

# Research

EXECUTIVE SUMMARIES : BY RONALD ASKIN AND LING ROTHROCK

*This month we highlight two articles focusing on logistics. The first article addresses the use of regional 3PL services for delivering periodic orders from warehouses to retail outlets. A mutually agreeable fee table is needed for pricing deliveries. The second article looks at routing pickups and deliveries in the nonprofit sector where a food bank wants to distribute donations to its client agencies equitably and at minimum distribution cost. These articles will appear in the December 2014 issue of IIE Transactions (Volume 46, No.12).*

## A fair day's pay for your logistics partners

To meet the demanding product delivery requirements of large retailers, manufacturing companies are partnering with regional third-party logistics (3PL) providers for “last echelon” distribution from the company’s warehouses or distribution centers (DCs) to retail stores.

Logistics managers at these companies face the important issue of deciding how much to pay the 3PL providers for their delivery services. Motivated by this problem that a building products manufacturer was facing, the article “Designing Delivery Fees for Retail Delivery Services by Third-Party Logistics Distributors” by Anant Balakrishnan of the University of Texas at Austin and Hari Natarajan of the University of Miami, Coral Gables, develops an optimization model to determine a fair and equitable delivery payment scheme.

The manufacturer relies on regional 3PL companies to pick up ordered items from the distribution center and periodically deliver to retail stores. The weight of products ordered varies with each delivery, but is less than a full truckload. Following



Hari Natarajan, shown here at a warehouse loading dock, helped develop a model to determine more equitable fee structures between 3PLs and manufacturers.

common payment practice in the less-than-truckload (LTL) freight transport industry, the companies agreed to use a fee table that specifies, for various ranges of DC-to-store distances and delivery weights, the amount to be paid to the 3PL company for each delivery.

The freight rates from commercial LTL rate tables do not directly apply because these tables typically assume occasional transport of smaller weight packages over long distances. In contrast, this manufacturing company commits to a long-term partnership with the 3PL providers for periodic deliveries.

So the main fee table decisions facing the company are what weight and distance ranges to use and how much the regional 3PL providers should be paid for each range combination.

This article provides an operational tool for setting fees by framing the problem as an optimization model. The mixed-integer program considers the distance of each store from the distribution center, the probability distribution of delivery weights to each store, and the total delivery cost incurred by each 3PL provider. The authors

tailor a solution procedure that exploits the problem’s structure to strengthen the model formulation and also obtain good optimization-based heuristic solutions.

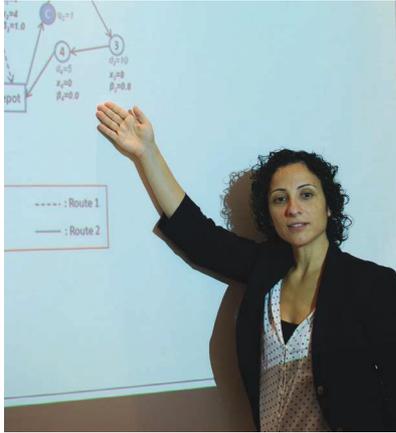
When applied to actual data from the building products manufacturer, the model and methodology was able to determine a fair and more equitable fee structure than the previous manually chosen table, while also reducing the manufacturer’s distribution costs. The paper provides a rigorous and systematic approach to support negotiations between companies and their 3PL service providers in retail distribution and other supply chain contexts.

**CONTACT:** Anant Balakrishnan; anantb@mail.utexas.edu; (512) 471-5216; McCombs School of Business, 1 University Station B6500, Austin, TX 78712

## Maximizing equity and minimizing waste in food bank deliveries

Food banks play an increasingly important role in delivering food to those who are food insecure. Rising demand, limited resources and high transportation costs

## research



Burcu Balcik discusses an example of how routing decisions affect equity and waste.

increase the importance of effective design and management of food distribution operations. However, unlike traditional commercial distribution systems, which typically are designed to reduce costs and/or maximize profits, food banks are nonprofit organizations, so their more critical objectives are maximizing equity and minimizing waste.

The Food Rescue Program (FRP) at the Greater Chicago Food Depository (GCFD) operates by collecting surplus food from donors (such as grocery stores, restaurants) and distributing the food to agencies (such as shelters and senior centers) that directly serve people in need. Each day, multiple vehicles are dispatched from the GCFD, and each vehicle visits a number of donors and agencies. Once a vehicle collects all donations, the vehicles visit agencies to distribute food according to agency demands.

While drivers try to meet the agency's demand, they also strive to reserve food for the remaining agencies to be visited along the route so that all agencies can benefit equitably from the program. In this system, routing decisions greatly affect the degree to which supplies and demands can be matched; however, incorporating sequential resource allocation decisions into route design while ensuring equity and low waste is challenging.

The problem of designing equitable



A sign language interpreter performs simulated interpretation in the lab while the research team measures and monitors upper arm movements.

routes for the FRP operations is addressed in "Multi-Vehicle Sequential Resource Allocation for a Nonprofit Distribution System" by professor Burcu Balcik from Ozyegin University and professors Karen Smilowitz and Seyed Iranavi from Northwestern University.

A set partitioning model is formulated to design vehicle routes, which primarily focuses on maximizing equity while implicitly considering waste. The authors present an efficient decomposition-based heuristic that can obtain high-quality solutions in terms of equity and waste. The numerical study demonstrates that supply availability and demand variability are important factors that affect the size and composition of routes.

