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KRANNERT SCHOOL OF MANAGEMENT

Highlighting Management Department
Faculty Research

CONTENTS :

Conflict Management Interviews
Are Effective, but Only if the
Quality Is High

Page 5

Verifying the Structure of Multi-
Dimensional Martingale Optimal
Transport

Page 8

Are Financially Distressed People
More Likely to Vote? Evidence
from the Housing Crisis
Contradicts the 'Angry Voter'
Theory

Page 11

Keeping Up With Their Peers: Are
Corporations Influenced to Make
Disclosure Decisions?

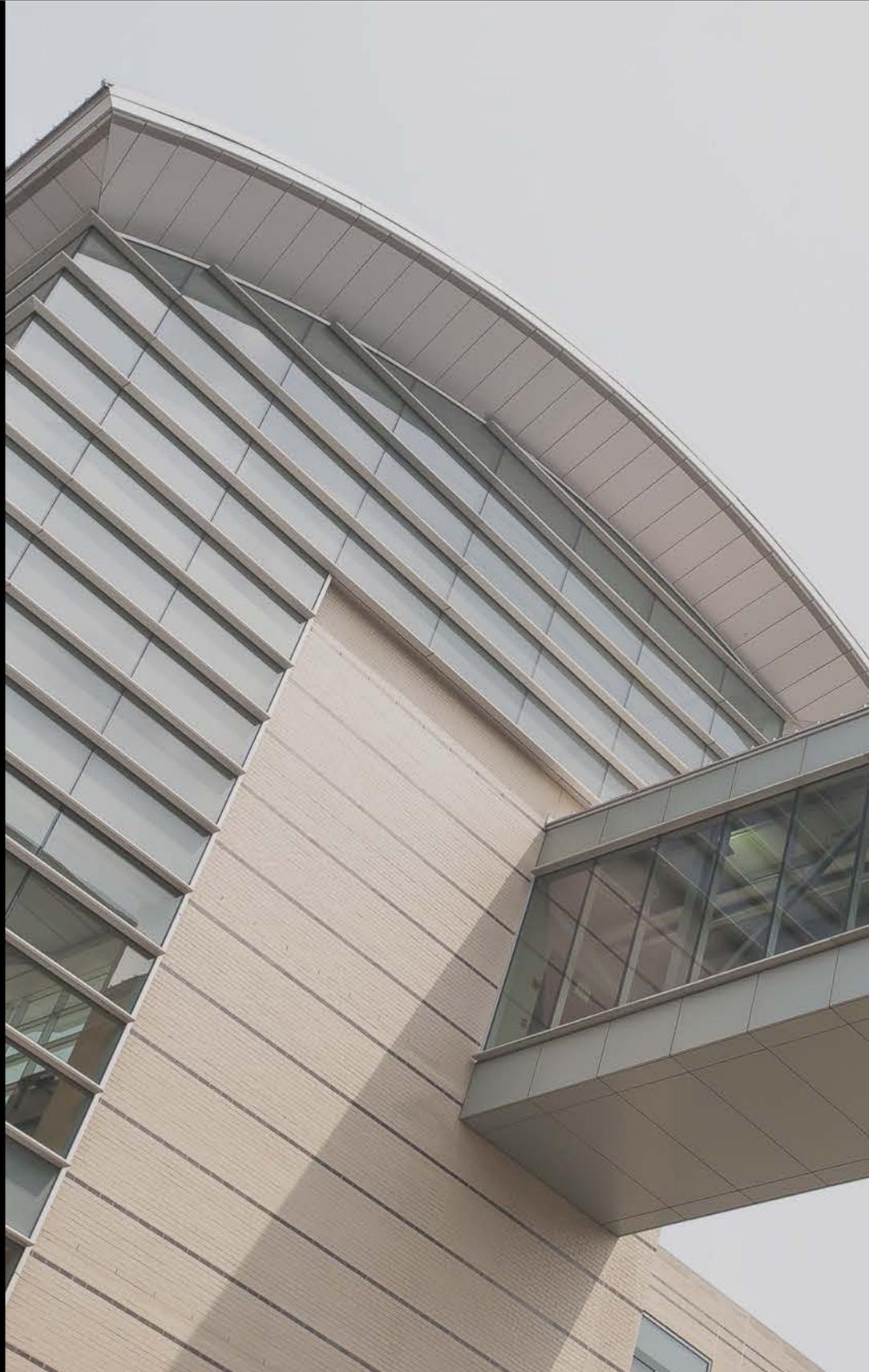
Page 15

No Room in the Hospital? An
Analytical Tool Helps Doctors
Decide Which Patients to
Discharge

