Mu Sigma

Predicting Food Delivery Time using Quantile Regression

Thursday Learning Hour – Maaheen Jaiswal

Do The Math

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Topics you will learn in today's session:

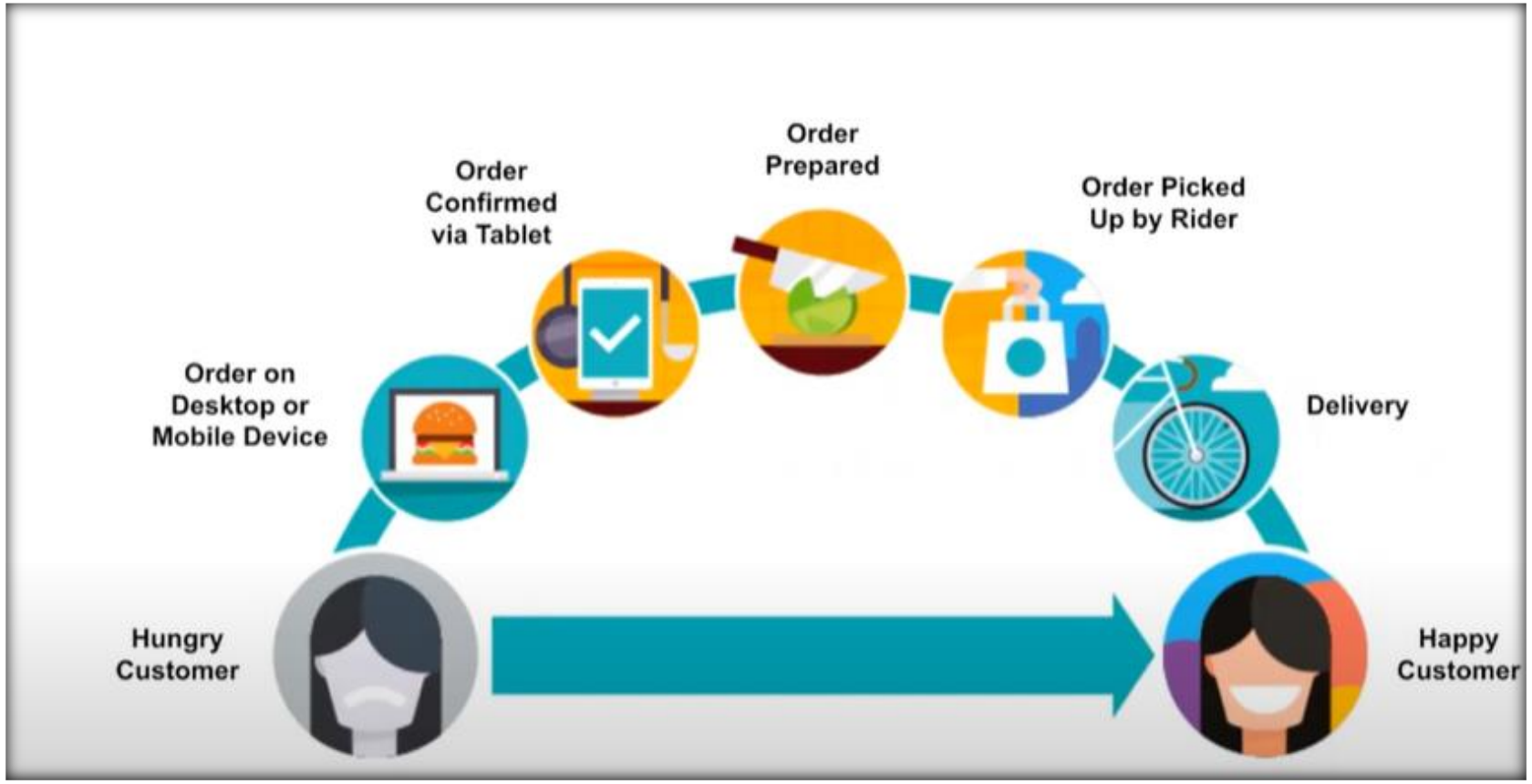
- AI use cases in food industry
- Challenges with food delivery apps
- Confidence Intervals
- Last Mile Time Prediction using statistical and ML based approaches
- Simple Linear Regression Vs Quantile Regression

