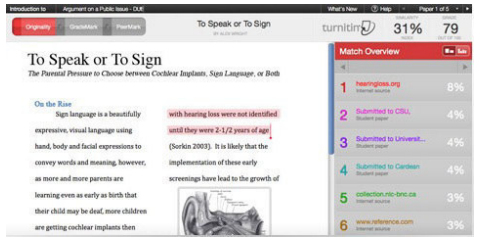
Research Seminar Production Management (OPM 761)

Key topics:

- Application of business analytics approaches
- Literature review
- Paper discussion

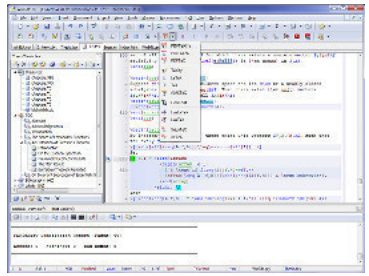


Grading: (6 ECTS)

- Seminar thesis (15-20 pages) (70%),
- presentation (20%) and discussion (10%)

Dates/course structure:

- Application together with other OPM chairs (at the end of previous semester)
- Kick-Off, individual meetings with supervisor
- Introduction to literature research, scientific writing & presentations
- Master's thesis in the same semester is possible



CHAIR OF PRODUCTION MANAGEMENT
Prof. Dr. Raik Stolletz
http://stolletz.bwl.uni-mannheim.de

UNIVERSITY OF MANNHEIM

OPM 761 – Research Seminar Production Management

Fall Term 2019

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 (15 to 20 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 Monday, **April 29th 2019** until Sunday, **May 12th, 2019**. Admission to the seminar will be confirmed by e-mail on Monday, May 20th, 2019 and must be reconfirmed by the participant at the kick-off meeting.

The **Kick-off meeting** will be held on Tuesday, **May 28th, 2019** between 15:30 and 18:00 o'clock in room SO 322. During this meeting, an introduction to scientific writing and presentations for term papers will be given.

The **written reports** have to be submitted by Friday, **September 16th, 2019** 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 between October 1st and October 10th, 2019 (exact times and the room will be announced). Attendance at the 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%). The report and the presentations can be delivered either in English or in German, unless stated otherwise.

There is a joint application process for all seminars offered by the chairs of the Area Operations Management. In the Fall term 2019, 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 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 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 Amir Foroughi (A.foroughi@bwl.uni-mannheim.de), who can also be contacted for general questions concerning the seminar.

Topics Catalog

P1 – Product Launching Strategies for Fast Fashion Products

Objectives: There is a trend in fashion product industry that firms launch new styles of their products more frequently. Fashion firms need to decide on prices and sales quantities while considering potential cannibalization effects between product styles that are sold simultaneously. Zhou et al. (2015) propose a stylized two-period model to determine the optimal lunching strategy for fast fashion products.

The objective of this seminar thesis is to identify the main issues addressed by the basic paper by Zhou et al. (2015), explain the developed quantitative model and the applied solution methodology, position it in the corresponding stream of scientific literature, and critically assess the paper's contribution to the literature as well as to practice.

Prerequisites: Basic knowledge in quantitative modeling (e.g., OPM 561, OPM 662).

Basic Paper: Zhou et al. (2015)

> **Abstract**: There is a trend in fashion product industry that firms launch new styles of their products more frequently. To investigate the optimal style launching strategy for a fashion firm, we propose a two-period pricing model for a fashion product firm. The firm sells a style of products in the first period as well as that he may utilize three different strategies in the second period, i.e., (i) the N-Strategy: the firm does not launch a new style; (ii) the S-Strategy: the firm launches a new style and stops selling the previous one immediately; and (iii) the D-Strategy: the firm sells the new and old style simultaneously in the second period. Different from previous literatures, we incorporate the satiation effect of consumers in our model and try to analyze its impacts on the fashion firm's new product launching strategy. Specifically, we assume that a consumer occurs a certain mental book value cost x if he/she has already purchased a previous style of the same brand. Our main work is to illustrate in what condition and which one of the three strategies mentioned above is the firm's best choice, as well as

