OPM 760 – Project Seminar Operations Analytics

Fall 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 **May 10th, 2026** until **May 22nd, 2026**. Admission to the seminar will be confirmed by e-mail at latest on May 29th, 2026 and must be reconfirmed by the participant at the kick-off meeting.

The **Kick-off meeting** will be held on **June 9th, 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, **October 6th, 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 **26th and 30th October 2026**. 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 fall term 2026, 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 – Operational Challenges of Heterogeneous Delivery Lead Times in Spare Parts Logistics

Type: Individual topic

Objectives: In service fulfillment centres such as spare parts logistics, customers request deliveries with varying levels of urgency. For example, in aircraft maintenance, where downtime costs are high, deliveries must be completed within a few hours or days. These heterogeneous service requirements create competition for limited operational capacity and require firms to balance rapid response for urgent orders with overall system efficiency. Moreover, demand arrivals in spare parts logistics are stochastic due to unexpected maintenance requirements. Consequently, system variability combined with heterogeneous delivery deadlines increases the complexity of capacity optimization. In these systems, various prioritization policies are used to structure the demand of different lead time classes, such as First-Come-First-Served (FCFS), Earliest Due Date (EDD), or random assignment. Discrete-event simulation can therefore be applied to evaluate relevant performance measures.

The objective of this seminar topic is to analyze how different delivery lead-time classes affect system performance, (e.g., on-time delivery by class, backlog, fill rate). Relevant priority rules used in the context of service fulfillment centres should be introduced. A discrete event simulation should be implemented in Python to conduct what-if analyses. The numerical analysis should compare two relevant prioritization rules for handling demand from different lead-time classes and evaluate their impact on system performance. In particular, the analysis should derive managerial insights into how delivery lead-time classes influence service levels and examine the corresponding opportunities and potential drawbacks associated with these classifications.

Prerequisites: Knowledge in variability and stochastic systems (e.g. OPM 561), programming in Python (e.g. OPM 560)

Basic Papers: Mohring et al. (2024); Wang et al. (2014)

> **Abstract**: Warehouses recently face increasing stress imposed by a volatile customer demand and increasing customer expectations in terms of ever shorter order response times. In that respect, warehouses more and more offer same-day and next-day shipment conditions. However, same-day shipment promises are challenging to fulfil, especially as the order fulfilment process operates against fixed deadlines imposed by the predefined truck departure times. As a natural mitigation strategy, warehouses set a cutoff point and offer same-day shipment only to customers that order until the cutoff point, but next-day shipment to all customers ordering thereafter. Setting an appropriate cutoff point is challenging as it affects multiple facets of the service quality, such as the order response time and the service level. In this paper, we study the design of cutoff-based shipment promises for stochastic deadline-oriented order fulfilment processes in warehouses…

P2 – Sustainable Lot-sizing for Inventory Optimization

Type: Individual topic

Objectives: In recent years, sustainability and environmental impact have become increasingly important in production and inventory management due to increasing regulatory pressure, rising carbon pricing schemes, and growing social awareness of environmental impacts.Traditional inventory models, such as the Economic Order Quantity (EOQ), focus primarily on minimizing costs related to ordering and holding inventory, while ignoring environmental externalities such as carbon emissions generated during production, transportation, and storage.

The objective of this seminar thesis is to describe and analyze the extended EOQ-based inventory models by incorporating carbon emission considerations. The thesis should present the classical EOQ formulation and its sustainable extensions, summarize key modelling approaches and numerical insights from the base paper, and extend the model by including features such as carbon taxes or emission constraints and extended model should be implemented in Python. A numerical study should be conducted to investigate the impact of parameters such as carbon tax levels, emission rates, demand, and holding costs on optimal order quantities and total costs. The numerical results should be used to derive managerial insights regarding the trade-offs between economic and environmental objectives. The thesis should conclude with a research trends and potential future directions in sustainable lot-sizing.

