OR and COVID-19: From Research to Policy Making an Impact Lightning Talk

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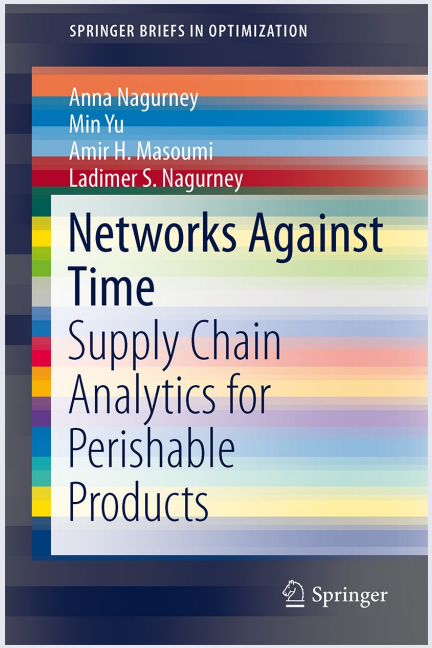
EURO Conference, July 11-14, 2021

A Multidisciplinary Approach to Supply Chain Networks

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 and vaccines to food.



Many such supply chains have been severely disrupted in the pandemic due to negative impacts on labor!

It's All About People

A major research theme of ours in the COVID-19 pandemic is the inclusion of labor in supply chains, using optimization and game theory.

ORMS TODAY informs membership magazine

NEWS FEATURES PODCASTS

January 29, 2021 in Supply Chain Networks

In the End, It's All About People

COVID-19 vaccine production reveals dependency on supply chains, labor workforce in the U.S.