Page 18

Can Investors Profit from Indirect
Ties to Startup Companies? Only
if the Ties are Strong

Page 21



Management Department Head Ananth Iyer

We are pleased to present the 5th edition of the management department's research newsletter, showcasing faculty research across academic areas, published by the management department at the Krannert School of Management at Purdue University. If there is one theme in all of these papers, it is the dedication of our faculty to scholarship, to their drive to understand, synthesize and recommend actions in their domain of interest. I hope you learn from their insights, and provide us feedback regarding this newsletter. We will continue to strive to communicate our faculty's research to our stakeholders.

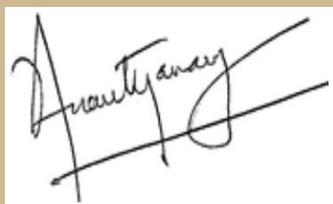
This newsletter contains a diverse set of topics. Ben Dunford's research focuses on the effectiveness of integrated conflict management systems. Using an eight-year dataset from a non-union healthcare system, he explores the benefit of high-quality management interviews on retention and perceptions of department culture. Tongseok Lim describes his research on multi-dimensional martingale transport problems, with the aim to develop deep theoretical insights. Ben McCartney's paper explores the "angry voter" theory that financially distressed people are more likely to vote. But his research shows that they are less, not more likely, to vote by considering the costs of voting. His research suggests that a 10% decline in house prices decreases participation rate of mortgaged borrowers by 1.6%.

Hojun Seo explores whether “disclosures made by industry peers significantly influence the disclosures made by individual firms.” He suggests two mechanisms that impact disclosure and finds that “peer effects are a significant determinant of corporate disclosure decisions.”

Pengyi Shi studies how hospitals manage the readmission risk from early patient discharge and whether an analytical tool can help make them better decisions. Her research, conducted with a partner hospital in Indiana, shows that extending the length of stay can decrease more than 50% of the readmission. Umit Ozmel studies whether institutional investors can benefit from their indirect connection to entrepreneurial firms in the private equity market, once the firms have gone public. Her research shows that an investor with strong indirect ties to an entrepreneurial firm can earn about 13 to 20 percent higher risk-adjusted returns per quarter by investing in the entrepreneurial firm's stock, compared with investments in other publicly traded firms.

This research newsletter provides you but a glimpse of the intense focus on research excellence and the clarity of the problem framing by our faculty, as well as the care with which results are presented to ensure timeless value. We hope that you are motivated to look up the associated academic papers, or connect with the faculty for more detail. But, more importantly, please do not hesitate to seek out the expertise of our faculty to provide you with insights regarding your own business environment. We hope you will continue to read our research newsletters and provide us feedback.

Have a wonderful day.

A handwritten signature in black ink, appearing to read "Ananth V Iyer", written over a white rectangular background.

Ananth V Iyer
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Krannert School of Management



Conflict Management
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Crisis Contradicts the 'Angry
Voter' Theory

Ben McCartney



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Companies? Only if the Ties
are Strong

Umit Ozmel Yavuz

Conflict Management Interviews Are Effective, but Only if the Quality Is High

by Melvin Durai

An office assistant feels that he's being overworked and resents his boss for not giving him a raise. A restaurant manager fails to provide adequate training to her cooks, but berates them for inconsistent quality. A factory supervisor pressures his workers to accept overtime assignments, ignoring their personal needs.

A variety of circumstances, from perceived inequities to unreasonable expectations, can trigger workplace conflict. If left to smolder, this conflict can flare up into costly outcomes that may include absenteeism, turnover, arbitration and litigation. Perhaps worst of all, it may produce a dysfunctional culture that stifles innovation and hinders an organization's effectiveness.