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

Basic Paper: Battini et al. (2014)

Abstract: Traditional inventory models involve different decisions that attempt to optimize material lot sizes by minimizing total annual supply chain costs. However, the increasing concern on environmental issues stresses the need to treat inventory management decisions as a whole, by integrating economic and environmental objectives. Recent studies have underlined the need to incorporate additional criteria in traditional inventory models in order to design "responsible inventory systems". This paper explores the integration of factors affecting the environmental impact within the traditional EOQ model and proposes a "Sustainable EOQ Model". All sustainability factors linked to the material lot size are analyzed from the beginning of the purchasing order to the end of its life inside the buyer plant. Thus, the environmental impact of transportation and inventory is incorporated in the model and investigated by an economic point of view. In particular internal and external transportation costs, vendor and supplier location and the different freight vehicle utilization ratio are considered in order to provide an easy-to-use methodology. The optimization approach is applied to representative data from industrial problems to assess the impact of sustainability considerations on purchasing decisions if compared with the traditional approaches. Finally, an illustration of the effect of using the new "Sustainable EOQ model" is presented and discussed.

P3 – 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 should 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 (e.g. OPM 560)

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.

P4 – Scheduling Call Center Agents under Service Level Constraints

Type: Individual or team topic

Objectives: Managers of call centers face the following trade-off: On the one hand, personnel costs are increasing when employing more agents to serve customer calls, but on the other hand, decreasing the number of agents will deteriorate the service quality, thus increasing customer dissatisfaction. Therefore, in practice, managers set service level constraints (SLCs), which define acceptable levels of service quality. Measures for the service quality are, e.g., the expected waiting time, the probability that an arriving customer has to wait, or the Telephone Service Factor (TSF), which measures the portion of customer calls that are served within a specified time. When deciding on the number of agents to staff for a given day, they have to consider that agents cannot be scheduled for single hours, e.g., but need to work in shifts, covering multiple hours. Thus, the managers have to decide how many agents are assigned to which type of shift. Robbins and Harrison (2010) analyze this scheduling problem, minimizing the sum of staffing costs and a penalty term for not meeting a minimum level of the TSF. As the problem is hard to solve, the authors apply a piecewise linear function to approximate the TSF.

The goal of this thesis is to analyze the shift scheduling problem based on the paper of Robbins and Harrison (2010). The mixed-integer linear programming model (MIP) of the base paper should be described and briefly positioned within the existing body of literature. Furthermore, the authors model should be implemented, using an optimization tool such as Python's DoCPLEX, GAMS, or AMPL. Thereby, instead of the TSF, SLCs based on other performance measures (e.g., the expected waiting time) should be utilized. A sensitivity analysis should be conducted, focusing on differences between different service level constraints. 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 (e.g. OPM 560)

Basic Paper: Robbins and Harrison (2010)

> **Abstract**: We consider the issue of call center scheduling in an environment where arrivals rates are highly variable, aggregate volumes are uncertain, and the call center is subject to a global service level constraint. This paper is motivated by work with a provider of outsourced technical support services where call volumes exhibit significant variability and uncertainty. The outsourcing contract specifies a Service Level Agreement that must be satisfied over an extended period of a week or month. We formulate the problem as a mixed-integer stochastic program. Our model has two distinctive features. Firstly, we combine the server sizing and staff scheduling steps into a single optimization program. Secondly, we explicitly recognize the uncertainty in period-by-period arrival rates. We show that the stochastic formulation, in general, calculates a higher cost optimal schedule than a model which ignores variability, but that the expected cost of this schedule is lower. We conduct extensive experimentation to compare the solutions of the stochastic program with the deterministic programs, based on mean valued arrivals. We find that, in general, the stochastic model provides a significant reduction in the expected cost of operation. The stochastic model also allows the manager to make informed risk management decisions by evaluating the probability that the Service Level Agreement will be achieved.

P5 – Planning of Setups when Customer Demand is Uncertain

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 direct 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), which can be solved very efficiently. However, this standard model lacks many real world constraints, such as uncertainty in demand, where the exact customer demand of a period is not known beforehand, but can only be observed in the respective period it occurs. By this, also the exact inventory and backorder levels at the end of each period are not known beforehand anymore, but have to be estimated. Their expected values are 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, GAMS, or AMPL. 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).

P6 – 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 (e.g. OPM 560)

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.

Battini, D., Persona, A., and Sgarbossa, F. (2014). A sustainable eoq model: Theoretical formulation and applications. *International Journal of Production Economics*, 149:145–153. The Economics of Industrial Production.

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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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