FACULTEIT ECONOMIE EN BEDRIJFSKUNDE

UNIVERSITEIT GENT

Invitation

You are cordially invited to the public defense to obtain the academic degree of

DOCTOR OF BUSINESS ECONOMICS

by Léon Sobrie

Explainable predictive analytics and decision support for real-time control room management

Supervisors:
Prof. dr. Johan Christiaens - Prof. dr. Marijn Verschelde - Dr. ir. Bart Roets

Tuesday, 7 May 2024 at 17h00
In room 'Faculteitsraadzaal', Campus Tweekerken, Tweekerkenstraat 2, 9000 Ghent
Please confirm your attendance no later than 26 April by email to leon.sobrie@ugent.be

EXAMINATION BOARD

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Abstract

Control rooms are widely present in industry, with a plethora of examples in transportation, healthcare, energy, and supply chains. The ongoing digitization over the past decades transformed control rooms into highly digitized centers with capabilities to capture data. This dissertation leverages these vast amounts of data present in control rooms with predictive analytics to inform decision-makers on expected outcomes. Next to predictability, the focus is directed towards explainability and implementation. The former serves as a mechanism to stimulate user acceptance and trust of decision support, whereas the latter revolves around bringing analytics to the end-user to both increase situational awareness and support decision-making. The Traffic Control Centers at Infrabel, Belgium's railway infrastructure company, are the center of attention for this dissertation.

Study 1 dives into *train delays*, a key indicator of railway service quality. This study compares the performance of an event-driven model and a customized data-driven model for predicting train delays across settings. The former is an implemented rule-based system, whereas the latter is a recurrent neural network. The performance analysis shows the ability of the recurrent neural network to perform well on unseen data, especially when compared to the event-driven model. Given the promising results of the neural network, the research team develops a business analytics application for train delay prediction, offering tailored insights to different end-users.

Study 2 pertains to *workload* from a human-centric angle as the repercussions of overload and underload on well-being have been well-documented in literature. This study takes a granular approach by focusing on distinct workload items that require specific reasoning and have different transferability. As there are no prior beliefs that the presence and magnitude of workload items have similar underlying mechanisms, a Heckman setup is proposed to disentangle the effects. A proof of concept utilizes the insights to provide granular insights into the expected workload item's presence and magnitude with explainable predictive analytics and decision support for end-users.

Study 3 investigates *automation usage* to open railway signals as employees decide on the spot to open a signal manually or through automation. This study remains neutral on the desirability of using less/more automation but rather investigates in what settings automation can be a key production factor. The related decision support system provides different types of analytics – descriptive, predictive, and prescriptive – tailored to end-users. Furthermore, the concept of learning from peers as a knowledge transfer mechanism is introduced in this setting to better understand automation usage and its impact on operational outcomes.

Study 4 proposes a *unifying framework* – PIVOT – that stimulates user-centricity for the deployment of business analytics, and aligns technical, organizational, and user perspectives. The tools from previous studies are combined into a single proof of concept, for which semi-structured interviews are conducted. The interview results report a predominantly positive attitude toward the proof of concept's potential for decision support but stress the need for further validation and refinement to reach greater value and impact on operations.

In summary, the analyses of machine learning models for predictive analytics and decision support in control rooms show that a focus on accuracy is unquestionably necessary but insufficient to capture the bigger impact on decision-makers. The advent of a movement for explainability and transparency of these models gave rise to a more meaningful connection with the environment, countering the hard-to-establish trust of decision-makers in predictive analytics and decision support. This dissertation highlights the importance of this movement in control rooms, where the dynamic nature of the setting adds to the need for explainability and transparency of models.

Curriculum vitae

Léon Sobrie (°1997, Gent) holds the degree of Master of Science in Business Engineering, with a major in Data Analytics (2020, Universiteit Gent). He joined the On Track Lab Research Group at Ghent University (Faculty of Economics and Business Administration) in 2020 as a PhD Student. Study 1 is published in the 'European Journal of Operational Research' (EJOR, *https://doi.org/10.1016/j.ejor.2023.03.040*). Study 2 is forthcoming in EJOR in the special issue on 'Explainable Analytics for Operational Research' (EJOR, *https://doi.org/10.1016/j.ejor.2023.09.016*). For Study 2, he was awarded first place at the Railway Application Section poster competition at INFORMS 2022 (Indianapolis, IN). Study 3 is accepted in 'Decision Support Systems' in the special issue on 'Explainable AI for Enhanced Decision Making' (DSS, *https://doi.org/10.1016/j.dss.2024.114216*). Léon presented his research at several international conferences, including the INFORMS Annual Meeting (Virtual, 2021; Indianapolis, IN, 2022; Phoenix, AZ, 2023), the European Conference on Operational Research (EURO: Virtual, 2021; Espoo, 2022), the INFORMS 2022 Invited Student Seminars (Blacksburg, VA, 2022), and the 11th Symposium of the European Association for Research in Transportation (Zürich, 2023).