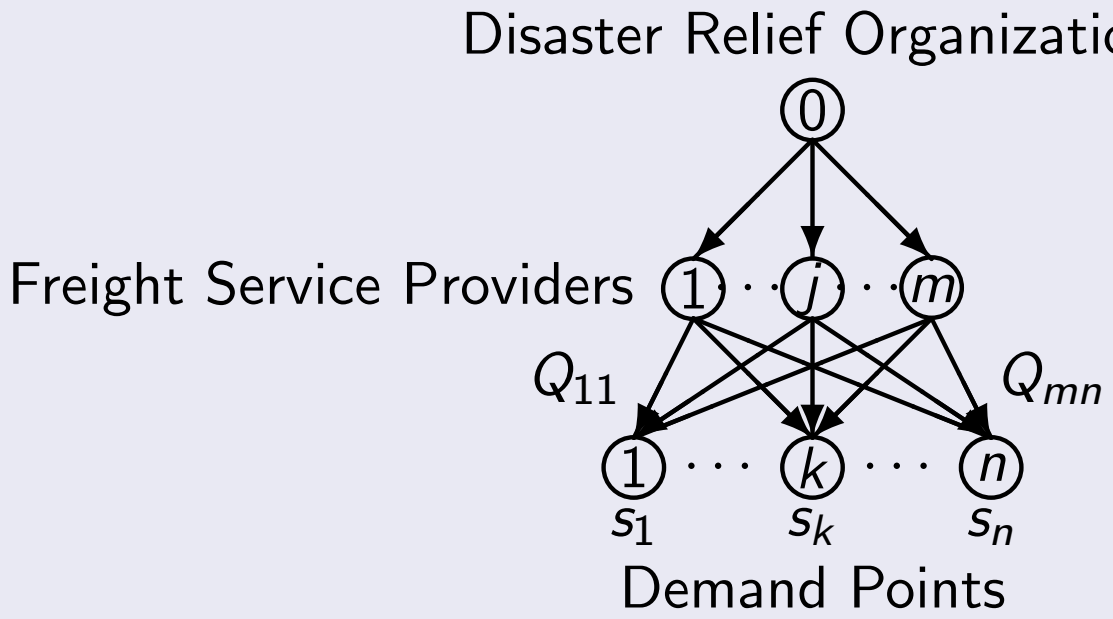


Figure: Network Structure of the Competitive Freight Service Provision Model for Disaster Relief

A. Nagurney, "Freight Service Provision for Disaster Relief: A Competitive Network Model with Computations," in *Dynamics of Disasters: Key Concepts, Models, Algorithms, and Insights*, **I.S. Kotsireas, A. Nagurney, and P.M. Pardalos, Eds., Springer International Publishing Switzerland (2016), pp 207-229.**

Battling Ebola and PPEs

We introduce a *price of anarchy* in this new setting, where the price $\mathcal{P}$ is defined below:

$$\mathcal{P} = \frac{\text{TC(Equilibrium Solution)}}{\text{TC(System-Optimized Solution)}}$$

where the total cost $\text{TC}=\sum_{j=1}^{m} \hat{c}_j(\sum_{k=1}^{n} Q_{jk}) + \sum_{j=1}^{m}\sum_{k=1}^{n} c_{jk}(Q)$ is evaluated at the equilibrium solution in the numerator and at the system-optimized solution in the denominator.

In the paper, a case study on the shipment of PPE supplies in the context of the Ebola humanitarian healthcare crisis in west Africa.

The computational results yield insights on the equilibrium shipment and price patterns in the freight service provision sector for humanitarian operations in terms of enhanced or reduced competition, as well as increases in demand.

Where are the PPEs?

• In early March, it was reported that by the Department of Health and Human Services **that the national stockpile had about 12 million N95 respirators and 30 million surgical masks - 1% of the estimated 3.5 billion masks the nation would need in a severe pandemic. Another 5 million N95 masks in the stockpile were expired.**

• **Prior to the coronavirus outbreak, China made half the world's face masks.** When the outbreak took off there, China started to use its supply and hoard what remained. This problem has only spread since, as more countries hoarded medical supplies, with some even banning most PPE exports. So as demand increased due to Covid-19 there was less supply to go around.

• **"We are out of everything, wrote a staffer at a large hospital in Tennessee in mid April. "Providers using one mask for 3+ weeks. Many COVID patients. Zero gowns."**

N95 Mask Supply Chain

1. **Individual state governments and health care systems are currently competing for resources, especially PPEs and ventilators.**
2. N95 are quite complex to manufacture and require a lot of quality control.
3. **In late April, 2020, 3M Co., Honeywell International Inc. and a unit of Owens & Minor Inc. received Pentagon contracts to make 39 million N95 face masks for medical workers under the Defense Production Act. The military's first use of the Defense Production Act in the coronavirus crisis was announced April 11 – $133 million in contracts for the masks.**
4. Because of shortages that continue there is impetus to devise mechanisms for disinfection and reuse. **Another possibility is the use of elastomerics.**

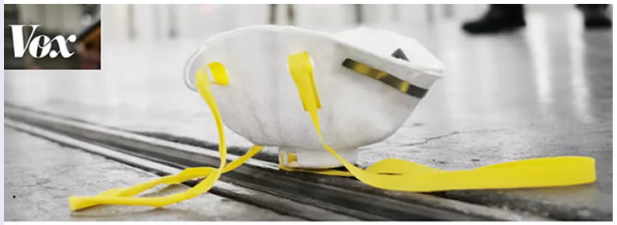
Where Are the PPEs?

The Press Democrat

Face masks in the national stockpile have not been substantially replenished since 2009

The New York Times

F.D.A. Bans Faulty Masks, 3 Weeks After Failed Tests



Why America ran out of protective masks — and what can be done about it

FierceHealthcare

A physician exec was trying to secure PPE for his hospital. Then the feds showed up

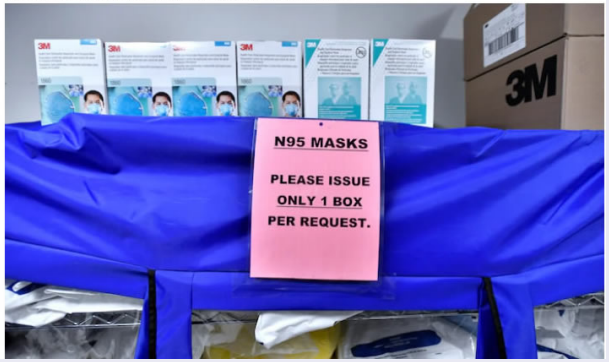
TIME

Begging for Thermometers, Body Bags, and Gowns: U.S. Health Care Workers Are Dangerously Ill-Equipped to Fight COVID-19

Why don't hospitals have enough masks? Because coronavirus broke the market.

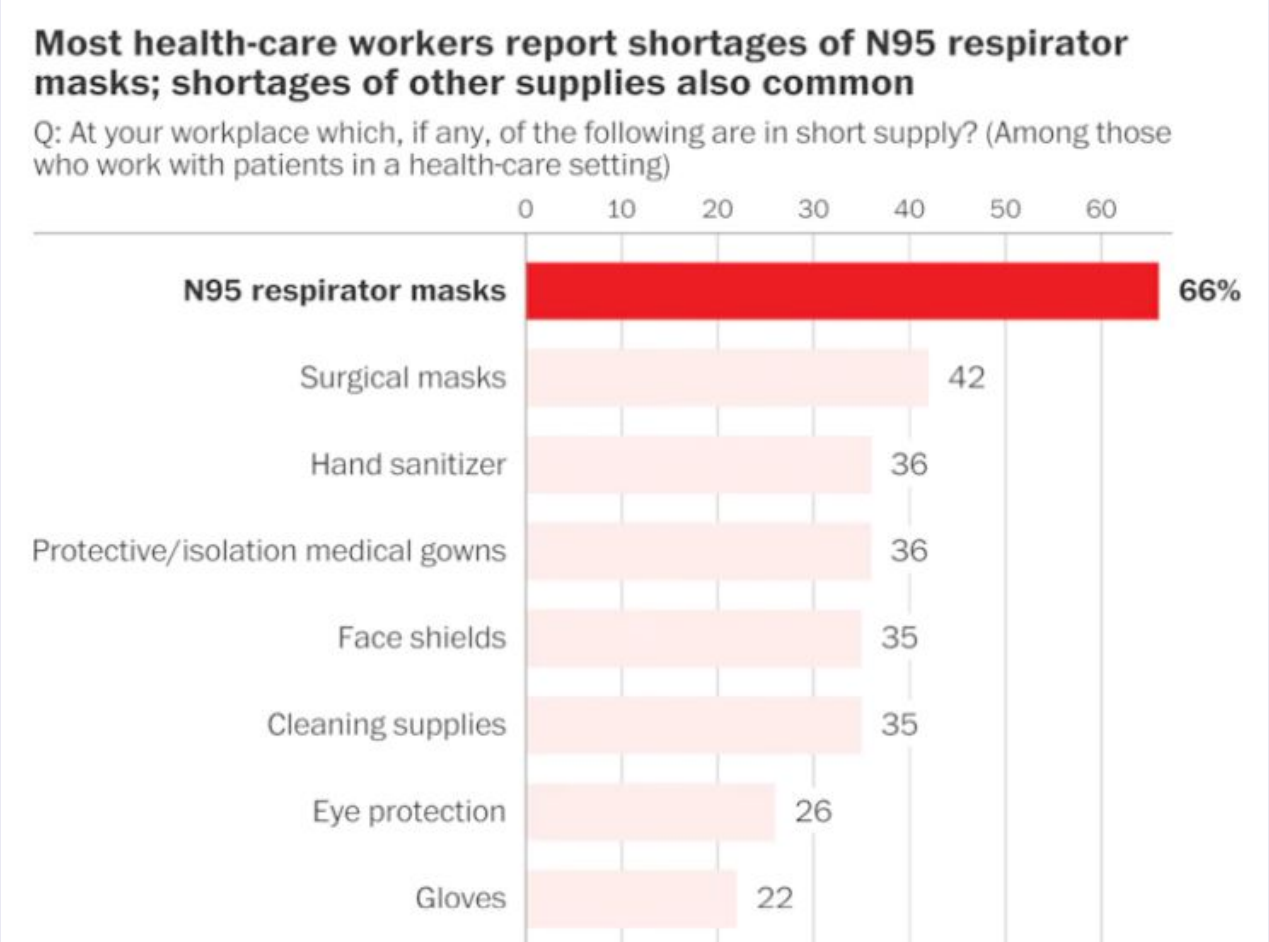
The Washington Post
Democracy Dies in Darkness

