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Simulation in Revenue Management

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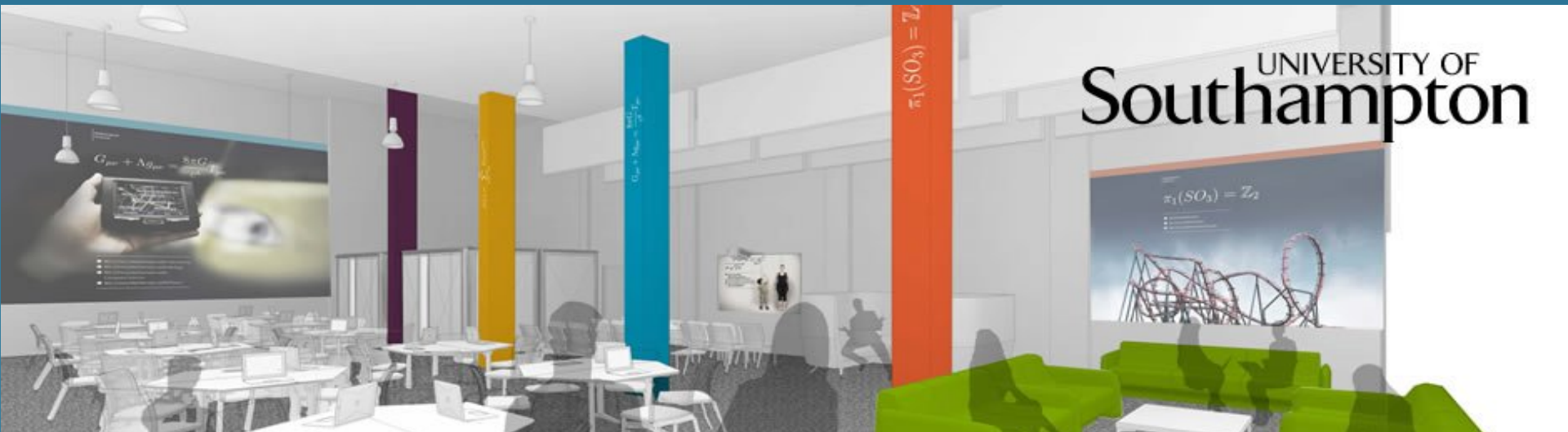
Introduction

- Associate Professor of Operational Research at the University of Southampton
- ~ 10 years experience in RM and simulation
- Projects with British Airways, Ocado, P&O Ferries, Thomas Cook, East Coast and others
- Director of the MSc in Operational Research



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Agenda

- **What** is simulation?
- **Why** is it useful?
- **How** can it be used in RM?
- Conclusion

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Simulation

an introduction

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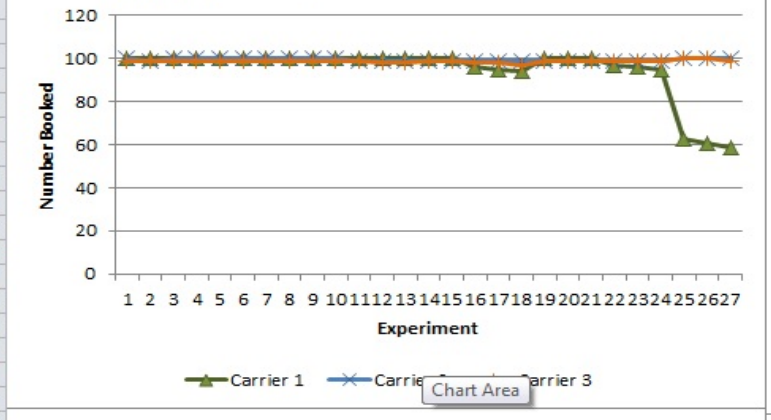
Instead …

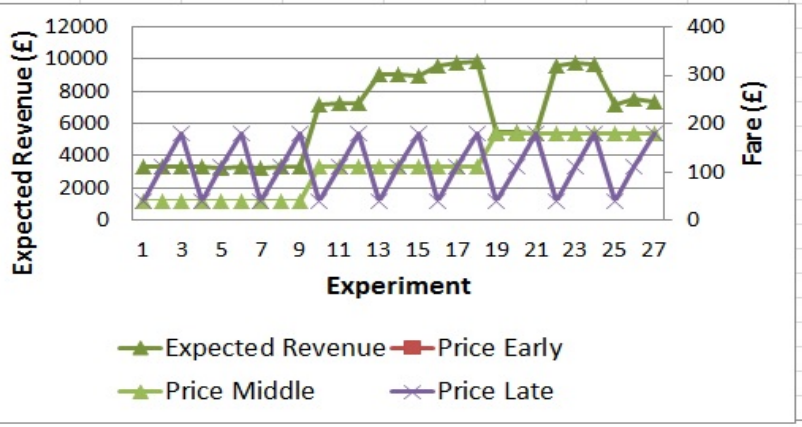
- Process Simulation
  - e.g. call centre
- Market Simulation
  - e.g. effect of competition
- Agent-Based Modelling
  - e.g. impact of individual behaviour on revenue

