ICO Price Optimization

Cox Automotive Case Study

Samuel Longenbach

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Problem Overview

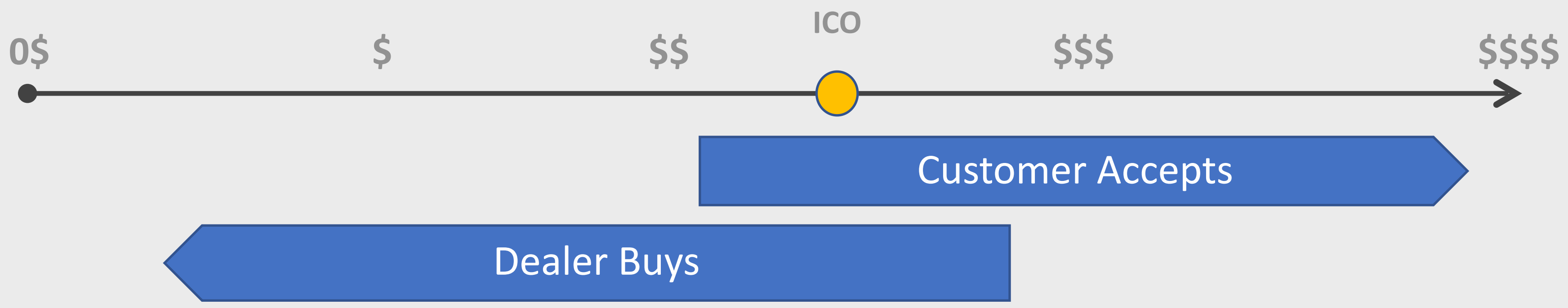
1. Instant Cash Offer (ICO) - **Prediction**

2. Instant Cash Offer (ICO) - **Optimization**

Customer vs. Dealer

ICO = Instant Cash Offer

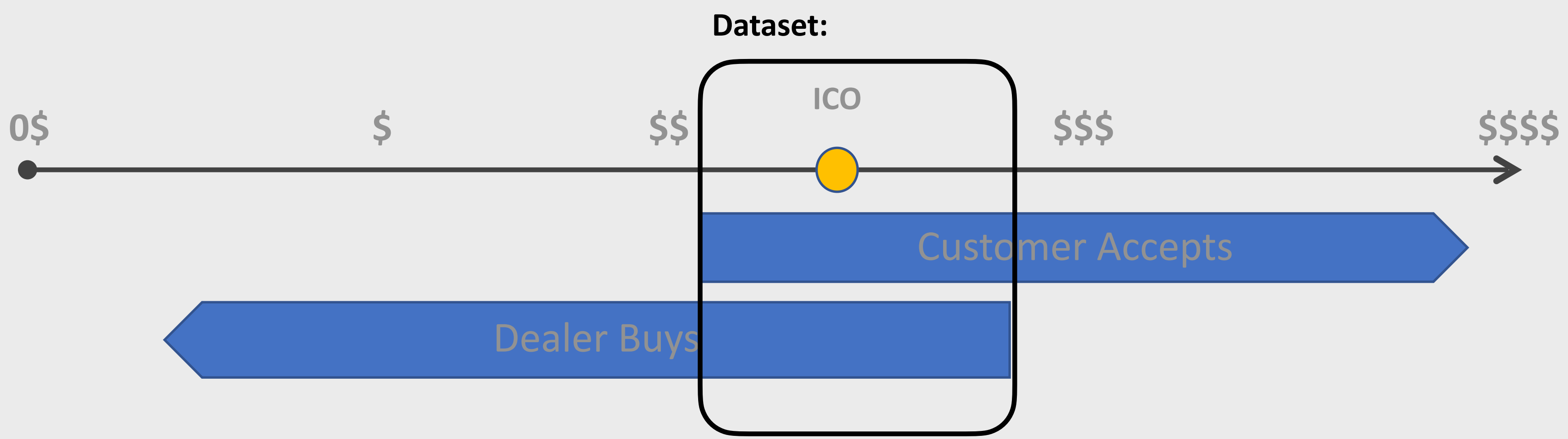
If a customer accepts the ICO, then Dealers have the chance to buy the vehicle at ICO.



Predicting Dealer Buys

ICO = Instant Cash Offer

Historical data has ICO values paid by the dealer to the consumer.



Goal: Build a model to predict ICO values based on historical dealer buys.

Historical Dataset includes: Make, model, mileage, vehicle condition etc…..

ICO Prediction Steps

Dataset

	Varibles	.....	ICO Value
1			
2			
3			
.			
.			
.			
40491			

Training Data (80%)

Testing Data (20%)

1. Split dataset for model training and testing
2. Add & remove variables
3. Fit several models on training data
4. Report errors on testing data*

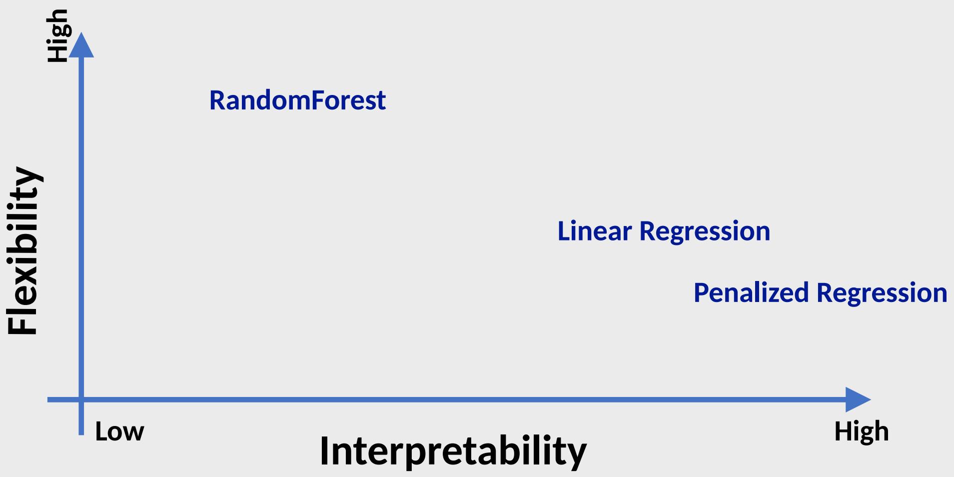
Mean Absolute Error = | Actual ICO - Predicted ICO |

Mean Square Error = (Actual ICO - Predicted ICO)^2

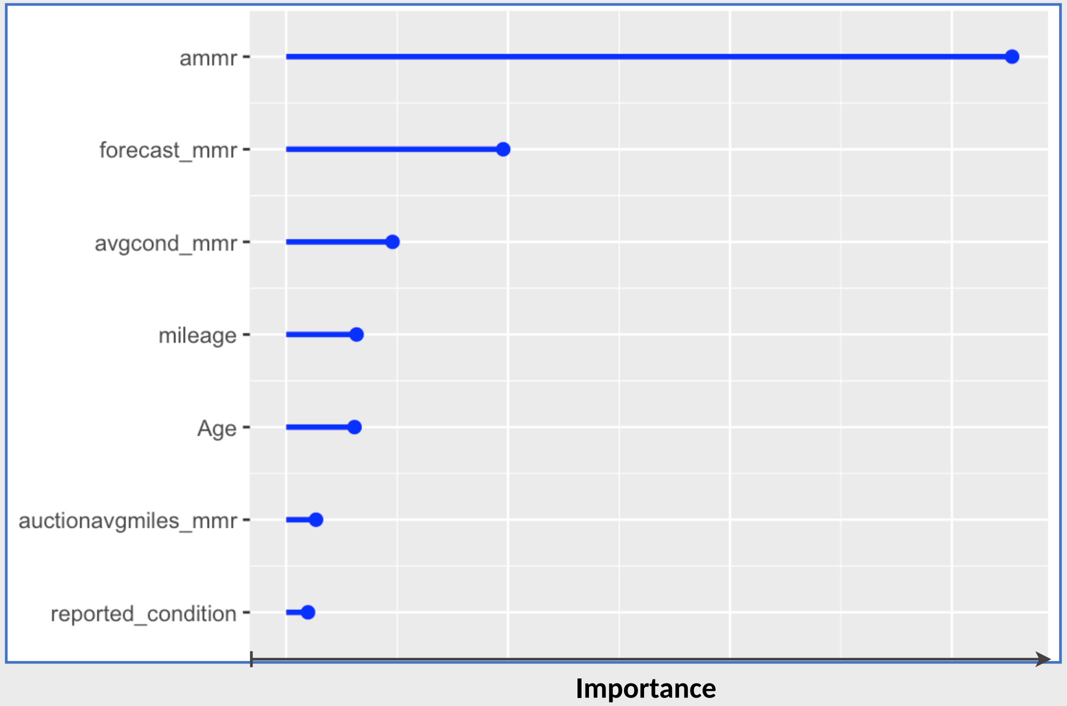
**Why? Report on test to simulate how our model will preform on unseen future data.*

