Data Analytics for Operational Risk Management

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Today, in a market full of turbulence, business operations face unforeseen challenges. The most recent events, such as the global outbreak of Coronavirus Disease 2019 (COVID-19), also known as the Wuhan coronavirus outbreak, have created a huge global crisis in "breaking many global supply chains" as China is commonly viewed as the "world factory". In fact, as reported by World Economic Forum Global Risks Report (2020): "*The global economy is facing an increased risk of stagnation, climate change is striking harder and more rapidly than expected, and fragmented cyberspace threatens the full potential of next-generation technologies*"[1]. Despite the fact that many sources of risks are uncontrollable by humans, we may be able to sense and respond quickly with the use of data and establish a resilient supply chain system. This is especially critical to humanitarian operations (Ataseven et al. 2018) which respond to disaster and other risks (Apte et al. 2016).

Thanks to the explosive expansion and advances of digital technologies such as smart mobile phones, social media platforms, e-commerce, etc., data are around in every organization. As the analytics capabilities of organizations develop rapidly, artificial intelligence tools, big data analytics, blockchain, etc., are all tools available and being used in the industry. A natural question arises: in light of the highly volatile market environment and unpredictable global economic system, how should organizations, both profit making and non-profit making ones, make use of data analytics to enhance their operational risk management (ORM) practices? This question is a timely and critical one and calls for scientific research from the operations management (OM) community.

Motivated by the importance of data analytics for ORM, we organize this special issue of *Decision Sciences* focusing on novel and timely studies that address ORM challenges by using data analytic tools. We also aim to theoretically quantify the benefits and values of using data for ORM. We concisely introduce the featured papers one by one as follows. First of all, **Araz, Choi, Olson and Salman** discuss the critical roles played by data analytics for ORM. The authors examine the selected literature in operations management (OM). They classify the literature into different types and propose a three-stage framework which can be applied to enhance data analytics for operational risk analyses. In the scope of fashion retailing, **Shi, Wang and Alwan** explore a Chinese retail company which fulfills "cross-border orders using online platforms". The company has to cope with the complex inventory management problems associated with overseas warehouses. Non-trivial operational risks are present. To cope with this challenge, the authors develop a novel two-stage data-driven predictive analytical tool in which all items are first well-classified. Then, SKU demand points are forecasted.

[1] https://www.weforum.org/reports/the-global-risks-report-2020 (accessed 4 March 2020)

The authors employ several machine learning techniques in the analyses. They report significant performance improvement using their proposed two-stage predictive tool. In the fresh-product supply chain, **Zhang, Xu and Cai** consider the respective risk management practices. The authors consider the presence of a distributor who sells fresh products during a fixed trading time window, and it may procure the products from multiple supply sources. Naturally, the distributor faces uncertainties in both demand and delivery processes, which will lead to mismatches between the delivery arrival time and trading time as well as supply and demand. The authors formulate the basic problem as a multi-source selection model with random yields, taking into account the trade-off between the purchasing cost and other costs such as deterioration losses arising from delivery uncertainties. Based on the analytical and numerical results, they reveal that while the average cost plays an important role at the sourcing stage, the delivery uncertainty decides how much to order from each supplier at the buying stage. In general, the problem the authors formulated is a concave optimization problem. They derive an iterative algorithm for the case when suppliers have sufficient capacity and heuristic algorithms for the case when suppliers have limited capacity to enhance decision making for the corresponding problems. Despite the importance of ORM in supply chain financing systems, little is known about how to measure a decision-maker's risk attitude in the financing process for business operations under competition. As a result, **Li, Liu, Feng, Wang, Xu** develop a data-driven approach called ordinary least squares method which employs the conditional value at risk (CVaR) approach to measure the risk attitude of decision-makers. To investigate the manufacturer's financing provision strategy and identify the impact of risk aversion on the supply chain financing system, the authors compare the equilibrium outcomes under trade credit finance (TCF), retailer independent finance (RIF), and partial credit guarantee (PCG) finance scenarios by using game theoretic models. The results show how the optimal financing provision mode changes with the degree of risk aversion and the retailer's initial capital. The authors also propose an interesting variable parameter guarantee mechanism to encourage more retailers to choose PCG instead of RIF, so as to achieve Pareto improvement of the whole financing system. Furthermore, a Pareto optimality mechanism is presented to realize super-centralization and to coordinate the decentralized risk averse financing system. Two featured studies focus on exploring transportation related risks. Exploring the operational risk in airline business, **Sun, Chung and Ma** first examine the characteristics of the flying time at flight level. Then, they apply the heteroscedastic regression model to model the structure of the flying times. As a result, a recursive relationship of the expected departure and arrival times of each flight leg is established, which helps improve the accuracy of the corresponding crew-induced flight delay prediction. The authors then propose a novel data-driven bi-criteria mathematical model in which the interdependent structures of the departure and arrival times of the consecutive flights are incorporated into the robust optimization. Their real-data based computational examples demonstrate the cost-efficiency of the proposed model and verify the impacts of the interdependency between the departure and arrival times on the robustness of crew pairings. The results suggest that an appropriate level of robustness consideration may help airlines attain the best cost-effective operations decisions. However, extreme risk-aversion against flight delays may do more harm than good to airlines. Moreover, the cost ratio of the basic crew cost to the compensation expenses due to flight delays may affect the impact of the robustness level on the optimal decisions. Finally, the authors uncover that when the cost ratio is low, a higher robustness level can be set for a risk-averse decision maker. To study a driver dispatching system for a control center for order assignment in ride-hailing services, **Wang and Wu** build a data-driven optimization model. In their model, the operational risk arises when disruptive events (such as urgent transportation demand) occur in a short period. The designed system is capable of managing the operational risk via the built-in allocation constraints in the optimization model. The