Health-care supply chains are made for efficiency, not pandemics.



Where Are the PPEs?

Results of a survey of healthcare workers reported in *The Washington Post*, May 20, 2020.



Supply Chain Model with Different Labor Constraints

The modeling framework considers first elastic demands for a product and then fixed demands, coupled with distinct types of labor capacities in order to capture the availability of this valuable resource in a pandemic, as well as possible flexibility.

The supply chain network framework includes electronic commerce and is relevant to many different supply chain applications including protective personal and medical equipment.

A. Nagurney, "Optimization of Supply Chain Networks with Inclusion of Labor: Applications to Covid-19 Pandemic Disruptions," April 2020.

Supply Chain Model with Different Labor Constraints

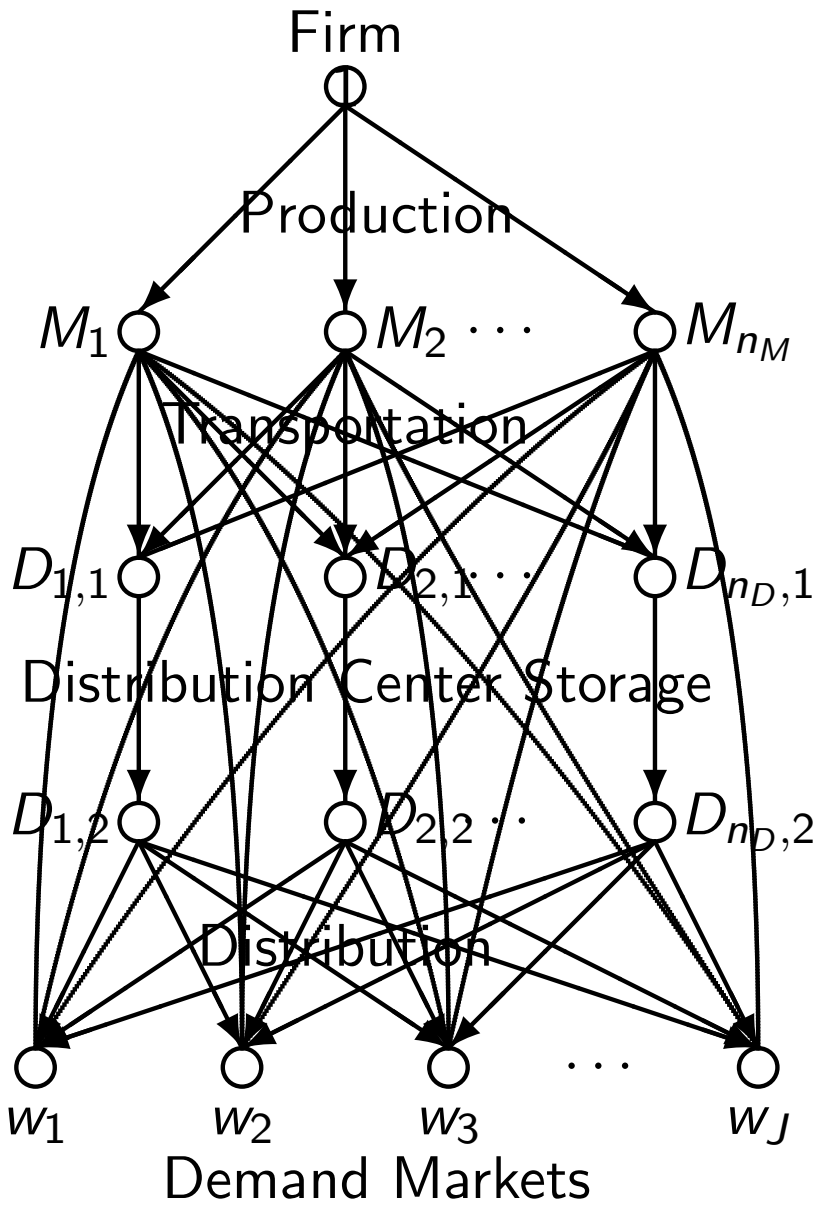


Figure: The Supply Chain Network Topology

Supply Chain Model with Different Labor Constraints

The model considers three sets of labor constraints, of increasing flexibility of movement.

1. **In the first set**, **each supply chain link has an upper bound of available labor.** Labor is is not free to move to other production sites, nor to other distribution centers, or assist in freight service provision.
2. **In the second set**, **labor is free to move across a supply chain set of network economic activities (such as production, or transportation, or storage, and, finally, distribution).** There is a capacity of labor associated with each such "tier" of supply chain links. Those who have skills in production, or in distribution, etc., may be reallocated. This has been happening in freight service provision, for example, during the Covid-19 pandemic.
3. **In the third set**, **labor is free to move across all the supply chain network economic activities, and there is a single capacity.** McKinsey & Company noted this is a means towards resilience and returning the supply chain to effectiveness while reenvisioning and reforming.

Supply Chain Performance Assessment

Earlier, we developed a multitiered competitive supply chain network game theory model, which includes the supplier tier. The firms are differentiated by brands and can produce their own components, as reflected by their capacities, and/or obtain components from one or more suppliers, who also are capacitated.

We construct **supply chain network performance measures for the full supply chain and the individual firm levels** that assess the efficiency of the supply chain or firm, respectively, and also allow for **the identification and ranking of the importance of suppliers and the components of suppliers with respect to the full supply chain or individual firm**.

D. Li and A. Nagurney, "Supply Chain Performance Assessment and Supplier and Component Importance Identification in a General Competitive Multitiered Supply Chain Network Model," *Journal of Global Optimization* **(2017) 67(1), pp 223-250.**

