Workshop on Agreement Technologies 2009
(WAT 2009)

Negotiation with Price-dependent Probability Models

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Outline

- Introduction
- A Taxonomy of CRM Prescription Problems
  - CRM Prescription Problems without Negotiation
  - CRM Prescription Problems with Negotiation
- Scenario with Negotiable Price and several Customers
- Conclusions and Future Work

Introduction

Customer Relationship Management (CRM) prescription problems

Customers

Seller

Products



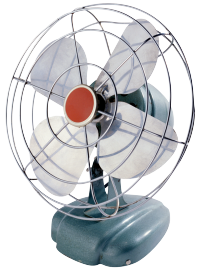








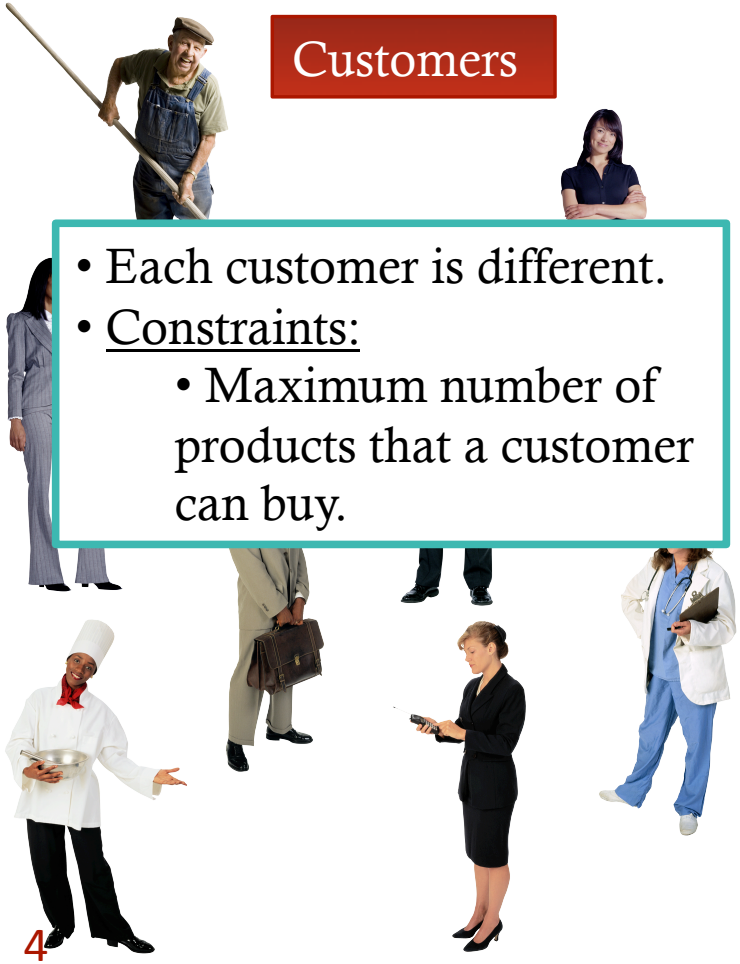




Introduction

Customer Relationship Management (CRM) prescription problems



Customers

- Each customer is different.
- Constraints:
  - Maximum number of products that a customer can buy.

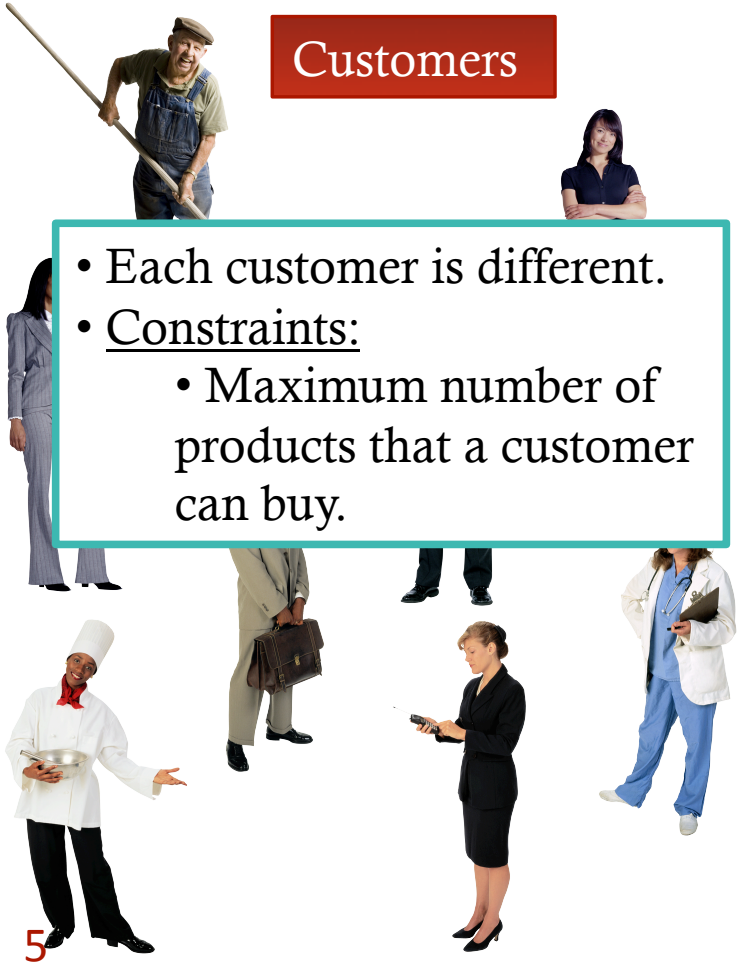
Seller

Products

- Each product is different.
- Constraints:
  - Stocks.

Introduction

Customer Relationship Management (CRM) prescription problems



Customers

- Each customer is different.
- Constraints:
  - Maximum number of products that a customer can buy.

Seller

Products

- Each product is different.
- Constraints:
  - Stocks.

Offer each product to a customer at a price, in order to obtain the maximum global profit.

Introduction

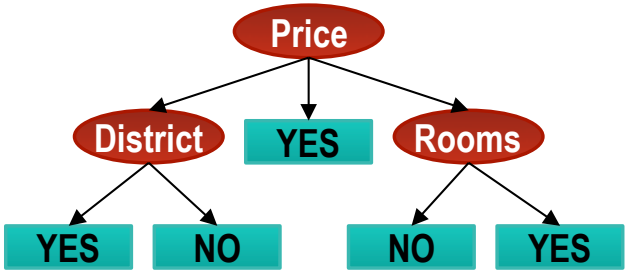
How can data-mining help?

- One probabilistic data-mining model for each customer or/and product is learned from previous data.

Training Data

District	Rooms	M²	Price	Buy?
Centro	3	130	248.352	NO
Ruzafa	2	71	260.000	NO
Patraix	1	36	159.680	YES
Botánico	3	120	351.000	YES
Mestalla	3	90	232.000	YES
Ruzafa	2	114	348.587	NO
Malilla	3	78	224.000	YES
Patraix	2	140	286.000	NO
Nazaret	3	70	126.000	YES
Centro	3	100	240.405	YES
…	…	…	…	…
Mestalla	2	75	225.500	YES

Data Mining Model



New Data

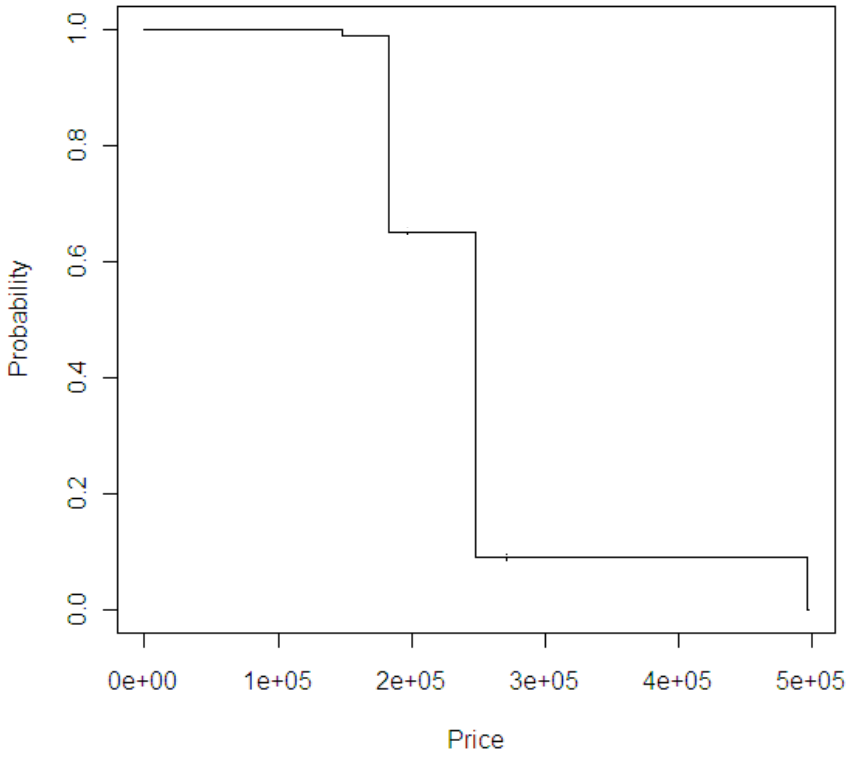
District	Rooms	M²	Price	Prob. (YES)
Ruzafa	2	101	244.752	0,83
Patraix	3	90	280.000	0,42
Centro	2	70	236.900	0,27

