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# MSOM Society Student Paper Competition: Abstracts of 2022 Winners

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**Abstract.** The journal is pleased to publish the abstracts of the six finalists of the 2022 Manufacturing and Service Operations Management Society's student paper competition. The 2022 prize committee was chaired by Florin Ciocan (INSEAD), Ersin Korpeoglu (University College London), and Nikos Trichakis (Massachusetts Institute of Technology). The judges were Adam Elmachtoub, Adem Orsdemir, Agni Orfanoudaki, Alp Akcay, Alper Nakkas, Amrita Kundu, Amy Pan, Andrew Wu, Antoine DESIR, Anyan Qi, Arian Aflaki, Ashish Kabra, Auyon Siddiq, Bilal Gokpinar, Bob Batt, Bora Keskin, Can Zhang, Dan Iancu, Dan Iancu, Daniel Freund, Daniel Lin, Daniela Saban, David Drake, Dawson Kaaua, Ekaterina Astashkina, Elena Belavina, Elodie Adida, Emre Nadar, Fabian Sting, Fanyin Zheng, Fei Gao, Georgina Hall, Gizem Korpeoglu, Gonzalo Romero, Guoming Lai, Hessam Bavafa, Hummy Song, Ioannis (Yannis) Bellos, Ioannis Stamatopoulos, Iris Wang, Itir Karaesmen, Jiankun Sun, Jiankun Sun, Jiaru Bai, Jiayi Joey Yu, Jing Wu, Joel Wooten, John Silberholz, Jonathan Helm, Jose Guajardo, Karen Zheng, Ken Moon, Kenan Arifoglu, Kimon Drakopoulos, Kostas Bimpikis, Lennart Baardman, Lina Song, Luyi Gui, Luyi Yang, Miao Bai, Mika Sumida, Ming Hu, Mumin Kurtulus, Nazli Sonmez, Negin Golrezaei, Nektarios Oraiopoulos, Nil Karacaoglu, Nitin Bakshi, Nitish Jain, Nur Sunar, Olga Perdikaki, Ovunc Yilmaz, Ozan Candogan, Panos Markou, Pengyi Shi, Philip Zhang, Philipp Cornelius, Qi (George) Chen, Qiuping Yu, Ruslan Momot, Ruth Beer, S. Alex Yang, Saed Alizamir, Safak Yucel, Sanjith Gopalakrishnan, Santiago Gallino, Sarah Yini Gao, Scott Rodilitz, Sebastien Martin, Sheng Liu, Shouqiang Wang, Simone Marinesi, Sina Khorasani, So Yeon CHUN, Somya Singhvi, Soo-Haeng Cho, Soroush Saghafian, Sriram Dasu, Stefanus Jasin, Stephen Leider, Tian Chan, Tim Kraft, Tom Tan, Vasiliki Kostami, Velibor Misic, Vishal Agrawal, Xiaojia Guo, Xiaoshan Peng, Xiaoshuai Fan, Xiaoyang Long, Yangfang (Helen) Zhou, Yasemin Limon, Yehua Wei, Ying-Ju Chen, Yonatan Gur, Yuqian Xu, Zhaohui (Zoey) Jiang, Zhaowei She, and Zumbul Atan.

The 2022 prize winners are as follows:

**First Prize**

*Unmasking Human Trafficking Risk in Commercial Sex Supply Chains with Machine Learning*
Pia Ramchandani, University of Pennsylvania
Emily Wyatt, TellFinder Alliance

**Second Prize**

*Fair Exploration via Axiomatic Bargaining*
Jackie Baek, Massachusetts Institute of Technology

**Finalists (in alphabetical order according to the author's last name):**

*Learning from Observational Commerce Data*
Tianyi Peng, Massachusetts Institute of Technology

*The Digital Lives of the Poor: Entertainment Traps and Information Isolation*
Alp Sungu, London Business School

*Improving Drinking Water Access and Equity in Rural Sub-Saharan Africa*
Chengcheng Zhai, Indiana University

