

# Supernetworks and Ukraine

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**Shevchenko Scientific Society Expert-A-Thon for Ukraine**  
**April 29, 2022**



**Shevchenko Emergency Fund**

to support Ukrainian Scholars and Artists displaced by war

# Acknowledgments

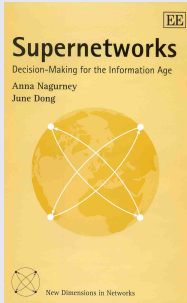
**Thanks to the organizers of this important all-day event for the invitation to speak.**



**This presentation is dedicated to peace-loving Ukrainians as they fight for their freedom. Slava Ukraini!**

# The Supernetworks Book and the Founding of the Center

The book, “Supernetworks: Decision-Making for the Information Age,” was written in 2001.



The Virtual Center for Supernetworks was established in the Fall of 2001, after several NSF grants plus an AT&T Industrial Ecology Fellowship.

# Supernetworks

Supernetworks are networks of networks and their applications are vast and growing.



The study of supernetworks focuses on the interactions among networks that underpin our societies and economies.

# Supply Chains Are One of the Most Important Applications of Supernetworks



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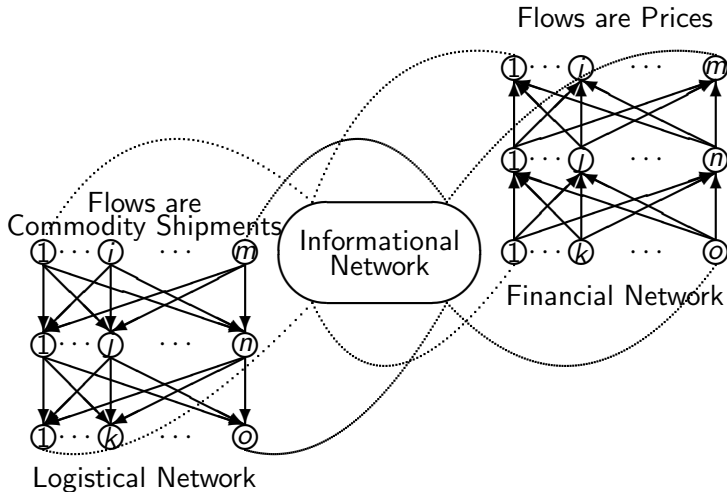
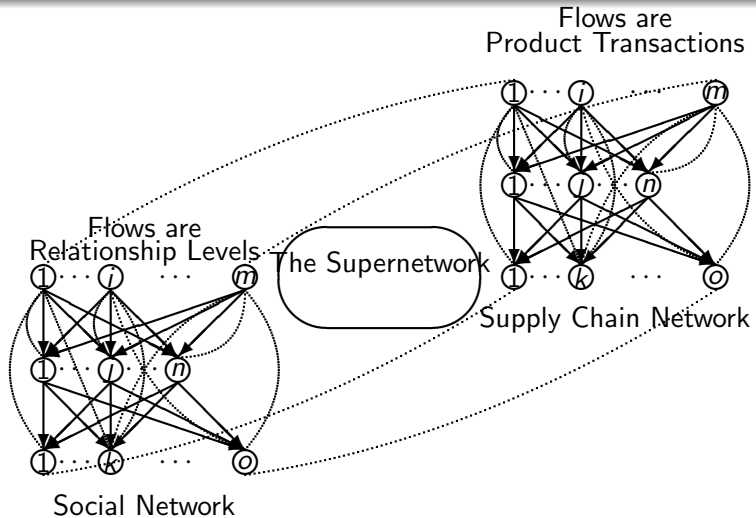


Figure: Multilevel Network Structure of the Supply Chain System

# Supply Chains Integrated with Social Networks



**Figure:** The Multilevel Supernetwork Structure of the Integrated Supply Chain / Social Network System

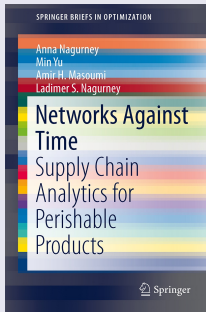
# Some of My Books





# 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.



- food
- blood
- medical nucleotides
- pharmaceuticals
- vaccines.

Many such supply chains are essential and have been severely challenged in the pandemic due to various disruptions and 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. This research is highly relevant also to Ukraine as the war there rages on.