the firm's best optimal retail prices over the two periods under them. Results show that a fashion firm's optimal launching strategy is mainly determined by the production cost and the consumer's mental book value. In detail, (i) when the consumer's mental book value and/or the production cost are relatively high, N-Strategy is the firm's optimal choice; (ii) when the consumer's mental book value is low and the production cost is high, S-Strategy is the best strategy; and (iii) when both the consumer's mental book value and the production cost are relatively low, the D-Strategy dominates the other two.

P2 – Trading-off Quality and Waiting for Imaging Tests in Healthcare

Objectives: Physicians in eye clinics or orthopedics rely on several imaging tests of a patient in order to examine their state of health. For such imaging tests, a trade-off between quality and waiting exists. The quality of an examination increases with the number of tests ordered, on the contrary, the waiting time of all waiting patients increases. Furthermore, it needs to be considered that the fees are partially covered by an insurance which drives the patient's behavior to request the service.

The goal of this seminar thesis is to carefully discuss the decision problem considered in the base paper, to position it in the corresponding literature stream, and to present and critically assess the results that are found.

Prerequisites: Basic knowledge in queueing theory (e.g., OPM 661).

Basic Paper: Dai et al. (2016)

Abstract: Motivated by a collaborative study with one of the most comprehensive ocular imaging programs in the United States, we investigate the underlying three-way trade-off among operational, clinical, and financial considerations in physicians' decisions about ordering imaging tests. Laboratory tests may be processed in parallel and thus have a limited effect on patients' waiting times; imaging tests, by contrast, require patient presence and thus directly influence patients' waiting times. We use a strategic queueing framework to model a physician's decision of ordering imaging tests and show that insurance coverage is the key driver of overtesting. Our further analysis reveals the following: (i) Whereas existing studies hold that lower out-of-pocket expenses lead to higher consumption levels, we refine this statement by showing the copayment and the coinsurance rate drive the consumption in different directions. Thus, simply expanding patient cost sharing is not the solution to overtesting. (ii) Setting a low reimbursement ceiling alone cannot eliminate overtesting. (iii) The joint effect of misdiagnosis concerns and insurance coverage can lead to both overtesting and undertesting even when no reimbursement ceiling exists. These and other results continue to hold under more general conditions and are therefore robust. We enrich our model along two extensions: one with patient heterogeneity in diagnostic precision, and the other with disparities in health insurance coverage. Our findings have implications for other healthcare settings with similar trade-offs.

P3 – Learning and Process Improvement During Production Ramp-up in the Semiconductor Industry

Objectives: With shrinking product life cycles, many industries face increasing pressure on ramping up production quickly. During this phase, learning and process improvement are key drivers of the utilization and yield of the production. Different models have been proposed, distinguishing between induced and autonomous learning. The first occurs when experiments are conducted in order to improve the process while the latter refers to cumulative experience from the production itself.

The student is expected to present and structure the different optimization problems for learning and process improvement during production ramp-up presented in the literature. The different assumptions underlying these models as well as the structural findings have to be presented.

Prerequisites: Knowledge of modeling for production systems (e.g. OPM 661).

Basic Paper: Terwiesch and Bohn (2001)

> **Abstract**: Rapid product lifecycles and high development costs pressure manufacturing firms to cut not only their development times (time-to-market), but also the time to reach full capacity utilization (time-to-volume). The period between completion of development and full capacity utilization is known as production ramp-up. During that time, the new production process is ill understood, which causes low yields and low production rates. This paper analyzes the interactions among capacity utilization, yields, and process improvement (learning). We model learning in the form of deliberate experiments, which reduce capacity in the short run. This creates a trade-off between experiments and production. High selling prices during ramp-up raise the opportunity cost of experiments, yet early learning is more valuable than later learning. We formalize the resulting intertemporal trade-off between the short-term opportunity cost of capacity and the long term value of learning as a dynamic program. The paper also examines the tradeoff between production speed and yield/quality, where faster production rates lead to more defects. Finally, we show what happens if managers misunderstand the sources of learning.

