OPM 760 – Project Seminar Operations Analytics

Spring Term 2027

The goal of this seminar is conducting of scientific research in the field of operations management. Thereby, it prepares the students for writing an analytics-oriented Master's thesis. The seminar is geared towards students intending to write their thesis at the Chair of Production Management.

Participants will explore one of the topics listed below, designated as either individual or in teams of two students, as specified in the catalog. Team topics can be assigned as individual topics with reduced workload.

Based on scientific literature, participants will apply and implement predictive or descriptive business analytics approaches to solve an operations management problem. They will present their findings in a written report (18 to 22 pages) as well as in an in-class presentation (15 - 20 min + 20 min discussion). Each participant is also expected to critically assess the presentations of the other students in the ensuing discussion.

Applications will be accepted from **November 9th, 2026** until **November 22nd, 2026**. Admission to the seminar will be confirmed by e-mail at latest on December 1st, 2026 and must be reconfirmed by the participant at the kick-off meeting.

The **Kick-off meeting** will be held on **December 4th, 2026** between 10:15 and 11:45 (CET). During this meeting, an introduction to scientific writing and presentations for term papers will be given.

A brief session on introduction to Overleaf and LaTeXwill also be offered. The time and date of this session will be decided in the Kick-off meeting among the interested students.

The **written reports** have to be submitted by Monday, **February 23rd, 2027** in the following formats:

- Two-fold hard copy version.
- Electronic version including a copy of the references cited in the report and auxiliary information (tables, data, programming code, etc.).

The **presentations** will be held as a blocked session during between **1st and 5th March 2027**. Attendance at all presentations is mandatory.

The final grade for the seminar is composed of the following components: Written report (50%) and presentation (50%).

There is a joint application process for all seminars offered by the chairs of the Area Operations Management. In the spring term 2027, this includes the following seminars:

- **OPM 701:** Research Seminar Supply Chain Management
  Chair of Logistics and Supply Chain Management, Prof. Dr. Moritz Fleischmann
  (Topics labeled with "L"),
- **OPM 760:** Project Seminar Operations Analytics,
  Chair of Production Management, Prof. Dr. Raik Stolletz
  (Topics labeled with "P"),
- **OPM 761:** Research Seminar Production Management,
  Chair of Production Management, Prof. Dr. Raik Stolletz
  (Topics labeled with "P"),

- **OPM 781:** Research Seminar Service Operations Management
  Chair of Service Operations Management, Prof. Dr. Cornelia Schön
  (Topics labeled with "S"),
- **OPM 791:** Research Seminar Procurement
  Endowed Chair of Procurement, Prof. Dr. Christoph Bode
  (Topics labeled with "B").

Detailed information on the seminar topics and the link to the online registration tool are available on the home pages of the respective chairs. In their applications, students can indicate up to five preferred topics from all seminars.

In addition, applicants for OPM 760 must send an email with (1) CV, (2) official B.Sc. and M.Sc. grades overviews, and (3) the list of courses in the Area Operations that you are currently enrolled in to opm760@uni-mannheim.de. For any further question concerning the seminar please also contact the chair via opm760@uni-mannheim.de.

Topics Catalog

P1 – Capacity and Service-Level Analysis in Remanufacturing Systems

Type: Individual topic

Objectives: Remanufacturing offers companies an opportunity to combine environmental responsibility with economic value creation. By recovering and restoring used products and components, companies can contribute to industrial decarbonization, which is particularly important in industries such as automotive, industrial equipment, and electronics. However, realizing these benefits depends on the efficient organization of remanufacturing operations. Returned products arrive irregularly and differ in condition and required processing effort. Consequently, limited processing capacity can create bottlenecks, long waiting times, and delays, whereas excessive capacity increases operating costs. Companies therefore need quantitative tools to understand how uncertainty and capacity constraints affect operational performance and to identify configurations that balance resource utilization, operating costs, and customer service.

The objective of this seminar thesis is to describe and analyze the stochastic remanufacturing model presented in the starting paper. The thesis should explain its main modelling assumptions, summarize the modelling approach and key findings. Based on this, a simplified version of the model should be implemented and validated against analytical results where available. The implementation should then be extended to compare alternative capacity configurations. A sensitivity analysis should investigate how different system settings affect relevant performance measures. The thesis should conclude with managerial insights regarding capacity allocation and the trade-offs between operating costs, resource utilization, and service quality.

