StoreIQ

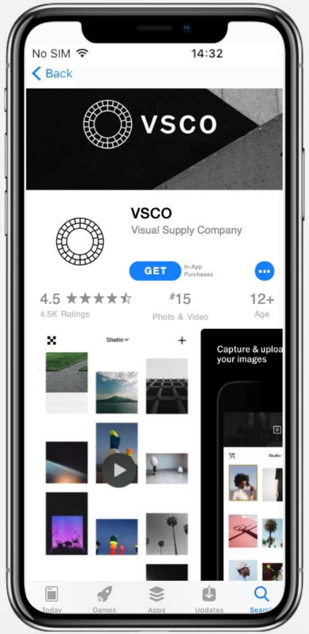
The Multi-Armed Bandit
for App Store Optimization

Introduction

100% of users pass through the App Store essentially making it your new "homepage" and impacting your business success.

Introduction

A



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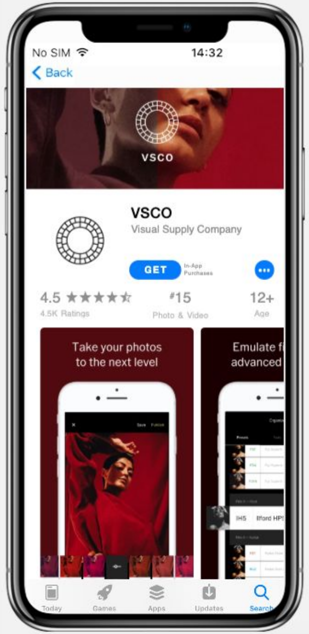

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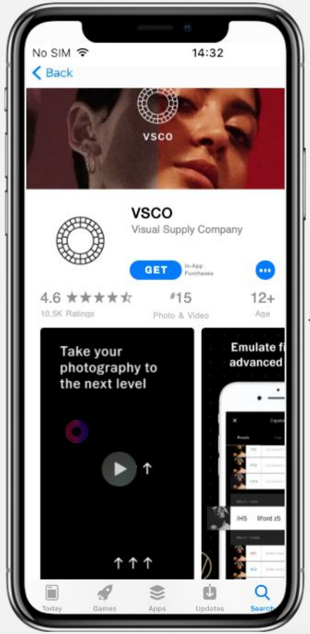

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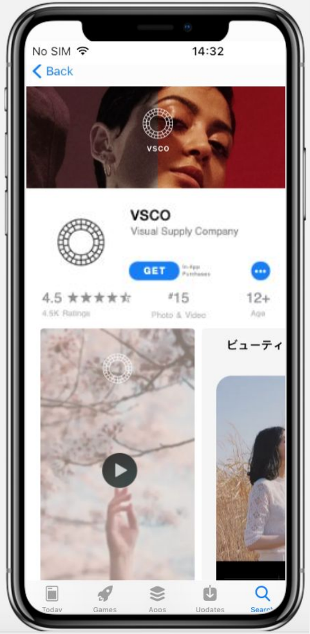
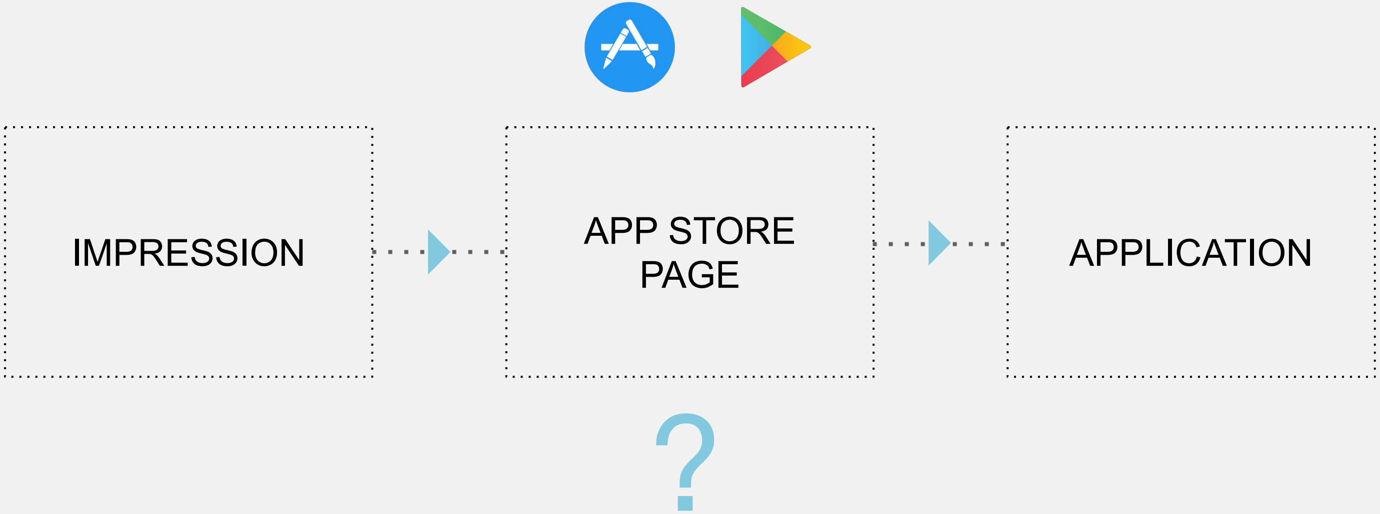


