Activity Report

2020

Mercator Endowed Chair of Demand Management & Sustainable Transport

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FOREWORD

2020 has been an eventful year for everyone, and in particular for the newly created Mercator Chair. Much effort has been spent this year on building up the Chair, finding excellent team members, creating course materials and much more (not to mention the birth of my second son and an international move of a full household, both during the Corona crisis). I would like to use this opportunity to thank my team here at the Chair as well as at WHU in general for all their outstanding support.

The first iteration of various courses in the BSc, MSc and PhD programmes have been successfully run, with excellent – average mark “sehr gut” – feedback in every course. It is a pleasure to teach at WHU given the very engaged and capable student body! Sustainability and data-driven modelling are important topics, and it is great that student interest is reflecting this. Going forward, further course developments are planned in the MBA programme as well.

The Horizon 2020 project CADENZA kicked off in the summer and we are excited to be able to continue working in the field of air traffic management, this time in conjunction with Eurocontrol in addition to various academic consortium members. Despite not being able to meet in person, the consortium came off with a good start to embark on the planned agenda of building the core concept of a future European air traffic management system. The project builds on the previous Horizon 2020 project COCTA for which we won the international Jane’s ATC Innovation Award 2019.

A research project with Slicker Recycling (a waste oil collection and recycling company) is nearing completion, being scheduled to end in mid 2021. We developed a mechanism to dynamically contact potential customers (garages and workshops) in anticipation of their need for waste oil collection in a way so as to reduce overall mileage (and thereby emissions). Our data-driven approach to contacting customers dynamically already has been successfully been implemented.

For 2021, various new projects are being planned, both in collaboration with other academics and with industry. I am looking forward to it!

Best wishes,

Prof. Dr. Arne K. Strauss
1 TEAM

Professor Dr. Arne Strauss
Chairholder

Tel. +49 261 6509 – 750
arne.strauss@whu.edu

Dr. Arne K. Strauss is Professor for Demand Management & Sustainable Transport at WHU – Otto Beisheim School of Management since the beginning of the year 2020. Previously, he held positions as Associate Professor of Operational Research in the Operations Group at Warwick Business School and as Turing Fellow at The Alan Turing Institute in London.

He was the Academic Director of Warwick Business School’s MSc Business Analytics programme (ranked by QS in the global top 10) and served as external examiner in the MSc Business Analytics programmes at Imperial College London, University of Southampton and Manchester Metropolitan University. Furthermore, he is a member of the Analytics Curriculum Advisory Group of the accreditation body AACSB.

He is a member of the Strategic Advisory Team (Mathematical Sciences) of the British Engineering and Physical Sciences Research Council, the Research Panel of The Operational Research Society and the "Big Mathematics Initiative" of the British Council of Mathematical Sciences. He serves as referee for various international journals such as European Journal of Operational Research, Production & Operations Management, Transportation Research Part B, Management Science and Operations Research.
Johanna Häring
Personal Assistant

Tel. +49 261 6509 - 777
johanna.haering@whu.edu

Since May 2020 has been Johanna Häring the Personal Assistant of the Chair.

Jan Rasmus Künnen
Research Assistant – Doctoral Candidate

Tel. +49 261 6509 – 776
jan-rasmus.kuennen@whu.edu

Jan-Rasmus Künnen (born in 1993) joined the Mercator Endowed Chair of Demand Management & Sustainable Transport at WHU as an doctoral student and research assistant in May 2020. He holds a B.Sc. in International Business from Maastricht University and M.Sc. in Operations Research from the London School of Economics. His studies focused on applying quantitative methods (simulation, game theory, modeling) to transportation and logistics problems. The focus of his thesis was on modeling distance constraints in vehicle routing. After graduation, Jan-Rasmus Künnen worked as a consultant with McKinsey & Company, specializing in supply chain and operations transformations.
During his two years, he worked on projects across industries in Europe, South Africa and Canada. His research interests lie in mathematical modeling, transportation optimization and machine learning.

