# OPM 761 – Research Seminar Production Management

## Fall Term 2024

The goal of this seminar is to introduce the participants to conduct scientific research. Thereby, it prepares the students for the writing of their 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. They will review and critically assess the corresponding scientific literature and 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 **April 26th, 2024** until **May 10th, 2024**. Admission to the seminar will be confirmed by e-mail at latest on May 17th, 2024 and must be reconfirmed by the participant at the kick-off meeting.

The **Kick-off meeting** will be held on **May 21st, 2024** between 8:30 a.m. and 10 a.m. (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 4th, 2024** 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 **10th and 17th October 2024**. 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 fall term 2024, 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 761 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 opm761@uni-mannheim.de. For any further question concerning the seminar please also contact the chair via opm761@uni-mannheim.de.

## P9 – Overview of optimization models in call center staffing

**Objectives**: In many service systems, staffing drives both costs and service quality by ensuring that the right number of employees are available for various processes. A call center for example, might aim to minimize personnel cost while ensuring a certain service level. One example could be to consider the negative impacts on waiting time or customer abandonments.

The goal of this research seminar is to provide a comprehensive overview of utilized optimization models for time-dependent staffing in call centers. Existing literature should be critically assessed and compared by describing the utilized optimization models (objective, constraints, ...). Relevant trade-offs (e.g. balancing cost savings and lost sales) and managerial findings presented in literature should be presented and discussed.

**Prerequisites:** Knowledge in variability and optimization models (e.g. OPM 561)

**Basic Paper**: Defraeye and Van Nieuwenhuyse (2016); Stolletz and Tan (2024)

> **Abstract**: Many service systems display nonstationary demand: the number of customers fluctuates over time according to a stochastic—though to some extent predictable—pattern. To safeguard the performance of such systems, adequate personnel capacity planning (i.e., determining appropriate staffing levels and/or shift schedules) is often crucial. This paper provides a state-of-the-art literature review on staffing and scheduling approaches that account for nonstationary demand. Among references published during 1991–2013, it is possible to categorize relevant contributions according to system assumptions, performance evaluation characteristics, optimization approaches and real-life application contexts. Based on their findings, the authors develop recommendations for further research.

## P10 – Ramp-up phase: how to realize when it's over?

**Objectives**: In production management, ramp-up refers to the process of gradually increasing the production capacity of a system until the planned long-term production capacity is exploited. Ramp-up phase, i.e. the period in which this gradual increase in production occurs, takes place when a new product is introduced or when a new production technology starts up. The time-dependent production capacity (variability; dynamics) during a ramp-up phase makes planning tasks difficult from an operations perspective. For example, decreased system output can cause violation of contracts with clients and harm the reputation of the firm. In order to avoid such problems and perform a good resource allocation, the period in which a stationary production capacity is reached has to be identified correctly. Predictive analytics approaches can be used to identify the end of ramp-up phase. One of the possible predictive analytics approaches is the usage of truncation heuristics. This approach utilizes system output to identify the end of the ramp-up phase by trying measuring standard deviation of system output and analyzing patterns.

The goal of the research seminar is to give an overview on predictive analytics approaches to identify the end of ramp-up phase. The importance and causes of ramp-up phase should be explained and managerial implications should be critically assessed. The student is expected to describe and compare the predictive analytics approaches: 1) truncation heuristics, 2) machine learning, 3) graphical methods based on their methodology and limitations.

**Prerequisites:** Knowledge in stochastic manufacturing systems (e.g. OPM 561)

**Basic Paper**: White Jr (1997); Surbier et al. (2014); Stolletz and Tan (2024)

**Abstract**: The start-up or warm-up problem arises in steady-state, discrete-event simulation, where the arbitrary selection of initial conditions introduces bias in simulated output sequences. In this paper, we develop and test a new truncation heuristic or resolving the start-up problem. Given a finite sequence, the truncation rule deletes initial observations until the width of the marginal confidence interval about the truncated sample mean is minimized. This rule is easy to implement, has strong intuitive appeal, and is remarkably effective in mitigating initialization bias. We illustrate the performance of the heuristic by comparison with enhanced implementations of alternative truncation rules proposed in the literature. All rules are applied to output sequences generated by ten runs each of four representative queuing simulations. Results confirm the significance of the start-up problem and demonstrate that simple truncation heuristics can solve this problem. All of the rules tested are shown to provide improved accuracy without undue loss of precision. We conclude that all four of the rules tested represent attractive solutions to the start-up problem.

