OPM 760 – Project Seminar Operations Analytics

Spring Term 2026

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 8th, 2025** until **November 22nd, 2025**. Admission to the seminar will be confirmed by e-mail at latest on November 30th, 2025 and must be reconfirmed by the participant at the kick-off meeting.

The **Kick-off meeting** will be held on **December 1st, 2025** between 12:00 and 13:30 (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, **March 2nd, 2026** 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 **9th and 13th of March 2026**. Attendance at all presentations is mandatory.

The final grade for the seminar is composed of the following components: Written report (60%), presentation (30%), and contribution to the discussion (10%).

There is a joint application process for all seminars offered by the chairs of the Area Operations Management. In the spring term 2026, this includes the following seminars:

- **OPM 741:** Applied 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 792:** Applied 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 – Optimization of Rework Strategies in Semiconductor Manufacturing with Imperfect Yield

Type: Individual topic

Objectives: In semiconductor manufacturing systems, factors such as process complexity, stringent quality standards, environmental conditions, machine malfunctions, and other sources of variability often result in a proportion of produced wafers failing to meet quality inspection criteria. This phenomenon is known as imperfect yield. Imperfect yield refers to situations in manufacturing or production processes where a portion of the output is defective, lost, or requires rework. In such high-tech industries, where the unit cost of each produced item is substantial, manufacturers generally prefer reworking defective wafers to recover value and reduce waste rather than scrapping them. Consequently, determining the optimal batch size and timing of rework operations becomes crucial for minimizing total system costs while maintaining production efficiency.

The objective of this seminar thesis is to model, analyze, and extend the single-stage production and rework optimization problem presented in the base paper. The student should (1) describe and mathematically formulate the two operational policies proposed in the paper, immediate rework within the same cycle and delayed rework after multiple cycles; (2) implement the models computationally in Python; and (3) conduct numerical experiments to examine how parameters such as defect rate, rework timing, and cost structure affect total cost and batch size decisions. In this thesis, in addition to the existing sensitivity analysis on the effect of defective proportion on batch size, it is also required to perform a sensitivity analysis of rework cycles with respect to the defective proportion. It should conclude with a critical assessment of the assumptions (e.g., constant demand, single-stage system) and explore potential extensions, such as stochastic demand, multi-stage systems, yield uncertainty, or learning-based rework rates.

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

Basic Paper: Jamal et al. (2004)

> **Abstract**: Determining an optimal batch quantity in a production system that produces defective items has been the primary focus recently among the researchers. While most of the work has been reported to explore the traditional optimal inventory level in ideal cases, little appears to have been done with rework option. In this paper, models have been developed to determine the optimum batch quantity in a single-stage system in which rework is done under two different operational policies to minimize the total system cost. The first policy deals with rework being completed within the same cycle. The second policy deals with the rework being done after N cycles causing less than the desired quantity of good products in each cycle. The models have been validated with illustrating numerical examples and the sensitivity of optimal batch size and total system cost with respect to the defective proportion have also been performed.

P2 – Integrated Lot-sizing and Scheduling for Abrasive Products Manufacturing

Type: Individual topic

Objectives: In production processes such as the manufacture of abrasives (e.g., sandpaper), production planning involves determining optimal lot sizes and production schedules. The primary objective in such systems is to meet demand at minimal total cost while accounting for setup times, inventory holding costs, and capacity constraints. The Discrete Lot-Sizing and Scheduling Problem (DLSP) integrates these two decisions into a unified framework and has been the subject of extensive research. Extensions of the classical DLSP model incorporate factors such as sequence-dependent setups, parallel machines, multi-level production structures, and stochastic demand, thereby increasing both the complexity and the realism of the planning process.

The objective of this seminar thesis is to describe and analyze the main modelling extensions of the DLSP as discussed in the base paper. The thesis should summarize the key formulations, solution approaches (e.g., Lagrangian relaxation, decomposition, heuristics), and computational insights. As an extension, the impact of machine unavailability due to maintenance or breakdown should be modelled and implemented (e.g., in Python). The results should be illustrated through numerical examples and discussed in terms of managerial and computational implications. The thesis should conclude with a critical review of research trends and potential future directions in lot-sizing and scheduling.