Introduction

Negotiable feature (Price)

District	Rooms	M²
Mestalla	3	90

District	Rooms	M²	Price	Prob.
Mestalla	3	90	0	0,998
Mestalla	3	90	100	0,998
…	…	…	…	…
Mestalla	3	90	182.900	0,988
Mestalla	3	90	183.000	0,65
…	…	…	…	…
Mestalla	3	90	248.000	0,65
Mestalla	3	90	248.100	0,091
…	…	…	…	…
Mestalla	3	90	496.200	0,091
Mestalla	3	90	496.300	0

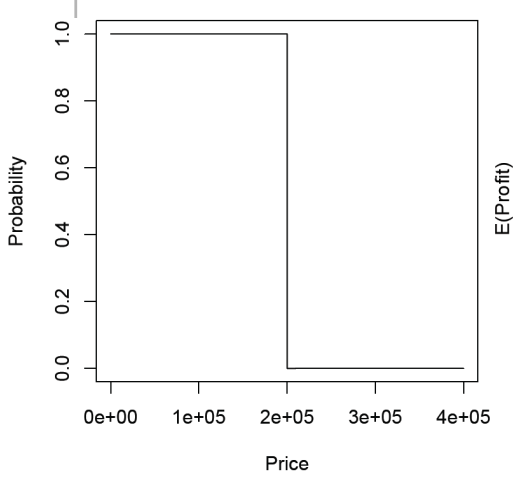


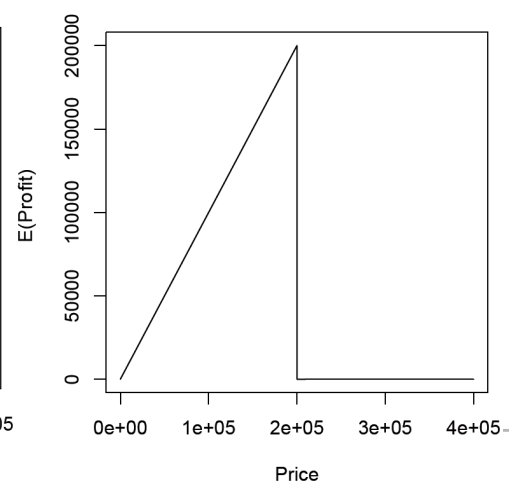
Introduction

Expected profit curves

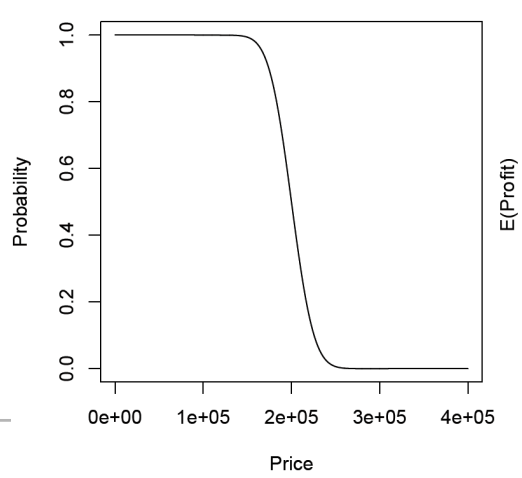
- The buying probability changes depending on the price (negotiable feature).
- The seller does not know the real model and tries to learn the most accurate model from previous data by using data-mining techniques.
- E(Profit) = Probability * Price

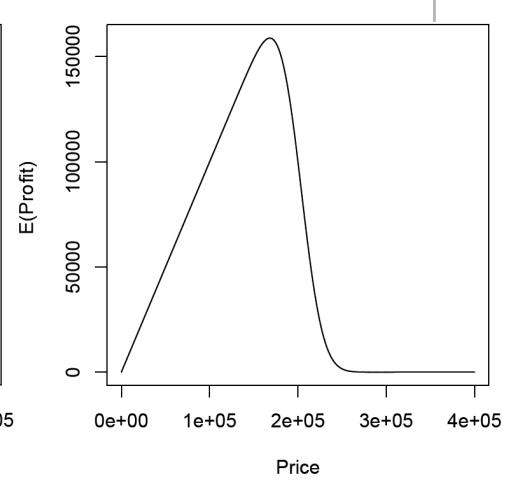
Real Model





Learned Model





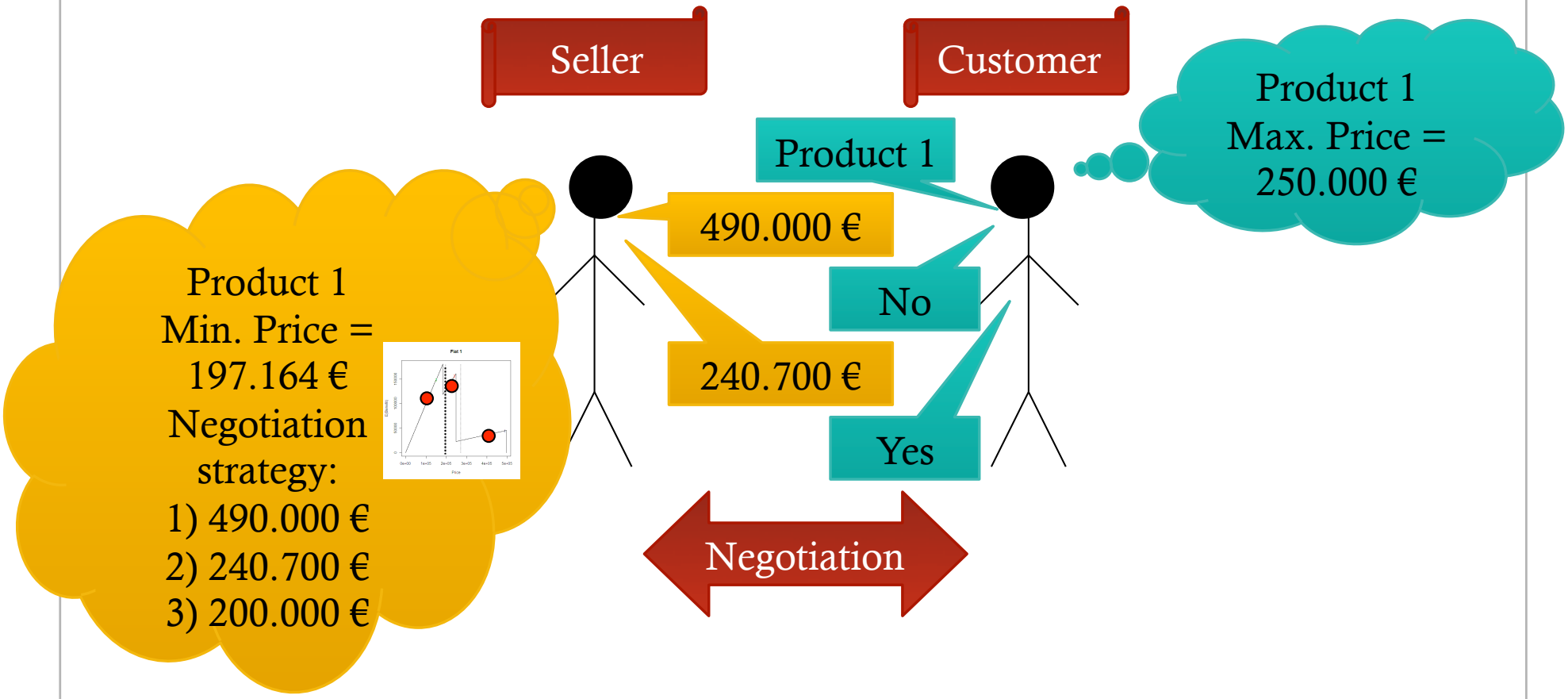
Introduction

Negotiation scenario

- The **customer** is interested in the product.
- He will buy the product if the price is less than or equal to the maximum price that he could pay for it.
- The **seller** will not sell the product if its price is under a minimum price.
- He has a probabilistic model of the customer that assigns a probability of buying the product for each price (learned from previous data).
- Appropriated negotiation strategy → Agreement

Introduction

Example of a negotiation



A Taxonomy of CRM Prescription Problems

Case	Kinds of products	Net price	Number of customers	Approach
1	1	fixed	1	Trivial
2	1	fixed	M	Customer ranking
3	N	fixed	1	Product ranking
4	N	fixed	M	Joint Cut-off **[1]**
5	1	negotiable	1	Negotiable Features **[2]**
6	1	negotiable	M	**This work**
7	N	negotiable	1	**This work**
8	N	negotiable	M	Future work

[1] A. Bella, C. Ferri, J. Hernández-Orallo, and M.J. Ramírez Quintana. Joint Cut-off Probabilistic Estimation Using Simulation: A Mailing Campaign Application. In IDEAL, volume 4881 of LNCS, pages 609-619. Springer, 2007.

[2] A. Bella, C. Ferri, J. Hernández-Orallo, and M.J. Ramírez Quintana. Feature Dependent Models. Technical Report, Universidad Politécnica de Valencia, 2009

CRM Prescription Problems without Negotiation

Trivial

Case	Kinds of products	Net price	Number of customers	Approach
1	1	fixed	1	Trivial

- The seller offers the product to the customer at a fixed price and the customer may or not buy the product.