	Minimum	Maximum	# Increments
Price Range	40	180	2

#Iterations 27

Run Experiments





14
110
110
110
9043.1
12494.3
9014.4
9130
12630
9140
9130
12600
9060
100

Existing Simulation in RM

- **Testing RM Algorithms**
- E.g. PODS
  - Simulation model developed by Boeing and MIT
  - Simulates a competitive market
  - Complex simulation model
- **Simulation Optimization**
  - Stochastic approximation algorithm (Robbins and Munro, 1951)
  - Used to improve heuristics for solving particular optimization problems

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Simulation Education

- Hotel RM simulation: wide range of organisations offering business simulation
  - Useful tool for training people to consider new ideas
- Other examples
  - http://web.mit.edu/urban_or_book/www/animated-eg/ym/
  - Mainly academic

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Why simulate?

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Benefits of Simulation

- Obtain a better understanding of the system
  - e.g. understand interactions between inputs
- Test a new system or process
  - Low-cost method of evaluating a new system or optimisation algorithm: *proof of concept*
- Determine the most efficient way of working
  - Compare different processes on a full range of scenarios
- **Allows development of a robust solution**

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How to simulate

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Typical Simulation Project

1. Collect data and talk to system experts to get a good understanding of the system

2. Build the simulation model: using a package (simple but inflexible) or coding

3. Test the simulation model: is it a good representation of the system?

4. Run some trials: run the simulation for relevant scenarios to get some results

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1. Collect Data and Talk

- Requirements: what's the question?
  - How complex does the model need to be?
  - What data are required?
  - What data are missing?

However much data you have, you will always want more

- Provides an excuse for talking to other interested parties
  - Asking "stupid" questions

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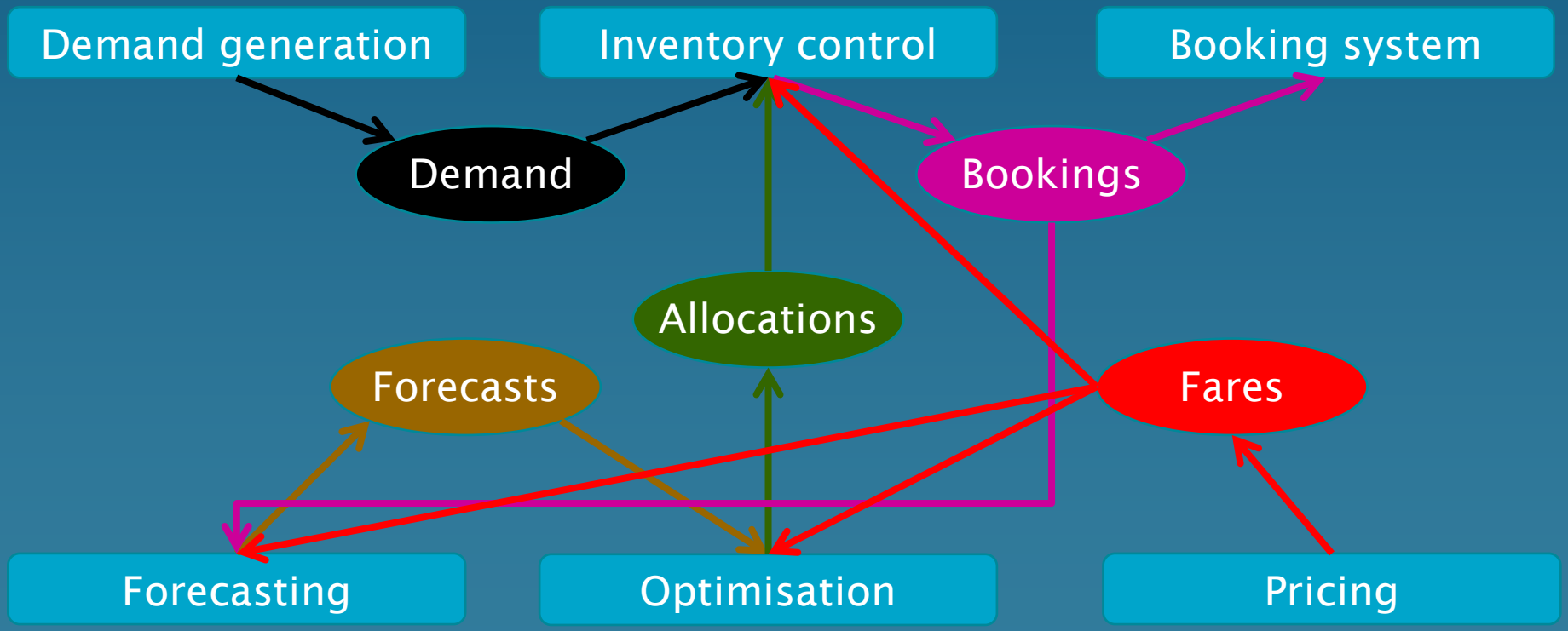
2. Design of an RM Simulation