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

Basic Paper: Gupta and Magnusson (2005)

> textbfAbstract: We consider the single machine capacitated lot-sizing and scheduling problem (CLSP) with sequence-dependent setup costs and non-zero setup times, with the additional feature that setups may be carried over from one period to the next, and that setups are preserved over idle periods. We provide an exact formulation of this problem as a mixed-integer program. It is well known that the CLSP is NP-hard. Therefore, we have also developed a heuristic for solving large problem instances. This is coupled with a procedure for obtaining a lower bound on the optimal solution. We carry out a computational study to test the accuracy of several different lower bounding linear relaxations and the approximate solution obtained by the heuristic. In our study, the average deviation of the heuristic solution from the corresponding exact solution depends on the size of the problem and ranges from 10 to 16%. The heuristic is more effective when there are many more products than there are planning periods. This is a desirable property from a practical viewpoint since most firms are likely to implement such a procedure on a rolling horizon basis, solving the problem repeatedly for a few periods at a time.

P3 – Shift Scheduling: Prescriptive Analytics for Fair Schedules

Type: Individual or team topic

Objectives: Besides creating feasible schedules, fairness considerations are relevant in workforce planning. Employees want to be treated in a fair manner - but as fairness can be a subjective topic, the question is which objective to pursue. In Karsu and Morton (2015), different measures of fairness are presented. Thereby, they differentiate between equitability and balance. The first concept comes into play if customers are indistinguishable, then the goal is to, e.g., allocate some resources over the population or to ensure, that workloads are distributed fairly among employees (Ernst et al., 2004). Balance is important under heterogeneity, e.g., if customers or employees have different preferences regarding products or shift schedules.

This thesis analyzes an optimization model incorporating fairness aspects into the shift scheduling of physicians. Different measures of fairness in the context of workforce planning should be presented, characterized and quantified. The mixed-integer linear programming model (MIP) proposed by Stolletz and Brunner (2012) should be described and briefly positioned within the existing body of literature. Both the reduced set covering and the implicit modeling approach of the model will be implemented using an optimization tool such as Python's DoCPLEX, GAMS, or AMPL. A sensitivity analysis will be conducted, focusing on parameters like minimum and maximum shift length to assess their impact on optimal shift scheduling and provide managerial insights into shift scheduling under fairness considerations.

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

Basic Paper: Stolletz and Brunner (2012)

> **Abstract**: This research addresses a shift scheduling problem in which physicians are assigned to demand periods. We develop a reduced set covering approach that requires shift templates to be generated for a single day and compare it to an implicit modeling technique where shift-building rules are implemented as constraints. Both techniques allow full flexibility in terms of different shift starting times and lengths as well as break placements. The objective is to minimize the paid out hours under the restrictions given by the labor agreement. Furthermore, we integrate physician preferences and fairness aspects into the scheduling model. Computational results show the efficiency of the reduced set covering formulation in comparison to the implicit modeling approach.

P4 – Setting Production Quantities when Demand is Uncertain

Type: Individual topic

Objectives: Production quantities of manufacturing companies are often planned for a time horizon of multiple periods, in which demand can differ between different periods. In the capacitated lot sizing problme (CLSP), managers trade-off setup cost with inventory cost. However, the classical CLSP assumes deterministic demand, which often does not reflect reality. The stochastic capacitated lot sizing problem (SCLSP) incorporates the demand that only known after production quantities are set. If available units during a period surpasses actual demand, inventory holding costs are incurred, whereas actual demand exceeding available units results in backlog. Instead of strict demand fulfillment as in the deterministic case, the SCLSP often uses constraints on service levels to ensure satisfied customers. Such service levels can be, e.g., the β service level, which is the expected fraction of demand of a period that is served in the same period. These expected values are often non-linear expressions of the production quantity, thus requiring the use of nonlinear programs (NLP). However, these NLP are computationally challenging to solve. For managers that have to decide on production quantities frequently, solving these models is often not feasible. Therefor, authors such as Helber et al. (2013) propose linearization techniques to transform the nonlinear formulations into linear programs.

The goal of this thesis is to describe and analyze the optimization approach proposed in the base paper for setting production quantities in the SCLSP. The mixed-integer linear programming model (MIP) proposed by Helber et al. (2013) should be described and briefly positioned within the existing body of literature. The linearized SCLSP of the base paper will be implemented using an optimization tool such as Python's DoCPLEX, GAMS, or AMPL. A sensitivity analysis will be conducted, focusing on the number of segments used in the linearization of the expected backlog and inventory functions. A critical review of the the model and a discussion of potential future directions concludes the thesis.