Supply Chain Performance Assessment

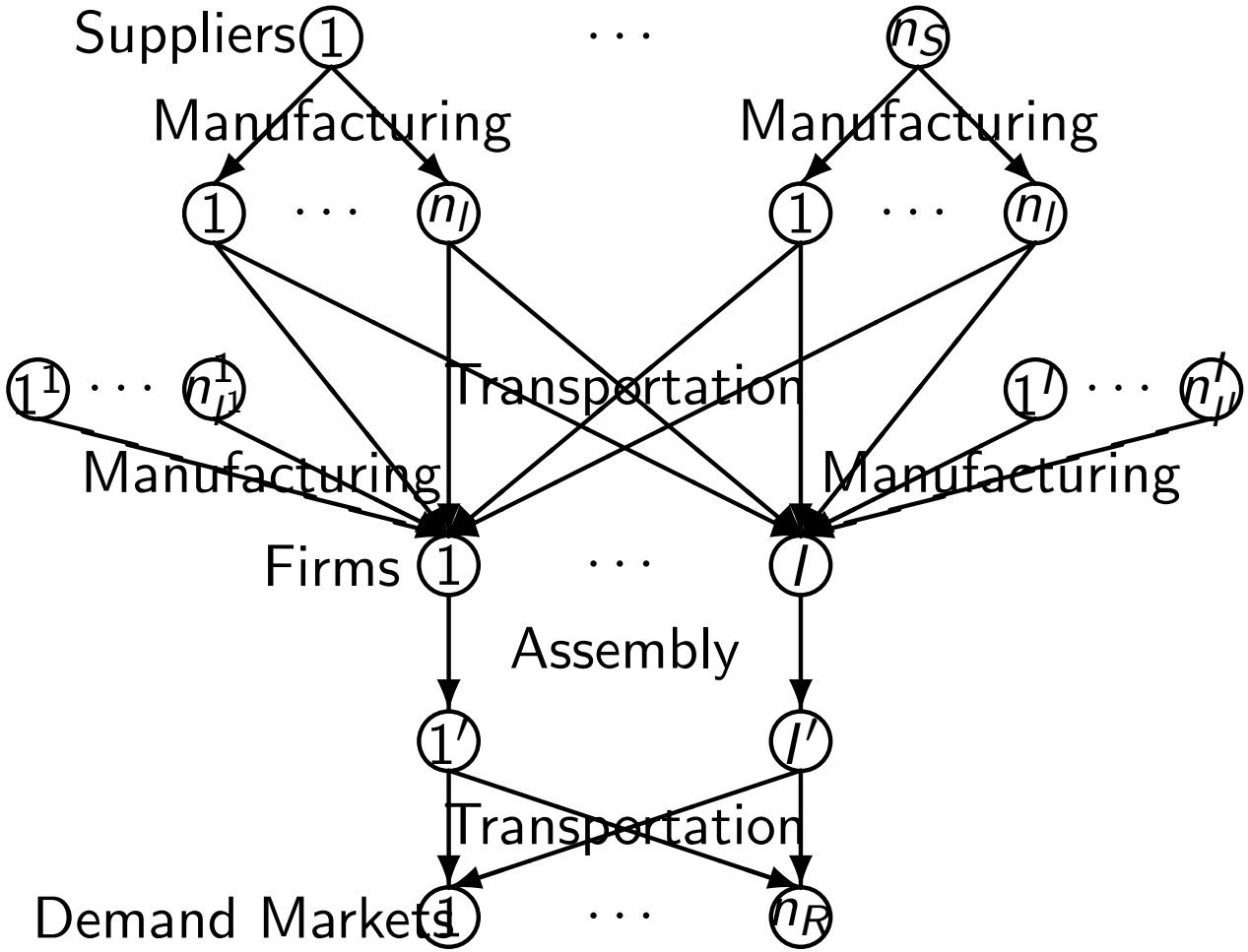


Figure: The Multitiered Supply Chain Network Topology

Blood Supply Chains in the Pandemic and Convalescent Plasma

Blood Supply Chains

Blood is a unique product since it cannot but manufactured but must be donated.

Blood is a perishable product with the shelf life of platelets being **5 days** and of red blood cells – **42**.

Blood transfusions are integral parts of major surgeries. Blood is used in the treatment of diseases, particularly sickle cell anemia and some cancers. Blood is also needed for victims who have injuries caused by accidents or natural disasters.

Blood Supply Chains - Some Background

- **Before the pandemic, every day, the US needed 36,000 units of red blood cells, 7,000 units of platelets, and 10,000 units of plasma.**

- An estimated **38%** of the US population is **eligible to donate** blood at any given time. However, **less than 10%** of that eligible population actually **donates** blood each year.

- **Issues of seasonality** place additional pressure on blood service organizations on obtaining blood donations.

Blood Supply Chains - Some Background

- **The blood services industry has gone through a massive transformation in the past decade, even before the pandemic hit.**

- There have been **economic pressures, driven by the need to reduce costs**, while, at the same time, having to test for new diseases such as Zika.

- At the same time, with enhanced medical procedures, there has been a decrease in demand for blood in certain surgeries.

- Blood service organizations, the majority of which are nonprofits, have been subject to competition and also **to mergers and acquisitions**.

Blood Supply Chains

The American Red Cross is the major supplier of blood products to hospitals and medical centers satisfying about **40%** of the demand for blood components nationally.

American Red Cross

Together, we can save a life

Blood Supply Chain in the Pandemic

ABC NEWS | CORONAVIRUS HEALTH & SCIENCE

COVID-19 battle takes toll on New York City blood supply: Mayor

The city's blood center is down to a two-day supply.

By Bill Hutchinson
May 17, 2020, 2:18 PM • 7 min read

FDA STATEMENT

Coronavirus (COVID-19) Update: FDA Provides Updated Guidance to Address the Urgent Need for Blood During the Pandemic

American Red Cross Faces Severe Blood Shortage As Coronavirus Outbreak Threatens Availability of Nation's Supply

KHQA

Blood donations needed during pandemic

by Iowa's News Now | Friday, April 24th 2020

WHYY PBS npr

CORONAVIRUS PANDEMIC

How COVID-19 led to a blood shortage, and why that's troubling

By Alan Yu · May 1, 2020

c|net Health and Wellness

FEATURED FITNESS SLEEP HEALTHY EATING CAREGIVING

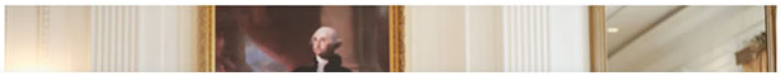
How to donate blood during the coronavirus pandemic

The Surgeon General is urging healthy Americans to give in the wake of a mass blood shortage due to blood donation drive cancellations.

The Washington Post
Democracy Dies in Darkness

Health

Blood banks narrowly averted a supply crisis. But they're 'worried about four weeks from now.'



Coronavirus Crisis

NOOZHAWK the freshest news in Santa Barbara

Blood Banks Call for Urgent Donations Due to COVID-19 Pandemic

Officials urge potential givers to make appointments in the next few weeks; type O donors are especially needed

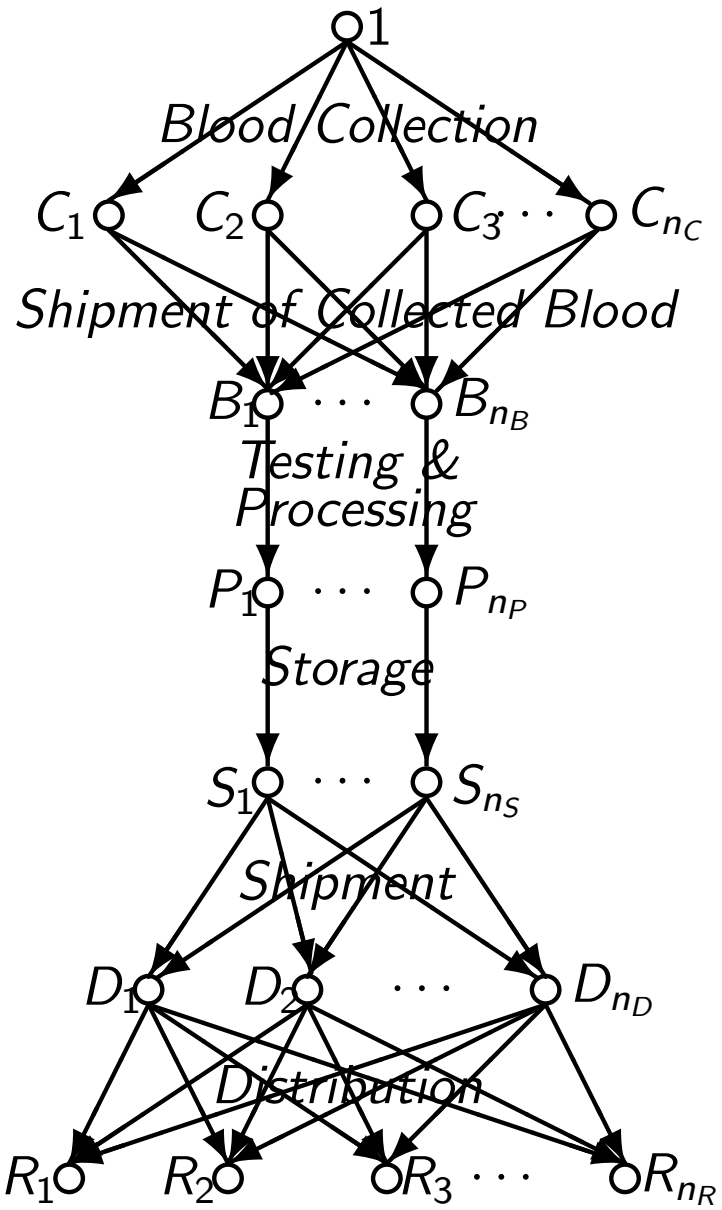
Additional Challenges in the Pandemic

- **With the pandemic, and school and business office closures**, there are fewer convenient collection sites, and also fewer available donors since one cannot donate while sick. **The Red Cross in mid March had to cancel nearly 2,700 blood drives resulting in some 86,000 fewer blood donations.** More than 80% of the blood the Red Cross collects comes from drives held at these locations.
- Elective surgeries were postponed / cancelled in the first months of the pandemic causing a potential surge in demand once restrictions are loosened.
- **Some donors are concerned about risk of contracting Covid-19, although blood service organizations have now stepped up with greater attention to sanitation but extra infection control takes time.**
- Workers are getting ill causing disruptions to the labor supply as well as greater difficulty in getting appointments for blood donations.

Blood Supply Chains for the Red Cross

A. Nagurney, A.H. Masoumi, and M. Yu, "Supply Chain Network Operations Management of a Blood Banking System with Cost and Risk Minimization," *Computational Management Science* **9(2) (2012), pp 205-231.**

Supply Chain Network Topology for a Regionalized Blood Bank



ARC Regional Division

Blood Collection Sites

Blood Centers

Component Labs

Storage Facilities

Distribution Centers

Demand Points

Blood Supply Chains for the Red Cross

Our blood supply chain network optimization model for the management of the procurement, testing and processing, and distribution has such novel features as:

- It captures **perishability of this life-saving product** through the use of arc multipliers;
- It contains **discarding costs** associated with waste/disposal;
- It handles **uncertainty** associated with demand points;
- It assesses **costs associated with shortages/surpluses at the demand points**, and
- It quantifies the **supply-side risk** associated with procurement.

Blood Supply Chains

In the paper, **"Mergers and Acquisitions in Blood Banking Systems: A Supply Chain Network Approach," A.H. Masoumi, M. Yu, and A. Nagurney,** *International Journal of Production Economics* **193 (2017), pp 406-421**,

we constructed network models to assess possible synergies associated with mergers and acquisitions among blood service organizations, taking into account capacities and frequencies of various supply chain network link activities.

