34. Workshop für Quantitative Betriebswirtschaftslehre (QBWL)

24.03.2025 – 27.03.2025

Pfronten-Rehbichl

Helmut-Schmidt-Universität Hamburg
und
Universität Hamburg

QBWL-Workshop 2025 Agenda

Montag, 24.03.2025	Dienstag, 25.03.2025
	07:45 – 09:00 Frühstück
	09:00 – 10:00 **Block II: Urban Transportation**
	10:00 – 10:15 Pause
	10:15 – 11:45 **Block III: Personell Planning, Scheduling I**
	11:45 – 12:00 Pause
	12:00 – 13:00 Mittagessen
	13:00 – 14:00 **Block IV: Healthcare II**
	14:00 – 14:10 Pause
	14:10 – 15:10 **Block V: Order Picking, Revenue Management**
	15:10 – 16:00 Kaffeepause
14:30 – 16:30 Kaffee (falls bereits angereist)	**16:00 – 17:00** **Block VI, VII: Automated Warehouses, Disaster Management**
17:15 – 17:45 **Begrüßung**	17:00 – 18:00 Pause
18:00 – 19:00 Abendessen	
19:15 – 20:15 **Block I: Healthcare I**	18:00 – 19:00 Abendessen
20:30 **Treffen der Professor:innen**	

Mittwoch, 26.03.2025	Donnerstag, 27.03.2025
07:45 – 09:00 Frühstück	07:45 – 09:00 Frühstück
09:00 – 10:20 **Block VIII: Scheduling II, Staffing**	**09:00 – 10:20** **Block X: Analytics, Applications II**
10:20 – 10:30 Pause	10:20 – 10:30 Pause
10:30 – 11:50 **Block IX:** **Healthcare III, Applications I**	**10:30 – 11:00** **Block XI: Assortment Optimization** **11:00 – 11:30** **Verabschiedung**
11:50 – 13:00 Mittagessen	11:30 – 12:00 Pause 12:00 – 13:00 Mittagessen/ Ausgabe Lunchpaket
13:00 – ca. 17:30 Wanderung	
18:00-19:00 Abendessen	

Tagungsprogramm QBWL-Workshop 2025

Montag, 24.03.2025

14:30 - 16:30 **Kaffee und Kuchen**

17:15 - 17:45 **Begrüßung und Vorstellung der Lehrstühle** **30 min**
Prof. Dr. Simone Neumann (Universität Hamburg)
Prof. Dr. Dominik Kreß (Helmut-Schmidt-Universität Hamburg)

18:00 - 19:00 **Abendessen** **60 min**

1. Sitzung, Leitung: Prof. Dr. Justus Arne Schwarz (Universität Regensburg)

19:15 - 20:15 **Block I: Healthcare I**

Linda Bentzen (Technische Universität München) 30 min
Midwife Scheduling in Hospitals

Markus Schüller (Danmarks Tekniske Universitet) 30 min
A Logic-Based Benders' Decomposition approach to ensure robust personnel scheduling in healthcare amidst uncertain patient demand

20:15 - 20:30 **Pause** **15 min**

20:30 **Treffen der Professor:innen**

Dienstag, 25.03.2025

07:45 - 09:00 Frühstück 75 min

2. Sitzung, Leitung: Prof. Dr. Sven Müller (RWTH Aachen)

09:00 - 10:00 Block II: Urban Transportation

Laura Knappik (RWTH Aachen) 30 min
Optimizing passengers' boarding and alighting operations in urban mass transit

Simon Schmidbaur (Universität der Bundeswehr München) 30 min
Block Now or Relocate Later? – Availability Control of Short-Term Rentals in Vehicle Sharing Systems

10:00 - 10:15 Pause 15 min

3. Sitzung, Leitung: Prof. Dr. Erwin Pesch (Universität Siegen)

10:15 - 11:45 Block III: Personell Planning, Scheduling I

Gerriet Fuchs (Universität Hohenheim) 20 min
Fairness in Personnel Scheduling

Guangrui Yang (Technische Universität München) 30 min
Workforce Planning for Airline Pilots

Maximilian Kunz (Universität Regensburg) 20 min
Staffing for queueing systems with stochastic and finite populations

Julius Hardt (Helmut-Schmidt-Universität Hamburg) 20 min
Position Dependent Maintenance

11:45 - 12:00 Pause 15 min
12:00 - 13:00 Mittagessen 60 min

4. Sitzung, Leitung: Prof. Dr. Alexander Hübner (Technische Universität München)

13:00 - 14:00 Block IV: Healthcare II

Luis Rocha (Universität Passau) 30 min
Healthcare Logistics: Planning and Optimization Problems for Lab Specimen Collection and Analysis

