UNIVERSITY OF MANNHEIM
Business School

CHAIR OF SERVICE OPERATIONS MANAGEMENT
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Bachelor Thesis FSS 2024

"Current topics in Service Operations Management"

Topic overview

Topic B1: Optimierungsmodelle für die Erstellung von Stundenplänen

Jedes Halbjahr stehen tausende Schulen vor dem gleichen Problem: Alle Schüler bzw. Klassen müssen Lehrer und Unterrichtsräume so zugeordnet bekommen, dass keine Schulstunde oder Ressource doppelt belegt ist und Schüler sowie Lehrer attraktive Stundenpläne haben. Dies lässt sich als Ganzzahliges Optimierungsproblem formulieren und mittels der dazu passenden Techniken und Methoden lösen, so z.B. genetische Algorithmen. Generell ist die Lösung dieses Problems eine große Herausforderung, da der Lösungsraum oft groß und nicht zusammenhängend ist. Außerdem wurde das Problem weniger stark von der Wissenschaft beachtet als beispielsweise das Planungsproblem in Universitäten. Der Grund dafür sind die üblicherweise geringeren Schnittpunkte der Forscher mit dem Schul- als dem Universitätsalltag. Jedoch lässt die große Anzahl an Schulen die Wichtigkeit dieses Problems in den Vordergrund treten und auch kommerzielle Anbieter haben sich zur Lösung dieser Herausforderung engagiert.

Ziel der Bachelorarbeit ist es,

- das Optimierungsproblem zur Erstellung von Stundenplänen zu präsentieren,
- die deutschsprachige und aktuelle Literatur anhand einer Struktur wie bspw. von Tan et al. (2021) einzuordnen,
- ein spezifisches Modell detaillierter vorzustellen und anhand eines akademischen Beispiels zu erklären (beides optional)
- offene Forschungsfelder und -lücken sowie kommerzielle Anwendungen vorzustellen.

Basic Literature:

Brodersen, O., Schumann, M. (2007). Einsatz der Particle Swarm Optimization zur Optimierung universitärer Stundenpläne. *Arbeitsberichte des Instituts für Wirtschaftsinformatik, Professur für Anwendungssysteme und E-Business, Universität Göttingen*, *5*.

Pillay, N. (2014). A survey of school timetabling research. *Annals of Operations Research*, *218*, 261-293.

Tan, J. S., Goh, S. L., Kendall, G., & Sabar, N. R. (2021). A survey of the state-of-the-art of optimisation methodologies in school timetabling problems. *Expert Systems with Applications*, *165*, 113943.

Topic B2: Machine Learning for the Crew Scheduling Problem

The crew scheduling problem for airlines and railways is one of the toughest challenges in integer programming due to the sheer size of feasible solutions as well as complex regulations and flight time limitations, which need to be considered in every solution. A common method in the literature is Column Generation but also Integer Programming and several heuristics are used. Machine learning has the potential to generate heuristic solutions for the crew scheduling problem in a comparatively fast time but it may not provide a guarantee for a feasible solution. This challenge is tackled by recent literature e.g. by including it in other solution methods.

The objectives of this thesis are

- to introduce crew scheduling and the underlying basic assumptions,
- to summarize the use of machine learning in the field,
- to discuss a specific model with machine learning in detail (optional), and
- to provide open research gaps and future trends.

Basic Literature:

Gattermann-Itschert, T., Poreschack, L. M., & Thonemann, U. W. (2023): Using Machine Learning to Include Planners' Preferences in Railway Crew Scheduling Optimization. *Transportation Science*, *57*(3), 796-812.

Heil, J., Hoffmann, K., & Buscher, U. (2020): Railway crew scheduling: Models, methods and applications. *European Journal of Operational Research*, *283*(2), 405-425.

Kasirzadeh, A., Saddoune, M., & Soumis, F. (2017): Airline crew scheduling: models, algorithms, and data sets. *EURO Journal on Transportation and Logistics*, *6*(2), 111-137.