**ORMS** TODAY **informs**  
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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: [f](#) [in](#) [t](#) 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 through e-commerce. Also, COVID-19 vaccine production may lack the human resources to ensure product quality and efficacy, as well as its distribution and ultimate administration into our arms. Without healthcare workers to administer COVID-19 vaccines, the battle against the coronavirus cannot be won. Many hospitals are already short-staffed because of the pandemic.

# Some Motivation - Food Supply Chains

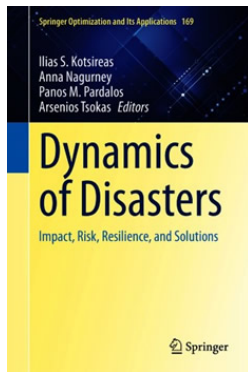
**Food is essential to our health and well-being. During the COVID-19 pandemic, the associated supply chains suffered major disruptions.**



**Ukraine is known as the breadbasket of the world, and the war against Ukraine is exacerbating global food insecurity.**



**“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

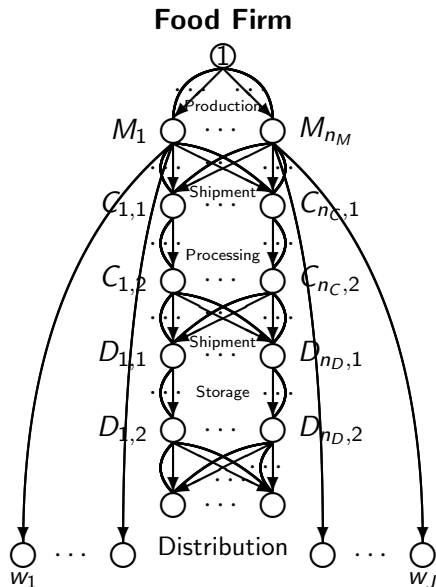


Figure: The Perishable Food Supply Chain Network Topology

In a series of journal articles, we constructed additional supply chain network models with labor, both optimization and game theory ones, that included productivity factors and different sets of constraints on labor in order to identify the impacts of disruptions and to suggest possible mitigation procedures.