Philipp Pelz (Universität Regensburg) 30 min
Patient to room allocations in hospital wards using Markov Decision Processes

14:00 - 14:10 Pause 10 min

5. Sitzung, Leitung: Prof. Dr. Claudius Steinhardt (Universität der Bundeswehr München)

14:10 - 15:10 Block V: Order Picking, Revenue Management

Martin Sauer (Universität Hohenheim) 20 min
A MIP Model for the Order and Break Scheduling under Energy Expenditure Considerations in ZPSs

Christian Jost (Technische Universität München) 20 min
Improving Human Picking Performance in Compact Warehouses: An Experimental Investigation

Henrik Nordhaus (Universität Duisburg-Essen) 20 min
Handling Flexibility: A framework for incompletely specified products in revenue management

15:10 - 16:00 Kaffeepause 50 min

6. Sitzung, Leitung: Prof. Dr. Alena Otto (Universität Passau)

16:00 - 17:00 Block VI - Automated Warehouses; Block VII: Disaster Management

Lara Nehrke (Helmut-Schmidt-Universität Hamburg) 30 min
Nice to Meet You! Collaborative Routing Problems in Automated Warehouses

Mira Baude (Universität Duisburg-Essen) 30 min
Modellierung von Pandemien und der Auswirkung von Gegenmaßnahmen - Grundlage Netzwerk-SIRD-Ansatz

17:00 - 18:00 Pause 60 min

18:00 - 19:00 Abendessen 60 min

Mittwoch, 26.03.2025

07:45 - 09:00 Frühstück 75 min

7. Sitzung, Leitung: Prof. Dr. Katja Schimmelpfeng (Universität Hohenheim)

09:00 - 10:20 Block VIII - Scheduling II, Staffing

Ömer Özümerzifon (Universität Mannheim) 30 min
When customers call back: The impact of retrial distribution

Shu Sun (Universität Hamburg) 30 min
Research on Multi-Equipment Cooperative Scheduling in U-shaped Automated Container Terminals

Hendrik Schanz (Helmut-Schmidt-Universität Hamburg) 20 min
Solving the Job Shop Scheduling problem with certain processing flexibilities

10:20 - 10:30 Pause 10 min

8. Sitzung, Leitung: Prof. Dr. Jens Brunner (Danmarks Tekniske Universitet)

10:30 - 11:50 Block IX: Healthcare III, Applications I

Dr. Sandra Zajac (Katholische Universität Eichstätt-Ingolstadt) 30 min
Regional Food in Communal Catering: Challenges and Opportunities

Lorenz Wagner (Universität Augsburg) 20 min
Optimizing Inpatient Postoperative Therapy Scheduling: Integrating AI-assisted Physical Therapy

Emily Lex (Technische Universität München) 30 min
Dynamic Integrated Patient-Room and Nurse-Patient Assignment in Hospital Wards

11:50 - 13:00 Mittagessen und Mittagspause 70 min
13:00 - 17:30 Wanderung 4,5h
18:00 - 19:00 Abendessen 60 min

Donnerstag, 27.03.2025

07:45 - 09:00 Frühstück 75 min

9. Sitzung, Leitung: Prof. Dr. Jochen Gönsch (Universität Duisburg-Essen)

09:00 - 10:20 Block X: Analytics, Applications II

Julian Maihöfer (Universität Hohenheim) 20 min
Label printing with color constraints

Dr. Matthias Soppert (Universität der Bundeswehr München) 30 min
Optimal Conformal Counterfactual Explanations in Regression

Kai Winheller (Universität Duisburg-Essen) 30 min
Dynamic Pricing in Last Mile Delivery with Occasional Drivers

10:20 - 10:30 Pause 10 min

10. Sitzung, Leitung: Prof. Dr. Heinrich Kuhn (Katholische Universität Eichstätt-Ingolstadt)

10:30 - 11:00 Block XI: Assortment Optimization

Kevin Djoenneady Poetera (RWTH Aachen) 30 min
Error Bounds for Assortment Optimization under Random Parameters Logit

11:00 - 11:30 Verabschiedung 30 min
11:30 - 12:00 Pause 30 min
12:00 - 13:00 Mittagessen/ Ausgabe Lunchpaket 60 min
14:00 Ende

Abstracts

1. Sitzung, Leitung: Prof. Dr. Justus Arne Schwarz (Universität Regensburg)

Linda Bentzen (Technische Universität München, Prof. Dr. Rainer Kolisch)
Midwife Scheduling in Hospitals