P4 – Newsvendor Models with Stochastic Yield

Objectives: Yield problems occur when a share of the produced products does not meet the quality specifications and can therefore not be used to fulfill demand. Yield problems play a critical role in many high-tech industries, such as the semiconductor industry. Typically, yield is stochastic and can be modeled by a probability distribution. Different Newsvendor models have been proposed to obtain the optimal production quantity for different yield and demand models.

The student is expected to present the literature on Newsvendor models with yield, specifically highlighting the different assumptions of the yield and demand models. Furthermore, the student is expected to implement a sampling-based Newsvendor model and conduct a numerical study on the impact of the different yield and demand models found in the literature.

Prerequisites: Knowledge of a modeling language for Linear Programming (e.g., OPM662).

Basic Paper: Choi et al. (2019)

Abstract: We study a binomial yield production process using a newsvendor approach by considering the mismatch costs between a given demand and a non-defective yield amount. Using a normal approximation, we re- formulate the original discrete and exact model as a continuous and approximate model. We conduct a comparative static analysis of the parameters in the approximate model and derive the monotone prop- erties of the (approximate) optimal solution in the case that the given demand is sufficiently large. The analytical results are all consistent with our insights and are also supported by economic explanations. Our numerical study with sample-based optimization indicates that the approximate model is sufficiently close to the exact model in most real-world examples, with some limiting cases included. Then, a simple and naive solution is found to have significant suboptimality. Finally, the results of a sensitivity analysis of the model parameters are confirmed numerically.

P5 – Improving Healthcare Systems with Queueing Models

Objectives: In healthcare, appointment systems mainly work to regulate the patient demand for various services. They help reduce the variability in the patients' arrival process so that patients wait less and the system is kept highly utilized. Two scheduling approaches can be considered in appointment systems: on-line (i.e., sequential) and offline (i.e., simultaneous). In the offline approach, appointments are scheduled after all requests have arrived, while in the online approach, patients are scheduled immediately upon the arrival of their request. Online systems are more common in practice. Kemper et al. (2014) apply the online approach and optimize the arrival times.

The objective of this seminar thesis is to identify the main issues addressed by the paper by Kemper et al. (2014), explain the developed quantitative model and the applied solution methodology. In addition, students are expected to position the paper in the corresponding stream of scientific literature and critically assess its contribution.

Prerequisites: Basic knowledge in queueing theory (*e.g.,* OPM 661).

Basic Paper: Kemper et al. (2014)

Abstract: In service systems, in order to balance the server's idle times and the customers' waiting times, one may fix the arrival times of the customers beforehand in an appointment schedule. We propose a procedure for determining appointment schedules in such a D/G/1-type of system by sequentially minimizing the per-customer expected loss. Our approach provides schedules for any convex loss function; for the practically relevant cases of the quadratic and absolute value loss functions appealing closed-form results are derived. Importantly, our approach does not impose any conditions on the service time distribution; it is even allowed that the customers' service times have different distributions. A next question that we address concerns the order of the customers. We develop a criterion that yields the optimal order in case the service time distributions belong to a scale family, such as the exponential family. The customers should be scheduled then in non-decreasing order of their scale parameter. While the op-

timal schedule can be computed numerically under quite general circumstances, in steady-state it can be computed in closed form for exponentially distributed service times under the quadratic and absolute value loss function. Our findings are illustrated by a number of numerical examples; these also address how fast the transient schedule converges to the corresponding steady-state schedule.