Goal

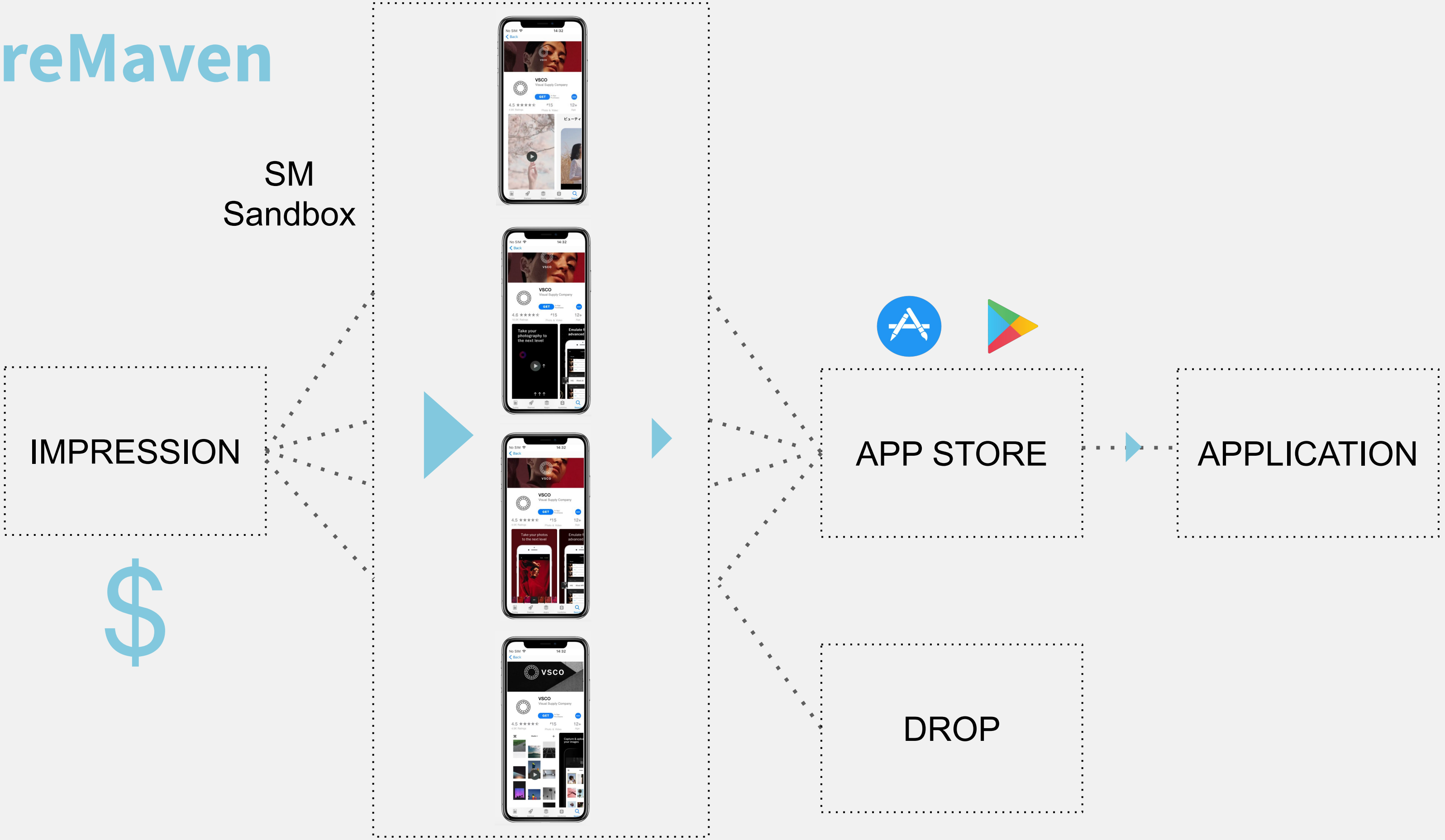
Conversion Rate

Cost Per Install

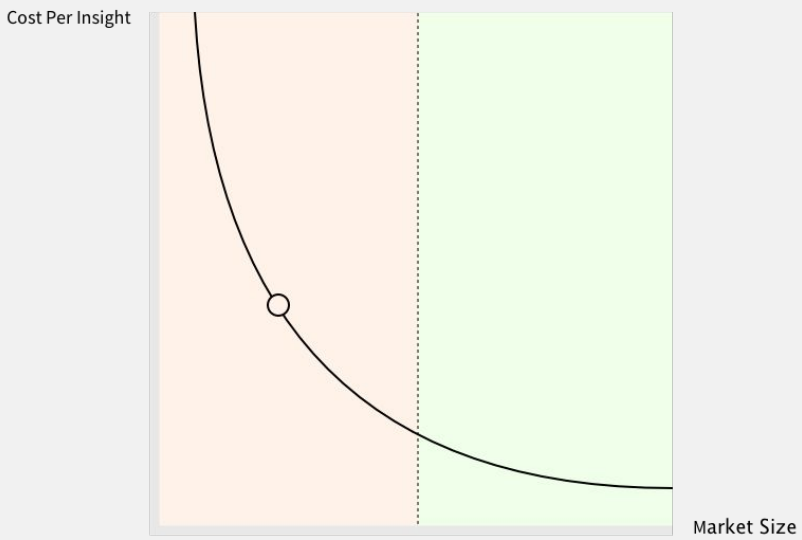
App Installation Flow

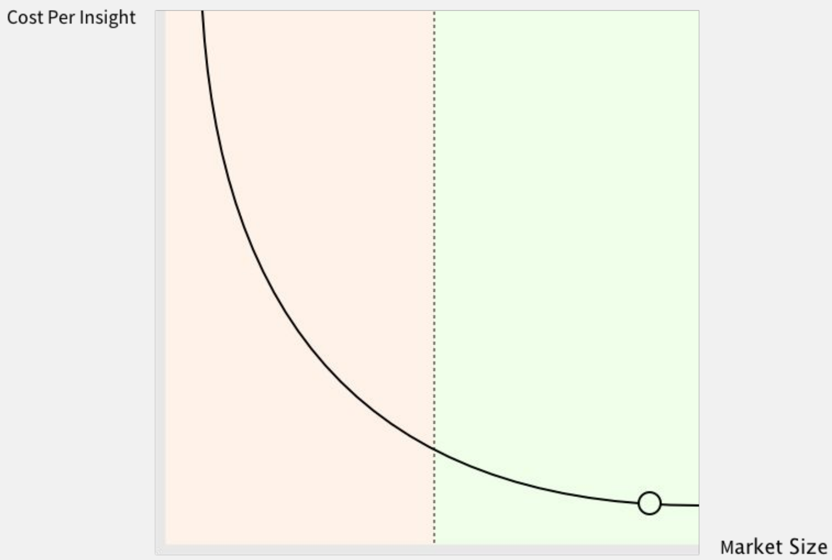


StoreMaven



StoreMaven





The Challenge

Minimize the cost per insight
without compromising accuracy

Today's Talk

1	Why not Proportion Testing ?
2	Multi-Armed Bandit – consideration & rejection
3	Cracking our business challenge with **StoreIQ**
4	Q & A

Proportion Testing – Why not ?