Midwives play a vital role in maternal care, providing medical, emotional, and educational support throughout pregnancy, labor, and postnatal recovery. Effective midwife scheduling ensures the availability of skilled personnel to deliver safe and personalized childbirth experiences. However, in German hospitals, scheduling attending midwives presents unique challenges due to their freelance employment status and the unpredictable nature of childbirth. Unlike nurses, midwives independently decide the number of shifts they work, leading to significant variability in availability. Current manual scheduling methods, often performed by the head midwife, are time-consuming and struggle to balance individual preferences, which can result in feelings of unfairness, reduced job satisfaction, and potential implications for maternal care quality. To address these challenges, we propose a novel mathematical model for midwife scheduling that emphasizes fairness and incorporates individual preferences. Preliminary results demonstrate the model's potential to improve planning efficiency and overall care quality.

Markus Schüller (Danmarks Tekniske Universitet, Prof. Dr. Jens Brunner)
A Logic-Based Benders' Decomposition approach to ensure robust personnel scheduling in healthcare amidst uncertain patient demand

Scheduling of medical staff represents a time-consuming task, even during relatively stable patient demand and personnel availability. Since rosters are built based on long-term patient loads, significant discrepancies may occur between expected and actual patient emergence. Especially high-stress periods, as seen during the COVID-19 pandemic, can endanger patients' well-being. In this work, we develop a stochastic Mixed-Integer Programming (MIP) model to allocate medical staff and, therefore, ensure appropriate care of all patients. Our two-stage optimization model performs robust scheduling in the first stage. Based on this, shift extensions are applied as recourse decisions to cover realized patient demand. We generate various scenarios regarding patient emergence and patients' length of stay to mimic different patient load states. As numerous scenarios increase model complexity, a Logic-Based Benders' Decomposition approach is developed. Our robust schedules are created within comparable short runtimes. Furthermore, our results show great potential for covering demand peaks by combining recourse decisions with multi-skilled staff.

2. Sitzung, Leitung: Prof. Dr. Sven Müller (RWTH Aachen)

Laura Knappik (RWTH Aachen, Prof. Dr. Sven Müller)
Optimizing passengers' boarding and alighting operations in urban mass transit

Urban mass transit systems often struggle with increasing demand, which exceeds the capacity of public transport facilities. A major source of inefficiency is the dwell time of vehicles at stations, which is significantly influenced by variability in boarding and alighting times. Passengers often prefer boarding through specific doors (e.g., those near the station entrance or closer to the exit at their destination), resulting in overcrowding at some doors while others remain underutilized. This imbalance not only prolongs dwell time, as the vehicle must wait for the last passengers to board or alight, but also disrupts operational efficiency across the network. Therefore, we propose a nonconvex MINLP to minimize boarding and alighting times—a function of the number of boarding and alighting passengers—by optimally allocating passengers to doors. This optimization model is formulated as a network flow model. To incorporate the behavioral aspect, we integrate a discrete choice model into the optimization model. We influence passengers' door and trip choices to encourage compliance with the optimal allocation of passengers. We use economic incentives, such as discounts, to motivate the passengers to board through specific (less crowded) doors. The discounts determined in the integrated choice model influence passengers' choices, thereby determining the number of passengers boarding (and alighting) through each door.

Simon Schmidbaur (Universität der Bundeswehr München, Prof. Dr. Claudius Steinhardt)
Block Now or Relocate Later? – Availability Control of Short-Term Rentals in Vehicle Sharing Systems

Vehicle sharing system providers traditionally offer spontaneous short-term rentals, e.g., for cars or bikes. However, most recently, leading providers have started offering customers to reserve long-term rentals in advance, including the choice of departure location and time. For the customers, these reservations now allow to reliably plan trips. For the provider, novel challenges of operational control arise. To ensure the vehicle availability at a reservation's desired location and time, the provider has two options: Either, a suitable vehicle, which is located adequately, can be blocked for spontaneous short-term rentals before the required time, or, a vehicle is relocated on short notice to the required location. The former can cause lost profit due to missed short-term rentals while the latter causes relocation cost. In this work, we address a profit-maximizing provider's problem of controlling vehicle availability for short-term rentals under the consideration of given long-term rental reservations. We develop a solution approach based on a Markov Decision

Process formulation which captures the dynamic and stochastic aspects of the problem.

