Business School
Chair of Supply Chain Management
Prof. Dr. Moritz Fleischmann

UNIVERSITY OF MANNHEIM
Business School

OPM 701 Research Seminar Supply Chain Management (HWS 2025)

"Current Topics in Supply Chain Management Research"

General Information:

1. The goal of this seminar is to introduce the participants to the conducting of scientific research. It thereby prepares the students for the writing of their MSc thesis. The seminar is geared towards students intending to write their thesis at the Chair of Supply Chain Management.

2. Each participant will explore one of the research papers listed below. The task is to review and critically assess the assigned research paper and to relate it to the corresponding stream of scientific literature. Each participant presents their findings in a written report (about 20 pages) as well as in a presentation (20 min + 20 min discussion).

3. A **kick-off meeting** for all participants will be held on **Wednesday, 28 May, at 15:30** (room O 226-28). General guidelines for conducting a scientific literature review will be discussed and the deliverables of the seminar will be explained in detail.

4. The written reports must be **submitted** electronically and as a hard copy in twofold by **Tuesday, 4 November**.

5. The **presentations** will be held as a blocked session, most probably on **13 and 14 November** (subject to change; exact times and room to be announced).

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

7. As the seminar is usually attended by a class of international students, the report and the presentations should be delivered in English.

8. There is a **joint application process** for all seminars offered by the chairs of the Area Operations Management. In HWS 2025, this includes the following seminars:

   - OPM 701: Research Seminar Supply Chain Management (Chair of Supply Chain Management), **labeled with 'L'**
   - OPM 760: Project Seminar Operations Analytics (Chair of Production Management), **labeled with 'P'**
   - OPM 761: Research Seminar Production Management (Chair of Production Management), **labeled with 'P'**
   - OPM 781: Research Seminar Service Operations (Chair of Service Operations Management), **labeled with 'S'**
   - OPM 791: Research Seminar Procurement (Chair of Procurement), **labeled with 'B'**

Detailed information on the seminar topics is available on the home pages of the respective chairs. In their application, students can indicate three to five preferred topics from all seminars.

9. Applications are open within the period **2 – 16 May**. Students must join the ILIAS group Seminar Application Area Operations and complete the **application form** there.

10. Additionally, students applying for a topic of OPM 701 must send an e-mail to scm@uni-mannheim.de, titled "Seminar Application Documents", including **a current CV and a grades overview**. If you are applying for topics of the other chairs, please check if you must send documents to them as well.

11. For any questions concerning the seminar, feel free to contact Katrin Waßmuth at katrin.wassmuth@uni-mannheim.de.

Seminar topics:

Each participant will be assigned one of the **topics listed below**. The task then is to identify the main issues addressed by the paper, explain its methodology, including potential quantitative models, position it in the corresponding stream of scientific literature, and critically assess the paper's contribution to the literature as well as to practice.

<u>Topic L01</u>: Jiang, Z.-Z., Li, K., Tang, C. S., & Yang, S. A. (2025). Offering EV Battery Swapping as a Service: EV Manufacturers or Battery Producers? *SSRN Electronic Journal*, Preprint.

Problem Definition. To accelerate EV adoption and overcome the limitations of traditional EV charging – such as long charging time and lack of access to home chargers for urban residents – Battery as a Service (BaaS) has emerged as a promising alternative. Under the BaaS model, customers can purchase the vehicle body without owning the battery packs. By paying a battery service fee, customers can swap depleted batteries for fully charged ones at battery-swapping stations. Implementing the BaaS model requires investment and operation of battery-swapping stations. As both EV manufacturers and battery producers venture into this domain, it raises the question: which party is better positioned to build and operate such infrastructure? Methodology. We develop a game-theoretical model with one battery supplier and one vehicle manufacturer to compare two BaaS operating models. In the "manufacturer-operated" model (Model-M), the vehicle manufacturer procures EV batteries from the supplier and invests in and operates the battery swapping stations. Conversely, in the "supplier-operated" model (Model-S), the vehicle manufacturer sells battery-free EVs to customers while the supplier invests and operates the battery swapping stations. Results. Model-S can induce a higher number of battery swapping stations being built. However, Model-M always entices more customers to adopt EVs and generates higher profits for the manufacturer. Interestingly, Model-M may also be preferred by the supplier, despite requiring the supplier to cede some decision-making authority. Extending the model to include two competing EV manufacturers, we reveal that the relative efficiency between Model-M and Model-S hinges on the degree of downstream competition. Specifically, while Model-M tends to be socially optimal in low-competition environments, Model-S gains ground as competition intensifies. Finally, we identify scenarios when the two parties favor different BaaS operating models and design governments mediation that helps resolve such conflicts. Implications. By elucidating how different operational and economic factors affect the relative merits between the two BaaS operating models, our paper offers insights for industry leaders and policymakers in determining which party should lead the effort of investing and operating the BaaS model.