Dr. Bahar Rezaei
Post-Doctoral Researcher

Tel. +49 261 6509 -778
Bahar.rezaei@whu.edu

Dr. Bahar Rezaei is a research fellow for Demand Management & Sustainable Transport at WHU – Otto Beisheim School of Management since October 2020, employed on the Horizon 2020 project CADENZA. Her research lies at the interface between economics and operations management and has strong ties with mechanism design, network economics, behavioral decision-making, and sustainable business operations.

Bahar Rezaei finished her Ph.D. in economics with Utrecht University and her M.Sc. in mathematics with Amirkabir University of Technology. Before joining WHU, she was a research fellow at UCLA Anderson School of Management, Department of Decision, Operations & Technology Management.
2 TEACHING

2.0 Teaching Innovation

In light of the Corona restrictions, teaching moved in 2020 and early 2021 first to hybrid and then to pure online teaching. Likewise, exams were administered online. To enable an experience as close as possible to face-to-face teaching, the Mercator Chair introduced the usage of broadcasting software that allows to combine the video source of the presenter with any other media, e.g. slides, PDF files, programming studio environments, spreadsheets etc (see screenshots below).

Figure 1: Screenshot of Sustainable Urban Transport online lecture.

Figure 2: Screenshot of Data Science for Business online lecture (working with R Studio).
Furthermore, students work in online breakout groups on live case studies, and report on their findings in the plenary; all courses use a format of going back and forth between lecture-style presentations and applied activities. There is no distinction between lectures and workshops; both take turns in each session. At the end of each teaching session, time is being reserved for general feedback, questions or for a casual chat, mimicking the usual informal chats following a face-to-face lecture.

2.1 BACHELOR OF SCIENCE PROGRAMME

2.1.1 Data Science for Business

This course is dedicated to conveying a sense of how analytics projects work so as to be able to manage them and/or assess their merit.

It is not a modelling course - although we will do modelling. It is also not a programming course - although we will do plenty of programming in R. Instead, the modelling and programming just serves as an illustration of the steps featured in typical analytics projects. This should help in the planning of such a project, starting from understanding of the business problem over modelling up to model assessment and communication of the project's results (or a project proposal) to a client.

There is no classic split between lecture sessions and tutorial sessions; instead, lecture elements, practical demonstrations and exercises are mixed together in all sessions so as to create a more engaging environment. In an assessed groupwork, you will go through all the stages of a data science project including shaping the business objectives and connecting the modelling results to them.

We will also cover visualization concepts in both theory and practice, using Tableau for the latter.
In particular, we will look into dashboard design, interactive maps (such as the one shown in Fig 1) and charts, and how to structure sales pitches.

The syllabus looks as follows:

- Introduction to the CRISP-DM process (business understanding)
- Sampling and Partitioning (data preparation)
- Information selection, modelling and overfitting (modelling)
- Model evaluation
- Evidence combination (Naïve Bayes, association mining) and visualization
- Visualization, dashboards, selling your project to end users

### 2.1.2 Pricing Analytics

Pricing analytics and revenue management focuses on how a firm should model demand, set and update automated pricing and product availability decisions across its various selling channels in order to maximize its profitability. The use of such strategies has transformed the transportation and hospitality industries, and they are increasingly important in retail, telecommunications, entertainment, financial services, health care and manufacturing.

Within the broader area of pricing theory, the course places emphasis on tactical optimization of pricing and capacity allocation decisions, tackled using demand modeling and constrained optimization – the two main building blocks of revenue management systems.

Case studies provide hands-on experience of the subject. Students are using R for most of the exercises within the RStudio environment, involving training on both demand modeling and optimization problems. For example, in the context of B2B customized pricing, we look into the question of how to estimate the win probability function from historical data and how to use this to optimize individual price quotes.