3. Sitzung Leitung: Prof. Dr. Erwin Pesch (Universität Siegen)

Gerriet Fuchs (Universität Hohenheim, Prof. Dr. Katja Schimmelpfeng)
Fairness in Personnel Scheduling

Personnel is widely recognized as a scarce and valuable resource in the healthcare sector. As a result, various approaches to enhance employee satisfaction have been studied in the literature. One noteworthy approach is the implementation of a person-centric planning framework that emphasizes fairness in scheduling. However, a significant challenge of this approach is that it often requires employees to effectively communicate their preferences. The literature establishes that no strategy-proof mechanisms exist for the assignment of indivisible goods without monetary compensation. In light of this, various objectives have been proposed within mathematical decision models to approximate fairness in such contexts. This presentation will examine the different objectives commonly discussed in the literature while also introducing a new objective. We will evaluate the performance of these objectives in a basic resource assignment problem with minimal constraints. Subsequently, we will focus on the most promising approaches for the shift assignment problem to analyze how these objectives perform in a constrained environment. Through this discussion, we aim to enhance the understanding of fairness in allocating indivisible goods and the implications of the various objectives in both unconstrained and constrained scenarios.

Guangrui Yang (Technische Universität München, Prof. Dr. Rainer Kolisch)
Workforce Planning for Airline Pilots

This project develops an optimization model for pilot workforce planning that integrates seniority rules and equitable overtime distribution. Before operations commence, airlines must estimate workload distribution among pilots to design a feasible crew schedule. Our approach employs a mixed-integer programming model to minimize total labor costs by balancing recruitment expenses and overtime utilization. The model incorporates practical upgrading and promotion mechanisms, as well as a realistic cost framework for regular and overtime hours. A case study using Lufthansa CityLine data highlights the model's effectiveness, demonstrating optimized workforce management that aligns with operational demand. Ongoing work includes proving the convexity of nonlinear constraints, simplifying the model's formulation, and extending its application to multiple scenarios.

Maximilian Kunz (Universität Regensburg, Prof. Dr. Justus Arne Schwarz)
Staffing for queueing systems with stochastic and finite populations

Efficiently staffing check-in counters at dedicated airport check-ins presents a challenge for service providers. Insufficient staffing leads to long wait times, passenger dissatisfaction, and missed check-in deadlines, while overstaffing increases operational costs. In practice, demand for check-in services is highly variable, influenced by fluctuating arrival rates and traffic conditions. Furthermore, when service providers and airlines agree on staffing, the exact number of passengers remains uncertain due to ongoing ticket sales, necessitating a stochastic representation of the finite passenger population. This makes workforce flexibility beneficial to maintain service quality and operational efficiency.
To balance flexibility and the cost of enabling flexible responsiveness in the check-in process, we propose a new staffing policy that combines two types of personnel. The proposed staffing policy includes personnel for counters scheduled according to a time-dependent policy, predetermined for the entire planning horizon. A second type of personnel is also planned according to a time- and state-dependent policy. This second type of personnel provides flexibility in reacting to the realization of the arrival process. We formalize the optimization problem for queuing systems with a stochastic finite population of passengers as a single-stage optimization problem.

Julius Hardt (Helmut-Schmidt-Universität Hamburg, Prof. Dr. Florian Jaehn)
Position Dependent Maintenance

In this talk, we consider a one-machine scheduling problem with position-dependent maintenance operations. Here, a maintenance operation must be performed after at most k normal jobs have been scheduled. The goal is to minimize the maximum lateness, while taking ready times into account and also allowing the preemption of normal jobs. After the problem definition, we present some new theoretical insights and some improvements to existing results. Furthermore, we propose a new MILP model and present some computational results.

4. Sitzung, Leitung: Prof. Dr. Alexander Hübner (Technische Universität München)

Luis Rocha (Universität Passau, Prof. Dr. Alena Otto)

Healthcare Logistics: Planning and Optimization Problems for Lab Specimen Collection and Analysis

The analysis of laboratory specimens (such as blood, urine, sputum, and tissue samples) plays a vital role in basic healthcare infrastructure, serving as an essential

tool for diagnosing conditions, monitoring diseases, and assessing treatment effectiveness for patients. This talk reviews over 100 papers on the logistics of specimen collection and its delivery to laboratories for analysis. From an operations management perspective, specimen logistics is influenced by a distinct combination of factors that shape planning and give rise to novel relevant optimization problems. Among these factors are the importance of a fast turnaround time of each specimen and the limited capacity of laboratories. We will provide an in-depth overview of the field based on the literature and our cooperation projects with a laboratory company, as well as discuss arising novel optimization problems. We classify the reviewed papers and identify most promising avenues for future research.