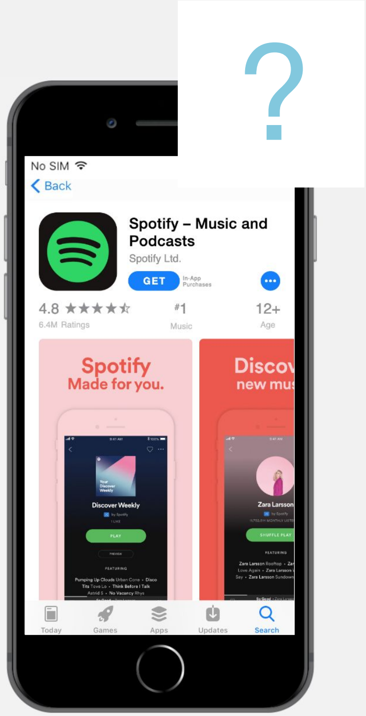
High cost per experiment: collecting large number of samples to achieve statistical validity in classical A/B test

Multiple Hypotheses problem: test that $H_0: P_i = P_j, i \neq j$ when there are more than 2 variations, significance is 'harder' to reach

Accuracy issue: assumes all observations are IID (Independent Identical Distribution)

Robust experimental design is barely achievable pre-test though crucial for valid frequentist setting in the dynamic ASO ecosystem

How?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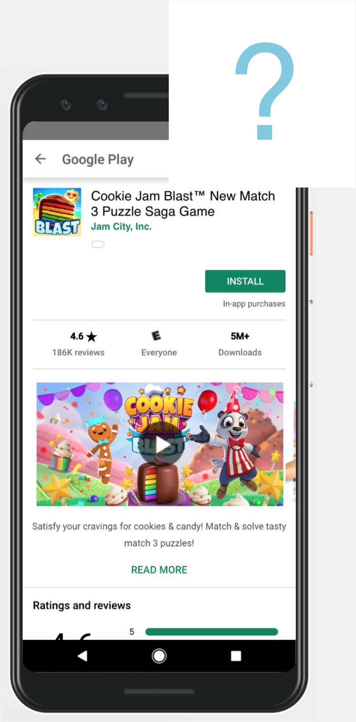
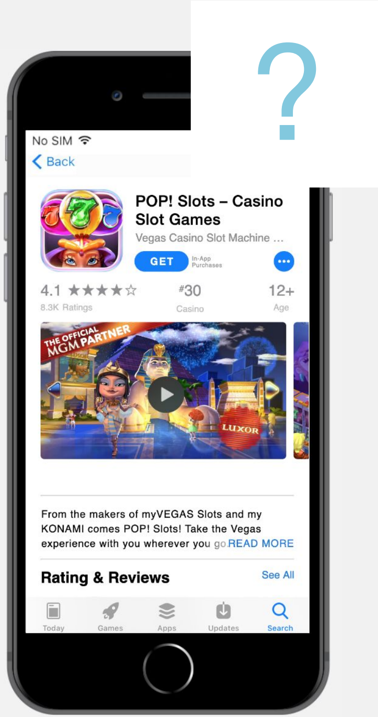

?
Google Play
Cookie Jam Blast™ New Match 3 Puzzle Saga Game
Jam City, Inc.
INSTALL
In-app purchases
4.6 ★
186K reviews
Everyone
5M+
Downloads
Satisfy your cravings for cookies & candy! Match & solve tasty match 3 puzzles!
READ MORE
Ratings and reviews


?
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POP! Slots – Casino Slot Games
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GET
In-App Purchases
4.1 ★★★★☆
8.3K Ratings
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Age
THE OFFICIAL MGM PARTNER
LUXOR
From the makers of myVEGAS Slots and my KONAMI comes POP! Slots! Take the Vegas experience with you wherever you go READ MORE
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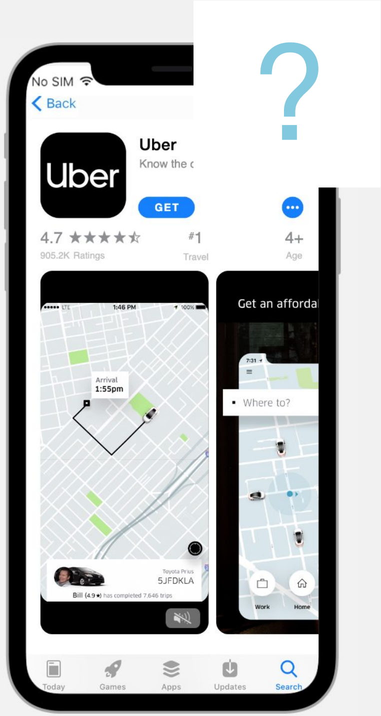
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Updates
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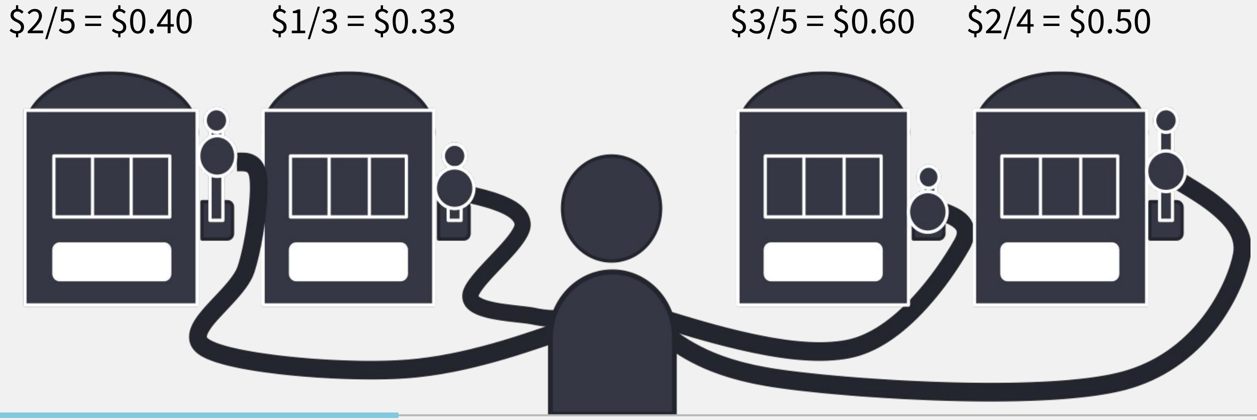
Multi-Armed Bandit

Exploitation vs Exploration dilemma

Bandits try to balance the trade-off to maximize total rewards

$$R_T = \Sigma_{t=1}^{T}\left(P^* - PA_{(t)}\right)$$



Multi-Armed Bandit – Why Not?