The syllabus consists of the following:

- Introduction, customer valuation game
- Demand modelling (parametric, non-parametric models, unconstraining)
- Constrained price optimization, capacity control, network revenue management
- Dynamic price control, (approximate) dynamic programming
- Markdown pricing, behavioural pricing
- Customized B2B pricing, win probability function estimation

### 2.1.3 Sustainable Urban Transport

This course is concerned with creating awareness of what is currently happening in the domain of sustainable mobility and transport solutions. Moreover, we will discuss how to evaluate innovative business models, assess their eco-efficiency and sustainability potential, and consider some data-driven modelling approaches that help to achieve sustainability.
The course features several case studies to illustrate the concepts in a hands-on fashion. Content-wise, we look at post-Covid-19 trends, sustainability assessment, green vehicles (electric, shared mobility, autonomous driving), innovative logistics concepts and on-demand air mobility.

Content:

- **Introduction.** We start with an investigation of why transport is an important factor in reducing GHG emissions. Implications of the Corona virus pandemic on transport and mobility. Case study of an innovative business idea (centres to remotely control various types of vehicles).

- **Connectivity & Autonomy:** Current trends on both subjects. Game changing aspects, in particular concerning new business models and effects across the whole economy.

- **Electrification.** Why it is important and sensible. Commercial buyers and fleet electrification. Private car buyers and how to motivate them. Tesla case study.

- **Smart Mobility and Logistics.** Car sharing, circular economy concepts in transportation, sustainability in last-mile logistics, break-even analysis for an underground freight transportation system.

- **Urban Air Mobility:** VTOL background, use cases, sustainability. Case study Uber Elevate. Business models related to "flying cars". Excursion to international flight management.

**2.2 MASTER OF SCIENCE PROGRAMME**

**2.2.1 Data Science for Business**

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There is no classic split between lecture sessions and tutorial sessions; instead, lecture elements, practical demonstrations and exercises are mixed together in all sessions so as to create a more engaging environment. In an assessed groupwork, you will go through all the stages of a data science project including shaping the business objectives and connecting the modelling results to them.

We will also cover visualization concepts in both theory and practice, using Tableau for the latter. In particular, we will look into dashboard design (and create a few such as the one in Fig. 1), interactive maps and charts, and how to structure sales pitches.
The syllabus looks as follows:

- Introduction to the CRISP-DM process (business understanding)
- Sampling and Partitioning (data preparation)
- Information selection, modelling and overfitting (modelling)
- Model evaluation
- Evidence combination (Naïve Bayes, association mining) and visualization
- Visualization, dashboards, selling your project to end users
- Tableau: using web data connectors, calling R from within Tableau, and other more advanced topics

2.3 PHD PROGRAMME

2.3.1 Fundamentals of Optimization

Optimization is important to many applications in business, be that finance, operations, marketing or others. This course aims to provide a broad overview of the concepts that underpin optimization to help students to gain an understanding of what type of optimization problem they may be dealing with in their studies, and how this could be tackled.

Coverage includes:

- Structure of an optimization problem
- Deterministic versus stochastic optimization
- Continuous versus discrete optimization
- Constrained versus unconstrained optimization
- Fundamentally important concepts like convexity, duality, complexity, total unimodularity, ...
- Introduction to various techniques including linear and non-linear mathematical programming, (approximate) dynamic programming for control problems, optimal learning

We do not delve overly deep into the topics due to time constraints; instead, the focus is on imparting an intuitive understanding of optimization techniques and of structures that can be exploited. The intention is to make this course useful and relevant to any students who face some form of optimization problem and who do not yet have received formal training in optimization.

Various applied examples are used to illustrate the use of optimization techniques, for instance in the context of incentive allocation to induce a shift of delivery traffic to off-hours.
3 THESES

3.1 BSc PROGRAMME

- Maurice Schneider
  Charging for food delivery – what is the right price at the right time?

- Paul Wilhelm Patt
  EV adoption in Germany – what are enablers and barriers to an electric transition? (logistics)

- Simon Weber & Kilian Dötsch
  Delivery by drone – how can radical innovation reshape last-mile logistics?

