PRESCRIPTIVE CUSTOMER ANALYTICS

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What we’ve covered so far

- Descriptive – Collect and analyze data to map and understand patterns.
- Predictive – Use the data from customers to predict what they will do in the future.

Prescriptive Analytics

- Provide a recommendation ("prescription") on what actions to take to achieve some objective goal.

- We will cover:
  - Defining a problem – what do we need to do to be able to give a good recommendation.
  - Objectives and Goals – how to define a good objective.
  - Optimization – how to find the best action to take.
  - Examples from pricing and online advertising.
  - A (very) brief intro to competition.

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Defining a problem

- A problem we would like to solve will typically have a set of **goals** we want to achieve, a set of **actions** we can take to achieve this goal and a **model**, which describes how the actions impact the goal.
- Since this all sounds very abstract, let's look at the details of two examples.

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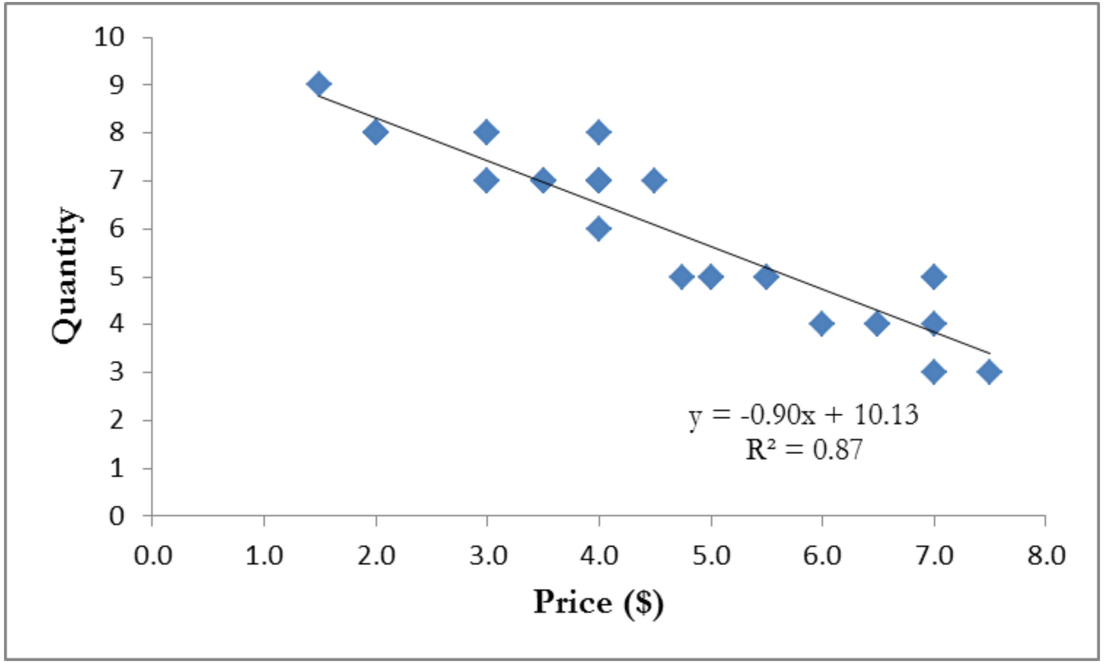
Example 1 – Selling the maximum quantity

- In the Descriptive section, Prof. Iyengar has shown the following demand curve:

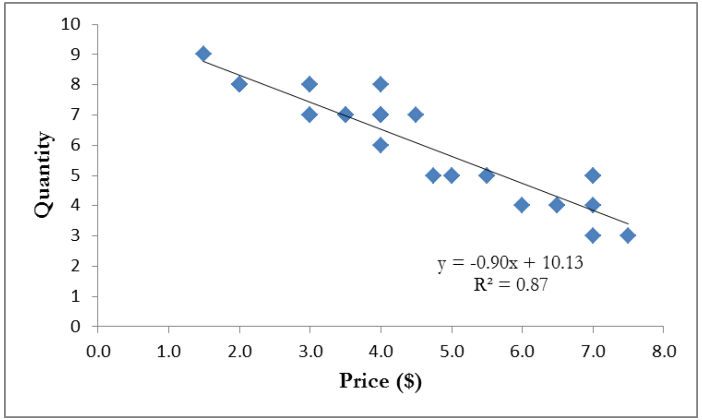


Example 1 – Objective and Actions

- One question we may ask about the data is: “how can we maximize the quantity of the product sold?”.
- In this example, the **goal** is to “**maximize quantity** sold”.
- The **action** we can take is to **change the price** to encourage consumers to buy the product.

Example 1 - Model

- We already have a **model** that tells us how quantity is impacted by price – it is the graph from 2 slides ago.
- We can see from the graph the maximum quantity was sold at the lowest price of 1.0.
- Can we do better? Well, we may not be able to pay people to take the product, but we can definitely give it for free.
- If we plug in x=0 into the regression equation, we will get a maximum quantity of y=10.13 items.



Example 2 – Maximize Revenue

- In the previous example we only looked at the quantity sold, but most of the time we will be interested in making money, or generating revenue by selling a product.
- Can we use the demand curve estimated by Prof. Iyengar to find the price that will achieve the maximum revenue?

- The answer is Yes.

Example 2 – Goal and Actions

- The **goal** in this problem is to receive the highest revenue possible, or to **maximize revenue**.
- The possible **action** (again) is **setting different prices** for the product.

- How does setting a price change the revenue from selling product?

Example 2 - Model

- There are two “forces” in operation when we change the price.
- When the price is decreased, the quantity sold is higher, but the revenue for each item sold is lower.
- When the price is increased, we make more money for each item sold, but we sell less items.
- This is called a **tradeoff**, and in most models identifying the tradeoff beforehand helps us understand what we are looking to solve.

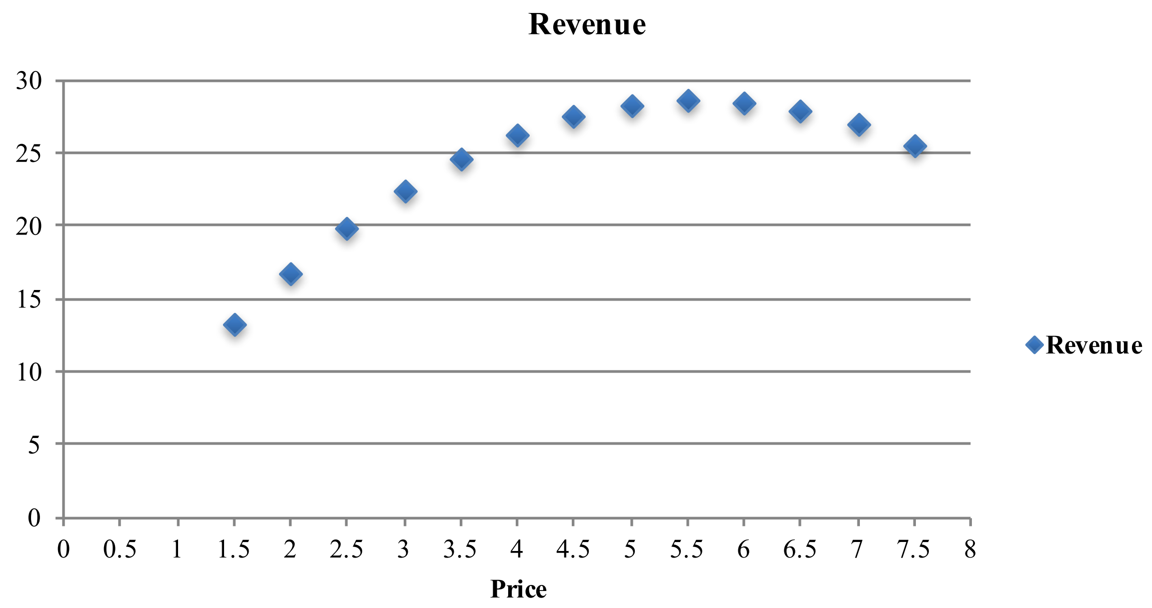
EXAMPLE 2 - MODEL

- The revenue from a product is the multiplication of the number of items sold by the price of each item.
- Assuming the demand follows the regression equation:

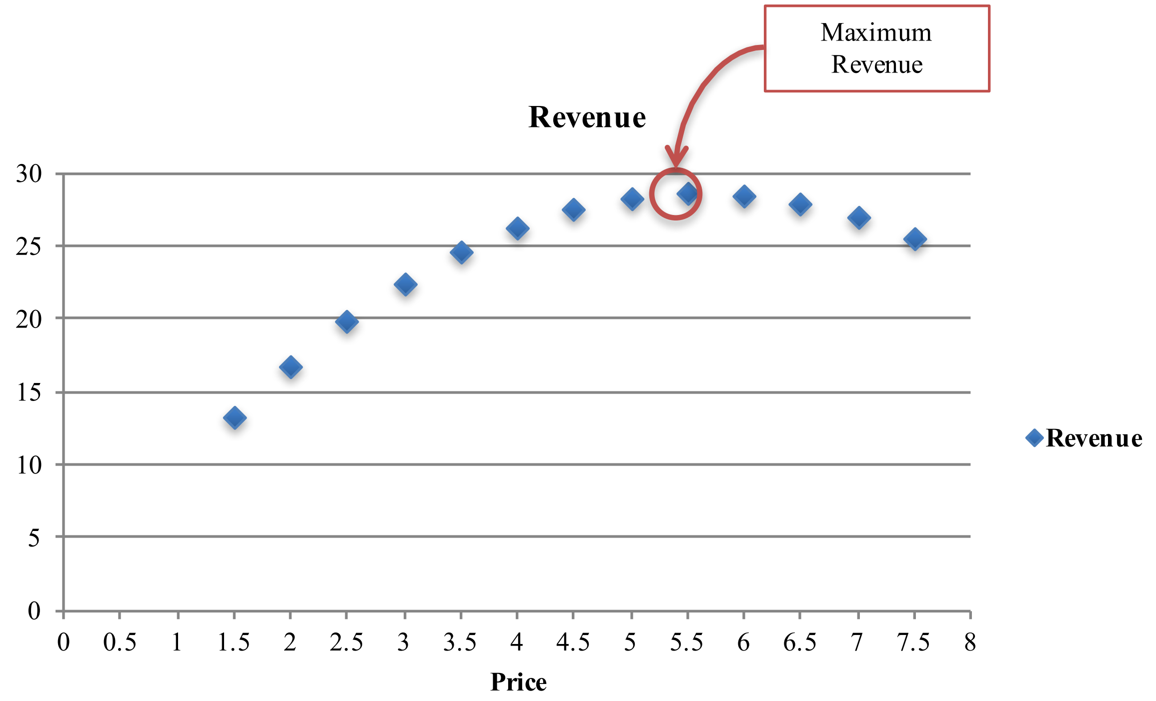
Price	Demand	Revenue
1.5	8.78	13.17
2	8.33	16.66
2.5	7.88	19.7
3	7.43	22.29
3.5	6.98	24.43
4	6.53	26.12
4.5	6.08	27.36
5	5.63	28.15
5.5	5.18	28.49
6	4.73	28.38
6.5	4.28	27.82
7	3.83	26.81
7.5	3.38	25.35

Example 2 – Revenue Graph

- We can draw a graph using the Excel data to see the impact of increasing the price:



Example 2 – Finding the Maximum



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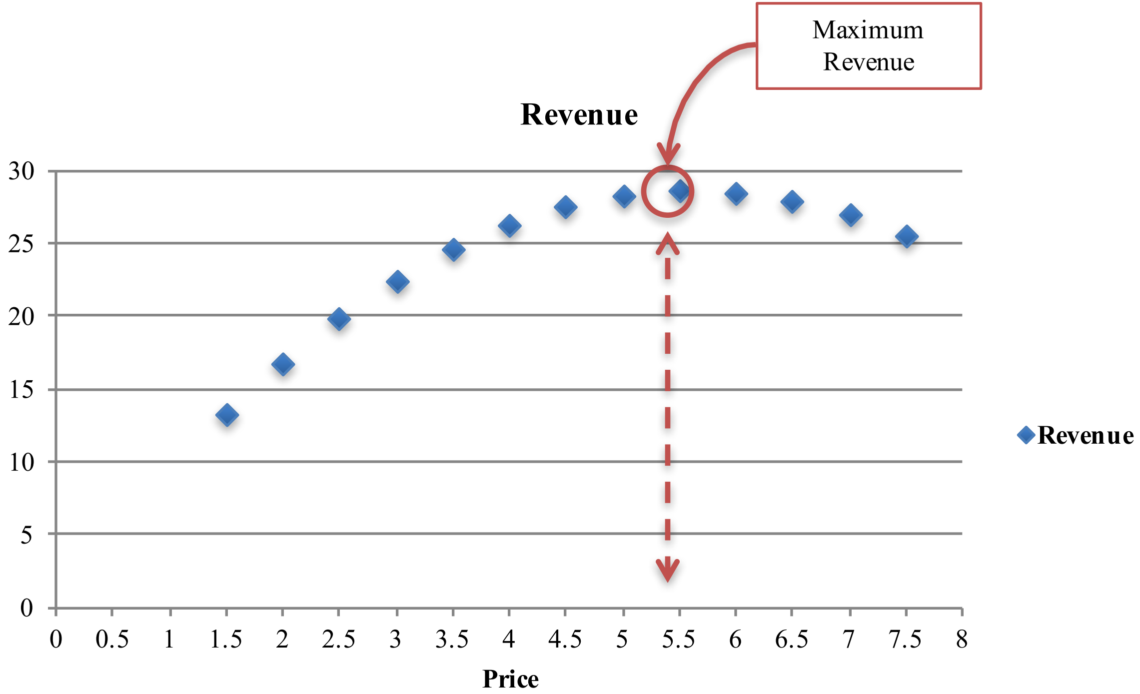

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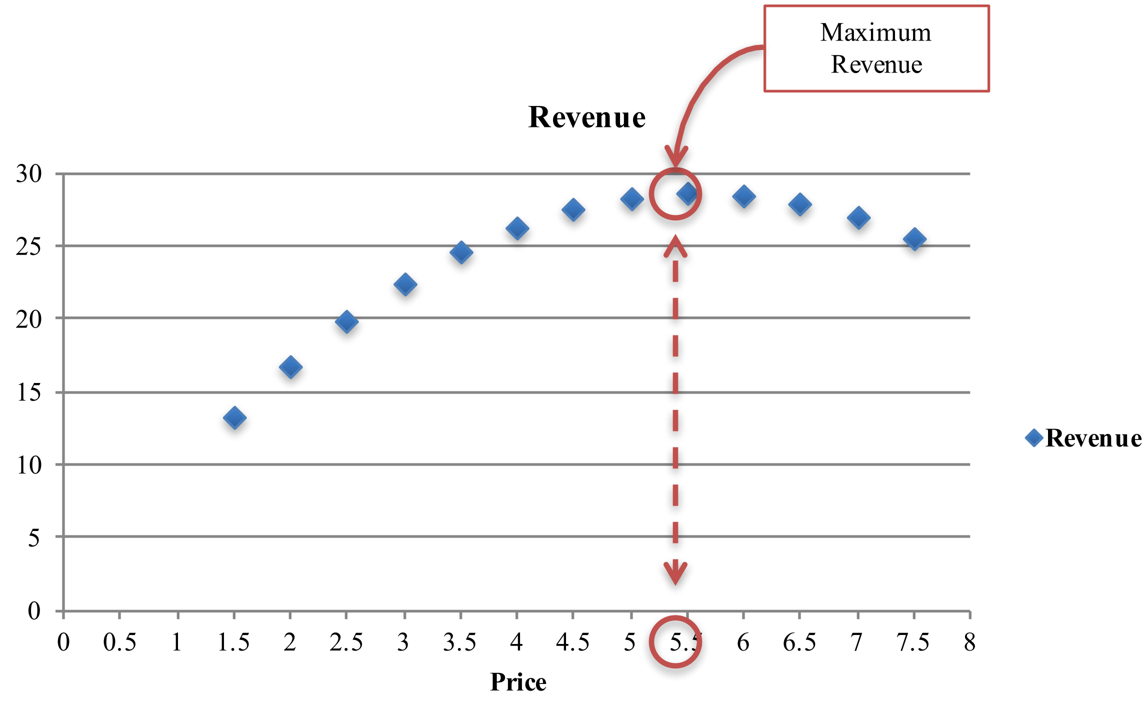