Putting out the sparks of conflict before they ignite is one of the goals of Integrated Conflict Management Systems (ICMS), which place the responsibility of conflict resolution directly on managers and employees, rather than ombudspersons, human resource personnel, mediators, arbitrators and others.



"The rationale is that if you can create an environment in a team where people can come to you and you can have an open dialogue with a supervisor, you can resolve a lot of things very simply before they have to escalate and become formalized," said Benjamin B. Dunford, associate professor in Krannert School of Management.

Source:
Ben Dunford

But how effective are conflict management systems? Dunford and his co-researchers had a unique opportunity to test key predictions of ICMS theory by analyzing an eight-year longitudinal data set from a non-union healthcare system in the eastern United States. They found that employees whose managers provide high-quality conflict management interviews (CMIs) are less likely to file grievances or leave the organization, and have significantly greater perceptions of participative department culture.

Their findings suggest that it's not enough to just hold conflict management interviews — the quality of these CMIs is critical.

"If you're not doing them well, then they may not be very beneficial," Dunford said. "In fact, they may actually be detrimental. Supervisors who do this poorly can sometimes exacerbate mistrust."

Dunford collaborated with Kevin J. Mumford, associate professor in Krannert, as well as R. Wayne Boss of Leeds School of Business at University of Colorado at Boulder, Alan D. Boss of the College of Business at University of Arkansas at Little Rock, and David S. Boss of the College of Business at Ohio University.

They published their findings in an article entitled "Integrated Conflict Management Systems Pay Off with Lower Levels of Formal Grievances and Lower Turnover Rates," which appeared in the March 2020 issue of ILR Review.

The researchers studied data collected over an eight-year period from a health care system that includes more than 200 small-scale physician clinics, four hospitals, a nursing home and a hospice center. The system, which employs about 5,000 people, hired a new CEO in 2001, hoping to rebound from a troubling period in the mid-1990s in which revenues and health care quality dropped, employee morale slumped, and conflict and competition among various units and departments was fostered.

Under the new leadership, the health care system implemented system-wide CMIs as a strategy to regain a competitive edge in the regional market. The new CEO believed strongly in CMIs as a way to prevent and quickly resolve interpersonal problems and disputes.

In contrast to performance appraisals, CMIs are designed to promote communication and feedback in both directions between supervisor and subordinate. In essence, they enter into a contract about what they expect from each other, and check back once a month to see how they're doing and whether they need to revise anything.

While the CEO of the health care system had mandated CMIs, the researchers expected to find variations in implementation in three primary ways: occurrence, frequency and quality.

"Some managers are better than others at doing it," Dunford said. "Some of them turned their noses up and said, 'We don't have time for this.' And others said, 'We can't afford not to do this.'"

The researchers collected survey data on the occurrence, frequency and quality of CMIs over the eight-year-period. They analyzed the data to determine how these variables were associated with three key outcomes of conflict management systems: reducing formal grievance filings, improving participative culture, and reducing employee turnover.

They found evidence that the quality of CMIs was associated with fewer formal grievances, more participative culture perceptions, and increased retention. They also found that the occurrence and frequency of CMIs improved perceptions of participative culture, but did not reduce turnover or formal grievances.

To improve the quality of CMIs, organizations must be willing to invest in significant training, incentives, mentoring, and follow-up, the researchers say.

CMIs should be seen as an investment, not simply as a cost, Dunford said. "You talk to a chief financial officer and he or she will ask, 'Why are we spending money on all this training? Why don't we just pay one person to be the grievance person? That's cheaper than doing all this training.' Well, think of all the incredible loss of productivity, and the turnover and ill will that's caused when grievances don't get resolved. And think of how much more productivity we can have as an organization if we create the sort of culture where I can sit down at my interview regularly and have a very productive, open-ended conversation. This is something that doesn't happen as much as it should in the corporate world today."

