International Collaborations

WORMS Panel

Anna Nagurney

John F. Smith Memorial Professor
Department of Finance and Operations Management
University of Massachusetts
Amherst, MA 01003

ALIO-INFORMS

Buenos Aires, Argentina, June 6-9, 2010

Funding for these activities has been provided by:

National Science Foundation

WHERE DISCOVERIES BEGIN

Fulbright Scholar Program

INSTITUTE OF INTERNATIONAL EDUCATION

Royal Institute of Technology (KTH)

Sweden

THE ROCKEFELLER FOUNDATION

RADCLIFFE INSTITUTE FOR ADVANCED STUDY

HARVARD UNIVERSITY

My first, substantive experience with international collaborations, after my receipt of my PhD from Brown University, was taking part in a European Advanced Summer Institute in Umea, Sweden, June 9-28, 1986.

At this Institute it was announced that I was the recipient of the Kempe Prize, along with Professor Jacques Thisse, which led to stronger connections with Sweden.

When I was approached several years later to apply for a Distinguished Guest Professorship at the Royal Institute of Technology (KTH) in Stockholm, Sweden, in a competition across all fields, I did so. KTH wished to increase the visibility of female academics.

From June -December 1996, I assumed this appointment, taught a course there, and had offices in two different departments.

During this period, my family and I lived at the Wenner Gren Center in Stockholm. This is a community of international scholars and researchers (150 families). Living and working in Sweden was an outstanding experience.

In order to continue the linkages that were established, in 2000, I applied for, and received, a grant from NSF – *U.S.-Sweden Collaborative Research: Sustainable Transportation and Land Use in the Information Society.*

As part of this grant, a doctoral student of mine spent time at KTH.

The experiences in Sweden led me to actively pursue other international collaborations and experiences (over and above the usual international conferences).

In 2001, I was awarded a Fulbright / University of Innsbruck Distinguished Faculty Chaired Professorship and my family and I lived from March – June, 2002, in Innsbruck, Austria.

FULBRIGHT SCHOLAR STORIES

Anna Nagurney, John F. Smith Memorial Professor
Department of Finance and Operations Management
Isenberg School of Management
University of Massachusetts - Amherst
Lectureship: Distinguished Chair, economics
Host: University of Innsbruck, Innsbruck, Austria
March 2002 - July 2002

Anna Nagurney and her family lived in Austria for four months while she taught courses in network economics, financial networks, and sustainable transportation at the SOWI Business School of the University of Innsbruck.

"The exchanges and discussions surrounding the applications of the material to Austria and Europe as compared to the United States were lively, fascinating and often filled with laughter," she explained.

As a result of her stay, several students would like to continue their studies on topics that Nagurney taught and have suggested that they might participate in an exchange program with the United States.

In addition to her busy class schedule, she gave guest lectures in Switzerland, France, and in Germany at the John F. Kennedy Institute in Berlin. Nagurney was also able to continue her scholarly research on Supernetworks, Supply Chain Management, Electronic Commerce, and International Financial Networks while in Innsbruck. "My research productivity was maintained with the completion and submission of several papers and the revision and subsequent acceptance of two additional papers," she said.

Besides the professional fulfillment from Nagurney's Fulbright experience, her family members' lives were also enriched by living, working, and attending school in the majestic Austrian Alps. According to Nagurney, her eight-year-old daughter's experience was greatly enhanced by attending an Austrian school.

"My daughter's experiences in her Austrian Volksschule are alone worth the stay in Innsbruck," noted Nagurney. "Not a day goes by that she does not mention how much she loved living in Austria and says that whenever I can go on another Fulbright adventure, she will be ready.

"The Fulbright experience at the University of Innsbruck, Austria exceeded my expectations," she added. "The students in my courses called Innsbruck paradise with which I fully agree. Clearly, I hope to return someday!"