<u>Topic L02</u>: Wijnsma, S. C., Lauga, D. O., & Toktay, L. B. (2024). Treat, Dump, or Export? How Domestic and International Waste Management Policies Shape Waste Chain Outcomes. *Management Science*, 70(11), 7397-7421.

Illegal or unwanted waste disposal methods such as dumping and export are prevalent in practice. To minimize the environmental harm of these methods, policymakers have implemented laws and regulations designed to combat them. Even so, violations are rampant as a high degree of heterogeneity between firms and proprietary information render monitoring imperfect. Decentralized waste disposal chains, a common form of interbusiness organization in this sector, compound this problem as firms also have limited information available on their waste chain partner, creating complex interactions between firm behavior and policy interventions. Against this background, we analyze the effects of domestic and international waste regulations targeting dumping and export, respectively, on firm incentives and compliance. We develop a two-tier waste chain with a producer that generates waste and an operator that treats it. The producer's waste quality and the treatment operator's efficiency can be private information. Either party can avoid compliance cost by violating regulations where the producer can arrange for export and the operator can dump locally. Our analysis reveals that primarily focusing on penalizing dumping by treatment operators can worsen environmental harm. Solely focusing on penalizing low-quality waste exports, a common intervention in

practice, can also backfire. Instead, penalizing producers for downstream dumping should be given consideration. In addition, the asymmetry in export burden between waste quality levels should be reduced.

Topic L03: Pina-Pardo, J. C., Moreno, M., Barros, M., Faria, A., Winkenbach, M., & Janjevic, M. (2022). Design of a two-echelon last-mile delivery model. *EURO Journal on Transportation and Logistics*, 11, 100079.

Due to high congestion in cities and growing demand for last-mile delivery services, several companies have been implementing two-echelon distribution strategies over the past few years. Notably, the installation of urban transshipment points has gained increasing attention, used by logistics operators to transfer goods from large freight trucks to smaller and more agile vehicles for last-mile delivery. Nevertheless, the main challenge is how to decide the number and location of these facilities under the presence of demand uncertainty. In this paper, we develop a two-stage stochastic program to design two-echelon last-mile delivery networks under demand uncertainty. This approach decomposes the problem into strategic decisions (facility location) and operational decisions (daily distribution of goods). To address large-scale instances, we solve the model through the sample average approximation (SAA) technique and estimate the optimal routing costs (of the SAA counterpart) using a continuous approximation method. Using a real-world case study with more than 1300 customers from New York City, our results provide several managerial insights regarding the mix of transportation modes, facility location, and the impact of allowing the outsourcing of customer demand. We provide extensive validation of the two-stage stochastic program results through a simulation-based approach and the calculation of the value of the stochastic solutions.

Topic L04: Setiawan, F., Bektaş, T., & Iris, Ç. (2025). The role of hubs and economies of scale in network expansion. *Omega*, 131, 103220.

Freight distribution often operates on the basis of consolidation, which is achieved through the use of hub facilities that allow for economies of scale. Freight networks need to be expanded to meet future demand, to cater for new markets, and to accommodate trends in global supply chains, for which strategic decisions need to be made. These decisions mainly entail the number and location of new hubs to be established. As network expansions require significant capital, striking a balance between the benefits afforded by the new hubs and the expansion costs is crucial. This paper investigates a hub network expansion problem where the configuration of the resulting network is determined by the trade-off between the fixed costs of locating new hubs and new links, as well as routing costs of shipping commodities, and the cost reductions achieved through economies of scale, without imposing a predetermined network structure. This paper also describes a mixed integer programming formulation of the problem and a Benders decomposition algorithm that uses several enhancement techniques to efficiently solve the model to optimality. The application of the algorithm on a real-life case study arising in the expansion of the Indonesian freight transport network yields several managerial insights. In particular, expanding the network with additional hubs and links can yield substantial cost savings, averaging at 47.6%, although at the expense of an increase in the length of the commodity paths. Failing to operate the network at the selected level of economies of scale can result in an increase in the routing costs by up to 58.8%. Expanding the network with no additional hubs leads to a rise in total costs of up to 20.9%. Finally, lower economies of scale

leads to an increase in the length of commodity paths, with the routing cost being identified as the most sensitive parameter.

