ORMS TOMORROW

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BLAST FROM THE PAST
10 Years Into the Magazine's New Era

RISING COLLEGE COSTS
The How and the Why

CONVERGING PATHWAYS
OR, Data & Science, and Women in STEM



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Letter from the Lead Editor

Dear OR/MS Community Members,

Our all-volunteer student team is pleased to share the Fall/Winter 2023 edition of *OR/MS Tomorrow*!

Since our last Spring/Summer 2023 issue, we had several members depart and move on to the next step in their professional careers. We would like thank them for their great service and contributions to our magazine:

- Sofia Perez-Guzman, Co-lead/lead Editor
- Yassine Yaakoubi, Editorial Board Member
- Vasilis Pavlopoulos, Editorial Board Member
- Gauri Vaidya, Editorial Staff Writer
- Madhulika Chilla, Editorial Staff Writer
- Gulten Busra Karkili, Social Media Coordinator

We missed you during the production of this issue, but we wish you all a bright future!

This issue is filled with 8 articles on a variety of hot topics related to OR/MS and students! First, we have a special anniversary article celebrating a decade within the new era of the magazine, "Blast from the Past: OR/MS Tomorrow Turns 10!" In continuation of our industry series, we have an article on "Energy Future Perspectives" about how OR tools can be used to create a more efficient and sustainable environment. We took a short break from our Mental Health series, but we have started a new series on science, technology, engineering, and mathematics (STEM) outreach. Our first article in the series is a recap of the K-12 Education Panel from the 2023 INFORMS Annual Meeting in Phoenix, AZ. We also interview Nitish Saji, Operations Research Scientist at FedEx, as part of "Where are our alumni?" series.

For our one-off articles, we start off with a basic Python tutorial for image recognition in, "An Introduction to Computer Vision with Keras." We also interviewed Dr. Aineth Torres-Ruiz who provided insights on the intersection of operations research & data science, and how women are making an import in both fields. Taking a short trip to the ocean, we consider the impact of smart ports in, "Smart Ports: How Analytics is Reshaping the Global Shipping Industry." We conclude the articles by looking at one of the causes of rising higher education costs in "College Competition and the Connection to Rising Student Costs." Last, but not least, we introduce the three winners of our crossword puzzle competition from the last issue!

In our last issue, we announced our annual mini-poster competition! To increase the number of entries, we extended our submission date, and thus, the winners will be included and announced in the Spring/Summer 2024 issue! Keep an eye out when we release our next issue to show the excellent work of our team. Additionally, we would like to give photo credit to Christine Roy for the cover image, Joshua Rawson for the Contents page image, and Kelly Sikkema for the Letter from the Lead Editor header photo.

Did you know about our website? Check it out at www.informs.org/Publications/OR-MS-Tomorrow! You can check this issue's individual articles, browse all our previous issues, and meet our editorial staff.

Stay tuned with all of our updates, events, and more by following us on our socials. Watch for our announcement for the open application period to join us in early 2024! Find us on Facebook, X (formerly known as Twitter), and LinkedIn!

We hope you enjoy this issue!

Kara Combs

OR/MS Tomorrow Fall/Winter 2023 Editorial Team

This issue wouldn't have been possible without the effort of our Fall/Winter 2023 editorial team members:

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OR/MS Tomorrow Current & Alumni Members at the 2023 INFORMS Annual Meeting



A Blast From the Past: 10 Years of the New Era!



Paula Penagos
Ph.D. Student
University of Missouri - St. Louis

Ten years of the new era! (Yes, OR/MS Tomorrow has existed for more than ten years)! *We are celebrating and eager to share part of our past with you, and maybe share some future insights. It brings us immense joy to have you as a part of our dedicated readership, and for those who have been a part of our editorial family, we extend our heartfelt gratitude - THANK YOU! The journey of the past decade, marked by transformation, evolution, and the profound ideas we've brought to light, has been nothing short of extraordinary. We are optimistic that many more exciting chapters are yet to be written. Below, we present a snapshot of our history, showcasing the diverse range of topics that have graced our pages over the years. It is proof of our commitment to delivering informative and engaging content to our readers. Thank you for being a part of this incredible journey.*

We are celebrating 10 years and we wanted to understand the path of the magazine. However, in the journey, we realized the magazine had existed for longer than 10 years. To be honest, we don't even know exactly how long, maybe 1997 (a good moment to remind you that storing data is quite important sometimes), so we will celebrate the 10 years of the new era. The era since we have records and issues posted on our webpage (if you haven't checked them out yet, it is always good to know how thinking has evolved and maybe find some inspiration for future research). This new era has been a blast for our members, our readers, and the INFORMS community!

Although we are not sure how the magazine came to life, we are certain that it is giving nowadays students the opportunity to speak up and raise their voice. Tracy Cahall, the INFORMS Member Engagement Manager, told us that students are almost 28% of the total INFORMS member population. This big community needed a space to express themselves, to simplify the world of OR, MS, and analytics to regular words, and an opportunity to put into practice their skills, network, and connect with both the industry and academic side.

> **"Joining the team meant attending late-night meetings due to the time difference from India, yet the positive energy of the team made the odd timing inconsequential. Whenever I chime in with 'It's 12:30 am or 1 am here,' in response to their customary 'What time is it there?' query, I'm always met with their amused chorus of 'Oh, that's quite late!'" - Nandan Kumar Singh(2022-present)**

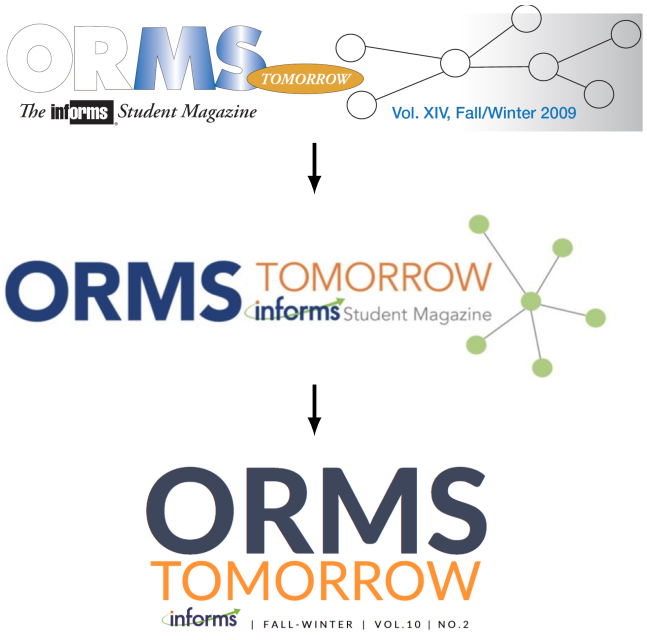
The magazine has also served as a sensor. Yes! A sensor of topics, interests, and needs that students all over the world have and since we are an important part of the membership, it provides insights to the INFORMS community on how to make us

engage, what topics we like, what needs we have, and make us part of a vibrant, interesting, and amazing community.

This article allows us to acknowledge all these years of work and commitment, all the years of service and generation of Knowledge, and all those years of being a safe space for people like you (and me). But acknowledging all those outputs makes us remember the most important part of this project: the students, professors, and industry professionals who have contributed with their time, efforts, and experience to shaping more than 15 issues full of amazing things.

The issues have changed significantly in format, colors, content, and frequency; the magazine has learned how to adapt. It started as a newsletter without regular publishing frequency and then, transitioned to a virtual magazine with two main issues a year. The first online issue in the record (Summer 2013) has yellow-colored pages written in one-column format. Then in 2014 pages' colors changed, three columns were incorporated, and in 2017 our logo changed to the one we still use today.

What all these issues have in common is the new and relevant topics included, from stochastic modeling to the development of OR in Africa, consumer returns, machine learning (questioning if it was really a hero in OR/MS and some of its applications), game theory applications, and the use of OR in the "saving lives" moto. Our issues have always included an interview with a distinguished professor or relevant practitioner and highlighted the participation and growth of all the INFORMS student chapters around the world.



"Working with amazing students and Kara to develop manuscripts/articles that impact different areas of society." - Egbe-Etu Emmanuel Etu (2020-2022)

The magazine has transitioned for the better. Every day there is more and more improvement. we always strive for the best, and we try to acknowledge what is needed and when it is needed, not only in the research part, but what students as human beings and the future of this field are going through.

One of the most important series in this regard has been "What Nobody Likes to Discuss, But We Are All Starting to Care About: Mental Health in Graduate School" (see Fall/Winter 2022). When asking former members about the articles they considered were our outstanding contributions, this series came into the conversation. As graduate students (and if you are at the undergraduate level or you are already in what we call the sweet life – having a job and more stability- it also applies to you), we have been living with pressures, burnouts, impostor syndrome, doubts, but also happiness and victories. We have been there and I can say I firmly believe knowing that others are going through the same you are feels refreshing. I was not even part of the magazine at that moment and when reading the articles, I appreciated the tips, the recognition, the feeling of not being alone and knowing that things get better and there is a community cheering you up (even in the distance and virtually). Beyond articles, we have hosted competitions highlighting our readers' contributions: the crossword puzzle and the mini-poster competition. They have also been a blast! From undergrads to senior Ph.D. Students, we have contributions and winners of all types. Some of those articles and competitions have been the ones that have motivated students to join our board and start creating content. Dr. El-Adle, now a professor, remembers how the first article he read from OR/MS Tomorrow was about how to get your first job. One of his professors recommended reading it. After that, he joined the magazine to keep working and keeping the legacy alive. Nowadays, he still reads our articles and remembers how the magazine helped him connect during the conferences and improve his skill sets.