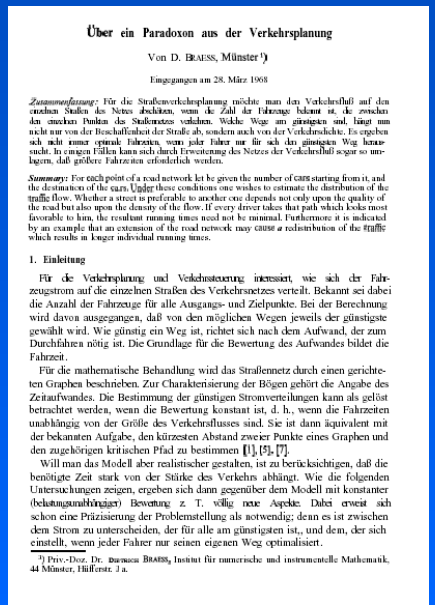
While at the University of Innsbruck, I taught several courses, conducted research, and my family and I had experiences that we treasure to this day. We have returned on several occasions.

Also, one of my students there, Tina Wakolbinger, later became my PhD student at the Isenberg School at UMass Amherst. Many of you know Dr. Wakolbinger, who is very active in WORMS and is now an Assistant Professor at the University of Memphis.

The international collaborations multiplied and together with Braess, we translated from German to English the Braess (1968) article with this famous paradox:

On a Paradox of Traffic Planning

by Braess, Nagurney, Wakolbinger, which appeared in the November 2005 issue of *Transportation Science*



Über ein Paradoxon aus der Verkehrsplanung

Von D. Braess, Münster [1])

Eingegangen am 28. März 1968

Zusammenfassung: Für die Straßenverkehrsplanung möchte man den Verkehrsfluß auf den einzelnen Straßen des Netzes abschätzen, wenn die Zahl der Fahrzeuge bekannt ist, die zwischen den einzelnen Punkten des Straßennetzes verkehren. Welche Wege am günstigsten sind, hängt nun nicht nur von der Beschaffenheit der Straße ab, sondern auch von der Verkehrsdichte. Es ergeben sich nicht immer optimale Fahrzeiten, wenn jeder Fahrer nur für sich den günstigsten Weg heraussucht. In einigen Fällen kann sich durch Erweiterung des Netzes der Verkehrsfluß sogar so umlagern, daß größere Fahrzeiten erforderlich werden.

Summary: For each point of a road network let be given the number of cars starting from it, and the destination of the cars. Under these conditions one wishes to estimate the distribution of the traffic flow. Whether a street is preferable to another one depends not only upon the quality of the road but also upon the density of the flow. If every driver takes that path which looks most favorable to him, the resultant running times need not be minimal. Furthermore it is indicated by an example that an extension of the road network may cause a redistribution of the traffic which results in longer individual running times.

1. Einleitung

Für die Verkehrsplanung und Verkehrssteuerung interessiert, wie sich der Fahrzeugstrom auf die einzelnen Straßen des Verkehrsnetzes verteilt. Bekannt sei dabei die Anzahl der Fahrzeuge für alle Ausgangs- und Zielpunkte. Bei der Berechnung wird davon ausgegangen, daß von den möglichen Wegen jeweils der günstigste gewählt wird. Wie günstig ein Weg ist, richtet sich nach dem Aufwand, der zum Durchfahren nötig ist. Die Grundlage für die Bewertung des Aufwandes bildet die Fahrzeit.

Für die mathematische Behandlung wird das Straßennetz durch einen gerichteten Graphen beschrieben. Zur Charakterisierung der Bögen gehört die Angabe des Zeitaufwandes. Die Bestimmung der günstigen Stromverteilungen kann als gelöst betrachtet werden, wenn die Bewertung konstant ist, d. h., wenn die Fahrzeiten unabhängig von der Größe des Verkehrsflusses sind. Sie ist dann äquivalent mit der bekannten Aufgabe, den kürzesten Abstand zweier Punkte eines Graphen und den zugehörigen kritischen Pfad zu bestimmen [1], [5], [7].

Will man das Modell aber realistischer gestalten, ist zu berücksichtigen, daß die benötigte Zeit stark von der Stärke des Verkehrs abhängt. Wie die folgenden Untersuchungen zeigen, ergeben sich dann gegenüber dem Modell mit konstanter (belastungsunabhängiger) Bewertung z. T. völlig neue Aspekte. Dabei erweist sich schon eine Präzisierung der Problemstellung als notwendig; denn es ist zwischen dem Strom zu unterscheiden, der für alle am günstigsten ist,, und dem, der sich einstellt, wenn jeder Fahrer nur seinen eigenen Weg optimalisiert.