CRM Prescription Problems without Negotiation

Customer and product rankings

Case	Kinds of products	Net price	Number of customers	Approach
2	1	fixed	M	Customer ranking
3	N	fixed	1	Product ranking

- Mailing campaign design.
- Ranking of customers or products from a probabilistic estimation data mining model.

CRM Prescription Problems without Negotiation

Example of a mailing campaign design with one product

- Example:
  - I_{cost} = 250 €
  - price = 200 €
  - cost = 20 €
- Accumulated Profit:

$$- I_{cost} + \Sigma_{k=1..j} (price * p(c_k) - cost)$$

Customer	Prob.	E(Profit)	Acc. Profit
			-250
3	0,8098	141,96	-108,04
10	0,7963	139,26	31,22
8	0,6605	112,10	143,32
1	0,6299	105,98	249,3
4	0,5743	94,86	344,16
6	0,5343	86,85	431,01
5	0,4497	69,94	500,95
7	0,2675	33,50	534,45
9	0,2262	24,24	**558,69**
2	0,0786	-4,29	554,4

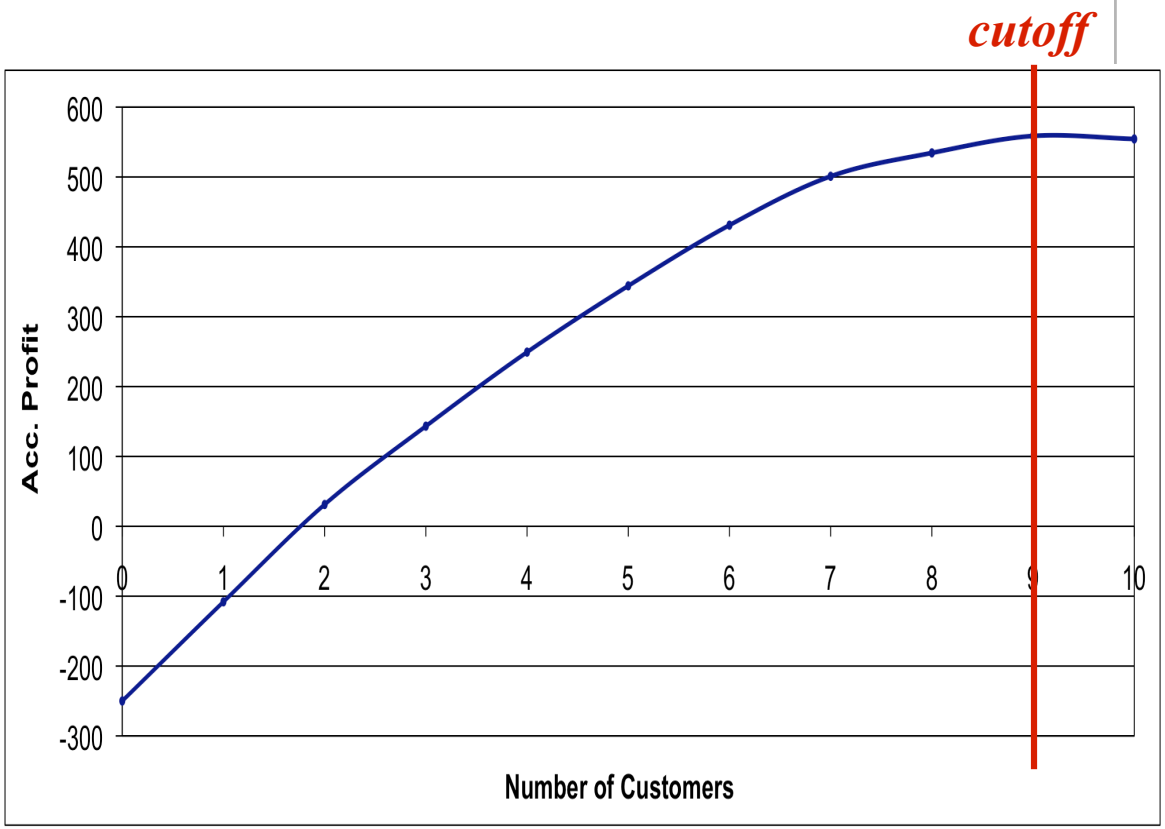
CRM Prescription Problems without Negotiation

Example of a mailing campaign design with one product

- Example:
  - I_{cost} = 250 €
  - price = 200 €
  - cost = 20 €

- Accumulated Profit:

$$- I_{cost} + \Sigma_{k=1..j} (price * p(c_k) - cost)$$



CRM Prescription Problems without Negotiation

Joint cut-off probabilistic estimation using simulation

Case	Kinds of products	Net price	Number of customers	Approach
4	N	fixed	M	Joint Cut-off **[1]**

- Mailing campaign application with more than one product.
- N rankings of customers (one for each product).
- Obtain the set of customers that gives the maximum global profit fulfilling the constraints.
- The best local cut-off for each product does not give the best global profit.

CRM Prescription Problems without Negotiation

Methods to calculate the global cut-off

- Single Approach:
  1. calculate local cutoffs
  2. order all the pairs (customer, product)
  3. global cutoff is the average of local cutoffs
- Joint Simulation Approach:
  1. order all the pairs (customer, product)
  2. calculate best global cuttoff by simulation (using Petri nets)

- Example:
  - 10 customers
  - 2 products
  - $Icost_{p1} = 150$ €
  - $Icost_{p2} = 250$ €
  - $price_{p1} = 100$ €
  - $price_{p2} = 200$ €
  - cost = 20 €

Product p_1			
Customer	E(Profit)	f_{p1}	Acc. Profit
			-150
2	76.61	1	-70
8	75.71	1	10
9	60.37	0	-10
5	48.19	1	70
1	44.96	1	150
7	30.96	0	130
10	24.58	1	210
3	23.04	0	190
6	7.81	1	**270**
4	-4.36	0	250

Product p_2			
Customer	E(Profit)	f_{p2}	Acc. Profit
			-250
3	141.96	1	-70
10	139.26	1	110
8	112.10	1	290
1	105.98	1	470
4	94.86	0	450
6	86.85	0	430
5	69.94	1	**610**
7	33.50	0	590
9	25.24	0	570
2	-4.29	0	550

Single & Joint Approaches			
Customer	Product	Acc. Profit	
		-400	
3	p_2	-220	
10	p_2	-40	
8	p_2	140	
1	p_2	320	
4	p_2	300	
6	p_2	280	
2	p_1	360	
8	p_1	340	
5	p_2	**520**	**Joint**
9	p_1	500	
5	p_1	480	
1	p_1	460	
7	p_2	440	
7	p_1	420	
9	p_2	400	
10	p_1	**380**	**Single**
3	p_1	360	
6	p_1	440	
2	p_2	420	
4	p_1	400	

CRM Prescription Problems with Negotiation

Negotiation strategies (I)

- Strategies to obtain the maximum profit using the profit curves.
- If we have only 1 bid:
  - Maximum Expected Profit (MEP):

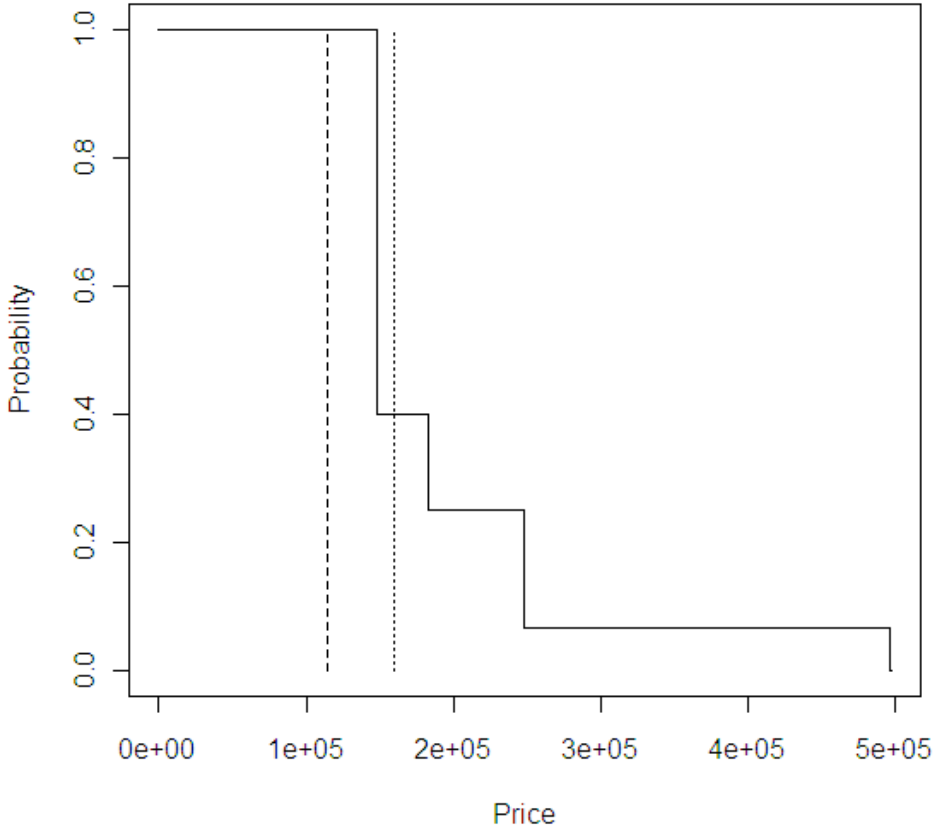
    MAX(Probability * Price)