Our results reveal that, for geographically distant merging blood banks, under a demand surge scenario, the merged organization will experience a significant synergy, both in terms of the total operational cost as well as the expected shortage penalty despite the distance between the blood banks.

This is relevant also to the teaming of blood banks as in the pandemic.

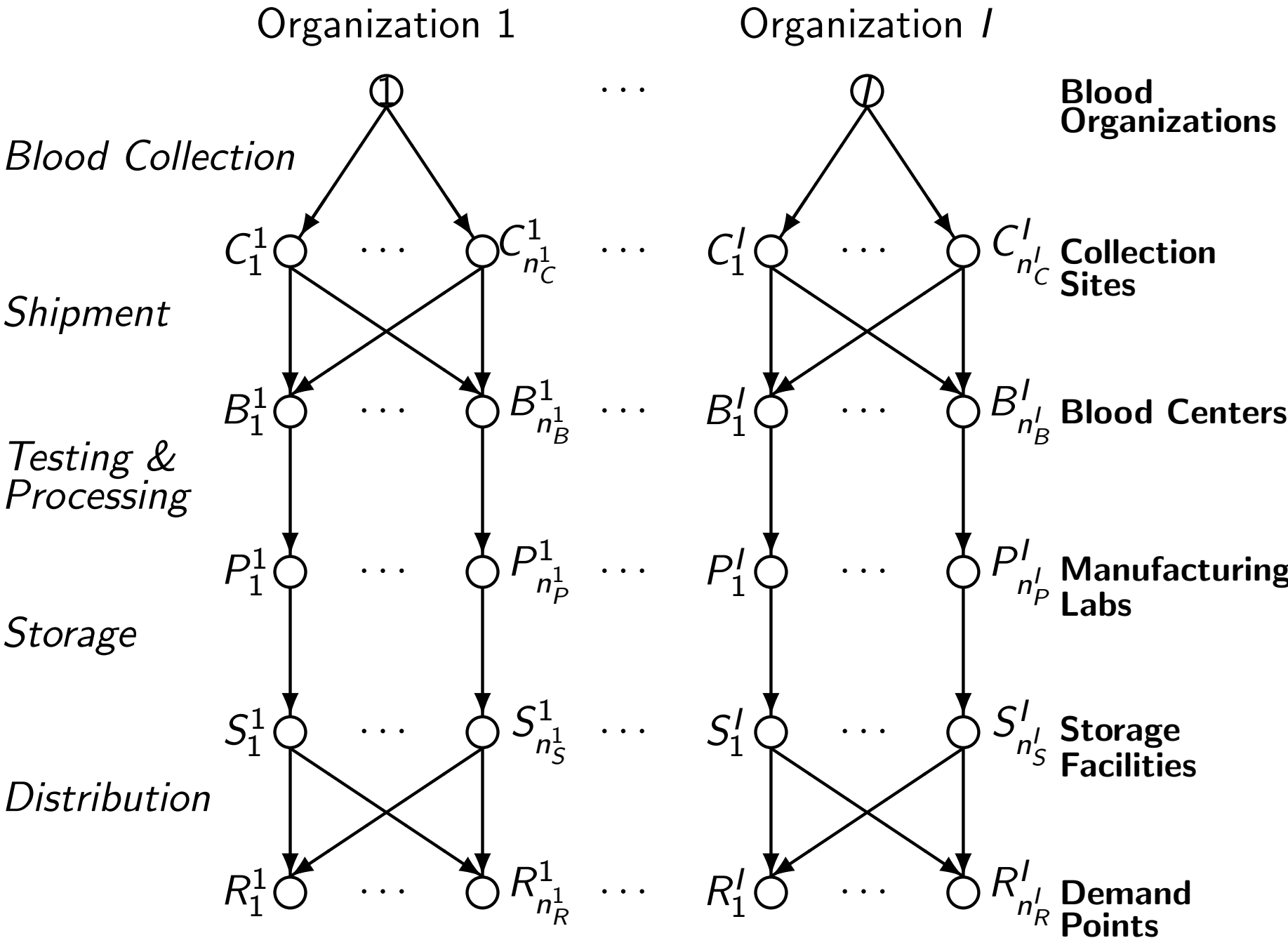


Figure: Supply Chain Network Topology Pre-Merger

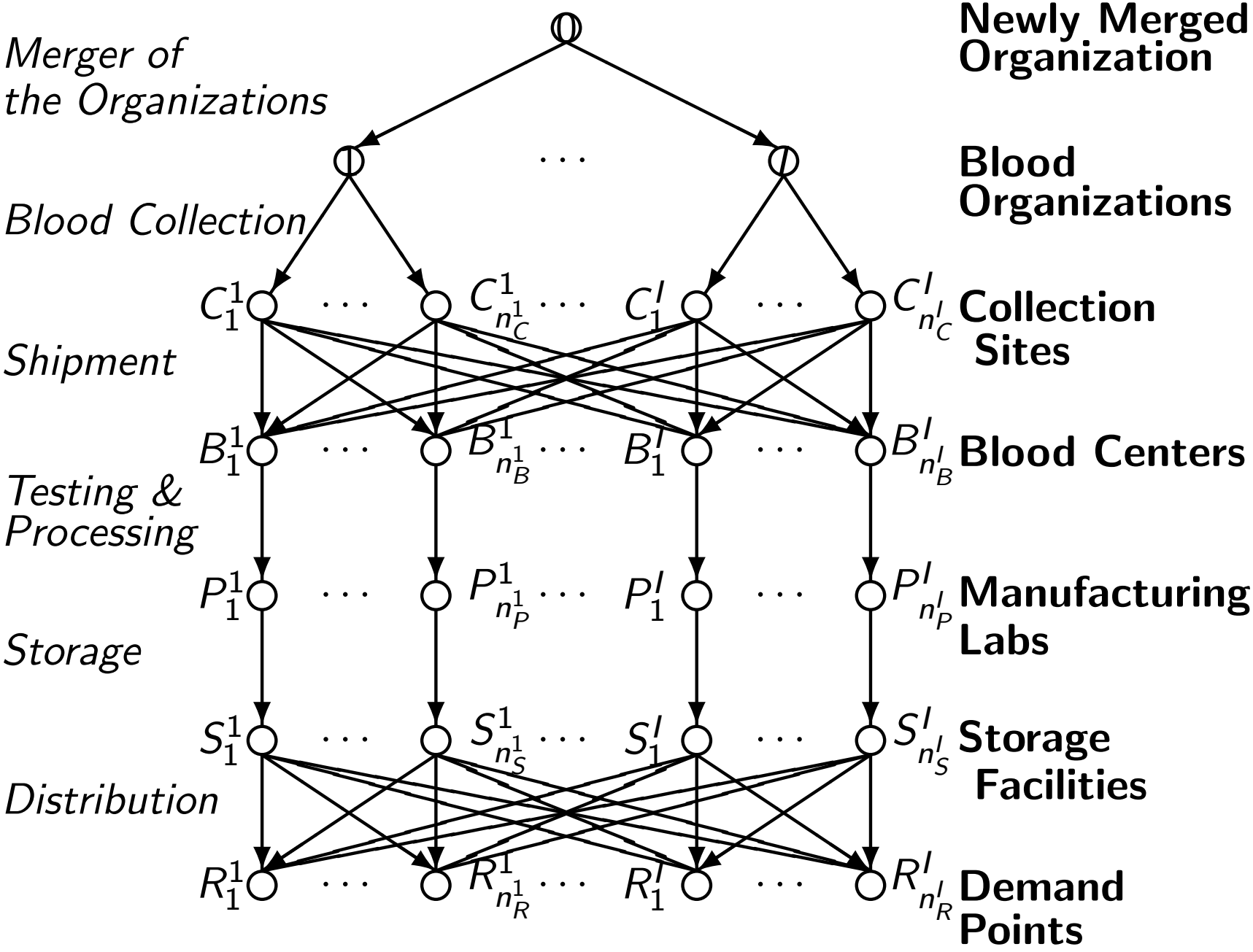
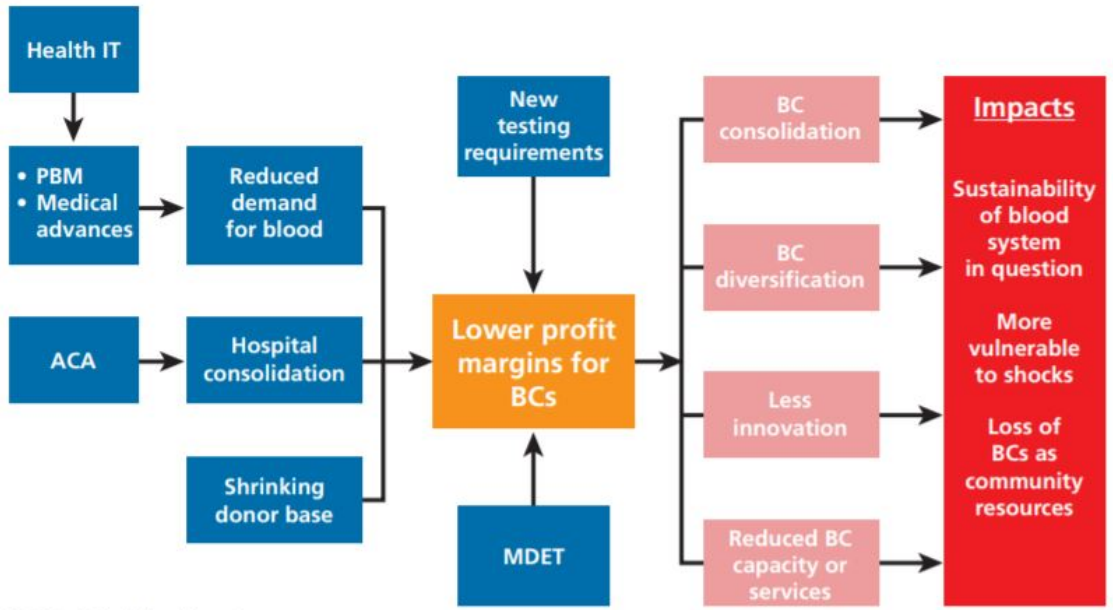