# Supply Chain Model with Different Labor Constraints

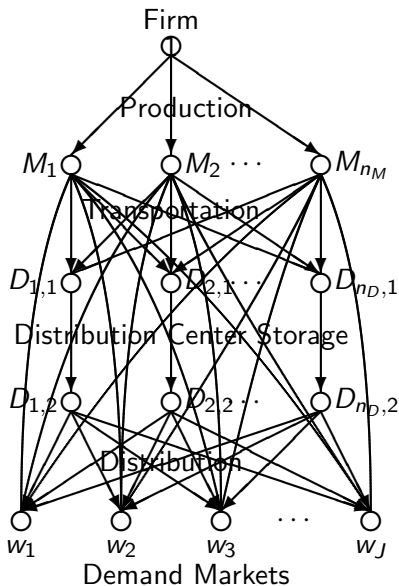


Figure: The Supply Chain Network Topology for the Optimization Model

# Game Theory Supply Chain Network Model with Labor

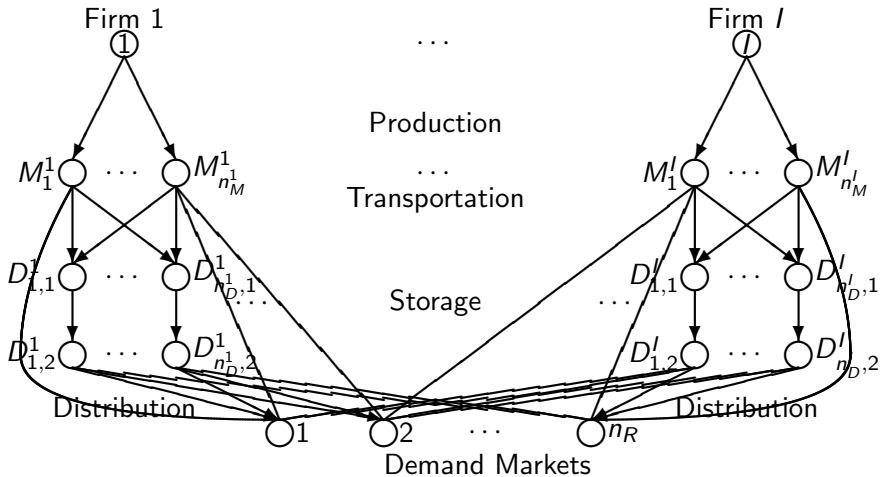
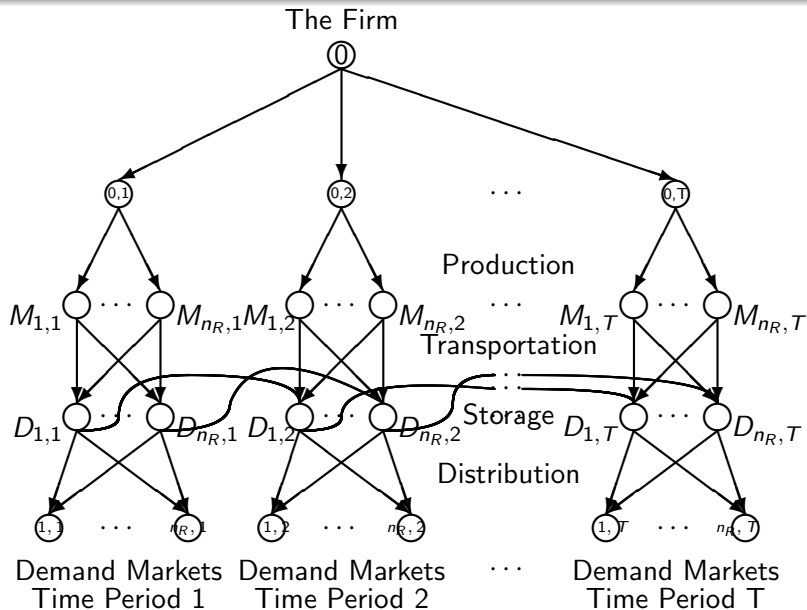


Figure: The Supply Chain Network Topology for the Game Theory Model



# A Supernetwork Model of Multiperiod Supply Chains



**Figure:** Supernetwork Structure of the Model with Labor Productivity

Our research on supernetworks, of relevance to Ukraine, has also focused on network models of human migration as well as a refugee networks.

Journal of Global Optimization  
<https://doi.org/10.1007/s10898-020-00934-4>



## Refugee migration networks and regulations: a multiclass, multipath variational inequality framework

Anna Nagurney<sup>1</sup> · Patrizia Daniele<sup>2</sup> · Ladimer S. Nagurney<sup>3</sup>

Received: 17 November 2020 / Accepted: 11 July 2021  
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### Abstract

In this paper, we take up the timely topic of the modeling, analysis, and solution of refugee migration networks. We construct a general, multiclass, multipath model, determine the governing equilibrium conditions, and provide alternative variational inequality formulations in path flows and in link flows. We also demonstrate how governmental imposed regulations associated with refugees can be captured via constraints. We provide qualitative properties and then establish, via a supernetwork transformation, that the model(s) are isomorphic to traffic network equilibrium models with fixed demands. Illustrative examples are given, along with numerical examples, inspired by refugee crisis from Mexico to the United States, which are solved using the Fath method embedded with exact equilibration. The work sets the foundation for the development of additional models and algorithms and also provides insights as to who wins and who loses under certain refugee regulations.

**Keywords** Refugees · Human migration · Networks · Variational inequality · Regulations

### 1 Introduction

Refugees have historically always been part of human migration, seeking locations of greater safety and security for themselves and their families. Now, with the increasing impacts of climate change, and associated increases in the severity, as well as the frequency, of many disasters, including hurricanes and floods, coupled with numerous conflicts, strife, and violence in many parts of the globe, the number of refugees and asylum seekers is escalating. According to the United Nations [52], the number of international migrants was approximately 258 million (3.4% of the global population) in the year 2017, with the total number of international migrants increasing by almost 50% since 2000 (United Nations [52]). Also,

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Published online: 21 July 2021



# Cooperation in the Pandemic and in the War Against Ukraine

**We recognize the great competition for various products including medical supplies, vaccines, etc., as well as labor in multiple sectors of the economy, but there are also opportunities for cooperation among stakeholders.**

There is also great promise now for enhanced partnerships and these even may be between private companies as well as between private and nonprofit organizations.

**Lessons learned from disaster management are potentially of great benefit to pandemic preparedness and also in the war.**

# Cooperation in Disaster Relief

Our paper, **“Quantifying Supply Chain Network Synergy for Humanitarian Organizations,”** A. Nagurney and Q. Qiang, *IBM Journal of Research and Development*, **64(1/2)**, 2020, pp. 12:1-12:16, identifies potential synergy of cooperation.



