Operational Data Analytics for Newsvendors

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Decision making with limited data is challenging. In this talk, we introduce the framework of operational data analytics (ODA) that integrates data to predictive or prescriptive solutions. This framework strikes a delicate balance between the (likely imprecise) structural knowledge and the data. The two pillars of the ODA framework are (i) a *data-integration model* that identifies the class of *operational statistics* based on the desired structural properties of the models within the domain of validation, and (ii) a *validating model* that appropriately utilize the data to validate the choice of the operational statistics. Using the classical newsvendor model as an example, we show that the ODA framework generalizes the existing approaches including predict-then-optimize, regularized empirical optimization, robust optimization, robust satisfying, order statistics and smart-predict-and-optimize. We further demonstrate that the data-integration model and the validating model in ODA must be formulated in a coordinated way based on the preciseness of the knowledge and the availability of the data. We present three specific applications.

(1) In the price-setting newsvendor problem, the ODA solution, being asymptotically optimal, exhibits superior performance over existing approaches in both magnitude and robustness for extremely small sample size (e.g., 5 or 10). In parametric settings, the ODA solution is shown to be uniformly optimal, and thus other solutions are inadmissible.
(2) When ample data form a related system can be used to supplement the limited data from the focal system, we demonstrate that the ODA solution exhibits apparent advantages over the popular *transfer-learning* solutions. In particular, we propose *cross learning* by adapting the parametric ODA solution for non-parametric decision making. Under this approach, we utilize the ample data from the related system to mimic the stochastic environment of the focal system, which allows for effective validating. The resulting ODA solution significantly improves the performance of the focal system over the transfer-learning solution and is shown to be asymptotically optimal.
(3) When there are multiple related systems each with limited data, we transform the data from different systems to create a generic stochastic environment for the decision-making problem, which facilitates the implementation of the ODA solution. We show that the derived co-learning solution is asymptotically optimal for each involved system, as well as the aggregate system, and outperforms the existing data-pooling strategies, which focus only on aggregated performance.

Our results underscore the importance of domain knowledge and the structural relationships (between the data and the decision) in designing efficient decisions with limited data.

Bio: Qi Annabelle Feng is the John and Donna Krenicki Chair in Operations Management at Purdue Business School, Purdue University since 2014. She joined Purdue in 2012 and was a faculty member at McCombs School of Business, The University of Texas at Austin during 2006-2012. She received her Ph.D. in Operations Management from UT Dallas in 2006. Her current research interests lie in developing notions of stochastic functions and approaches for data-integrated decision making with the applications to supply chain management, service design, resource planning, and policy making. She was a Department Editor of Data Science, Stochastics and Optimization for *Production and Operations Management*, and is currently serving as the Department Editor of Supply Chain Management for *Flexible Manufacturing and Service Journal*, an Associate Editor for *Operations Research*, an Associate Editor for *Management Science*, and an Associate Editor for *Manufacturing & Service Operations Management*. She received the first prize in the INFORMS Junior Faculty Paper Competition in 2009, the Franz Edelman Award in 2009, the Wickham Skinner Early-Career Research Accomplishment Award in 2012, and the Wickham Skinner Best Paper Award in 2018. She is a fellow of Production and Operations Management Society since 2020.