Figure: Supply Chain Network Topology Post-Merger

Blood Supply Chain Competition

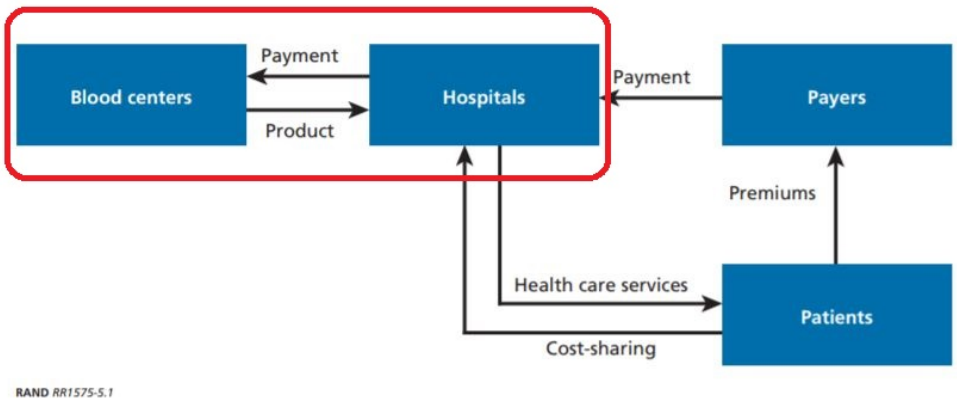
- One of the implications of these challenges is the **rise of competition** among the blood service organizations.
- On one hand, they compete for the **limited pool of eligible blood donors** and on the other hand, for **supply contracts with hospitals**.



Blood Supply Chain Competition

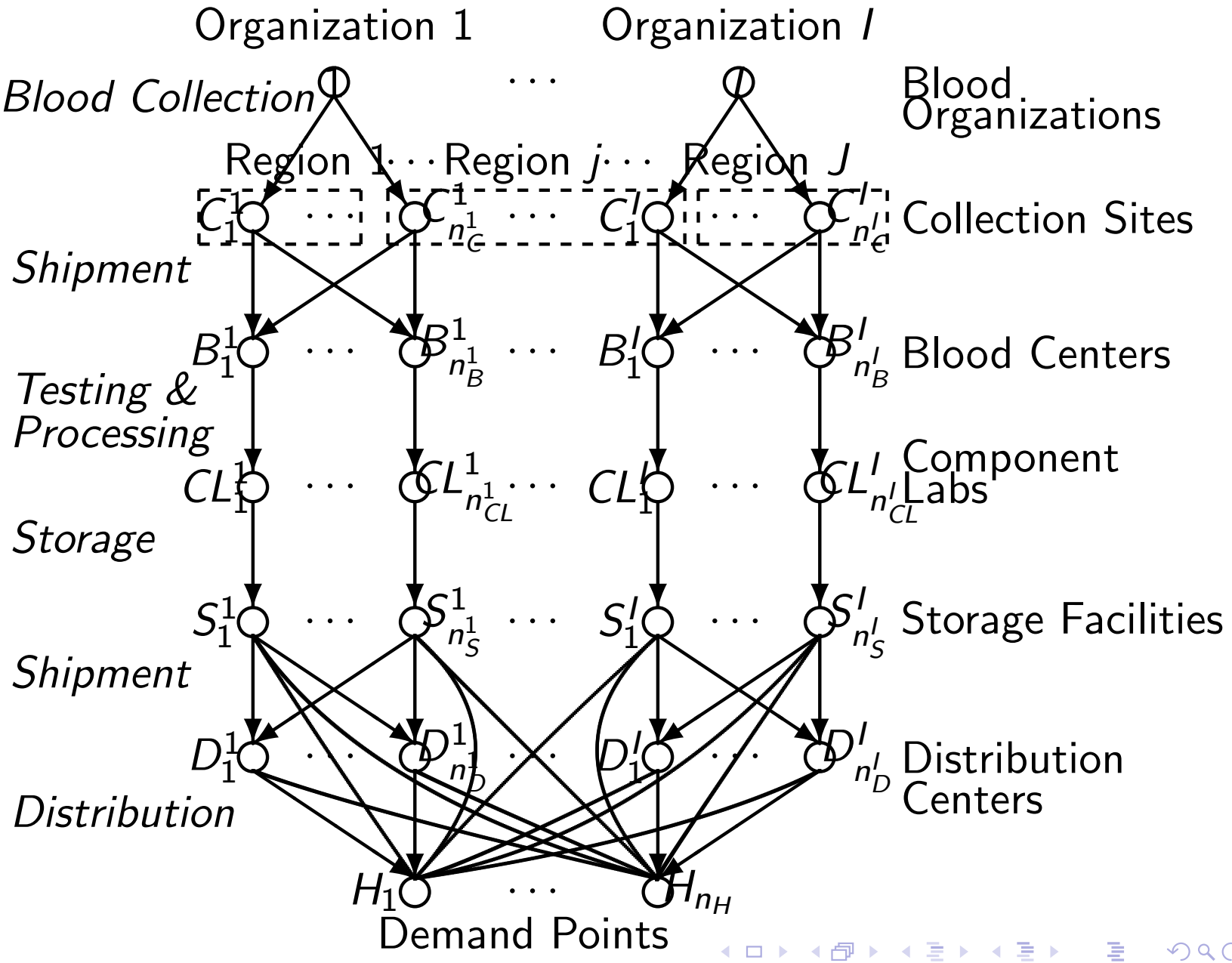
A. Nagurney and P. Dutta, "Supply Chain Network Competition Among Blood Service Organizations: A Generalized Nash Equilibrium Framework," *Annals of Operations Research* **275(2) (2019), pp 551-586.**

We focus on the **operational challenges faced by blood service organizations** and their transactions with hospitals.



A. Nagurney and P. Dutta, "Competition for Blood Donations," *Omega* **212** (2019), pp 103-114.

Blood Supply Chain Competition

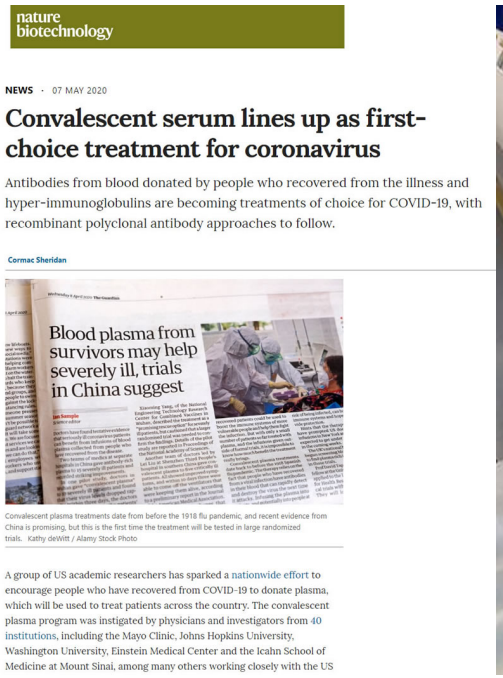


Convalescent Plasma and Hope

- **As of May 1, 2020, according to data tracked by Johns Hopkins University, about 154,000 people in the United States have recovered from the deadly virus.**
- Convalescent plasma of those who have recovered from Covid-19 contains antibodies that can fight the virus SARS-CoV-2 causing the disease.
- **In a study posted on May 22, 2020, and reported in the WSJ: Sick patients who got plasma transfusions from those who had recovered from the coronavirus infection had better survival rates compared with a control group.**
- **Investigations into convalescent plasma are taking place globally, including in Europe and India.**

Convalescent Plasma and Hope

As of May 14, 2020, almost 10,500 COVID-19 patients have now received the treatment at facilities across the country, according to the Mayo Clinic in Rochester, Minnesota, with Mount Sinai Hospital in NYC, which is part of the national coalition, using it on more than 350 COVID-19 patients.



nature biotechnology

NEWS · 07 MAY 2020

Convalescent serum lines up as first-choice treatment for coronavirus

Antibodies from blood donated by people who recovered from the illness and hyper-immunoglobulins are becoming treatments of choice for COVID-19, with recombinant polyclonal antibody approaches to follow.

