PRICE PROMOTIONS & CUSTOMER LIFETIME VALUE

Pricing Strategies
2024

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CHICAGO BOOTH
The University of Chicago Booth School of Business

Overview

- Price Promotions
  - One-shot segmentation

  versus

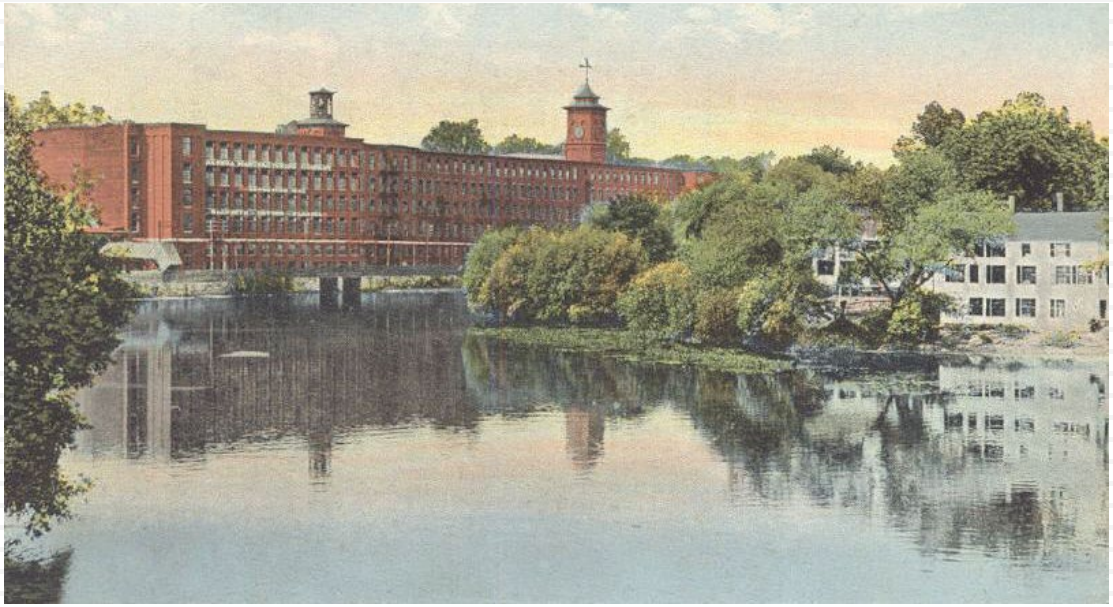
  - Long-run investment
- Pricing as an **investment**
  - Pricing objectives & the **lifetime value of the customer**
  - Pricing decisions to balance **acquisition** & **retention**

→ **Pricing & *CRM***

Case Study: Nashua Photo

NASHUA

Your Source for Solutions.



See Appendix for examples of coupons as ***segmented pricing***

Evaluating Price Promotions

Example: Nashua Photo

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- Based on 1993 *Efficiency Report*, how does Nashua evaluate its price promotion campaigns?

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Promotion Number	Mailer Type	Circ	CPM	Total Resp.	New Cust.	Total Cost	Cost per Resp.
Agfa-Showtime	FREE	336	$0.00	14196	6678	$3,286	$0.23
AMA free Dev Offer	FREE	5	$0.00	211	99	$49	$0.23
Corpus Chirsti Caller	59	81	$20.78	3044	852	$2,475	$0.81
Cambden Courier-Post	59	318	$12.36	8030	2248	$7,041	$0.88
Action Arena	TO	6	$38.50	315	123	$290	$0.92
The Times Herald	59	72	$34.96	3157	990	$3,221	$1.02
Coachman Deluxe	59	10	$0.00	93	52	$98	$1.05
Parents	59/89	315	$16.50	7518	4042	$8,278	$1.10
Freedom Press	59	40	$19.64	1017	399	$1,177	$1.16
Advantage Promotions	59/89	435	$16.50	9861	5301	$11,432	$1.16
Bonnie Walton	89	6	$0.00	47	22	$59	$1.25
Baby's first foto	59/89	132	$37.40	4972	2784	$6,228	$1.25
Lansing Journal	59	20	$16.50	401	189	$526	$1.31
Pittstown Press	59	72	$21.98	1702	705	$2,287	$1.34
Wheeling Reader	59	390	$34.50	12498	3079	$17,268	$1.38
Christian Books	59	100	$24.20	2418	1083	$3,398	$1.41
Winn Dixie	59	1624	$28.05	42752	20110	$61,436	$1.44

Average cost per respondent across campaigns is $2.40

Click to see entire list of campaigns

Evaluating Price Promotions

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- How effective are these campaigns?
  - Avg promotional GM = $1.07

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Return on marketing investment

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Agfa-Showtime	FREE	336	$0.00	14196	6678	$3,286	$0.23	-$1.75	-$24,843	-8.56
AMA free Dev Offer	FREE	5	$0.00	211	99	$49	$0.23	-$1.75	-$369	-8.55
Corpus Chirsti Caller	59	81	$20.78	3044	852	$2,475	$0.81	$0.97	$2,953	0.19
Cambden Courier-Post	59	318	$12.36	8030	2248	$7,041	$0.88	$0.97	$7,789	0.11
Action Arena	TO	6	$38.50	315	123	$290	$0.92	$1.97	$621	1.14
The Times Herald	59	72	$34.96	3157	990	$3,221	$1.02	$0.97	$3,062	-0.05
Coachman Deluxe	59	10	$0.00	93	52	$98	$1.05	$0.97	$90	-0.08
Parents	59/89	315	$16.50	7518	4042	$8,278	$1.10	$1.01	$7,585	-0.08
Freedom Press	59	40	$19.64	1017	399	$1,177	$1.16	$0.97	$986	-0.16
Advantage Promotions	59/89	435	$16.50	9861	5301	$11,432	$1.16	$1.01	$9,962	-0.13
Bonnie Walton	89	6	$0.00	47	22	$59	$1.25	$1.32	$62	0.06
Baby's first foto	59/89	132	$37.40	4972	2784	$6,228	$1.25	$1.09	$5,403	-0.13
Lansing Journal	59	20	$16.50	401	189	$526	$1.31	$0.97	$389	-0.26
Pittstown Press	59	72	$21.98	1702	705	$2,287	$1.34	$0.97	$1,651	-0.28
Wheeling Reader	59	390	$34.50	12498	3079	$17,268	$1.38	$0.97	$12,123	-0.30
Christian Books	59	100	$24.20	2418	1083	$3,398	$1.41	$0.97	$2,345	-0.31
Winn Dixie	59	1624	$28.05	42752	20110	$61,436	$1.44	$0.97	$41,469	-0.32

Click to see entire list of campaigns

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- How effective are these campaigns?
  - Avg promotional GM = $1.07

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Click to see entire list of campaigns

Only 4 campaigns with ROMI>0

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- What about cannibalization of bounce-back mailers? Suppose 10% of *repeats* would have used bounce-back…

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Many users are likely not new customers, resulting in cannabilization.

and

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Cambden Courier-Post	59	318	$12.36	8030	2248	$7,041	$0.88	$0.97	$6,477	-0.08
Action Arena	TO	6	$38.50	315	123	$290	$0.92	$1.97	$577	0.99
The Times Herald	59	72	$34.96	3157	990	$3,221	$1.02	$0.97	$2,570	-0.20
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Freedom Press	59	40	$19.64	1017	399	$1,177	$1.16	$0.97	$846	-0.28
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Pittstown Press	59	72	$21.98	1702	705	$2,287	$1.34	$0.97	$1,425	-0.38
Wheeling Reader	59	390	$34.50	12498	3079	$17,268	$1.38	$0.97	$9,985	-0.42
Christian Books	59	100	$24.20	2418	1083	$3,398	$1.41	$0.97	$2,042	-0.40
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Click to see entire list of campaigns

Only 1 campaigns with ROMI>0

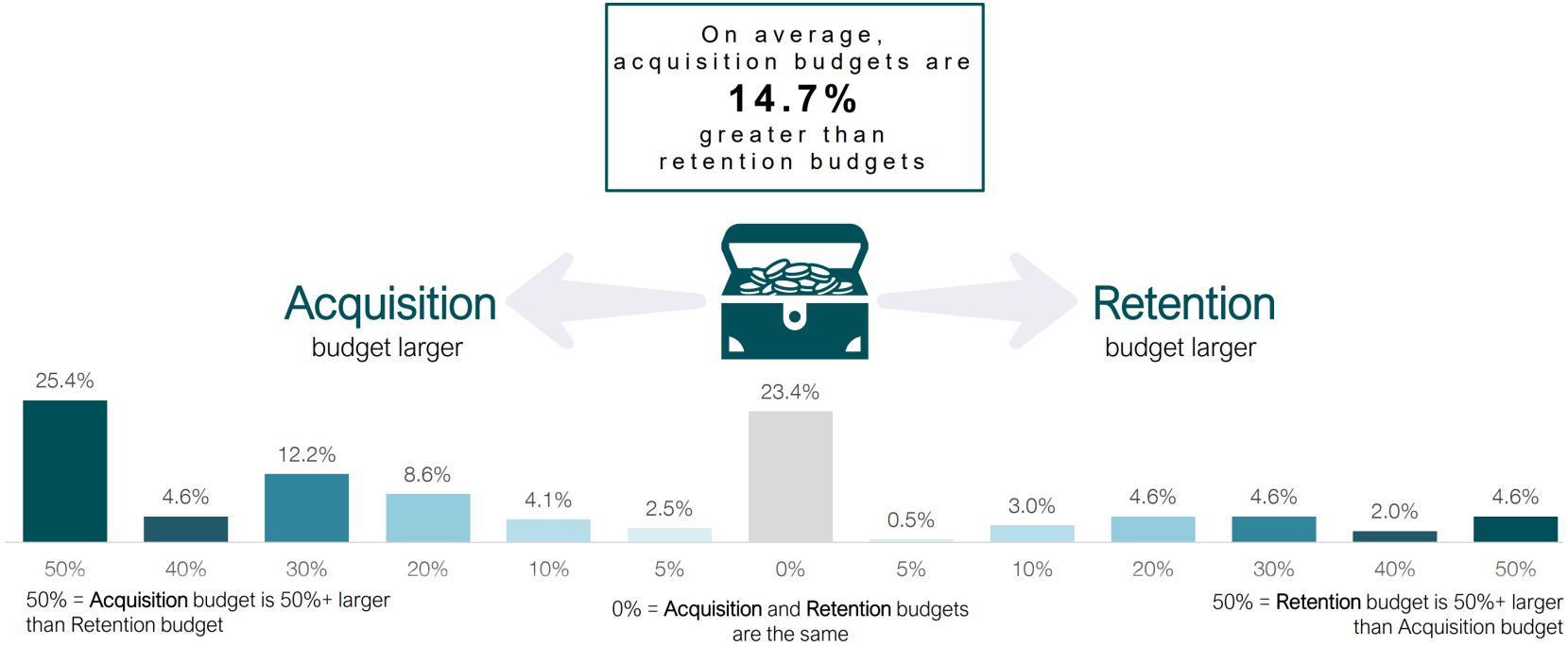
Long Run Effects of Promotions

- Price promotion induces **trial**
- Trial may lead to future **repeat** purchases

*How much should firm be willing to **discount** price to acquire a new customer?*

"Companies spend significantly more of their budgets on customer acquisition than on customer retention"

How do your company's budgets for customer acquisition and customer retention compare?



Source: CMOSurvey.org, 2022

Customer Lifetime Value (CLV)

Simple NPV Calculation for customer's *cash-flow*

What is CLV of a customer who will spend $10 each period (starting today) over some time horizon (e.g., annuity)?