Philipp Pelz (Universität Regensburg, Prof. Dr. Justus Arne Schwarz)

Patient to room allocations in hospital wards using Markov Decision Processes

Effective bed management in hospitals has become increasingly important due to the rising demand for and decreasing supply of hospital beds. The allocation of patients to rooms is a challenging task that must take into account three critical aspects: (i) stochastic factors, such as the arrival for emergency patients and the variability in the length of stay and severity changes for already allocated patients; (ii) constraints, including the limited bed capacity in specific rooms and gender-based room allocations; and (iii) the management of overflow situations. To ensure optimal patient care, actions that are negatively perceived—such as room-to-room reallocations, allocations to the overflow areas, or rejections - should be minimized.

The existing literature primarily focuses on deterministic approaches to allocate patients to rooms. These methods either neglect stochastic influences by assuming full prior knowledge of patient arrivals and lengths of stay or use dynamic rolling-horizon approaches, which iteratively solve deterministic problems while updating current states.

We propose a Markov Decision Process (MDP) formulation for the patient to room allocation problem in hospital wards. Our approach explicitly accounts for stochastic influences within a finite planning horizon. Actions include allocating a patient to a regular room, the overflow area, or rejecting them based on the current state. Additionally, our model allows for reallocations of patients initially allocated to the overflow area to regular rooms, as well as reallocations between regular rooms. The objective is to minimize allocations to the overflow area, room-to-rom reallocations, and rejections. An efficient state space formulation avoiding symmetries and first numerical results are presented.

5. Sitzung Leitung: Prof. Dr. Claudius Steinhardt (Universität der Bundeswehr München)

Martin Sauer (Universität Hohenheim, Prof. Dr. Katja Schimmelpfeng)
A MIP Model for the Order and Break Scheduling under Energy Expenditure Considerations in ZPSs

Zone picking refers to the partitioning of a warehouse picking area into multiple non-overlapping zones, with each zone assigned to an order picker responsible for manually retrieving the corresponding parts of an order. One variation of zone picking systems is sequential zone picking, where all orders follow an identical fixed-zone visitation sequence from one zone to the next. In such zone picking systems, the pick rate and repetitiveness of tasks are extraordinarily high, leading to significant levels of physical fatigue among order pickers, which increase the likelihood of injuries.
To address this issue, we introduce a mixed-integer programming formulation for the newly developed Sequential Zone Picking Systems combined Order and Break Scheduling Problem under consideration of physical fatigue in form of Energy Expenditure (SZPOBSP-EE). Specifically, we monitor physical fatigue and recovery through the concepts of energy expenditure, working allowable energy expenditure, and rest allowance, while additionally integrating the German labor law regulations for break taking in our problem formulation.

Christian Jost (Technische Universität München, Prof. Dr. Sebastian Schiffels)
Improving Human Picking Performance in Compact Warehouses: An Experimental Investigation

In compact warehouses, human labor remains essential for tasks like picking and packing, even at highly automated picking stations. Workforce efficiency in such settings depends on how human-machine interactions are designed. In an experimental study with human participants, we investigate the impact of various picking settings on human picking speed and error rate. In particular, we focus on the simultaneous vs. sequential processing of multiple small load carriers by a single worker. Moreover, we compare the impact of a pull system in which a load carrier is requested by the worker to a push system in which the retrieval process determines the arrival of load carriers. We hypothesize that increased worker autonomy and control over the picking process can reduce fatigue and enhance performance.

Henrik Nordhaus (Universität Duisburg-Essen, Prof. Dr. Jochen Gönsch)

Handling Flexibility: A framework for incompletely specified products in revenue management

A new sales strategy is becoming increasingly popular in various sectors, from travel to retail. By purchasing an incompletely specified product (ISPs), the customer acquires a product consisting of several alternatives, from which the supplier only selects one at a later date. These include upgrades, blind bookings and flexible products where, for example, the departure date is known but not the exact flight on that day. This allows on the one hand, demand segmentation based on consumer preference and on the other hand the optimization of the utilized resources due to the obtained flexibility.
When managing capacity of conventional products, a decision has to be made for each incoming demand as to whether the demand is to be met or whether the capacity is to be reserved for later, higher-valued demand. This is done by using a proven method consisting of two steps. Firstly the opportunity costs of the resources utilized by the product are determined in order to derive bid prices. These in turn are used in an Assortment Optimization Problem to derive optimal pricing or offering structures. However, the application of this approach to ISPs has a decisive drawback with the loss of flexibility.
This drawback can be overcome by pursuing two basic strategies. First, the stochastic distribution of the resource-specific bid prices can be approximated based on the analysis of various scenarios and thus incorporated into the existing approach. Second, the bid prices remain unchanged but are complemented with information on the value of flexibility.
In this short presentation, these concepts will be discussed, as well as the methodical approaches.