"Interactions during collaborating on writing articles, particularly writing the first article with Abigail, Zoom discussions with Etu, and overleaf chats with Sofia. The associated banter was very refreshing and fun." - Mihir Mehta (2021-2022)

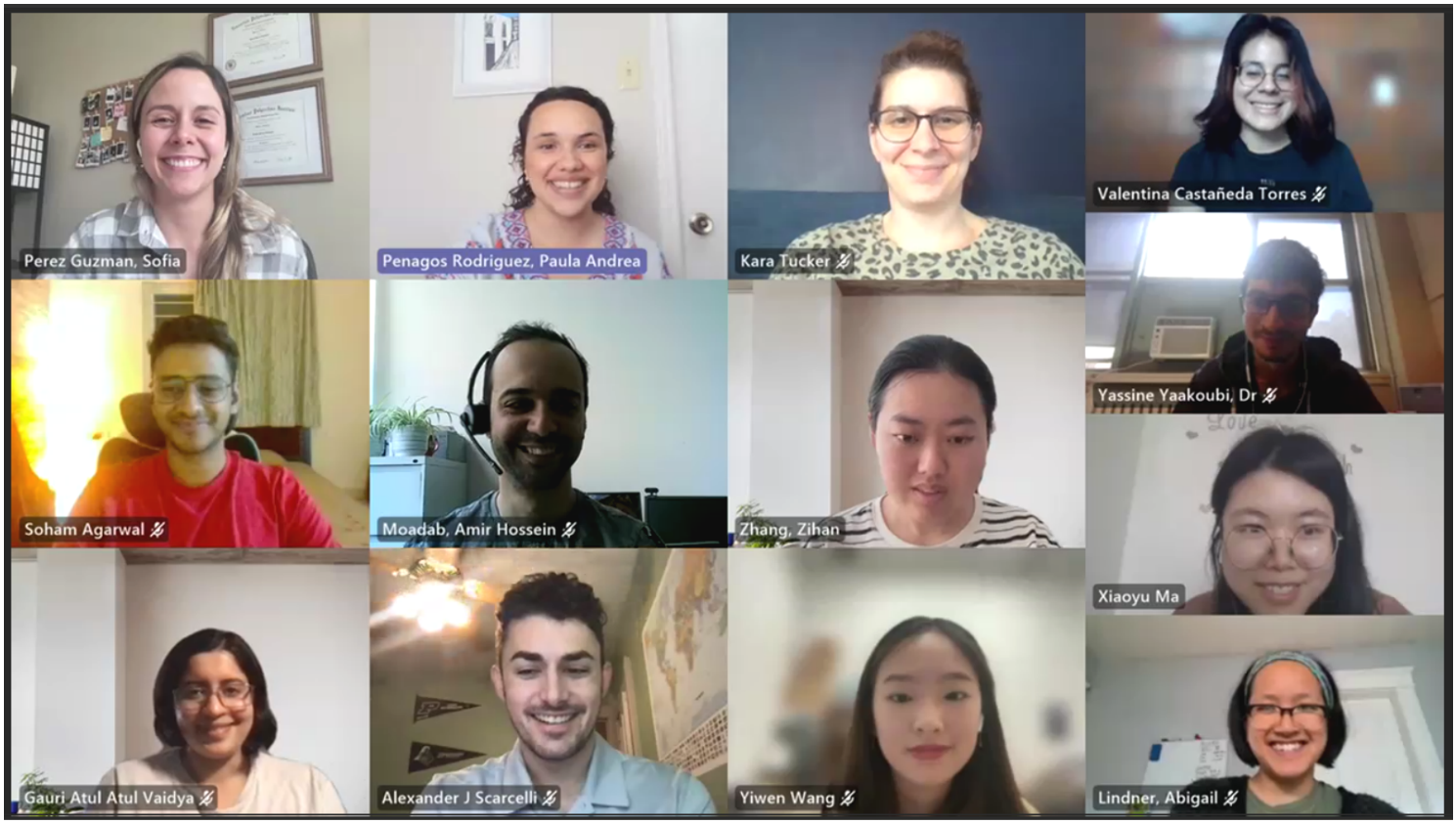
I have to be honest. It is amazing to see how people all over the world, in different time zones, with different backgrounds, and multiple future plans can be united and build a family around OR/MS, student life, and the desire to be the change we want to be outside. I interviewed some of our former and current members, and their words are below. In summary, they remember the magazine with gratitude, the people they worked with are now colleagues, the articles they wrote are now legacy, and they keep inspiring their students, their colleagues, and their teammates to read us and connect with us.

Last but not least, we have put some emphasis on futuristic technologies. It started with machine learning, some key concepts on modeling innovations, artificial intelligence, and more are coming. We have witnessed 10 years of growth and contri-

butions and would like you to think how you imagine this magazine in 10 years down the road (I really want you to take a moment and do it, please). I did the same with all our interviewees. It was funny for me to hear every single time that all of them agreed hoping that the ones writing and reading this content would be human beings. They want to see the magazine keep evolving, getting to further places, growing, incorporating DOIs into our articles (fingers crossed that will happen soon), and bringing more and more students to this community that was built by students for students. Reach out! We would love to have you on board and well… keep reading us, you are the main reason why we dedicate our time and energy to simplify weird, complex, or transcendental topics into easy words and highlight from different backgrounds and different skill sets what OR/MS is. If you love finance, energy, supply chain, transportation, health care, humanitarian logistics, public policy, or even other fields we have not covered (but we hope we will), stay tuned and keep reading with us for the next 10 years and on!

To the staff: "keep the amazing work! People read and pay attention." - Amro M. El-Adle (2021-2021)

Acknowledgements: *I want to take a moment to thank all those professors who have been an important part of the magazine's growth, to our INFORMS liaisons for helping us understand and navigate the world and guide our steps in the publication, to all our former members to make this 10 years possible and to our current members for contributing with their work to make the next 10 years look bright ahead, and to all of our readers for interact with us. Special thanks to Dr. David Czerwinski for advising us in this journey for the last 5 years, and Kara Tucker and Tracy Cahall for linking us to the broader INFORMS world. Also, thank you Kara Combs for reviewing this article. Header photo credit goes to Jon Tyson.*





Industry Series: Future Energy Perspectives



Yiwen Wang
University of Massachusetts, Amherst

The energy industry is essential in powering our daily lives and fueling economic growth. This sector revolves around corporations that produce and supply primary energy products (crude oil, natural gas, and renewables) and secondary energy (electricity, gasoline, and heat). As the cornerstone of various social aspects, the energy industry imposes significant economic and environmental impacts. However, it faces challenges that restrict the sustainable impact on societal development. This article examines these challenges, offers insights into the energy sector's potential prospects, and proposes operations research frameworks that enhance and sustain the industry's contributions to society.

The energy industry is highly dynamic and evolving rapidly. Global energy demand has surged 91% from 2000 to 2022.[1] Adding to this problem, cities have growing heating and cooling needs to combat extreme weather. Furthermore, the emergence of new technologies has also made people more dependent on energy to power households' needs. For instance, electric vehicle (EV) charging can significantly increase families' nighttime electricity consumption. The overall digitalization trend in recent decades has also imposed substantial requirements for facilities such as data centers, which now account for 2% of electricity use in the US (DOE). On the supply side, air pollutants and greenhouse gas emissions heated critiques on the extensive use of fossil fuels in the energy system. From 2000 to 2022, more than 1 million MW of renewable energy was generated under the influence of environmental and climate pledges. Renewable energy is typically sustainably created using sources such as hydropower, solar, wind, biomass, and geothermal. However, the uncertainty and inconsistency of these resources pose challenges to the electricity system operations, especially during severe weather. To make matters worse, the unstable energy prices and security further enhance the complexity of the energy industry.

Considering all these challenges, let us envision a transformed energy industry shaped by operations research (OR) tools. In this blueprint, the energy industry is guided by three core objectives:

- to minimize energy consumption and costs
- to reduce emissions and pollution
- to enhance energy security and affordability

In an ideal future, the energy industry will become efficient, sustainable, and reliable.

Efficient

Transportation accounts for 27% of total energy consumption in the US (EIA, 2023). Promoting EVs and replacing Internal Combustion Engine Vehicles (ICEV) is a promising yet challenging task to improve energy use in the transportation industry. EVs, powered by batteries, have an efficiency close to 90%. This number is substantially higher than ICEVs, which is around

[1] Numbers in this article are from ourworldindata unless otherwise cited.