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$$\boldsymbol{NPV = \$10 + \left(\frac{1}{1+r}\right)\$10 + \left(\frac{1}{1+r}\right)^2 \$10 + \cdots}$$

r = interest rate
i.e., Firm's cost of capital

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$$\boldsymbol{= \frac{\$10}{1-\delta}}$$

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$$= \frac{\$10}{1-\delta}$$

$$\Rightarrow NPV = \$10 + \delta NPV$$

this recursive formulation will be useful shortly.

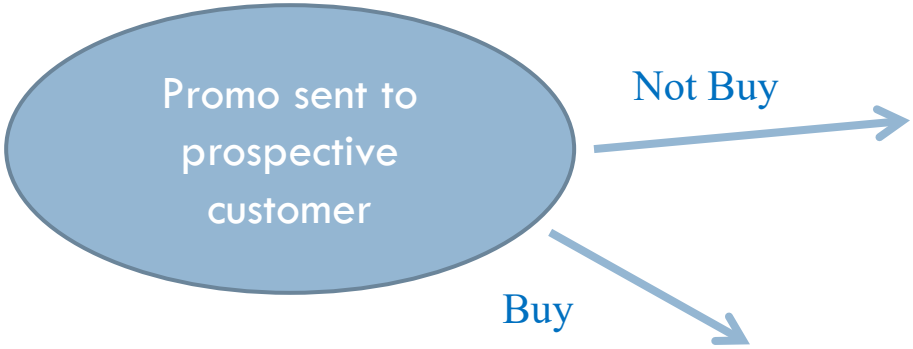
LR promotion benefit: **Customer Journey**

example: Nashua Photo

Promo sent to prospective customer

LR promotion benefit: **Customer Journey**

example: Nashua Photo



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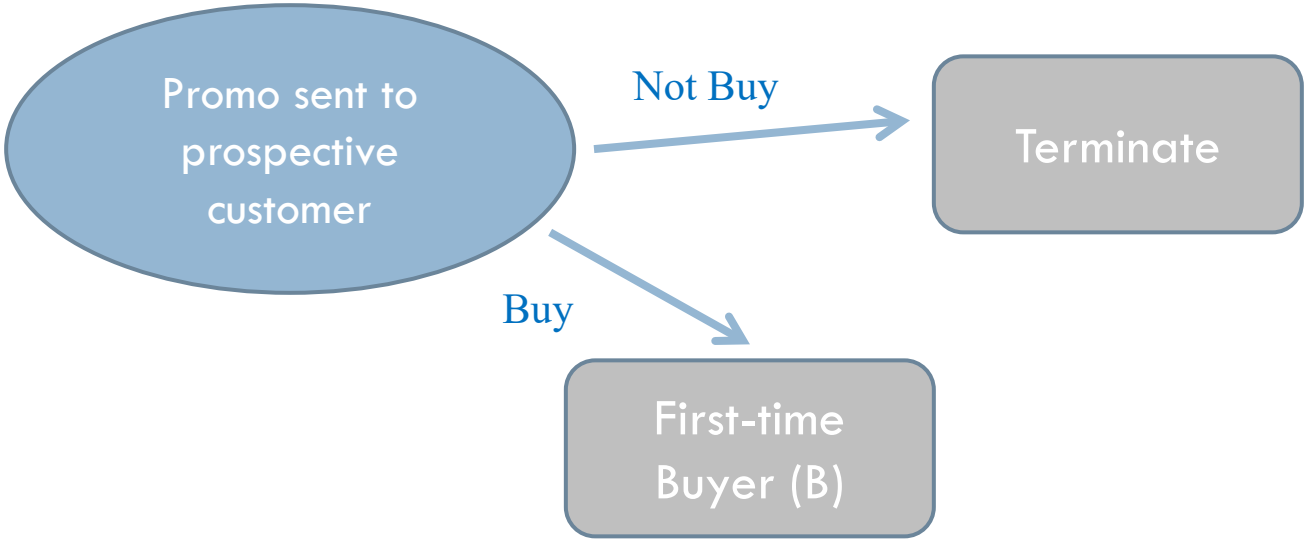

Get 'Em

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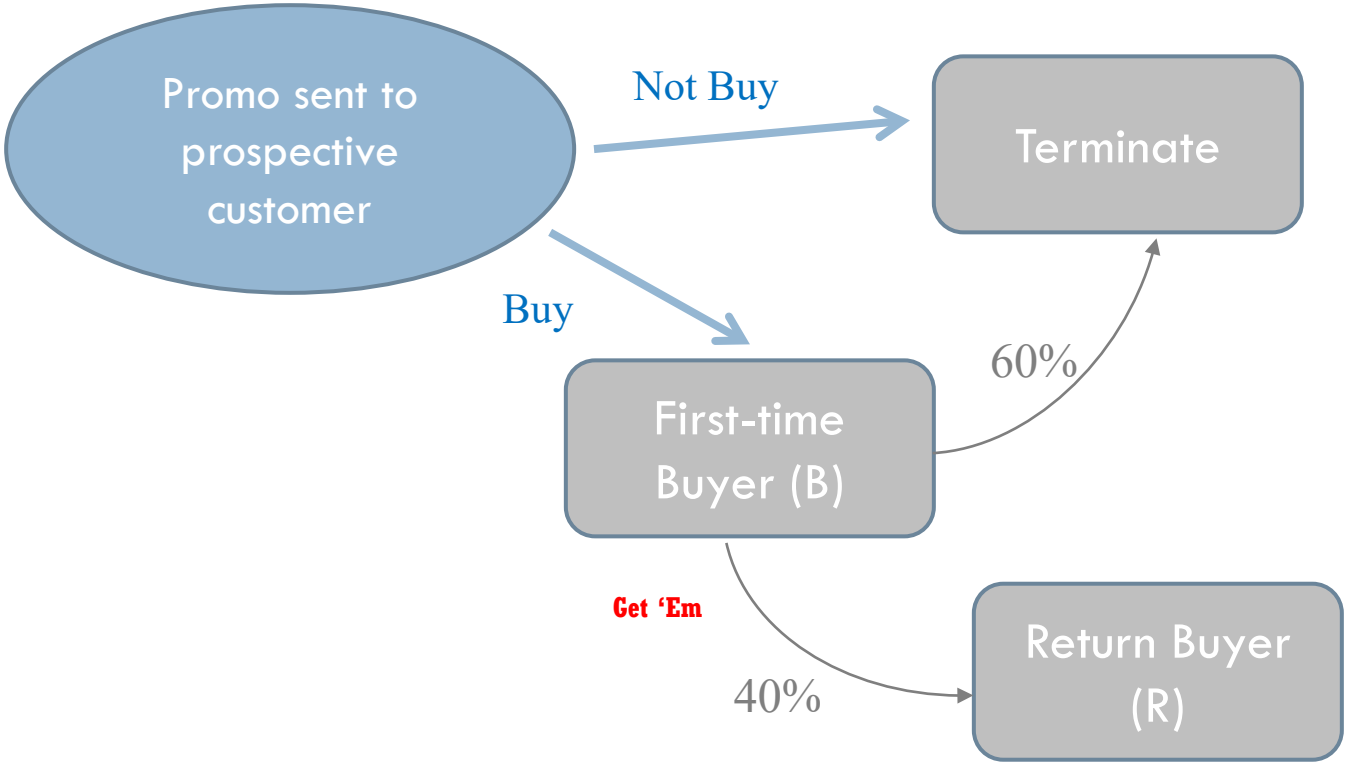

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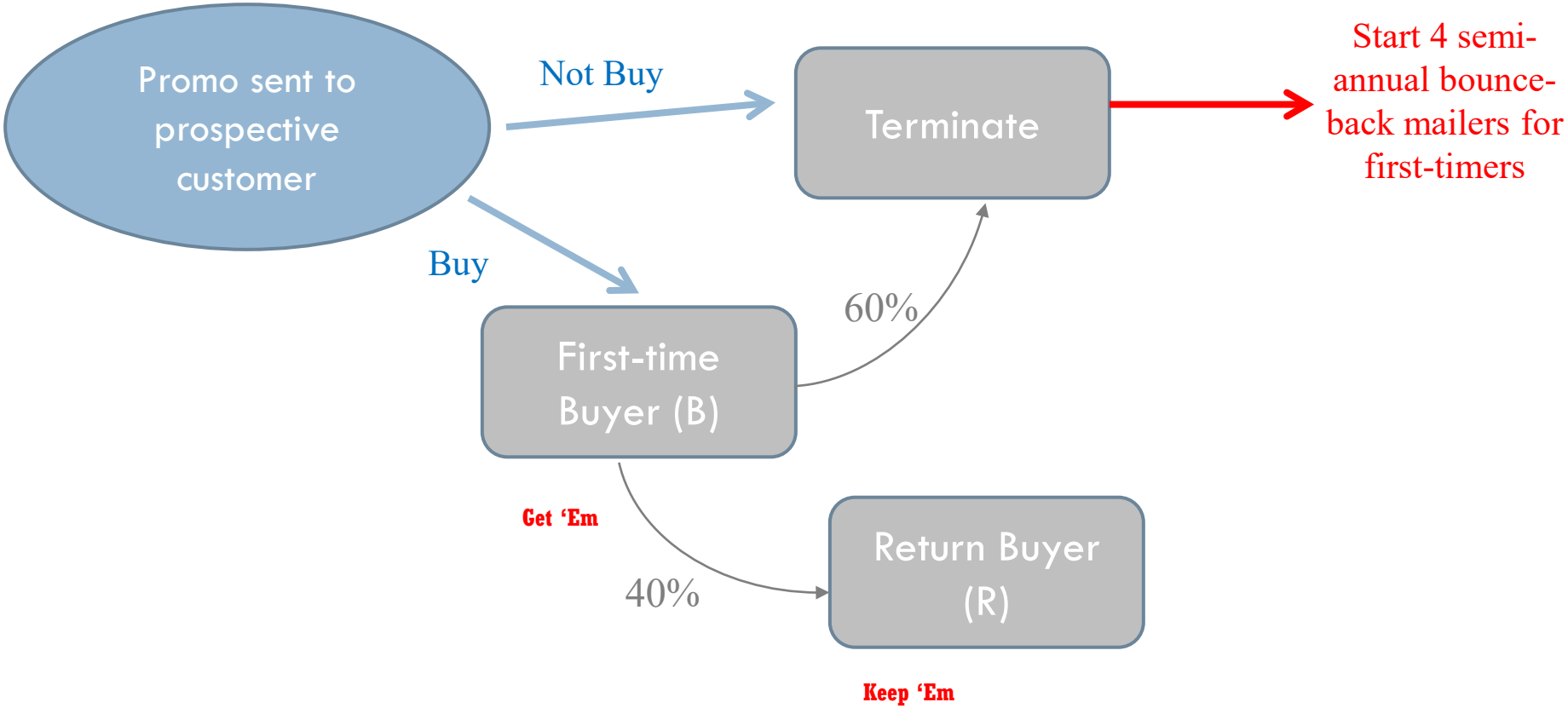