## P11 – Overview of resilience metrics in operations systems

**Objectives**: It is estimated that almost three quarters of organizations experience a supply chain disruption each year, i.e. an event that impacts the flow of goods, materials and/ or services, thereby limiting the ability of an organization to serve the end consumer (BCI, 2018). Possible external disruptions can originate from natural or man-made disasters, financial and political turbulences, others are internal, e.g. production line break downs, IT problems, demand fluctuations, sustainability issues or quality problems. Meanwhile, the performance impact of such events is also dependent on the severity and duration of the disruption as well as on the organizations' ability to manage disruptions and threats. Resilience is defined as the ability to recover quickly and effectively from a disruption, e.g. restoring normal operations as swiftly as possible. This can be quantified with different metrics; for example by the fraction of the disrupted performance that is recovered after a recovery period, or the difference between the performance that is affected by a disruption and the baseline performance. Resilience can give the organization a competitive advantage, as it is able to continue operating even in the face of disruptions.

The goal of the research seminar is to give an overview on resilience metrics in different operations systems. Quantitative approaches for analyzing resilience levels should be explained and compared for different applications. Furthermore, the difference between resilience and traditional optimization approaches under uncertainty (e.g. stochastic programming and robust optimization) should be explained in detail. Resulting managerial implications of utilized resilience levels should be presented and discussed.

**Prerequisites:** Knowledge of stochastic variability and optimization problems (e.g. OPM 561)

**Basic Papers**: Behzadi et al. (2020); Stolletz and Tan (2024)

**Abstract**: Resilience, defined as the ability to recover quickly and effectively from a disruption, is critically important for supply chains. Yet, it has not been quantified as frequently as supply chain robustness. In this paper we review the existing metrics for supply chain resilience and introduce a new metric, titled the net present value of the loss of profit (NPV-LP). We test these metrics on a small supply chain problem consisting of one supply and one demand node for a perishable good over a multi-period horizon with a possible port shut-down. We show how the different metrics cause different investment decisions for the supply chain, and hence why it is important to carefully pick the correct metric when modeling supply chain resilience.

## P12 – Time-dependent Queueing in Airport Terminals

**Objectives**: Variability in operations management arises from changes in volume or timing due to uncertainty, time dependency, or diversity. Time dependency refers to variations across time, for example, due to seasonal demand fluctuations. Service counters across different industries, such as aviation or the restaurant sector, experience time-dependent arrivals. Additionally, the total number of available servers, and thus the overall processing capacity, can vary over time. Most classical methods assume steady rates, rendering them unsuitable or requiring modification for the analysis and optimization of these time-dependent systems.

The goal of this thesis is to provide a comprehensive overview of the recent publications on the application of time-dependent queueing systems in service systems in airport terminals, such as check-in counters, security checks, departure lounges, and baggage claim facilities. The reviewed articles must be classified based on their assumptions, application area, performance evaluation measures, and assumptions on the optimization problem (if applicable), i.e., input data, decisions, objective functions, etc. The thesis must also provide an overview of the managerial insights mentioned in the reviewed research papers. A critical assessment of the literature and suggestions for future research concludes this thesis.

**Prerequisites:** Basic knowledge in stochastic systems (e.g. OPM 561)

**Basic Papers**: Schwarz et al. (2016); Stolletz and Tan (2024)

> **Abstract**: Many queueing systems are subject to time-dependent changes in system parameters, such as the arrival rate or number of servers. Examples include time-dependent call volumes and agents at inbound call centers, time-varying air traffic at airports, time-dependent truck arrival rates at seaports, and cyclic message volumes in computer systems. There are several approaches for the performance analysis of queueing systems with deterministic parameter changes over time. In this survey, we develop a classification scheme that groups these approaches according to their underlying key ideas into (i) numerical and analytical solutions, (ii) approaches based on models with piecewise constant parameters, and (iii) approaches based on modified system characteristics. Additionally, we identify links between the different approaches and provide a survey of applications that are categorized into service, road and air traffic, and IT systems.

## P13 – Reinforcement learning for order release planning

**Objectives**: Make-to-order (MTO) manufacturing is a production strategy where goods are manufactured only after receiving an order, allowing for high customization but challenging firms to maintain efficiency and speed. For make-to-order manufacturing firms, the ability to achieve short flow times is crucial to remaining competitive. This objective becomes even more difficult with the rapid increase in customer expectations. Order release planning is the process of determining when and in what quantities to release orders into production. Effective order release planning is important for make-to-order firms because it directly impacts manufacturing lead times and on-time delivery performance. By controlling the timing and rate of order releases, firms can smooth production workload, avoid bottlenecks, and reduce flow times.

Machine learning methods in general, and reinforcement learning in particular, have shown potential to improve order release planning by learning from the system's behavior without restrictive assumptions. Reinforcement learning agents can learn effective release policies through repeated interactions with a simulation model of the manufacturing system.

The goal of this seminar thesis is to explain the details of the problem and method presented in the base paper. In addition, the student is expected to position the research study in the related literature with respect to the underlying problem and method. A comprehensive critical assessment of the base paper's assumptions and method will conclude this thesis.

