Dynamic Pricing on Online Marketplaces: Strategies and Applications

Introduction

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Hasso Plattner Institute (EPIC)

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Outline

- Motivation: What is Dynamic Pricing?
- Goals of the Course & Grading
- Introduction: Lecturer & Students
- Structure of the Course
- Preview
- Potential Projects
- What will be expected from you?

Motivation

- Markets are more transparent, customers compare prices.
  Competitors' prices can be observed, prices can be easily adjusted.
  Market data (offer prices, sales) can be stored and analyzed.

- There are new opportunities to gain profit
  or: firms are force to keep track with new developments

- But: even with tons of data and the ability to adjust prices frequently,
  it is not clear how to set prices!

Motivation: Selling Books on Amazon

The Making of a Fly: The Genetics of Animal Design (Paperback)
by Peter A. Lawrence

‹ Return to product information

Always pay through Amazon.com's Shopping Cart or 1-Click.
Learn more about Safe Online Shopping and our safe buying guarantee.

Price at a Glance

List Price: ~~$70.00~~
Used: from **$35.54**
New: from **$1,730,045.91**

Have one to sell? Sell yours here

All | New (2 from $1,730,045.91) | Used (15 from $35.54)

Show: New | Prime offers only (0) — Sorted by: Price + Shipping

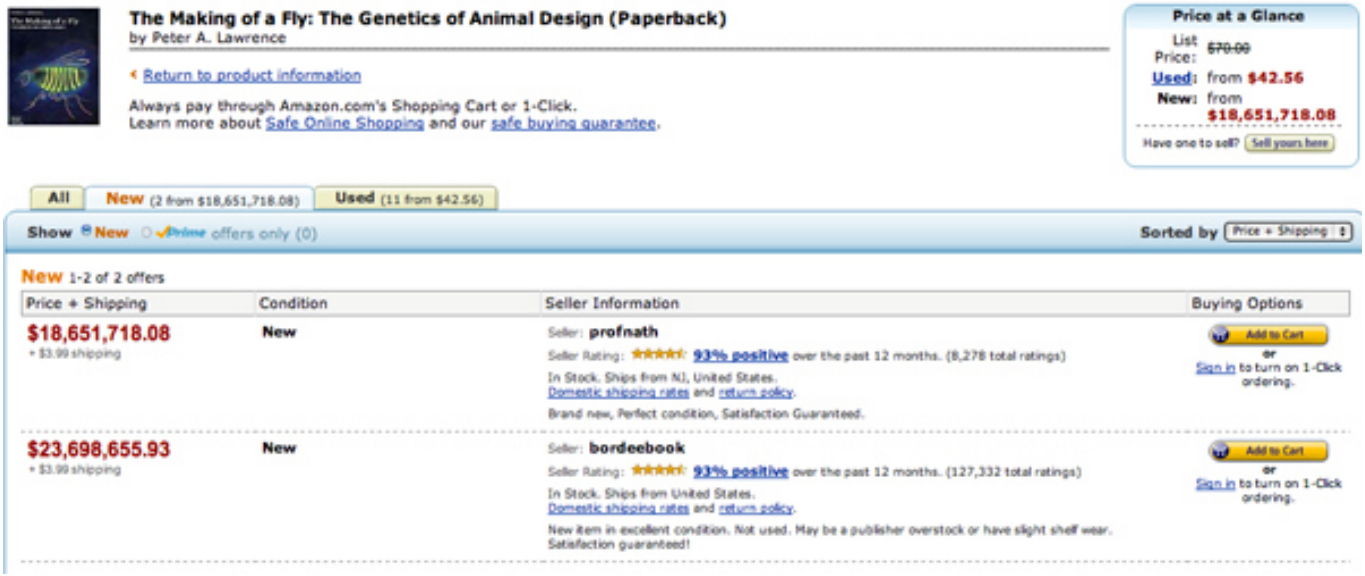
New 1-2 of 2 offers

Price + Shipping	Condition	Seller Information	Buying Options
$1,730,045.91 + $3.99 shipping	**New**	Seller: **profnath** Seller Rating: ★★★★★ **93% positive** over the past 12 months. (8,193 total ratings) In Stock. Ships from NJ, United States. Domestic shipping rates and return policy. Brand new, Perfect condition, Satisfaction Guaranteed.	Add to Cart or Sign in to turn on 1-Click ordering.