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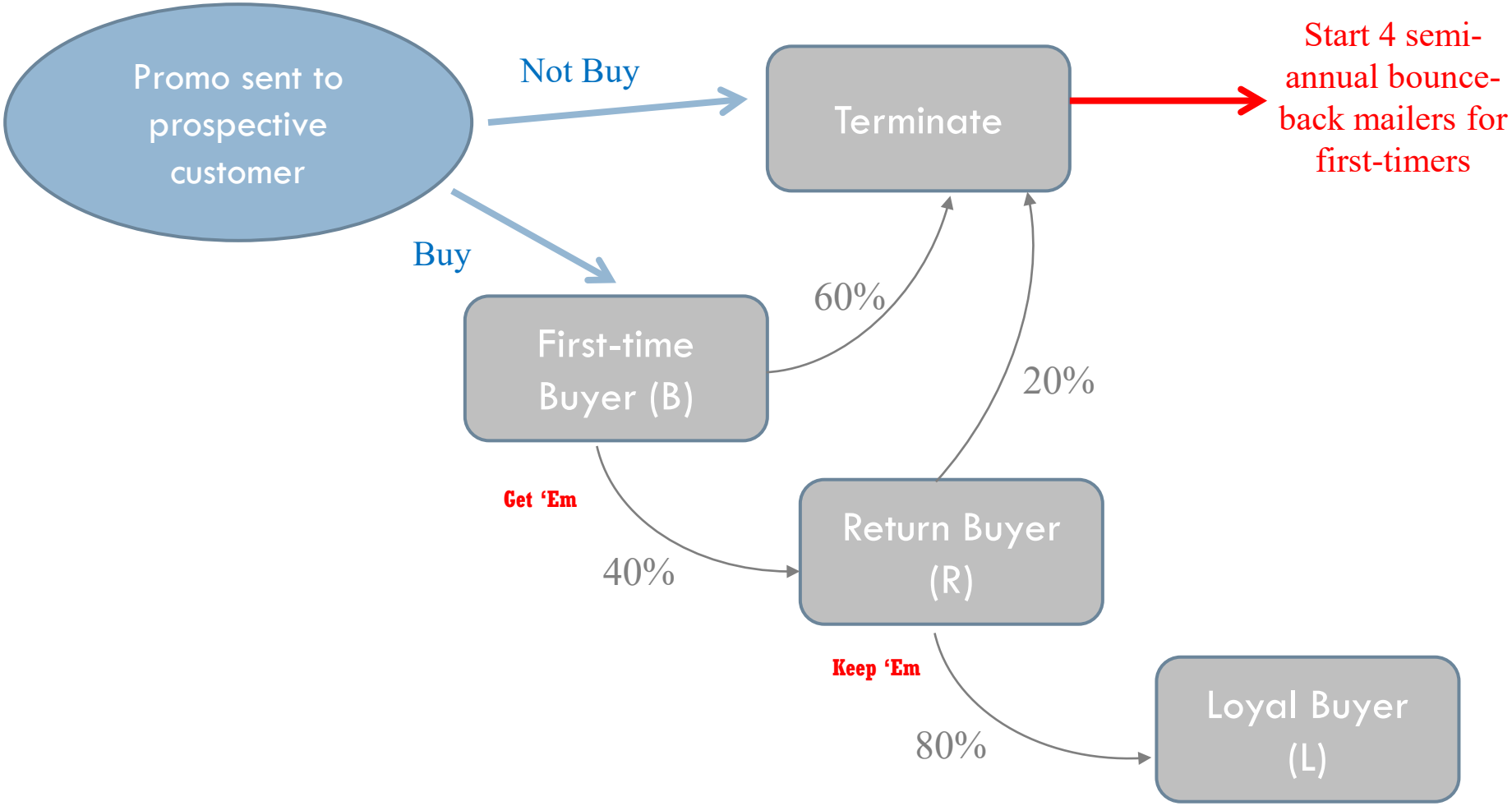

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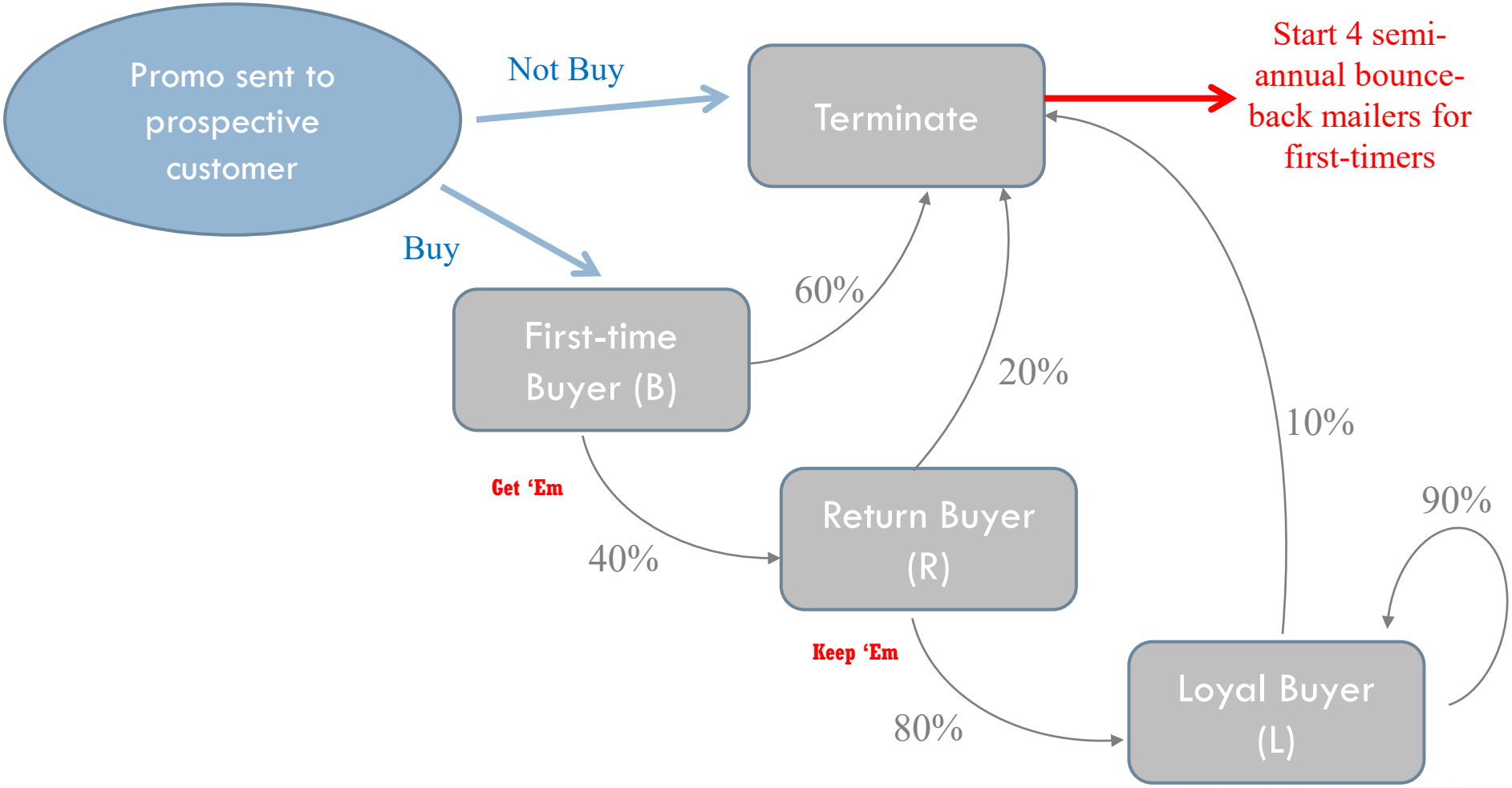

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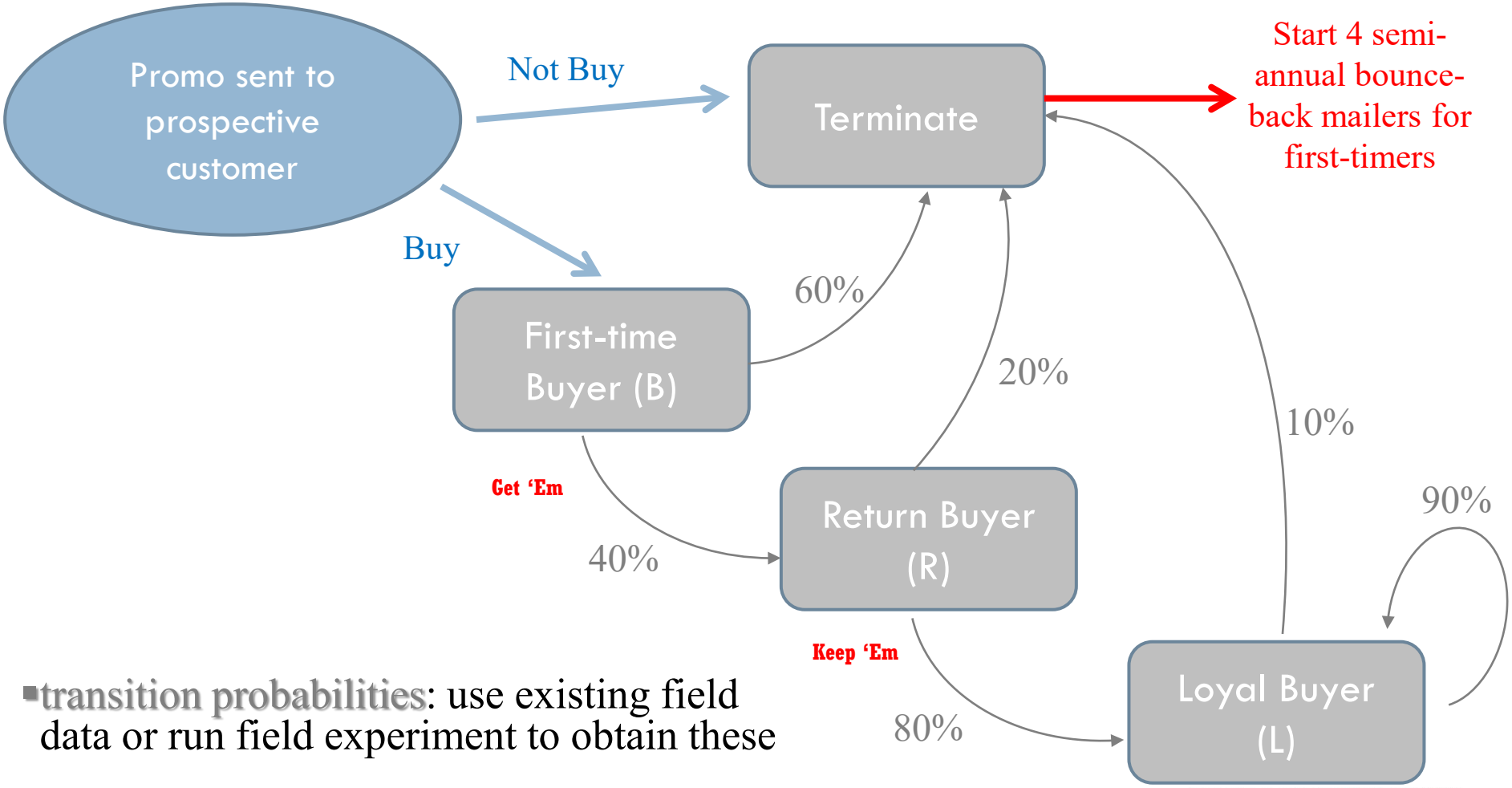

- transition probabilities: use existing field data or run field experiment to obtain these