Adapted from Fig 1 Frank et al., Journal of Revenue and Pricing Management, Vol.7, pp 7-16

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3. Testing!!

Simulation Model

- Sense check: does it react the way that an expert expects it to react?
- Numerical calibration: do the numbers match those seen in the real system?

- **Testing is vital to ensure the model is mimicking the real system**

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4. Run Scenarios

Golden Rule of Simulation
Always use more than one run

- The output is stochastic/random so one run is never enough: find an average
- Account for the validity of the input data
  - Don't go too far outside the observed range
- Take time to set up the right scenarios

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Simulation for Experimentation

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Using Simulation to Set Policies

- Moving beyond testing
- Simulation has a place for
  - Optimizing what is a highly variable system
  - Understanding missing data
  - Allowing all complexities to be included
  - Investigating customer behaviour

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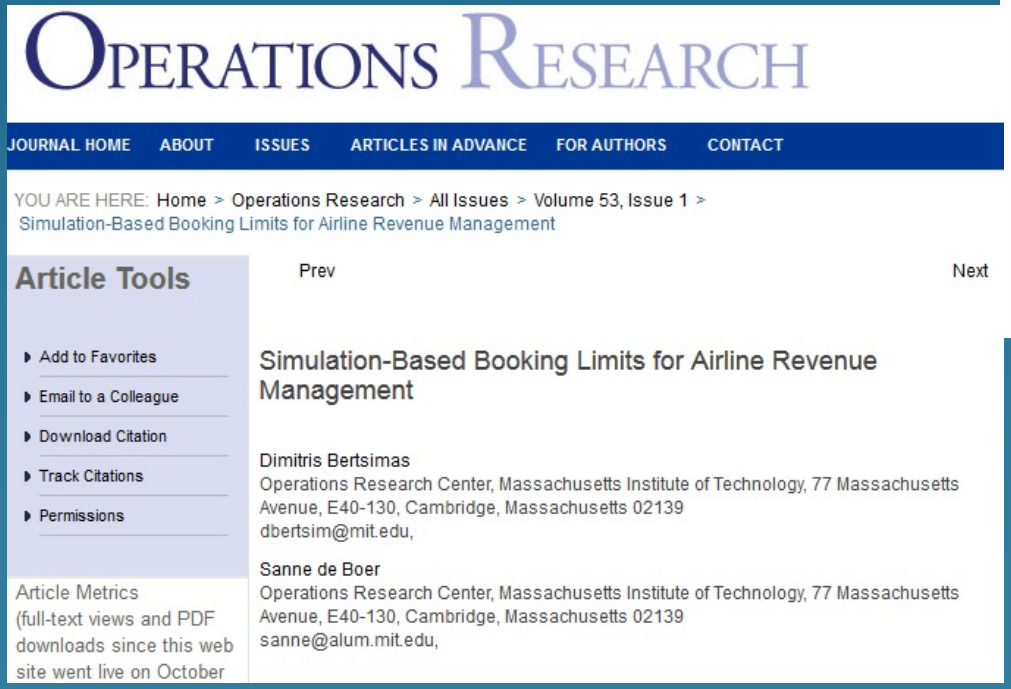
Simulation Optimization

- Using simulation to set booking limits
- Changing the engine inside RM systems



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Simulation-Based Booking Limits for Airline Revenue Management