Experiments are conducted in our ‘sandbox’ testing environment, no real-time optimizations are done (our regret is defined differently)

Doesn’t necessarily reduce the cost of testing. Usually it is not a testing model it is an optimization method

Many ways to determine a definitive winner and conclude the experiment

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Backed by

4 years of Mobile App Stores user engagement events

More than 3 billion data points

Hundreds of millions of unique mobile users examined

20+ GEOs around the world

Bayesian approach

We use prior knowledge when calculating statistics

Bayes provides starting point from which we update our knowledge

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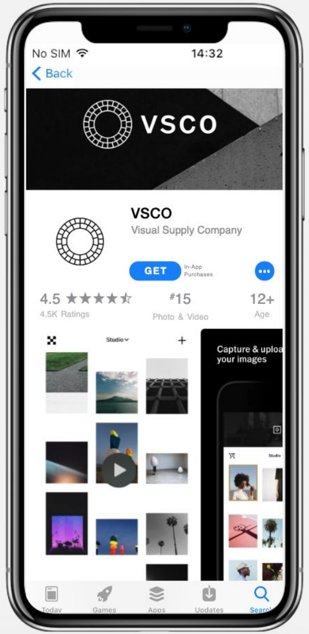
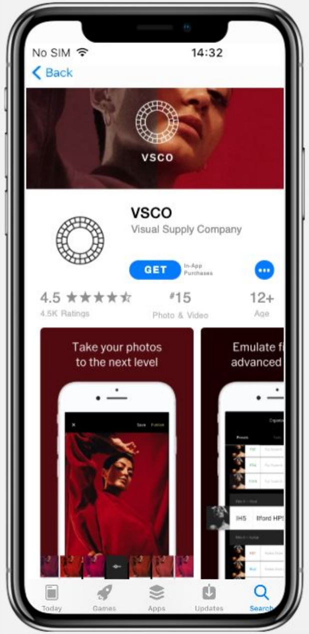
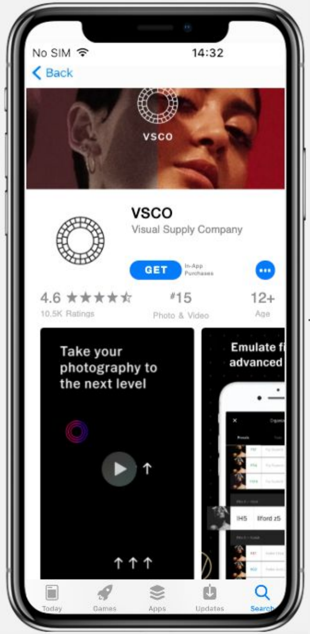
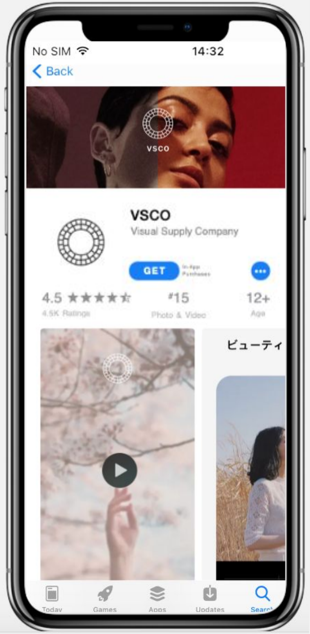
An Experiment









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Each experiment starts with a warm-up period in which the algorithm gathers initial information on the competing variations

Defining **warm-up thresholds**:

T ; days of traffic (to control for the time of day)

O ; minimum observations per variation (users who started a session within the page)

C ; minimum conversions per variation (user who clicked through / installed)

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Prior knowledge is comprised of:

Learning the daily volatility of the traffic per variation

Learning weights per traffic sources & app categories

Learning ‘high quality’ user behaviour using app’s experiments history

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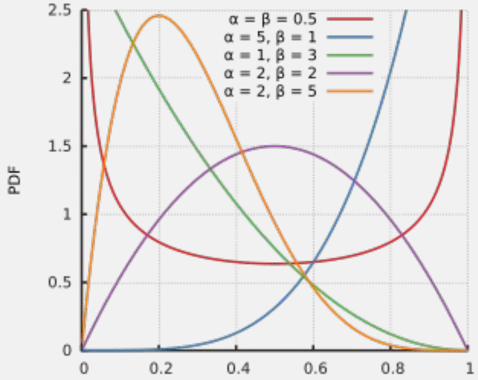
StoreIQ uses beta distribution to model its belief regarding competing variant conversion rates

The beta distribution is a suitable model for the random behavior of percentages and proportions.

The beta distribution is the conjugate prior probability distribution for the Bernoulli distribution



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$$IF\ CVR \sim Beta(\alpha, \beta)$$
$$THEN\ CVR \in [0, 1]$$

$$Round\ 1:$$

$$x \sim Bernoulli(\theta) \quad IID$$
$$x \in \{0,1\}$$

$$X - vector\ of\ x$$

$$f_\theta = ?$$
$$\theta = ?$$

In round 1, our prior is a derivation of the Beta distribution and is not dependent on the posterior a,b

$$f_{\theta|X} \propto L(X|\theta) \cdot prior = \theta^{\Sigma x} \cdot (1-\theta)^{N-\Sigma x} \cdot prior$$
$$\sim$$
$$Beta(\Sigma x + 1,\ N - \Sigma x + 1)$$

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$$Round\ 2:$$

$$y \sim Bernoulli(\theta) \quad IID$$
$$y \in \{0,1\}$$

$$X - vector\ of\ y$$

$$f_\theta = ?$$
$$\theta = ?$$

$$f_{\theta|X} \propto L(X|\theta) \cdot prior = \theta^{\Sigma x + \Sigma y} \cdot (1-\theta)^{M+N-\Sigma x - \Sigma y} \cdot prior$$
$$\sim$$
$$Beta(\Sigma x + \Sigma y + 1,\ M + N - \Sigma x + \Sigma y - \ + 1)$$