Topic L05: Dou, G. & Choi, T.-M. (2024). Compete or cooperate? Effects of channel relationships on government policies for sustainability. *European Journal of Operational Research*, 313, 718-732.

The importance of sustainability has led governments worldwide to impose emission regulations on manufacturers. However, it is largely unknown how channel relationships between manufacturers (i.e., competitive or cooperative) affect government policies, such as the emission tax price. In this paper, we address this pertinent yet underexplored issue by building formal analytical models. In the context of different channel relationships and with the goal of increasing social welfare, we also explore whether providing positive incentives is more effective than imposing taxes. We show that although cooperation leads to better economic performance, competition may be the channel relationship that better improves sustainability and social welfare. We find that government incentives to promote green technology need not be effective in enhancing sustainability. If investment is needed to fund green technology, increasing taxes on greenhouse gas emissions (hereafter "emissions") can protect the environment only if the product's initial emission intensity is sufficiently high. We also reveal that the total emissions are not necessarily decreased when (i) the consumers are more environmentally aware and (ii) there is a reduction in emission-abatement costs. Finally, we generalize our model to the extended modeling cases with (i) N-manufacturer and (ii) market segments with a proportion of environmentally aware consumers. Our main conclusions remain valid in the extended cases. The practical relevance and real-world implications of these results are discussed.

Topic L06: Fan, X., Chen, K., & Chen, Y.-J. (2023). Is Price Commitment a Better Solution to Control Carbon Emissions and Promote Technology Investment? *Management Science*, 69(1), 325-341.

Recent years have seen considerable debate about the practicability of a global quantity/price commitment to control carbon emissions and tackle environmental issues. In this paper, we study the impact of the cap-and-trade policy (quantity commitment) and the carbon tax policy (price commitment) on a firm's technology investment and production decisions. The main feature captured in our model is that there exist correlated uncertainties between the sales market (demand uncertainty) and the permit trading market (permit price volatility) under the cap-and-trade policy. The correlation relationship stands on the following intuition. The demands for final products affect firms' production output, which generates the needs of emission permits and influences the permit price. We show that under the cap-and-trade policy, with the uncertainty of the future emission price, the firm could flexibly adjust its production quantity to enhance its profit, resulting in low incentives to invest in clean technology. However, as the (positive) correlation between the sales market and the permit trading market increases, the production flexibility is constrained so that the firm has to increase its technology investment to hedge against the future risk of a high emission price. Making a comparison between the cap-and-trade and carbon tax policies, we find that when the correlation coefficient is moderate, the carbon tax policy generates a multiwin situation (i.e., more technology investment, higher expected profit and consumer surplus, and fewer carbon emissions). Case studies are provided to illustrate the implications and model variants are examined to check the robustness of the

main results. Overall, our analysis sheds light on recent debate over carbon pricing and identifies the important role of correlated uncertainties in carbon policy design.

Topic L07: Liu, X., Hu, M., Peng, Y., & Yang, Y. (2024). Multi-Agent Deep Reinforcement Learning for Multi-Echelon Inventory Management. ***Production and Operations Management*****, Forthcoming.**

We apply heterogeneous-agent proximal policy optimization (HAPPO), a multi-agent deep reinforcement learning (MADRL) algorithm, to the decentralized multi-echelon inventory management problems in both a serial supply chain and a supply chain network. We also examine whether the upfront-only information-sharing mechanism used in MADRL helps alleviate the bullwhip effect. Our results show that policies constructed by HAPPO achieve lower overall costs than policies constructed by single-agent deep reinforcement learning and other heuristic policies. Also, the application of HAPPO results in a less significant bullwhip effect than policies constructed by single-agent deep reinforcement learning where information is not shared among actors. Somewhat surprisingly, compared to using the overall costs of the system as a minimization target for each actor, HAPPO achieves lower overall costs when the minimization target for each actor is a combination of its own costs and the overall costs of the system. Our results provide a new perspective on the benefit of information sharing inside the supply chain that helps alleviate the bullwhip effect and improve the overall performance of the system. Upfront information sharing and action coordination in model training among actors is essential, with the former even more essential, for improving a supply chain's overall performance when applying MADRL. Neither actors being fully self-interested nor actors being fully system-focused leads to the best practical performance of policies learned and constructed by MADRL. Our results also verify MADRL's potential in solving various multi-echelon inventory management problems with complex supply chain structures and in non-stationary market environments.