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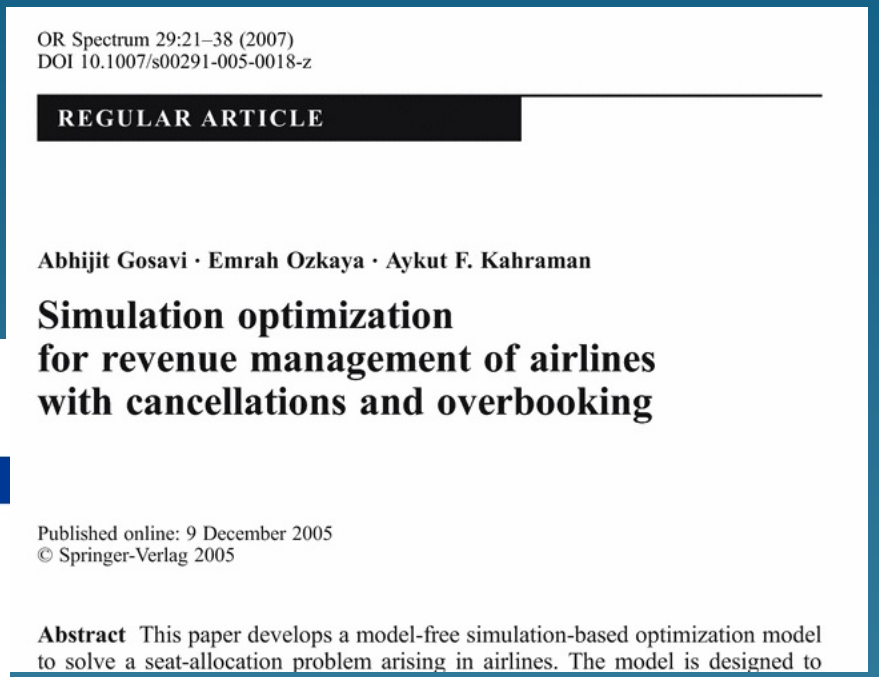

OR Spectrum 29:21–38 (2007)
DOI 10.1007/s00291-005-0018-z

REGULAR ARTICLE

Abhijit Gosavi · Emrah Ozkaya · Aykut F. Kahraman

Simulation optimization for revenue management of airlines with cancellations and overbooking

Published online: 9 December 2005

Abstract This paper develops a model-free simulation-based optimization model to solve a seat-allocation problem arising in airlines. The model is designed to

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Example

3 competitors

No Frills

Our Airline

Established

Increasing price

If all 3 companies charge the same price, customers would purchase from Established

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Competition in RM

- Two types of competition
  - 1. Competition between different companies
  - 2. Competition between different services offered by the same company
- Currie et al. (2008) considers a duopoly where customers base decisions purely on price (type 1 competition)
- Other work utilises the multinomial logit model (MNL) to describe the probability of purchase of different services based on their characteristics (type 2 competition), e.g. Vulcano and van Ryzin, 2010

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Assumptions

- We aim to maximise revenue from an airline
  - Single-leg, single-class, no cancellations
- We focus on optimization of prices
  - Change prices at 2 reading days
  - Allow anyone to book between reading days (up to capacity)

Arrival Rate

- Observation: few bookings early on with an increase to a peak close to departure
- Non-homogeneous Poisson Process
- Rate parameter
  - $f(t) = (f + dt)\exp(-ht)$
- Common assumption in RM (e.g. Zhao and Zheng, 2000; Talluri and van Ryzin, 2005)