Verifying the Structure of Multi-Dimensional Martingale Optimal Transport

By Melvin Durai

The optimal transport problem, first studied by the French mathematician Gaspard Monge in 1781, seeks to match two distributions of objects in the most cost-efficient way. In the classic example of mines and factories, optimal transport determines how to efficiently move iron ore from a set of mines to a set of factories.



Soviet mathematician and economist Leonid Kantorovich made major advances in optimal transport theory during World War II, discerning most notably that the OT problem can be seen as a special case of infinite-dimensional linear programming with a dual problem. This led to a wide array of applications in fields such as probability, statistics, economics, and data sciences.

To solve problems in probability and mathematical finance, optimal transport needed to also satisfy the martingale condition and became known as martingale optimal transport (MOT). While optimal transport seeks to find the optimal allocation cost, MOT seeks the upper and lower price bounds of financial instruments.

Optimal transport as a multi-dimensional theory has been well-researched, but MOT was confined to a one-dimensional setup in scientific literature, until Tongseok Lim and others began filling in the gap.

One-dimensional MOT corresponds to a situation where an option payoff depends only on one asset price, which isn't common, according to Lim, visiting assistant professor in quantitative methods at Krannert School of Management.

Financial instruments typically depend on a large number of assets, or on indices like the S&P 500, he says.

"That's why multi-dimensional MOT theory should be well-developed to have a deeper impact on theory and applications," he said.

Among his pioneering contributions to the field, Lim published the first paper that studies the structure of MOT in multiple dimensions. Entitled "Optimal Martingale Transport Between Radially Symmetric Marginals in General Dimensions," it appeared in *Stochastic Processes and their Applications* in 2019.

For that study, Lim uses a variational principle in MOT called the monotonicity principle and introduces a symmetrization operator acting on the transport plans, which allows the symmetry of the problem to be exploited.

Continuing his work in this area, Lim contributed to a paper entitled "Structure of Optimal Martingale Transport Plans in General Dimensions," published in January 2019 in *The Annals of Probability*.

Lim and his co-authors, Nassif Ghoussoub and Young-Heon Kim, both at University of British Columbia, sought to verify the structure of multi-dimensional martingale transports subject to general marginal constraints.

"We show that the dual attainment – the existence of optimizers for the dual optimization – is the key, and to obtain such existence we verify that MOTs should be decomposed in a systematic way," Lim said.

One major challenge was applying a calculus of variations, which needed a certain level of regularity of the dual optimizers.

"To resolve this, we introduce the martingale version of the Legendre transform and show how it can be applied to deduce the required regularity," Lim said.

"To resolve this, we introduce the martingale version of the Legendre transform and show how it can be applied to deduce the required regularity," Lim said.

As a culmination of the new theory, the researchers prove a statistical correlation theorem which states that two-dimensional martingales, if they solve the MOT problem, must be correlated in a certain unique, extremal way.

A generalization of this structural result into a higher dimension is an open problem that intrigues researchers in the field. Lim is exploring this problem in his current research.

Are Financially Distressed People More Likely to Vote? Evidence from the Housing Crisis Contradicts the 'Angry Voter' Theory

By Melvin Durai

In the days preceding the general election in November 2020, the unemployment rate in America hovered just below 7 percent, almost twice as high as in February 2020. The economy was still reeling from shutdowns that the coronavirus pandemic had triggered, and millions of people had lost their regular paychecks and were struggling to pay their bills.

With so many Americans in the throes of financial distress, it may have seemed reasonable to expect them to turn out in droves on Election Day and vent their frustration at the polls. After all, doesn't financial trouble propel people to vote and voice their disapproval for policies that may have contributed to their plight?



Source:
Ben McCartney

This "angry voter" theory may seem logical, but research by W. Ben McCartney, assistant professor of finance in Purdue University's Krannert School of Management, indicates that people under financial distress are actually less likely to vote.

That's because the act of voting requires a commitment of time and energy. You not only have to travel to a polling place, you have to wait in line, sometimes for hours.

"Voting is not costless," McCartney said. "The time cost becomes especially expensive for households who need to worry about their economic well-being. You can't just vote, you have to fit it in your schedule and add it to your to-do list and potentially not do something else. And financially distressed households are more likely to have other things that they need to do."