Cormac Sheridan

Blood plasma from survivors may help severely ill, trials in China suggest

Convalescent plasma treatments date from before the 1918 flu pandemic, and recent evidence from China is promising, but this is the first time the treatment will be tested in large randomized trials. Kathy deWitt / Alamy Stock Photo

A group of US academic researchers has sparked a nationwide effort to encourage people who have recovered from COVID-19 to donate plasma, which will be used to treat patients across the country. The convalescent plasma program was instigated by physicians and investigators from 40 institutions, including the Mayo Clinic, Johns Hopkins University, Washington University, Einstein Medical Center and the Icahn School of Medicine at Mount Sinai, among many others working closely with the US

This convalescent plasma has been found to be safe.

Our Work on a Convalescent Plasma Model

Our new paper, **"A Multiclass, Multiproduct Covid-19 Conavescent Plasma Donor Equilibrium Model," A. Nagurney and P. Dutta (2020), captures competition between nonprofit organizations and for profit ones for convalescent plasma.**

A very interesting market has now arisen in which organizations are competing for survivors blood and some for profit organizations are offering monetary compensation to donors that can be quite high.

Additional products from convalescent plasma include hyperimmune globulin and monoclonal antibodies.

Our Work on a Convalescent Plasma Model

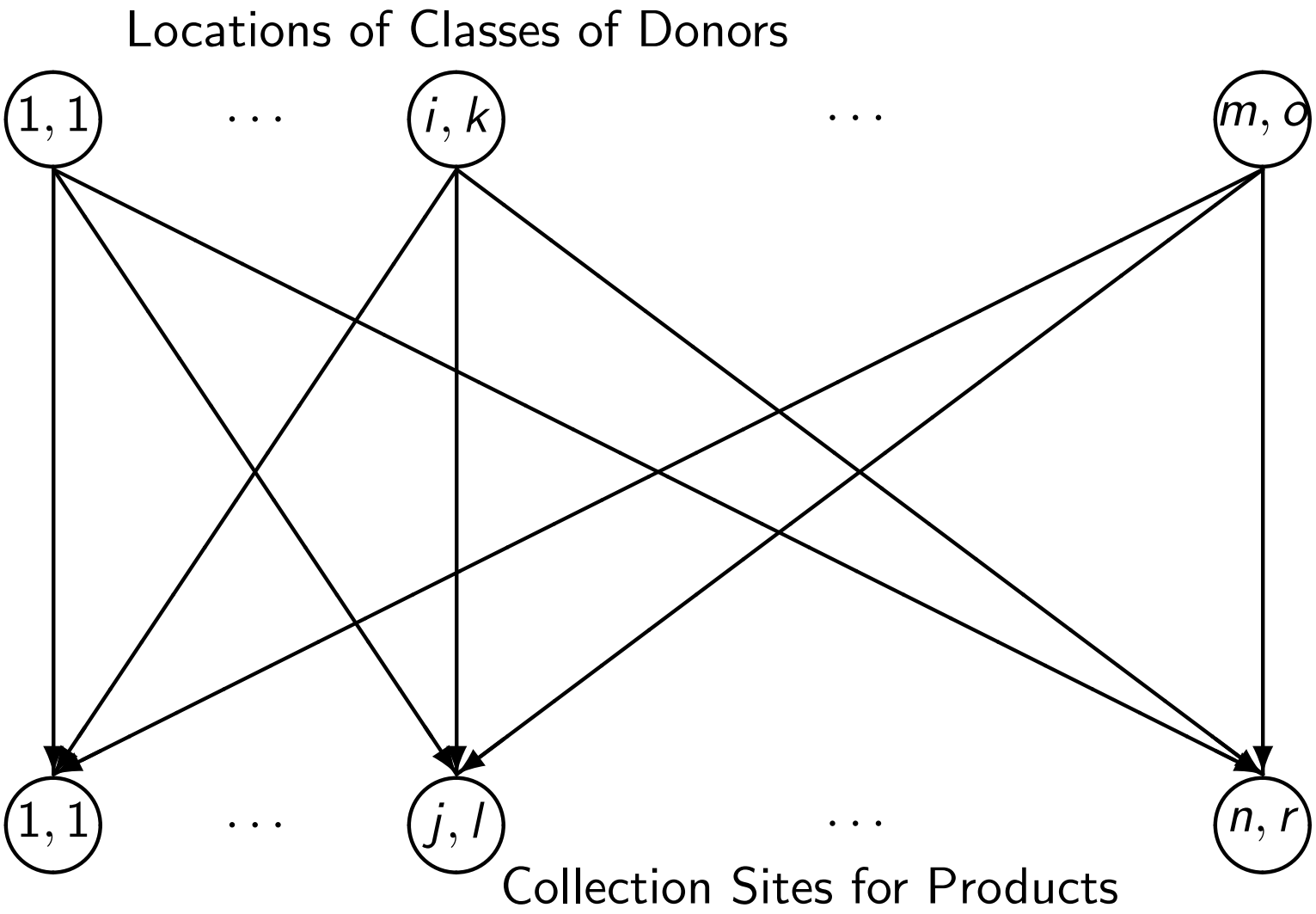


Figure: The Network Structure of the Multiclass, Multiproduct Convalescent Plasma Donor Model

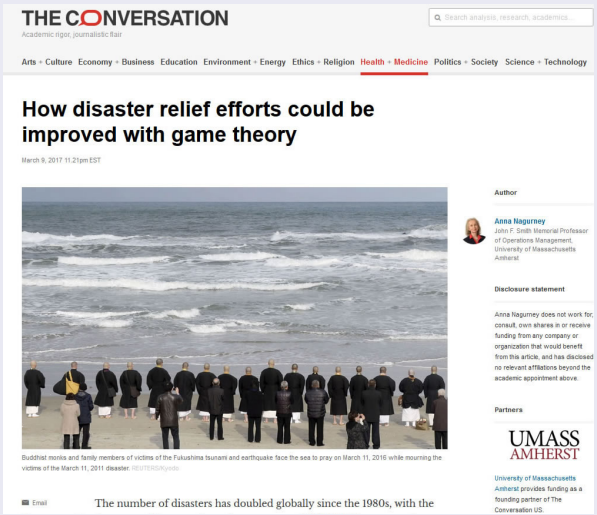
Our Work on a Convalescent Plasma Model

Some findings from the numerical computations which focus on NYC, which is now an epicenter of the pandemic in the United States.

- It is important to make the experience of donating convalescent plasma as positive as feasible since a decrease in a utility function fixed term can impact donations.
- Care should be taken when a for profit moves in since convalescent plasma donors may shift their donations from nonprofit organizations to a for profit one.
- Proximity matters and convenience of collection sites.
- Availability of labor needed for the collection process during the pandemic and capacities of the collection sites play an important role. Organizations collecting convalescent plasma need to have the resources to collect from the donors.

Impacting Policy Through Analytics

Writing OpEds



THE CONVERSATION

Academic rigor, journalistic flair

Arts + Culture Economy + Business Education Environment + Energy Ethics + Religion Health + Medicine Politics + Society Science + Technology

How disaster relief efforts could be improved with game theory

March 9, 2017 11.21pm EST

Buddhist monks and family members of victims of the Fukushima tsunami and earthquake face the sea to pray on March 11, 2016 while mourning the victims of the March 11, 2011 disaster. REUTERS/Kyodo

Email

The number of disaters has doubled globally since the 1980s, with the

Author

Anna Nagurney

John F. Smith Memorial Professor of Operations Management, University of Massachusetts Amherst

Disclosure statement

Anna Nagurney does not work for, consult, own shares in or receive funding from any company or organization that would benefit from this article, and has disclosed no relevant affiliations beyond the academic appointment above.

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University of Massachusetts Amherst provides funding as a founding partner of The Conversation US.

Chicago Tribune

SPORTS BREAKING HOY MOST POPULAR OPINION SUBURBS ENTERTAINMENT ADVERTISING

Response to natural disasters like Harvey could be helped with game theory

By Anna Nagurney

Associated Press

AUGUST 29, 2017 | BOSTON, MASSACHUSETTS

(The Conversation is an independent and nonprofit source of news, analysis and commentary from academic experts.)

Anna Nagurney, University of Massachusetts Amherst

(THE CONVERSATION) The devastation by Hurricane Harvey continues, with the National Weather Service calling the event unprecedented, thus making the response even more complicated.