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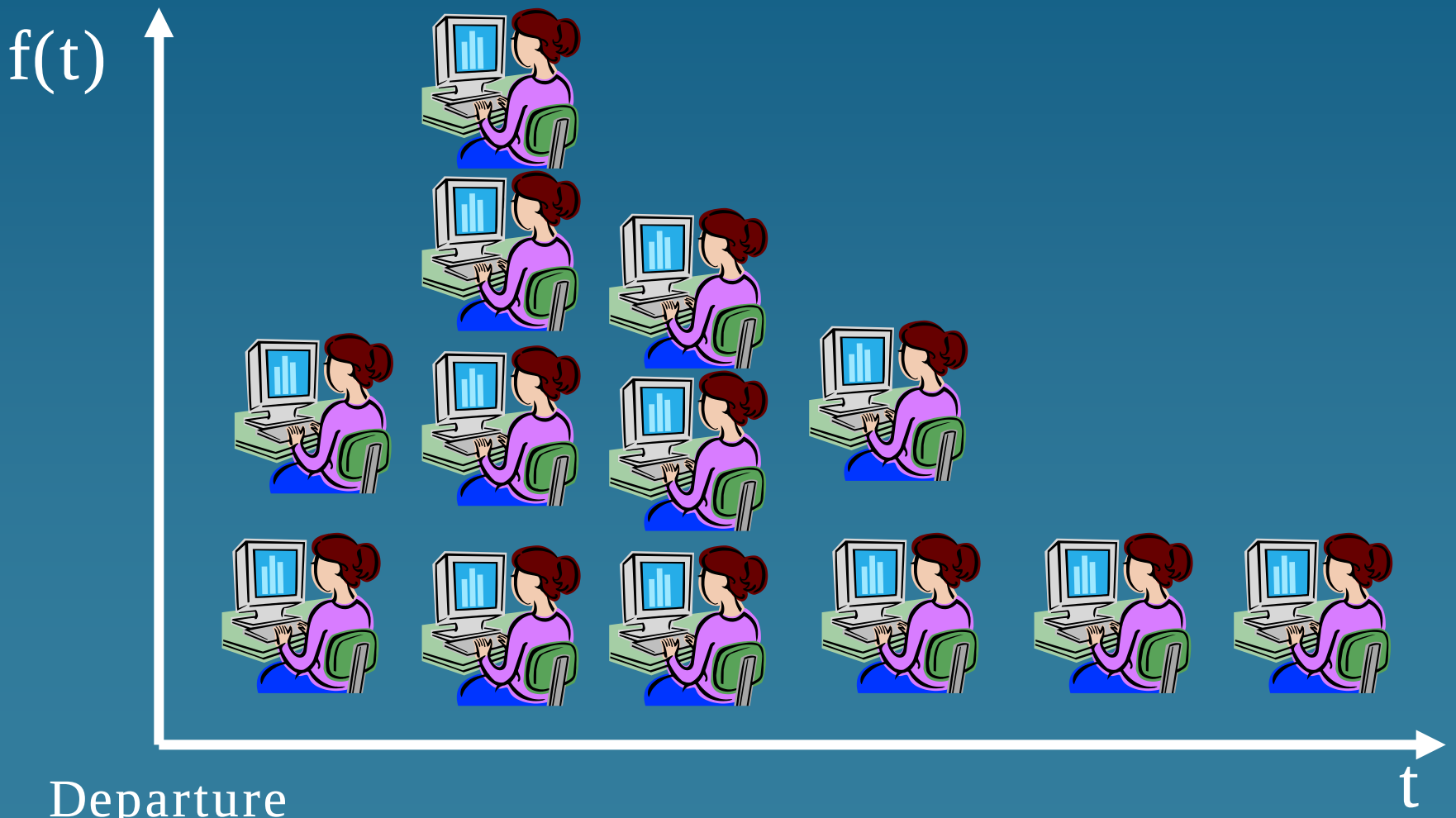
Customer Arrival



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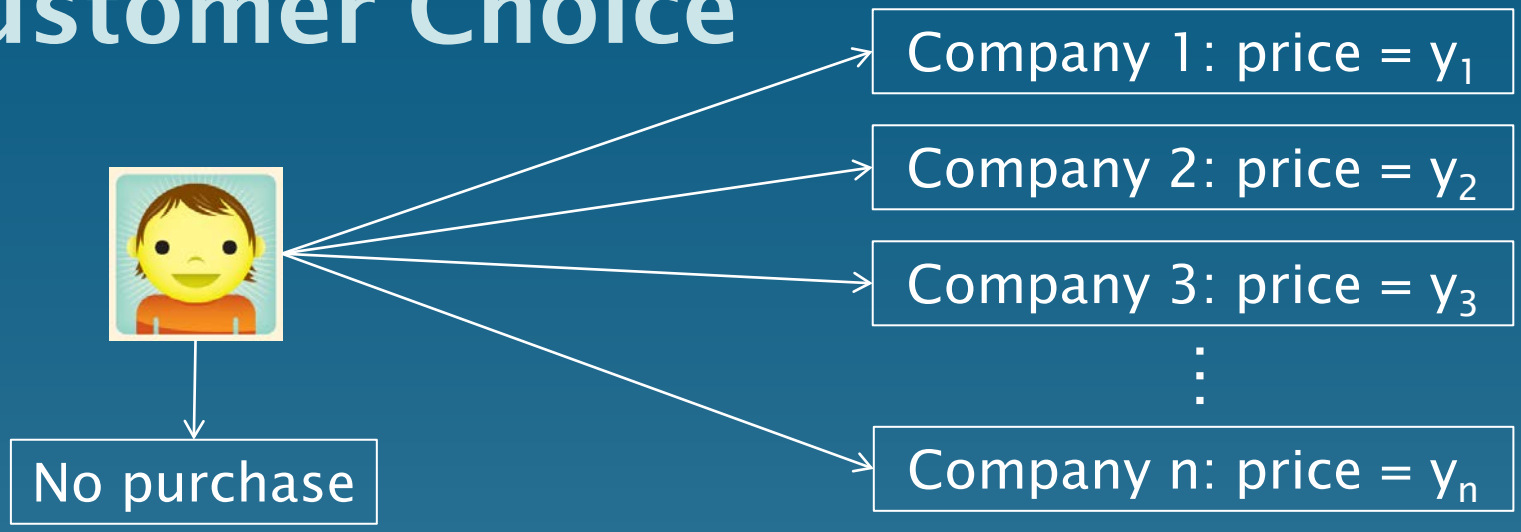
Customer Choice