Assumptions to measure LR benefits example: Nashua Photo

- Customer purchase cycle: 6 months
- Discounting
  - Semi-annual discount rate: $r = 4.88\%$
  - Semi-annual discount factor:

$$\boldsymbol{\delta} = \frac{1}{1+r} = 0.95$$

- Bounce-back mailers (BB):
  - Cost per bounce-back mailer: $\$0.35$
  - PV of mail cost:

$$\boldsymbol{c} = 0.35 + \delta 0.35 + \delta^2 0.35 + \delta^3 0.35 = \$1.31$$

  - Assume can't convert churned customers back
- Gross Margin per repeat order:

$$\boldsymbol{m} = \$2.27$$

CLV of a Buyer model

example: Nashua Photo's 3 buyer types

First-time buyer

- $\boldsymbol{B} = Prob(not\ Buy|\boldsymbol{B})(-c) + Prob(Buy|\boldsymbol{B})(m + \delta\boldsymbol{R})$

Repeat buyer

- $\boldsymbol{R} = Prob(not\ Buy|\boldsymbol{R})(0) + Prob(Buy|\boldsymbol{R})(m + \delta\boldsymbol{L})$

Loyal buyer

- $\boldsymbol{L} = Prob(not\ Buy|\boldsymbol{L})(0) + Prob(Buy|\boldsymbol{L})(m + \delta\boldsymbol{L})$

where

Need to know the value of customer at every stage, then we can backward calculate the value of customer at the start of the relation.

$$c = \$1.31 \qquad Prob(Buy|B) = 0.4$$

$$m = \$2.27 \qquad Prob(Buy|R) = 0.8$$

$$\delta = 0.95 \qquad Prob(Buy|L) = 0.9$$

CLV of a Buyer model

example: Nashua Photo's 3 buyer types

First-time buyer ➢ $\boldsymbol{B} = 0.6 \times (-\$1.31) + 0.4 \times (\$2.27 + 0.95\boldsymbol{R})$

Repeat buyer ➢ $\boldsymbol{R} = 0.2 \times (\ \$0\ ) + 0.8 \times (\$2.27 + 0.95\boldsymbol{L})$

Loyal buyer ➢ $\boldsymbol{L} = 0.1 \times (\ \$0\ ) + 0.9 \times (\$2.27 + 0.95\boldsymbol{L})$

➡ 3 equations & 3 unknowns: $\boldsymbol{B}$, $\boldsymbol{R}$ and $\boldsymbol{L}$

- ❑ *Can you solve it?* (you could literally use pencil & paper)
- ❑ *Can you interpret the solution?*

CLV of a Buyer

example: Nashua Photo's 3 buyer types

		New State			
		Terminate	*New*	*Return*	*Loyal*
	Terminate	1.00	-	-	-
Current	*New*	0.60	-	0.40	-
State	*Return*	0.20	-	-	0.80
	Loyal	0.10	-	-	0.90

Cost of BB mailers	$	(1.31)
AGM on Order	$	2.07
Discount Rate		4.88%
Discount Factor		0.95

Lifetime Value		
1st-time Buyer (B)	$	4.49
Return (R)	$	11.67
Loyal (L)	$	13.13

Click to see CLV analysis via solver

(steps in Appendix)

CLV of a Buyer

example: Nashua Photo's 3 buyer types

		New State			
		Terminate	*New*	*Return*	*Loyal*
	Terminate	1.00	-	-	-
Current	*New*	0.60	-	0.40	-
State	*Return*	0.20	-	-	0.80
	Loyal	0.10	-	-	0.90

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Return (R)	$	11.67
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Click to see CLV analysis via solver

(steps in Appendix)

➡ ***get'em*** promotion is investment in acquisition of **1st-time Buyers (B)** where $CLV^B = \$4.49$

Evaluating Price Promotions with CLV

Example: Nashua Photo

- Which coupons are valuable when positive CLV is added?

Evaluating Price Promotions with CLV

Example: Nashua Photo

- Which coupons are valuable when positive CLV is added?

Promotion Number	Mailer Type	Circ	CPM	Total Resp.	New Cust.	Total Cost	Cost per Resp.	Gross Margin	Total Return	ROMI
Agfa-Showtime	FREE	336	$0.00	14196	6678	$3,286	$0.23	-$1.75	$3,459	0.05
AMA free Dev Offer	FREE	5	$0.00	211	99	$49	$0.23	-$1.75	$50	0.03
Corpus Chirsti Caller	59	81	$20.78	3044	852	$2,475	$0.81	$0.97	$6,284	1.54
Cambden Courier-Post	59	318	$12.36	8030	2248	$7,041	$0.88	$0.97	$16,578	1.35
Action Arena	TO	6	$38.50	315	123	$290	$0.92	$1.97	$1,130	2.90
The Times Herald	59	72	$34.96	3157	990	$3,221	$1.02	$0.97	$7,019	1.18
Coachman Deluxe	59	10	$0.00	93	52	$98	$1.05	$0.97	$315	2.22
Parents	59/89	315	$16.50	7518	4042	$8,278	$1.10	$1.01	$24,959	2.02
Freedom Press	59	40	$19.64	1017	399	$1,177	$1.16	$0.97	$2,639	1.24
Advantage Promotions	59/89	435	$16.50	9861	5301	$11,432	$1.16	$1.01	$32,747	1.86
Bonnie Walton	89	6	$0.00	47	22	$59	$1.25	$1.32	$155	1.65
Baby's first foto	59/89	132	$37.40	4972	2784	$6,228	$1.25	$1.09	$17,416	1.80
Lansing Journal	59	20	$16.50	401	189	$526	$1.31	$0.97	$1,190	1.26
Pittstown Press	59	72	$21.98	1702	705	$2,287	$1.34	$0.97	$4,593	1.01
Wheeling Reader	59	390	$34.50	12498	3079	$17,268	$1.38	$0.97	$23,821	0.38
Christian Books	59	100	$24.20	2418	1083	$3,398	$1.41	$0.97	$6,909	1.03
Winn Dixie	59	1624	$28.05	42752	20110	$61,436	$1.44	$0.97	$126,696	1.06

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Accounting for CLV, 103 campaigns with ROMI>0!!!
(over 80% of campaigns!)

Price Promotion & CLV of customer

Example: Free Unlimited Service at Sprint

"Sprint's Latest Salvo in Wireless Price War: Free, Unlimited Service"

Ryan Knutsen, *Wall Street Journal*, 6-13-2017

- One year free service if switch from rival
  - Unlimited text, data, calling

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Free?

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- Sprint's argument:
  - Offer only advertised online and sign-up online
  - Lower acquisition cost than other forms of advertising

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Free?

- Sprint's argument:
  - Offer only advertised online and sign-up online
  - Lower acquisition cost than other forms of advertising
- Concern:
  - Targeted at Verizon customers
  - competitive reaction!

CLV Pricing and **Marketing for Bad**?

Example: Free OxyContin & **addiction**

- Purdue used a "patient starter coupon program"
  - Free limited-time subscription for 7 to 30 days
  - 34,000 coupons redeemed nationally in 2001

See https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2622774/

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CLV Pricing and **Marketing for Good?**

Example: Netflix and inattention

"Netflix's Plan to Auto-Cancel Subscriptions Is Radically Sane"

Brian Barrett, *Wired*, May 24, 2020

"If you don't watch anything on Netflix for a year after you join, the company will send you an email asking if you want to keep your membership. You'll also get a message if you go two years without watching anything on Netflix at any point. If you write back to say, "Yes, please keep charging me for all these seasons of Riverdale I'm ignoring," nothing changes. If you ask to cancel or don't write back at all, Netflix automatically stops charging you."

NETFLIX

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NETFLIX

CLV Pricing: **acquisition & retention**

Example: Ziprecruiter.com

- Recall online recruiting B2B pricing experiment
- Originally charging $99 per month
- August 2015, tested 10 randomized price levels
- Determined $281 **optimal** in short-run

Can $99 be rationalized under CLV?

Pricing and CLV at Ziprecruiter

Pricing & Retention

- What about customer **retention**?
  - Cash flows from all subsequent months customer survives
  - Plausible that retention decreases for higher prices
- So retention is not a fixed number, it's a **function** of price

Pricing and CLV at Ziprecruiter

Measuring Retention

- Immediately after experiment, don't observe retention rates
- So need an assumption
- For instance, assume at price $\boldsymbol{p}$:

$$Prob(trial|\boldsymbol{p}) = Prob\ (retention|\boldsymbol{p})$$

  - Monthly discount rate: $r = 0.4\%$ (i.e., annual rate $= 5\%$)
  - ➡ Monthly discount factor: $\delta = \frac{1}{1+r} = 0.996$

See Appendix for retroactive analysis using actual retention rates

Pricing and CLV at Ziprecruiter

Assume retention rate same as acquisition rate

- Expected Net Present Value of revenues at a given price **p**:

Pricing and CLV at Ziprecruiter

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Probability customer survives for $\boldsymbol{t}$ months:

$$Prob(buy|\boldsymbol{p}) \times \cdots \times Prob(buy|\boldsymbol{p}) = [Prob(buy|\boldsymbol{p})]^{\boldsymbol{t}}$$

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$$= \underbrace{\left(\frac{\mathbf{1}}{\mathbf{1} - \boldsymbol{\delta}Prob(buy|\boldsymbol{p})}\boldsymbol{p}\right)}_{\textbf{Retention value}} Prob(buy|\boldsymbol{p})$$

Retention value
(i.e., CLV)

Probability customer survives for $\boldsymbol{t}$ months:

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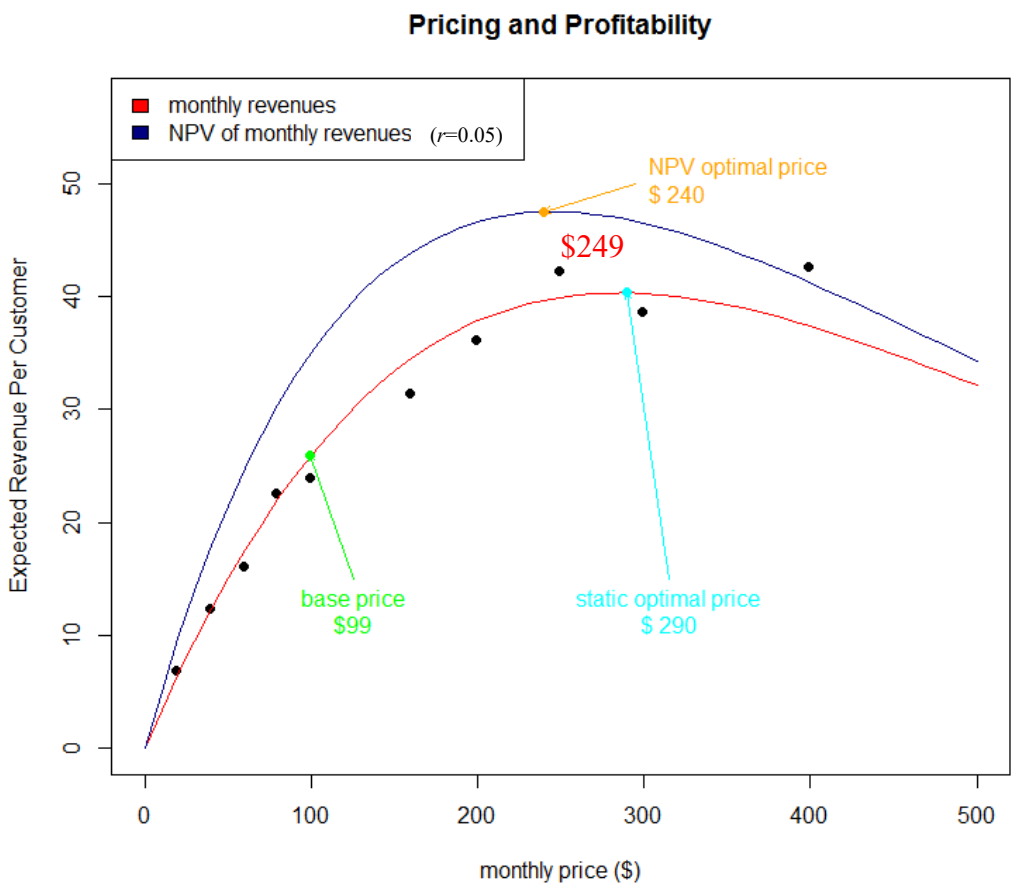
<u>Recall</u>: $Prob(buy|\boldsymbol{p})$ can be estimated via logistic regression (see module 2 and Appendix)

