

Tariffs, Trade, and OR: Impacts on Producers, Consumers, and Labor

Anna Nagurney

Department of Operations and Information Management
Isenberg School of Management
University of Massachusetts, Amherst, Massachusetts

Making an Impact Session
34rd European Conference on Operational Research
University of Leeds, UK, June 22-25, 2025



UMassAmherst | Isenberg School
of Management

Acknowledgment

I'd like to thank Ruth Kaufman for all her work in organizing this very interesting session. The photo below was taken after my Blackett Lecture at The Royal Society in London on December 5, 2024.



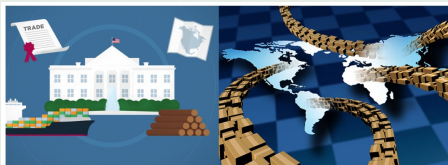
International Trade

International trade provides us with commodities throughout the year and has benefits for producers and consumers alike.



Supply Chains Are Essential to Global Trade

- **Global supply chain networks** have made possible the wide distribution of goods, from agricultural products to textiles and apparel as well as aluminum and steel.
- Nations engage in trade to increase their productivity levels, employment rates, and general economic welfare.
- The increased level of world trade has also garnered **the attention of government policy makers**.
- Governments may attempt to protect their domestic firms from the possible effects of the **highly competitive** global arena.



World's Biggest Importers

Largest Importers In The World



In 2022, global imports climbed to \$25.6 trillion in value, or about the size of the U.S. GDP. As an engine of growth, global trade broadens consumer choices and can lower the cost of goods. For businesses, it can improve the quality of inputs and strengthen competitiveness.

*(in Billion USD)

	United States	\$3,376B
	China	\$2,716B
	Germany	\$1,571B
	Netherlands	\$899B
	Japan	\$897B
	United Kingdom	\$824B
	France	\$818B
	South Korea	\$731B
	India	\$723B
	Italy	\$689B
	Hong Kong SAR	\$668B
	Mexico	\$626B
	Belgium	\$621B
	Canada	\$582B
	Spain	\$493B
	Singapore	\$476B
	Taiwan	\$436B
	UAE	\$425B
	Poland	\$381B
	Türkiye	\$364B

	VietNam	\$359B
	Switzerland	\$356B
	Australia	\$309B
	Thailand	\$303B
	Malaysia	\$294B
	Brazil	\$290B
	Russia	\$242B
	Indonesia	\$237B
	Czech Republic	\$236B
	Austria	\$232B
	Sweden	\$202B
	Saudi Arabia	\$188B
	Hungary	\$163B
	Ireland	\$146B
	Philippines	\$144B
	South Africa	\$136B
	Romania	\$132B
	Denmark	\$127B
	Portugal	\$115B
	Slovakia	\$113B

Source: World Trade Organization, USAFacts

www.rankingroyals.com

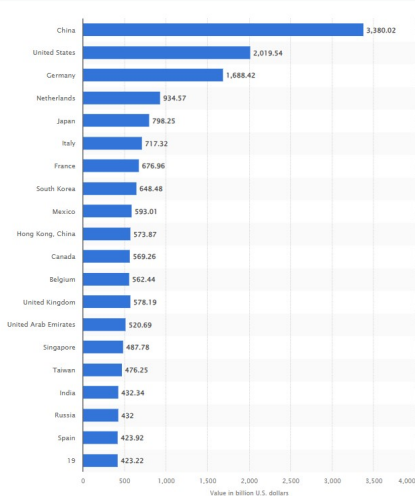
RankingRoyals



World's Biggest Exporters

Leading export countries worldwide in 2023

(in billion U.S. dollars)



Global Trade Policies

Examples of policy instruments that have been applied by governments to modify trade patterns include: **tariffs**, **quotas**, and a combination thereof

- **tariff rate quotas**.