ICO Models & Insights

Models Considered



Key Variables Identified



Ammr = *Whole price estimate from Manheim Market Report*
Forecast_mmr = *Whole price forecast 5 weeks future*
Avgcond_mmr = *Average condition for vehicle type*
Mileage = *Odometer mileage*
Age = *Offer Date - Model Year (created variable)*

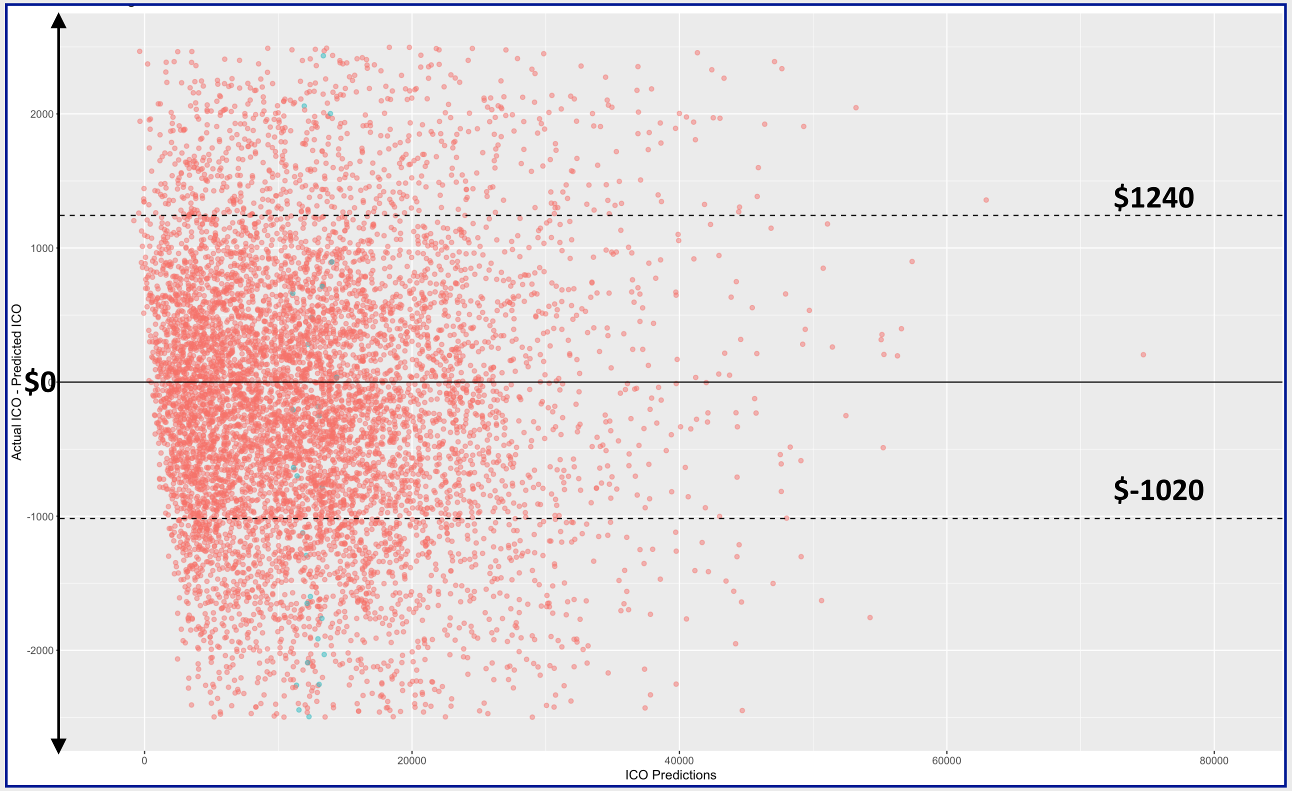
Random Forest Model beats Linear model:

X-Axis = Predicted ICO
Y-Axis = Actual ICO - Predicted ICO

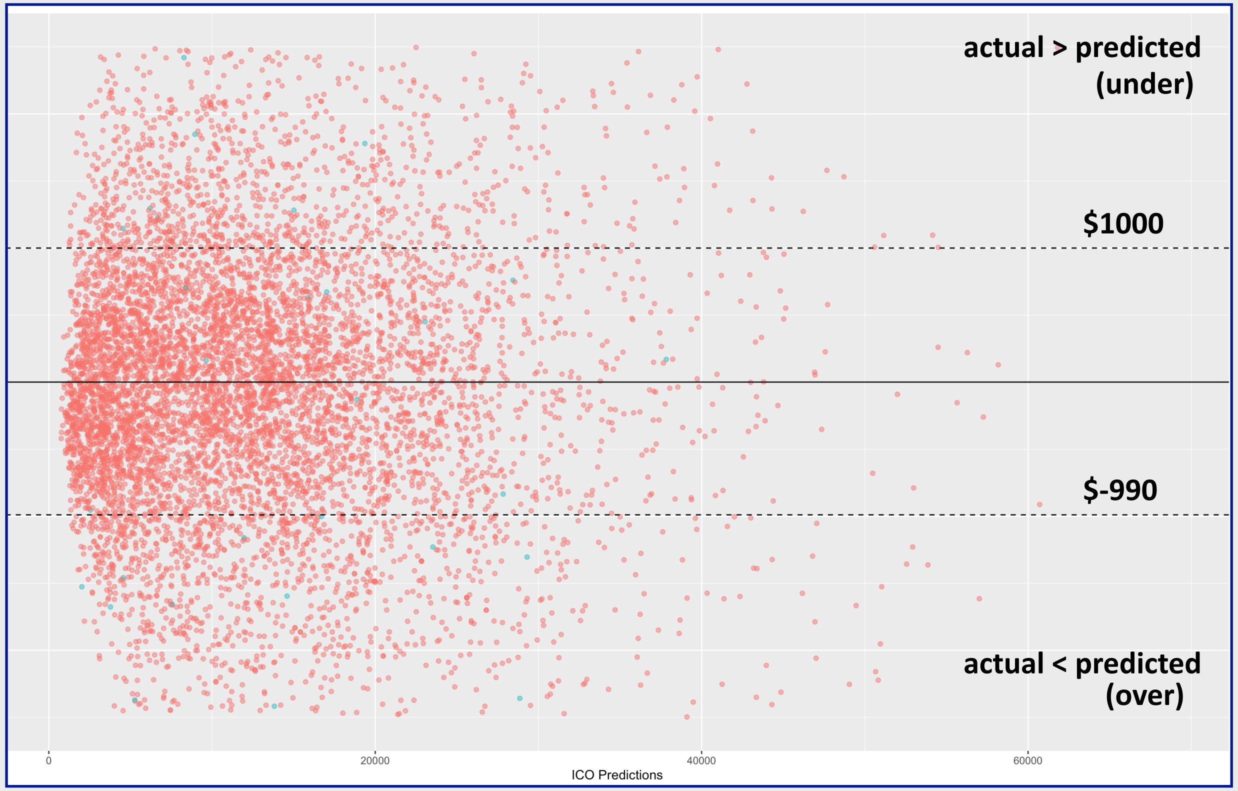
1. Overall smaller ICO errors -> business impact **more accurate** predictions **reduces COX risk.**