Pricing and CLV at Ziprecruiter

Assume retention rate same as acquisition rate



See Appendix for R code

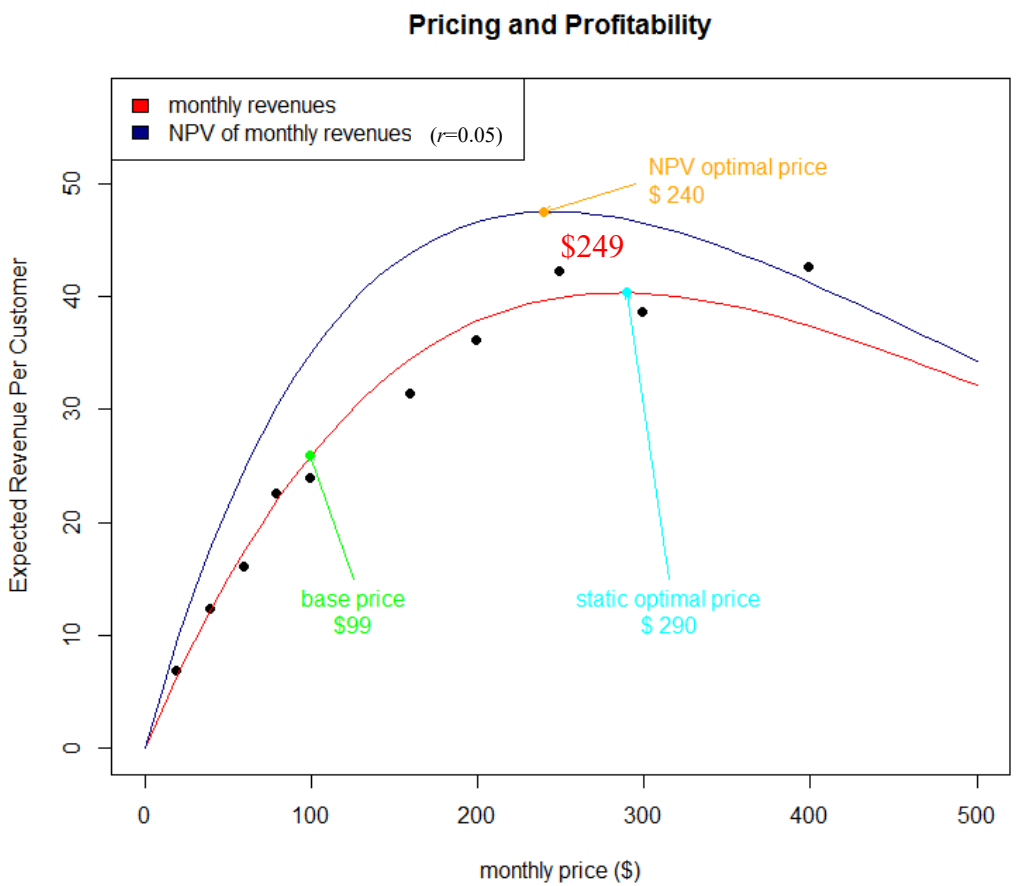
Optimal lifetime value price slightly lower: $240

Pricing and CLV at Ziprecruiter

Assume retention rate same as acquisition rate

Note:
Pricing to CLV did not improve Ziprecruiter's profits much due to relatively low repeat rates

Growth mainly from static optimization as in weeks 2 & 5



Will 99 give us longer relation with paying customers?

optimal price falls from 249 slightly to 240.

static vs dynamic (require excel Goal Seek).

See Appendix for R code

Optimal lifetime value price slightly lower: $240

Pricing and CLV at Amazon

Example of pricing with the future in mind

The 20 Smartest Things Jeff Bezos Has Ever Said

Words from the wise.

Morgan Housel (cmfhousel)
Sep 9, 2013 at 5:09PM

10. "We've done price elasticity studies, and the answer is always that we should raise prices. WE don't do that, because we believe – and we have to take this as an article of faith – that by keeping our prices very, very low, we earn trust with customers over time, and that that actually does maximize free cash flow over the long term."

Pricing and CLV at Tesla?

Penetration pricing or price/turf war?

"Tesla Earnings Dented by Price Cuts"

Several rounds of reductions in the first months of the year weighed on Tesla's first-quarter results

Rebecca Elliott, *WSJ*, April 19, 2023

"We've taken a view that pushing for higher volumes and a larger fleet is the right choice here versus a lower volume and higher margin…"
"We're the only ones making cars that technically could sell for zero profits now and yield tremendous profits in future through autonomy [and charging and software]…"

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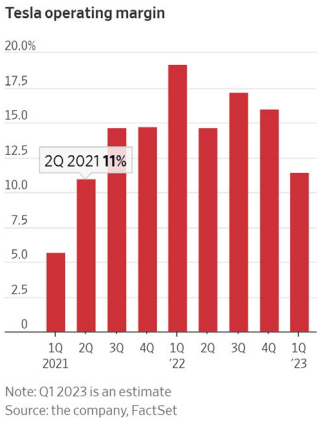

Tesla Is Pulling Back From EV Charging, and People Are Freaking Out

By Jennifer Hiller, WSJ, May 1, 2024

CHICAGO BOOTH
The University of Chicago Booth School of Business

Take-Away

- Discounts: *short-run gain* vs **CLV** (i.e., investment)
- Pricing to the **customer Lifetime Value (CLV)**
- Pricing and **CRM** – balancing **acquisition** & **retention**

  Think *Razors & Blades over time* (initial trial = Razor)
- See Appendix for "*Freemium*" as pricing to CLV

Razor and blades; First price at low cost, and we get back over time (retention).

Extra

Coupons can also be used for static Segmented Pricing (like a product line)

Promotions as a "One Time Gain"

Example: Coupons…But *is it always profitable?*

- 2 types of customers who vary in disutility of coupon

Segment	WTP	Disutility	Size
H	$15	-$5	100
L	$11	-$4	100

- What's the optimal uniform price?
  - Strategy 1: Shelf Price=$15, profit: $1500
  - Strategy 2: Shelf Price=$11, profit: $2200
- What's the optimal coupon price?
  - hint: This is just product line pricing…

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    - Coupon face value: $4.99
    - Shelf Price: $7 + $4.99 = $11.99
    - Profit = $1199 + $700 = $1899

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    - Profit = $1199 + $700 = $1899

Promotions as a "One Time Gain" Exercise

- Would you ever offer both a coupon and a price discount at the same time?

- 2 types of customers who vary in disutility of coupon

Segment	WTP	Disutility	Size
H	$15	-$5	100
L	$7	-$1	100

Extra

Using *Solver* in Excel to compute CLV of consumers at different stages of relationship

The solver add-in

In Excel:

1. Go to “Options,” then “add-ins” and select “solver”
2. Under “Manage” select “Excel Add-ins”
3. In menu above, select “Solver Add-in”
4. Click “Go”
5. Make sure “Solver Add-in” is checked and hit “ok”

The spreadsheet

Transition Probabilities

How to read transition probabilities:

For a New customer, there is a 40% chance they become a returning customer.

For a Loyal customer, there is a 10% chance they Terminate

You can adjust the transition probabilites

Solving for the LTV

From each state, you can calculate a LTV.

Use Solver to do this.

You can adjust the transition probabilites, cost of mailing, AGM on Order, Discount Rate (anything in orange).

			New State		
		Terminate	*New*	*Return*	*Loyal*
Current State	*Terminate*	1.00	-	-	-
	New	0.60	-	0.40	-
	Return	0.20	-	-	0.80
	Loyal	0.10	-	-	0.90

Cost of BB mailers	$	(1.31)
AGM on Order	$	2.07
Discount Rate		4.88%
Discount Factor		0.95

You can vary these.