proposed data-driven system contains a future demand forecaster which uses a hybrid forecasting model based on classic linear regression (ARIMA), machine-learning based Long Short Term Memory (LSTM), and Recurrent Neural Network (RNN). The system runs on a Rolling Time Horizon approach, where a build-in off-line optimization problem is solved in each iteration. Due to the NP-hardness nature of the problem, the authors propose a heuristic approach which combines the Hungarian method and the Simulated Annealing metaheuristic to solve the problem. Through a numerical experiment based on actual past yellow cab order data, the authors implement and compare the proposed system with the conventional request-driven dispatching and order assignment methods. Their findings highlight that the system outperforms the others in that it decreases the average waiting time. Remarkably, the order density provided by the LSTM forecaster turns to be a reliable indicator for the system. Finally, natural disasters and extreme weather are viewed as the top two potential risks that can cause the global economic system to be vulnerable. Such risks are the foremost obstacles that directly lead to production halts or reduction, which may even cause supply disruptions for downstream manufacturers. To guard against disruption risks, **Li, Liu, Bian and Sethi** consider a case in which a downstream manufacturer employs two representative contracts to incentivize the upstream supplier, privileged with private information on supply disruption risks, to enhance supply reliability. The authors specify two typical regimes, namely, the push and pull regimes under the wholesale price contract, while two possible regimes: contracting both regime, and contracting high regime, under the screening menu contract. They analytically show that the manufacturer prefers the pull regime under the wholesale price contract to either regime under the screening menu contract when the reliability enhancement cost or initial supply reliability heterogeneity is relatively high. In contrast, the contracting both regime under the screening menu contract becomes a dominant strategy for the manufacturer when the reliability enhancement cost and initial supply reliability heterogeneity are both low. Interestingly, in the pull regime, the authors further uncover that more information transparency may be detrimental to the manufacturer's payoff when the supplier has low initial reliability, whereas the high-type supplier can surprisingly gain a higher profit under information asymmetry.

We strongly believe that the featured articles help present how ORM can be enhanced by using data and proper analytical tools. We hope this special issue will lay the foundation to stimulate more future data analytics research on ORM.

Before closing, we would like to take this opportunity to show our sincere appreciation to Mark Ferguson, Xenophon Koufteros and Cheri Speier-Pero, the current and former Co-Editors-in-Chief of *Decision Sciences*, for supporting us in organizing this important special issue. We also show our hearty thanks to all the reviewers and authors for their excellent contribution to make this special issue a success. Tsan-Ming Choi would express his thanks to Dr. Xin Wen (Windy) for her assistance in this special issue.

References

1. Apte A, Khawam J, Regnier E, Simon J. (2016). Complexity and self-sustainment in disaster response supply chains. *Decision Sciences,* 47, 6, 998-1015.
2. Ataseven C, Nair A, Ferguson M. (2018). An examination of the relationship between intellectual capital and supply chain integration in humanitarian aid organizations: a survey-based investigation of food banks. *Decision Sciences,* 49(5), 827-862.

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