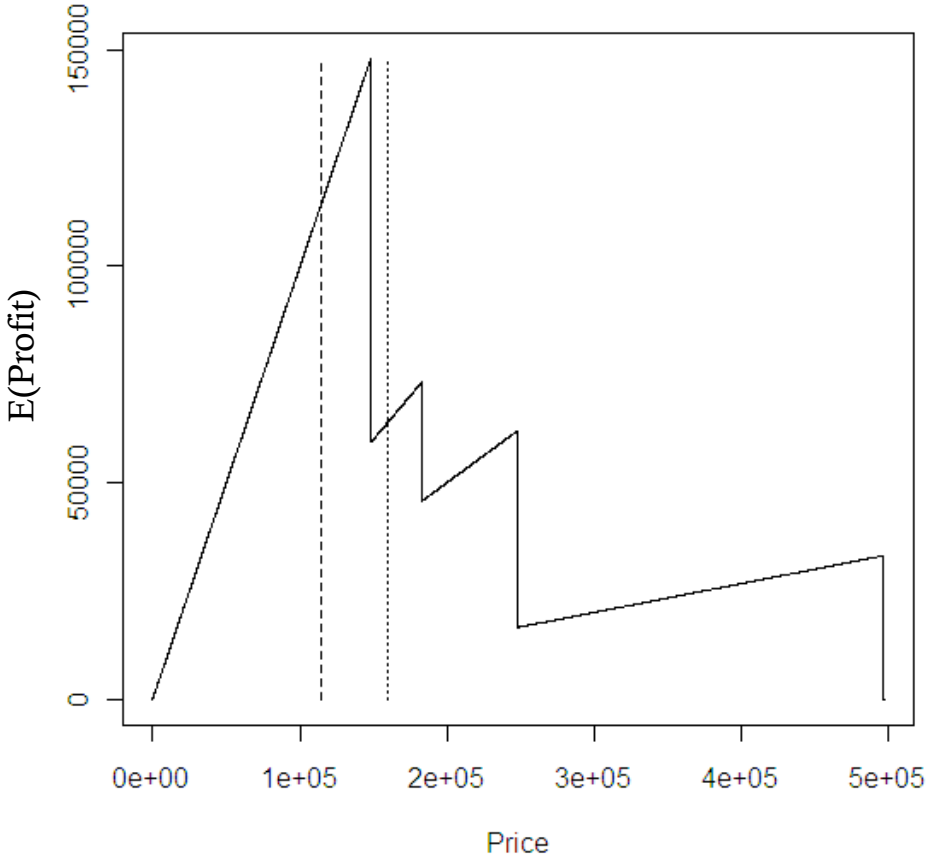
  - Baseline method.

CRM Prescription Problems with Negotiation

Example MEP

District	Rooms	M^2	Min. Price	Max. Price	**MEP**
Benimaclet	3	70	113.868	160.000	**148.000**





CRM Prescription Problems with Negotiation

Negotiation strategies (II)

- ∞ bids !!!

- N bids (e.g. 3 in *"Negotiable Features"*)
  - Best Local Expected Profit (BLEP)
  - Maximum Global Optimisation (MGO)

CRM Prescription Problems with Negotiation

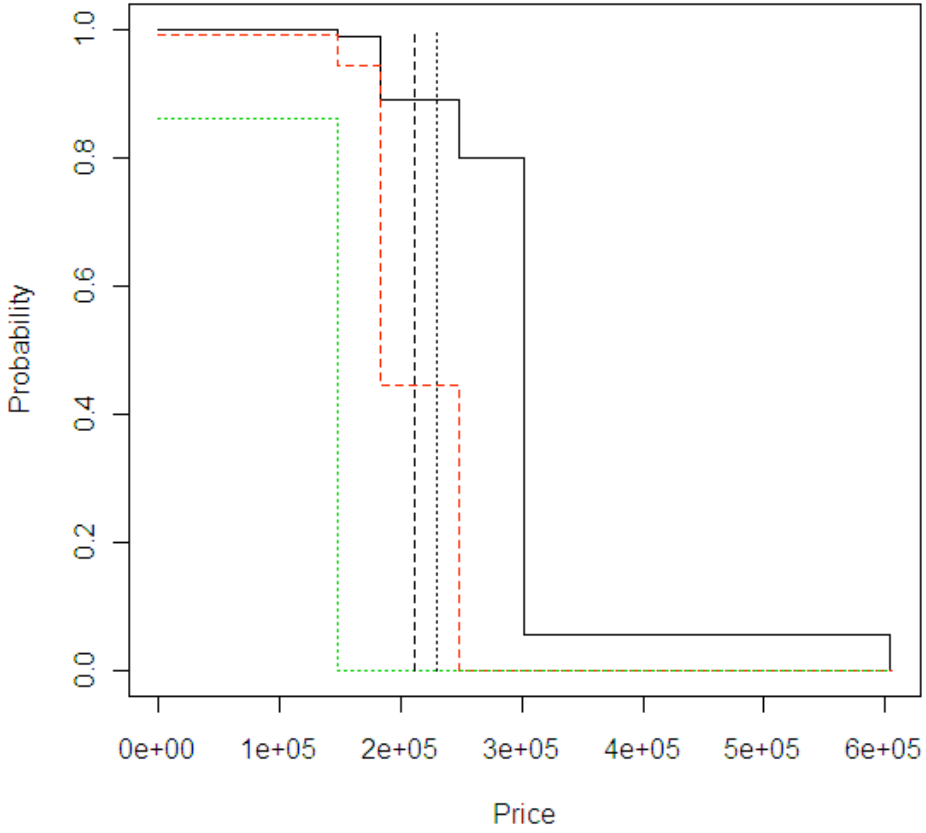
Best Local Expected Profit (BLEP) algorithm

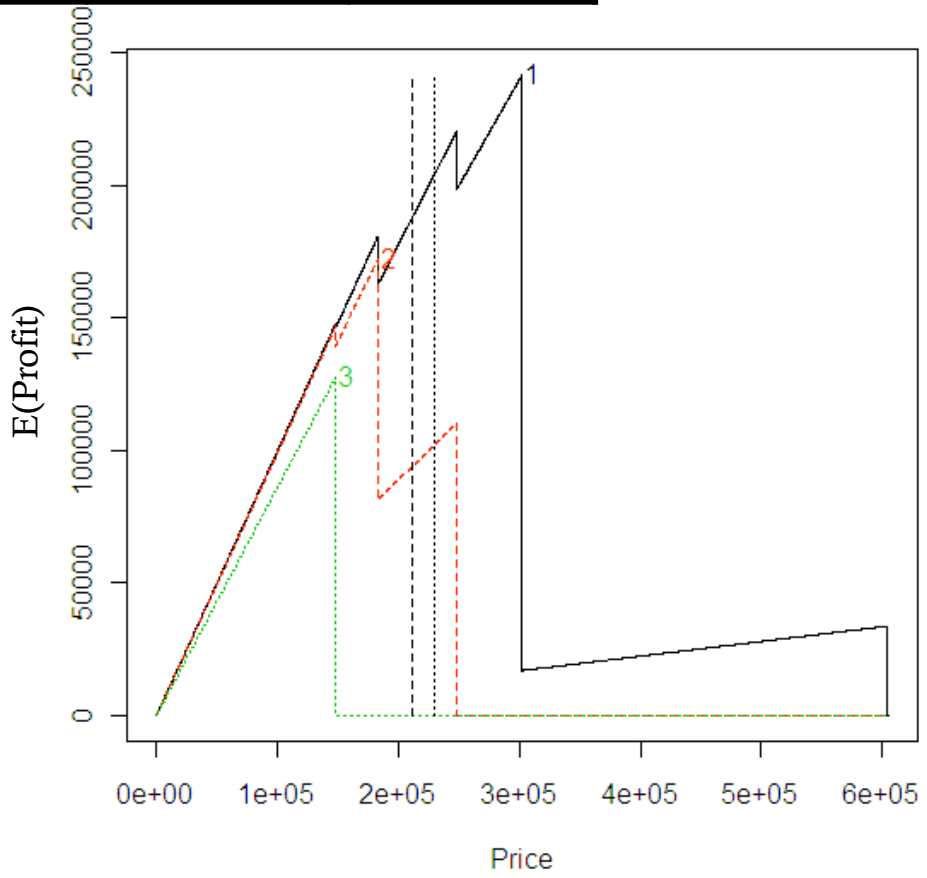
$Bid_1 \leftarrow MEP$
$Bid \leftarrow Bid_1$
FOR (Bid_2 and Bid_3){
    IF p(Bid) != MAX(probabilities)
    THEN {
        probabilities[probabilities ≤ p(Bid)] ← 0
        normalise(probabilities, p(Bid), MAX(probabilities))
        $Bid_x \leftarrow MEB$
        $Bid \leftarrow Bid_x$
    ELSE {
        $Bid_x \leftarrow Bid / 2$
        $Bid \leftarrow Bid_x$
    }
}

CRM Prescription Problems with Negotiation

Example BLEP (I)

District	Rooms	M^2	Min. Price	Max. Price	**BLEP**
Patraix	3	93	211.422	230.000	**0**