- A potential customer chooses whether to purchase from company *i* with probability dependent on
  - *Airline*
  - *Time until departure*
  - *Price of ticket*

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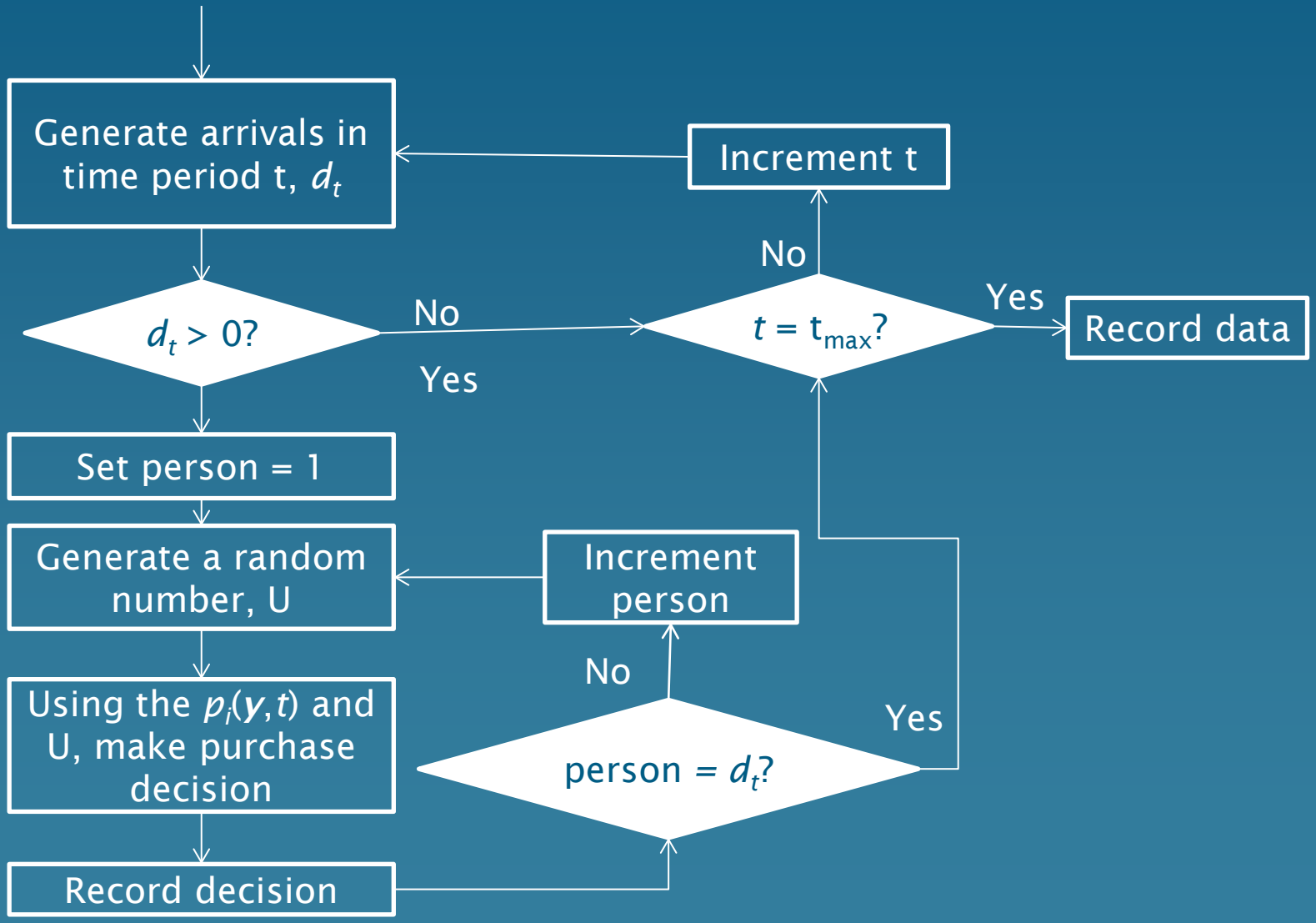
The Simulation Model