6. Sitzung, Leitung: Prof. Dr. Alena Otto (Universität Passau)

Lara Nehrke (Helmut-Schmidt-Universität Hamburg, Prof. Dr. Dominik Kreß)

Nice to Meet You! Collaborative Routing Problems in Automated Warehouses

The pick-and-drive system is a novel solution for warehouse automation. It integrates two types of autonomous mobile robots (AMRs). Storage and supply AMRs (S-AMRs) navigate to a storage area, where they lift unit loads and transport them to a disposition area. Picking AMRs (P-AMRs) move freely within this disposition area. They carry bins to collect items of customer orders from the unit loads attached to the S-AMRs by means of robotic arms. We take an operational perspective on the pick-and-drive system and focus on the problem of determining and timing meeting locations and sequences of the AMRs, so that
the completion of all customer orders is ensured. This setting can be interpreted as a vehicle routing problem, where the customers (S-AMRs) collaborate with the vehicles (P-AMRs). We consider two objective functions, minimizing the total distance driven by the AMRs and minimizing the sum of completion times. We translate these operational routing problems into a mathematical framework
and provide theoretical insights by examining a specific case where the potential meeting points lie along a line. For this scenario, we present an approximation algorithm for the case of minimizing the overall distance traveled and demonstrate that minimizing the sum of completion times is strongly NP-complete. Additionally, we prove strong NP-completeness of the general case when minimizing the overall distance traveled. Leveraging the structural insights, we develop heuristics to address the problems. These algorithms are evaluated in a comprehensive numerical study based on real-world data.

Mira Baude (Universität Duisburg-Essen, Prof. Dr. Alf Kimms)

Modellierung von Pandemien und der Auswirkung von Gegenmaßnahmen - Grundlage Netzwerk-SIRD-Ansatz

Aus der Zeit der Corona Pandemie kennen wir die Notwendigkeit, aber auch die negativen Auswirkungen des Ergreifens von Maßnahmen zur Eindämmung der Pandemie. Maßnahmen verursachen Kosten. Daher stellt sich die Frage, wann man wo welche Maßnahmen ergreift. Es wird ein Modell vorgestellt, mit dem man die Pareto-Front der Kosten-Wirkung-Kurve berechnen kann. Zur Modellierung epidemischer Infektionskrankheiten und dessen Ausbreitung wir in dem Modell das SIRD-Modell als Grundlage verwendet. Erste Ideen für ein Lösungsverfahren werden präsentiert.

7. Sitzung Leitung: Prof. Dr. Katja Schimmelpfeng (Universität Hohenheim)

Ömer Özümerzifon (Universität Mannheim, Prof. Dr. Raik Stolletz)
When customers call back: The impact of retrial distribution

Call centers face challenging staffing and scheduling decisions due to the stochastic variability of arrival and service times. Although various approaches for staffing and scheduling rely on queueing theoretical formulas, important characteristics of call centers are ignored. For example, the phenomenon of retrial, where some customers leave the queue and call back later, is often observed in call centers. This project focuses on the impact of retrial distribution in call centers. We analyze empirical data of a call center on retrial phenomenon and show that, in practice, retrials can follow general distributions. We present a novel approach that integrates retrials into staffing procedures. Through a numerical study, the impact of retrials on performance measures and staffing decisions is demonstrated.

Shu Sun (Universität Hamburg, Prof. Dr. Stefan Voß)
Research on Multi-Equipment Cooperative Scheduling in U-shaped Automated Container Terminals

The U-shaped automated container terminal (ACT) was first implemented at the Beibu Gulf Port in 2022. This innovative terminal layout features double-cantilevered rail cranes that simultaneously handle loading and unloading tasks for external container trucks and automated guided vehicles operating within the yard. The unique layout of U-shaped ACTs creates a highly complex scheduling interdependency among multi-equipment, posing significant challenges in optimizing terminal efficiency. This research addresses these challenges by developing a practical and comprehensive collaborative scheduling optimization model and algorithm.