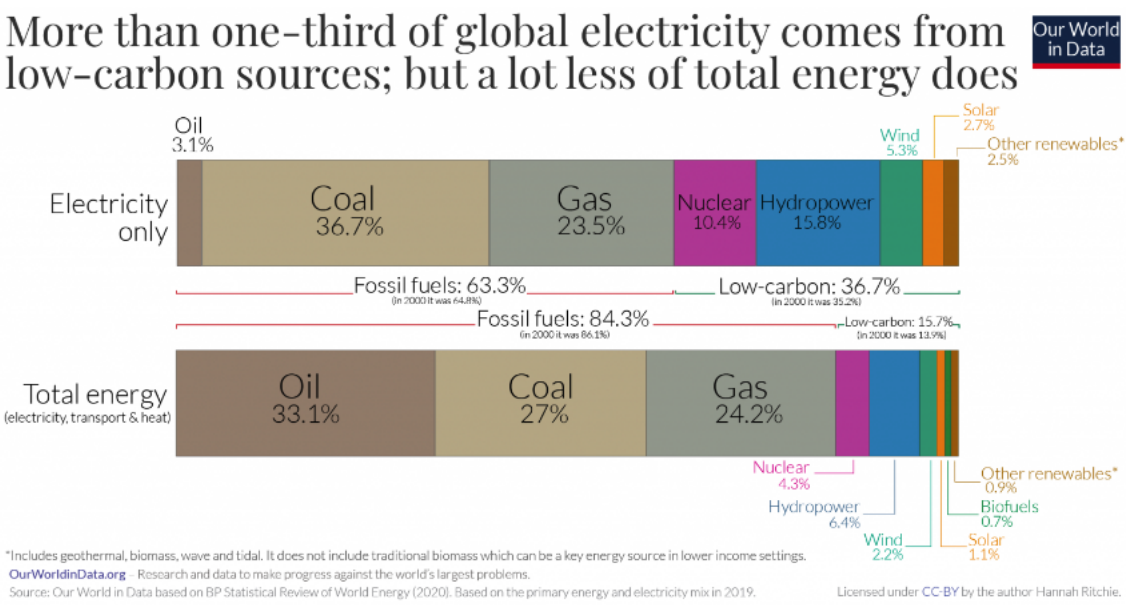


Figure 2: Global Energy and Electricity Supply Mix by Energy Source

40%. Therefore, EVs only consume half the primary energy of a gasoline-powered vehicle. Besides, EVs also have clear environmental advantages. For instance, EVs have near-zero emissions, while ICEVs consume gasoline and diesel that produce greenhouse gases and toxic pollutants like CO, SO_2, and NO_x. Despite these advantages, EVs may be less convenient than ICEVs in practice. The range of EV per charge is 250 miles on average, compared to a typical gasoline car's range of 500 miles. Mileage anxiety has held back many individuals from purchasing an EV. Furthermore, gas stations are far more accessible than charging stations. This causes some EV owners to experience "range anxiety" as they fear the vehicle may run out of power before reaching a charging point.

Range anxiety can be resolved in the future by optimally designing the EV chargers network through optimization algorithms. A promising project published on Google Blog (Kollias and Gollapudi, 2021) introduces route optimization for EVs in Google Maps using a modified shortest path algorithm. These researchers built a network with charging stations as intermediate nodes between the origin and destination. Next, each node was replicated to represent different levels of "entering" and "exiting" battery status. Through this method, EV drivers can choose routes based on their traveling time preferences and battery status without worrying about power shortages on the highway.

Sustainable

Fossil fuels has dominated energy production for centuries. As shown by Figure 2, 84.3% of global total energy is still generated from fossil fuels including oil, gas, and coal. More than 63.3% of global electricity is from these unsustainable resources. Such a production system face issues such as fluctuating prices which impose uncertainty on energy supply (IEA, 2022). Furthermore, fossil fuels release severe air pollutants and greenhouse gases in the power and transportation sectors, which cause severe threats to public health in many regions. Fortunately, acknowledging the scarcity, climate, and environmental consequences of fossil fuels, many countries have navigated a more sustainable and climate-friendly energy path.

Renewable energy, such as solar and wind, offers a clean alternative to fossil fuels. However, renewable energy also faces challenges, especially with implementation and adoption. One of the primary motivations for replacing fossil fuels with renewable energy is the lower electricity prices from zero-cost generation inputs. Although sunlight and wind are free resources, they have inconsistent supply and may not meet the general demand patterns. A good example is the duck curve observed in California's electricity market, as shown in Figure 3. The figure shows the real-time electricity demand minus solar production in California throughout the day. A duck curve pattern appears because solar production peaks at midday while demand is at its lowest; as solar production wanes, the demand quickly ramps up to its evening peak. Despite being a worldwide leader in solar adoption with abundant sunlight, California faces this unmatched pattern between power supply and demand. The challenge for the grid operators is quickly boosting other energy resources needed to compensate solar as the sun falls down(Jones-Albertus, 2017). The ideal strategy is to harness more electricity from solar when it is available and only use thermal generators (mostly fossil fuels) as standbys to continue the production. Nonetheless, the availability of sunlight varies by weather and season and can only be predicted with short foresight. It becomes a challenging task to secure the supply while maintaining grid reliability simultaneously.

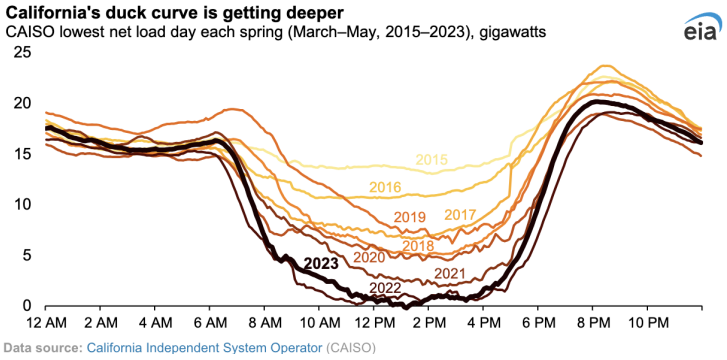


Figure 3: Duck Curve in California

One approach to sustaining the future energy industry operation is through more accurate forecasts of renewable energy availability. Stochastic optimization, for example, can be a helpful OR method for integrating the uncertainty about renewable energy into modeling. Zheng et al. (2015) reviewed works that used stochastic optimization to improve the NP-hard deterministic unit commitment model for power plant scheduling. Zakaria et al. (2020) summarized the state-of-the-art stochastic optimization techniques for renewable energy applications, including Monte Carlo Simulation, Markov Chain, stochastic programming, and dynamic programming.

Reliable

Beyond technical challenges, many other factors need to be addressed in the transformation process. This includes risk tolerance, technological innovation beliefs, conflicting objective resolution, and equity justice. However, these elements are usually difficult to measure or build models. Equity justice is particularly the case, which is a challenging objective to quantify in decision-making. Therefore, some victim neighborhoods are overlooked in energy policy decision-making despite experiencing energy crises. For example, many regions have launched rooftop solar and EV programs with incentives like electricity bill reduction and tax credits. Low-income communities are often more vulnerable to energy price variations, yet the high investment cost restricts their participation in these programs.

Energy crises such as shortages or grid failures during extreme weather significantly impact society. The future energy industry must remain reliable under emergent conditions. This requires careful and attentive energy planning. Decision-making methods can help policymakers find a set of robust and practical solutions. Policymakers can apply the utility theory to quantify preferences in outcomes and multi-criteria decision-making to find the optimal point between the trade-offs with conflicting objectives (Pohekar and Ramachandran, 2004). For example, Heleno et al. (2022) uses a multi-objective model for energy justice and examines the trade-offs between intervention costs and energy burden reduction.

Conclusion

The future energy industry has many promising opportunities with the advancement of technology and the increasing concerns for the environment. This article proposes to apply OR to assist in optimizing networks, predicting resources, and engaging in long-term planning under uncertainty. Even though how OR can play a bigger role in the transition of the energy industry is still an open question, it holds great potential for shaping a more efficient, sustainable, and reliable energy future.

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Acknowledgements: *I would like to thank Sen Li for taking time to review this article.*



A Panel Discussion Recap and Future Outlook From INFORMS Education Outreach Committee (EOC) K-12



Zihan Zhang
Georgia Institute of Technology

In the evolving landscape of K-12 education, the panel discussion held at the 2023 INFORMS Annual Meeting, featuring esteemed experts Pascal Van Hentenryck, Afrooz Jalilzadeh, and Mary Elena Ogidigben, sheds light on innovative strategies, challenges, and opportunities to enhance access and engagement in education. Neil Desnoyers, who co-chairs the INFORMS EOC K-12 alongside Zihan Zhang, also brings valuable experience and insights to the conversation. Together, they provide a comprehensive overview of current practices and future directions in K-12 education, with a particular focus on STEM and Operations Research (OR).

Improve Access to Education Resources

Pascal highlighted the importance of leveling the playing field by offering summer camps at three different levels, with a specific focus on high school students from disadvantaged backgrounds, including those from Historically Black and Hispanic high schools. His approach also involves empowering teachers with the necessary tools to continue the learning experience in the classroom.

Mary emphasized the need to bridge the gap with rural schools, proposing lunch sessions as a viable solution to logistical issues related to after-school activities. As an INFORMS DEI ambassador, she has been instrumental in creating resources and guides to extend the reach of educational programs to universities.

Afrooz, through her involvement in teaching classes and serving as an INFORMS DEI ambassador, is forging connections with local high schools to introduce students to AI and hosting tours at the University of Arizona to expose them to a wide range of STEM and OR topics. Her primary focus is on first-generation college students, ensuring they have the resources and knowledge needed to pursue higher education.

Neil, with his direct involvement in his local school district and math club, echoed the importance of providing safe spaces for students to develop critical thinking skills. He underlined the essential role of teacher support in maintaining these initiatives. Furthermore, he highlighted the potential of leveraging innovations and additional funding introduced during the COVID-19 pandemic to address education disparities.

Virtual Design

The shift to a virtual or hybrid education was a recurring theme.

Pascal emphasized the advantages of a hybrid format. Through combining online material with in-person projects, it provides flexibility and enhances student engagement.

Mary highlighted the benefits of virtual workshops in navigating bureaucratic challenges and engaging students throughout virtual presentations. She shared these practices in a comprehensive guide.

Afrooz shared her experiences with virtual lectures, which allowed students to engage with material at their own pace and come to class prepared with questions, enriching the in-person experience.

