# Data-Driven Demand Learning and Dynamic Pricing Strategies in Competitive Markets

## Customer Behavior

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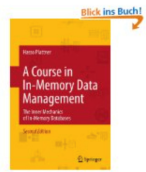
# Outline

- Goals of today's meeting: Customer Behavior
- How to model customer choice: First approaches
- Exercise I: Simulation of Customer Decisions
- Exercise II: Simulation of Pricing Adjustments

# Motivation

- Big picture: Modelling dynamic pricing competition
- Separable components: Customers, Markets, Merchants
- How to describe Customer Behavior?
- We look for a general model which is simple yet reasonable
- How do you decide?

# Example: Buying Books on Amazon




A Course in In-Memory Data Management: The Inner Mechanics of In-Memory Databases (Gebundene Ausgabe)
von Hasso Plattner (Autor)
Schreiben Sie die erste Bewertung

**Optimieren durch** Alles löschen

**Versand**
- ☐ Prime
- ☐ Versandkostenfrei

**Zustand**
- ☐ Neu
- ☑ Gebraucht
  - ☑ Wie neu
  - ☑ Sehr gut
  - ☑ Gut
  - ☑ Akzeptabel

| Preis + Versand (inkl. USt) | Zustand | Verkäufer-Information | Lieferung |
|---|---|---|---|
| **EUR 44,90**<br>+ EUR 3,00 Versandkosten | **Gebraucht - Akzeptabel**<br>Einband intakt und in sehr gutem Zustand, einige Seiten haben kle... » Weitere Informationen | **ialvamani**<br>★★★★★ 100% positiv. (4 alle Bewertungen)<br>Verkäuferinformationen, Impressum, AGB, Widerrufsrecht. | • **Ankunft zwischen** April 26 - Mai 2.<br>• Versandtarife |
| **EUR 45,00**<br>+ EUR 3,00 Versandkosten | **Gebraucht - Sehr gut**<br>Versand aus Deutschland / We dispatch from Germany via Air Mail. ... » Weitere Informationen | **lange_und_springer_antiquariat**<br>★★★★★ 98% positiv in den letzten 12 Monaten. (28.584 Bewertungen insgesamt)<br>Verkäuferinformationen, Impressum, AGB, Widerrufsrecht. | • **Ankunft zwischen** April 27 - Mai 2.<br>• Versand aus Deutschland<br>• Versandtarife |
| **EUR 65,60**<br>+ EUR 3,00 Versandkosten | **Gebraucht - Wie neu**<br>New, Excellent customer service. Satisfaction guaranteed!! | **Totalbookstore**<br>★★★★½ 89% positiv in den letzten 12 Monaten. (439 Bewertungen insgesamt)<br>Verkäuferinformationen, Impressum, AGB, Widerrufsrecht. | • **Ankunft zwischen** Mai 3-20.<br>• Versandtarife |
| **EUR 79,56**<br>+ EUR 3,00 Versandkosten | **Gebraucht - Sehr gut**<br>Publisher: Springer<br>Date of Publication: 2014<br>Binding: hard... » Weitere Informationen | **Herb Tandree Philosophy Books**<br>★★★★½ 90% positiv in den letzten 12 Monaten. (338 | • **Ankunft zwischen** Mai 2-6.<br>• Versand aus Vereinigtes Königreich<br>• Versandtarife |

# Customer Choice based on a given Market Situation

| seller $k$ | price $p_k$ | quality $q_k$ | rating $r_k$ | feedback $f_k$ | shipping $c_k$ |
|---|---|---|---|---|---|
| 1 | **44.90** | **akzeptabel** | **100%** | **4** | **5 Tage** |
| 2 | 45.00 | sehr gut | 98% | **28,584** | 6 Tage |
| 3 | 65.60 | **wie neu** | **89%** | 439 | **11 Tage** |
| 4 | **79.56** | sehr gut | 90% | 338 | 10 Tage |
| . . . | | | | | |
| $K$ | | | . . . | | |

# Goals of Today's Meeting (Exercise I)

- Task: Understand & describe Customers' Decisions over time
- Assume: A product with multiple features (price, quality, ratings)

  A list of competitors' offers (market situation)

  Stream of interested customers + buying decisions
- Goal: Simulate arriving customer and their buying decision

  given a simulated set of competitors' offers

# (1) Stream of Arriving Customer

- Any ideas?
- Simulate random delays (waiting times) between two customers
- Use, e.g., Uniform distributions or Exponential distributions
- Is this doable?