2. Symmetrical errors -> **under predicting less** than Linear model means **more consumer accepts.**

Linear Regression

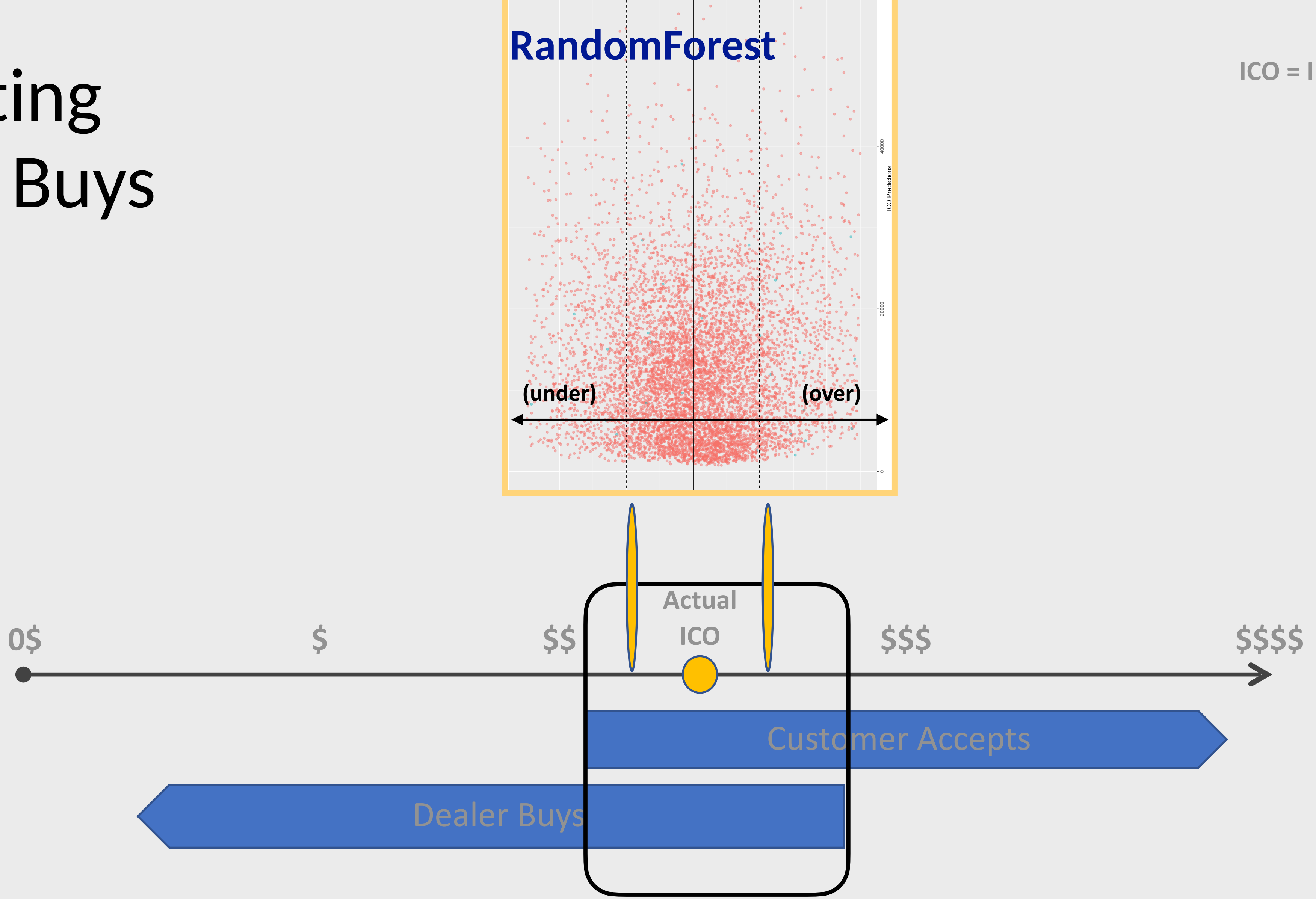


RandomForest



Predicting Dealer Buys

ICO = Instant Cash Offer



Goal: Build a model to predict ICO values based on historical dealer buys.

Problem Overview

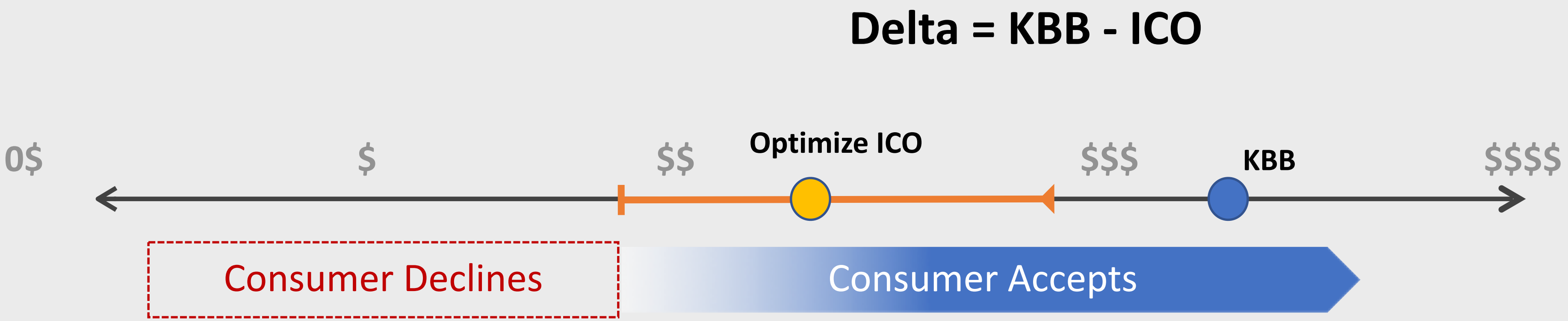
1. Instant Cash Offer (ICO) - **Prediction**

2. Instant Cash Offer (ICO) - **Optimization**

Part 2: Optimizing ICO

KBB = Kelly Blue Book

The market value of selling the car.