Tahir, A., Quesnel, F., Desaulniers, G., El Hallaoui, I., & Yaakoubi, Y. (2021): An improved integral column generation algorithm using machine learning for aircrew pairing. *Transportation Science*, *55*(6), 1411-1429

Topic B3: Flight Schedule Design under Customer Choice

The task of the schedule design (SD) is to assign frequencies and departure times for specific routes by choosing from a set of proposed flights while aiming for the highest possible profit. Schön (2008) states that the schedule in combination with the fare conditions is the main criterion for passengers to choose an airline; similarly, Barnhart and Cohn (2004) call it the "single most important product of an airline". These arguments underline on one hand the large impact of the schedule on profitability but on the other hand, suggest to include customer behavior in the modelling approach to account for the market side. All these influences make the subproblem so complex that Airlines are still challenged by using models for their schedule design and rely on a manual approach as Barnhart, Belobaba and Odoni (2016) suggest. Lately, sustainability has been an often-discussed factor for airlines and first scheduling models take it into account.

The objectives of this thesis are

- to review schedule design models including sustainability,
- to compare the different approaches,
- to discuss a specific model in detail,
- to provide open research gaps and future trends.

Basic Literature:

Barnhart, C., & Cohn, A. (2004): Airline schedule planning: Accomplishments and opportunities. *Manufacturing & service operations management*, 6, 3-22.

Barnhart, C. (2016): *Airline Schedule Optimization,* in: Belobaba, P., Odoni, A., & Barnhart, C. (Eds.). *The global airline industry*. John Wiley & Sons.

Krömer, M. M., Topchishvili, D., & Schön, C. (2024): Sustainable airline planning and scheduling. *Journal of Cleaner Production*, *434*, 139986.

Noorafza, M., Santos, B. F., Sharpanskykh, A., Zengerling, Z. L., Weder, C. M., Linke, F., & Grewe, V. (2023). Airline Network Planning Considering Climate Impact: Assessing New Operational Improvements. *Applied Sciences*, *13*(11), 6722.

Topic B4: Evaluation of Choice-Based Conjoint Analysis Tools for Predicting Discrete Choices

Conjoint analysis stands as a cornerstone methodology in market research, product design, and consumer behavior analysis, offering valuable insights into individuals' preferences and decision-making processes. By systematically decomposing products or services into attributes and levels, conjoint analysis allows researchers to quantify the relative importance of different features and predict how changes in these attributes influence consumer choices. However, as the landscape of choice modeling evolves and the complexities of decision-making phenomena become more apparent, the need for robust and versatile conjoint analysis tools tailored to discrete choice models is increasingly evident.

In recent years many new software providers offer different capabilities for conjoint studies. One prominent software provider is Sawtooth Software which offers various options for choice based conjoint studies and different estimation methods. Other providers like OptionX, conjointly or Pollfish might have the same or superior capabilities.

The objectives of this thesis are

- to provide an introduction into conjoint analysis and discrete choice models,
- to discuss which type of conjoint analysis is suited best for discrete choice models,
- to create a framework on how to evaluate software to be the best choice for scholars in this field,
- to evaluate different conjoint software based on this framework,
- to summarize and discuss all findings,
- to critically assess the limits of your findings and outline any research gaps.

Basic Literature:

Eggers, F., Sattler, H., Teichert, T., & Völckner, F. (2018). Choice-Based Conjoint Analysis. *Handbook of Market Researc*h, Springer, Cham, 1-39.

Train, K., & Ebrary, Inc. (2009): Discrete choice methods with simulation (Second ed.). *Cambridge University Press*. New York Melbourne Madrid Cape Town Singapore São Paulo Delhi Mexico City

Louviere, Jordan J.; Flynn, Terry N.; Carson, Richard T. (2010): Discrete Choice Experiments Are Not Conjoint Analysis. In: *Journal of Choice Modelling* 3 (3), S. 57–72. DOI: 10.1016/S1755-5345(13)70014-9.