McCartney found a novel way to determine whether economic distress affects voter participation: he examined the effect of house price declines during the Great Recession of 2007 to 2009 on voter participation in the subsequent primary and general elections.

Revealing his results in a paper entitled "Does Household Finance Affect the Political Process? Evidence from Voter Turnout During a Housing Crisis," published on May 27, 2020, in *The Review of Financial Studies*, McCartney found that a 10 percent decline in local house prices decreases the participation rate of mortgaged homeowners by 1.6 percentage points.

"Why do house price declines decrease voter participation? Because house price declines financially distress people in a way that makes their time more valuable," McCartney said. "It's harder to take off work and you are less likely to be able to pay for a babysitter to go vote, especially if you have to stand in line for four hours."

To conduct his study, McCartney collected housing and voter data from North Carolina, choosing the state because it allows voter rolls to be easily downloaded from its website.

"North Carolina is also unique in that their data goes all the way to 2005, so I can watch people over time vote or not vote," McCartney said.

The housing data, available through recorder's and assessor's offices in each county, gave McCartney detailed information on each property, including homeowner names and mortgage status. He also collected housing price information from Zillow.

McCartney conducted a variety of tests to ensure the validity of his results. His models included individual-level controls for factors such as age, race, ethnicity, sex, state of birth, and year of registration. He also controlled for each person's participation in the pre-recession elections of 2008 and accounted for regional and political party differences.

Models with voter fixed effects helped McCartney rule out that his results could be attributed to unobserved differences between people living in ZIP codes where house price declines were severe and people living in ZIP codes where house price declines were mild. He also looked at the voting participation of not just mortgaged homeowners, but also renters and homeowners without mortgages.

If voter turnout was being affected by something else, such as a surge in unemployment or a decline in political advertising, then renters and homeowners without mortgages would be equally affected.

But McCartney found that renters and homeowners without mortgages are not significantly affected by a 10 percent decline in home prices, while households with mortgages are 1.6 percentage points less likely to participate.

Using a conservative estimation, McCartney showed that house price declines can explain about 30,000 abstentions in North Carolina during the 2010 and 2012 election cycles, or an average of 7,500 abstentions per election. Putting those numbers in perspective, he noted that Barack Obama received 14,177 more votes in North Carolina than John McCain in the 2008 presidential election.

McCartney's results raise concerns that people in financial distress, by voting in lower numbers, may not be able to bring about changes that are more favorable to them. Approaching the 2010 midterm elections, for example, voters were considering the merits of the Economic Stimulus Act, the bank bailout, and the Dodd-Frank Act.

"The concern was that all the people who wanted more stimulus and big banking reform couldn't vote because they were trying not to get foreclosed on," McCartney said. "So it's not actually the case that the will of the people is reflected, because a bunch of the people were able to vote more easily than the other bunch, and the people who were able to vote more easily had very different policy preferences. That's the big picture concern, and it's a concern going forward – that the people who make the rules can make them in a way that makes their lives easier, and when your lives are easier, it's easier to be the one making the rules. So, you get this vicious cycle or virtuous cycle, depending on which side of cycle you find yourself on."

The solution, he believes, is to reduce the costs of voting, such as ensuring that polling places are easily accessible and allowing all voters to use mail-in ballots. "If everyone got a ballot mailed to their house and they had three weeks to fill it out and send it back, then you would imagine the effects of financial distress become very small."

Keeping Up With Their Peers: Are Corporations Influenced to Make Disclosure Decisions?

by Melvin Durai

A streaming service sends out a press release announcing the "Top Ten Most Watched Movies" on its platform and revealing that its original movies are extremely popular with subscribers. Soon, two other streaming services disclose viewership metrics for their productions. A fourth company within the industry grapples with a decision: Should it reveal to investors and others how well its original entertainment is faring?

Peer effects occur in many different contexts, whether it's students emulating the study habits of their friends, factory workers striving to match the productivity of their co-workers, or neighbors inducing each other to adopt solar energy. But are corporate disclosure decisions also subject to peer effects?