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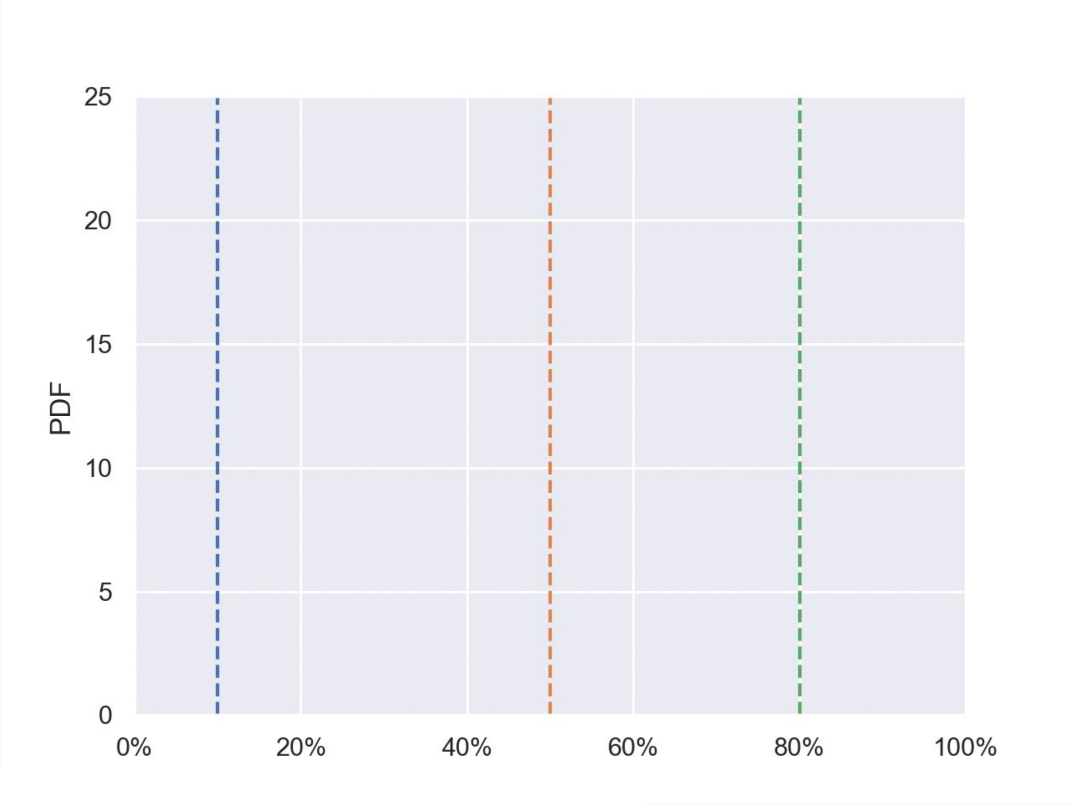

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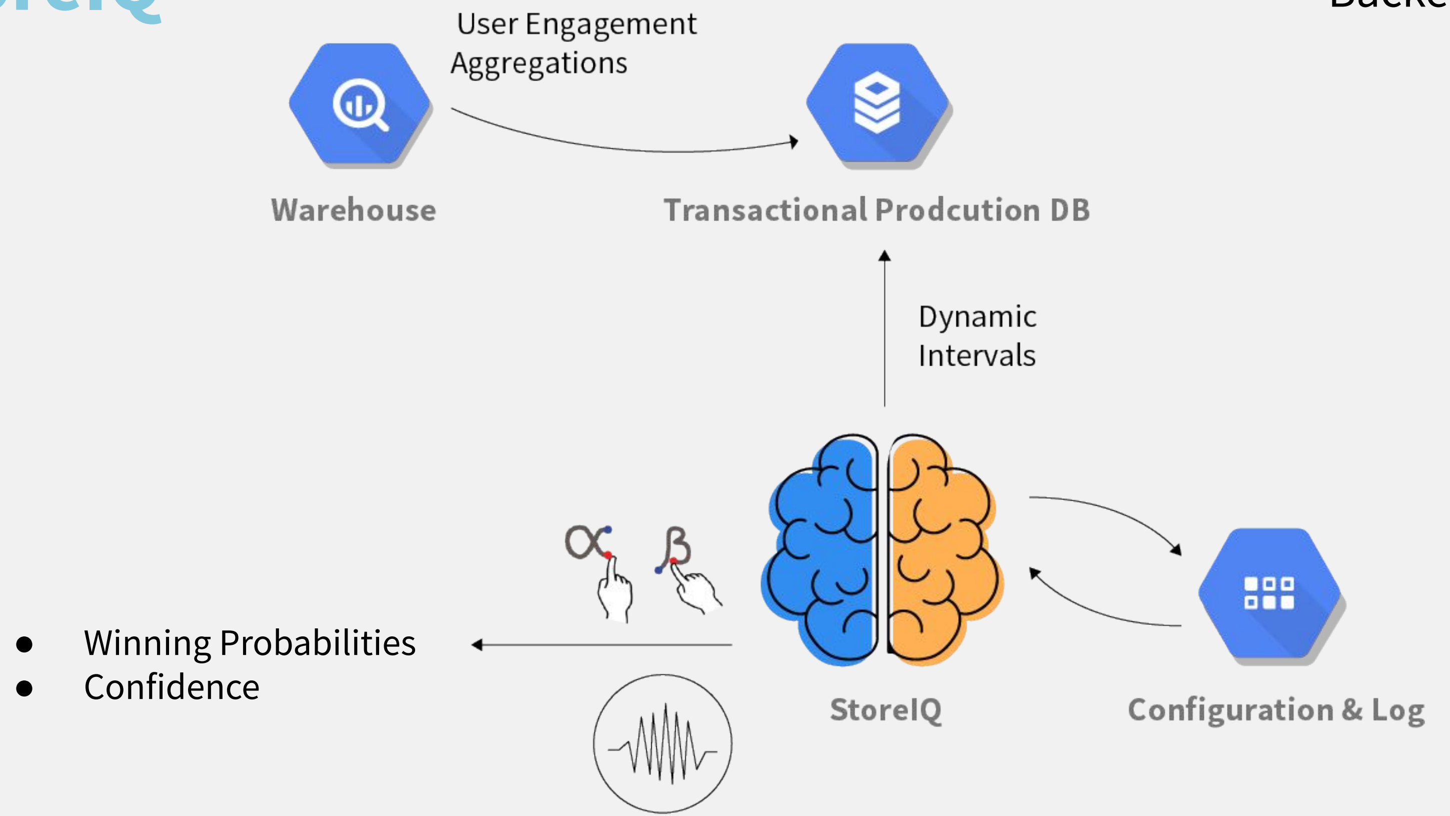
Backend Peek