$2,198,177.95 + $3.99 shipping	**New**	Seller: **bordeebook** Seller Rating: ★★★★★ **93% positive** over the past 12 months. (125,891 total ratings) In Stock. Ships from United States. Domestic shipping rates and return policy. New item in excellent condition. Not used. May be a publisher overstock or have slight shelf wear. Satisfaction guaranteed!	Add to Cart or Sign in to turn on 1-Click ordering.

Motivation: Price Responses in a Duopoly

	profnath	bordeebook	profnath over previous bordeebook	bordeebook over profnath
8-Apr	$1,730,045.91	$2,198,177.95		1.27059
9-Apr	$2,194,443.04	$2,788,233.00	0.99830	1.27059
10-Apr	$2,783,493.00	$3,536,675.57	0.99830	1.27059
11-Apr	$3,530,663.65	$4,486,021.69	0.99830	1.27059
12-Apr	$4,478,395.76	$5,690,199.43	0.99830	1.27059
13-Apr	$5,680,526.66	$7,217,612.38	0.99830	1.27059

Motivation: Price Responses in a Duopoly



The Making of a Fly: The Genetics of Animal Design (Paperback)
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Price at a Glance
List Price: $70.00
Used: from $42.56
New: from $18,651,718.08
Have one to sell? Sell yours here

All | New (2 from $18,651,718.08) | Used (11 from $42.56)

Show: New | Prime offers only (0) — Sorted by: Price + Shipping

New 1-2 of 2 offers

Price + Shipping	Condition	Seller Information	Buying Options
$18,651,718.08 + $3.99 shipping	New	Seller: profnath Seller Rating: 93% positive over the past 12 months. (8,278 total ratings) In Stock. Ships from NJ, United States. Domestic shipping rates and return policy. Brand new, Perfect condition, Satisfaction Guaranteed.	Add to Cart or Sign in to turn on 1-Click ordering.
$23,698,655.93 + $3.99 shipping	New	Seller: bordeebook Seller Rating: 93% positive over the past 12 months. (127,332 total ratings) In Stock. Ships from United States. Domestic shipping rates and return policy. New item in excellent condition. Not used. May be a publisher overstock or have slight shelf wear. Satisfaction guaranteed!	Add to Cart or Sign in to turn on 1-Click ordering.