[1]) Priv.-Doz. Dr. Dietrich Braess, Institut für numerische und instrumentelle Mathematik, 44 Münster, Hüfferstr. 3 a.

TRANSPORTATION SCIENCE
Vol. 39, No. 4, November 2005, pp. 446–450
issn 0041-1655 | eissn 1526-5447 | 05 | 3904 | 0446

informs

doi 10.1287/trsc.1050.0127
©2005 INFORMS

On a Paradox of Traffic Planning

Dietrich Braess
Faculty of Mathematics, Ruhr University Bochum, 44780 Bochum, Germany, dietrich.braess@rub.de

Anna Nagurney, Tina Wakolbinger
Department of Finance and Operations Management, Isenberg School of Management, University of Massachusetts, Amherst, Massachusetts 01003 {nagurney@gbfin.umass.edu, wakolbinger@som.umass.edu}

For each point of a road network, let there be given the number of cars starting from it, and the destination of the cars. Under these conditions one wishes to estimate the distribution of traffic flow. Whether one street is preferable to another depends not only on the quality of the road, but also on the density of the flow. If every driver takes the path that looks most favorable to him, the resultant running times need not be minimal. Furthermore, it is indicated by an example that an extension of the road network may cause a redistribution of the traffic that results in longer individual running times.

Key words: traffic network planning; paradox; equilibrium; critical flows; optimal flows; existence theorem
History: Received: April 2005; revision received: June 2005; accepted: July 2005.

Translated from the original German: Braess, Dietrich. 1968. Über ein Paradoxon aus der Verkehrsplanung. *Unternehmensforschung* 12 258–268.

1. Introduction

The distribution of traffic flow on the roads of a traffic network is of interest to traffic planners and traffic controllers. We assume that the number of vehicles per unit time is known for all origin-destination pairs. The expected distribution of vehicles is based on the assumption that the most favorable routes are chosen among all possible ones. How favorable a route is depends on its travel cost. The basis for the evaluation of cost is travel time.

The road network is modeled by a directed graph for the mathematical treatment. A (travel) time is associated with each link. The computation of the most favorable distribution can be considered solved if the travel time for each link is constant, i.e., if the time is independent of the number of vehicles on the link. In this case, it is equivalent to computing the shortest distance between two points of a graph and determining the corresponding critical (here meaning shortest) path. See Beltrami (1958), von Falkenhausen (1963), and Pollack and Wiebenson (1960).

In more realistic models, however, one has to take into account that the travel time on the links will strongly depend on the traffic flow. Our investigations will show that we will encounter new effects compared to the model with flow-independent costs. Specifically, a more precise formulation of the problem will be required. We have to distinguish between flow that will be optimal for all vehicles and flow that is achieved if each user attempts to optimize his own route.

Referring to a simple model network with only four nodes, we will discuss typical features that contradict facts that seem to be plausible. Central control of traffic can be advantageous even for those drivers who think that they will discover more profitable routes for themselves. Moreover, there exists the possibility of the paradox that an extension of the road network by an additional road can cause a redistribution of the flow in such a way that increased travel time is the result.

2. Graph and Road Network

Directed graphs are used for modeling road maps, and the links, the connections between the nodes, have an orientation (Berge 1958, von Falkenhausen 1963). Two links that differ only by their direction are depicted in the figures by one line without an arrowhead.

In general, the nodes are associated with street intersections. Whenever a more detailed description is necessary, an intersection may be divided into (four) nodes with each one corresponding to an adjacent road; see Figure 2 (Pollack and Wiebenson 1960).

We will use the following notation for the nodes, links, and flows. The indices belong to finite sets. Because we use each index only in connection with one variable, we do not write the range of the indices.