Neil's experience during the pandemic also underscored the value of virtual and hybrid learning models. He noted how these models facilitated continuous learning during uncertain times, and how they could be utilized post-pandemic to maintain inclusivity and accessibility.

Challenges & Opportunities

Younger generation's familiarity with technology imposes unique challenges yet creates exciting opportunities.

Pascal noted the challenge of capturing the interest of high school students, emphasizing the need for unique and less accessible projects to excite them about technology.

Mary spoke of the significant knowledge gap between high school students and Ph.D. students, underscoring the necessity of making workshops accessible and approachable for all.

Afrooz shared her perspective as an international educator, highlighting the importance of understanding the diversity in students' prior knowledge and experiences, and the need to stay updated on technology used in classrooms.

Neil added that his experience working with diverse student populations revealed the importance of tailored approaches to engage students from varying backgrounds.

The panel discussion with Pascal, Afrooz, Mary, and the insights provided by Neil offered a comprehensive overview of the current state of K-12 education, particularly in STEM and OR fields. Their strategies and experiences emphasize the importance of accessibility, the potential of virtual learning, and the necessity of adapting to the unique challenges presented by different demographics and technological familiarities. Together, they set the stage for future innovations and continued efforts to ensure that quality education is within reach for every student, regardless of their background or location.

Acknowledgements: *We would like to thank Haokun Du for taking time to review this article and thank Kara Combs for taking notes for the panel session.*





OR/MS Tomorrow Alumni Spotlight: Navigating Career Paths with Nithish Saji



Soham Agarwal
M.S. Student Purdue University

As recent graduates and to-be graduates prepare for their Spring career fairs and online job search, it becomes imperative to consider the various features the predictive model of "the job search" has to be built upon. *Even with a surge of tech layoffs at the start of 2023, we see an estimated decline in layoffs from over 84,000 in January to over 4,600 layoffs in September. (Stringer, 2023) This suggests potential improvements in the employment situation within the tech industry. Nithish Saiji, a former OR/MS Tomorrow member and an operations research scientist at FedEx for the past 3-4 years, breaks down the complexity of this black box by describing the process through anecdotes and his journey of finding a job as an international student.*



Nithish Saji
Operations Research Scientist, FedEx

Generalization vs. Specialization

The longstanding debate between generalization and specialization continues to shape the professional landscape. As highlighted in David Epstein's TED Talk (Epstein, 2019), there's a case to be made for a broad-based approach before diving deep into a specialized field. Nithish's journey provides a practical perspective on this debate. With a foundation in simulation engineering from India, he sought to expand his knowledge at North Carolina State University, enrolling in courses such as automation systems engineering and logistics engineering. In my interview with him, Nithish emphasized the value of exploring various courses across different departments. This approach not only offers a comprehensive learning experience but also helps in determining if one's interests genuinely align with their chosen path.

> "From my own experiences in the job market, it's common to see professionals navigating through different roles before settling on a perfect fit. This exploration can be accelerated during graduate and postgraduate studies by sampling a range of courses of potential interest."

However, there's also an 'It depends' case for specialization. As Nithish points out, "For entry-level roles, a diverse background can offer flexibility. But for roles in specialized teams, like computer vision, deep expertise is essential."

Nithish's background in simulation engineering, especially with tools like FlexSim which are favored by many US firms, gave him a competitive advantage. He also highlighted the importance of skills like Gurobi for optimization. On the softer side, adaptability and an open mindset are key. As the technical landscape evolves, flexibility becomes crucial. For instance, when Nithish joined his company, FedEx was collaborating with tech giants like Microsoft and Google on cloud solutions. This shift required transitioning from SAS systems to more scalable solutions like Python or Spark, necessitating training on platforms like Azure. Nithish's adaptability enabled him to address challenges, such as revamping the facility location model, originally developed in SAS, to meet changing demands and service priorities.

A Different Day, a Different Market

Considering the widespread knowledge of the lackluster market conditions, finding a job can seem like a mirage with the

illusion being a prospective job looming in the distance. Companies aren't hiring as predictably or as far ahead as six months to a year in advance. Although challenges in job searches and job security plague the market, some companies are looking for innovative solutions to current challenges, indicating that there are pockets of opportunities.

Attesting to his own job search process, referrals were instrumental in landing a job at FedEx. Referrals can help bypass the initial stages, which are often the hardest part of the job search process. A significant 82% of employees favor referrals over other recruitment methods. Impressively, 45% of these referred employees remain with the company for more than four years, whereas only 25% of employees sourced from job boards stay beyond two years. (Stafiej, 2021).

People run the world, and so does the hiring process that you apply through. Networking helps align interests with employers and allows you to play a winning hand at a win-win game that involves mutual interest. Interests, as we talked about, can also be discovered through engaging with as many people as possible, as they can provide you with insights into their work. This allows you to potentially skip years of work that you might not have liked.

As the social media coordinator at *OR/MS Tomorrow*, Nithish had the opportunity to further validate his interest in the field of Operations Research. He mentions that interacting with industry professionals helped him understand the direction the industry was heading in, and helped him build a web of networks that he could later rely on to capture an opportunity. Actively getting involved in areas that involve people, allows one to learn a lot of traits that would have taken a longer time otherwise to learn, and doing that with a diverse group such as the one at the *OR/MS Tomorrow* magazine allowed this learning to be expedited.

- **Social Media Screening**: Over 70% of employers use social media profiles for screening, and 55% have found content that led them to reject a candidate. (Glynn, 2023)
- **Customize Your Resume**: 87% of recruiters use LinkedIn to check candidates, so ensure your LinkedIn profile matches your resume. (Jobvite, 2016)
- **Mind the ATS**: 98.2% of Fortune 500 companies use Applicant Tracking Systems (ATS). Make sure your resume is ATS-friendly. (Myers, 2023)
- **Soft Skills Matter**: 91% of recruiters want to see interpersonal skills on your resume. (LinkedIn, 2019)
- **Follow Up**: 80% of job openings are never advertised, so always follow up on applications and interviews. (Townsend, 2023)

A Glimpse of Recovery

Nithish plans to stay in the same sector but acknowledges the rapid changes in the industry. FedEx is exploring new techniques for shipping tracking and merging different techniques. With automation and AI on the rise, companies are exploring the use of these technologies for forecasting as well. Large language models (LLMs) are being used as supplements, but copyright concerns and data privacy can hint at companies trying to create their own models for specific tasks within the organization. With a huge flux of jobs in the market, Nithish recommends staying up to date with the latest tools to stay ahead of the curve.

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An Introduction to Computer Vision with Keras



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Visual detection and identification of objects is important when it comes to our daily lives and comes quite naturally to us humans. However, many robust artificial intelligence (AI) agents still struggle to do it quickly and accurately. This article gives a brief introduction to how computer vision models are created.

As the world evolves with the introduction of AI-driven innovations like drones, self-driving cars, and other autonomous technologies, the field of computer vision gains unprecedented importance (IBM, 2023). Computer vision, a key area within artificial intelligence, involves a computer's ability to interpret visual cues (IBM, 2023). The accuracy of these interpretations is vital for the algorithms that power computer vision, particularly in high-stakes applications. For example, in the automotive industry and specifically for companies like Tesla, the precision of these predictions is critical, as it can mean the difference between life and death (Shepardson, 2022). A cornerstone of most computer vision systems is a type of artificial neural network known as a "convolutional" neural network (CNN), which plays a crucial role in processing these visual cues (IBM, 2023).

CNNs & Their Hyperparameters

Convolutional neural networks (CNNs) create various feature maps (which are similar to viewing different aspects of a picture) that are quite successful at processing images (Meel, 2023). CNNs started with the small five-layer LeNet, which was trained on the Modified National Institute of Standards and Technology (MNIST) dataset (see (LeCun et al., 2010)), consisting of handwritten digits ranging from zero to nine (LeCun et al., 1998). However, CNNs became more prominent over a decade later due to a CNN called AlexNet (see (Krizhevsky et al., 2017)), which won the 2012 ImageNet Large Scale Visual Recognition Challenge (often abbreviated as "ILSVRC") (Russakovsky et al., 2015). AlexNet was a 10-layer CNN that was the first to win the ILSVRC competition since its inception in 2010 (Russakovsky et al., 2015). In subsequent years the ImageNet Large Scale Visual Recognition Challenge and more generally, computer vision algorithms, have been dominated by CNNs such as VGG-16, ResNet-50 (Residual Network), and PNASNet-5 (Progressive Neural Architecture Search Network) (Russakovsky et al., 2015).

Although CNNs are powerful and produce impressive results, their hyperparameters and parameters are typically fine-tuned for the specific problem at hand. It is important to note the differences between a hyperparameter and a parameter. Hyperpa-

rameters are controlled and set by the user and influence parameter values; whereas, parameters are set by the algorithm based on the data being passed through (Simic, 2023). There are many hyperparameters associated with CNN such as the number of layers, layer types, number of nodes, etc. Determining the best settings for a CNN's hyperparameters becomes extremely important as each hyperparameter impacts the overall accuracy of the model. Therefore, a design of experiments is often needed to determine the best settings for the model's hyperparameters. Many times researchers do not have to create a CNN from scratch and can use the architecture of a previously-trained neural network, which only necessitates some fine-tuning of the hyperparameters and parameters. This phenomenon is called "transfer" learning since pre-trained "base" knowledge is "transferred" to a new, but related knowledge domain (Hosna et al., 2022; Zhuang et al., 2020). Essential to any computer vision model is the data it is being trained to classify since this determines the model's internal parameters and the resulting outcomes.