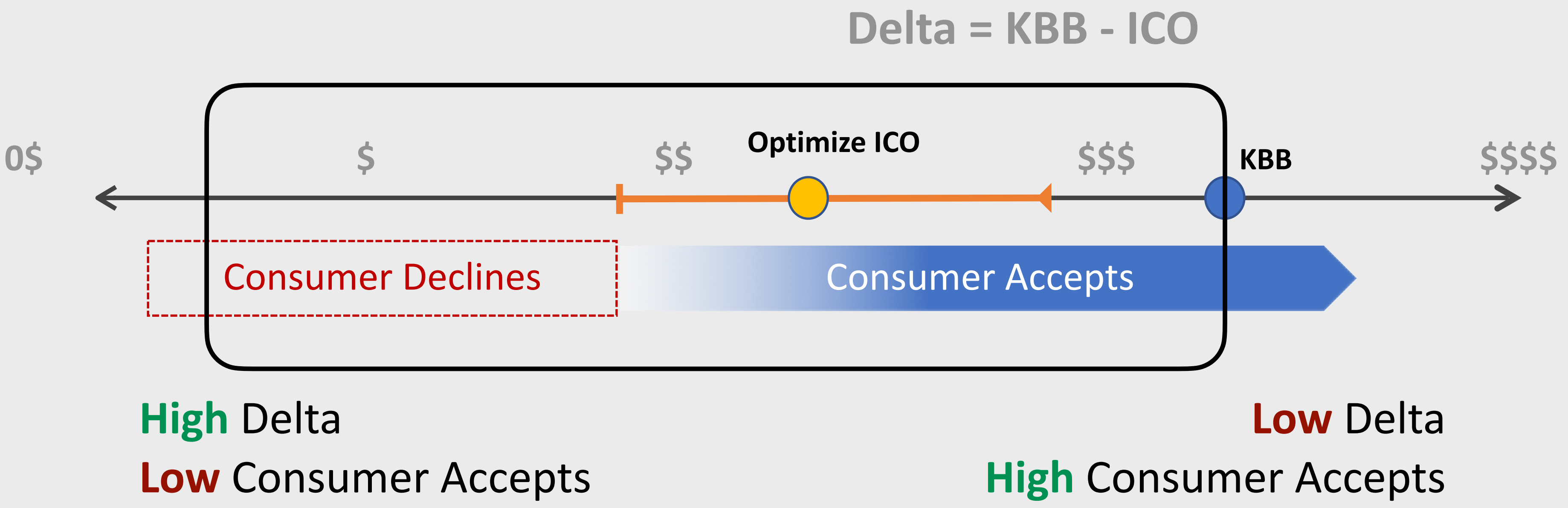


Part 2: Optimizing Dealer Profit

KBB = Kelly Blue Book

Formally:
Profit = Probability (accept | delta) * delta

Profit = *Probability Consumer Accepts * Delta*



Available Data

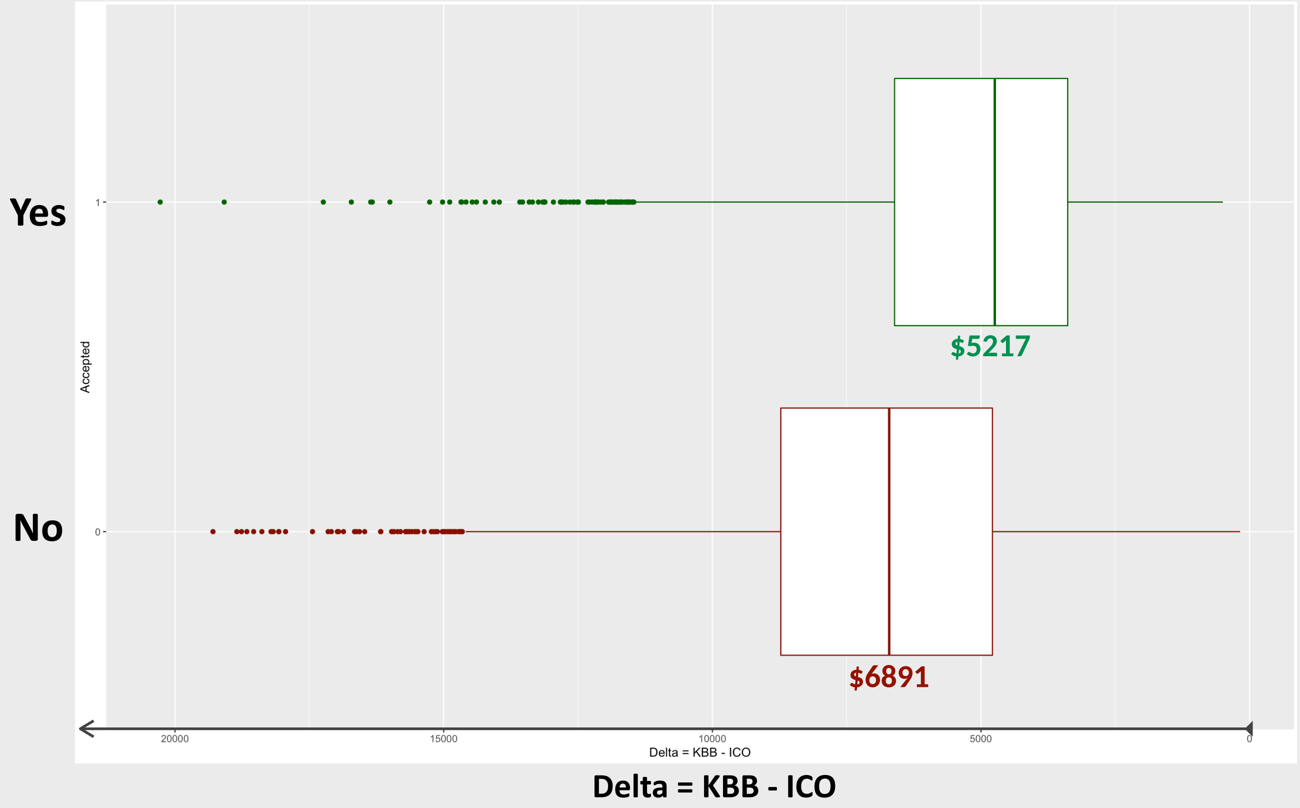
Dataset

	KBB	ICO	Accept
1	$	$	Yes
2	$	$	No
3	$	$	Yes
.	.	.	.
.	.	.	.
15243	$	$	Yes

> KBB - Market value of the car

> ICO - Offer made to Consumer

> Accept - Consumer accepted or not



> Consumers accepted ICO offers on avg* $5217 less than KBB

> Consumers did not accept ICO offers on avg* $6891 less than KBB

*avg is actually the median or 50% percentile of the data

Modeling Expected Profit

Expected Profit = Probability Consumer Accepts * Delta

Linear:

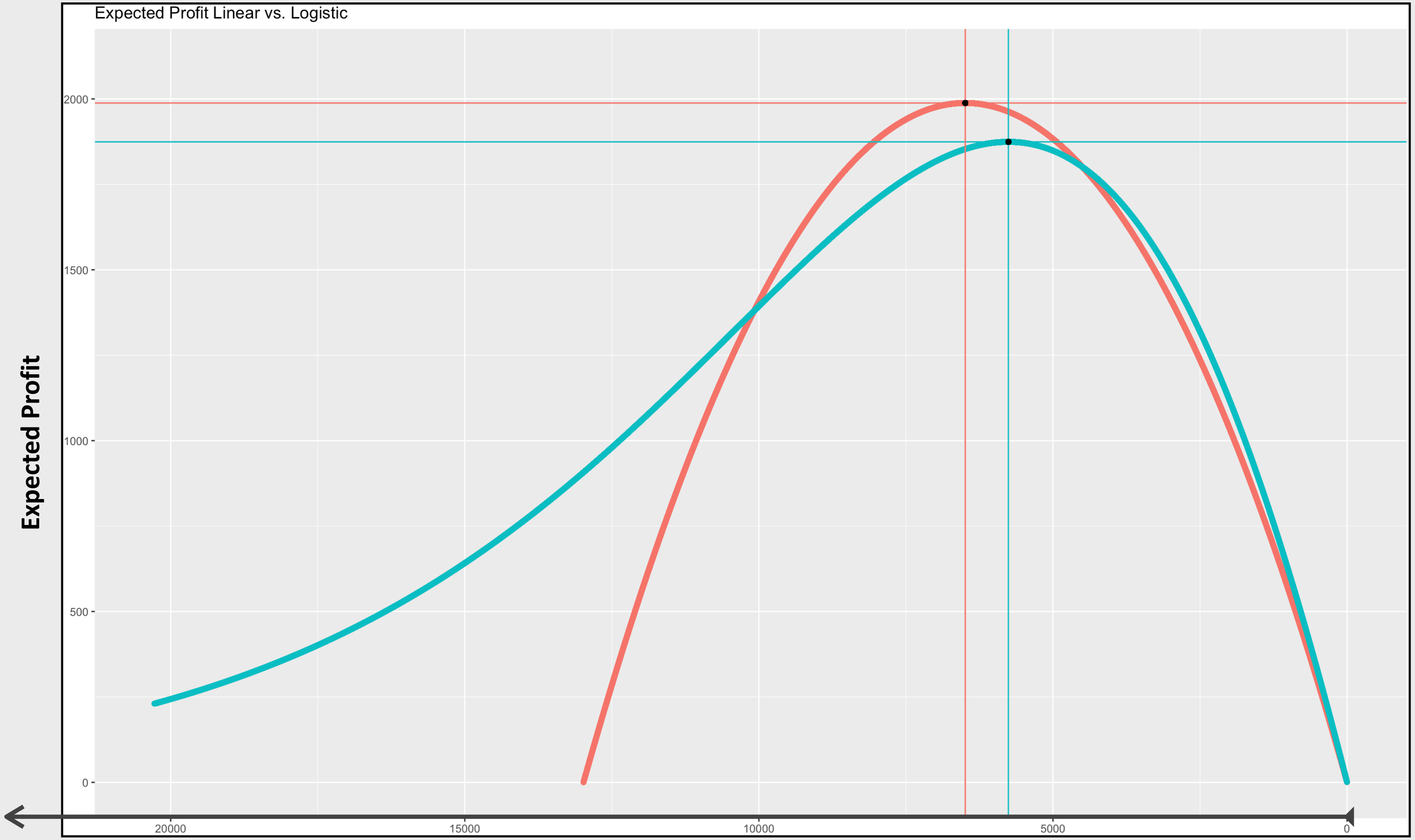
Delta = $6491
31% Chance of Accept

Expected Profit =
$1988.13

Logistic:

Delta = $5758
33% Chance of Accept

Expected Profit =
$1874.4

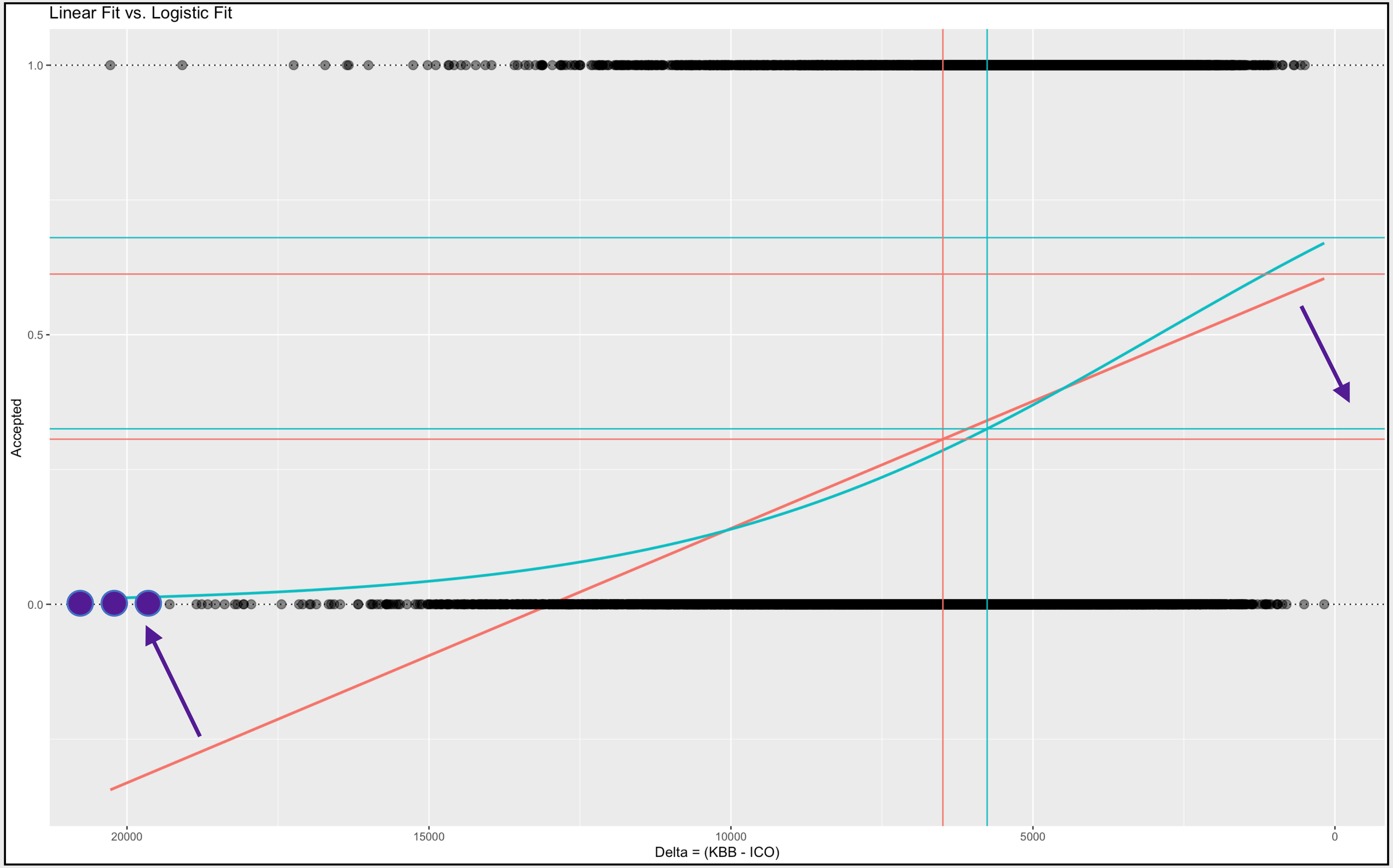


Delta = KBB - ICO

High Delta
Low Consumer Accepts

Low Delta
High Consumer Accepts

Why Logistic over Linear?



Linear:

Delta = $6491

31% Chance of Accept

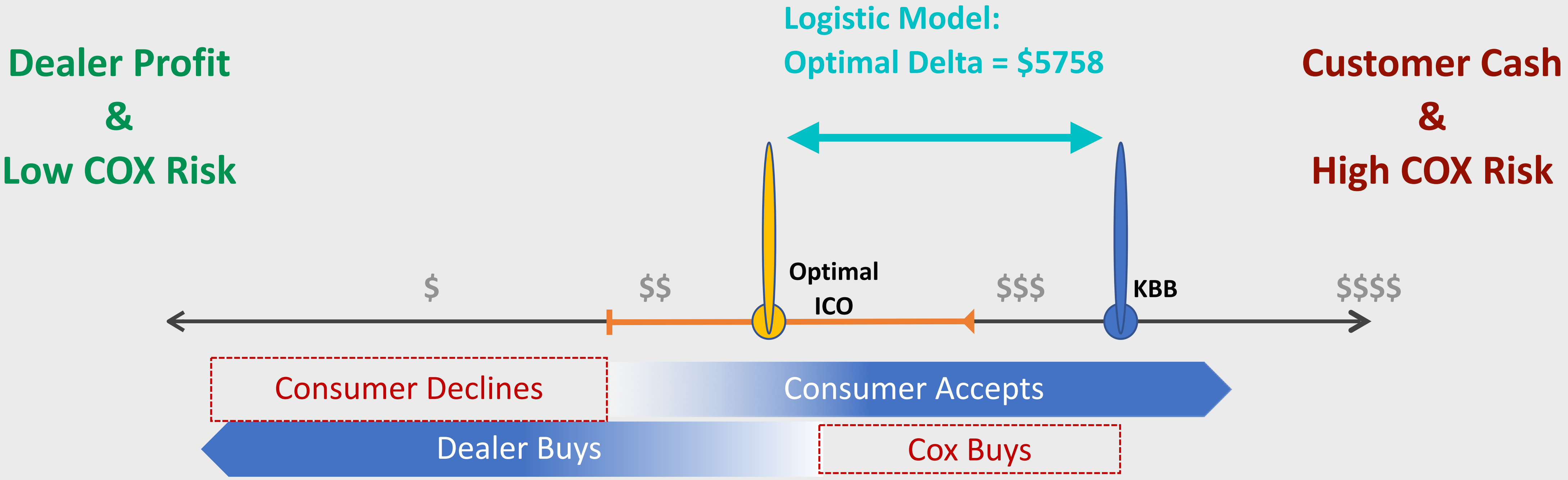
Logistic:

Delta = $5758

33% Chance of Accept

Part 2: Optimizing Dealer Profit & Minimizing Cox Risk

KBB = Kelly Blue Book
Delta = KBB - ICO



Summary

1. RandomForest **predicts ICO dealer buys** with error of ~ $1000 over/under.

2. Logistic Regression shows **ICO predictions should be optimized** to $5758 less than KBB value to maximize dealer profit & reduce Cox risk.