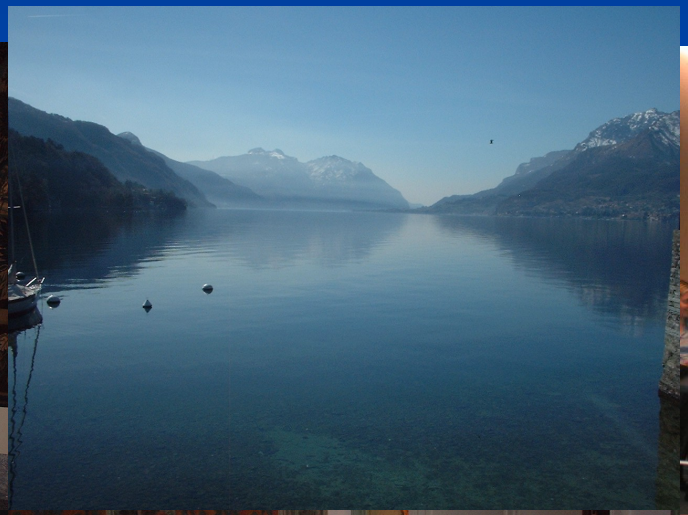
Sometimes one has to travel to forge international collaborations, and, sometimes, one gets approached to participate in international collaborations.

It is important to avail oneself of funding for such collaborations.

Two female researchers, Patrizia Daniele, from Italy, and Monica-Gabriela Cojocaru, based in Canada, the country of my birthplace, had been following and citing my research and had contacted me.

In order to further our research (and to allow us to meet, face to face) I applied for a Rockefeller Foundation Bellagio Center team residency at the Center on Lake Como, Italy.

Bellagio Research Team Residency March 2004



2005-2006, I was one of twelve Science Fellows at the Radcliffe Institute for Advanced Study at Harvard University.

Professor Daniele visited me for several months there and we worked with Professor David Parkes of Harvard on dynamic networks.

In March 2008, I was a Fulbright Senior Specialist in Business Administration at the University of Catania, Italy.

Professor Patrizia Daniele and I organized a workshop on complex networks, and I gave several lectures, plus reviewed the curriculum in operations research there.









In May 2008, I organized the Workshop: Humanitarian Logistics: Networks for Africa, under the auspices of the Rockefeller Foundation's Bellagio Center Conference Programs; http://hlogistics.som.umass.edu/



Virtual Center for Supernetworks


Now that several of my former doctoral students have academic positions in different countries this further extends our international collaborations.

Other recent international activities have included serving on the Advisory Board of a European Union funded project COMISEF.

The opportunities to serve as an external examiner on doctoral dissertations is another great experience. I have done this for doctoral students in Norway, New Zealand, and Canada.

The Virtual Center for Supernetworks

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

Home | About | Background | Activities | Publications | Media | Links | What's New | Search

The Virtual Center for Supernetworks at the Isenberg School of Management, under the directorship of Anna Nagurney, the John F. Smith Memorial Professor, is an interdisciplinary center, and includes the Supernetworks Laboratory for Computation and Visualization.

Mission: The mission of the Virtual Center for Supernetworks is to foster the study and application of supernetworks and to serve as a resource to academia, industry, and government on networks ranging from transportation, supply chains, telecommunication, and electric power networks to economic, environmental, financial, knowledge and social networks.

The Applications of Supernetworks Include: multimodal transportation networks, critical infrastructure, energy and the environment, the Internet and electronic commerce, global supply chain management, international financial networks, web-based advertising, complex networks and decision-making, integrated social and economic networks, network games, and network metrics.

Announcements and Notes from the Center Director Professor Anna Nagurney

Updated: March 14, 2010

Professor Anna Nagurney's Blog

RENeW

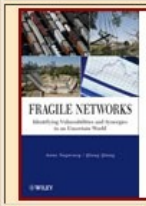
Research, Education, Networks, and the World: A Female Professor Speaks

INFORMS Podcasts: Anna Nagurney on Supernetworks

Why did closing New York's Time Square to cars improve traffic? How are energy and finance like large networks? Can biologists learn from operations researchers? Anna Nagurney, Director of the Virtual Center from Supernetworks at UMass Amherst shares fascinating insights about networks in the latest INFORMS podcast. Tune in at www.scienceofbetter.org/podcast

June 10- 14, 2009 New York City

World Science Festival



New Book

Fragile Networks

Available June 2009

Spring 2010 Operations Research / Management Science Seminar Series

Photos of Center Activities

The Braess Paradox

Translation

Information

Photos

You are visitor number

62,395

to the Virtual Center for Supernetworks.

Google

Google Search

http://supernet.som.umass.edu