Tariffs, which are taxes, have been around since ancient Greece and Rome. There are different types of tariffs: unit tariffs, ad valorem tariffs, and tariff rate quotas.

- A tariff rate quota (TRQ) is a **two-tiered tariff**, in which a lower **in-quota tariff** is applied to imports until a quota is attained and then a higher **over-quota tariff** is applied to all subsequent imports.
- The Uruguay Round in 1996 induced the creation of more than 1,300 new TRQs.
- The world's four most important food crops: rice, wheat, corn, and bananas have all been subject to tariff rate quotas.



Tariffs Are Again Big News

Tariffs continue to dominate the news.

Canada | Newsroom | United States

Trump's Proposed 25% Tariff on Canada and Mexico: Potential Impacts on Agriculture and Trade

By Jim Eadie - January 23, 2025



NEWS

Shipping companies warn of delays and new charges from Trump's China tariffs

Temu, Shein, and Amazon Haul are about to get wrecked



/ Delays, taxes, &
– shipping from
just got more co

What might be the impact on agriculture of tariffs on Canadian and Mexican imports?

» // BLOG // WHAT MIGHT BE THE IMPACT ON AGRICULTURE OF TARIFFS ON CANADIAN AND MEXICAN IMPORTS?

Tariffs on Canadian and Mexican Imports: The Impact on Agriculture

It should come as no surprise that Mexico and Canada are the top-two US agricultural export markets

PUBLISHED ON JANUARY 29, 2025

America's favorite beer, avocados, gas and cheap stuff from Temu will get more expensive as economists warn of Trump tariffs impact

By Renny Reyes

Published Feb. 2, 2025, 6:29 p.m. ET

1.9K Comments

New Tariffs That Start Tomorrow Could Affect Farmers and Food Prices

The Trump administration will impose a 25 percent tariff on imports from Canada and Mexico, the U.S.' first and third largest suppliers of agricultural products.

BY LISA HELED - JANUARY 31, 2025

Trump's tariffs will hurt UK wherever they're imposed, says Bank

A global trade war would hit growth even if Britain is not a 'direct recipient' of the US president's levies on imports, the Bank of England governor says

NEW

LOCAL NEWS

Colorado agriculture producers brace for tariff impacts



By Olivia Young
February 3, 2025 / 7:01 AM MST / CBS Colorado



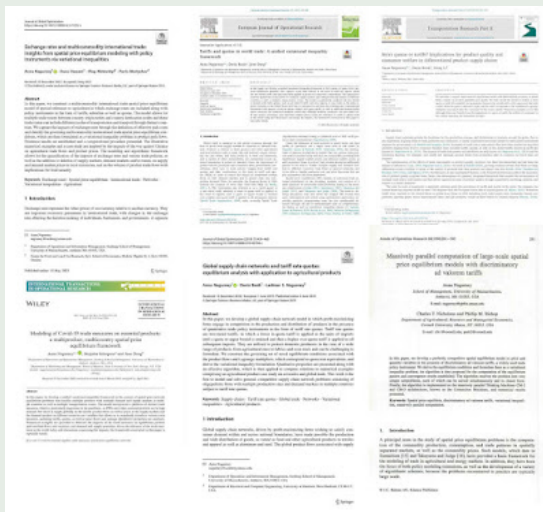
Tariffs Are Again Big News

- The tariffs that are being imposed by the Trump administration, in his second term, are resulting in a great deal of uncertainty for businesses and for consumers.
- Some of the tariffs have been pulled back or delayed, whereas other such as those on aluminum and steel have been increased.
- Countries, including China, are retaliating, even banning exports of critical rare earths needed for high tech products.
- **OR models and tools can provide very valuable insights as to who wins and who loses in the case of tariffs.**

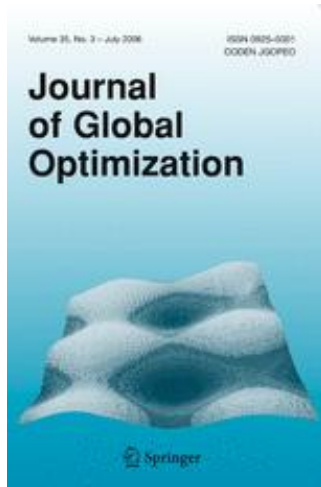
We, over the past 25 years, have been constructing **computable operational mathematical models** that enable the assessment of the impacts of trade policy instruments such as tariffs, subsidies, quotas, and also tariff rate quotas on consumer prices, trade flows, as well as on the profits of producers/firms.