CIFAR-10 Dataset

A common dataset for testing computer vision models is the CIFAR-10[2] dataset. Originally part of the much larger 80 million tiny images dataset (see (Torralba et al., 2008)), the CIFAR-10 dataset consists of 60,0000 images with 50,000 images to be used for training and the remaining 10,000 images for validation. The images' dimensions are 28 x 28 and are evenly split between 10 classes (Krizhevsky, 2009). Along with the earlier mentioned MNIST dataset, CIFAR-10 is one of the most widely used computer vision datasets and is often used as an initial starting point. Since each individual image is small in size, it looks rather pixelated to the human eye when enlarged, which is clear in Figure 4. Since these images are multi-colored, they have three color channels; whereas, monochromatic images would only have 1 color channel. This is an important piece of information when designing an architecture.



Figure 4: Sample CIFAR-10 Images

Example Convolutional Neural Network

An example architecture based on Keras's Convolutional Neural Network Tutorial is shown in Figure 5 (Chollet et al., 2015). Starting on the left, the input layer (white left-most block in Figure 5) are the actual images themselves which, in this case, have a height and width of 28 and three color channels. These images are then passed through three convolutional layers (blue) with max-pooling layers (green) in between. The third convolutional layer is followed by two fully connected layers (orange) with the final layer being the classification (or output) layer (purple). A classification layer is a specific type of fully connected layer where the number of nodes corresponds to the number of classes, which in our case is ten. Between the second fully connected and the classification layers, there is a dropout rate that will remove a certain number of nodes from one layer to the next. A dropout can occur at any point in the model to best assist with overfitting the model to the data. The number of layers and their dimensions are all customizable, though there are some constraints due to the input image size and the number of classes.

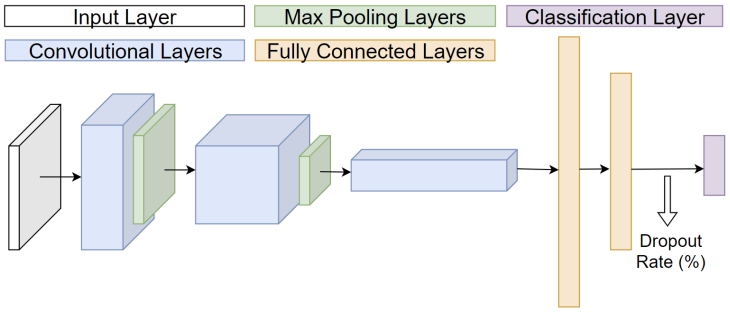


Figure 5: Example CNN Architecture

After the architecture of the CNN is designed, there are still two required hyperparameters that are needed for Keras's `model.compile` method, the optimizer and the loss function. The optimizer adjusts the CNN's weights, which determine how much emphasis to place on that particular amount of information being passed through, to yield better predictions in the final output layer. Most standard problems utilize the popular `Adam` optimizer which is a stochastic gradient descent algorithm originally discussed in (Kingma and Ba, 2017) that is conveniently a built-in Keras class.

A popular loss function is the Sparse Categorical Crossentropy class, which is used for categorical outputs (opposed to numerical ones). A loss function attempts to quantify the differences (if any) between CNN's predicted value of an observation compared to the observation's ground truth (or label). Additionally, the function's `from_logits` parameter standardizes the prediction probability when set to `True` and is usually needed with the final fully-connected layer as it does not have its `activation` argument set to `softmax` (Landup, 2022). Finally, a metric needs to be specified. Unless circumstances dictate otherwise, accuracy is usually the standard metric to select which compares the number of times the predicted class of an image matches the image's true class in this example. However, other built-in metrics include area under the curve (AUC), precision, and recall.

[2]CIFAR: Canadian Institute For Advanced Research

One of the last lines of code related to the Keras model is the `model.fit` function, which includes, perhaps the two most influential factors to a CNN outside of the architecture itself, the batch size and number of epochs hyperparameters.

A batch is the number of input samples that the model evaluates prior to updating its weights, which is known as an iteration (Brownlee, 2022; Baeldung, 2022). Larger batch sizes decrease the amount of time it takes for a model to train since the model does not update itself after every iteration when the `batch_size > 1` (i.e., "stochastic gradient descent") (Brownlee, 2022). Usually, batch sizes occur in powers of two (2^n) depending on the dataset size, and the default Keras `batch_size` is 32. A concept related to batch size and iteration is the number of epochs.

The number of epochs, which is the number of times the CNN cycles through all the training data (Brownlee, 2022; Baeldung, 2022). An iteration is the number of batches that are completed to complete an epoch and as mentioned earlier, the batch size is the number of training samples evaluated within one iteration (Baeldung, 2022). The number of epochs is a hyperparameter typically determined by the experimenter selecting the value or determining the value based on performance (when the model is no longer making significant improvements) (Baeldung, 2023). The more epochs that take place usually correlate to a higher accuracy; however, it takes more time.

In conclusion, CNNs have had a profound impact on computer vision by being able to computationally interpret visual data. While the state-of-the-art seem complex, they are all constructed with the same basic building blocks introduced herein. Ongoing research continues to enhance their abilities within fields such as autonomous vehicles and medical image diagnostics. CNNs have undeniably revolutionized our interaction with the visual world as a cornerstone of artificial intelligence and computer vision.

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Converging Pathways of Operations Research, Data Science, and Sustainable Futures





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Navigating the intricate web of business variables, ensuring the alignment of outcomes with KPIs, and championing sustainable, practical strategies are the hallmarks of an Operations Research Scientist. Dr. Aineth Torres-Ruiz, a data scientist at Fractal, delves into the nuances of her role, discusses the importance of sustainability, addresses the challenges and opportunities for women in STEM, and explores the expansive horizons of these domains.

The Life of an Operations Research and Data Scientist

At Fractal, Dr. Aineth Torres-Ruiz's third consulting engagement, the focus is on enhancing human decision-making in businesses through advanced analytics. Their strategic approach spans across Finance, Supply Chain, and Behavioral Sciences, integrating data-driven insights to drive actionable outcomes. Dr. Torres-Ruiz emphasizes her involvement in specialized optimization tasks, complemented by roles in exploratory data analysis and data science. "Tools like Azure, Python, SQL, and Pyspark are foundational in this industry. To truly harness the power of optimization, it's imperative to grasp the fundamentals of these technologies," she says. Her prowess in these areas is evident in projects enhancing product supply, streamlining inventory and truck management, and optimizing staff scheduling processes.

Inquiring about the essence of operations research, Dr. Torres-Ruiz highlighted its multifaceted nature. It encompasses techniques, methodologies, and decision-centric projects, underpinned by quantitative methods. Mathematical programming tools, like Gurobi and CPlex, play a pivotal role, as do systems such as queuing, inventory management, and simulations. These components synergistically contribute to enhancing a business's operational efficiency.

Dr. Torres-Ruiz also expressed concerns about many companies' inability to fully capitalize on these advanced technologies. "Some firms either lack the infrastructure or have an untrained workforce, missing out on tools like Arena, Semio, or Anylogic,"

she notes. However, the solution may lie in online platforms like Udemy and Coursera, which offer accessible training. Despite the diversity of tools, the core principles remain consistent and rooted in optimization.

> "A dual expertise in mathematics and coding paves the way for addressing business challenges quantitatively."

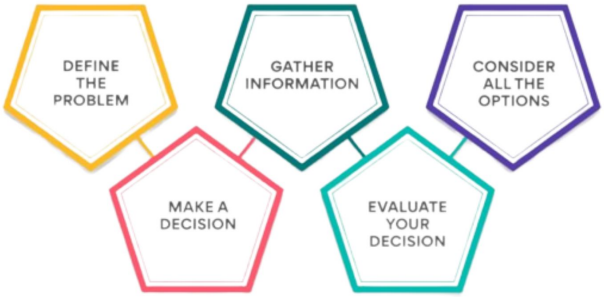


Figure 6: The key points in Operations Research. Data source

Embracing Sustainability: Preparing For The Days Ahead

The importance of sustainability for Dr. Aineth lies primarily in two regions.

1) Personal reasons: In her experience, she has seen the effect that sustainability has on her personal life. By extrapolating these ideas within any company, she believes that she can replicate traits that will allow the well-oiled machine of a corporation to function toward a greener world.

2) Professional reasons: The government can impose regulations that the companies have to comply with. This involves developing decision frameworks to identify criteria for sustainable production systems while keeping in mind costs and the qualities of products and services. Her role as a professional comes into play when she is called to solve these issues.

Having worked with several companies in procurement, identification of criteria, and handling demand and supply, she still finds the incorporation of sustainability a mammoth task. With large amounts of data accessible at Fractal, she tries identifying metrics that can be tweaked to provide a rippling effect in the direction of a positive environmental change. However, the challenges lie in the complexity of such tasks and the general workforce's lack of experience in related fields. Understanding engineering, carbon measurement, and how processes have effects on the environment will allow these corporations to make a tangible difference in changing the world.

Pioneering Women in Operations Research and Management Sciences

The ongoing challenges faced by women in the workforce, particularly in STEM fields, are critical yet unresolved issues. Dr. Aineth sheds light on traditional biases and the hurdles women encounter when asserting themselves compared to men. There's a notable decline in women staying in STEM fields and a lack of representation in managerial roles.

Women often seek a balance between personal and professional responsibilities, but the work environment doesn't always support this. For instance, some companies overlook the skills of women, especially those with parental responsibilities, preferring men for similar roles.