Nearly half a million people are expected to seek federal aid in the aftermath of the Category 4 hurricane, which already has dumped more than 30 inches on the Houston

SALON VIDEO NEWS POLITICS ENTERTAINMENT LIFE

THURSDAY, AUG 31, 2017 10:38 AM EST

Time for some game theory: How responses to natural disasters like Harvey could be improved

The damage and losses from natural disasters are estimated to cost us $100 billion a year since 2000

ANNA NAGURNEY, THE CONVERSATION

Homeland Security News Wire

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Disaster response

How disaster relief efforts could be improved with game theory

By Anna Nagurney

Published 13 March 2017

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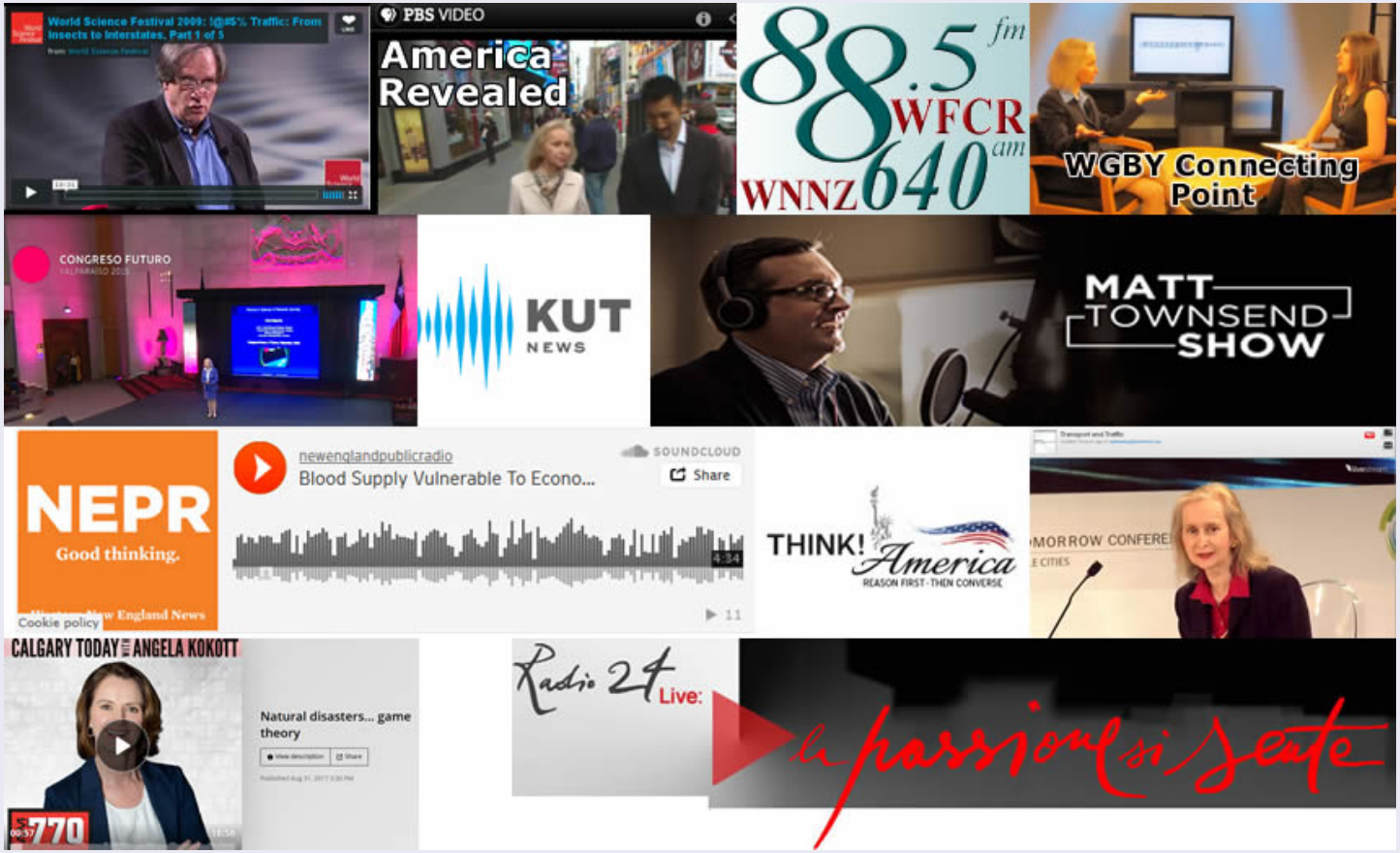
The number of disasters has doubled globally since the 1980s, with the damage and losses estimated at an average

Coverage by the Media



Writing OpEds

On March 11, 2020 the WHO declared the pandemic. On March 12 my article on blood supply chains in *The Conversation* appeared and, on March 24 my article in INFORMS *Analytics Coronavirus Chronicles*.

THE CONVERSATION

Academic rigor, journalistic flair

How coronavirus is upsetting the blood supply chain

March 12, 2020 8.05am EDT

Email
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The coronavirus, which causes the disease COVID-19, has created enormous anxiety, uncertainty, and disruption to our lives. Much has already been written about potential shortages of medicines and face masks, but little has been said about something only you and I can provide – lifesaving blood.

Our nation's blood supply is essential to our health care security. Blood transfusions are integral parts of major surgeries. Blood is used in the treatment of diseases, particularly sickle cell anemia and some cancers. Blood is needed for victims who have injuries caused by accidents or natural disasters. Every day, the U.S. needs 36,000 units of red blood cells, 7,000 units of platelets, and 10,000 units of plasma.

I am a professor and director of the Virtual Center for Supernetworks at the University of Massachusetts Amherst. Because of the escalating coronavirus health care crisis, I am deeply concerned the U.S. blood supply chain is under stress. The timing could hardly be worse; the COVID-19 outbreak coincides with our seasonal flus and colds.

Patients need blood in many states

Many states, including Washington, California, Kansas, Pennsylvania, the Carolinas, Massachusetts and Rhode Island, are now calling for blood donations. At the same time, some states are closing schools and other sites that typically host mobile blood drives; even prior to the coronavirus, some events had been canceled. In Massachusetts, the Red Cross announced last September it would no

Analytics

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informs

March 24, 2020 in Coronavirus Chronicles

The COVID-19 Pandemic and the Stressed Blood Supply Chain

By Anna Nagurney

SHARE: PRINT ARTICLE: https://doi.org/10.1287/LYTX.2020.02.18

Blood is essential to our nation's healthcare security. It is a life-saving product that cannot be manufactured and comes solely from volunteer donors. No substitute for blood has yet been invented. Blood transfusions are integral parts of major surgeries. Blood is a must for saving victims of accidents and natural disasters. Blood is also used in the treatment of certain diseases, including certain cancers. In the United States, 36,000 units of red blood cells are needed daily as are 7,000 units of platelets and 10,000 units of plasma. A typical donation of one pint, which can be divided into red blood cells, plasma and platelets, can save up to three lives. Adults have 8-12 pints of blood.

Even in the best of times, the complex blood supply chain in the United States is under stress. Although 38% of the U.S. population is eligible to donate blood, less than 10% actually does so in a year. Furthermore, issues of seasonality come into play with flu and colds cutting donations; the same for weather-related events and holidays. To further complicate matters, blood is perishable; platelets last five days and red blood cells have a shelf life of 42 days.

The blood banking industry, entrusted with maintaining a sufficient supply of blood, is facing a battle of the century with the COVID-19 pandemic. The timing could not be worse with this year's heavy flu and cold season, and the blood banking industry having recently undergone a massive transformation due to both economics and changes in medical procedures [1]. For example, there is increased competition among blood service organizations for donors [2]. The American Red Cross has closed some testing facilities and even eliminated mobile collection units in parts of the country. There have also been mergers and acquisitions of blood service organizations [3]. On the other hand, hospitals are now requiring less blood for certain procedures as compared to a few years ago because of changes in medical practices. This has resulted in requests for lower prices for blood from blood banks, who still have to cover costs, and some of the new costs include higher testing costs due to diseases such as Zika. And now, because of the COVID-19 pandemic, a major source of blood donations – schools – is removed.

The critical blood supply chain is unique from others that we study in operations research (O.R.) because it requires altruistic donations, collection, testing, processing and distribution to hospitals and medical centers. The blood supply chain can be visualized, modeled and studied as a network [4]. The coronavirus can disrupt the links in the blood supply chain network through a variety of means. If donors are ill, they cannot donate; if the staff is ill, they cannot collect, test, process and distribute blood. If our healthcare workers are compromised, they cannot transfuse.

In China, specifically Wuhan where the coronavirus is generally thought to have originated, blood donations have

Coverage by the Media During the Pandemic

Impacting Policy Through Analytics

On April 22, 2020, a letter from California Attorney General Xavier Becerra to the Admiral Brett Giroir, the Assistant Secretary of the US Department of Health & Human Services, and signed by US Attorney Generals of 21 other states, requested updates, because of the pandemic blood shortages, to blood donation policies that discriminate.

My article in *The Conversation*, which was reprinted in LiveScience, was the first reference and was cited on the first page.

Impacting Policy Through Analytics

State of California
Office of the Attorney General
XAVIER BECERRA
ATTORNEY GENERAL

April 22, 2020

Via Electronic Mail

The Honorable Admiral Brett Giroir, MD
Assistant Secretary for Health
U.S. Department of Health & Human Services
Mary E. Switzer Building
330 C Street SW, Room L600
Washington, DC 20024
Attn: ACBTSA-PAHPAIA Sec. 209
ACBTSA@hhs.gov

RE: "Solicitation for Public Comments on Section 209 of the Pandemic and All-Hazards Preparedness and Advancing Innovation Act," 85 Fed. Reg. 16,372 (March 23, 2020)

Dear Assistant Secretary Giroir:

The undersigned State Attorneys General from California, Colorado, Connecticut, Delaware, the District of Columbia, Hawaii, Illinois, Iowa, Maine, Massachusetts, Michigan, Minnesota, Nevada, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Vermont, and Virginia submit this letter in response to the federal government's "Solicitation for Public Comments on Section 209 of the Pandemic and All-Hazards Preparedness and Advancing Innovation Act," (85 Fed. Reg. 16,372). We support the Office of the Assistant Secretary for Health in the U.S. Department of Health and Human Services' (HHS) efforts and work in maintaining an adequate national blood supply during the COVID-19 pandemic.