Hendrik Schanz (Helmut-Schmidt-Universität Hamburg, Prof. Dr. Dominik Kreß)
Solving the Job Shop Scheduling problem with certain processing flexibilities

In Job Shop Scheduling, traditionally each job has a fixed sequence of operations, since traditional manufacturing environments provide a rigid framework of production. Flexible manufacturing systems (FMS) on the other hand, provide more versatility in production. In the context of Job Shop Scheduling, this means that the sequence of operations or the machines assigned to each operation often have multiple options. Having different processing options for a job is especially useful in the event of a machine failure. Thus, a planner tasked with finding a production

schedule, can benefit immensely from the different processing flexibilities provided by FMS. On the other hand, these processing flexibilities heavily increase the solution space of a given job shop scheduling problem. To overcome this obstacle, we formulate an exact branch-and-price approach to solve our problem to holistically find a feasible sequence of operations for each job and plan a schedule.

8. Sitzung, Leitung: Prof. Dr. Jens Brunner (Danmarks Tekniske Universitet)

Dr. Sandra Zajac (Katholische Universität Eichstätt-Ingolstadt, Prof. Dr. Heinrich Kuhn)

Regional Food in Communal Catering: Challenges and Opportunities

With an increased focus on sustainability and strengthening the autonomy of a region, interest and demand for regionally produced food has grown in recent years. Customers can buy regionally produced food at farm markets, designated grocery stores and restaurants, or through regional food box delivery services. However, regional food is less frequently offered in out-of-home catering, especially in communal catering. This is due to significant additional costs associated with local food provision, which are not always matched by customers' willingness to pay. Furthermore, communal catering faces unique challenges, such as the need for large quantities, consistent quality, and cost efficiency. These challenges require an efficient logistic structure, including optimized transport routes, collaboration between producers, and digital tools to streamline supply chains. This talk deals with the challenges in regional food supply for communal catering and elaborates on possible solutions, especially with regard to logistics and cooperation.

Lorenz Wagner (Universität Augsburg, Prof. Dr. Sebastian Schiffels)

Optimizing Inpatient Postoperative Therapy Scheduling: Integrating AI-assisted Physical Therapy

At hospitals, receiving postoperative therapy is essential after lung cancer, cardiac, and orthopedic surgeries. However, the limited availability of specialized therapists often delays treatments and prolongs hospital stays. To address this challenge, companies offer visual Artificial Intelligence assisted therapy to supplement in-person therapy. This creates new opportunities for the efficient scheduling of therapy sessions. Our research offers a comprehensive optimization model to derive therapy schedules that integrate traditional in-person and Artificial Intelligence-assisted therapy. The proposed mathematical model minimizes the Length of Stay, contingent upon the treatment effectiveness of combined therapy and Artificial Intelligence sessions, intending to optimize therapist resource utilization. To efficiently solve large- scale scheduling instances, we introduce a Column Gen-

eration heuristic. Computational experiments using real-world data from our practice partner, Breathment, demonstrate that our approach can effectively complement traditional physiotherapy, providing a scalable solution to address therapist shortages while maintaining high-quality patient care. This research contributes to healthcare operations research by offering practical solutions for hospitals to optimize their physiotherapy services through technology integration.

Emily Lex (Technische Universität München, Prof. Dr. Alexander Hübner)
Dynamic Integrated Patient-Room and Nurse-Patient Assignment in Hospital Wards

Optimizing patient-to-room and nurse-to-patient assignments is crucial for efficient hospital workflows, high-quality care, and patient and staff satisfaction. Integrating both assignment problems enables the optimization of additional objectives that depend on the interaction of the two assignment problems. For example, minimizing the walking distances of nurses or assigning the minimum number of nurses to patients in the same room to mitigate negative effects, such as the spread of infections between rooms by nurses or the disturbance of patients. Existing literature tackles the static version of this integrated problem, assuming full prior knowledge of patient and nurse parameters. However, real-world hospital operations are rife with uncertainties, including patient no-shows, emergency admissions, fluctuating length of stays, and unforeseen nurse absences. Enhancing predictability and forecasting reliability necessitates accounting for stochastic variations within the planning horizon.
We have developed a decision support model that addresses the dynamic patient-to-room and nurse-to-patient assignment. The model is presented as a mixed integer optimization problem. We present an efficient heuristic to solve the assignment problem under data uncertainty. We conduct computational experiments on real-world and artificially generated instances. A comparative analysis against the static problem formulation underscores the efficacy and superiority of our dynamic extensions.