P6 – Designing and Planning Outpatient Appointment Systems

Objectives: The objective of appointment scheduling is to trade off the interests of physicians and patients: the patients prefer to have a short waiting time, the physician likes to have as little idle time as possible and to finish on time. Due to the high combinatorial complexity of outpatient appointment scheduling, heuristics are applied to this problem.

In this seminar, students are expected first to implement the model introduced in the basic paper in GAMS. In addition, a heuristic Tabu Search to solve the problem has to be implemented. They also need to numerically compare the heuristic with the solution obtained from GAMS on small benchmark instances.

Prerequisites: Basic knowledge in quantitative modeling (e.g., OPM 561, OPM 662), knowledge of a programming language or willingness to acquire basic programming skills (*e.g.,* Java, C#).

Basic Paper: Kaandorp and Koole (2007)

> In this paper optimal outpatient appointment scheduling is studied. A local search procedure is derived that converges to the optimal schedule with a weighted average of expected waiting times of patients, idle time of the doctor and tardiness (lateness) as objective. No-shows are allowed to happen. For certain combinations of parameters the well-known Bailey-Welch rule is found to be the optimal appointment schedule.

P7 – Scheduling Doctor's Appointments with Uncertainty in Demand

Objectives: Appointment systems are used in many service systems (e.g. healthcare systems) to manage access to service providers. They improve productivity and match capacity and demand by reducing uncertainty in demand. Appointment scheduling problems arise in such systems, which are to set appointed arrival times of clients/ patients. However, due to the presence of stochastic variability, obtaining a suitable appointment schedule is challenging. Sources of stochastic variability include random service times, unscheduled arrivals (walk-ins), and no-shows. No-shows refer to the clients/ patients who do no show up for their appointments and walk-ins are the clients/ patients who walk into the system without having any appointments.

The main goal of this seminar is to conduct a structured literature review for the papers dealing with appointment systems with no-shows and walk-ins together. We expect students first to describe the appointment scheduling problem with no-shows and walk-ins and then to classify all the papers related to the topic as well as briefly describe them. For each paper, students are expected to describe the purpose, the problems introduced, the assumptions of

the model, the basic ideas of the solution approaches, and the managerial insights reported.

Prerequisites: Basic knowledge in queueing theory (*e.g.,* OPM 661).

Basic Paper: Cayirli et al. (2012)

> This study introduces a universal "Dome" appointment rule that can be parameterized through a planning constant for different clinics characterized by the environmental factors-no-shows, walk-ins, number of appointments per session, variability of service times, and cost of doctor's time to patients' time. Simulation and nonlinear regression are used to derive an equation to predict the planning constant as a function of the environmental factors. We also introduce an adjustment procedure for appointment systems to explicitly minimize the disruptive effects of no-shows and walk-ins. The procedure adjusts the mean and standard deviation of service times based on the expected probabilities of no-shows and walk-ins for a given target number of patients to be served, and it is thus relevant for any appointment rule that uses the mean and standard deviation of service times to construct an appointment schedule. The results show that our Dome rule with the adjustment procedure performs better than the traditional rules in the literature, with a lower total system cost calculated as a weighted sum of patients' waiting time, doctor's idle time, and doctor's overtime. An open-source decision-support tool is also provided so that healthcare managers can easily develop appointment schedules for their clinical environment.

P8 – Workforce Planning in Multi-stage Systems

Objectives: Labor cost is one of the major cost components in many service systems. Accordingly, workforce planning in these systems has received lots of attention. The goal of shift scheduling is to determine what shifts the employees should be assigned to in each working day. Shift scheduling has been discussed in different settings in the literature. One special setting which appears in several production and service systems such as distribution centers is shift scheduling in multi-stage systems. The processing times in the stages are given endogenously. The assignment of the agents of different skill categories to different stages with specific skill requirements in possible shifts must be determined.

In this research seminar, the student is expected first to discuss the optimization problem presented in the base paper in detail. In addition, the model in the base paper must be implemented a modeling system (e.g. GAMS). Numerical experiments on the impact of the demand and the dependency of stages on the optimal solution and discussion of obtained managerial insights are the last steps of this research seminar.