3. Next Steps

Questions

Back Up

Confidence in Logistic

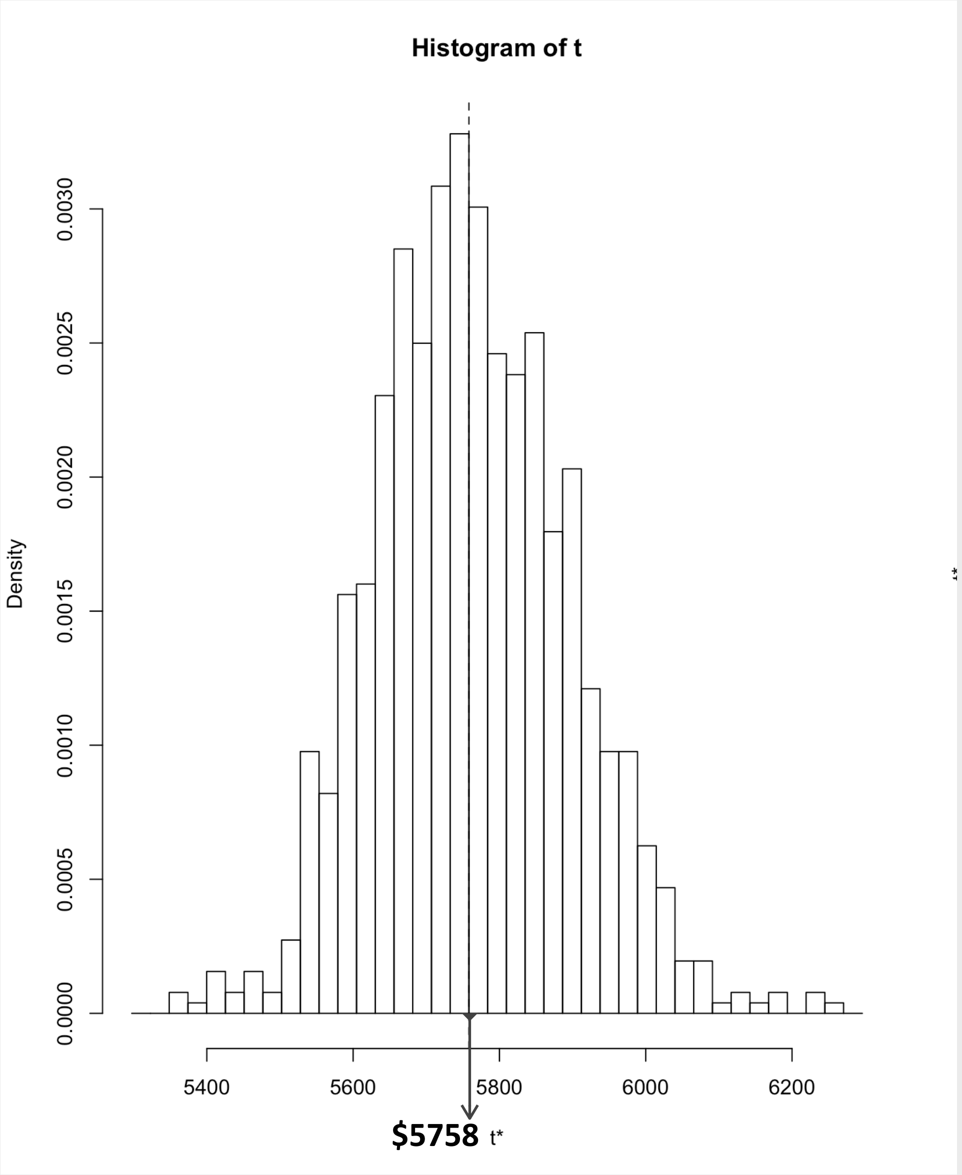
1. Sample data w/ replacement
2. Fit logistic model on sample
3. Extract coefficients
4. Plug into profit function derivative to get Delta value that maximizes profit.
5. Repeat 1000x

P(accept|d) = 1 / (1 + e ^ -(a * d + B))
Profit = P(accept|d) * d

$$\frac{\partial}{\partial d}\left(\frac{d}{1+e^{-(a\,d+b)}}\right) = \frac{e^{a\,d+b}\left(e^{a\,d+b}+a\,d+1\right)}{\left(e^{a\,d+b}+1\right)^2} = 0$$

$$d = \frac{-W\left(e^{b-1}\right)-1}{a} \approx \frac{-W\left(2.71828^{b-1}\right)-1}{a}$$

Logistic:

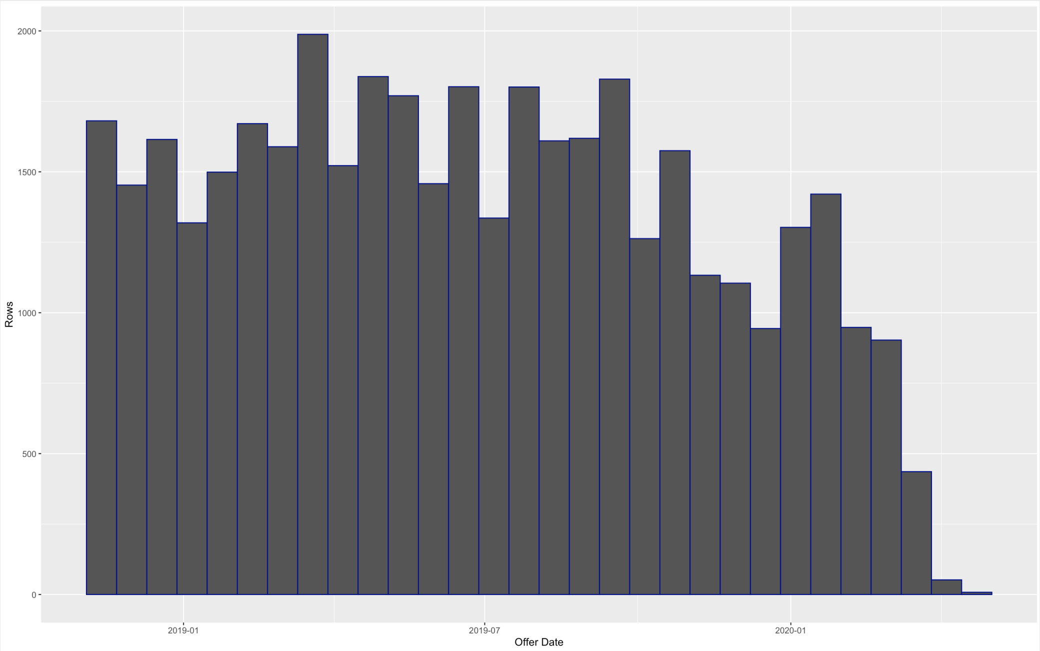


Optimal Delta

https://www.wolframalpha.com/input/?i=derivative+of+d%2F%281++%2B+e%5E-%28ad+%2B+b%29%29+wrt+d