Prerequisites: Knowledge of probability and stochastic models; basic knowledge of optimization is desirable.

Basic Paper: Souza et al. (2002)

> **Abstract**: This research examines production planning and control for a remanufacturer that can sell returned items on a graded as-is basis or remanufacture the returned items. Using a GI/G/1 queuing network, we model the firm's decision to remanufacture an optimal product mix over the long run that maximizes profits while maintaining a desired service level. We further use simulation to explore dispatching heuristics that can be used at the shop-floor level to achieve the desired optimal product mix, while meeting the service level constraint. Our research is grounded in actual practice and the results provide key insights into the decision-making process required to maximize profits and minimize average flow times for remanufactured products.

P2 – Matching Workforce Capacity to Demand in Distribution Centers

Type: Individual topic

Objectives: Fulfillment centers, such as distribution centers, often face substantial fluctuations in the number of customer orders that must be processed throughout the day. Since manual order picking is labor-intensive, efficiently scheduling workers to match the required workload is an important operational planning problem. Insufficient staffing can result in delayed order fulfillment, while excess capacity increases labor costs. To address this trade-off, managers must determine how many workers to assign to different shifts while considering operational constraints such as workforce availability, working hours, and order-processing requirements.

The goal of this seminar project is to develop and implement a deterministic optimization model for workforce shift scheduling in a distribution center. Relevant literature on workforce shift scheduling should be briefly reviewed, with particular attention to existing optimization models, their underlying assumptions, and operational constraints. Customer demand and the time required to process orders should be assumed to be known in advance. Students should formulate a mixed-integer linear programming model that determines the number of workers assigned to predefined shifts that sufficient processing capacity is available to meet demand optimal. The model should account for relevant operational constraints, while keeping the underlying order-picking process simplified. The formulated model should be implemented using an optimization tool, such as CPLEX or Gurobi. A numerical study should investigate how different demand patterns, staffing costs, and available shift structures affect the resulting shift schedules, labor costs, and workforce utilization. Finally, the limitations of the model and potential extensions should be critically discussed.

Prerequisites: Basic knowledge of optimization models (e.g., OPM 561, 662); basic programming skills in Python are desirable.

Basic Papers: Rijal et al. (2021), Beaumont (1997)

> **Abstract**: Scheduling the availability of order pickers is crucial for effective operations in a distribution facility with manual order pickers. When order-picking activities can only be performed in specific time windows, it is essential to jointly solve the order picker shift scheduling problem and the order picker planning problem of assigning and sequencing individual orders to order pickers. This requires decisions regarding the number of order pickers to schedule, shift start and end times, break times, as well as the assignment and timing of order-picking activities. We call this the order picker scheduling problem and present two formulations.(...)

P3 – Capacitated Lot-sizing with Energy Constraints

Type: Individual topic

Objectives: Production planning is an important task in manufacturing companies, where decisions about when and how much to produce affect production costs and inventory levels. In practice, production is often limited by available capacity and energy resources, which makes planning more challenging. Companies need to balance production and inventory costs while ensuring that customer demand is satisfied.

The objective of this seminar thesis is to describe and analyze capacitated lot-sizing models with energy constraints. The thesis should explain the main modelling assumptions, and summarize the modelling approach and key findings of the base paper. Based on this, the model should be implemented in Python using docplex and extended by allowing additional production or energy capacity to be purchased at an extra cost. A numerical study should be conducted to investigate how parameters such as demand, production capacity, energy availability, setup costs, and additional capacity costs affect optimal production quantities, inventory levels, and total costs. The numerical results should be used to derive managerial insights regarding the trade-offs between inventory holding, production flexibility, and capacity costs. The thesis should conclude with research trends and potential future directions in capacitated lot-sizing.