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Winning Probabilities

Iteration	Variation 1	Variation 2	Variation 3	Variation 4
1	0.251654	0.201544	0.4481	0.1043
2	0.355897	0.353784	0.156574	0.13
3	0.484654	0.5464651	0.564546	0.234
. . .	. . .	. . .	. . .	. . .
N	0.3684615	0.2654684	0.68474	0.1593
Winning Probabilities	0.122	0.0005	0.8745 (Leader!)	0.003

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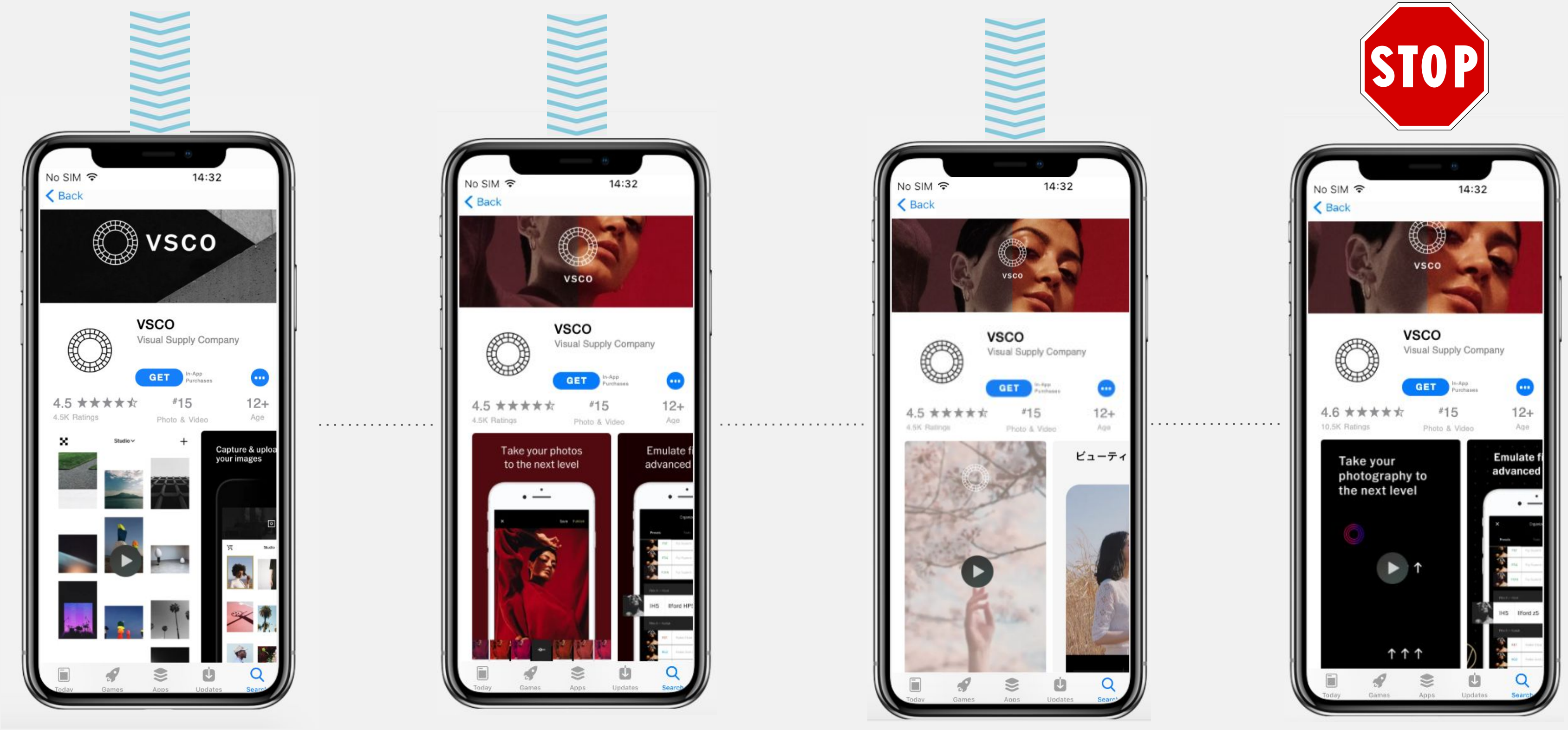