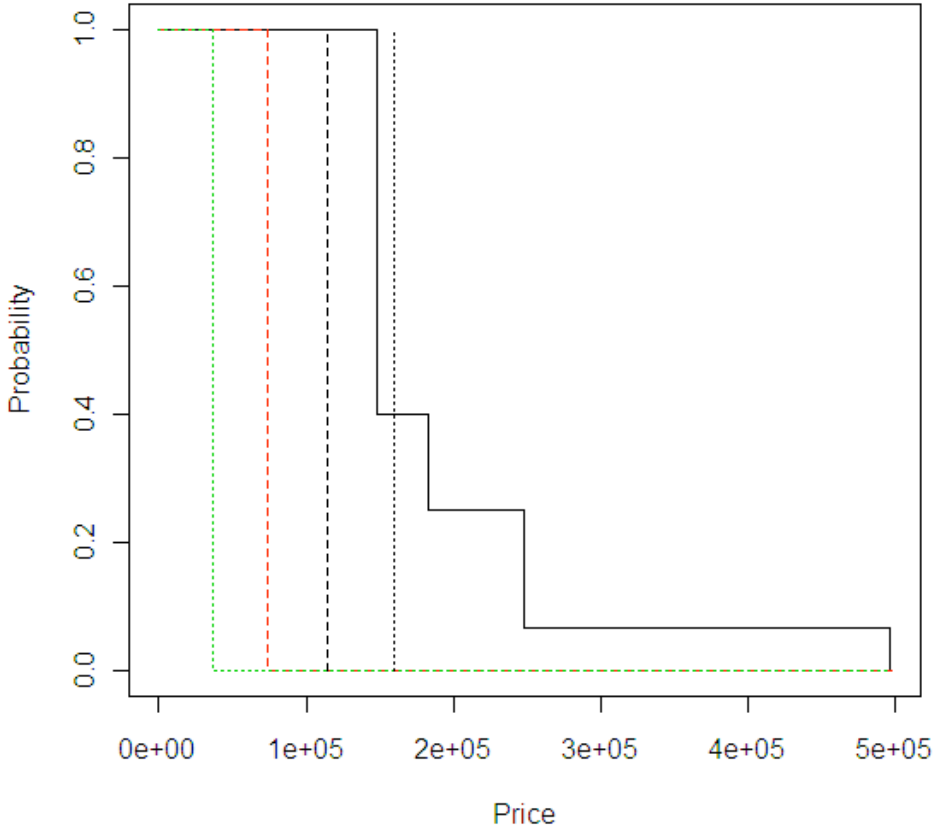


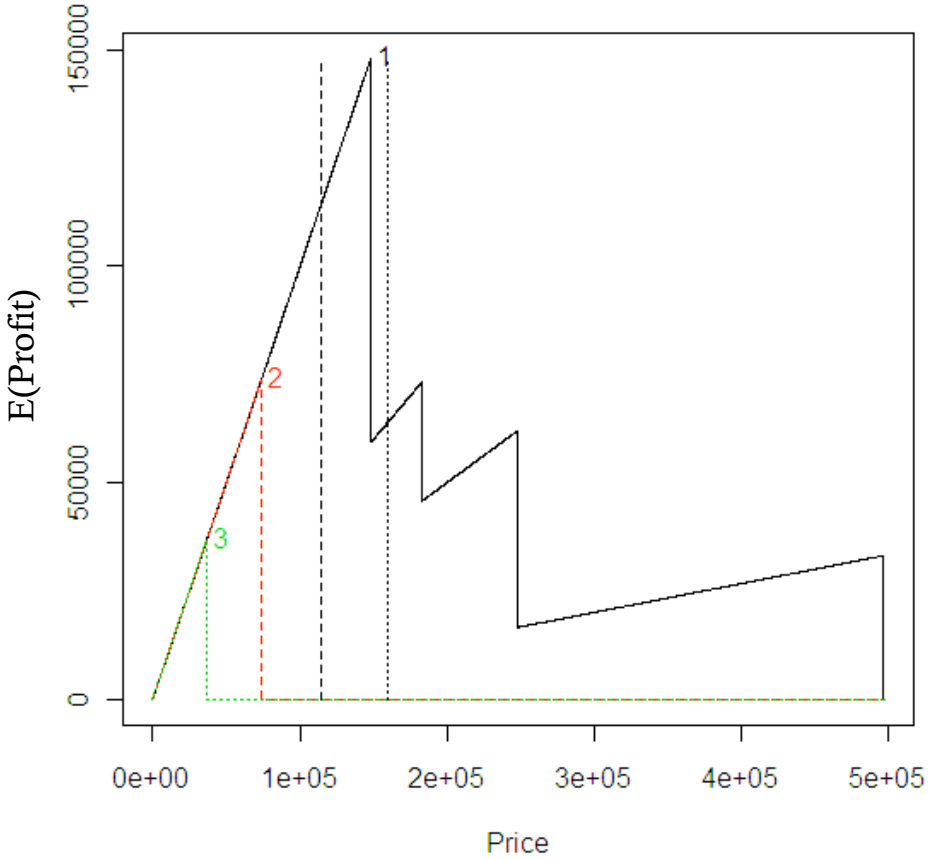


CRM Prescription Problems with Negotiation

Example BLEP (II)

District	Rooms	M^2	Min. Price	Max. Price	**BLEP**
Benimaclet	3	70	113.868	160.000	**148.000**





CRM Prescription Problems with Negotiation

Maximum Global Optimisation (MGO)

- Formula:

$$p_1 * bid_1 + (1-p_1) * p_2 * bid_2 + (1-p_1) * (1-p_2) * p_3 * bid_3$$

where p_x is the probability and bid_x is the price

- Montecarlo method:
  - 1.000 triplets of values generated randomly

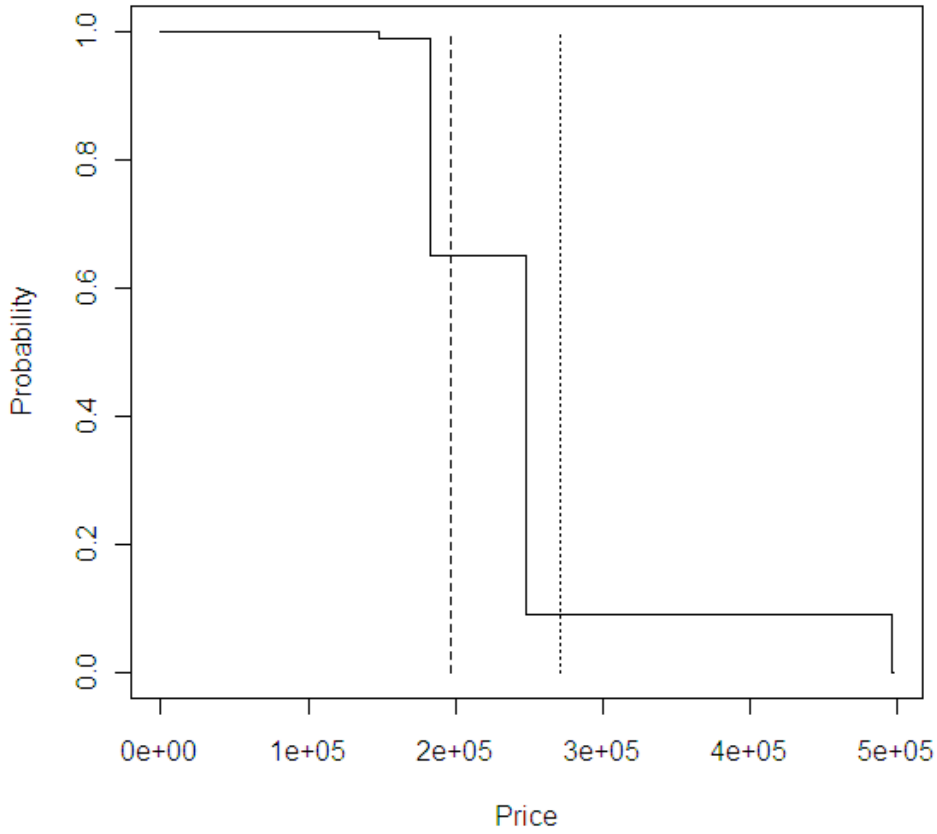
$$\text{bid}_1 > \text{bid}_2 > \text{bid}_3$$