The models capture the uncertainties associated with costs and demands.

# Case Without Cooperation

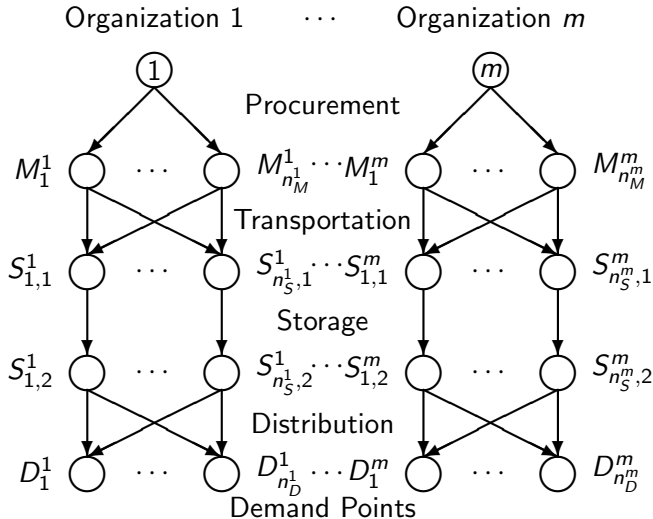


Figure: Supply Chains of Organizations 1 through  $m$  Prior to Cooperation

# Case with Cooperation

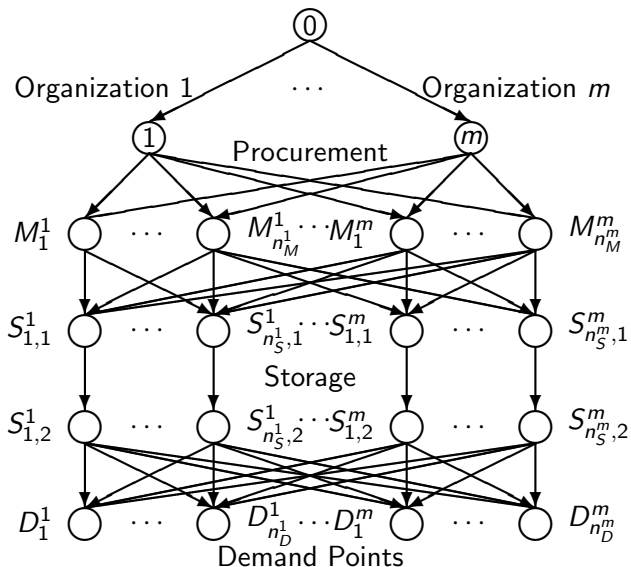


Figure: Supply Chain Network after Cooperation

# Synergy Quantification

We denote the synergy by  $S^{TGC}$ . It is the percentage difference between the total generalized cost without vs. with the horizontal cooperation (evaluated at the respective optimal solutions):

$$S^{TGC} \equiv \left[ \frac{TGC^{0*} - TGC^{1*}}{TGC^{0*}} \right] \times 100\%.$$

**The lower the total generalized cost  $TGC^{1*}$ , the higher the synergy associated with the supply chain network cooperation and, therefore, the greater the total cost savings resulting from the cooperation.**

**The total generalized costs include not only the monetary costs, but also the risks and uncertainties involved in the supply chain as well as the associated penalties of shortages and surpluses.**

**In specific disaster relief operations, including in the pandemic, one may evaluate the integration of supply chain networks with only a subset of the links connecting the original supply chain networks.**



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*.

## Supernetworks and Ukraine

# 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*.



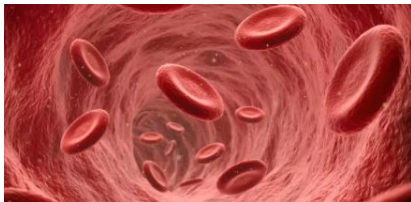
On April 5, 2021, I published the article,

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

# Writing OpEds in the Pandemic

On September 21, 2021, my article,

**“Global Shortage of Shipping Containers Highlights Their Importance in Getting Goods to Amazon Warehouses, Store Shelves and Your Door in Time for Christmas,”** appeared in *The Conversation*. It has had over 330,000 reads.



On February 3, 2022, my article,

**“Heading into the Third Year of the Pandemic, the US Blood Supply is at a 10-Year Low,”** was published in *The Conversation*.