Prediction Data

Number of rows over time



Nov 2018 April 2020

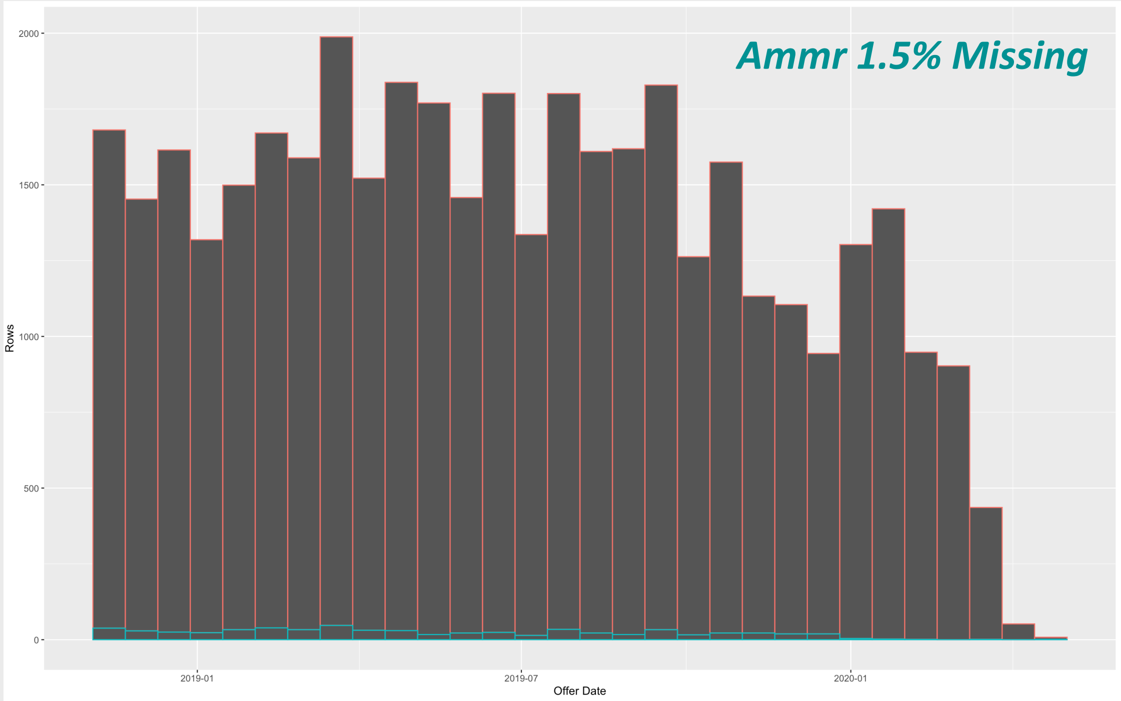
Trade in Value

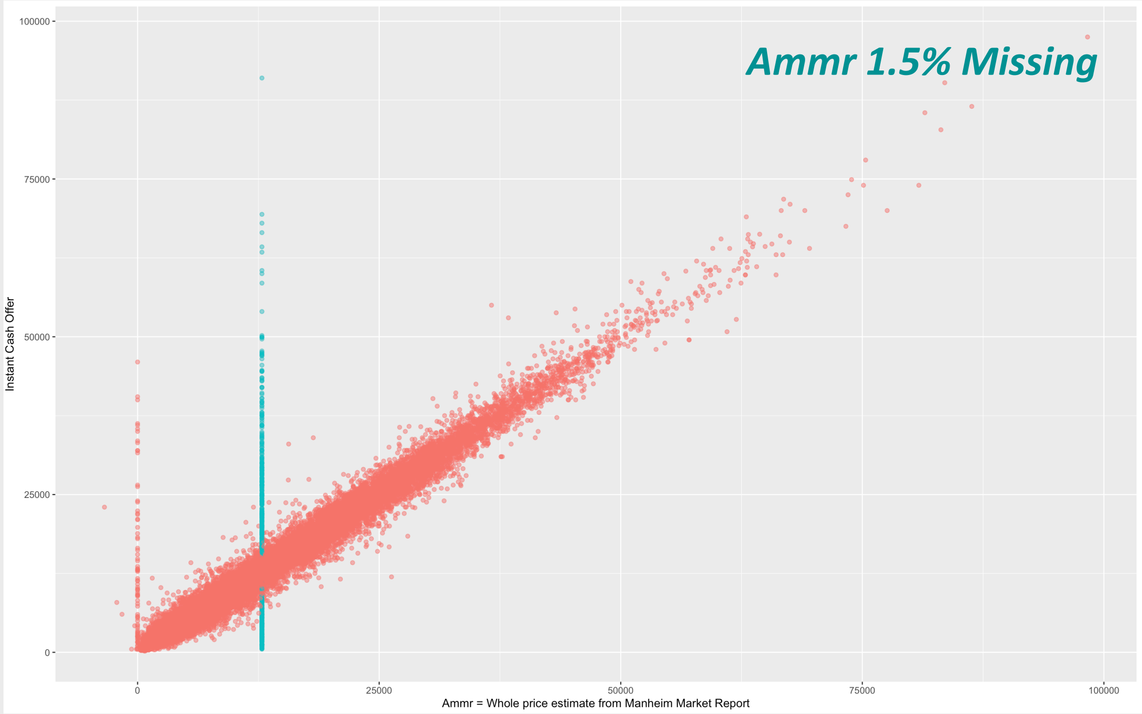
```
quantile(df$trade_in_value)

  0%   25%   50%   75%  100%
 200  5900 11300 17700 97500
```

Prediction Data

Missing Values of strongest predictor Ammr



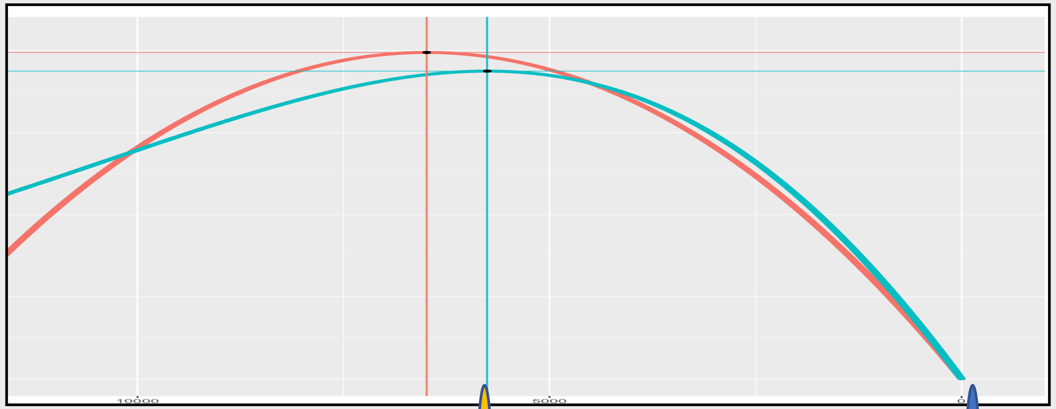


Part 2: Optimizing Dealer Profit & Minimizing Cox Risk

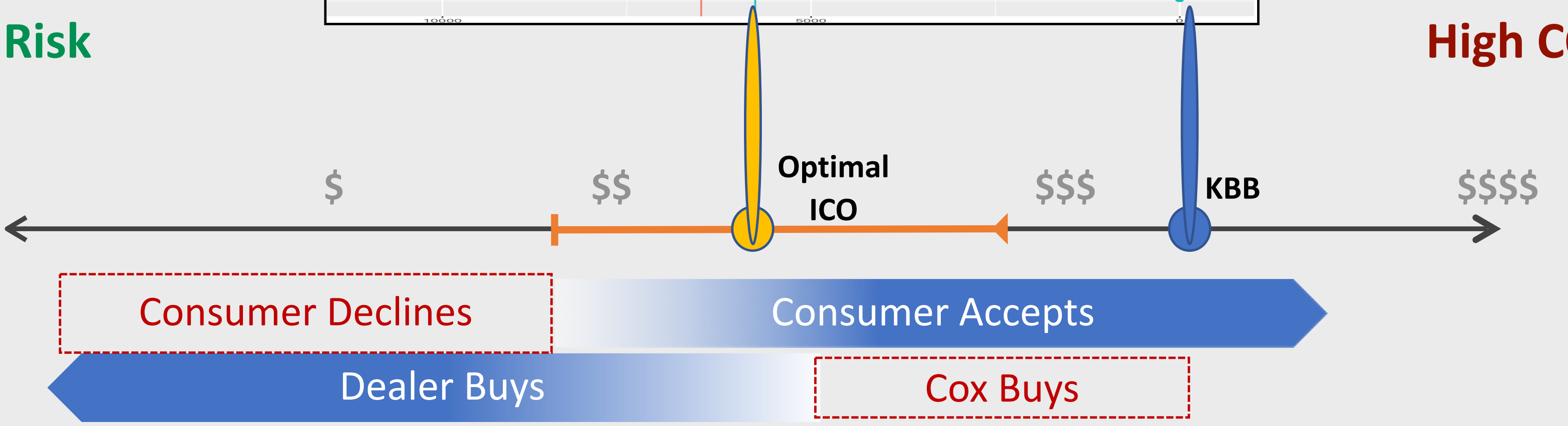
KBB = Kelly Blue Book

The market value of selling the car.