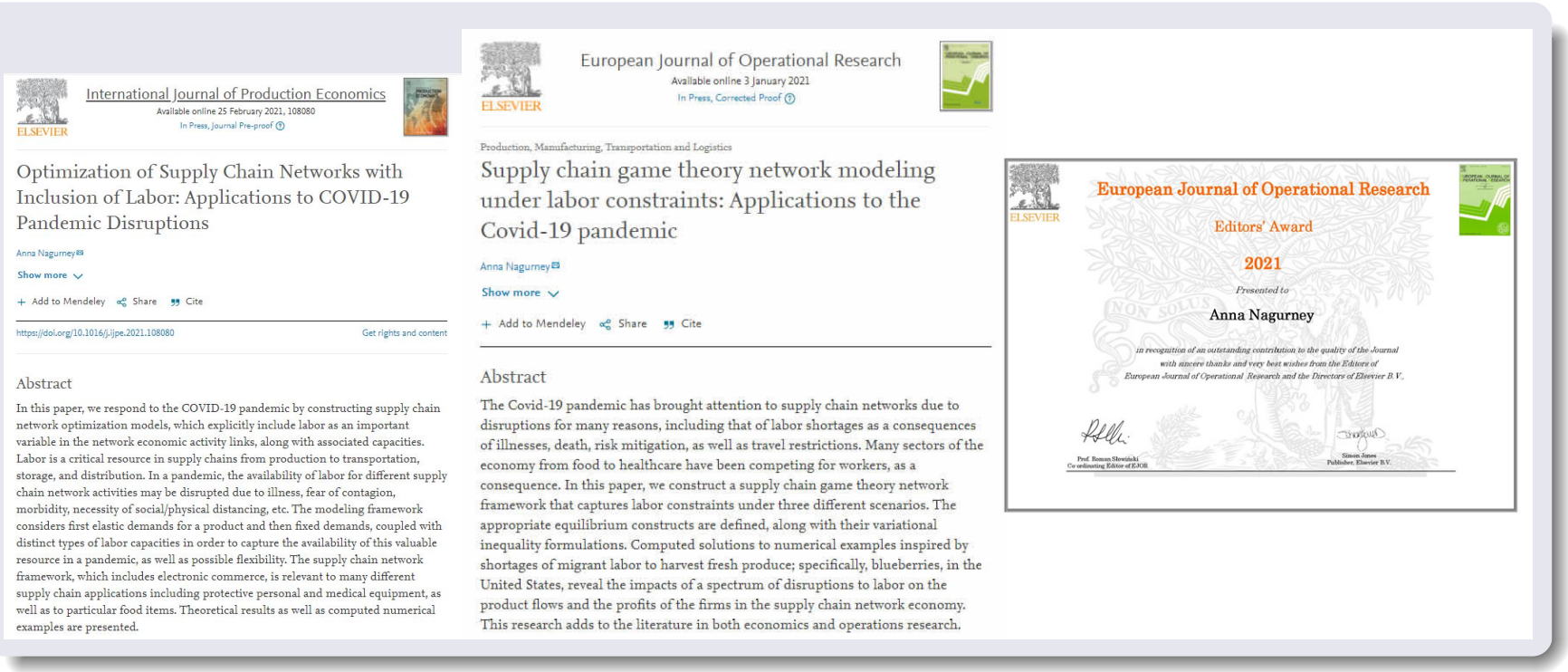
By Anna Nagurney

SHARE: PRINT ARTICLE: https://doi.org/10.1287/orms.2021.01.17

The COVID-19 pandemic has dramatically revealed how dependent we are on supply chains and the availability of labor. Without the human element, meatpacking plants cannot function; fresh produce cannot be picked; grocery stores cannot be shelved; PPEs cannot be produced and distributed; and products cannot be delivered to our homes

Research and Publications

In a series of papers we constructed supply chain network models with labor that included productivity factors and constraints on labor in order to identify the impacts of disruptions and to suggest possible mitigation procedures.



International Journal of Production Economics
Available online 25 February 2021, 108080
In Press, Journal Pre-proof

Optimization of Supply Chain Networks with Inclusion of Labor: Applications to COVID-19 Pandemic Disruptions

Anna Nagurney

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https://doi.org/10.1016/j.ijpe.2021.108080 Get rights and content

Abstract

In this paper, we respond to the COVID-19 pandemic by constructing supply chain network optimization models, which explicitly include labor as an important variable in the network economic activity links, along with associated capacities. Labor is a critical resource in supply chains from production to transportation, storage, and distribution. In a pandemic, the availability of labor for different supply chain network activities may be disrupted due to illness, fear of contagion, morbidity, necessity of social/physical distancing, etc. 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, which includes electronic commerce, is relevant to many different supply chain applications including protective personal and medical equipment, as well as to particular food items. Theoretical results as well as computed numerical examples are presented.

European Journal of Operational Research
Available online 3 January 2021
In Press, Corrected Proof

Production, Manufacturing, Transportation and Logistics

Supply chain game theory network modeling under labor constraints: Applications to the Covid-19 pandemic

Anna Nagurney

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Abstract

The Covid-19 pandemic has brought attention to supply chain networks due to disruptions for many reasons, including that of labor shortages as a consequences of illnesses, death, risk mitigation, as well as travel restrictions. Many sectors of the economy from food to healthcare have been competing for workers, as a consequence. In this paper, we construct a supply chain game theory network framework that captures labor constraints under three different scenarios. The appropriate equilibrium constructs are defined, along with their variational inequality formulations. Computed solutions to numerical examples inspired by shortages of migrant labor to harvest fresh produce; specifically, blueberries, in the United States, reveal the impacts of a spectrum of disruptions to labor on the product flows and the profits of the firms in the supply chain network economy. This research adds to the literature in both economics and operations research.

European Journal of Operational Research

Editors' Award

2021

Presented to

Anna Nagurney

in recognition of an outstanding contribution to the quality of the Journal with sincere thanks and very best wishes from the Editors of European Journal of Operational Research and the Directors of Elsevier B.V.

Prof. Roman Slowinski
Co-ordinating Editor of EJOR

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Supply Chain Model with Different Labor Constraints