Women in OR/MS is an organization addressing these disparities by organizing activities like webinars, mentorship sessions, and scholarship programs. They also hold events at the INFORMS business analytics conference to foster awareness and productive discussions.

A noteworthy initiative is the Scholarship Family Care Award (INFORMS, 2023), which helps cover costs for working women and caregivers wishing to attend the INFORMS annual conference.

Recent data reveals that women comprise 35% of the STEM workforce, despite earning about half of the science and engineering bachelor's degrees (Foundation, 2023). The representation is even lower in sub-fields like engineering, with women making up only 15% of the workforce (DeVille, 2023).

Leadership plays a crucial role in addressing these imbalances, with a call to empower women into STEM leadership roles, inspire change agents, and prioritize mentorship and support within workplaces (Pappas, 2022). These steps are essential for fostering an inclusive and supportive work environment, which is vital for collective advancement in STEM fields.

Gazing into Tomorrow: Predictions and Possibilities

In real-world work settings, challenges often arise without clear solutions, and addressing these can take companies a long time. This highlights the importance of problem-solving skills, which come into play daily both personally and professionally. Each problem resolved enhances the ability to tackle future issues more effectively.

Drawing from her experience, Dr. Aineth advises those interested in operations research and data science to actively engage in real-world projects. Her freelancing journey exposed her to a wide range of problems—an experience she finds may be limited in larger, more structured corporations. She encourages building a portfolio on platforms like GitHub, personal websites,

or Google Drive to showcase practical experience, as it often speaks louder than just credentials on a resume.

Roles in optimization and analytics require skills in cloud technologies, data handling, solution creation, and deep learning. Demonstrating proficiency in these areas, during interviews or discussions, can significantly bolster one's position in this field. Dr. Aineth mentions the vast potential this field holds for companies, a potential that remains largely untapped.

She further notes that as we interact more with complex systems, the limitations of solely relying on Artificial Intelligence (AI) become evident. Despite AI's ability to process vast amounts of data, its limitations highlight the growing importance of Operations Research (OR) for optimization and simulation tasks. Collaborating with experienced companies or investing in training for skilled professionals are suggested ways to harness the full potential of OR, aiding advanced problem-solving and decision-making.

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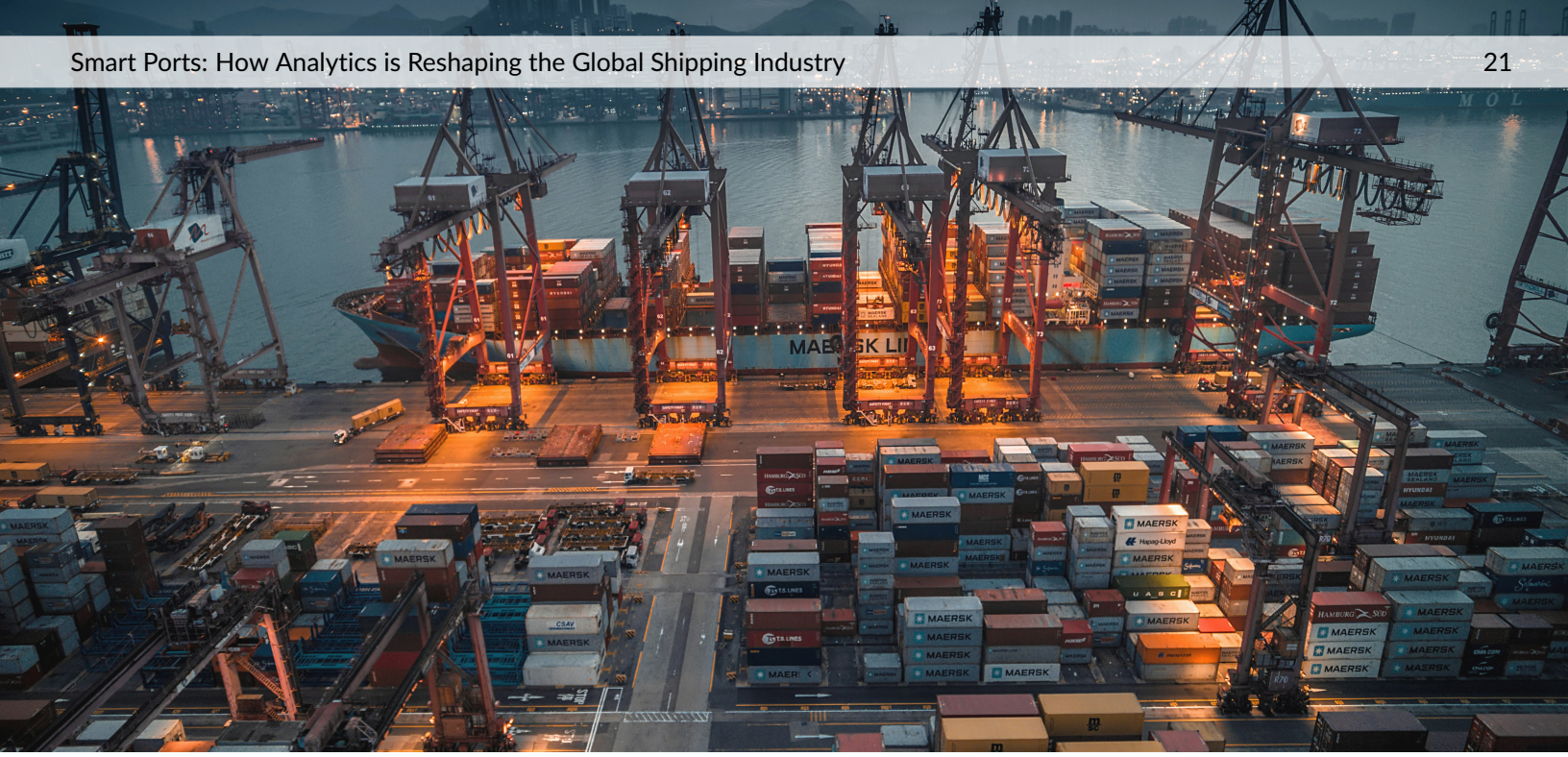
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Smart Ports: How Analytics is Reshaping the Global Shipping Industry



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The outbreak of the COVID-19 pandemic severely impacted the maritime supply chain, highlighting an urgent requirement for improved efficiency in port operations to meet the increasing demand. Considering that over 80% of global goods are transported by sea, the pandemic delivered a formidable setback to the international supply chain Gu (2023). The pandemic, while affecting multiple dimensions of maritime trade, particularly strained port operations. A notable number of ports were evidently unprepared to counter events like epidemics, causing a marked reduction in cargo throughput. Further, prevailing economic circumstances and governmental regulations amplified these challenges, inhibiting ports from adapting to the spike in online shopping and thereby leading to pronounced delays and reduced profitability.

An Introduction to Smart Ports

Before the pandemic, most ports focused on updating their physical infrastructure, often overlooking their digital counterparts. However, in the wake of the pandemic, most modern ports have embraced the potential of data analytics. By harnessing the power of big data, ports have not only enhanced their efficiency but also bolstered their resilience and profitability. Furthermore, incorporating state-of-the-art data solutions can help ports prevent congestion, minimize delays, improve overall safety, and minimize their economic impact. The growing emphasis on data-driven port solutions has given rise to the concept of the "smart port." However, there is no set definition of what makes a port “smart.” According to Karaś (2020), “the idea of Smart Ports is not only management of technological processes but also digitalization, increasing the efficiency of operations in ports, integration of ports with cities and acquiring energy from alternative sources”. Modern smart ports are generally equipped with the latest high-level port technologies, strive for full automation to prevent possible disruptions in the supply chain, can manage and appropriately use large amounts of data, and can be flexible and adapt to economic shocks. Smart ports typically outperform traditional ports in terms of efficiency and quality. Moreover, they provide a competitive edge while promoting environmental responsibility. All in all, if modern ports want to operate and compete as efficiently as possible, the incorporation of big data is needed to operate smoothly and prevent another maritime trade collapse.

Using Data for Operational Optimization

With the recent pandemic demonstrating that most ports were unequipped to deal with operational shocks, making better use of the data already available to ports has become critical. According to Wouter van Groenestijn, "most ports and terminals collect vast amounts of data about how they are performing. But it's often not used in a way that reveals why problems are occurring, what might happen, and what to do about it. And it only gives a partial picture because it doesn't involve everyone in the port ecosystem" van Groenestijn (2021). This underutilization of data leads to inefficient productivity and can result in delays and port congestion. For instance, most ports rely on estimated departure times to inform ships when it's safe to leave. However, these estimates are often inaccurate and subject to frequent changes. These inaccuracies can have a domino effect, causing delays in towage and lock operations, leading to port congestion and further delays. However, smart ports have begun to work around this problem by incorporating machine learning technologies. Machine learning technologies can make use of the data from individual vessels to understand how they have behaved historically and how they are likely to behave in each situation. According to Groenestijn, these insights can improve departure time accuracy by as much as 20%, enabling port employees to plan schedules more efficiently van Groenestijn (2021). Moreover, the use of big data and machine learning allows ports to forecast demand, optimize berth allocation, crane assignments, and efficiently manage resources, such as equipment, labor, and energy, ultimately reducing waste and downtime.