Prerequisites: Knowledge of a modeling language for Linear Programming (e.g., OPM662).

Basic Paper: Bhatnagar et al. (2007)

> **Abstract**: In this paper we present a framework that balances the significant tradeoffs and helps managers in crafting a strategy for the induction of contingent workers in a complex assembly environment. The key issues we have considered in this paper include distinct manufacturing sub-processes, hierarchical or nested workforce skills, regular and overtime capacity, and impact of learning. We report a real life case study pertaining to the Singapore operations of a global computer manufacturer that served as the backdrop of this research and

provided us with several intuitions. A linear programming model is presented to help determine the optimal allocation of permanent and contingent workers to all sub-processes. Our numerical study comprising more than 165 distinct experiments indicates that both the firm?s cost performance and the number of contingent workers inducted are significantly affected by key parameters such as cost of induction, overtime premium cost, and overtime capacity. We highlight the impact of demand variability, and emphasize the overall value of the model presented in this research through the managerial insights that can be drawn from it.

P9 – Production Planning with Workforce Transferring Plan

Objectives: Workforce and production decisions in many production and service systems are highly interdependent. Therefore several models have been proposed incorporating both workforce and production planning decisions. Transferring of workforce among the production lines or stages is one of the ways to provide flexibility for the planner to cope with demand fluctuations.

The goal of this research seminar is first to discuss the presented mathematical model in the basic paper in detail. Second, the model must be implemented in a modeling system (e.g. GAMS). The next step is to conduct numerical experiments on the impact of workforce transfer on the optimal production plan, workforce schedule and costs. Discussing the obtained numerical results concludes this research seminar.

Prerequisites: Knowledge of a modeling language for Linear Programming (e.g., OPM662).

Basic Paper: Techawiboonwong and Yenradee (2003)

Abstract: This paper presents the aggregate production planning for multiple product types where the worker resource can be transferred among the production lines. A mathematical model was formulated in spreadsheet format. Then the spreadsheet-solver technique was used as a tool to solve the model. A real situation of a manufacturing company was selected as a case study. The actual data was used to test and validate the proposed model. The optimal aggregate production plan provides the information on managing the available production capacity together with the useful workforce transferring plan. The obtained solutions were compared to those of another approach where the workers cannot be transferred among the production lines. The total cost is significantly reduced when the workers are allowed to transfer among the production lines.

P10 – Regulation-related Constraints in Personnel Scheduling

Objectives: Regulation-related constraints are part of the constraints usually taken into account in personnel scheduling. Constraints such as minimum and maximum number of consecutive work days, as well as minimum and maximum number of days-off of a single worker fall in this category. These constraints are modeled as both soft and hard constraints in the literature.

In this research seminar, the students are expected to review workforce planning studies,

present the underlying optimization problems and categorize them based on the regulation-related constraints taken into account. Each category of constraints must be explained in detail. Discussing the obtained managerial insights about the relationship between the problem settings and the regulation-related constraints will finish this research seminar.

Prerequisites: Knowledge of a modeling language for Linear Programming (e.g., OPM662).

Basic Paper: Van Den Bergh et al. (2013)

> **Abstract**: This paper presents a review of the literature on personnel scheduling problems. Firstly, we discuss the classification methods in former review papers. Secondly, we evaluate the literature in the many fields that are related to either the problem setting or the technical features. Each perspective is presented as a table in which the classification is displayed. This method facilitates the identification of manuscripts related to the reader?s specific interests. Throughout the literature review, we identify trends in research on personnel staffing and scheduling, and we indicate which areas should be subject to future research.