Some of Our Studies on Tariffs

Some of our papers on tariffs and applications using OR.



A. Nagurney, D. Besik, and L.S. Nagurney, “Global Supply Chain Networks and Tariff Rate Quotas: Equilibrium Analysis with Application to Agricultural Products, *Journal of Global Optimization* 75 (2019), pp 439-460.



A. Nagurney, D. Besik, and J. Dong, “Tariffs and Quotas in World Trade: A Unified Variational Inequality Framework,” *European Journal of Operational Research* 275(1) (2019), pp 347-360.



A. Nagurney, M. Salarpour, and J. Dong, “Modeling of Covid-19 Trade Measures on Essential Products: A Multiproduct, Multicountry Spatial Price Equilibrium Framework,” *International Transactions in Operational Research* 29(1) (2022), pp 226-258.



The Multicommodity International Trade Model

A. Nagurney, D. Hassani, O. Nivievskyi, and P. Martyshev, “Exchange Rates and Multicommodity International Trade: Insights from Spatial Price Equilibrium Modeling with Policy Instruments via Variational Inequalities,” *Journal of Global Optimization* 87 (2023), pp 1-30.

Journal of Global Optimization
https://doi.org/10.1007/s10833-023-00223-6

Exchange rates and multicommodity international trade: insights from spatial price equilibrium modeling with policy instruments via variational inequalities

Alexa Nagurney¹ · Daria Hassani² · Oleg Nivievskyi³ · Pavlo Martyshev⁴

Received: 29 December 2021 / Accepted: 3 May 2023

© The Author(s), under exclusive license to Springer Science+Business Media, LLC, part of Springer Nature 2023

Abstract

In this paper, we construct a multicommodity international trade spatial price equilibrium model of special relevance to agriculture in which exchange rates are included along with policy instruments in the form of tariffs, subsidies as well as quotas. The model allows for multiple trade routes between country origin nodes and country destination nodes and these trade routes can include different modes of transportation and transport through different countries. We capture the impacts of exchange rates through the definition of effective profit costs and identify the governing multicommodity variational trade spatial price equilibrium conditions, which are then formulated as a variational inequality problem in product path flows. Existence results are established and a computational procedure presented. The illustrative numerical example and a case study are inspired by the impacts of the war against Ukraine on agricultural trade flows and product prices. The modeling and algorithmic framework allows for the quantification of the impacts of exchange rates and various trade policies, as well as the addition or deletion of supply markets, demand markets and/or taxes, on supply and demand market prices in food categories, and on the volume of product trade flows with implications for food security.

Keywords Exchange rates · Spatial price equilibrium · International trade · Networks · Variational inequalities · Agriculture

1 Introduction

Exchange rates represent the value (price) of one currency relative to another currency. They are important economic parameters in international trade, with changes in the exchange rate affecting the decision-making of individuals, businesses, and governments. A separate

✉ Alexa Nagurney
nagurney@unh.edu

¹ Department of Operations and Information Management, Bentley School of Management,
University of Massachusetts, Lowell, MA 01826, USA

² Center for Food and Land Use Research, AgriSearch, AgriSchool of Economics, Waboly Shapir St. 3, Agri 60000,
Ukraine

Published online: 13 May 2023



What Our Research Has Shown

Whether in the context of supply chain networks under oligopolistic (imperfect) competition or perfect competition, our studies reveal that tariffs:

- increase prices for consumers;
- reduce the volume of the product;
- decrease consumer welfare;
- reduce profits for producers, and
- they can result in the same impacts as that of quotas.