Risk Management

In addition to operational inefficiency, the pandemic also exposed flaws in ports' risk management practices. As delays and congestion hours pile on, ports risk substantial operational costs and even the loss of key customers. To mitigate these risks, ports must gain a deeper understanding of the causes of congestion. Utilizing information available about each vessel entering and departing the port, such as overall vessel length, smart ports can analyze key congestion areas and identify the underlying causes of significant delays. Furthermore, by running simulations, smart ports can determine the optimal schedules for vessel movements within the port, making efficient use of available space. Smart port technologies can also become instrumental in curbing smuggling and theft. For instance, smart ports can employ anomaly detection techniques to flag suspicious activities, such as drug smuggling or theft.

Innovation and Competitiveness

Additionally, ports that have adopted analytics and machine learning tend to outcompete traditional ports. These smart ports not only enhance their operational efficiency but also leverage their data assets to collaborate with other maritime stakeholders and companies, such as technology providers, research institutes, and regulators. For example, a smart port could utilize cutting-edge information technologies to expedite and secure contracts faster than competitors. By utilizing blockchain technology, a port can secure smart contracts and receive almost instantaneous transactions. Additionally, new technologies, such as deep neural networks, offer more accurate forecasts and real-time solutions According to Dorota Owczarek, smart ports that efficiently manage vast data can receive long-term forecasts directly instead of relying on a series of predictions, each based on the previous outcome Owczarek (2022). This allows smart ports to outcompete traditional ports that rely on single machine learning algorithms and time series methods Shipping (2023).

Sustainability

With an increasing emphasis on environmentally friendly supply chain solutions, smart ports are minimizing the environmental impact of shipping. By utilizing data to enhance operational efficiency, smart ports can reduce their environmental footprint by ensuring that the port operates at maximum efficiency. For example, ports can use environmental analytics to monitor and manage their emissions, waste, energy, and water consumption. Additionally, improved database management allows for more accurate analysis of a port's environmental impact and total emissions, making it easier to communicate with regulators and government officials to ensure compliance with environmental standards.

Global Leaders in Smart Port Innovation

As the concept of smart ports gains momentum in the maritime industry, numerous countries are making significant investments in port technology. The Port of Gdynia, for instance, has implemented one of the most advanced guidance systems globally: the Global Navigation Satellite System - Real Time Kinematic. This system was implemented at the beginning of 2019 and allows for the visualization of ship movements with extreme precision, down to the centimeter. Moreover, the system supports the work of captains, which requires extreme precision during difficult weather conditions. Implementation of the system allows for maneuvering the ship not only with limited visibility but also prevents congestion in the port itself. Meanwhile, the Port of Antwerp, a hub for European chemical trade, has developed the iNose device. Over 23 iNose devices have been strategically installed throughout the port to measure and monitor changes in air composition. This allows the port to analyze its impact on the surrounding air quality, preventing over-pollution and ensuring a safe working environment Johnson (2020). Additionally, British Telecom has partnered with Gorilla Technology Group to develop an innovative Container Identification and Container Damage Detection solution. While traditional manual inspection methods are inefficient and prone to

human error, the new solution can accurately and rapidly identify containers, track movements, and detect any signs of damage or tampering. This new technology will optimize operations and improve the overall efficiency of ports, eliminating the need for manual container inspections McCabe (2023).

Outlook

As information technology continues to expand, smart ports are better able to adapt to meet current demand. AI, blockchain, and process automation are being integrated into ports worldwide to streamline maritime trade. Just as recently as 2022, the global Smart Ports market size was valued at USD 1954.88 million. It is projected to reach up to USD 6577.04 million by 2028. Leading companies in the field include IBM, Siemens, General Electric, and more. However, the growth of the smart port industry also presents challenges. The large amounts of data being gathered will mean ports will need to constantly maintain their database systems, possibly resulting in high costs as new systems are integrated. Moreover, the transition to full automation poses a risk of unemployment for physical laborers within the sector. While creating a fully automated port may make for a more efficient process, it also will cut out many human-operated aspects of traditional port operations. Finally, perhaps the biggest risk of all is cyber security. With an increasing reliance on technology, the risk of cyber-attacks grows. To prevent such attacks from completely disrupting port operations, ports will need to invest significantly in cyber security and backup systems to prevent significant financial loss.

Overall, to meet the growing demand, ports all over the world are adopting the latest technological and data applications to keep their operation running efficiently and better prepare ports to face the problems of tomorrow.

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College Competition and the Connection to Rising Student Costs



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Worcester Polytechnc Institute

It's not news that college tuition has been on the rise for years - decades, even. *Adjusting for inflation, tuition, fees, room, and board for a full-time student at a four-year college increased 180% from 1980 to 2019 (McGurran, 2023). What is behind this tuition inflation? Economists Pavlov and Katsamakas (2023) design a model to test one hypothesis: Competition is driving tuition increases.*

Economic theory and common sense affirm to us that competition lowers prices and improves quality. In the United States, United Kingdom, and other countries, various antitrust laws exist to limit market power and break up monopolies so as to promote competition. However, this dictum may not apply in all circumstances. One community seems to operate counter to this "competition lowers prices" paradigm: academia.

This was the observation of economists Oleg Pavlov and Evangelos Katsamakas, whose 2020 study on declining college enrollments and institutional efforts to offset resultant revenue losses and/or attract new students (Pavlov and Katsamakas, 2020) was featured in the Fall/Winter 2020 edition of *OR/MS Tomorrow*.

The Feedback Loops of Higher Education

In their 2020 study, Pavlov and Katsamakas (2020) deduced that, for colleges to survive despite decreasing enrollments, adjustments to faculty population, class size, and facility quality would be insufficient in the long-term and sometimes even in the short-term. In their most recent 2023 study, they explored explanations for tuition inflation among U.S. universities (Pavlov and Katsamakas, 2023).

> Their conclusion: Increasing competition between universities can explain increasing tuition.

The study takes a system dynamics approach, in which the behaviour of a complex system is interpreted using internal feedback loops and other tools. They start by highlighting the feedback effects of academic competition, which often takes the form of new facility construction and non-academic amenities provision. These are stoked in no small part, they argue, by college rankings, which have, over the years, played an increasingly important role in the higher education landscape. (I myself perused the U.S. News and World Report when I was deciding on an undergraduate program back in 2018.)

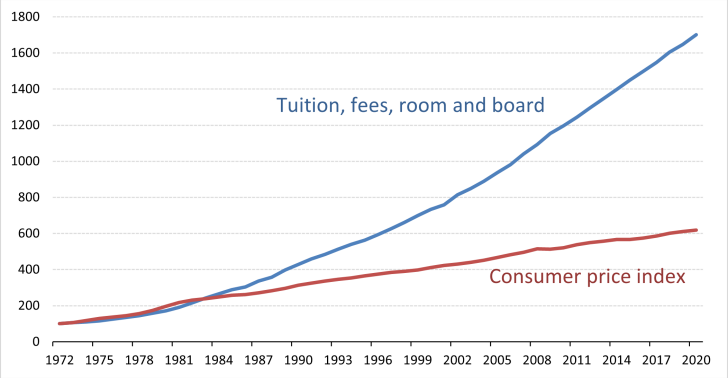


Figure 7: Published tuition, fees, room, and board for private nonprofit four-year institutions compared to the CPI data. For both time series, the base year is 1972. Data source: College Board, Trends in College Pricing 2021, https://research.collegeboard.org/media/xlsx/trends-college-pricing-excel-data-2021-0.xlsx

New buildings and amenities require significant financial investment not only in the construction stages, but also in post-construction maintenance. Universities take risks by embarking on facility expansion and improvement projects. However, the researchers note, they also take risks if they do not attempt such projects. Figure 9 illustrates the forces and circumstances at play between two generic, peer institutions, College A and College B, that are caught in the feedback loop of higher education competition. In this graph, loops R1 and R2 form the **success-to-the-successful structure** and loops B1 and B2 form the **positional competition structure**.

What do these terms mean? Along loops R1 and R2, we start with College A having an advantage over College B. Because of this advantage, College A receives more resources than College B, which translates to greater results for College A compared to College B and, consequently, a better reputation. As the reputation of College A improves, College B will struggle, with the resources they receive, to match results and similarly boost their reputation. Thus, due to the initial advantage of College A, College B remains at a positional disadvantage, assuming that all else stays the same.

Now, along loops B1 and B2, we have the addition of College B initiating activities to enhance their reputation and better compete against College A, assuming that College A has an advantage at the beginning. If the advantage of College A is so great that College B has very little chance of catching up, additional investments on their part are unnecessary and the self-reinforcing loop R1 keeps College A at #1. However, should College B's activity propel them closer to College A's rank, College A will have to invest in more activities themselves if they wish to maintain or regain their advantage.

Theoretically, this back-and-forth continues ad nauseam: College A has a higher reputation. College B initiates activities to meet or surpass College A. College A responds by taking action to reposition themselves as superior. College B invests more into activities that promote their reputation. And on and on. They are engaged in seemingly interminable positional competition, in which the activity taken by one is moderated by their position relative to their competitors.

What happens if one of the colleges decides to not answer the positional competition challenge? Say that, in this example, College B runs with the status quo. Then College B will fall farther and farther behind College A in results, reputation, and, consequently, enrollment. College B's financial situation will deteriorate and, eventually, they may be forced to close their doors. In my corner of the world (Massachusetts, U.S.A.), several colleges have closed or merged with larger ones in the last few years due to dwindling enrollment and lost tuition revenue (Higher Ed Dive Team, 2023; Larkin, 2017).