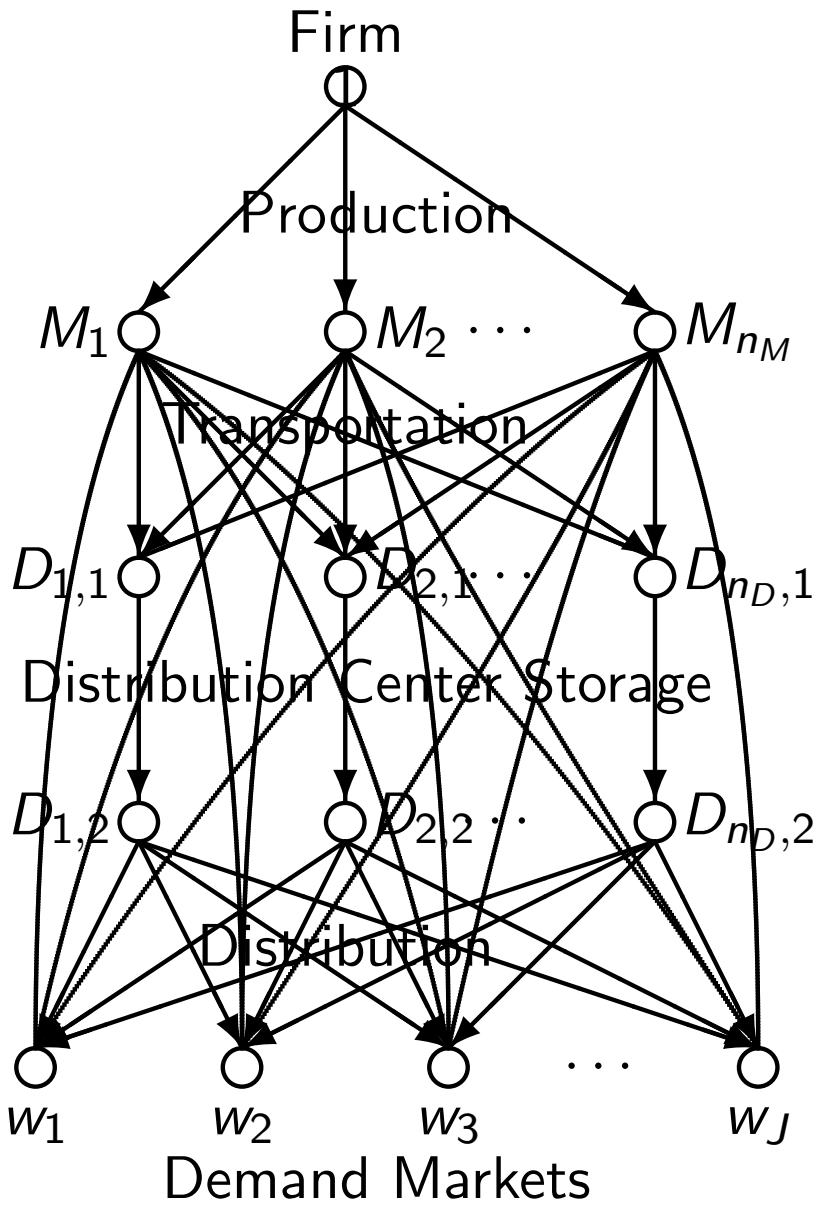


Figure: The Supply Chain Network Topology for the Optimization Model

Game Theory Supply Chain Network Model with Labor

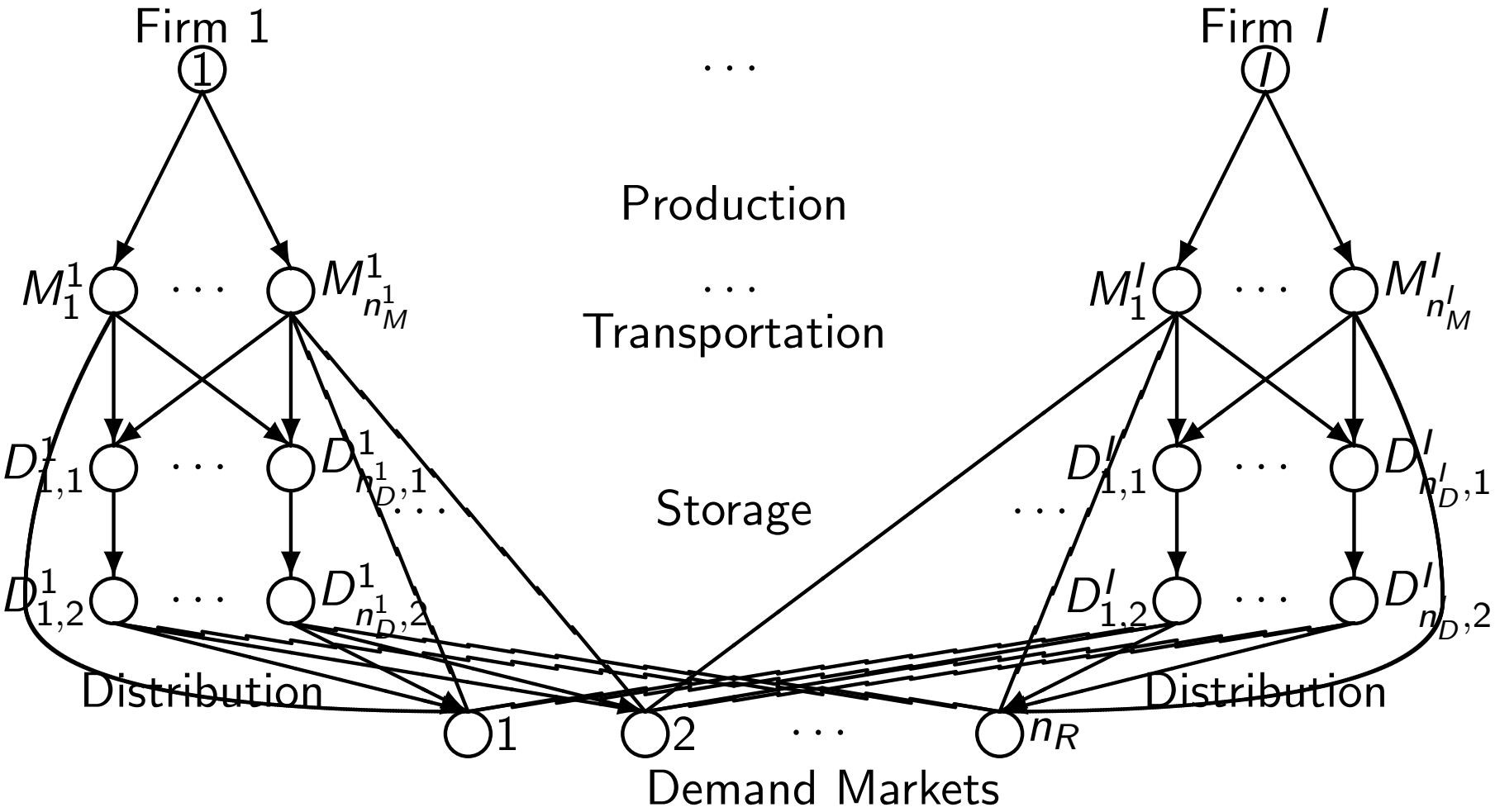
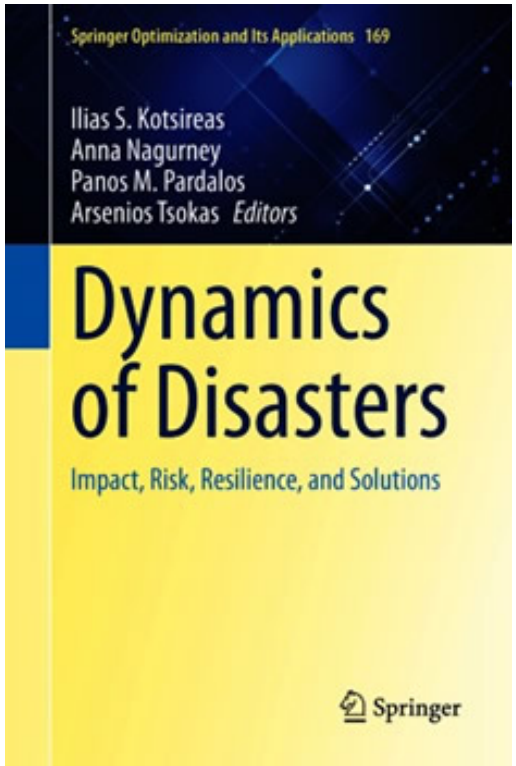


Figure: The Supply Chain Network Topology for the Game Theory Model with Labor

Research and Publications

"Perishable Food Supply Chain Networks with Labor in the Covid-19 Pandemic," A. Nagurney, in: *Dynamics of Disasters - Impact, Risk, Resilience, and Solutions*, **I.S. Kotsireas, A. Nagurney, P.M. Pardalos, and A. Tsokas, Editors, Springer International Publishing Switzerland, 2021, pp 173-193.**