Research by Hojun Seo, assistant professor of accounting in Krannert School of Management, indicates that disclosures made by industry peers significantly influence the disclosures made by individual firms.

"My study is the first step to understand this interactive mechanism between companies in an industry," said Seo, whose findings appear in a paper entitled "Peer Effects in Corporate Disclosure Decisions," forthcoming in the *Journal of Accounting and Economics*.



He describes two potential mechanisms underlying peer effects in disclosure. The first arises from the reluctance of company managers to disclose private information.

"There are a lot of concerns," Seo said. "For example, if they reveal somewhat proprietary information to the market, then it may hurt them, so they'd better not disclose such information. That's one motive. Another motive to withhold disclosure is that they do not have precise information. They do not want to disclose imprecise information."

But when competitors disclose information such as their future earnings, that information may improve the precision of an individual company's private information, making managers more willing to disclose it.

"All companies are competing with each other," Seo said. "Your company's performance is affected by your peer companies' performance and how they behave."

The second potential mechanism arises from the desire of companies to attract the attention of investors. If peer companies are revealing information that's attracting investors, it creates pressure for an individual company to also provide information and keep investors from being drawn to its competitors.

While prior research has shown common disclosure policies among firms within particular industries, this does not prove a causal effect. Firms within an industry, such as semiconductor competitors AMD and Intel, have similar fundamentals and experience common shocks.

"If Intel discloses something and AMD discloses it too, is it evidence of causal influence or just correlation?" Seo asks. "Does AMD's disclosing affect Intel's disclosing or do they just simultaneously disclose? It's hard to distinguish between these two cases in just a regression framework, so that's why I employ an instrumental variable approach in my paper to identify causal effect."

Seo uses peer firms' lagged idiosyncratic equity return shocks as the instrument to identify peer effects in disclosure.

"Econometrically we can decompose a firm's stock returns into two components: a firm-specific component and a systematic component," Seo said. "The systematic component is the common factor. The idiosyncratic and firm-specific component applies to firm-specific news."

Choosing the frequency of management forecasts as a proxy for firm disclosure, Seo analyzed 181,089 firm-quarter observations from 2002 to 2014, conducting a two-stage least squares estimation that included firm-specific characteristics, peer firm average characteristics, and firm and quarter fixed effects.

"In the first stage, I identify peer-firm disclosure that is driven by peer firms' firm-specific news and not driven by common factors," he said. "In the second stage, I associate that peer-firm disclosure with firm disclosure, so then I can identify peer effect."

He found that the average frequency of peer firm management forecasts has a significantly positive impact on the frequency of own-firm management forecasts. His findings suggest that peer effects are a significant determinant of corporate disclosure decisions.

Seo performed several cross-sectional tests to understand the underlying mechanism of these peer effects. He finds stronger peer effects for firms that are exposed to greater strategic uncertainty. While monopolist firms such as Nike and Coca-Cola are not affected much by what competitors are doing, many other firms do need to pay close attention to their competitors.

"If you're thinking about tech companies, such as cloud service providers, your performance is heavily affected by your peer companies' actions and strategies, so you need peer firm information to improve the precision of your information," Seo said.

Seo also finds that a firm is more likely to respond to peer firm disclosure when the firm is more dependent on external financing.

"The peer effect is driven by a company's motive to attract investor attention," Seo said. "If they want to sell their shares to the capital market, they need more investor attention. That's why I find stronger evidence of peer effect when a company is trying to raise external capital and when a company heavily relies on external capital."

No Room in the Hospital? An Analytical Tool Helps Doctors Decide Which Patients to Discharge

By Melvin Durai

The COVID-19 pandemic has put immense stress on hospitals around the country, many of them struggling to provide enough beds to accommodate the surge in patients. To create room for all these new patients, hospitals have been forced to discharge existing patients earlier than expected. But even in ordinary times, hospitals face difficult decisions regarding when to discharge patients. Sending them home early alleviates overcrowding and reduces costs, but it may put their health at risk, increasing the chances that they'll be back in hospital beds within a few weeks.