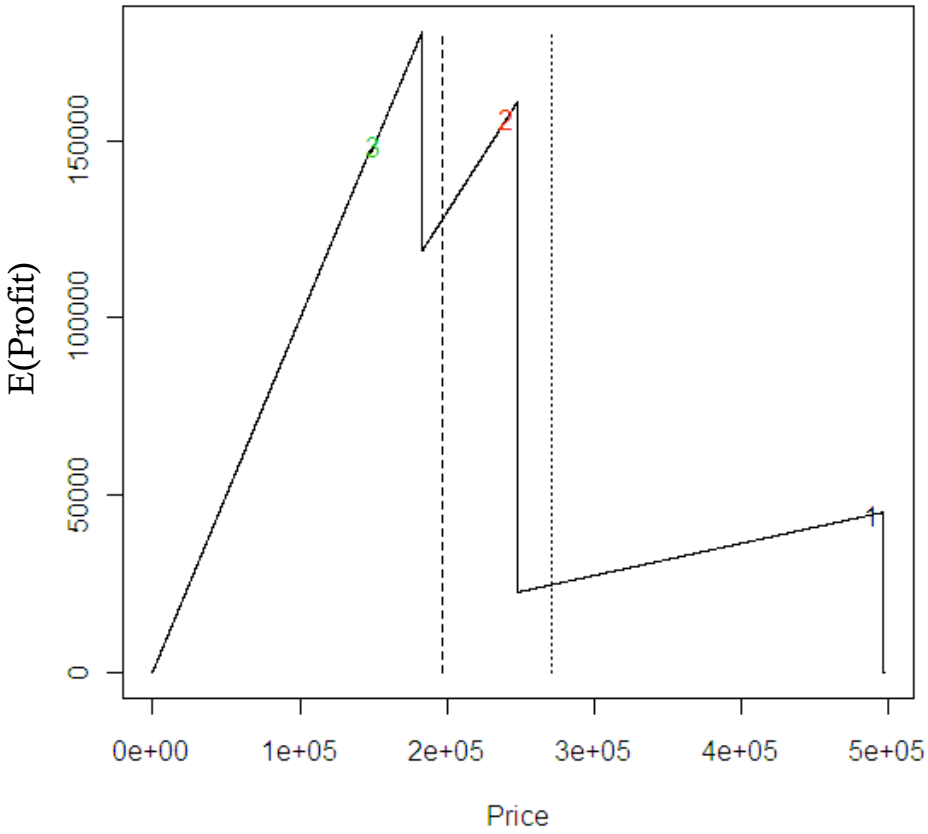
  - Choose the triplet of values that maximises the formula

CRM Prescription Problems with Negotiation

Example MGO

District	Rooms	M^2	Min. Price	Max. Price	**MGO**
Mestalla	3	90	197.164	271.000	**240.700**





CRM Prescription Problems with Negotiation

Negotiable features

Case	Kinds of products	Net price	Number of customers	Approach
5	1	negotiable	1	Negotiable Features **[2]**

- Obtain the maximum price for the product with limited number of bids.
- Learning one probabilistic data-mining model for the customer from previous product data and applying negotiation strategies in order to obtain the maximum profit.
- Only 1 profit curve.

CRM Prescription Problems with Negotiation

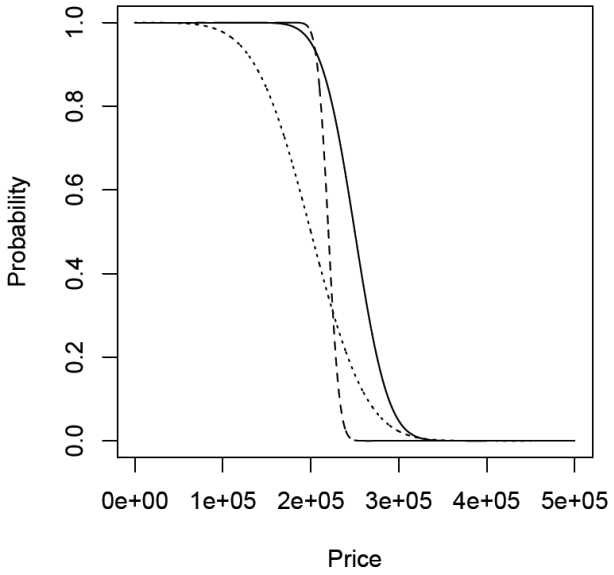
Negotiable price and multiple customers or products

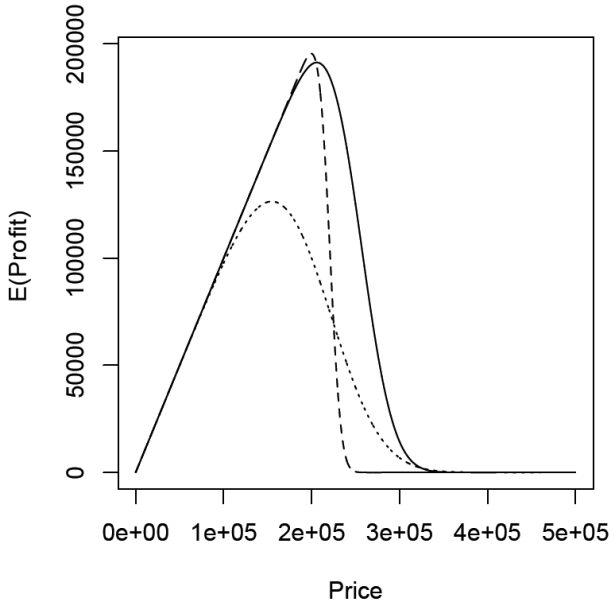
Case	Kinds of products	Net price	Number of customers	Approach
6	1	negotiable	M	**This work**
7	N	negotiable	1	**This work**

- Obtain the maximum global profit selling the product to each customer at his maximum price.
- Learning one probabilistic data-mining model for each customer or product and applying negotiation strategies.
- M or N profit curves. Apply the negotiation strategies to the envelope curve.

CRM Prescription Problems with Negotiation

Example with 3 different customers





- Extension of rankings to expected profit curves. A ranking of customers and/or products for each price of the product.

CRM Prescription Problems with Negotiation

Negotiable price, and multiple customers and products

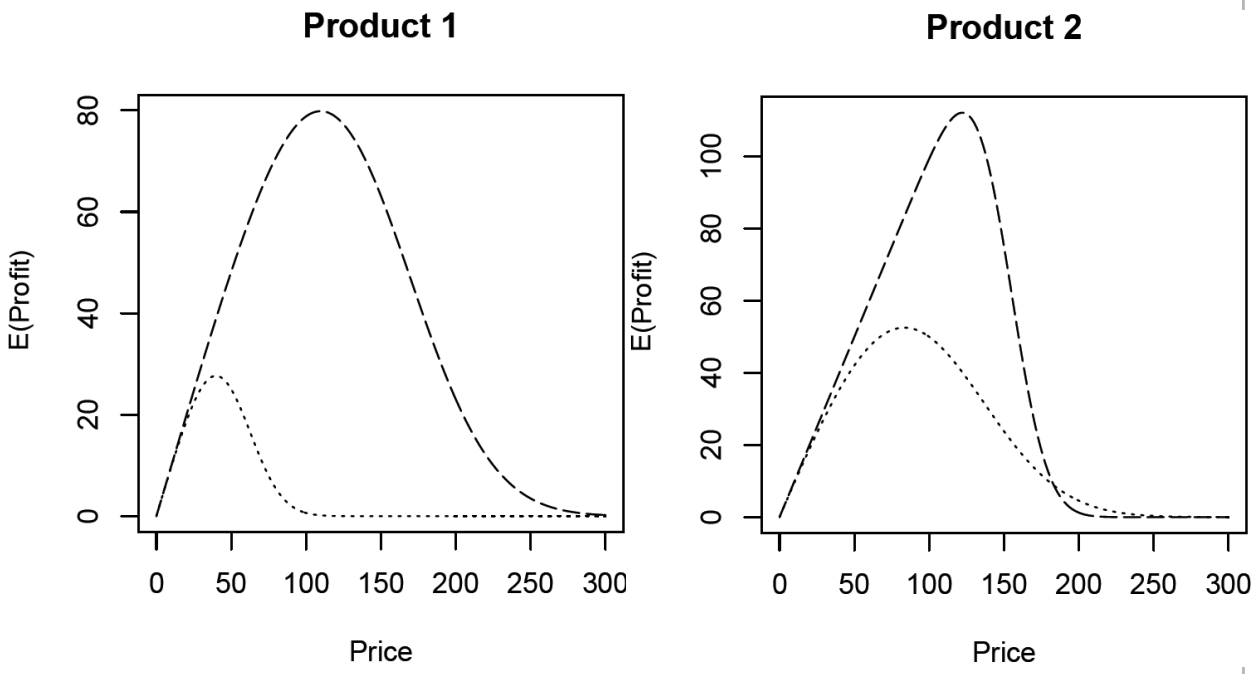
Case	Kinds of products	Net price	Number of customers	Approach
8	N	negotiable	M	Future work

- Obtain the maximum global profit selling the products to the customers at their maximum prices.
- (Ongoing work) using simulation or evolutionary computation. The best point in each curve does not give the best global solution.
- For each of the N kind of products, there will be M profit curves. (N x M profit curves)

CRM Prescription Problems with Negotiation

Example with 2 customers and 2 products

- 2 customers.
- ---- customer 1
  - MEP (p1) = 105 €
  - MEP (p2) = 120 €
- ···· customer 2
  - MEP (p1) = 48 €
  - MEP (p2) = 88 €