*Spatial Price Integration in Commodity Markets with Capacitated Transportation Networks*
Ian Yihang Zhu, University of Toronto

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## Unmasking Human Trafficking Risk in Commercial Sex Supply Chains with Machine Learning

**Pia Ramchandani**
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Coauthor: Emily Wyatt, TellFinder Alliance
Advisor: Hamsa Bastani, University of Pennsylvania

The covert nature of sex trafficking provides a significant barrier to generating large-scale, data-driven insights to inform law enforcement, policy, and social work. Existing research has focused on analyzing commercial sex sales on the Internet to capture scalable geographical proxies for trafficking. However, ads selling commercial sex do not reveal information about worker consent. Therefore, it is challenging to identify risks for trafficking, which involves fraud, coercion, or abuse. We leverage massive deep web data (collected globally from leading commercial sex websites) in tandem with a novel machine learning framework (combining natural language processing, active learning, and network analysis) to study how and where sex worker *recruitment* occurs. This allows us to unmask deceptive recruitment patterns (e.g., an entity that recruits for modeling, but sells sex). Our analysis provides a geographical network view of online commercial sex supply chains, highlighting deceptive recruitment-to-sales pathways that signal high trafficking risk. Our results can help law enforcement agencies along trafficking routes better coordinate efforts to tackle trafficking entities at both ends of the supply chain, as well as target local social policies and interventions toward exploitative recruitment behavior frequently exhibited in that region.

## Fair Exploration via Axiomatic Bargaining

**Jackie Baek**
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Advisor: Vivek F. Farias, Massachusetts Institute of Technology

Exploration is often necessary in online learning to maximize long-term reward, but it comes at the cost of short-term "regret." We study how this cost of exploration is shared across multiple groups. For example, in a clinical trial setting, patients who are assigned a suboptimal treatment effectively incur the cost of exploration. When patients are associated with natural groups based on, say, race or age, it is natural to ask whether the cost of exploration borne by any single group is "fair." So motivated, we introduce the "grouped" bandit model. We leverage the theory of axiomatic bargaining, and the Nash bargaining solution in particular, to formalize what might constitute a fair division of the cost of exploration across groups. On the one hand, we show that any regret-optimal policy strikingly results in the least fair outcome: such policies will perversely leverage the most "disadvantaged" groups when they can. More constructively, we derive policies that are optimally fair and simultaneously enjoy a small "price of fairness." We illustrate the relative merits of our algorithmic framework with a case study on contextual bandits for warfarin dosing where we are concerned with the cost of exploration across multiple races and age groups.

## Learning from Observational Commerce Data

**Tianyi Peng**
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Advisors: Vivek Farias (Massachusetts Institute of Technology) and Andrew Li (Carnegie Mellon University)

Experimentation is the gold standard in online and offline commerce for evaluating just about every marketing and operational decision. Unfortunately, deployment of experimental treatments is complex, and therefore the resulting data are effectively observational (i.e., the treatment is arbitrarily applied). The following is a fundamental version of this problem: Let $M^*$ be a low rank matrix and $E$ be a zero-mean noise matrix. For a treatment matrix $Z$ with entries in $\{0, 1\}$, we observe the matrix $O$ with entries $O_{ij} := M^*_{ij} + E_{ij} + \mathcal{T}_{ij}Z_{ij}$, where $\mathcal{T}_{ij}$ are unknown, heterogenous treatment effects. The problem requires we estimate the average treatment effect $\tau^* := \sum_{ij}\mathcal{T}_{ij}Z_{ij}/\sum_{ij}Z_{ij}$. Existing approaches work only for specific, highly structured classes of $Z$. We develop an estimator that provably achieves rate-optimal recovery of $\tau^*$ for general $Z$. Our guarantees are the first of their type in this general setting and allow the assignment of $Z$ depending on the historical observations. Computational experiments on synthetic and real-world data show a substantial advantage over competing estimators. Finally, we describe an implementation of our estimator at Anheuser-Busch InBev, which already frequently yields increases in sales volume of 1%–2%.