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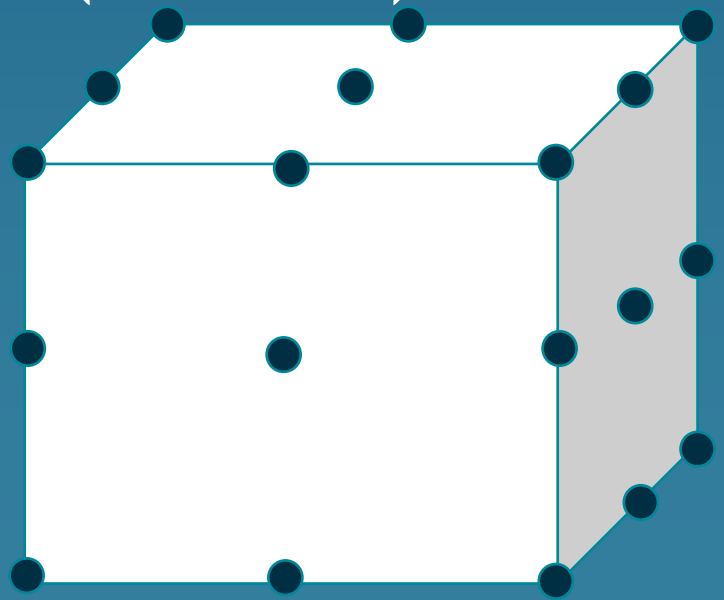
Research Question

- What price strategy should the middle player use?
  - Less preferred than player 2 (Established)
  - Can afford to charge higher prices than player 3 (No Frills)



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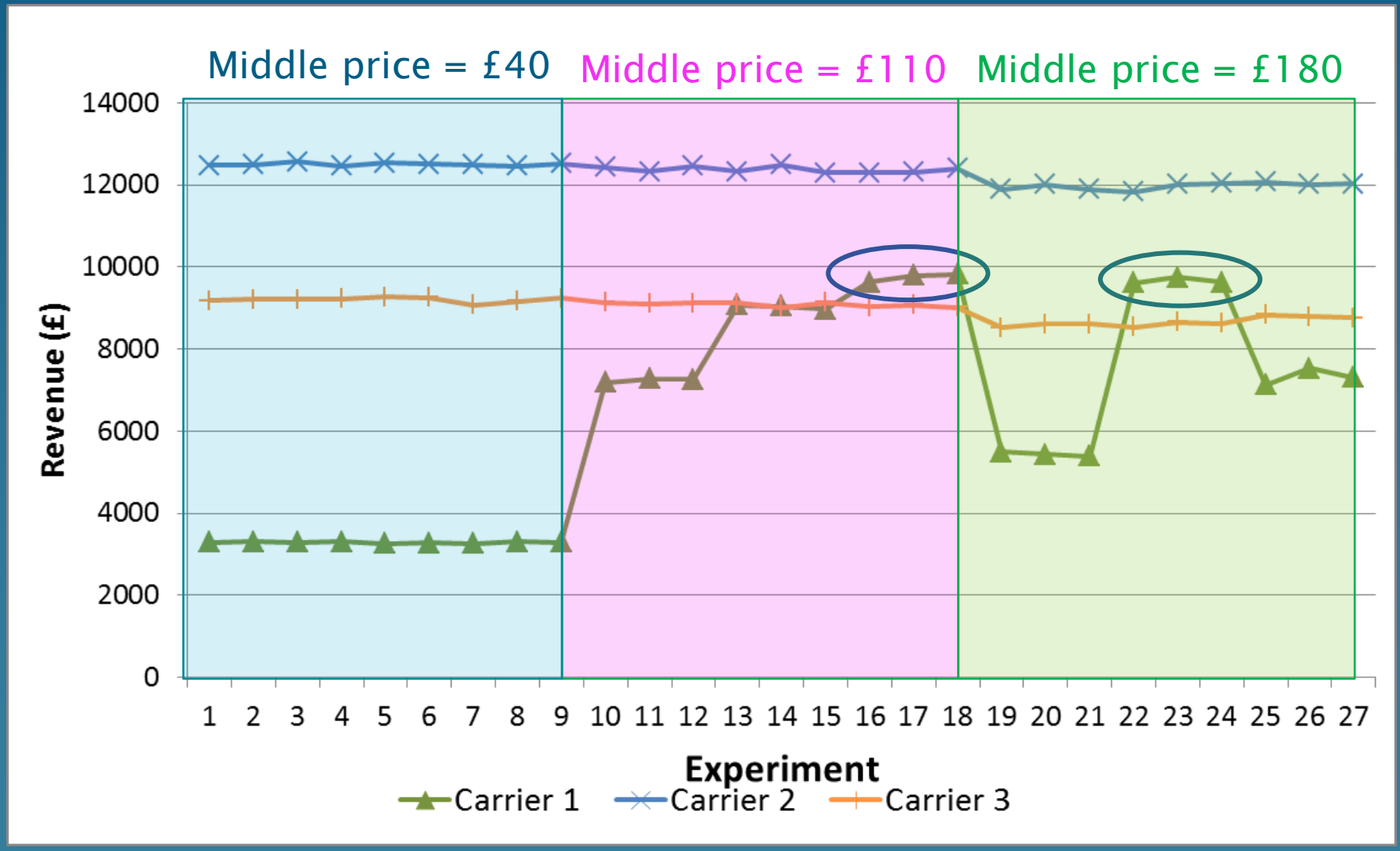
Expected Revenue