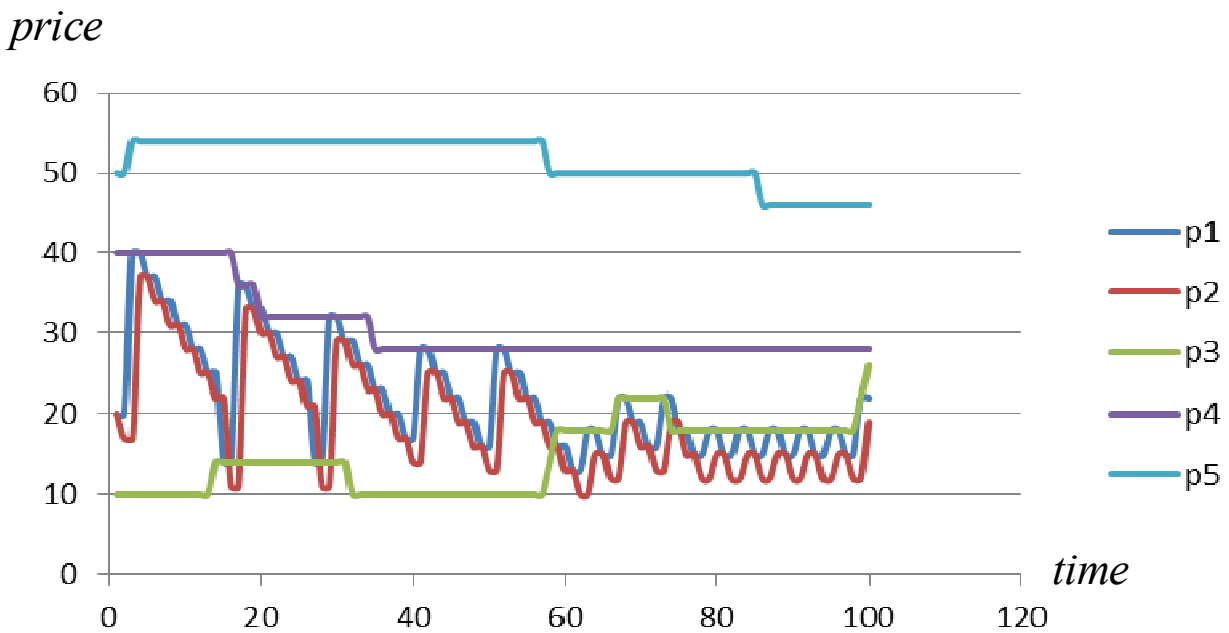
Technical Information

- Credits: 2 SWS, 3 ECTS (graded)
- When? Tuesday 13.30 - 15.00, weekly
  Start: 12.04.2016, End: 12.07.2016
- Where? D-E 9/10
- Who? Rainer Schlosser, rainer.schlosser@hpi.de
- Office hours? By arrangement, Room V-2.05
- Slides? HPI, Teaching, Summer 2016 (no key)

Goals of the Course & Grading

- Goal: Build Dynamic Pricing Prototypes for Competitive Online Markets
- Learn: Demand Estimation + Optimization + Simulation
- Do: Apply Approaches, Visualize Results
- Grading:
  - 10% Regular Attendance / Personal Engagement
  - 30% Presentations (Midterm + Final)
  - 30% Project Results (Demo)
  - 30% Project Documentation (End of Semester)

Example: Dynamic Pricing Strategies under Competition



Prerequisites

- Basic Mathematical Background

  Sets, Vectors
  Probabilities, Random Variables, Expected Values

- More does not harm

  Regression Analysis
  Nonlinear Systems of Equations
  Game Theory

- Programming Ideas

  Parameters, Tables
  Loops, Recursions

Introduction: Lecturer & Students

- Lecturer: Background / Education
  Interests / Field of Research
  Expectations

- Students: Background / Education?
  Interests / Field of Research?
  Expectations?

Content of the Course

- Use market data to estimate Demand, i.e.,
  we will use Regression Analyses to forecast Sales Probabilities.
- We learn how to compute optimized prices in dynamic settings.
  We will apply dynamic optimization techniques.
- We will evaluate the outcome of our Dynamic Pricing Strategies, i.e.,
  we will use Simulation Studies to Measure the Performance of Strategies.
- We want to build a Dynamic Pricing Demo, i.e.,
  we visualize the application of our Strategies.

Structure of the Course

- 3 Meetings: Lectures on „Dynamic Pricing“:
  - (i) Demand Estimation
  - (ii) Price Optimization Techniques
  - (iii) Approaches for Specific Scenarios (Projects)
- May: Assignment of Projects and Teams (ca. 4 Students)
- May/June: Weekly Meetings, Input, Questions/Answers
- June/July: Presentations (Midterm + Final)
- Aug/Sep: Documentation of Projects Results