Lifetime Value

First-time Buyer (B)	$	-
Return (R)	$	-
Loyal (L)	$	-

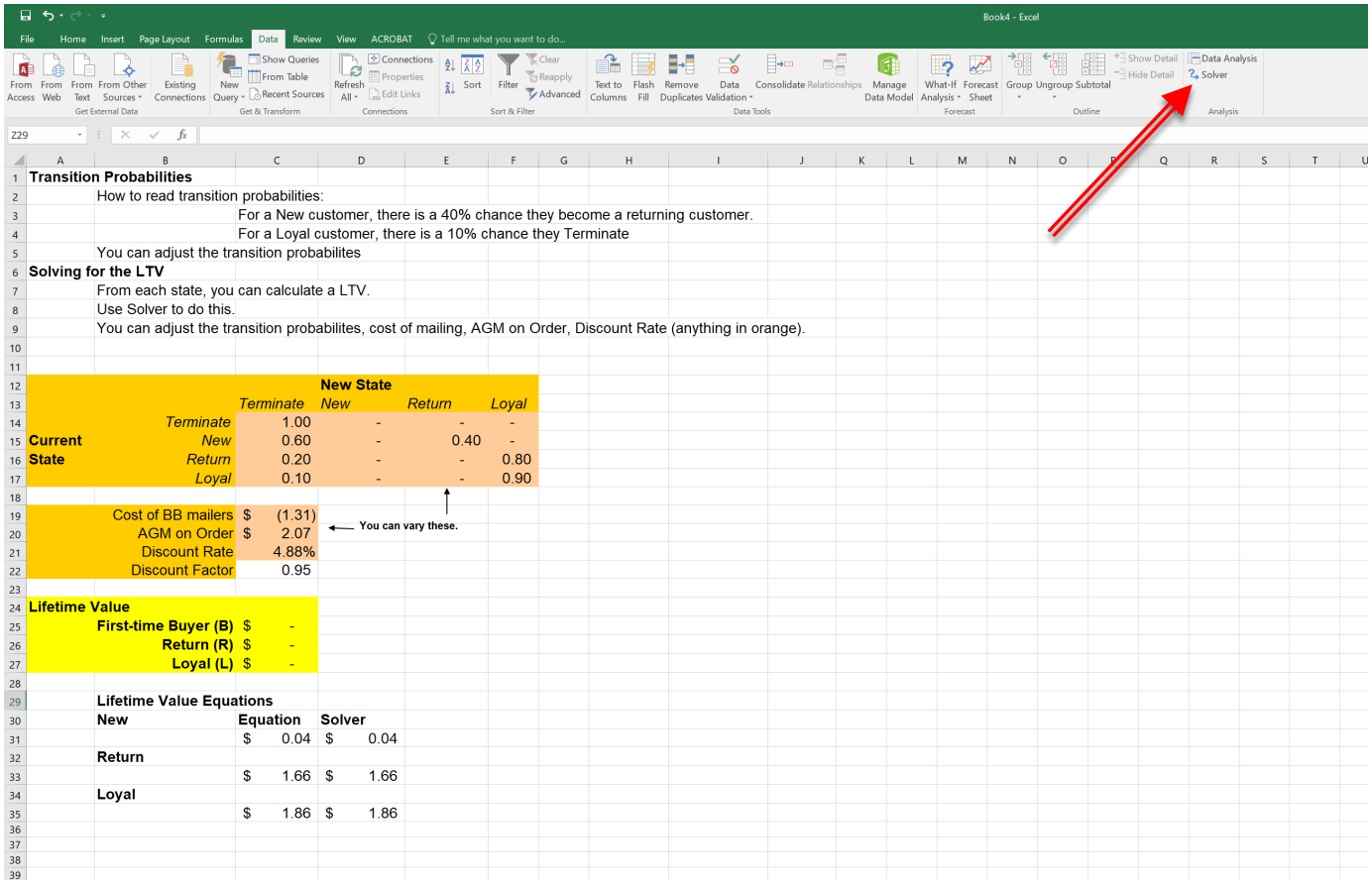
Lifetime Value Equations

	Equation	Solver
New	$ 0.04	$ 0.04
Return	$ 1.66	$ 1.66
Loyal	$ 1.86	$ 1.86

- This is the spreadsheet built into the slides

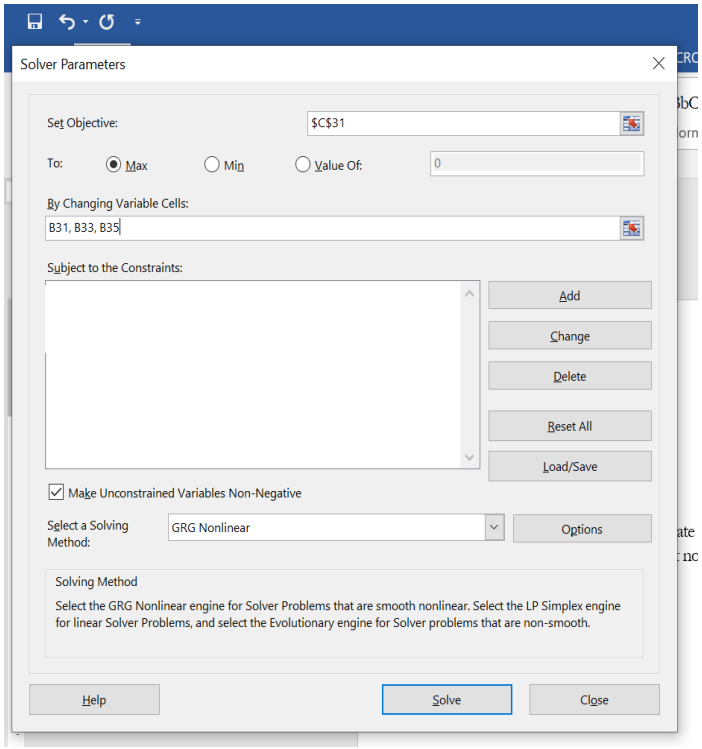
Use solver to compute CLV of consumer types B, R and L

1. Go to “Data” tab and click on “Solver” in “Analysis” group



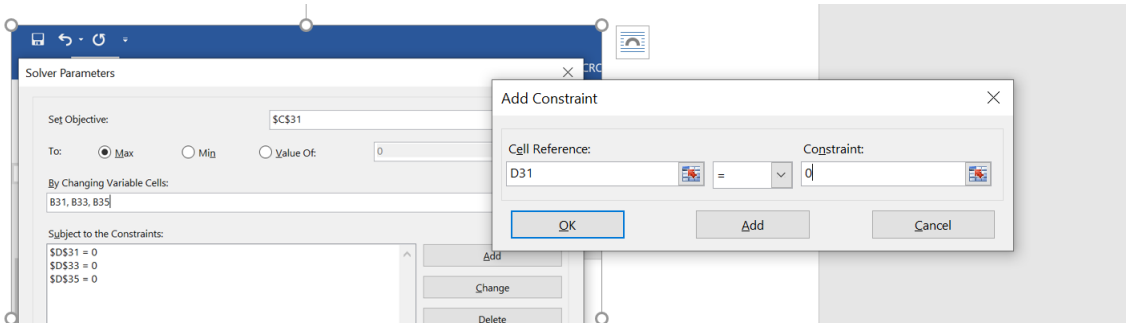
Enter equations into solver

2. In “Set Objective” box, insert cell reference C31, where we set formula for first equation of system.
3. Select the objective as “Max”.
4. Insert range of cell references B31, B33 and B35 in the “By Changing Variable Cells” box.



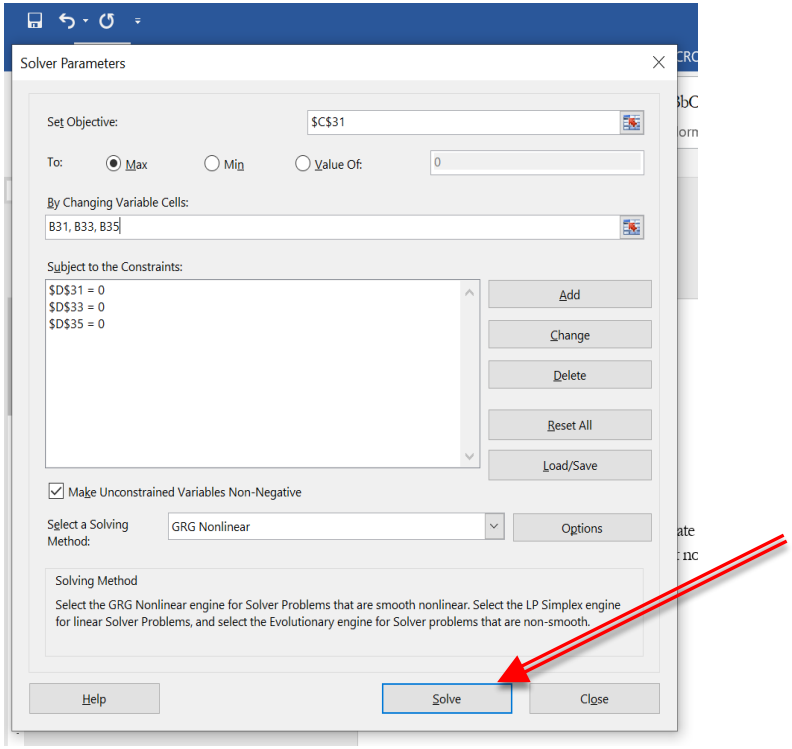
Enter constraints

5. In “Subject to Constraints” box, add constraints for each of the equations by clicking on “Add” button.
   - In “Add Constraints” window, enter the constraints for all equations one by one by pressing “Add” button. Press OK button when done with adding all the constraints.



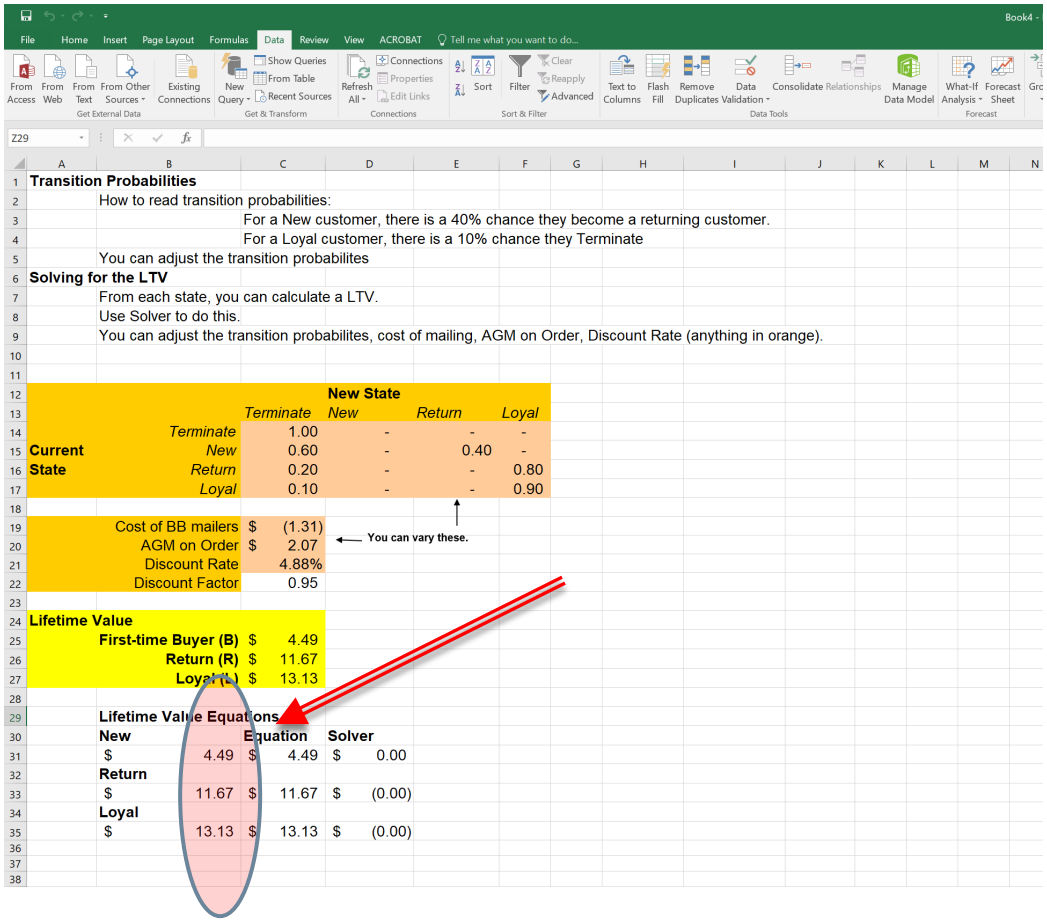
Now solve the system

6. Press “Solve” button



Solved

- Here's the solution



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			New State		
		Terminate	*New*	*Return*	*Loyal*
	Terminate	1.00	-	-	-
Current	*New*	0.60	-	0.40	-
State	*Return*	0.20	-	-	0.80
	Loyal	0.10	-	-	0.90

Cost of BB mailers	$	(1.31)
AGM on Order	$	2.07
Discount Rate		4.88%
Discount Factor		0.95

You can vary these.