- Moritz Hannig
  Covid impact on sustainable transport – what business models arise in the pandemic?

- Moritz Müller
  In line with Paris - what mobility mix is needed to achieve the 1.5° science-based target?

- Miron Fritz
  Does adopting a circular economy business model affect the share price of a company? (Roland Berger)

- Christopher Haas & Christian Burkhardt
  EV adoption in Germany – what are enablers and barriers to an electric transition?

3.2 MSc PROGRAMME

- Huy Phan-Ha-Minh.
  Dynamic credit product pricing using machine learning.

- Ha Nguyen.
  Exploiting AirBnB data in hotel revenue management

- Ngan Nguyen
  Demand modelling for bike sharing

- Niklas Brackmann
  Can flying cars help to achieve sustainable mobility?

- Shijia Liu
  Market mechanisms to match empty truck legs with transport demand
4 RESEARCH

The Chair is involved in various projects related to the theme of demand management and sustainable transport. We list below the work that has appeared in the public domain or that has been submitted; work in progress is not disclosed in this report. In the reporting period, we collaborated with various fellow academics (and practitioners), including colleagues at the University of Mannheim, University of Warwick, Sasin School of Management, and various others.

4.1 REFEREED JOURNAL PUBLICATIONS


4.2 SUBMITTED WORKING PAPERS

Dynamic Multi-Period Vehicle Routing with Touting

Insights on how budget and mid-range hotels can benefit from available competitor price data
4.3 EXTERNALLY FUNDED RESEARCH PROJECTS

CADENZA

The CADENZA Project has been successfully launched on June 1, 2020 and is planned to end around Dec 2022 under the direction of Professor Dr. Arne Strauss (leading the WHU team).

The project CADENZA, short for “Advanced Capacity and Demand Management for European Network Performance Optimization”, aims at developing a detailed trajectory broker concept for the European flight network. It builds upon the findings of the previous SESAR Exploratory Research project COCTA, in which Professor Dr. Strauss was already involved and which won the Jane’s-ATC Innovation Award in 2019, as well as upon latest industry developments. The trajectory broker will balance capacity and demand through a coordinated capacity provision process and collaborative trajectory management (including a novel trajectory charging scheme).

CADENZA covers all areas of capacity provision (en-route, terminal area, and airport) as well as all temporal levels (strategic, pre-tactical and tactical). Based on previous research, the researchers expect significant improvements in cost-efficiency as well as positive impacts on other key performance indicators, especially delays and CO2 emissions.

The CADENZA concept will be thoroughly validated, using mathematical models and comprehensive real-world trajectory data. Sensitivity analysis will incorporate non-nominal conditions as well as different assumptions with respect to the overall air traffic management framework, e.g., different levels of flexibility in capacity provision. Moreover, a high degree of stakeholder involvement – including an industry expert panel and stakeholder workshops – ensures practical relevance. The panel includes representatives from SWISS airlines, Vueling, Thomas Cook Airlines, London Heathrow Airport, Zurich Airport, Lufthansa Systems, NATS among others.

With a share of around €360,000 of the overall project cost of €2 million, the Mercator Chair of Professor Dr. Arne Strauss at WHU will lead the development of innovative methodological approaches to this new problem including scalable optimisation approaches.
SLICKER

Prof. Strauss is working together with colleagues from Warwick Business School (University of Warwick, UK) on a project to improve dynamic route planning in the B2B sector through targeted, pro-active contacting of regular customers. Together with the industry partner Slicker Recycling, the new concept is being developed and is currently being tested. Slicker Recycling is the UK market leader in the collection and recycling of hazardous waste. Its main business is focused on the collection, processing and regeneration of waste oil, which is then sold in the UK or Europe.

The research project aims to reduce CO2 emissions, provide a better customer-oriented service at a lower price and increase customer satisfaction. This will be achieved by improving the speed of collection and by competitive pricing to reach smaller customers. The project combines current research approaches from the fields of dynamic route planning and demand management; the core idea is to forecast the amount of waste oil at each customer and, based on this, to actively contact customers who are likely to have accumulated enough waste oil and whose location is favourable for ongoing route planning.