**Prerequisites:** Knowledge in Artificial Intelligence, and knowledge in modeling production management problems (e.g., OPM 561)

**Basic Papers**: Schneckenreither and Haeussler (2019)

> **Abstract**: An important goal in Manufacturing Planning and Control systems is to achieve short and predictable flow times, especially where high flexibility in meeting customer demand is required. Besides achieving short flow times, one should also maintain high output and due-date performance. One approach to address this problem is the use of an order release mechanism which collects all incoming orders in an order-pool and thereafter determines when to release the orders to the shop-floor. A major disadvantage of traditional order release mechanisms is their inability to consider the nonlinear relationship between resource utilization and flow times which is well known from practice and queuing theory. Therefore, we propose a novel adaptive order release mechanism which utilizes deep reinforcement learning to set release times of the orders and provide several techniques for challenging operations research problems with reinforcement learning. We use a simulation model of a two-stage flow-shop and show that our approach outperforms well-known order release mechanism.

## P14 – Optimization Models for the Design of Energy Systems

**Objectives:** The design of energy systems plays a key role in the development towards a more environmentally friendly future. E.g., with a growing number of privately owned electric vehicles the consumption of electrical power increases, as well as requirements for efficient power grids. Large power plants relying on fossil resources are to be shut down in the next decades. Furthermore, some countries do not operate nuclear power plants and are either not able or not willing to do so in future, thus decentralized power generation (e.g., wind and solar) is of growing importance. In literature, a wide variety of works consider the strategic design of energy systems via optimization methods as linear programming (LP), mixed integer linear programming (MIP), and non-linear programming (NLP). Since renewable energy generation is often subject to random fluctuations, it is important to incorporate this stochasticity into decision making.

The goal of this seminar thesis is to provide a comprehensive overview of the recent publications on optimization models for the long-term planning of energy systems under the assumption of stochasticity. The reviewed articles should be classified and compared according to their assumptions, objectives, and the methods used to deal with stochasticity. A critical assessment of the literature and suggestions for future research concludes this thesis.

**Prerequisites:** Knowledge in optimization models (e.g., OPM 561, 662)

**Basic Papers**: Moret et al. (2020)

> **Abstract**: Optimization models for long-term energy planning often feature many uncertain inputs, which can be handled using robust optimization. However, uncertainty is seldom accounted for in the energy planning practice, and robust optimization applications in this field normally consider only a few uncertain parameters. A reason for this gap between energy practice and stochastic modeling is that large-scale energy models often present features—such as multiplied uncertain parameters in the objective and many uncertainties in the constraints—which make it difficult to develop generalized and tractable robust formulations. In this paper, we address these limiting features to provide a complete robust optimization framework allowing the consideration of all uncertain parameters in energy models. We also introduce an original approach to make use of the

obtained robust formulations for decision support and provide a case study of a national energy system for validation.

## P15 – Balancing Speed and Quality in Service Systems

**Objectives:** Queueing systems are analyzed in a multitude of context: Call centers, traffic, airports, healthcare, restaurants, and customer services in general. One lever for the performance of such a system is the service rate, i.e., how many customers per time unit can be served. The service rate can be increased by, e.g., speeding up services, simplifying processes, and on the other hand reduced by additional up- and cross-selling, or by putting more diligence into the service. A higher service rate decreases congestion, and thus waiting. However, a higher service rate can come with other costs. In the so-called quality-speed trade-off literature it can also lower the value of the service provided to the customer. Depending on the business application, literature assumes different components in the objective function, such as waiting costs, revenues depending on the service rate, costs in the service rate, etc.

The goal of this seminar thesis is to provide a detailed overview, classification, and comparison of different objective functions in the quality-speed trade-off literature. The underlying motivation of the objective functions should be explained. Moreover, the optimization problems should be classified with respect to the dimensions of the variability cube (Stolletz and Tan, 2024). Relevant applications and managerial insights, as well as structural similarities and differences between the considered objective functions should be identified. A critical assessment of the literature concludes this thesis.

**Prerequisites:** Basic knowledge in stochastic modelling (e.g., OPM 561)

**Basic Papers**: Anand et al. (2011), Stolletz and Tan (2024)

**Abstract**: In many services, the quality or value provided by the service increases with the time the service provider spends with the customer. However, longer service times also result in longer waits for customers. We term such services, in which the interaction between quality and speed is critical, as customer-intensive services. In a queueing framework, we parameterize the degree of customer intensity of the service. The service speed chosen by the service provider affects the quality of the service through its customer intensity. Customers queue for the service based on service quality, delay costs, and price. We study how a service provider facing such customers makes the optimal “quality–speed trade-off.” Our results demonstrate that the customer intensity of the service is a critical driver of equilibrium price, service speed, demand, congestion in queues, and service provider revenues. Customer intensity leads to outcomes very different from those of traditional models of service rate competition. For instance, as the number of competing servers increases, the price increases, and the servers become slower.

## References


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