Karen Li '17 Publishes Honors Thesis in Operations Research for Health Care

Karen Li

ABSTRACT

We construct a game theory model to capture competition among hospitals for patients using Bertrand competition in prices charged to patients and quality levels of services provided. To further understand competition among hospitals, we use the Nash equilibrium conditions to develop the Nash equilibrium formations to explain the existence of equilibrium and price variations. Nash equilibrium is an equilibrium in the sense that hospitals will act optimally on the basis of the prices charged to patients as well as the quality levels of their procedures.

MODEL FORMULATION

Hospitals

\[ P_1, P_2, \ldots, P_n \]

\[ Q_1, Q_2, \ldots, Q_n \]

Medical Procedures

Figure 1: Network of the Game Theory Model for Hospital Competition

Novelistic of the Hospital Competition Model

1. Hospitals compete non-cooperatively on prices and quality, for patients that visit the hospital.
2. Utility function is the sum of all patients benefit from hospitals. 
3. Degree of illness is incorporated into the total benefit of patient receiving treatment at each hospital.
4. Patients in lower-priced and higher-quality hospitals are served as a mechanism to ensure outcomes.
5. Governing Nash Equilibrium may be solved as an optimization problem using the variational inequality formalism and present the existence of a solution.
6. Upper and Lower Price Constraints for hospitals: \( 0 < P_1 < P_2 < \ldots < P_n \)

Taxes and Lower Demix Price Constraints for hospital: \( 0 < P_1 < P_2 < \ldots < P_n \)

Internal Frictions of hospital: \( 0 < P_1 < P_2 < \ldots < P_n \)

Cost Function of hospital: \( c_i(q_i) \)

Quality Benefit Constraint of hospital: \( r_i(b_i) \)

Utility Function of hospital: \( u_i(p_i) \)

The equilibrium of prices and quality is reached when each hospital maximizes its profit and there are no Nash Equilibrium if the Nash equilibrium is a solution to the problem.

References


By: Hannah Depin
What's the key to a successful Honors thesis or project?

“No matter what you pursue, you have to be passionate about what you’re doing,” said CHC and Isenberg School of Management alumna Karen Li ’17. A pre-med and operations and information management student, Li studied healthcare efficiency, quality, and accessibility for her Honors thesis with Professor Anna Nagurney, the John F. Smith Memorial Professor of Operations Management. Following months of hard work and revisions, their research paper was recently accepted for publication by the journal Operations Research for Health Care.

Li began writing this thesis as a second-semester senior in the Honors College, after three and a half years working in a biochemistry lab. Inspired by operations healthcare, Li pursued another thesis outside the lab in operations and information management. “I picked a topic that would keep me up at night—a buzzing thought that wouldn’t leave,” she explained.

Li said she had always been interested in the efficacy of healthcare. She traveled to Haiti several times for public health and service work. As a junior, she enrolled in Professor Nagurney’s course, Humanitarian Logistics and Healthcare, where she completed the project Preventing Disease After Disaster: How the Infrastructure of Haiti Affected the Outbreak of Cholera. Nagurney took note of Li’s outstanding performance in the course.

“I just loved her passion and work ethic,” said Nagurney, who would become Li’s thesis advisor and the co-author of the research paper. “We did a lot of ‘brainstorming.’ We would talk for hours and it would feel like minutes.”

Nagurney and Li investigated the larger forces that affect hospitals, and the quality of healthcare that patients receive in turn. In April 2017, they submitted their paper to Operations Research for Health Care. After feedback and revisions, the paper was accepted for publication in early October.

Nagurney said that Li is an exemplar of the caliber of CHC students. While she was constructing a case study, gathering data and conducting interviews for her research, Li was also working as a Resident Assistant in the Honors College, teaching as a UMass Supplemental Instructor, and volunteering. She was also enrolled in Nagurney’s graduate-level seminar, in which she met with PhD students each week to discuss ideas and concepts related to her thesis.

“As an aspiring physician, I have always wanted to contribute to healthcare beyond the patient level, in a meaningful way,” said Li. She is now a research coordinator at Brigham and Women’s Hospital for Neurology and Neurocritical Care, and she says she’s already been able to use knowledge from her thesis process in the workforce.

Li expressed gratitude for Nagurney’s support and mentorship. “My advice for students who are interested in writing a thesis or publishing a paper is: find something you’re interested in. The professors at UMass are more than happy to support you in your endeavors and passions.”

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