Lifetime Value		
First-time Buyer (B)	$	4.49
Return (R)	$	11.67
Loyal (L)	$	13.13

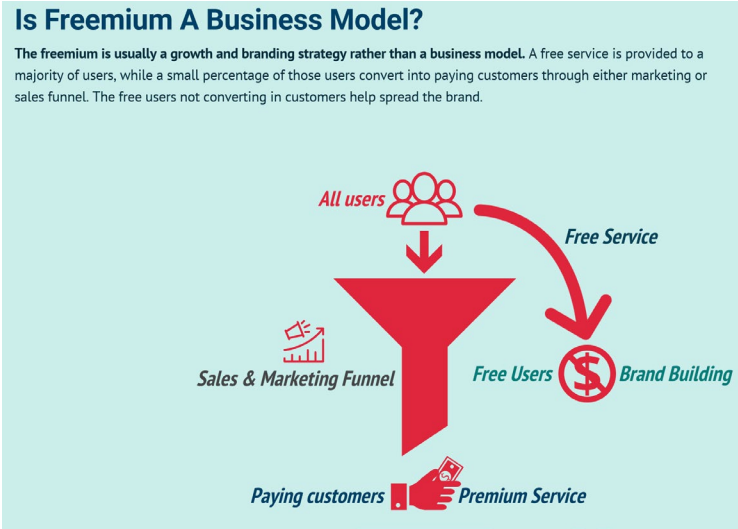
Lifetime Value Equations

New		**Equation**	**Solver**
$	4.49	$ 4.49	$ 0.00
Return			
$	11.67	$ 11.67	$ (0.00)
Loyal			
$	13.13	$ 13.13	$ (0.00)

Freemium as Pricing and LTV

Freemium and LTV

- Many software firms offer ***freemium*** versions to new customers
  - Free to induce trial
  - Then charge for upgrade as user's needs grow



Let's formalize this model …

Freemium and LTV

- freemium model:
  - F = free version, with ad revenues $\$\boldsymbol{a}$
  - P = paid version, with price $\$\boldsymbol{p}$

  Usually $a < p$
- Assume: after upgrading to paid, never downgrade to free
- LTV for a freemium customer:

$$F = Pr(renew\ Free)\underbrace{(\boldsymbol{a} + \delta F)}_{\text{Recurring cash flow from free}}$$

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where

$$P = \boldsymbol{p} Prob(renew\ paid) + \delta \boldsymbol{p}[Prob(renew\ paid)]^{\mathbf{2}} + \cdots$$

$$= \boldsymbol{p} \frac{Pr(renew\ Paid)}{1 - \delta Pr(renew\ Paid)}$$

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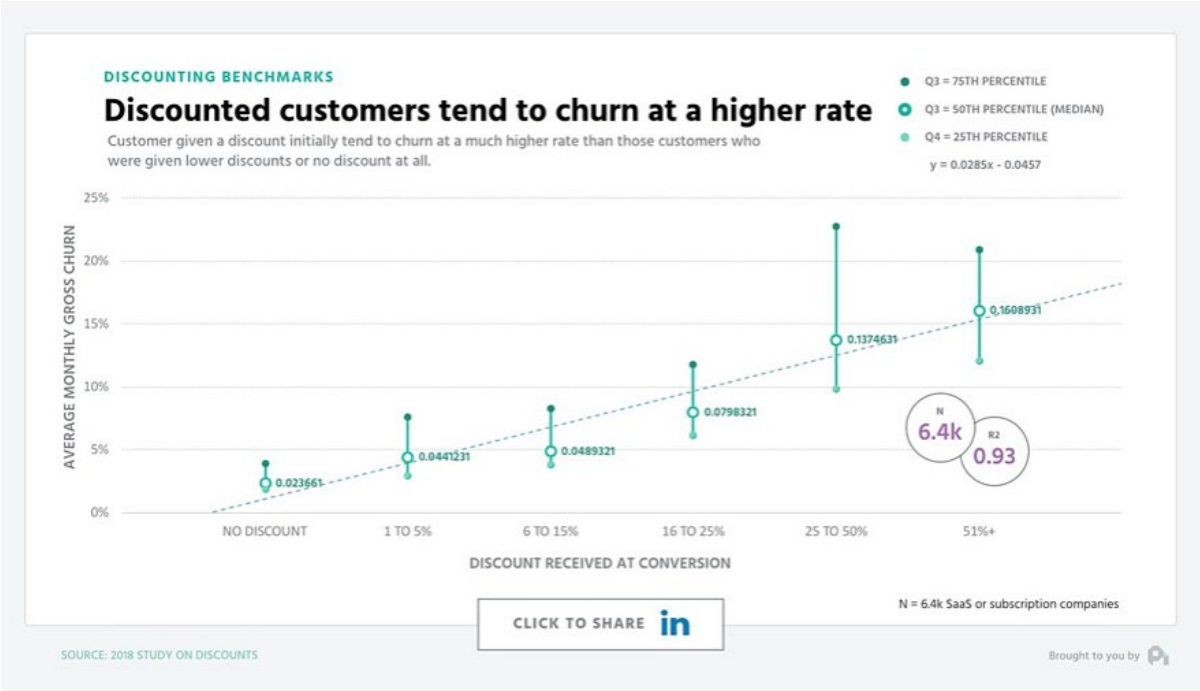
Careful: $Pr(renew\ Paid)$ probably depends on $\boldsymbol{p}$ and falls as $\boldsymbol{p} \uparrow$

Selection effects of introductory pricing

Discounting to *juice* acquisition rates



Customers acquired via discount may be <u>most likely to churn</u>.
Makes sense, discounts mechanically *select* low-value customers at the margin!

- Optimized LTV pricing must balance **acquisition** & **retention**.

Extra

LTV at Ziprecruiter using simulated data.

- R code
- Results
- Figures

Data and code overview

- The actual Ziprecruiter data are confidential and cannot be circulated
- So in this Appendix I will provide R code you can use:
  1. to simulate hypothetical purchase data
  2. to estimate demand
  3. to compute optimal monthly prices
  4. to compute optimal prices against the LTV of the customer
- Although these are simulated data, I set them up to mimic the actual choice behavior from out experiment

The Logistic model

- To predict membership demand at different price levels, I estimated a "Logit" model
- The model predicts the probability of buying at a given price

$$\mathrm{Prob}(Pay \text{ for month of service}|Price) = \frac{\exp(\beta_0 + \beta_1 Price)}{1 + \exp(\beta_0 + \beta_1 Price)}$$

The Logistic model and NPV

- Suppose we have just run the experiment. We obviously do not know the repeat rates (i.e. retention rates) yet.
- If you need to make an immediate pricing decision, you will need to make an assumption about repeat behavior.
- For this exercise, let's assume trial and repeat rates are identical each month. For Ziprecruiter, we later verified this assumption after 6 months had elapsed (in fact, repeat rates were much higher than initial trial rates!)
- Now we can compute the NPV of revenues:

$$NPV(\boldsymbol{p}) = \frac{\mathbf{1}}{\mathbf{1} - \boldsymbol{\delta} Prob(buy|\boldsymbol{p})} \boldsymbol{p} Prob(buy|\boldsymbol{p})$$

A simulation in R to illustrate

Code to create simulated choice data

- The next few slides replicate the logit simulation from the end of the elasticity slides in week 2

```
N = 8000                                                    # number respondents
betatrue = matrix(c(-0.64,-0.004))                          # inter. & price coeff
testprices=matrix(c(19,39,59,79,99,159,199,249,299,399))
Price = sample(testprices,size=N,replace=T)                 # randomize prices
epsilon = -log(-log(runif(N))) +log(-log(runif(N)))         # draw logistic errors
U = betatrue[1]+betatrue[2]*Price+epsilon                   # buying utility
Y = (U>0)*1                                                 # choice data
```

A simulation in R to illustrate

Demand Estimation

- ### Estimate Logistic demand using R's built-in function "glm"
- out = glm(Y~Price,family="binomial")
- betahat = out$coefficients

A simulation in R to illustrate

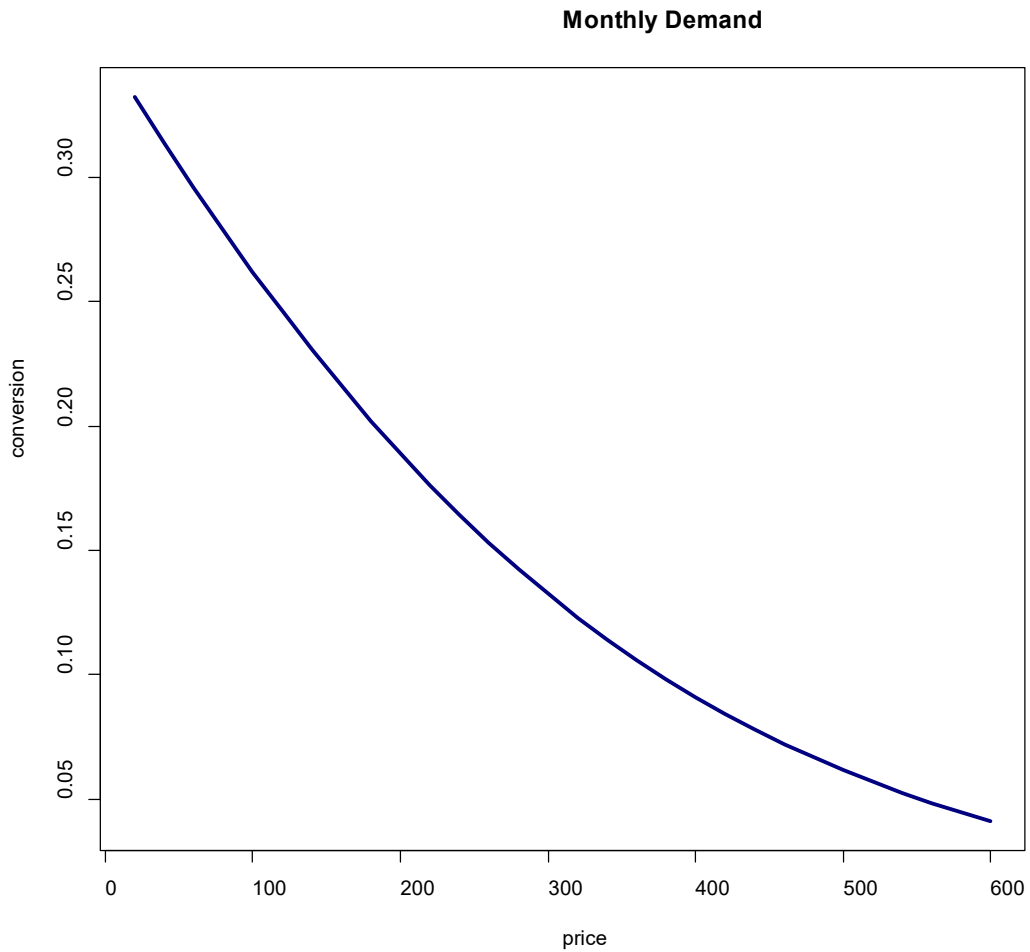
Plot demand estimates


```
# Function to compute logit probability
share = function(x,beta){1/(1+exp(-beta[1]-beta[2]*x))}

# Plot Predicted Demand along a price grid
Pricegrid = seq(from=20,to=600,by=20)
Qgrid = share(Pricegrid,betahat)
plot(Pricegrid,Qgrid,main="Monthly
Demand",type="n",ylab="conversion",xlab="monthly price ($)")
lines(Pricegrid,Qgrid)
```

A simulation in R to illustrate

Plot demand estimates



A simulation in R to illustrate

Compute Monthly Revenue-maximizing price

- # Function to compute expected montly revenue
- Erevenue = function(x,beta){share(x,beta)*x}

- # Optimal static monthly price
- Pstar = round(optimize(Erevenue,c(0,1000),beta=betahat,maximum=T)$maximum)