Prerequisites: Knowledge in optimization models (e.g., OPM 662), programming in Python and docplex (e.g., OPM 560)

Basic Paper: Rapine et al. (2018)

> **Abstract**: We study a single-item lot sizing problem integrated with some energy constraints, called energy-LSP in the rest of the paper. We consider a production system composed of identical and capacitated machines in parallel. One has to decide how many machines to start and how much to produce to serve the demand and/or to replenish the inventory. In addition to the production capacity limit in each period, induced by the machines on, we have a limit on the energy that can be consumed by the start-ups of the machines and the production of units. We first provide a mixed integer programming formulation for the problem in the general case. We then develop efficient polynomial time algorithms running in O(Tlog T), with T the length of the planning horizon, for several subproblems: (i) energy-LSP where all energy parameters are set to 0, (ii) energy-LSP where only the machine start-ups consume energy, (iii) energy-LSP where only the production of units consumes energy. We show that, in all these special cases, energy-LSP can be seen as an extension of the integrated capacity acquisition and lot sizing problem. This allows us, as by-product of our approach, to significantly improve the existing result proposed for the capacity acquisition problem without energy constraint nor subcontracting.

P4 – Planning of Setups when Customer Demand is Uncertain

Type: Individual or team topic

Objectives: For the production of many products, setups are necessary, i.e., the production can only start after some preparation (e.g., cleaning the machines). These setups reduce the effective production time and might also incur cost. However, using less setups, and thus less production runs increases the need for higher inventory levels to satisfy demand. The trade-off of minimizing setup and inventory cost is considered in the standard capacitated lot-sizing problem (CLSP). However, this standard model lacks real world constraints, such as uncertainty in demand, where the exact customer demand of a period is not known beforehand. By this, also the exact inventory and backorder levels at the end of each period are not known beforehand anymore. Their expected values can be determined via non-linear expressions, which makes solving the problem harder. Tempelmeier and Hilger (2015) include this demand uncertainty in their model. In order to solve the model, they linearize the non-linear parts, and propose a fix-and-optimize heuristic, which follows a rolling-horizon idea.

The thesis should analyze the lot-sizing problem with uncertain demand of Tempelmeier and Hilger (2015). The mixed-integer linear programming model (MIP) of the base paper should be described and briefly positioned within the existing body of literature. The MIP and the corresponding fix-and-optimize heuristic should be implemented using an optimization tool such as Python's DoCPLEX. A numerical study should analyze the solution behaviour of the model, focusing on choices regarding the linearization, especially the number of segments. Furthermore, the model should be critically reviewed, and opportunities for future research should be discussed.

Prerequisites: Knowledge in optimization models (e.g., OPM 561, 662), programming in Python and docplex (e.g. OPM 560)

Basic Papers: Tempelmeier and Hilger (2015)

> **Abstract**:In this paper the stochastic dynamic lot sizing problem with multiple items and limited capacity under two types of fill rate constraints is considered. It is assumed that according to the static-uncertainty strategy of Bookbinder and Tan (1988), the production periods as well as the lot sizes are fixed in advance for the entire planning horizon and are executed regardless of the realisation of the demands. We propose linear programming models, where the non-linear functions of the expected backorders and the expected inventory on hand are approximated by piecewise linear functions. The resulting models are solved with a variant of the Fix-and-Optimize heuristic. The results are compared with those of the column generation heuristic proposed by Tempelmeier (2006).

P5 – Optimization of Fleet Capacity in Urban Mobility Operations with Variable Demand

Type: Individual or team topic

Objectives: In many urban mobility services, such as taxi companies, car-sharing platforms, and other on-demand transportation services, customers may abandon their ride request (e.g. cancel the ride or switch to another service) due to a lack of patience. For urban mobility services, the number of available vehicles represents a significant investment and cannot be easily adjusted in real-time. Thus, efficient fleet capacity planning (i.e. determining the optimal number of vehicles to invest in and make available) is crucial for success. The fleet capacity planning should consider service level constraints (e.g. 90% of customers experience a wait time of less than 5 minutes), while accounting for time-dependent demand for the rides. Thus, the goal of fleet capacity planning for urban mobility services is to strategically determine the number of vehicles to deploy under time-dependent demand and service level constraints.

However, reliable methods for performance evaluation are needed to optimize the fleet capacity. For example, modified offered load (MOL) and stationary independent period by period (SIPP) approaches can be utilized. MOL approach approximates the time-dependent offered load in a queueing system by the number of busy servers in a corresponding infinite-server system. On the other hand, SIPP approach analyzes the system independently in each period utilizing stationary queueing models.