So how do hospitals manage this tradeoff between readmission risk and ward congestion? They follow an unstructured, reactive approach, according to Pengyi Shi, assistant professor of operations management in Krannert School of Management.



Source:
Pengyi Shi

Shi and her co-researchers found that at some hospitals, including a partner hospital in Indiana where they conducted research, a typical response to overcrowding is to send a message to all physicians asking them to discharge as many patients as possible.

"Without an analytical guided tool, the doctor may be discharging a suboptimal set of patients, and may overreact to this message by discharging too many patients unnecessarily," Shi said.

Collaborating with Jonathan E. Helm of Indiana University's Kelley School of Business, as well as Jivan Deglise-Hawkinson and Julian Pan of Singapore-based Lean Care Solutions, the data analytics contractor at the partner hospital, Shi developed a data-integrated decision support framework for managing the tradeoff between readmission risk and inpatient crowding.

It optimizes not only the number of patients to discharge each day, but also which patients specifically to discharge, based on personalized risk estimations as a function of length of stay.

"This framework can help support the discharge decision, particularly when the hospital is facing high demand, such as in the peak time of COVID," Shi said. "It can help balance many objectives in real time, which is difficult to be done by individual doctors."

The researchers describe the framework in a paper entitled "Timing it Right: Balancing Inpatient Congestion versus Readmission Risk at Discharge," accepted for publication on Dec. 30, 2019, in *Operations Research*.

In the paper, which has won several awards, including the 2018 Pierskalla Best Paper Award, INFORMS, the researchers discuss some of the complexities that their decision support framework needed to address.

"Uncertainty is one of the biggest challenges," Shi said. "That is, the amount of patients that will eventually show up at the hospital, and the type of new patients who will show up. Also, for existing patients in the hospital, they may have very diversified characteristics, such as the type of disease, how well they've recovered, whether they have support at home after being discharged – all these factors would affect their risk of being readmitted."

To create their discharge decision framework, the researchers built a large-scale Markov Decision Process (MDP) based on a patient flow model with re-entries. Unlike traditional service rate control models, it accounts for personalized patient risk trajectory and their history-dependent state.

The researchers tested their decision framework through a counterfactual study that used historical data from their partner hospital. They found that their tool would have potentially prevented more than 50 percent of actual readmissions by suggesting that the patients' length of stay be extended. Increasing the length of stay moderately can reduce the readmission risk significantly.

The "plug-and-play" design of the framework allows it to be easily adapted to a broad range of hospitals and hospital IT systems.

The researchers note that discharge decisions are complicated and involve a variety of factors. They emphasize that their tool is meant to provide analytical support for discharge decisions. Doctors can still use their own discretion in discharging patients and the tool would accommodate such deviations.

"The tool is providing a recommendation, not forcing doctors to use it," Shi said. "The doctors make the final call. Providing this flexibility is very important for implementation to work in healthcare. The tool can adjust to make subsequent recommendations after seeing the actual action doctors made."

Can Investors Profit from Indirect Ties to Startup Companies? Only if the Ties are Strong

by Melvin Durai

An institutional investor is connected to a startup company through a venture capital fund in the private equity market. After the startup has its initial public offering (IPO), can the institutional investor take advantage of this indirect connection—and any information exchanged through it—to generate high returns on the company's stock?

That depends on how strong the indirect tie is, according to research by Umit Ozmel, associate professor of strategic management in Krannert School of Management, and her co-authors.



If the connection is through a lead VC fund, one that participates in every round of funding for the startup, the investor can gain enough private information to more accurately assess the underlying value of the entrepreneurial firm and exploit this knowledge on the stock market once the entrepreneurial firm goes public.

"It's not enough to have an indirect tie between two parties, like an investor and an entrepreneurial firm, for the investor to generate higher risk-adjusted returns on its investment in the entrepreneurial firm," Ozmel said. "What is important is whether or not they have strong indirect ties—i.e., whether or not they have been connected through a shared partner that is the lead venture capital fund of the entrepreneurial firm, which can actually access private information from the entrepreneurial firm and which is also willing to carry the information to the investor."