In a first working paper the approach is presented and it is shown that it allows significant reductions of the distances to be driven. Extensions of the concept are currently being developed. The project is funded by Innovate UK and Slicker Recycling. Innovate UK is a public body funding innovative applied research in the United Kingdom.
5 OUTREACH

5.1 COUNCIL FOR THE MATHEMATICAL SCIENCES

The Council for the Mathematical Sciences (CMS) was established in 2001 by the Institute of Mathematics and its Applications (IMA), the London Mathematical Society (LMS) and the Royal Statistical Society (RSS). The CMS comprises representatives and observers from the mathematical sciences community, including the Presidents and Chief Executives of these three societies. The CMS provides an authoritative and objective body that exists to develop, influence and respond to UK policy issues that affect the mathematical sciences in higher education and research, and therefore the UK economy and society in general.

Prof. Dr. Strauss was part of the Council for the Mathematical Sciences’ “BIG Mathematics Review Panel” from 2019 until the panel was dissolved in June 2020. He contributed to reports to improve knowledge exchange for the mathematical sciences at a national level under leadership of the former Chief Scientific Advisor to the Home Office, Sir Bernard Silverman.

5.2 EPSRC – STRATEGIC ADVISORY TEAM

Prof. Dr. Strauss has been an external member of the committee for the Engineering & Physical Science Research Council (EPSRC) Strategic Advisory Team (Mathematical Sciences) since January 2020. His remit is to advise on research and education funding strategy. EPSRC invests £1 billion per year in research and postgraduate education. Appointment is for 3 years.

The Engineering and Physical Sciences Research Council (EPSRC) is the main funding body for engineering and physical sciences research in the UK. By investing in research and postgraduate training, they are building the knowledge and skills base needed to address the scientific and technological challenges facing the nation.

EPSRC is part of UK Research and Innovation, a new body which works in partnership with universities, research organisations, businesses, charities, and government to create the best possible environment for research and innovation to flourish. They aim to maximise the contribution of each of them component parts, working individually and collectively. They are working with many partners to benefit everyone through knowledge, talent and ideas.

5.3 THE OPERATIONAL RESEARCH SOCIETY

Prof Strauss is a member of the British Operational Research Society’s Research Panel since the panel’s establishment in June 2016. The panel offers strategi guidance to the OR Society on the landscape of research and relevant opportunities and threats. It strives to enable the OR community to access research funding and achieve impact. The panel meets at least three times per year.
6 REFEREE ACTIVITIES

6.1 TRANSPORTATION SCIENCE

Transportation Science is the flagship journal of the Transportation Science and Logistics Society of INFORMS and is the foremost journal in the field of transportation analysis. The journal features comprehensive, timely articles and surveys that cover all modes of transportation, present and prospective, and researches planning and design issues and the related economic, operational, and social concerns.

Transportation Science focuses primarily on fundamental theories, coupled with observational and experimental studies of transportation and logistics phenomena and processes, mathematical models, advanced methodologies and novel applications in transportation and logistics systems analysis, planning and design. The journal reflects the diverse interdisciplinary interests of the transportation science and logistics community, with members that hold primary affiliations in engineering (civil, industrial, and aeronautical), physics, economics, applied mathematics, and business.

6.2 EJOR – EUROPEAN JOURNAL OF OPERATIONAL RESEARCH

The European Journal of Operational Research (EJOR) publishes high quality, original papers that contribute to the methodology of operational research (OR) and to the practice of decision making.

6.3 PRODUCTION & OPERATIONS MANAGEMENT

The mission of Production and Operations Management is to serve as the flagship research journal in operations management in manufacturing and services.

The journal publishes scientific research into the problems, interest, and concerns of managers who manage product and process design, operations, and supply chains. It covers all topics in product and process design, operations, and supply chain management and welcomes papers using any research paradigm.