Tariffs can, however, offer some protection to domestic producers but one has to evaluate whether this will happen quantitatively through OR models.

Our Research is Deeply Influenced by Practice

Multicommodity Trade, Tariffs, and Rerouting

Anna Nagurney and Samiraseadat Samadi

Department of Operations and Information Management

Isenberg School of Management

University of Massachusetts

Amherst, Massachusetts 01003

April 2025

Accepted for publication in: *Convex and Variational Analysis with Applications: In Honor of Terry Rockafellar's 90th Birthday*. Panos M. Pardalos and Themistokles M. Rassias, Editors, Springer Nature Switzerland AG.

Abstract: The concept of “equilibrium” is fundamental to many disciplines, including economics and operations research. The theory of variational inequalities continues to provide a rich methodological framework for the formulation, analysis, and solution of a wide range of equilibrium problems with many recent applications, because of their relevance, including policies associated with the trade of commodities. In this paper, we add to the literature on multicommodity trade by constructing a spatial price equilibrium model with tariffs that allows for the investigation of rerouting of commodities to evade tariffs, as has been happening for several years now, along with “trade wars.”

Key words: multicommodity trade, tariffs, networks, equilibrium problems, rerouting, variational inequalities

Our Research is Deeply Influenced by Practice

The paper constructs a network model of tariff evasion with a case study on tea, China, Vietnam, and the US.

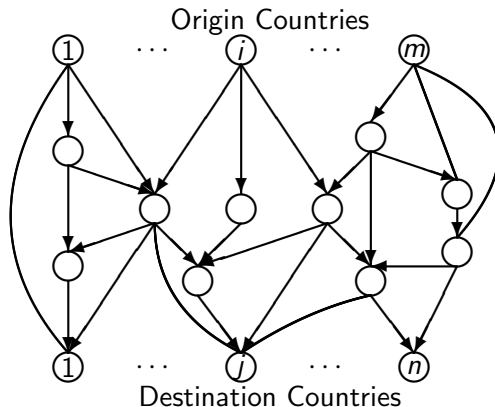
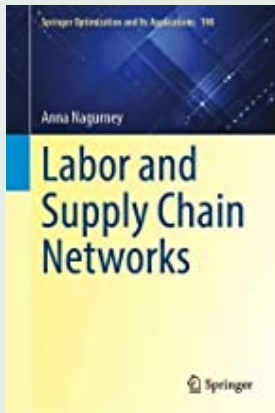


Figure: An Example of a Spatial Price Network Topology with Origin Countries and Destination Countries

Our Research is Deeply Influenced by Practice



Our ongoing research examines how ad valorem tariffs impact labor in terms of employment, using fundamental supply chain network models introduced in my book.

Responding to Media Requests on Tariffs

I believe that it is important to respond to media requests on topics that your research can inform, such as that of our work on tariffs and trade.





OR models and associated analyses on tariffs and trade can provide valuable insights (including unexpected ones) for policy-makers and decision-makers.


Thank You Very Much!

The Virtual Center for Supernetworks

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

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



Panel with K.S.E. Exchange Students
February 27, 2025

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 Eugene M. Isenberg Chair in Integrative Studies.

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

Announcements and Notes from the Center Director
Professor Anna Nagurney

Updated: June 8, 2025

Professor Anna Nagurney's Blog

RENw

Research, Education, Networks, and the World: A Female Professor Speaks

Sustaining the Supply Chain

Mathematical Moments Podcast

Competing in Supply Chain Quality

—New Books

Photos of Center Activities

Publications

The Braess Paradox Translation

Information

Photos

More information on our work can be found on the Supernetwork Center site: <https://supernet.isenberg.umass.edu/>