# (2) Merchants' Offers & Market Situations

- Simulate offers, i.e., random numbers for prices, quality, ratings

| seller $k$ | price $p_k$ | quality $q_k$ | rating $r_k$ |
|---|---|---|---|
| 1 | **44.90** | **akzeptabel (4)** | **100%** |
| 2 | 45.00 | sehr gut (2) | 98% |
| 3 | 65.60 | **wie neu (1)** | **89%** |
| 4 | **79.56** | sehr gut (2) | 90% |
| . . . | | | |
| $K$ | | | . . . |

# (3) Customers' Decision

- Assume: A customer arrives at time $t$ – how does he/she decide?

- Approach I: Always choose the cheapest offer

- Approach II: Use distribution of sales and price rank

- Approach III: Use (randomized) scoring functions

- Other: Combinations, data-driven, etc.

# Approach I: Cheapest Offer

- Idea: An interested customer always chooses the cheapest offer
- Easy / deterministic?
- In case of identical prices use probabilities:

$$P(k,\vec{s}) = P(k,\vec{p},...) = \begin{cases} \dfrac{1}{\left|\left\{k=1,...,K : p_k = \min\limits_{i=1,..,K} p_i\right\}\right|} & ,k=1,...,K : p_k = \min\limits_{i=1,..,K} p_i \\ 0 & ,k=1,...,K : p_k > \min\limits_{i=1,..,K} p_i \end{cases}$$

# Approach II: Sales vs. Price Rank

- Idea: Relative frequency of sales and price ranks

- Example: 100 sales $\rightarrow$ #60 rank 1, #30 rank 2, #10 rank 3, . . .

  i.e., $H$ sales - $h_1$=60, $h_2$=30, $h_3$=10, . . .

- Simulate the buying probability $P(k,\vec{s})$ that rank $k$ is chosen, $k=1,...,K$

  where $$P(k,\vec{s}) = P(k,\vec{p},...) = \frac{h_{rank(p_k,\vec{p})}}{\sum_{i=1,..,K} h_i}$$

# Approach III: Randomized Scoring

- Idea: Different customers use different scoring functions
- Customer Type1: $\arg\min_{k=1,\dots,K} \left\{ p_k + 0.1 \cdot q_k - 0.01 \cdot r_k - 0.01 \cdot f_k^{0.5} \right\}$
- Customer Type 2: $\arg\min_{k=1,\dots,K} \left\{ p_k + 0.15 \cdot q_k - 0.005 \cdot r_k - 0.03 \cdot f_k^{0.5} \right\}$
- Customer Type 3: $\arg\min_{k=1,\dots,K} \left\{ p_k + 0.2 \cdot q_k - 0.05 \cdot r_k - 0.02 \cdot f_k^{0.5} \right\}$

  . . .

- We can model the decision of a random customer as follows:

$$\arg\min_{k=1,\dots,K} \left\{ p_k + U(0,0.2) \cdot q_k - U(0,0.1) \cdot r_k - U(0,0.05) \cdot f_k^{0.5} \right\}$$

# How to Simulate Customer Choice?

- We need: Realisations of (stochastic) buying behavior for various market situations in our models
- Approach I+II: "*Inverse Verteilungsmethode* for $P(k, \vec{s})$ via U(0,1)"
- Approach III:
  - simulate random scoring coefficients, e.g., U(0,0.05)
  - compute scores for all $K$ offers
  - choose the offer with the best score
- Do you think you can do this?

# (4) Combination: Arriving and Buying Customers

- Assume a generated market situation
- Simulate arriving customers over time
- Simulate customers' individual decisions
- Doable?

# (5) Extensions: Changing Market Situations

- (i) Entry / Exit of firms
- (ii) Price adjustments
- Simulate streams of points in time of a merchant's actions ("arrivals")
- Doable?

# (6) Exercise II: Response Strategies

- Assume a merchant can place his/her action at time *t*

- Apply a rule-based price reaction strategy

  (i) Use a random price

  (ii) Undercut the cheapest competitor price

  (iii) Undercut others or raise the price if prices are too cheap

- Doable?

# Overview

| | | |
|---|---|---|
| 2 | April 24 | Customer Behavior |
| **3** | **April 30/1** | **Pricing Strategies, 1st Homework (simple)** |
| 4 | May 8 | Demand Estimation, 2nd Homework (cont.) |
| 5 | May 15 | Introduction Price Wars Platform |
| 6 | May 22 | Warm up Platform Exercise (in Groups) |
| 7 | May 29 | Dynamic Pricing Challenge / Projects |
| 8 | June 5 | no Meeting |
| 9 | June 12 | Workshop / Group Meetings |
| 10 | June 19 | Presentations (First Results) |
| 11 | June 26 | Workshop / Group Meetings |
| 12 | July 3 | Workshop / Group Meetings |
| 13 | July 10 | no Meeting |
| **14** | **July 17** | **Presentations (Final Results), Feedback, Documentation (Aug/Sep)** |