**CONTACT:** Burcu Balcik;

burcu.balcik@ozyegin.edu.tr; +90

(216) 564-9390; Industrial Engineering Department, Ozyegin University, Istanbul, Turkey

*This month we highlight two articles that appeared in the April issue of IIE Transactions on Occupational Ergonomics and Human Factors (Volume 2, No. 2). Authors of the first article examined how experience might influence injury risks among sign language interpreters. In the second article, the authors developed a new method, using a robotic device, to understand how shoe tread design and wear might affect the risk of a slip.*

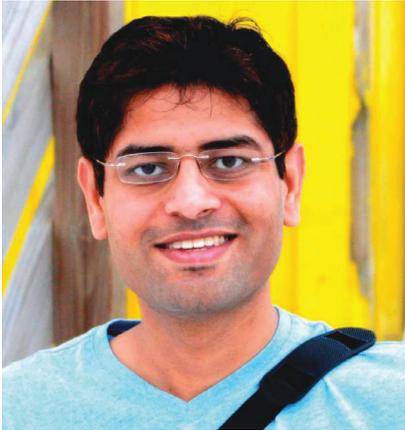
## Biomechanics researchers give sign language interpreters a helping hand

Sign language interpreters play a vital role facilitating communication between people who speak and millions of deaf and hard-of-hearing individuals who rely on signed languages. However, the day in, day out production of physical signs can greatly increase an interpreter's risk of musculoskeletal injury.

To learn more about factors thought to influence interpreters' injury risks, Steven Fischer and Ron Johnson from Queen's University teamed up with Kathryn Woodcock and Mohammad Abdoli-Eramaki from Ryerson University to conduct a study titled: "Investigating the Effect of Experience and Duration on Kinematics During One Hour of Sign Language Interpreting."

One of the first research studies of interpreter injury involving a deaf researcher, this study used lab simulations that replicated realistic interpretation appointments. It was believed that less experienced interpreters, being less efficient in their signing, might produce more signs while attempting to interpret given content and that the extra movement would fatigue these interpreters earlier.

Experienced and novice interpreters were not different in their movements, at least at the beginning. Novices were not moving more, but all interpreters were



Gurjeet Singh (left) and Kurt Beschorn developed a new method to determine how effective different shoe treads are at draining fluids.

signing at a high rate of movement relative to other repetitive hand-arm work. During 60 minutes of continuous sign production, both groups began to alter their movement patterns consistent with a reduced ability to keep up with the interpretation. This reduction was more severe among novice interpreters; however, it is not yet known if interpreters omitted important linguistic content due to this reduction.

Understanding how situational and personal factors can influence an interpreter's movement profile is critical for supporting evidence-based workplace interventions. Supported by this evidence, interpreter advocacy bodies such as the Association of Visual Language Interpreters of Canada (AVLIC) or the Registry for Interpreters of the Deaf in the United States can be urged to consider strategies and policies that limit the duration of continuous interpretation even below the current best practice of 90 minutes of solo work.

Additionally, rather than focusing only on sign technique training for new interpreters, the profession should consider recommending strength training activities to help new interpreters improve their resistance to fatigue.

**CONTACT:** Steven Fischer; steve.fischer@queensu.ca; (613) 533-6000, ext. 75210; assistant professor, School of Kinesiology and Health Studies,

Queen's University, 28 Division St., Kingston, Ontario, Canada, K7L 3N6

### How slippery the shoe tread? New method will tell

Slip and fall accidents are among the leading events that cause occupational injuries. A person's shoes play a major role in whether they slip and fall after stepping on a slippery surface.

One of the primary functions of shoe tread is to channel fluid out from under the shoe, and the ability of shoe tread to drain fluid may become reduced as the shoe becomes worn down. Therefore, worn shoes may increase slip risk just as worn tire treads increase the risk of sliding off of a wet road.

New research by Gurjeet Singh of the University of Wisconsin-Milwaukee and Kurt Beschorn of the University of Pittsburgh has developed a novel method for measuring this effect. In the study, "A Method for Measuring Fluid Pressures in the Shoe-Floor-Fluid Interface: Application to Shoe Tread Evaluation," a robotic device that simulates the forces and sliding speeds of a slip was moved across a floor surface in which a fluid pressure sensor was embedded. Fluid pressures were measured and mapped across the shoe surface. The authors found that worn shoes led to increased under-shoe fluid pressures in the presence of viscous fluids (like oil) but not in the presence of low

viscosity fluids (like water).

This new method allows researchers to determine the relative effectiveness of different tread designs at draining fluids and when worn shoes should be replaced. Therefore, this method is expected to contribute to a reduction of slip and fall accidents by improving slip-resistant shoe designs and shoe tread maintenance.

**CONTACT:** Kurt Beschorn; beschorn@pitt.edu; (412) 624-7577; Benedum Engineering Hall No. 302, 3700 O'Hara St., Pittsburgh, PA 15261

*Ronald Askin is a professor and director of the School of Computing, Informatics and Decision Systems Engineering at Arizona State University. He is editor-in-chief of IIE Transactions and a fellow of IIE.*

*Ling Rothrock is an associate professor in the Department of Industrial and Manufacturing Engineering at The Pennsylvania State University. He is an associate editor of IIE Transactions on Occupational Ergonomics and Human Factors.*



### About the journals

*IIE Transactions* is IIE's flagship research journal and is published monthly. It aims to foster exchange among researchers and practitioners in the industrial engineering community by publishing papers that are grounded in science and mathematics and motivated by engineering applications.

*IIE Transactions on Occupational Ergonomics & Human Factors* is devoted to compiling and disseminating knowledge on occupational ergonomics and human factors theory, technology, application and practice across diverse areas.

To subscribe, call (800) 494-0460 or (770) 449-0460.