Dealer Profit
&
Low COX Risk



Customer Cash
&
High COX Risk



X-Axis = Predicted ICO
Y-Axis = Actual ICO - Predicted ICO

Model Errors - Explainability vs. Accuracy

(-) when **predicted > actual**
(+) when **predicted < actual**

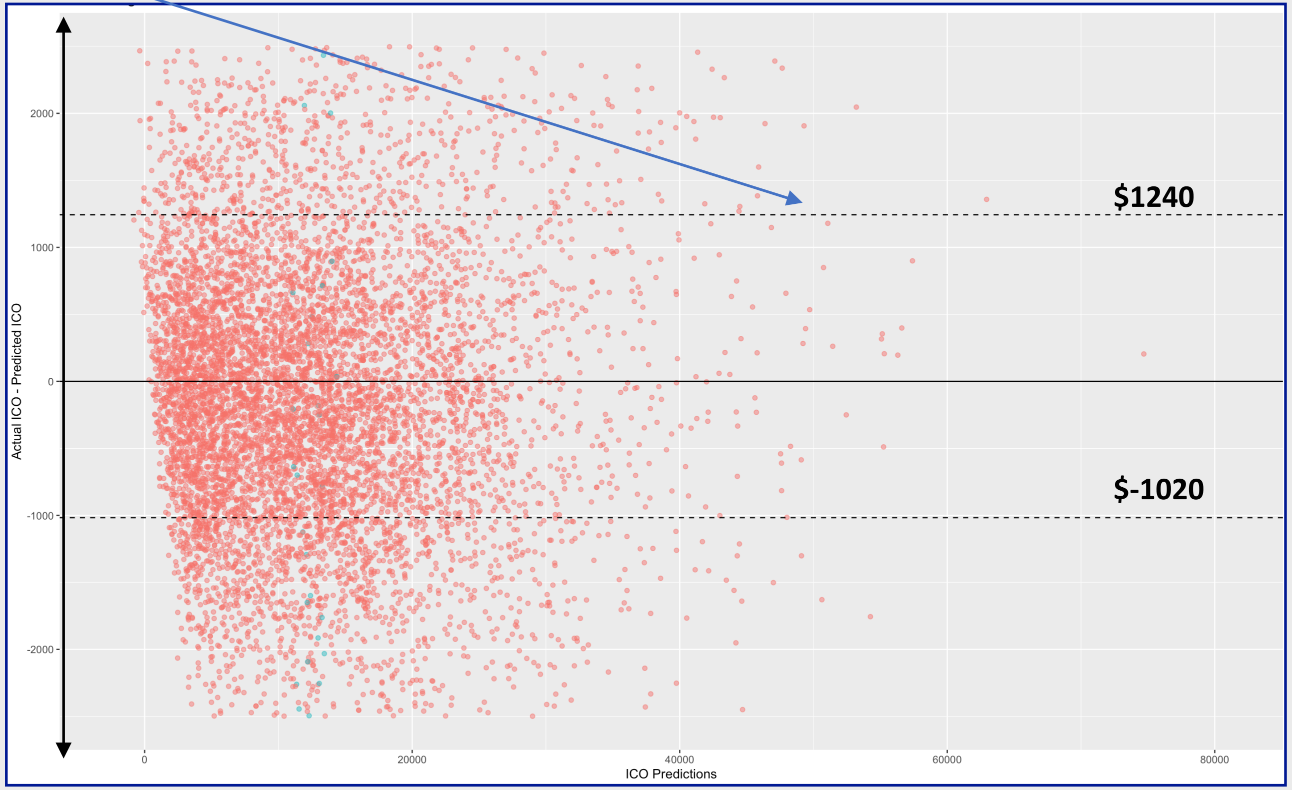
Linear Regression

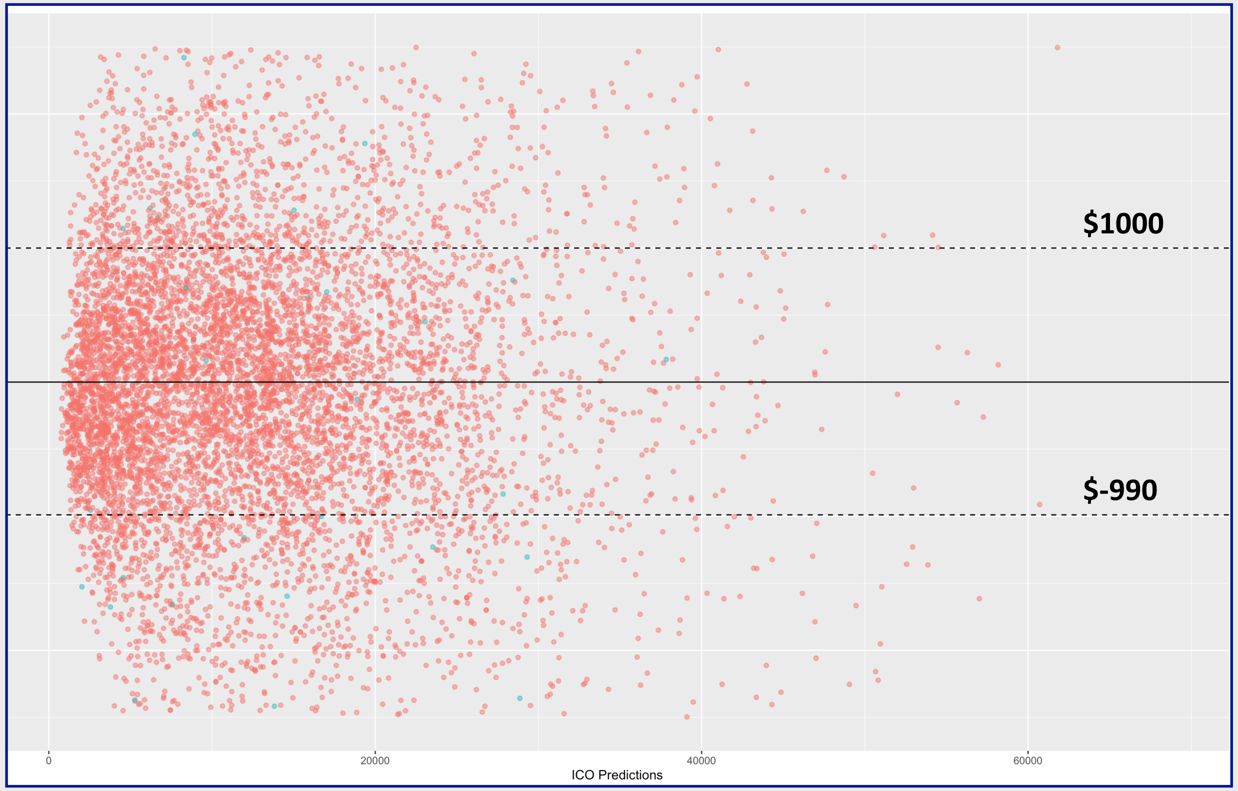
Average magnitude of errors is $1100

RandomForest

Average magnitude of errors is $990

Linear tends to make worse underestimate errors compared to the RandomForest





MAE = $1100
sqrt(MSE) = sqrt($4,807,894) = $2190

MAE = $990
sqrt(MSE) = sqrt($2,821,194) = $1680

Customer Perspective

ICO = Instant Cash Offer

The price Cox predicts a customer's vehicle is worth.