P11 – Patient Flow and Waiting Time Management in Inpatient and Emergency Departments

Objectives: The demand for health care services has been rapidly increasing over the last decades. Statistics show that in 2017 19.4 million patients required emergency or inpatient treatment with associated costs of about 91.3 billion in Germany. As patients may face serious consequences as well as mental distress if not treated in a timely manner, waiting time management is an important problem for hospitals and health care systems. A staffing and resource allocation is required that allows the health care system to run cost efficiently, while maintaining target waiting times. In order to determine an appropriate staffing and resource allocation, a performance evaluation is required to assess the expected waiting time for a given setting. Health care systems are not only facing a multitude of sources of stochasticity e.g. arrival rates and treatment times but they also consist of multiple processes with interdependencies. In order to capture both, queuing networks have been proposed in the literature to model the patient flows.

The student is expected to characterize and structure the different existing modeling approaches in inpatient and emergency departments. The different models as well as the underlying stochastic assumptions have to be presented. Particular attention should be paid to the way the process complexity is captured within the models.

Prerequisites: Basic knowledge in queuing theory (e.g. OPM 661) as well as optimization problem modeling (e.g. OPM 561).

Basic Paper: Kim and Kim (2015)

> **Abstract**: Unlike ordinary outpatient clinics, an emergency care center sees a variety of patients with diverse diseases and injuries of different levels of severity. Since patients who are in a critical condition face serious consequences, target waiting times must be determined based on patient acuity levels. To reflect the special situation in emergency care centers included in this study, patient flows are formulated using an open Jackson network with multiple patient classes. This paper is unique because of the integration of pooling and prior-

itizing patient classes with the open Jackson network. In particular, a hybrid priority model is presented in which a first-come-first-served discipline is applied in some processes and a priority discipline is applied in other processes in the open Jackson network, in order to minimize waiting times for patients with more urgent concerns. A case study based on actual data from an emergency care center demonstrates that the proposed model of pooling and prioritizing patient classes is effective in decreasing waiting times for higher-priority classes without substantially sacrificing those for lower-priority classes.

References

Bhatnagar, R., V. Saddikutti, and A. Rajgopalan (2007). Contingent manpower planning in a high clock speed industry. *International Journal of Production Research 45*(9), 2051–2072.

Cayirli, T., K. K. Yang, and S. A. Quek (2012). A universal appointment rule in the presence of no-shows and walk-ins. *Production and Operations Management 21*(4), 682–697.

Choi, S., S. Jeon, J. Kim, and K. Park (2019). A newsvendor analysis of a binomial yield production process. *European Journal of Operational Research 273*(3), 983–991.

Dai, T., M. Akan, and S. Tayur (2016). Imaging room and beyond: The underlying economics behind physicians' test-ordering behavior in outpatient services. *Manufacturing & Service Operations Management 19*(1), 99–113.

Kaandorp, G. C. and G. Koole (2007). Optimal outpatient appointment scheduling. *Health Care Management Science 10*(3), 217–229.

Kemper, B., C. A. Klaassen, and M. Mandjes (2014). Optimized appointment scheduling. *European Journal of Operational Research 239*(1), 243–255.

Kim, S. and S. Kim (2015, jul). Differentiated waiting time management according to patient class in an emergency care center using an open Jackson network integrated with pooling and prioritizing. *Annals of Operations Research 230*(1), 35–55.

Techawiboonwong, A. and P. Yenradee (2003). Aggregate production planning with workforce transferring plan for multiple product types. *Production Planning & Control 14*(5), 447–458.

Terwiesch, C. and R. E. Bohn (2001). Learning and process improvement during production ramp-up. *International Journal of Production Economics 70*(1), 1–19.

Van Den Bergh, J., J. Belien, P. De Bruecker, E. Demeulemeester, and L. De Boeck (2013). Personnel scheduling: A literature review. *European Journal of Operational Research 226*(3), 367–385.

Zhou, E., J. Zhang, Q. Gou, and L. Liang (2015). A two period pricing model for new fashion style launching strategy. *International Journal of Production Economics 160*, 144 – 156.