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

Basic Paper: Helber et al. (2013)

> **Abstract**:We present a stochastic version of the single-level, multi-product dynamic lot-sizing problem subject to a capacity constraint. A production schedule has to be determined for random demand so that expected costs are minimized and a constraint based on a new backlog-oriented δ-service-level measure is met. This leads to a non-linear model that is approximated by two different linear models. In the first approximation, a scenario approach based on the random samples is used. In the second approximation model, the expected values of physical inventory and backlog as functions of the cumulated production are approximated by piecewise linear functions. Both models can be solved to determine efficient, robust and stable production schedules in the presence of uncertain and dynamic demand. They lead to dynamic safety stocks that are endogenously coordinated with the production quantities. A numerical analysis based on a set of (artificial) problem instances is used to evaluate the relative performance of the two different approximation approaches. We furthermore show under which conditions precise demand forecasts are particularly useful from a production–scheduling perspective.

P5 – Facility location planning of closed-loop supply chains under stochastic demand

Type: Individual topic

Objectives: In closed-loop supply chains, products used by customers are collected, remanufactured, and subsequently sold to customers again. Optimal planning of closed-loop supply chains necessitate the optimization of locations for production facilities and collection centers, transportation routes, production, recycling, and disposal volumes. Due to the increasing emphasis on sustainability in the manufacturing industry, various environmental goals (e.g., minimizing CO_2 emissions) have to be considered. Additionally, the stochastic nature of customer demand plays a crucial role in planning and must be accounted for.

Optimization of a closed-loop supply chain with stochastic demand can be done with two-stage stochastic programming. The optimization procedure selects the facility location before the uncertain demand is realized (first stage), and adjusts transportation decisions afterwards (second stage). This helps to manage the variability in demand and provides a robust solution. Two key indicators that assess the impact of stochastic demand are the expected value of perfect information (EVPI), and the value of stochastic solution (VSS). While EVPI measures the potential cost savings that could be achieved with a perfect demand forecast, the VSS evaluates benefit of incorporating stochastic variability into the planning process compared to using a deterministic model.

The goal of this thesis is to analyze the impact of stochastic demand distributions on the optimal planning of a facility location problem for a closed-loop supply chain. A literature review should give an overview of objective functions and constraints related to environmental targets used in closed-loop supply chain planning problems. A two-stage stochastic problem for the facility location problem of a closed-loop supply chain should be modelled and implemented in Python. Managerial insights on the impact of demand distributions on the optimal solution, as well as on the EVPI and the VSS should be generated with a numerical study.

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

Basic Paper: Amin and Zhang (2013)

> **Abstract**: Integration of forward and reverse channels results in closed-loop supply chain networks. In this research, a mixed-integer linear programming model is proposed to configure a closed-loop supply chain network. The network includes multiple products, plants, recovery technologies, demand markets, and collection centres. The objective function is minimisation of the total cost. The model can determine number and locations of open facilities, and flows of products in the network. In addition, we develop the model to multi-objectives by considering minimisation of defect rates and time of operations in collection centres. To solve the model, weighted-sums and distance methods are applied in copier remanufacturing example and the results are analysed. Moreover, value path approach is applied to compare the results of different methods.

References

Amin, S. H. and Zhang, G. (2013). A multi-objective facility location model for closed-loop supply chain network under uncertain demand and return. *Applied Mathematical Modelling*, 37(6):4165–4176.

Ernst, A., Jiang, H., Krishnamoorthy, M., and Sier, D. (2004). Staff scheduling and rostering: A review of applications, methods and models. *European Journal of Operational Research*, 153(1):3–27.

Gupta, D. and Magnusson, T. (2005). The capacitated lot-sizing and scheduling problem with sequence-dependent setup costs and setup times. *Computers & Operations Research*, 32(4):727–747.

Helber, S., Sahling, F., and Schimmelpfeng, K. (2013). Dynamic capacitated lot sizing with random demand and dynamic safety stocks. *OR Spectrum*, 35(1):75–105.

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Stolletz, R. and Brunner, J. O. (2012). Fair optimization of fortnightly physician schedules with flexible shifts. *European Journal of Operational Research*, 219:622–629.