Topic L08: Oroojlooyjadid, A., Nazari, M., Snyder, L. V., & Takáč, M. (2022). A Deep Q-Network for the Beer Game: Deep Reinforcement Learning for Inventory Optimization. ***Manufacturing & Service Operations Management*****, 24(1), 285-304.**

Problem definition: The beer game is widely used in supply chain management classes to demonstrate the bullwhip effect and the importance of supply chain coordination. The game is a decentralized, multiagent, cooperative problem that can be modeled as a serial supply chain network in which agents choose order quantities while cooperatively attempting to minimize the network's total cost, although each agent only observes local information. Academic/practical relevance: Under some conditions, a base-stock replenishment policy is optimal. However, in a decentralized supply chain in which some agents act irrationally, there is no known optimal policy for an agent wishing to act optimally. Methodology: We propose a deep reinforcement learning (RL) algorithm to play the beer game. Our algorithm makes no assumptions about costs or other settings. As with any deep RL algorithm, training is computationally intensive, but once trained, the algorithm executes in real time. We propose a transfer-learning approach so that training performed for one agent can be adapted quickly for other agents and settings. Results: When playing with teammates who follow a base-stock policy, our algorithm obtains near-optimal order quantities. More important, it performs significantly better than a base-stock policy when other agents use a more realistic model of human ordering behavior. We observe similar results using a real-world data set. Sensitivity analysis shows that a trained model is robust to changes in the cost coefficients. Finally, applying transfer learning reduces the training time by one order

of magnitude. Managerial implications: This paper shows how artificial intelligence can be applied to inventory optimization. Our approach can be extended to other supply chain optimization problems, especially those in which supply chain partners act in irrational or unpredictable ways. Our RL agent has been integrated into a new online beer game, which has been played more than 17,000 times by more than 4,000 people.

Topic L09: Fang, Y., Yu, Y., Shi, Y., & Liu J. (2020). The effect of carbon tariffs on global emission control: A global supply chain model. *Transportation Research Part E*, 133, 101818.

This paper investigates the effect of carbon tariffs on global emission control. We propose a global supply chain model consisting of a retailer in an emission-regulated country and supplier in a non-emission-regulated country. The equilibrium solutions are obtained, and the effects of a carbon tariff on global emission control are studied. Through analytical study and numerical study, we find that a carbon tariff does not necessarily reduce global emissions under certain circumstances. The paper discusses insights and the carbon tariff policy implications from this finding.

Topic L10: Huang, X., Tan, T., & Toktay, L. B. (2021). Carbon Leakage: The Impact of Asymmetric Regulation on Carbon-Emitting Production. *Production and Operations Management*, 30(6), 1886-1903.

Regions with carbon emission regulations bear the risk of “carbon leakage” if local producers shift production capacity to an unregulated region. We investigate the problem for a producer subject to geographically asymmetric emission regulation with uncertain future emission price. The producer has two ex ante options to lower its compliance cost: investing in clean production technology in the regulated region and building production capacity in the unregulated region. The producer determines its production quantities ex post, after emission price uncertainty is resolved. We study two anti-leakage policies, Border Tax (BT) and Output-Based Allocation (OB), where the former adopts a “stick” approach that penalizes offshore production and the latter adopts a “carrot” approach that grants free emission allowances for production in the regulated region. First, we show that the emission price uncertainty can exert opposing effects in the absence of an anti-leakage policy: When the expected emission price is low (high), a higher uncertainty aggravates (mitigates) carbon leakage. Second, through a comprehensive comparison, we highlight that while both BT and OB are able to reduce carbon leakage, BT has a stronger effect in both the regulated and unregulated regions in multiple dimensions, especially when the carbon leakage risk is high. Third, we find that a higher emission price uncertainty weakens the effect of both BT and OB. We therefore suggest that emission price uncertainty should be accounted for when formulating anti-leakage policies. Finally, we extend our analysis to a competitive case and find that the superiority of BT relative to OB is enhanced.