# Some of My Media Interviews in the Pandemic



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 March 2020 article in *The Conversation*, which was reprinted in LiveScience, was the first reference and was cited on the first page.**



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: ACHTSA-PAHPAIA Sec. 209  
[ACBTS4@hhs.gov](mailto:ACBTS4@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.<sup>1</sup> Every day, the United States needs approximately 36,000 units of red blood cells, nearly 7,000

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



Hon. Brett Kavanaugh  
April 22, 2020  
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WILLIAM TONG  
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Delaware Attorney General



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District of Columbia Attorney General



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Nevada Attorney General



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New Jersey Attorney General



HECTOR BALDERAS  
New Mexico Attorney General



LETITIA JAMES  
New York Attorney General

**Xavier Becerra, previously California's Attorney General, has now been confirmed as President Joe Biden's Health and Human Services Secretary!**



# Some of the Media Interviews on the War on Ukraine

## Economic dangers from Russia's invasion ripple across globe

By PAUL WISEMAN and DAVID McHUGH March 2, 2022



Feedstuffs went live.

March 16 at 2:00 p.m. ⌵

The war in Ukraine is no longer just a story about a conflict between nations. It's having an immedi...

See More



Anna Nagurney with John Moore



The John Batchelor Show

1/2: #Ukraine: The Kyiv School of Economics is open for business under fire. Paul Gregory @HooverInst @PaulR\_Gregory. Anna Nagurney @Supernetworks, University of Massachusetts. Paul Becker, Duke University

## Russian war in world's 'breadbasket' threatens food supply

By JOSEPH WILSON, SAMY MAGDY, AYA BATRAWY and CHINEDU ASADU March 6, 2022

## 'I fear a cultural genocide'; Ukrainians in Western Mass. watch, worry and help

Published: Feb. 28, 2022, 5:55 p.m.



## Threat of Russian cyber attacks likely for not just Ukraine, but also in the US

## No Ikea Shelves, No Levis: The Retail Exodus From Russia Is On

Since the invasion of Ukraine began, the increasing financial and reputational risks of doing business in Russia are leading Western brands to halt operations.

## Russian Sanctions Snarl Shipping Even as Pandemic Pressure Eases



March 11, 2022

Levi's and Jerry Garcia

# Ukraine and the War Economy

Russia's war against Ukraine is an unmitigated disaster. According to the World Bank, Ukraine's economy is expected to contract by 45% in 2022 due to Russian invasion.

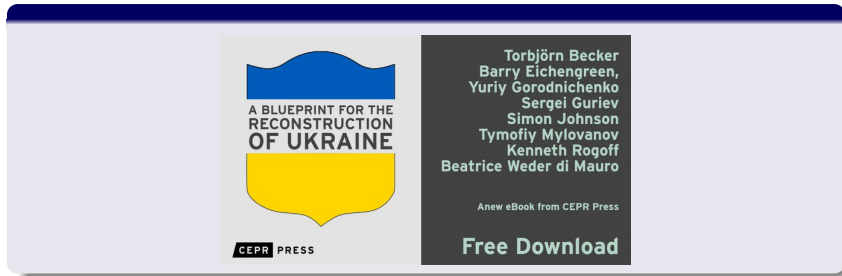
At the same time, the resilience of Ukrainians has been awe-inspiring.

Ukraine will have to rely on outside aid, which is estimated even now to be \$2 billion a month.

The disruption to critical infrastructure, from roads and other transportation links, to electric power networks and telecommunication networks, and even the mining of agricultural fields and destruction of food warehouses, healthcare facilities, manufacturing sites, and schools, plus housing, has been very significant and the social and environmental costs - immense.

# Ukraine and the War Economy

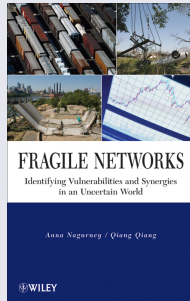
Academics are playing a pivotal role in Ukraine and have prepared a blueprint for reconstruction. Despite the massive economic disruption and mounting fiscal challenges, government functions are largely operational. Ukrainians have a strong sense of common purpose and unity.



I foresee the rebuilding of critical infrastructure networks in Ukraine as being pivotal in its reconstruction and renewal. Tools that we have developed can help.