STOP
No SIM
14:32
Back
VSCO
Visual Supply Company
GET
In-App Purchases
4.5
4.5K Ratings
#15
Photo & Video
12+
Age
Capture & upload your images
Take your photos to the next level
Emulate film advanced
ビューティ
4.6
10.5K Ratings
Take your photography to the next level
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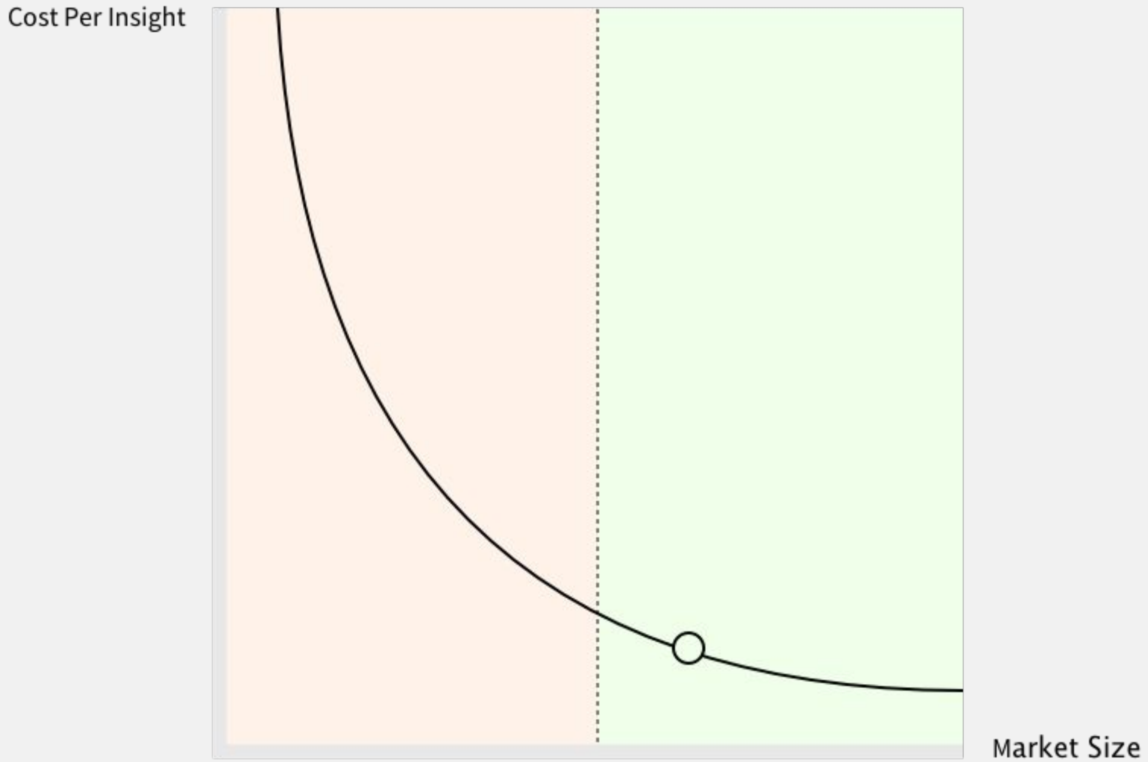

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Confidence

Iteration	Variation 1	Variation 2	Variation 3 - Current Leader	Lift function of iteration - Winner from Leader	Lift below threshold
1	0.251654	0.201544	0.5481	0	1
2	0.355897	0.354884	0.33566	0.06029	0
3	0.484654	0.5464651	0.564546	0	1
. . .	. . .	. . .	. . .	. . .	. . .
N	0.4684615	0.2654684	0.68474	0	1
Confidence	-	-	-	-	**0.95**

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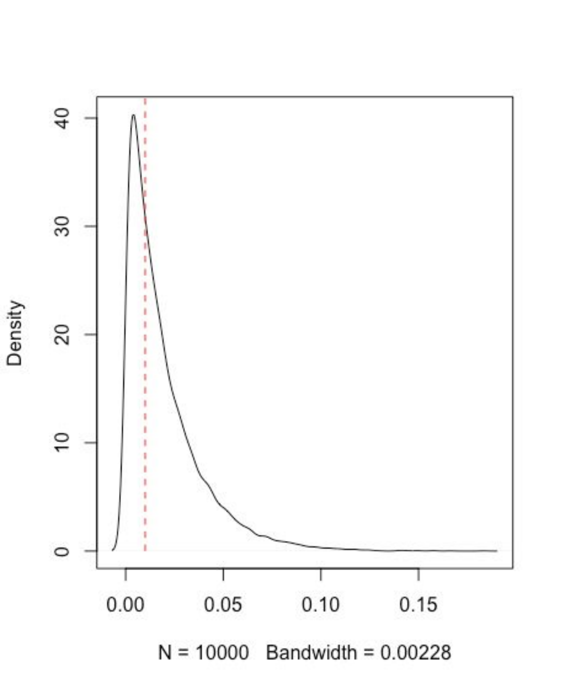
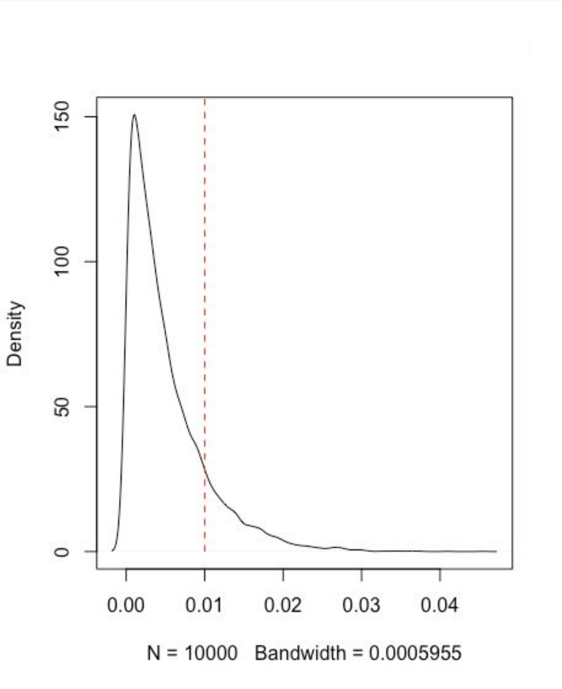
Confidence

Low confidence



High confidence



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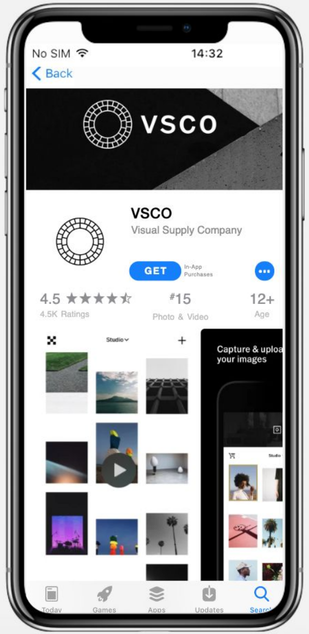
A