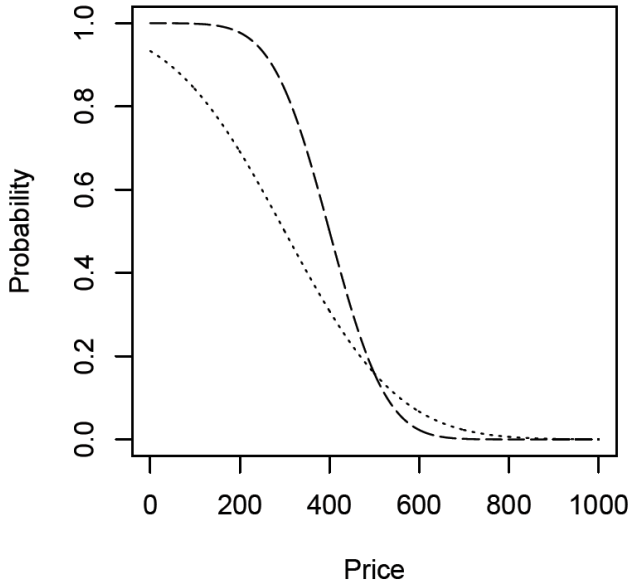


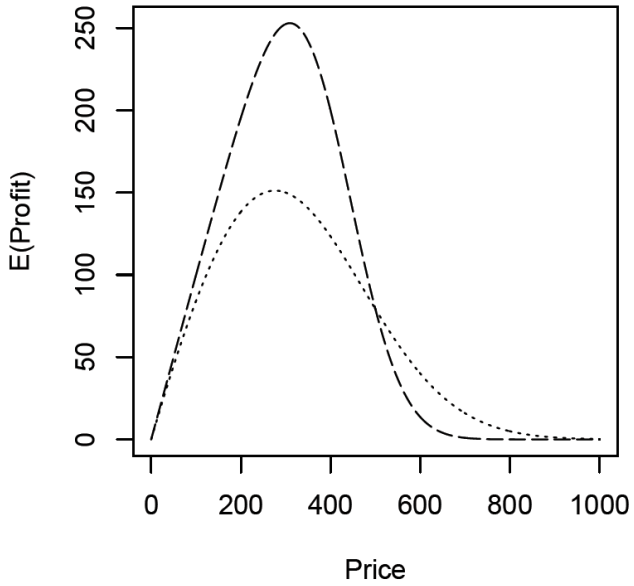
- c1·p2 + c2·p1 = 120 + 48 = 168 €
- c1·p1 + c2·p2 = 105 + 88 = 193 €

Scenario with Negotiable Price and several Customers

Example with 2 customers

- 2 customers and BLEP strategy.
- ---- customer 1 (max. 100 €)
- ····· customer 2 (max. 150 €)

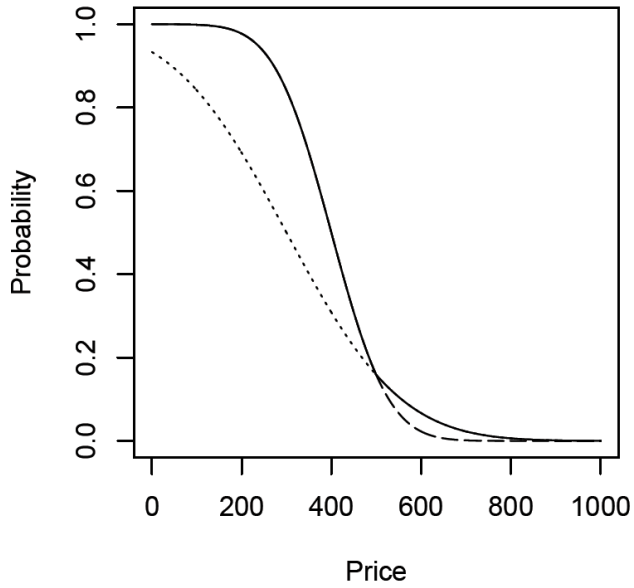


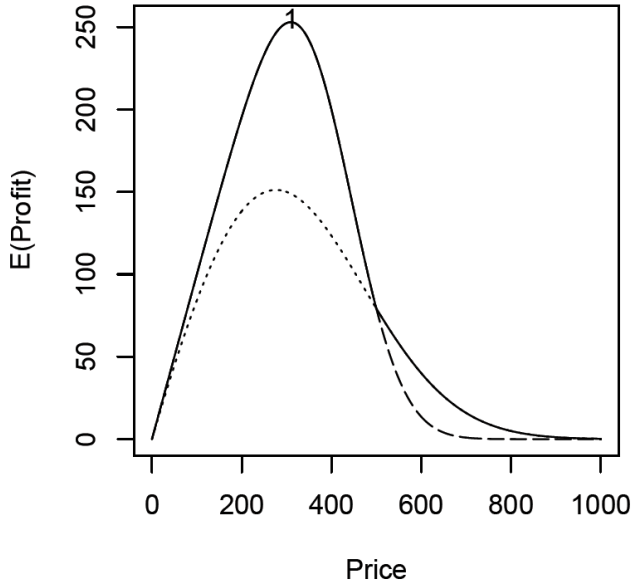


Scenario with Negotiable Price and several Customers

Example with 2 customers (1)

Offer	Price	Customer	Accepted
1	309	1	No

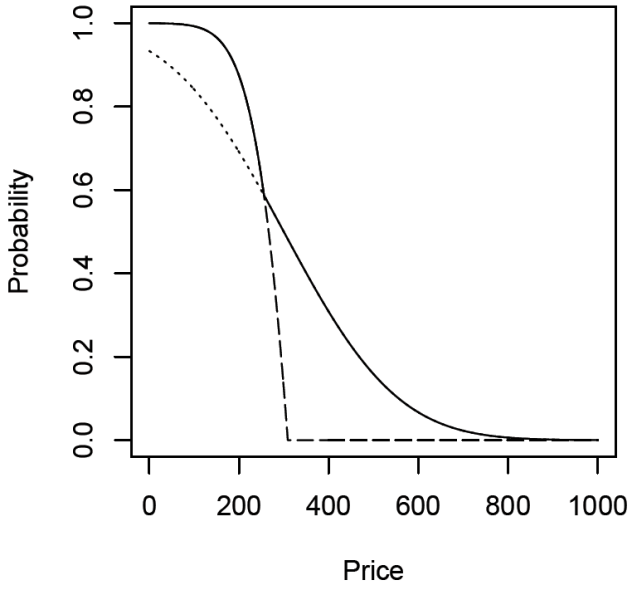


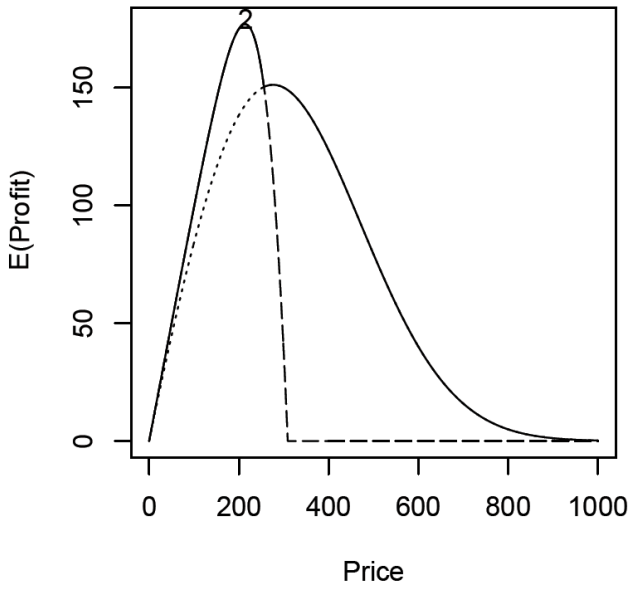


Scenario with Negotiable Price and several Customers

Example with 2 customers (2)

Offer	Price	Customer	Accepted
2	214	1	No

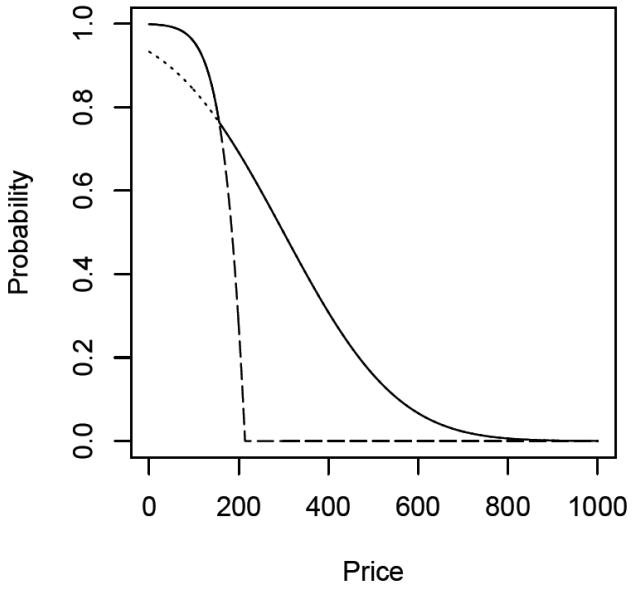


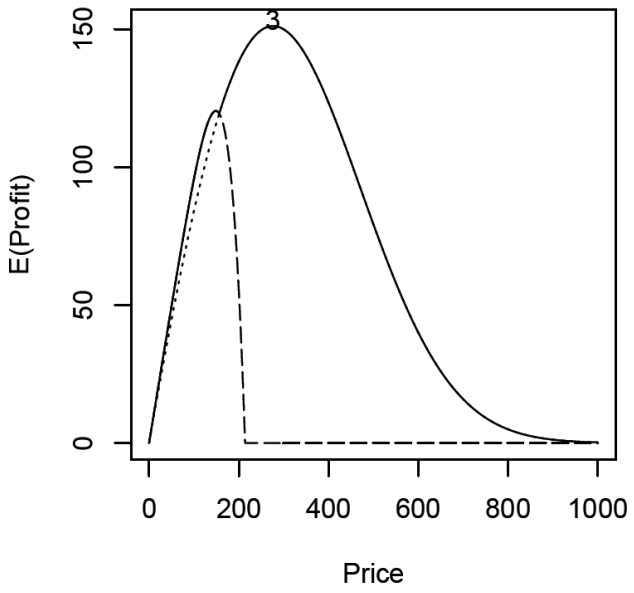


Scenario with Negotiable Price and several Customers

Example with 2 customers (3)