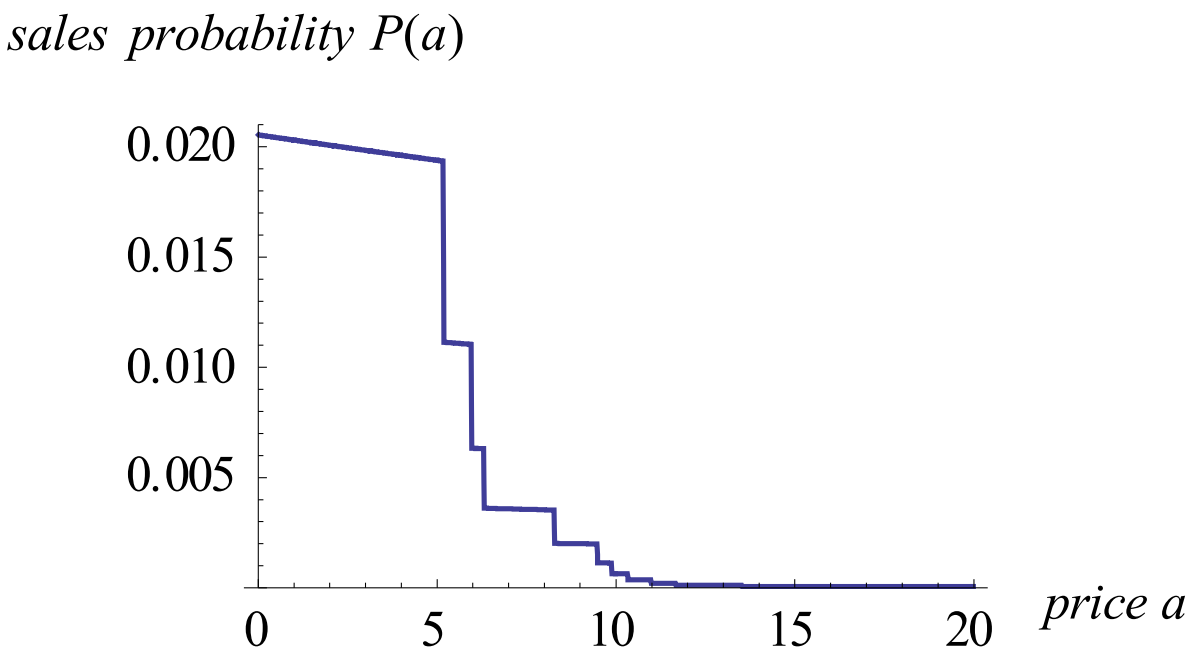
Preview I: Demand Estimation

- Study the dependence of competitors' prices, our offer prices and number of observed sales
- Analyze the likelihood of sales for different market conditions (competitor's prices)
- Use, e.g., Least Squares, Logistic Regression
- Define suitable explanatory variables
- Estimate sales probabilities for various offer prices and market conditions
- Use real-life data from the Amazon Market Place

Example: Market Data

period	**sale**	**price**	rank	competitors' prices for a product i				
t	$y_t^{(i)}$	$a_t^{(i)}$	$r_t^{(i)}$	$p_{t,1}^{(i)}$	$p_{t,2}^{(i)}$	$p_{t,3}^{(i)}$	$p_{t,4}^{(i)}$	...
1	**0**	**19**	3	13	17	20	25	
2	**0**	**15**	2	13	17	20	25	
3	**1**	**10**	1	13	15	20	/	
4	**0**	**10**	1	13	15	20	22	
5	**1**	**12**	2	11	15	20	24	
6	**0**	**14**	2	11	15	20	24	
...								