The goal of this thesis is to analyze the impact of MOL and SIPP approaches on capacity decisions for a time-dependent queueing system with abandonments. Applications and methodology behind MOL and SIPP approaches should be summarized; an overview of capacity planning approaches for time-dependent systems with abandonments should be presented. Capacity planning based on MOL and SIPP approaches should be implemented with Python. The accuracy of these approaches should be analyzed through a systematic comparison against a simulation tool (will be provided by the chair). The differences in obtained capacity decisions based on MOL and SIPP approaches and how these decisions are influenced in face of different system parameters (e.g. service and abandonment rates) should be analyzed in an extensive numerical study.

Prerequisites: Knowledge of stochastic systems (e.g. OPM 661), programming in Python (e.g. OPM 560)

Basic Paper: Liu and Whitt (2012); Green et al. (2001)

> **Abstract**: An algorithm is developed to determine time-dependent staffing levels to stabilize the time-dependent abandonment probabilities and expected delays at positive target values in the $M_t/GI/s_t + GI$ many-server queueing model, which has a nonhomogeneous Poisson arrival process (the M_t), has general service times (the first GI), and allows customer abandonment according to a general patience distribution (the $+GI$). New offered-load and modified-offered-load approximations involving infinite-server models are developed for that purpose. Simulations show that the approximations are effective. A many-server heavy-traffic limit in the efficiency-driven regime shows that (i) the proposed approximations achieve the goal asymptotically as the scale increases, and (ii) it is not possible to simultaneously stabilize the mean queue length in the same asymptotic regime.

P6 – Impact of Spare-Stock Policy on the Reliability of Semiconductor Manufacturing Lines

Type: Individual topic

Objectives: Semiconductor industry is a very substantial and growing industry, which generated over 600 billion EUR in revenue in 2021. Semiconductors are known as the building blocks of modern electronics, since they form the basis of integrated circuits and are used in virtually all electronic devices (e.g. smartphones, computers, automotive systems, ...). The production of semiconductors necessitates multiple stages, such as wafer slicing, defining the circuit patterns on wafers, annealing, and dicing of integrated circuits. In semiconductor manufacturing lines, the buffer spaces between these stages are limited due to high investment cost. Moreover, machines in production stages can also break down, e.g. due to material fatigue or failure of electronic components, and have to be repaired. A downtime of a production stage can cost up to 72 thousand EUR per hour and are important to manage. While buffers enables different stages to continue production while one other stage has stopped to a failure, it does not increase the availability of a stage. On the contrary, efficiently managing spare parts in production stages can reduce downtimes and increase availability of the system.

The goal of this thesis is to analyze the impact of spare-stock policies and buffer sizes in semiconductor manufacturing lines with unreliable machines. A literature overview on manufacturing lines with unreliable machines should summarize relevant application areas, utilized queueing models, and resulting managerial insights.. The unreliable manufacturing line with limited capacities and spare stock in Sachs et al. (2022) should be modelled as a Markov chain, where the steady-state probabilities and relevant performance measures (e.g. expected throughput, average inventory level, ...) should be calculated with Python. The impact of spare-stock policy, spare part replenishment rates, and buffer sizes between the stations on system performance should be investigated in an extensive numerical study.

Prerequisites: Knowledge in queueing theory (e.g. OPM 661), programming in Python (e.g. OPM 560)

Basic Paper: Sachs et al. (2022)

> **Abstract**: We consider a model of an N-stage flow line with stochastic processing times and interstage buffers that decouple adjacent production stages. Machine downtimes are induced by failures of critical machine components. Each machine is assumed to have exactly one of these failure-prone components. To achieve high machine availability, it is assumed that spare parts for those failure-prone critical components are kept in stock. Failed components are immediately replaced with new, functioning components, and a one-for-one replenishment policy is applied for the restocking of those spare parts. We present a novel decomposition approach to approximate the average throughput and inventory for a system with an arbitrary number of machines, buffers, and spare parts. With a detailed numerical study, we analyze the impact of different parameter constellations on the approximation quality. We demonstrate the remarkable accuracy of our method by comparing our results with both exact and simulated values. Using our method, we further study the complex interaction and partial substitution effects between buffer sizes and spare part base-stock levels on the logistical performance of the flow line.

References

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