Summary so far

- A problem will have a **goal to optimize**, **actions** to be taken and a **model** linking the actions and the goal.
- Using the same descriptive analytics we can find different answers to different problems:
  - Zero price maximizes quantity.
  - Price of $5.5 maximizes revenue.
- Next:
  - Adding parameters
  - Market Structure

Example 3 - Maximizing Profit

- In many cases a firm is not interested in maximizing its revenues. It wants to make sure that after paying for the cost of production of the items, it still has money left in the bank.

- We now must take into consideration the cost of producing the items.
- Our goal is to maximize profit, or in other words, maximize revenues minus costs.

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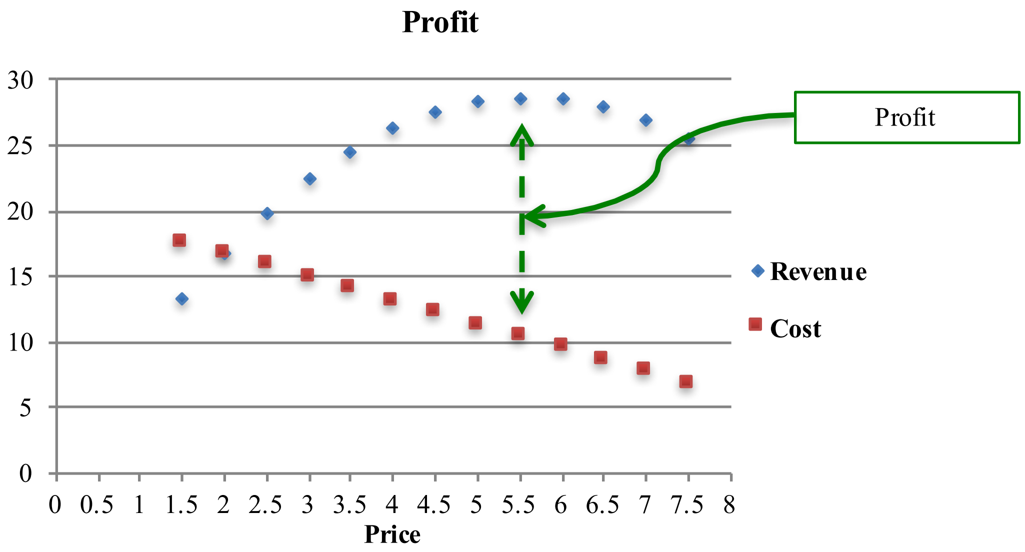
Introducing Costs to the Model

- Suppose each product costs $2 to produce. We can add a second plot to the graph outlining the total cost of producing the quantities sold at each price:



Finding Maximum Profit

- It is hard to tell from this graph where the maximum profit is.
- One way to solve this is to calculate the profit from each combination, and plot it in a new graph:

Things to Learn

- Pricing too low yields **negative** profit – there is a minimum amount of revenue that needs to be generated us to start making a profit.
- The optimal price is higher than the case for the revenue – it is now 6.5 instead of 5.5.
- Is this a principle we can always apply? Do higher costs mean the optimal price is higher?