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Expected Bookings

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Agent Based Modelling

- Bottom-up approach to modelling
  - Consider individual behaviour
  - Individuals communicate with each other and learn
- Macroscopic results
- Sustainable RM
  - Lovric et al. 2013 (EJOR)

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Conclusion and Future Work

- There is a great deal of potential for simulation to help understand RM markets
- Next steps involve
  - Working with more sophisticated probability functions
  - Increasing the number of competitors
  - Investigating ABM particularly with regard to behaviour between competitors
- This is a growing area!

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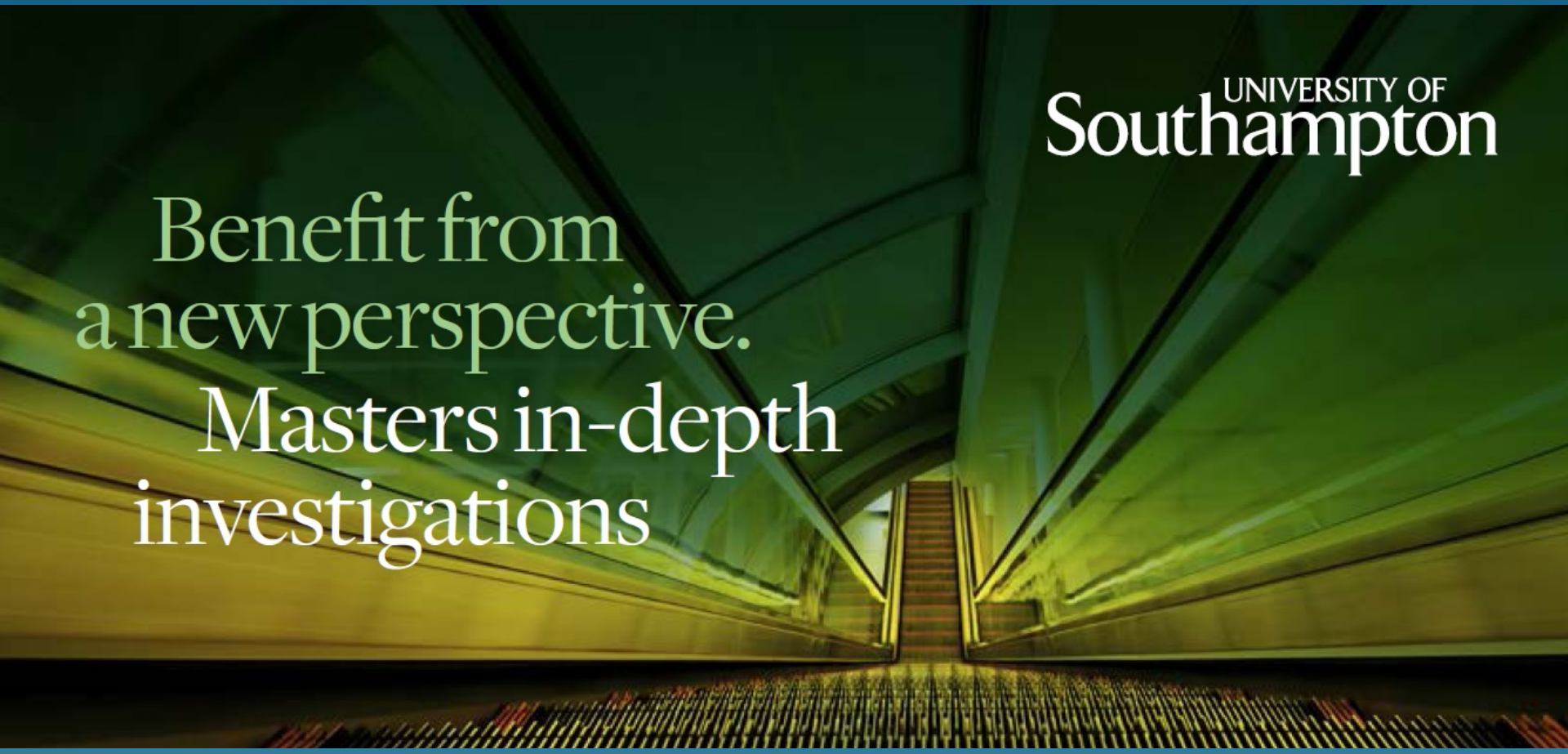
Thank you for listening …



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