Perishable Food Supply Chain Network Model with Labor

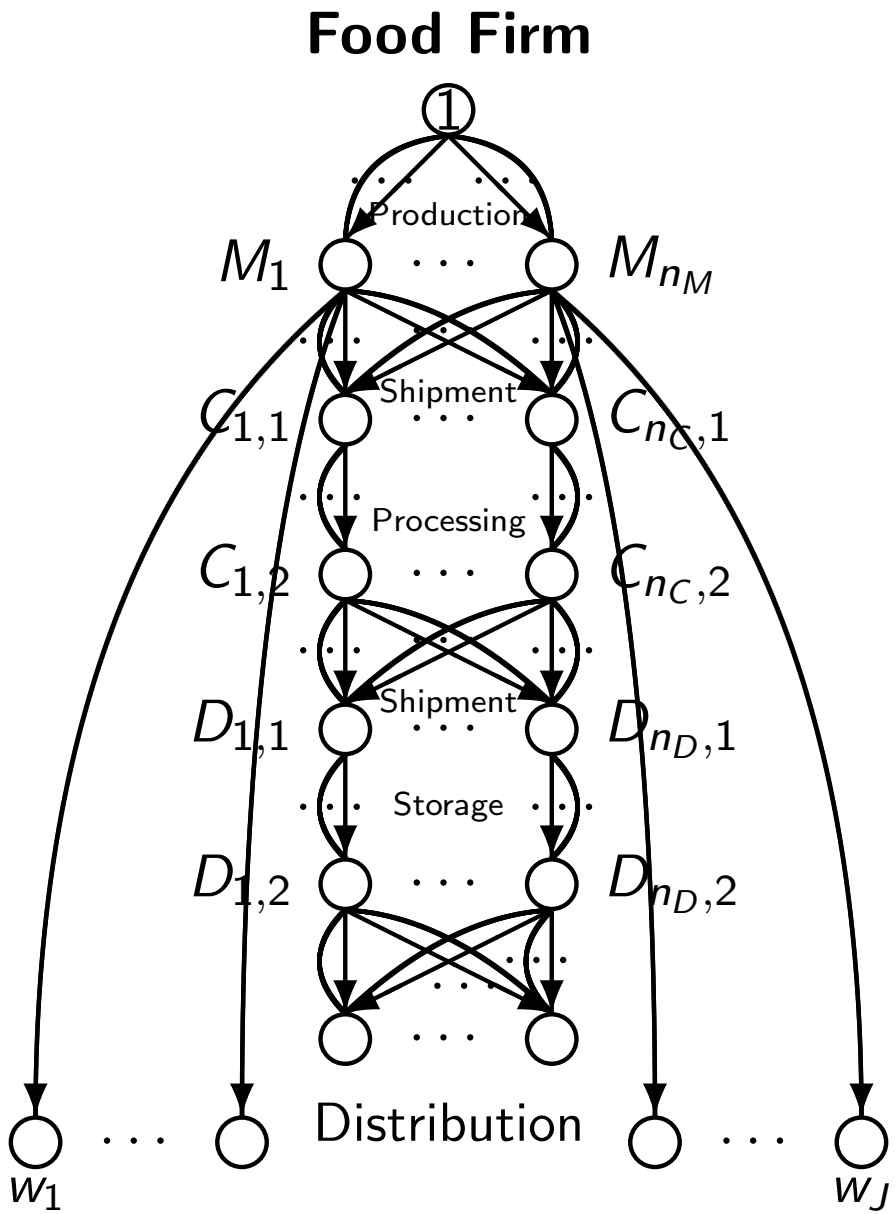


Figure: The Perishable Food Supply Chain Network Topology

Some Additional Research

The fierce competition for PPEs and other medical supplies also inspired the following work:

"Competition for Medical Supplies Under Stochastic Demand in the Covid-19 Pandemic: A Generalized Nash Equilibrium Framework," A. Nagurney, M. Salarpour, J. Dong, and P. Dutta, in: *Nonlinear Analysis and Global Optimization*, **T.M. Rassias, and P.M. Pardalos, Editors, (2021), Springer Nature Switzerland AG, pp 331-356.**

In this paper, we modeled the competition for medical supplies in the Covid-19 pandemic under stochastic demand and a fixed amount of supplies at different points.

Writing OpEds in the Pandemic

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

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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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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

Writing OpEds in the Pandemic

On August 4, 2020, I published an article in *The Conversation*,

"The Raging Competition for Medical Supplies is not a Game, but Game Theory Can Help."

On September 18, 2020, I published another article in *The Conversation*,

"Keeping Coronavirus Vaccines at Subzero Temperatures During Distribution Will Be Hard, but Likely Key to Ending Pandemic."

Writing OpEds in the Pandemic

On January 8, 2021, my article,

"Vaccine Delays Reveal Unexpected Weak Link in Supply Chains: A Shortage of Workers," appeared in *The Conversation*.

On April 5, 2021, I published the article,

"Today's Global Economy Runs on Standardized Containers, as the Ever Given Fiasco Illustrates," also in *The Conversation*.

Some of the Media Coverage of Our Work During the Pandemic

Impacting Policy Through Operations Research

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 on blood supply chains in *The Conversation*, which was reprinted in LiveScience, was the first reference and was cited on the first page.