What Optimization Does

- The process of optimization ("finding the best price to maximize profit") tries to increase price until the there is no additional gain in profit.
- For example, if we increase price from 1.5 to 2.0, the revenue will increase by 16.66-13.17 = 3.49, while the cost will decrease by .9. Therefore the increase is profit is positive, and it is worthwhile to increase the price.
- What happens if we increase the price from 6.5 to 7.0?
  – Revenue increases by 26.81-27.82=-1.01
  – Cost increases by 7.66-8.56 = -0.9
  – Total gain in profit is -1.01 - (-0.9) = -0.11

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MR=MC

- In the examples above we saw that one increase in price increases our profit, while the other decreases it.
- How far should we increase the price?
  - Until there is no gain in profit of course.
- How can we find when this happens?
  - We look for the case when the change in revenue equals the change in cost. Their difference will then be zero.
- The change in revenue is called “marginal revenue” (MR), and change in cost is called “marginal cost” (MC).

Summary

- To maximize the profit we need to take costs into account.
- A general principle that applies in many cases is that the optimal price is found when we increase the price until the gain from revenue equals the increase in costs.
- In other words: MR=MC.

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Market Structure

- Do you think the optimal price may change depending on the environment in which the product is sold?

- Think for a minute, what would be the impact of:
  - If there was only one consumer, or multiple consumers in the market?
  - If there are other competing products consumers can choose from?

Market Structure

- The structure of the market is part of the model. It adds to the question of “how do my actions affect outcomes”, also answers to questions such as “who else is also active in my market” and others.

- Can we use the same descriptive data from before to maximize profit in different cases?

- Of course we can!

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The One Consumer Case

- But what would happen if someone told us the demand curve that we saw came from only a single consumer?
- One thing we can notice is that this consumer may want to purchase more than one product based on the price.
- Is the consumer willing to pay the same amount for each item?
- Let’s see.

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Willingness to Pay (WTP)

- Willingness to pay is how much (at most) would a consumer pay for an additional item she buys.
- We find it by calculating the area below the demand curve for each additional item (or fraction of an item).
- For example, the table calculates the additional profit with an additional **half** item purchased.

Quantity	Price	WTP	Cost	Profit
0	11.26		0	
0.5	10.70	5.49	1	4.49
1	10.14	5.21	1	4.21
1.5	9.59	4.93	1	3.93
2	9.03	4.66	1	3.66
2.5	8.48	4.38	1	3.38
3	7.92	4.10	1	3.10
3.5	7.37	3.82	1	2.82
4	6.81	3.54	1	2.54
4.5	6.26	3.27	1	2.27
5	5.70	2.99	1	1.99
5.5	5.14	2.71	1	1.71
6	4.59	2.43	1	1.43
6.5	4.03	2.16	1	1.16
7	3.48	1.88	1	0.88
7.5	2.92	1.60	1	0.60
8	2.37	1.32	1	0.32
8.5	1.81	1.04	1	0.04
9	1.26	0.77	1	-0.23

Optimal Bundle

- What happens if we offer a bundle (quantity) of 8.5 items at a price of 55.53?
  - The consumer will still buy it. It is equal to her sum of WTP.
  - The cost will be 8.5x2=17.
  - The profit will be 55.53-17=38.53

- Notice that before the optimal profit was 19.26 at a lower quantity – about half the profit.