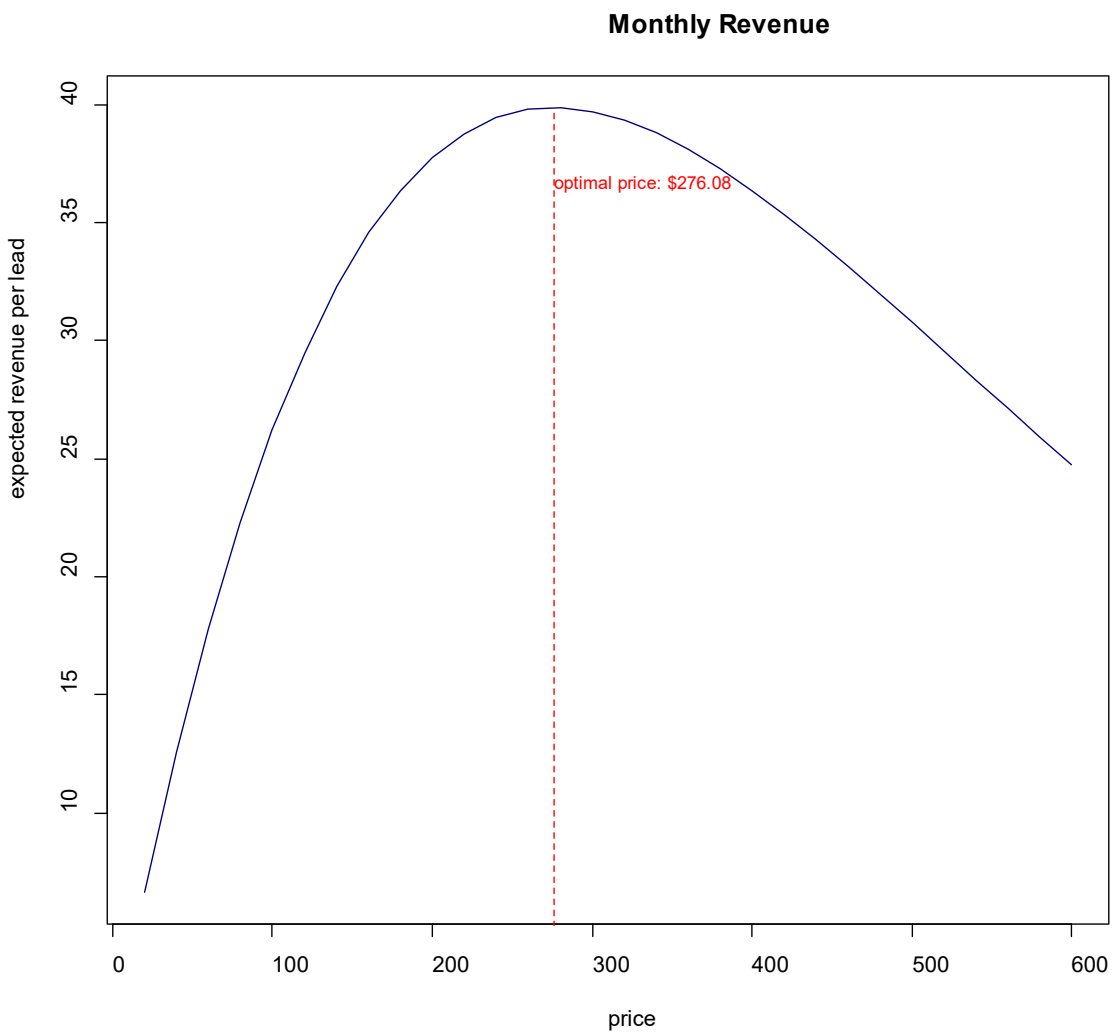
A simulation in R to illustrate

Plot Predicted Monthly Revenue & optimal price

- #Plot Predicted Monthly Revenue
- Revgrid = Qgrid*Pricegrid
- plot(Pricegrid,Revgrid,main="Monthly Revenue",type="n")
- lines(Pricegrid,Revgrid,col="navy")
- lines(c(Pstar,Pstar),c(0,revenue(Pstar,betahat)),lty=2,col="navy")
- text(Pstar,revenue(Pstar,betahat),paste("optimal price: $",Pstar,sep=""),pos=1,cex=.5,col="navy")

A simulation in R to illustrate

Plot Predicted Monthly Revenue & optimal price



A simulation in R to illustrate

Compute NPV of Revenue maximizing price

- #Function to compute NPV of Revenue
- NPVrevenue = function(p,beta,delta){1/(1-delta*share(p,betahat))*(share(p,betahat)*p)}

- # Compute NPV-maximizing price
- delta = .995
- PstarLR = round(optimize(NPVrevenue,c(0,1000),beta=betahat,delta=delta,maximum=T)$maximum)

A simulation in R to illustrate

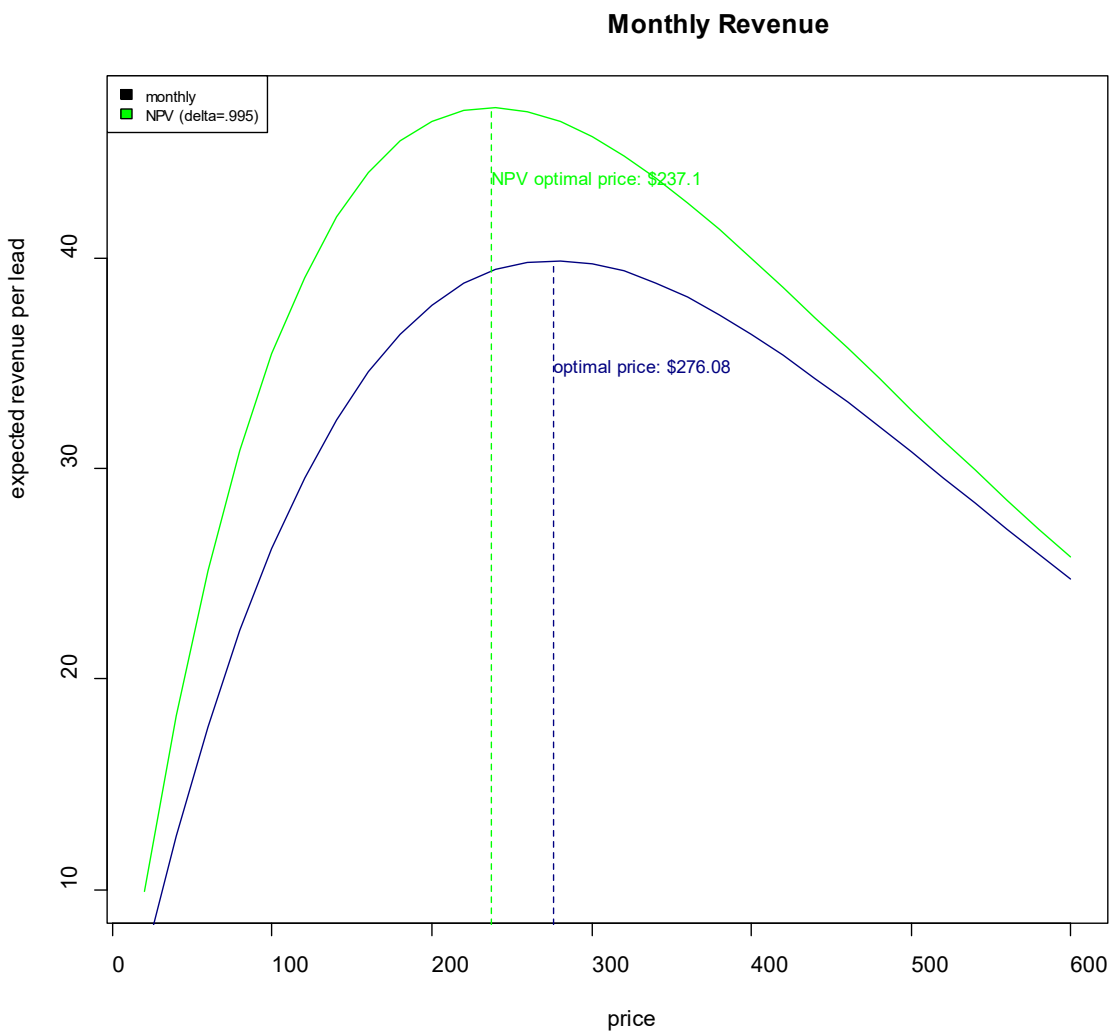
Plot monthly revenue and NPV revenue functions


```
# Compute NPV of Revenues along the price grid
NPVRevgrid = NULL
for(tt in 1:length(Pricegrid)) {NPVRevgrid = rbind(NPVRevgrid,NPVrevenue(Pricegrid[tt],betahat,delta))}

#Plot Predicted Monthly Revenue & NPV of Revenue
plot(Pricegrid,NPVRevgrid,main="Expected Monthly Revenue",type="n",ylab="expected revenue ($)",xlab="monthly price ($)")
lines(Pricegrid,Revgrid,col="navy")
lines(Pricegrid,NPVRevgrid,col="green")
lines(c(Pstar,Pstar),c(0,revenue(Pstar,betahat)),lty=2,col="navy")
text(Pstar,revenue(Pstar,betahat),paste("optimal price: $",Pstar,sep=""),pos=1,cex=.5,col="navy")
lines(c(PstarLR,PstarLR),c(0,NPVrevenue(PstarLR,betahat,delta)),col="green",lty=2)
text(PstarLR,NPVrevenue(PstarLR,betahat,delta),paste("NPV optimal price: $",Pstar,sep=""),pos=1,cex=.5,col="green")
legend("topleft",legend=c("static (delta=0)","NPV (delta=.995)"),fill=c("black","green"),cex=.7)
```

A simulation in R to illustrate

Plot monthly revenue and NPV revenue functions



Extra

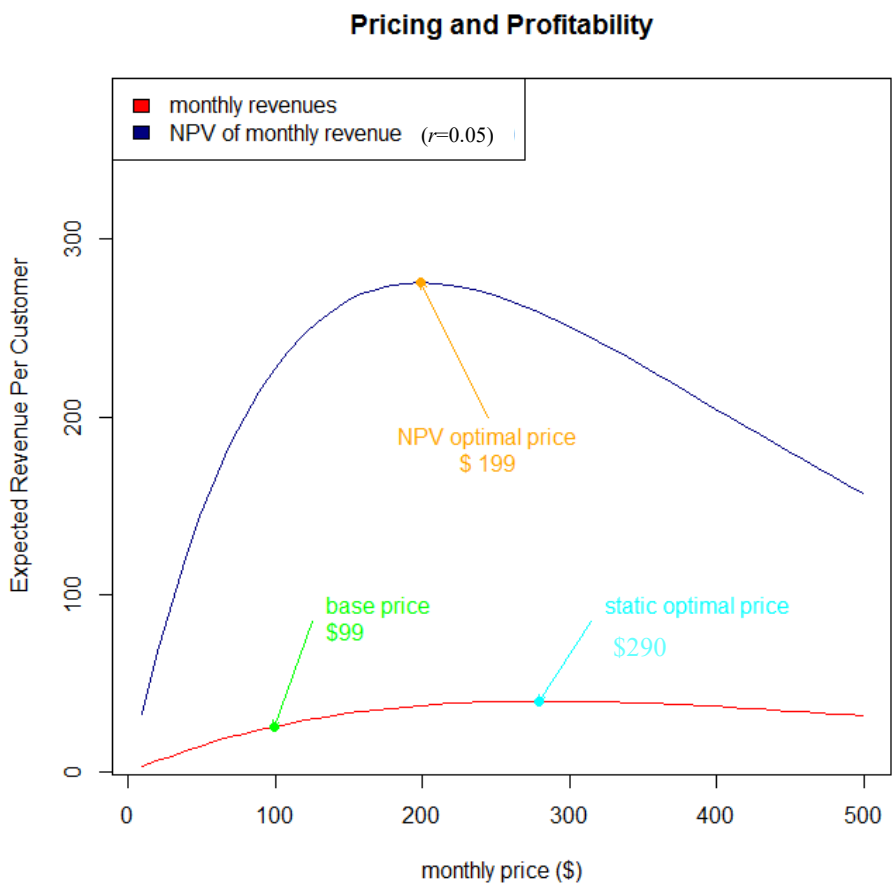
LTV at Ziprecruiter using actual retention rates

Pricing and LTV at Ziprecruiter

- In practice, trial and repeat rates are probably different:
  - $Prob(trial|\boldsymbol{p}) \neq Prob\ (retention|\boldsymbol{p})$
- 4 months after experiment, measure actual "retention' rate as function of price
  - At Ziprecruiter, **<u>retention rate higher than initial acquisition rate</u>**
  - Estimate repeat purchase probabilities for each of the first four months using the same customers from the experiment
  - assume repeat probability remains fixed after 4 months

Pricing and LTV at Ziprecruiter

use data to measure retention



Optimal price for **lifetime value** even lower: $199