Their research shows that an investor with strong indirect ties to an entrepreneurial firm can earn about 13 to 20 percent higher risk-adjusted returns per quarter by investing in the entrepreneurial firm's stock, compared with the institutional investor's investments in other publicly traded firms, including those to which the investor has weak or distant indirect ties.

"It shows that indirect ties between institutional investors and entrepreneurial firms through the lead venture capital funds of the entrepreneurial firms can actually provide institutional investors with quite valuable private information," Ozmel said. "In turn, they can make quite a bit of money out of it."

Ozmel and her co-authors, Deniz Yavuz of Krannert, Tim Trombley of Illinois State University's College of Business, and Ranjay Gulati of Harvard Business School, published their findings in a paper entitled "Interfirm Ties Between Ventures and Limited Partners of Venture Capital Funds: Performance Effects in Financial Markets," which appeared in the May-June 2020 issue of *Organization Science*.

The researchers suggest that a strong indirect tie is formed in the private equity investment market when an institutional investor, such as a pension fund or mutual fund, is a limited partner of an entrepreneurial firm's lead VC fund prior to the firm's IPO. To be considered a lead VC fund, the VC must participate in all rounds of funding.

The researchers conducted interviews with venture capitalists and private equity investors to support their argument that the lead VC fund of an entrepreneurial firm, unlike other VC funds that have invested in the same firm, has far more interactions with the entrepreneurial firm during its pre-IPO term. This interaction may include sitting on the entrepreneurial firm's board of directors, visiting the firm frequently, participating in conference calls and social events, which would facilitate information transfer from the entrepreneurial firm to its lead VC.

"As a result of this, the lead venture capital funds have much more information, much higher access to valuable private information about the entrepreneurial firm's underlying qualities, underlying problems, opportunities and threats than the non-lead VC funds that are investing in the same startup," Ozmel said.

The high investment means that there's less conflict of interest between the startup and the lead VC fund. As they get to know each other better, mutual trust develops.

"It gives the startup company's managers more incentive to share some private information—the information that isn't available to the public—with the lead VC fund," Ozmel said.

The private information that the VC fund has collected can be conveyed to its limited partner, the institutional investor, in a number of ways, both formal and informal, including through quarterly reports, annual meetings, phone calls and social events.

"There is this information exchange from startup to the lead VC fund to limited partner," Ozmel said. "You might say, there is always an information exchange between a startup company to the non-lead VC and to the non-lead VC's limited partners, but the problem is, the non-lead VC does not have access to as much private information about the startup as the startup's lead VC fund."

For their study, the researchers analyzed the investment returns of institutional investors in newly listed entrepreneurial firms' stocks between 1988 and 2014, restricting their analysis to 424 investments with indirect ties through VC funds.

Their finding that an investor can earn about 13 to 20 percent higher risk-adjusted returns per quarter by investing in a firm to which it has a strong indirect connection suggests that the investor had access to private information about the firm before its IPO.

"Because of their private information, they are better able to assess whether the stock is undervalued or overvalued in comparison to the rest of the market," Ozmel said. "They can make better informed investment decisions."

The researchers also determined several conditions in which the marginal value of private information gained through a strong indirect tie is higher. When there is higher exogenous market uncertainty —i.e., uncertainty that is outside the control of the investor, such as economic and political uncertainty—the institutional investor's private information can generate higher risk-adjusted returns.

"Stock prices fluctuate much more when there is high uncertainty," Ozmel said. "In other words, if there is an undervaluation or overvaluation, the extent of this would be much higher. So the value of being able to identify an undervalued asset would be much higher in magnitude."

Private information is also more valuable, they found, when the investor faces high information asymmetry—when very little information about the entrepreneurial firm is known to investors. In particular, the researchers showed that private information gained through a strong indirect tie is more valuable if the entrepreneurial firm is a high-tech firm; if its products are at an early stage; if it is geographically distant from the investor; or if the firm is younger.

"If you do not have access to information, you are more prone to making huge mistakes when investing in stock market," Ozmel said. "The private information is much more valuable in preventing you from investing in overvalued stocks and helping you identify/invest in undervalued stocks."



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