An adequate blood supply is critical to the nation's healthcare. Blood transfusions and blood products are needed for major surgeries, to treat diseases such as sickle cell anemia and some cancers, and to treat victims who have injuries caused by accidents or natural disasters.[1] Every day, the United States needs approximately 36,000 units of red blood cells, nearly 7,000

[1] Anna Nagurney, How Coronavirus is Upsetting the Blood Supply Chain, Live Science (Mar. 13, 2020), https://www.livescience.com/coronavirus-blood-supply-chain.html/.

Impacting Policy Through Analytics

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HECTOR BALDERAS
New Mexico Attorney General

LETITIA JAMES
New York Attorney General

Enhanced Visibility and Influencing Students

University of Massachusetts Amherst

Isenberg School of Management

Faculty Research: Blood Supply Chain Article Influences Public Policy

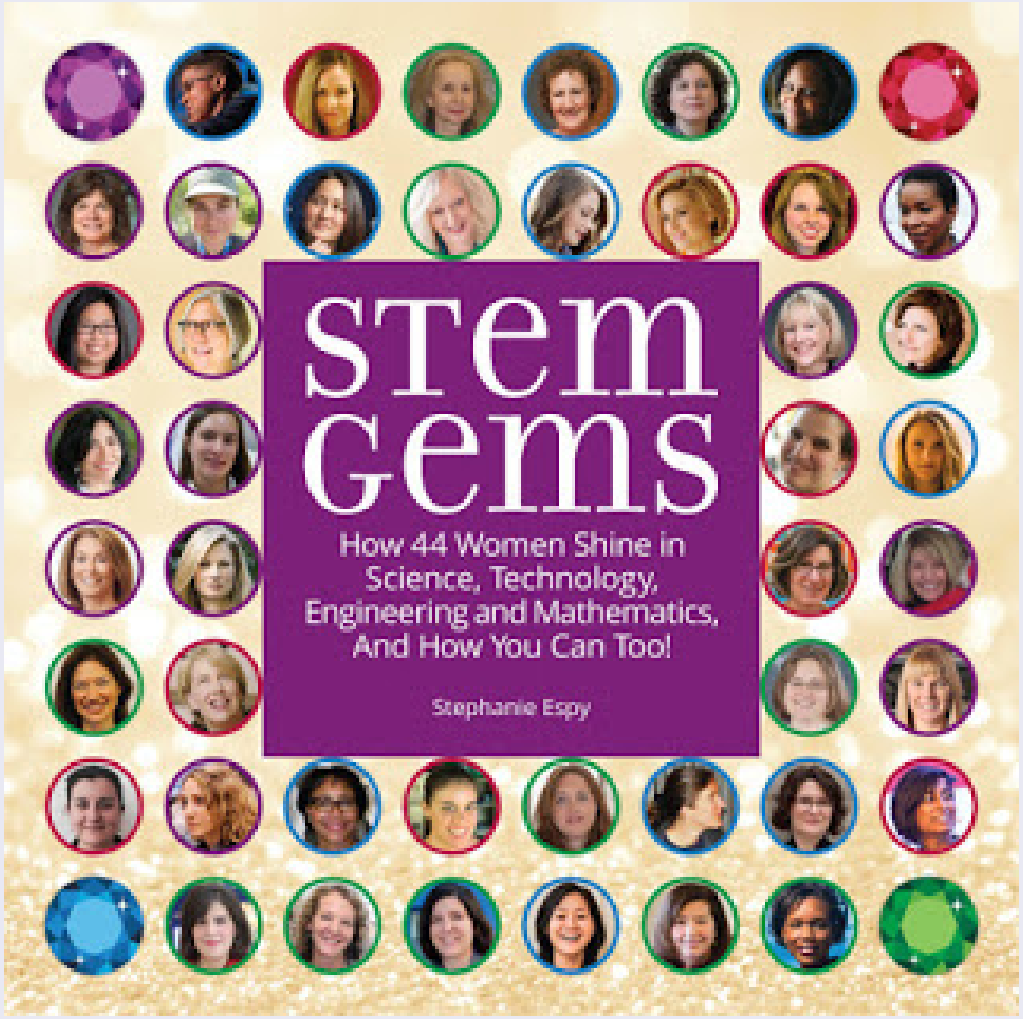
April 24, 2020

Isenberg's **Anna Nagurney**, John F. Smith Memorial Professor of Operations Management, has been getting calls from media outlets since it became clear that the coronavirus pandemic was leading to unusual supply chain shortages, from toilet paper and canned soup to surgical masks and pharmaceutical products.

Nagurney's academic research, which focuses on how supply chains can be optimized to respond to global crises, is in high demand among journalists and policy-makers: She has recently been quoted in several articles, including one in the *Verge* where she explains how retailers are having to totally rethink the algorithms they use to determine what items to keep on their shelves. In *USA Today*, Nagurney is quoted discussing shortages of diapers, and in the *Morning Consult*, she explains how shortages of blood supplies and pain medication could disproportionately affect people of color with sickle cell anemia and other chronic diseases. Her more general thoughts about supply chains during the pandemic have been featured on the UMass Amherst homepage, Greenwire, and in podcasts hosted by the American Mathematical Society and Farm Talk radio in Fargo, North Dakota. She appears (from her home office, via video feed) on the broadcast ofNBC 10 in Boston to chat about problems in the meat supply chain.

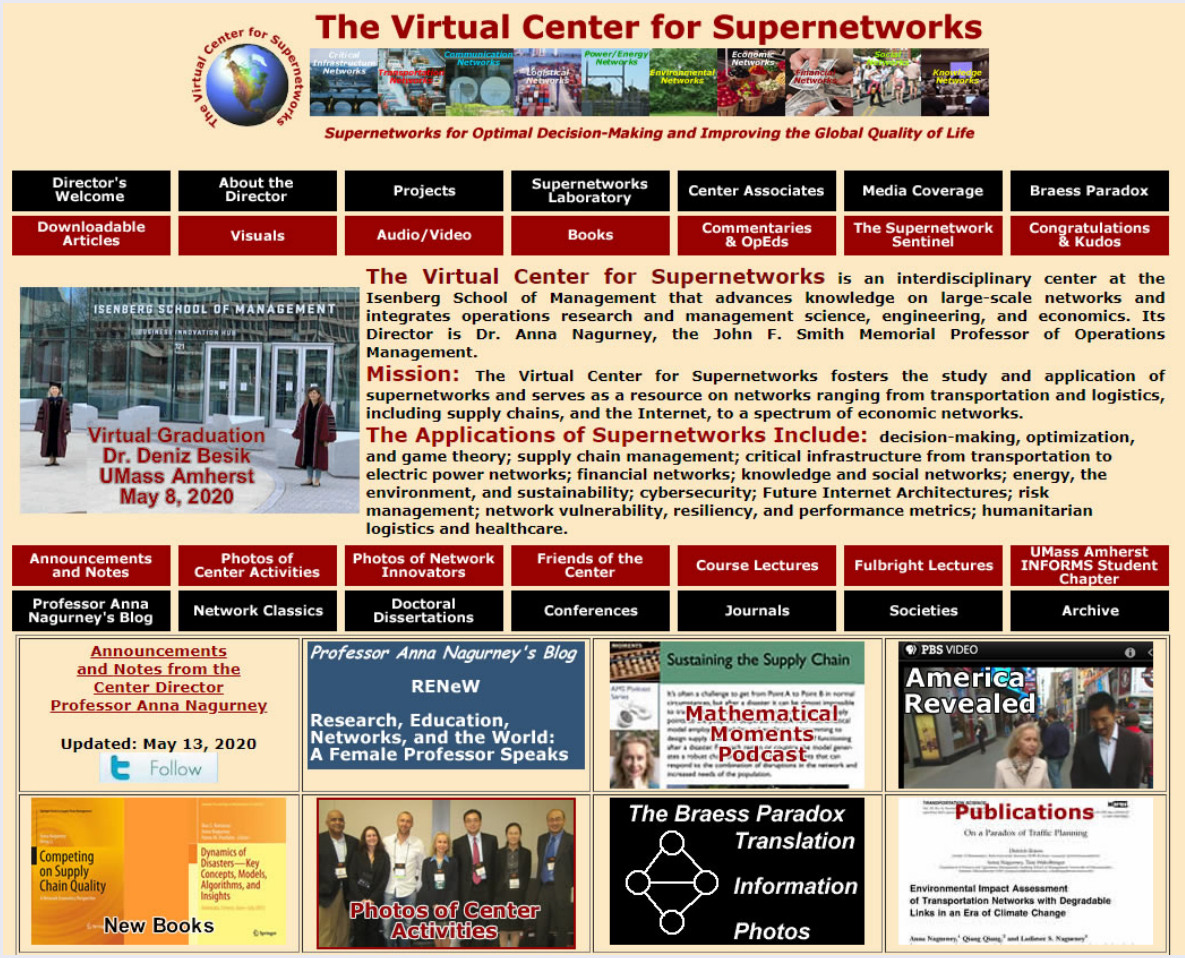
Article on the Isenberg School website.

Enhanced Visibility and Influencing the Younger Generation



Honored to be one of 44 Females in STEM featured in this book geared to inspiring girls.

Thank You!



For more information, see: http://supernet.isenberg.umass.edu