# Identification of the Most Important Nodes and Links

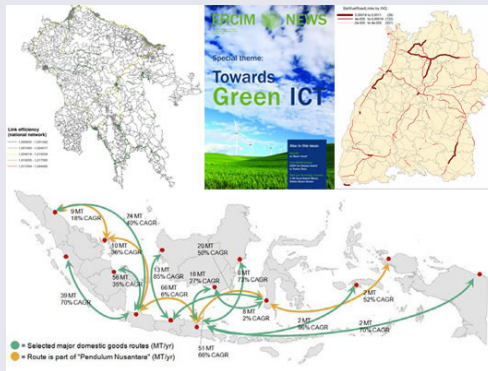
With Q. Qiang, in a series of publications, we constructed network performance measures that enable the ranking of the importance of nodes and links in networks from supply chains and financial networks to electric power ones and the Internet.



A reference is our book, which contains a complete set of citations.

## Identification of the Most Important Nodes and Links

The tools have been applied to identify the most important routes in Germany and in Greece (even for evacuation networks as in disasters or times of war); to determine whether to invest in a new subway line in Dublin as well as to identify enhanced maritime routes for Indonesia.



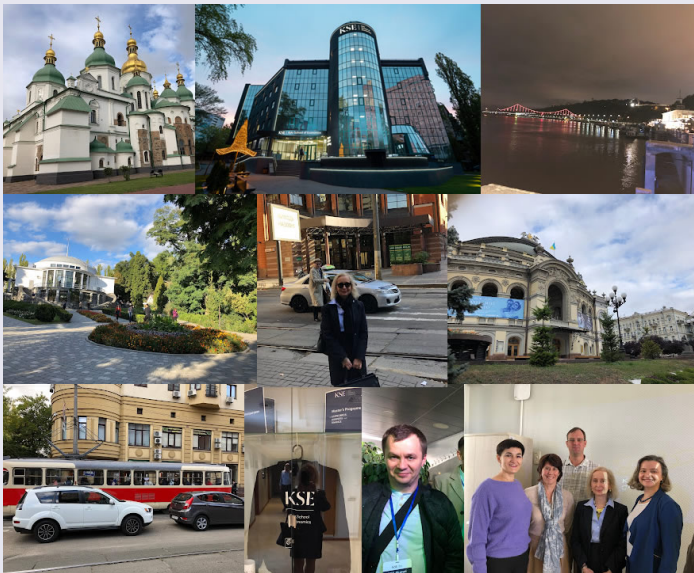
# My Work with the Kyiv School of Economics

**For the past several years, I have served on the International Academic Board and the Board of Directors of the Kyiv School of Economics (KSE).**

**Shortly after the invasion of Ukraine by Russia on February 24, 2022, I was elected Co-Chair of the KSE Board of Directors - a great honor.**

**I have done my best to support the great colleagues and leadership of KSE and am very pleased that the University of Massachusetts Amherst signed a Memorandum of Agreement with KSE.**

# My Work with the Kyiv School of Economics



# Thank You!



## The Virtual Center for Supernetworks



*Supernetworks for Optimal Decision-Making and Improving the Global Quality of Life*

Director's Welcome	About the Director	Projects	Supernetworks Laboratory	Center Associates	Media Coverage	Braess Paradox
Downloadable Articles	Visuals	Audio/Video	Books	Commentaries & OpEds	The Supernetwork Sentinel	Congratulations & Kudos



**The Virtual Center for Supernetworks** is an interdisciplinary center at the Isenberg School of Management that advances knowledge on large-scale networks and integrates operations research and management science, engineering, and economics. Its Director is Dr. Anna Nagurney, the John F. Smith Memorial Professor of Operations Management.

**Mission:** The Virtual Center for Supernetworks fosters the study and application of supernetworks and serves as a resource on networks ranging from transportation and logistics, including supply chains, and the Internet, to a spectrum of economic networks.

**The Applications of Supernetworks Include:** decision-making, optimization, and game theory; supply chain management; critical infrastructure from transportation to electric power networks; financial networks; knowledge and social networks; energy, the environment, and sustainability; cybersecurity; Future Internet Architectures; risk management; network vulnerability, resiliency, and performance metrics; humanitarian logistics and healthcare.

Announcements and Notes	Photos of Center Activities	Photos of Network Innovators	Friends of the Center	Course Lectures	Fulbright Lectures	UMass Amherst INFORMS Student Chapter
Professor Anna Nagurney's Blog	Network Classics	Doctoral Dissertations	Conferences	Journals	Societies	Archive

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