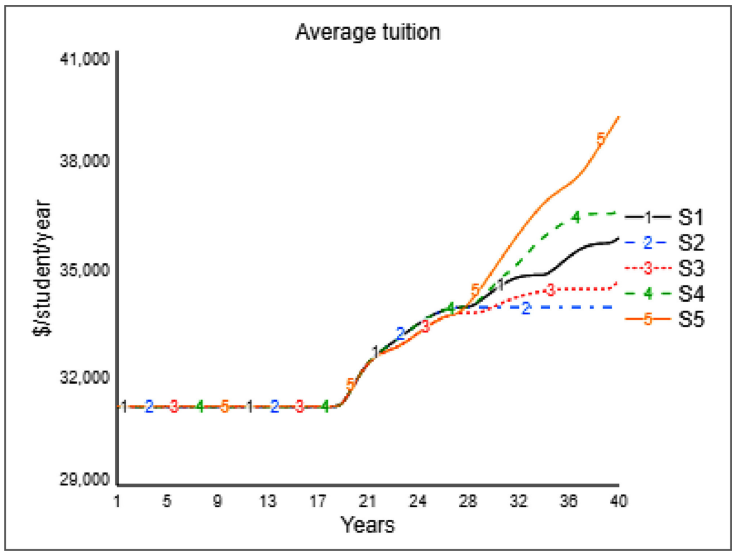


Figure 8: Average tuition increases in all the scenarios except S2, when one of the colleges dropped out of the positional competition

The Model

Testing this hypothesis about the feedback loops of the higher education sector, Pavlov and Katsamakas (2023) create a duopoly of two teaching-focused colleges, A and B, that are competing for reputation, applicants, and tuition money, with the simplifying assumption that the competition is over facilities only. The applicant population in this model selects between the colleges on the basis of financial aid package received and rankings.

With College A starting at a slightly better position than College B, the researchers run the model through five scenarios. In the first scenario, the competition between the schools is introduced in the form of rankings at Year 5 of the simulation. In the remaining scenarios, College A stays their existing course while College B attempts different policies or receives different inputs:

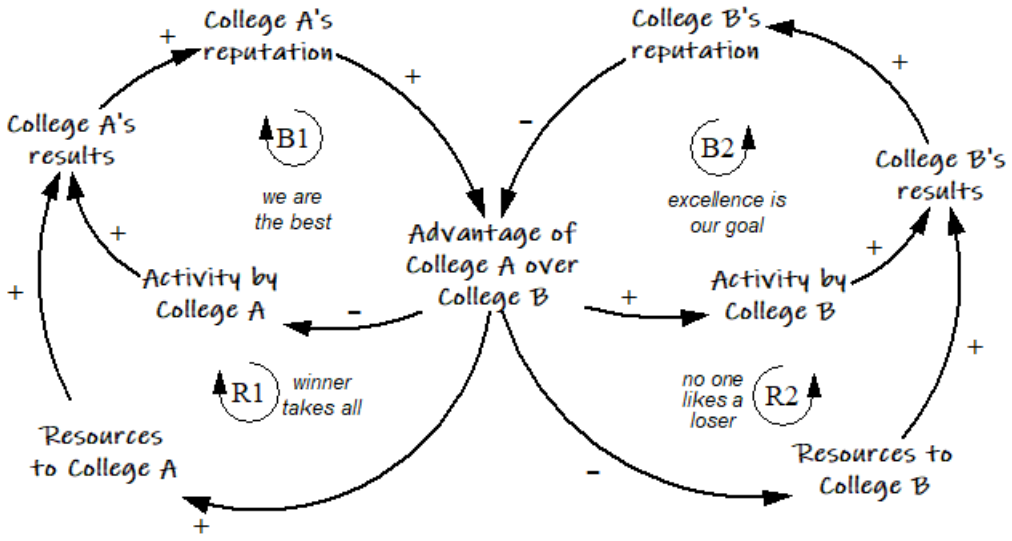


Figure 9: The four major feedback loops in the higher education sector. The reinforcing loops R1 and R2 result in the success-to-the-successful dynamics. The positional competition between academic institutions is described by the balancing loops B1 and B2.

ignoring rankings (Scenario 2), raising external funds (Scenario 3), undertaking aggressive facilities buildup (Scenario 4), or a combination of the last two (Scenario 5).

Comparing the scenarios, what do we find? First, in all scenarios except for the second, in which College B ignores rankings and thus, in essence, drops out of the competition, average tuition increases for both colleges (see 8). The researchers also compared the average institutional debt and the average per-student expenditures across the scenarios, finding that the former varies while the latter follows a pattern similar to the changes in average tuition.

Altogether, the simulations of this two-college model demonstrate that competition for resources and reputation greatly impacts rising tuition in the United States and that the proposed feedback model provides a viable explanation for this tuition inflation.

Read the original paper: Tuition too high? Blame competition

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2023 Crossword Puzzle Winners



Kara Combs
Air Force Institute of Technology

We are thrilled to unveil the brilliant minds who conquered the recent crossword puzzle to win the generated prize of $100 each. We would like to congratulate all the winners of the competition, thank the generous Bonder Foundation for their financial support of the competition, and to our staff writer, Abigail Linder, who took the time to craft the puzzle. The last year the crossword puzzle made an appearance was in 2020, and we hope to continue holding the competition in the future!

2023 Winners



Qingyang Sun
University of Massachusetts Amherst
Amherst, USA
Ph.D. Candidate
Ph.D. Mechanical and Industrial Engineering (Exp. 2024)
LinkedIn



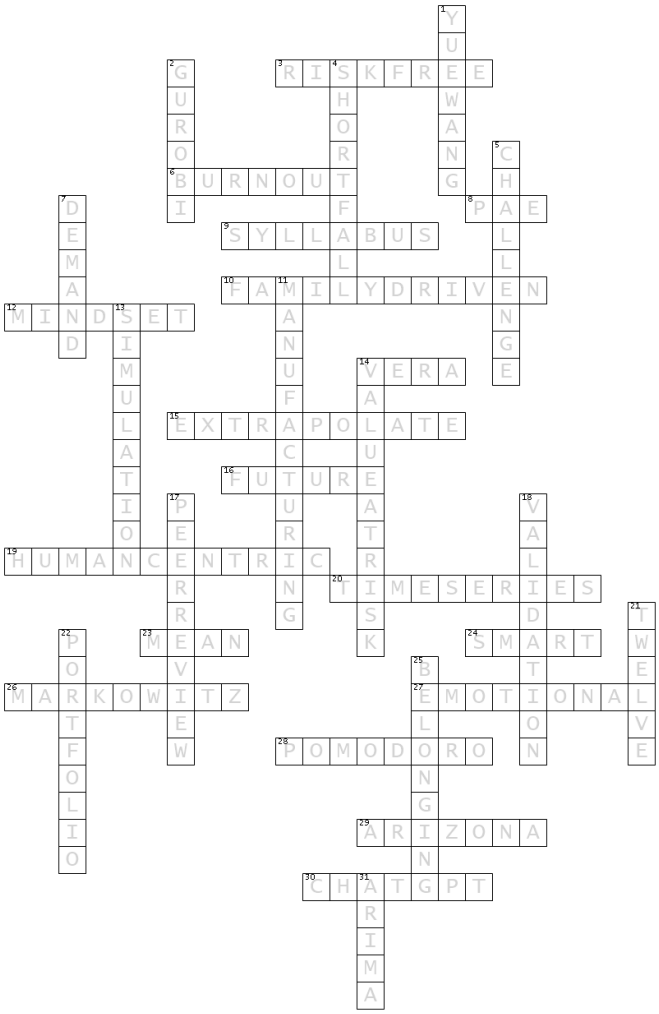
Tuba Ulusoy
Necmettin Erbakan University
Konya, Turkey
Research Assistant
M.S. Industrial Engineering (2016)
LinkedIn



Nasim Rashidi
Washington State University
Pullman, USA
Ph.D. Student
Ph.D. Civil Engineering (Exp. 2026)
LinkedIn

Acknowledgements: *Header photo is by Alexandra Lowenthal.*

Crossword Puzzle Solution



ACROSS

3. Assets with guaranteed future returns are called _____
6. Lack of motivation, energy, and increased stress are symptoms of this
8. Acronym for a Pennsylvania service for hard-to-place children
9. A course outline
10. A parent-child matching algorithm could be caseworker-driven or _____
12. MATTERS One section of the book Managing Your Mental Health During Your PhD (2 words)
14. Faculty advisor of an INFORMS student chapter in Chile
15. The Q world of mathematical finance wants to _____ the present
16. The P world of mathematical finance wants to model the _____
19. The type of algorithmic design approach needed in child welfare
20. A collection of data points over time (2 words)
23. _____ demand is a component in the standard formula for calculating inventory
24. Characteristics of realistic goals can be remembered with this acronym
26. Economist who introduced Modern Portfolio Theory
27. One of the reasons PhD students procrastinate is _____ overload
28. A studying technique based on 25-minute intervals
29. University where A2 will be an assistant professor
30. A new and controversial AI chatbot

DOWN

1. Our former social media coordinator (2 words)
2. A powerful optimization solver
4. A theoretically powerful, convex risk measure: expected _____
5. "The need is there. The _____ is now."
7. Demand _____ is a main S&OP process step
11. Profit margins have traditional been meager in this industry
13. A run of an experimental model
14. A possible root cause of the 2008 Recession in the United States was overreliance on _____ (3 words)
17. Academic process for which more and better AI detection tools are needed (2 words)
18. Process to determine the accuracy of a simulation model
21. Minimum font size for mini poster
22. A linear combination of assets
25. An INFORMS student chapter goal
31. A type of forecasting model