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What we've covered so far

- We discussed goals, actions and models.
- We have seen in several examples how changing the model, but using the same data impacts the recommended action – sometimes a lower price is better, sometimes a higher price.

- It is very important to ask the right question – let's see a few examples why.

Competition

- Did we assume anything about competition in the previous examples?
  - Yes we did – we assumed that if we change the price, the consumers respond in a specific way, but we assumed no other company also changes its price.
- But in reality, if we lower a price to increase profit, wouldn't our competitor do the same?
- This is called **strategic interaction** and the field of game theory provides the tools to answer these questions.

Online Advertising

- When running an online advertising campaign, companies can choose where to show their ads. For example, they can try to expose the same campaign to the same person on multiple ad networks – on Facebook, on Google, on Bing etc.
- Because it is very hard to tell which ad was the most impactful in a series of ads, and because it is hard to tell what the profit from a consumer is, many advertisers count “click-through-rate”, or “what percentage of the people exposed to an ad clicked on it” measure.

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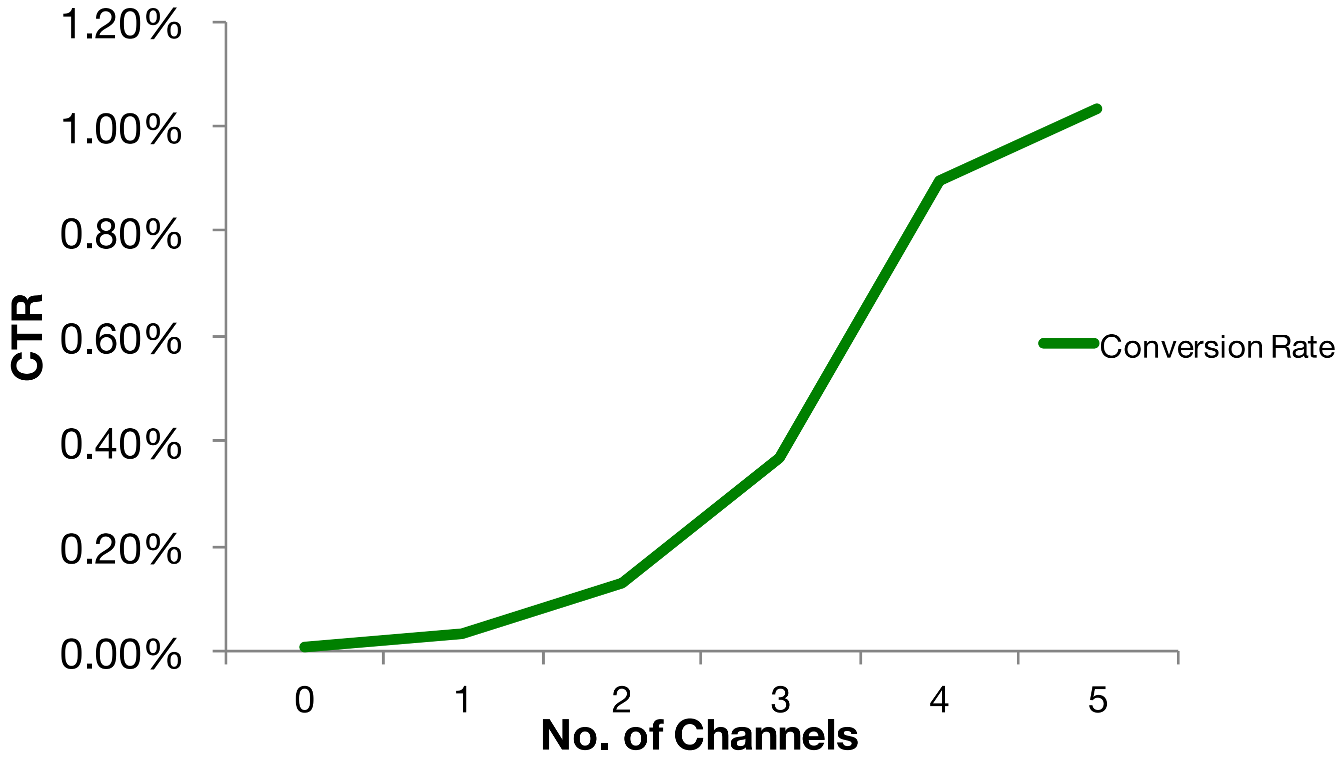
Sample Data