Example: Estimation of Sales Probabilities



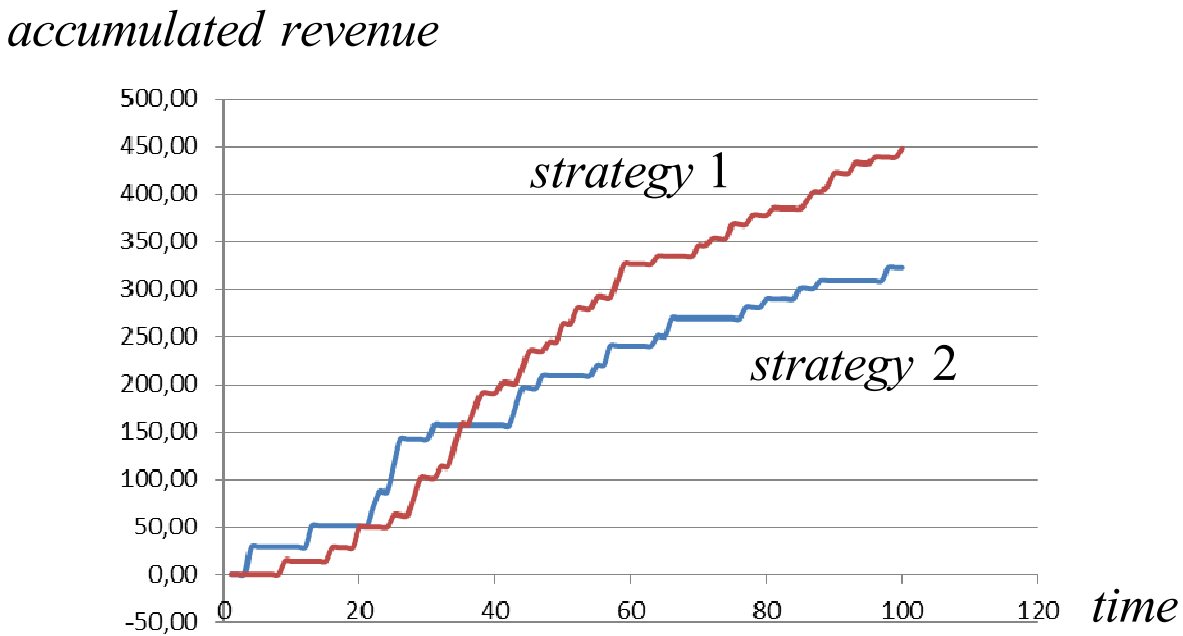
Preview II: Optimization Techniques

- What do we want to maximize?
- What is the set of possible price actions?
- Use estimated sales probabilities
- Compute optimized prices that maximize long-term profits
- Learn about Dynamic Programming Techniques
- Understand the Bellman Equation
- Apply backward induction

Preview III: Simulations

- Assume probabilities for sales under competition
- Use random numbers to simulate sales events
- Adjust competitors' prices
- Adjust offer prices according to different dynamic pricing strategies
- Simulate revenues over time, approximate expected revenues
- Compare different strategies
- Visualize (controlled) sales processes over time

Example: Simulation of Sales Revenue over Time



Potential Projects

- Projects may study the following scenarios in detail

A	Response Strategies	(Price Anticipation, Duopoly)
B	Multiple Features	(Price, Customer Ratings, Product Condition)
C	Multiple Products	(Substitution Effects, 2 Products)
D	Finite Horizon	(Perishable Products, Time Dependence)

- Common Elements for all Teams:

  Demand Estimation + Optimization + Simulation + Visualization

What will be expected from you?

- Use Regression Analyses to Estimate Demand / Sales Probabilities
- Implement Optimization Algorithms to Compute Optimized Prices
- Simulate the Outcome of Dynamic Pricing Strategies
  Measure the Performance of Strategies
- Document your Results (Documentation)
  Visualize the Application of your Prototype (Demo)

Overview

2	April 19	Demand Estimation
3	April 26	Optimization Techniques
4	May 3	Extensions / Projects A-D
5	May 10	Assign Projects to Teams
6	May 17	no Seminar
7	May 24	Workshop / Group Meetings
8	May 31	Workshop / Group Meetings
9	June 7	Presentations (First Results)
10	June 14	Workshop / Group Meetings
11	June 21	Workshop / Group Meetings
12	June 28	Workshop / Group Meetings
13	July 5	no Seminar
14	**July 12**	**Presentations (Final Results), Discussions, Feedback, Extensions**