Offer	Price	Customer	Accepted
3	276	2	No

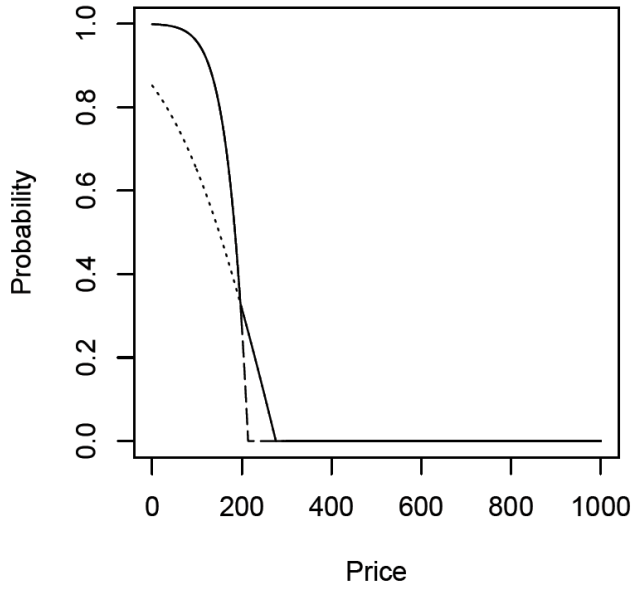


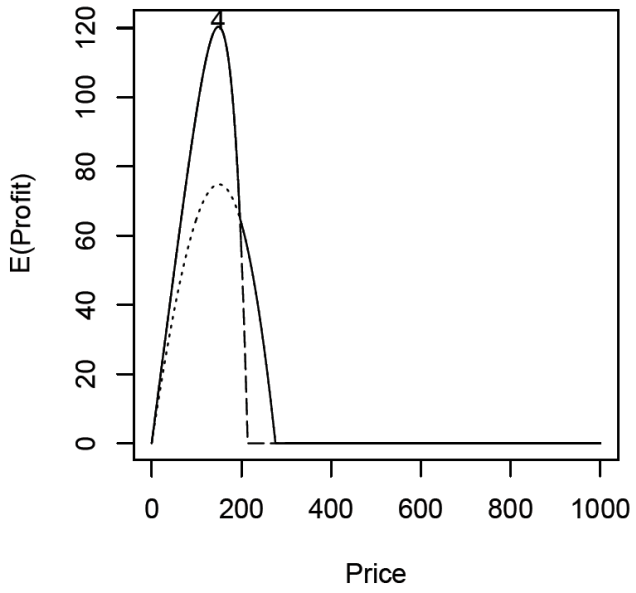


Scenario with Negotiable Price and several Customers

Example with 2 customers (4)

Offer	Price	Customer	Accepted
4	149	1	No

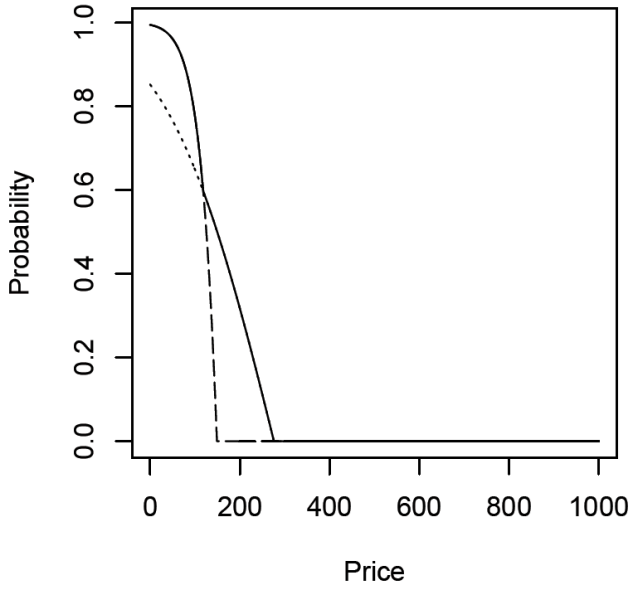


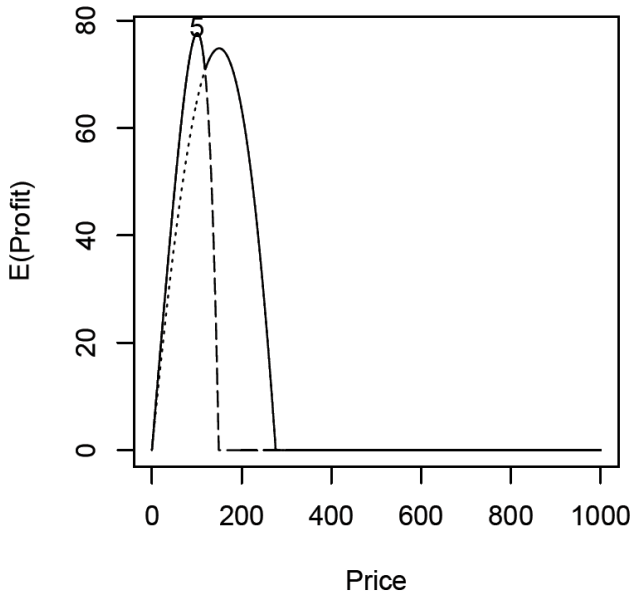


Scenario with Negotiable Price and several Customers

Example with 2 customers (5)

Offer	Price	Customer	Accepted
5	101	1	No

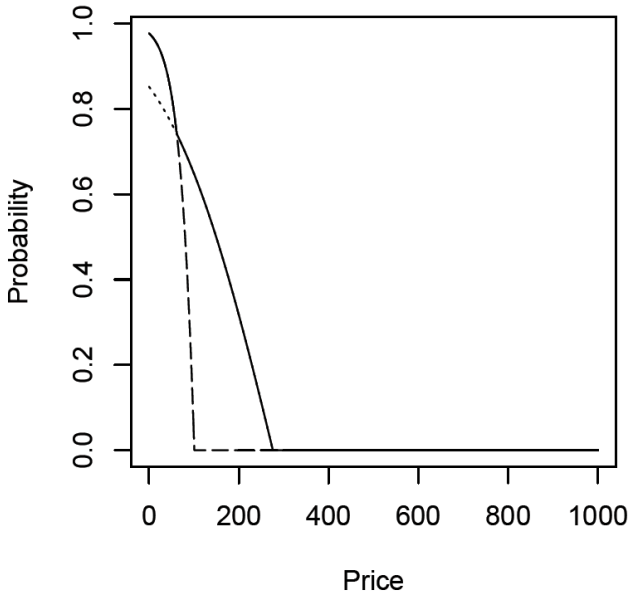


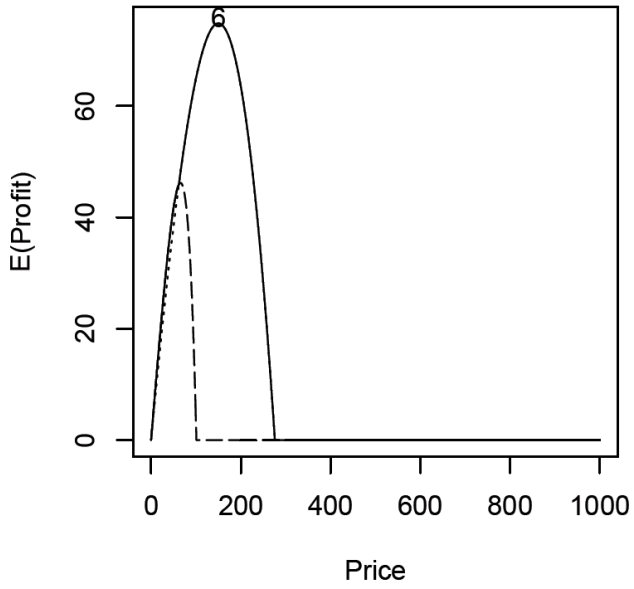


Scenario with Negotiable Price and several Customers

Example with 2 customers (6)

Offer	Price	Customer	Accepted
6	150	2	Yes





Scenario with Negotiable Price and several Customers

BLEP vs. BLEP with ordering pre-process

Offer	Price	Customer	Accepted
1	309	1	No
2	214	1	No
3	276	2	No
4	149	1	No
5	101	1	No
6	**150**	**2**	**Yes**

Offer	Price	Customer	Accepted
1	309	1	No
2	276	2	No
3	214	1	No
4	**150**	**2**	**Yes**

Conclusions

- A taxonomy of CRM prescription problems has been devised.
- Data-mining helps the seller to make a decision about which product should be offered to which customer and at what price in order to obtain as much overall profit as possible.
- Extension of rankings to expected profit curves. A ranking of customers and/or products for each price of the product.

Future Work

- Study the performance of the proposed methods.
- Experiments applying those negotiation strategies.
- … and other suitable negotiation strategies.
- Buyers can also use data-mining (counter-offers).
- Create a scenario with multiple sellers and buyers using negotiation strategies assisted by data-mining techniques.

Thanks for your attention!

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