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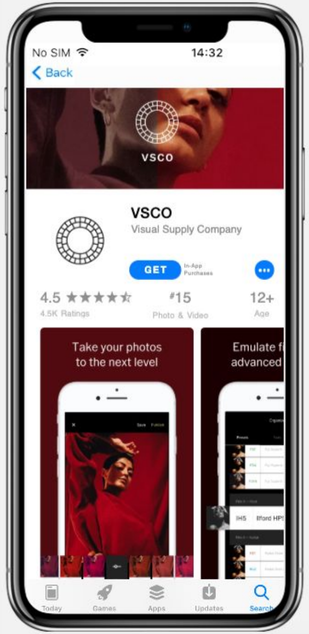
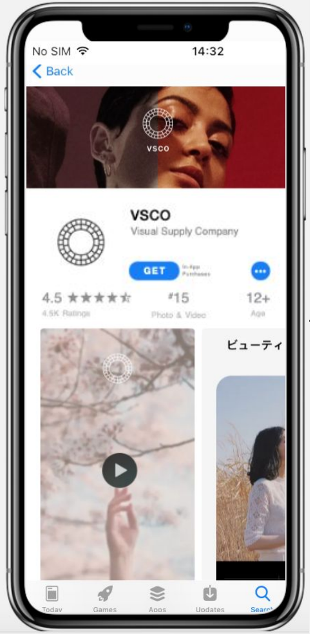


C - Winner!



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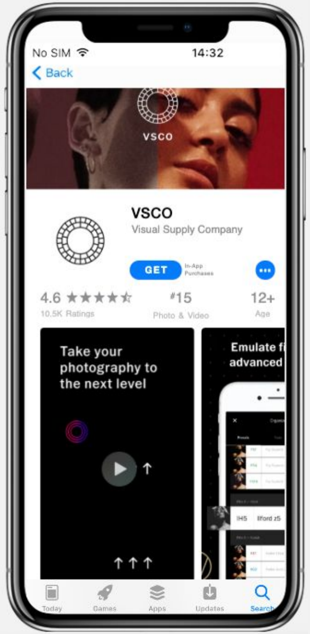
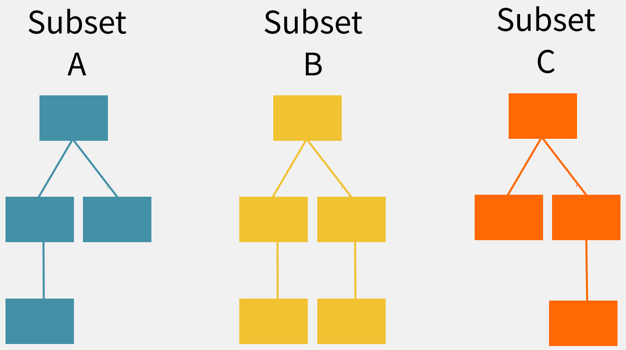


StoreIQ Booster – Bagging Trees (RF)

Train Dataset = user behavior from **app's** experiment history + user activity from a live experiments interval 0 to t-1



C1 = Compute the correlation between predicted and empirical CVR per variation

C2 = Compute the correlation between the per store CVR of the explorers and non-explorers

C3 = Compute the accuracy of the current model on Test Dataset (users from interval t in a live experiment)

Boost = baseline + (# of boosts given so far * $\mathcal{E}$)

Result = a model that predicts for a given user whether he will Install or not

If (C3 >= **accuracyThreshold** and C1*C2 >= **correlationThreshold**):

observationsToAdd_i = round(w_i*C3*C2*C1*boost*N)
conversionsToAdd_i = round(cvr_i * observationsToAdd_i)

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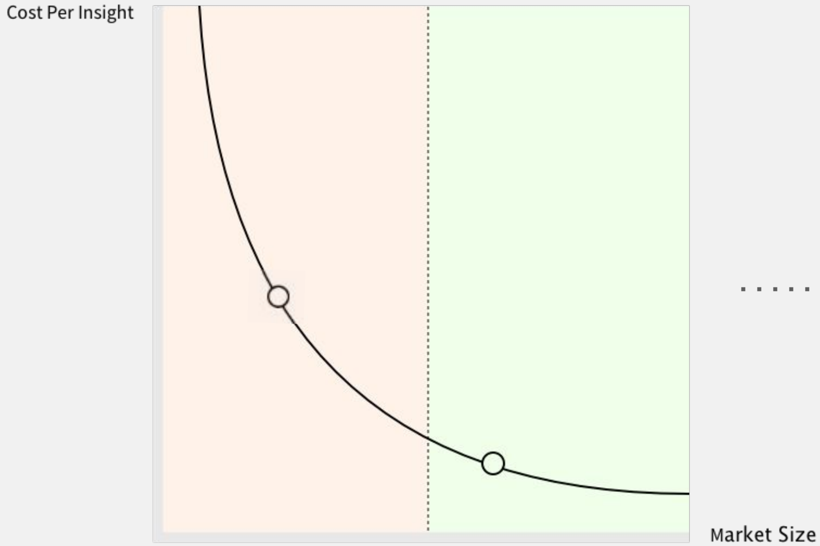
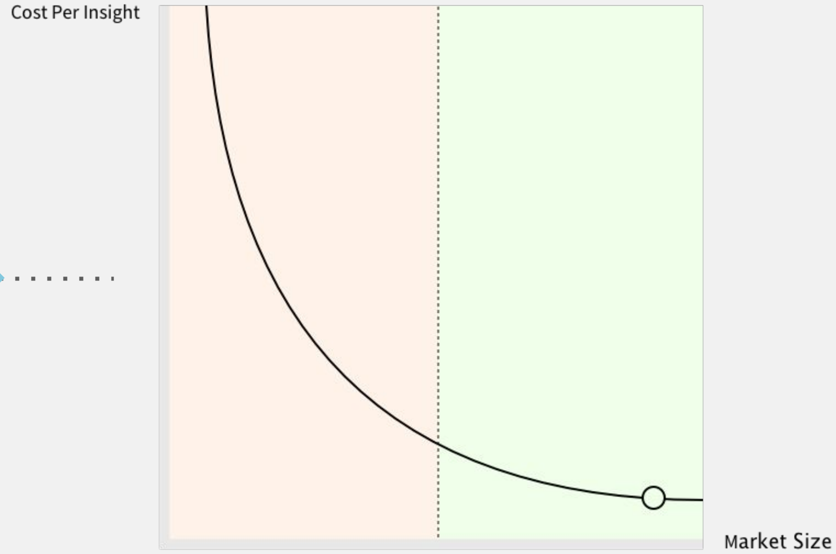
StoreIQ – Boosting





Q & A

Thank You!

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