1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
CTR
0
1
2
3
4
5
No. of Channels
Conversion Rate

(Possibly) Incorrect Conclusion

- The more we expose consumers to ads on different networks, the more likely they are to click on ads.

- Why may this be incorrect? What are alternative explanations?

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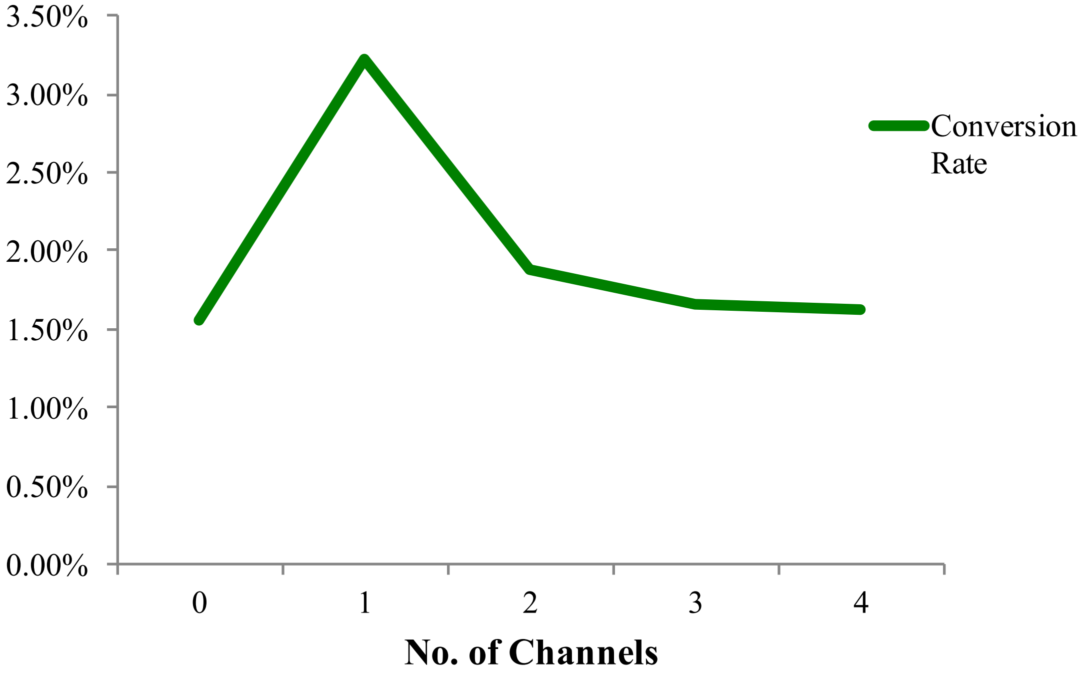
- Why may this be incorrect? What are alternative explanations?

- Because we measure the success of a network by the CTR it achieves, the networks can choose to expose the ads to consumers who will click anyway.

Retargeting Ads



Conclusion

- We have seen examples of applying descriptive data to different goals and models to find an optimal action.
- Many times we think we know how consumers behave, or we interpret the data in a causal way ("if I show more ads, people click more ads"), while there is only correlation.
- We need to be very careful about drawing these conclusions, and many techniques exist to help us avoid these mistakes.

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If you would like to learn more

The topics covered in this section include parts of “consumer theory” in Economics and basic optimization and pricing theories.

Competition and more sophisticated models require some understanding of game theory and typically falls under a field called “industrial organization (IO)”.

Next - Application

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