Impacting Policy Through Operations Research

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 Operations Research

Hon. Brett Giroir
April 22, 2020
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GURBIR S. GREWAL
New Jersey Attorney General

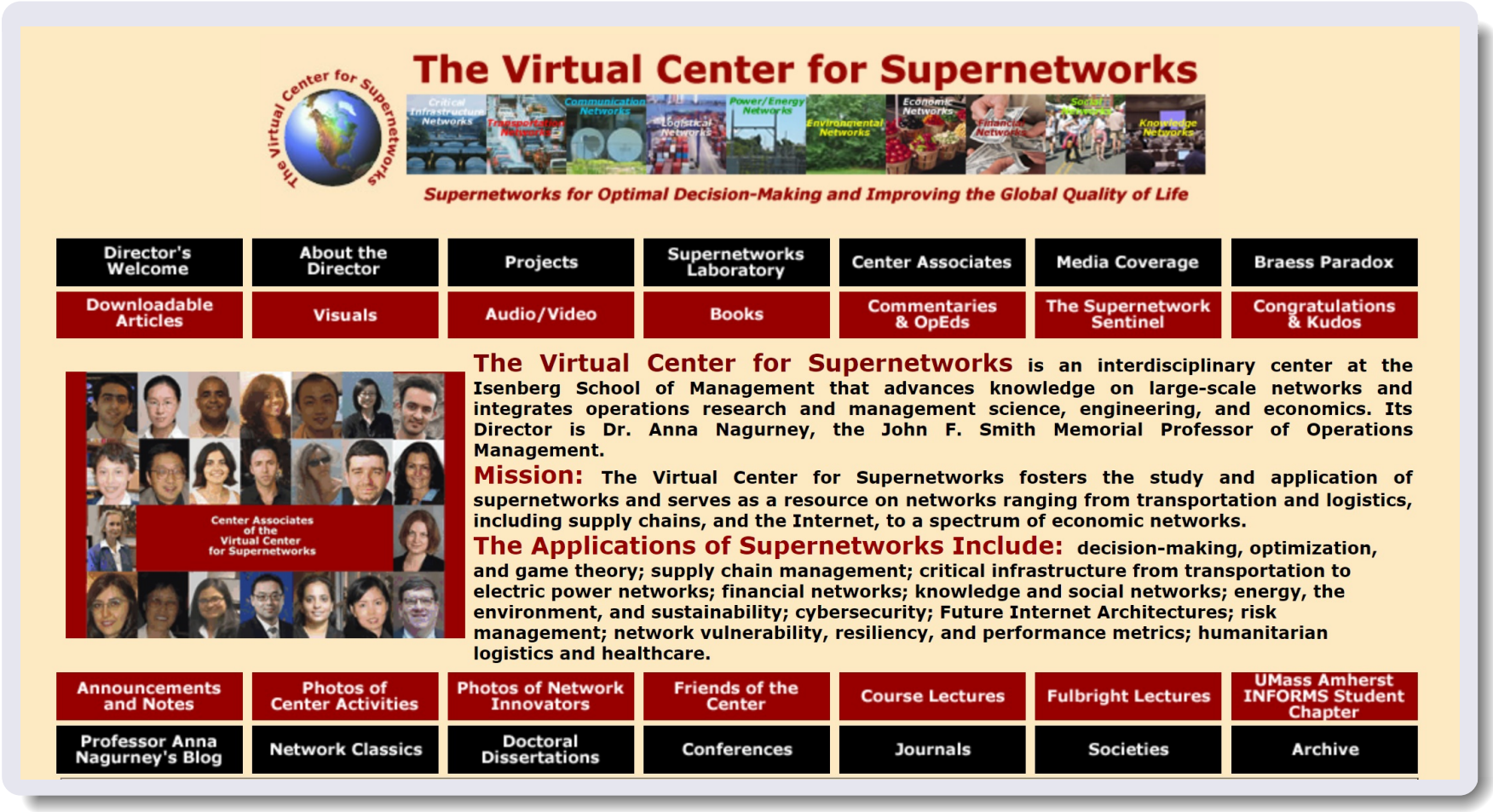
HECTOR BALDERAS
New Mexico Attorney General

LETITIA JAMES
New York Attorney General

Xavier Becerra, President Biden's choice as his Secretary of the Department of Health and Human Services, was recently confirmed!

And the rules for blood donations have now also been relaxed in the UK, as of mid-June 2021!

Thank You Very Much!



For more information: https://supernet.isenberg.umass.edu/