9. Sitzung, Leitung: Prof. Dr. Jochen Gönsch (Universität Duisburg-Essen)

Julian Maihöfer (Universität Hohenheim, Prof. Dr. Herbert Meyr)
Label printing with color constraints

In this talk, a real-world problem from the consumer goods' label printing industry is proposed. Unlike in well-known Label Printing or Cover Printing Problems, colors are taken into account, as they are linked to setup decisions in the production process. In the consumer goods industry, an order usually consists of several sorts of labels with similar dimensions. These must be printed on parallel lanes on a quasi-endless roll of paper using printing plates. Different types of labels require different colors, which must be installed in one of the printers limited color slots. Changing the colors and designing the plates both incur fixed costs. Due to the heterogeneous demand of the sorts and the technical characteristic that parallel lines must always be printed simultaneously, waste is produced, which causes variable costs per unit.
The challenge is to decide how many and which printing plates to create, the duration for which each plate will be used, and how to change the color in the slots to ensure that demand is met while minimizing overall costs. To solve this problem, two linear mixed integer programming (MIP) formulations and several decomposition heuristics have been developed and tested.
Our primary goal is to find ways to strengthen the models' formulation, discover more efficient solution approaches, and to explore the broader practical context of the model.

Dr. Matthias Soppert (Universität der Bundeswehr München, Prof. Dr. Claudius Steinhardt)
Optimal Conformal Counterfactual Explanations in Regression

Accurate predictions of real-valued quantities form the basis for data-driven decision-making in many applications across all industries. For example, online retailers as well as classical brick-and-mortar stores require accurate demand predictions for effective operations management, such as pricing and inventory control. Often, however, the best performing models regarding prediction accuracy are opaque and, thus, are considered as black boxes by the user. We propose a framework based on mixed-integer programming that increases the explainability of a wide range of state-of-the-art regressors, including random forests, gradient boosting regressors, and certain artificial neural networks. The framework is based on the determination of counterfactual explanations – an established approach to improve explainability. It yields answers to questions of the form "what is the minimum required change of a certain model input such that the model predicts a specific target output?". Thus, the answers are optimal with regard to the

required model input change. For example, for a given vector of product features and context information as well as its predicted sales value, the optimization returns the closest alternative vector that results in a specific desired higher sales value. Asking such counterfactual questions and analyzing their respective answers helps to explain the input-output relations that a trained regressor has learned, but they can also directly be used in decision-making – in the above example possibly regarding marketing activities. In addition, our framework provides guarantees for the explanations. These guarantees are based on conformal prediction and we propose two approaches for determining the prediction intervals – for the case that explanations can and cannot be tested. In a systematic numerical study with artificial and real data, we compare the regressors with regard to their prediction and explanations performance.

Kai Winheller (Universität Duisburg-Essen, Prof. Dr. Rouven Schur)

Dynamic Pricing in Last Mile Delivery with Occasional Drivers

As computing power becomes increasingly advanced and affordable due to ongoing technological advancements, companies are increasingly adopting dynamic pricing methods supported by data analysis. Another emerging trend in last-mile delivery is peer-to-peer delivery, where a private individual, who is not employed by the company, delivers goods to another customer on their way home in exchange for a small compensation. Due to the additional risks associated with delivery by a private individual, recipients would prefer delivery by an employee at the same price.

We are developing an integrative dynamic program that dynamically sets delivery prices from the perspective of an online customer with multiple delivery options (private or employed), models the arrival process of private couriers, and determines compensations based on the expected arrival of additional private couriers and delivery orders.

10. Sitzung, Leitung: Prof. Dr. Heinrich Kuhn (Katholische Universität Eichstätt-Ingolstadt)

Kevin Djoenneady Poetera (RWTH Aachen, Prof. Dr. Sven Müller)

Error Bounds for Assortment Optimization under Random Parameters Logit

Assortment optimization problems are revenue-maximizing problems, which involve the selection of a subset of products to be offered to customers. We present the assortment optimization problem under the mixed logit model demand (AOP-MXL). Due to the formulation of MXL, it is impossible to derive an analytical solution, therefore only the deterministic-equivalent solution using the MIP reformulation of AOP-MXL is obtainable. To evaluate the MIP reformulation solution's quality to the true optimal solution, we examine the margin of error between them (i.e., predictive error) using the Koksma-Hlawska inequality. We find that the predictive error depends on three factors: the random variables' distribution, the number of draws used for simulation, and the drawing strategies. Examining the predictive error enables us to evaluate the apriori potential performance of the solution, given a certain number of draws and drawing strategies. Our initial numerical experiment results suggest that having more information lowers the predictive errors. Moreover, increasing the number of draws and using drawing strategies such as Antithetics and Halton Sequence rather than classical pseudo-random generators also provide us with better performance.