## The Digital Lives of the Poor: Entertainment Traps and Information Isolation

**Alp Sungu**
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Advisor: Kamalini Ramdas, London Business School

Smartphones have enabled the delivery of life-improving information services to base-of-the-pyramid (BOP) consumers. However, little is known about how the poor interact with the digital world. Through a novel app we developed to investigate real-time smartphone use, we identify an unnoticed barrier to digital information access by the poor: data shortages. By analyzing

more than 9.4 million minutes of smartphone use data from 929 residents of a Mumbai settlement, we find that entertainment consumes 61% of their phone time. Our data reveal that under universally adopted monthly data plans, low-income individuals binge on YouTube and social media, resulting in data shortages and information isolation in the late-plan period. We offer a practical operational solution to this problem—shorter data replenishment cycles—that serve as a commitment device to curb binge use. We randomly assign participants to a "capped plan" —with daily data use caps—or a standard (monthly) plan. Assignment to the capped plan increases late-plan access of invites to health camps sent via WhatsApp, increases attendance at these in-person camps by 7%, and reduces social media binge use. Most participants (particularly those with low self-control and high fear of missing out) prefer the capped plan, even when costlier—clearly signaling demand. Because capped plans are inherently cheaper to provide, offering them could enable providers to increase BOP customer value and expand access. Our results suggest an opportunity to amplify the impact of life-improving services targeted at the poor by leveraging users' interactions with smartphone technology.

## Improving Drinking Water Access and Equity in Rural Sub-Saharan Africa

**Chengcheng Zhai**
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Advisors: Kurt Bretthauer, Jorge Mejia, and Alfonso Pedraza-Martinez, Indiana University

In 2020, 771 million people lacked access to clean drinking water. Building new water projects, such as handpumps and small piped systems, is the primary operational response by many nongovernmental organizations (NGOs) to bring people their first access to clean water in rural areas of developing countries. Based on knowledge gained from our collaboration with a local NGO and an international NGO and field research in Ethiopia, our research studies where to build new water projects optimally. We first develop a decentralized water project location optimization model based on current practice of a decentralized decision-making and project management system and an equal per-beneficiary budget. We further propose three new models to improve both water access *and* equity: a minimax model, an equitable budget model, and a centralized model that leverages the existing community involvement. Through numerical studies, we compare the model solutions and generate recommendations for NGOs. Last, motivated by the current civil war in Ethiopia, we develop a stochastic model to study how to improve drinking water access while mitigating the negative impact of water project supply shocks such as war. Our work studies the previously overlooked problem of drinking water access in rural areas of developing countries. It provides a generalizable and scalable methodology and managerial insights to NGOs building new water projects by combining large geo-coded data sets and field data.

## Spatial Price Integration in Commodity Markets with Capacitated Transportation Networks

**Ian Yihang Zhu**
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Advisor: Timothy C. Y. Chan, University of Toronto

Spatial price integration is extensively studied in commodity markets as a means of examining the degree of integration between regions of a geographically diverse market. Many commodity markets that are commonly studied are supported by stable and well-defined transportation networks. In this paper, we analyze the relationship between spatial price integration, that is, the distribution of prices across geographically distinct locations in the market and the features of the underlying transportation network. We characterize this relationship and show that price integration is strongly influenced by the characteristics of the network, especially when there are capacity constraints on links in the network. Our results are summarized using a price decomposition that explicitly isolates the influences of market forces (supply and demand), transportation costs, and capacity constraints among a set of equilibrium prices. We use these theoretical insights to develop a unique discrete optimization methodology to capture spatiotemporal price variations indicative of underlying network bottlenecks. We apply the methodology to gasoline prices in the southeastern United States, where the methodology effectively characterizes the price effects of a series of well-documented network and supply chain disruptions, providing important implications for operations and supply chain management.