“Your order is out for delivery”

Building a top-notch delivery app

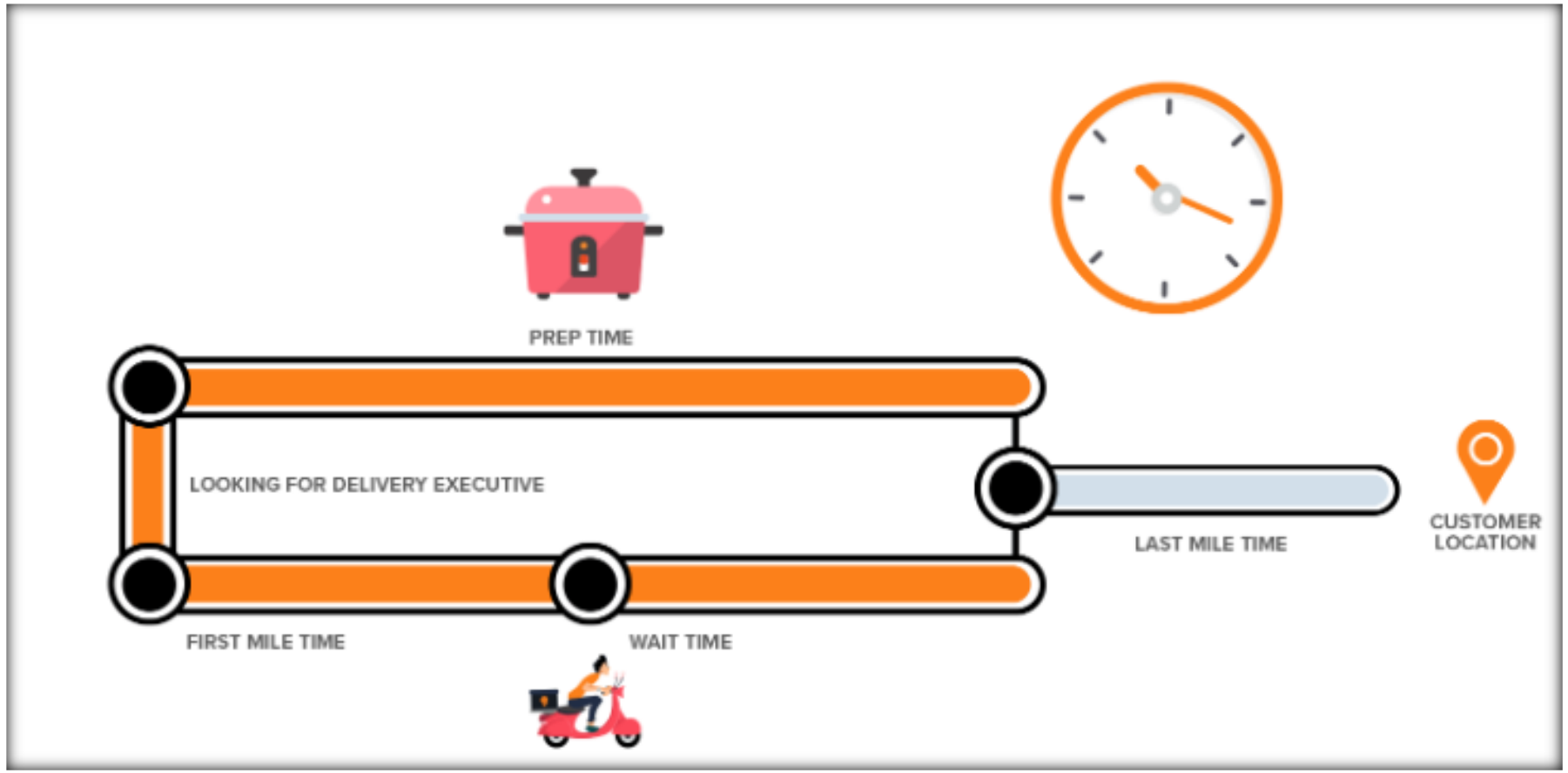
”Food delivery is probably the hardest challenge in the Logistics space”

Order Journey



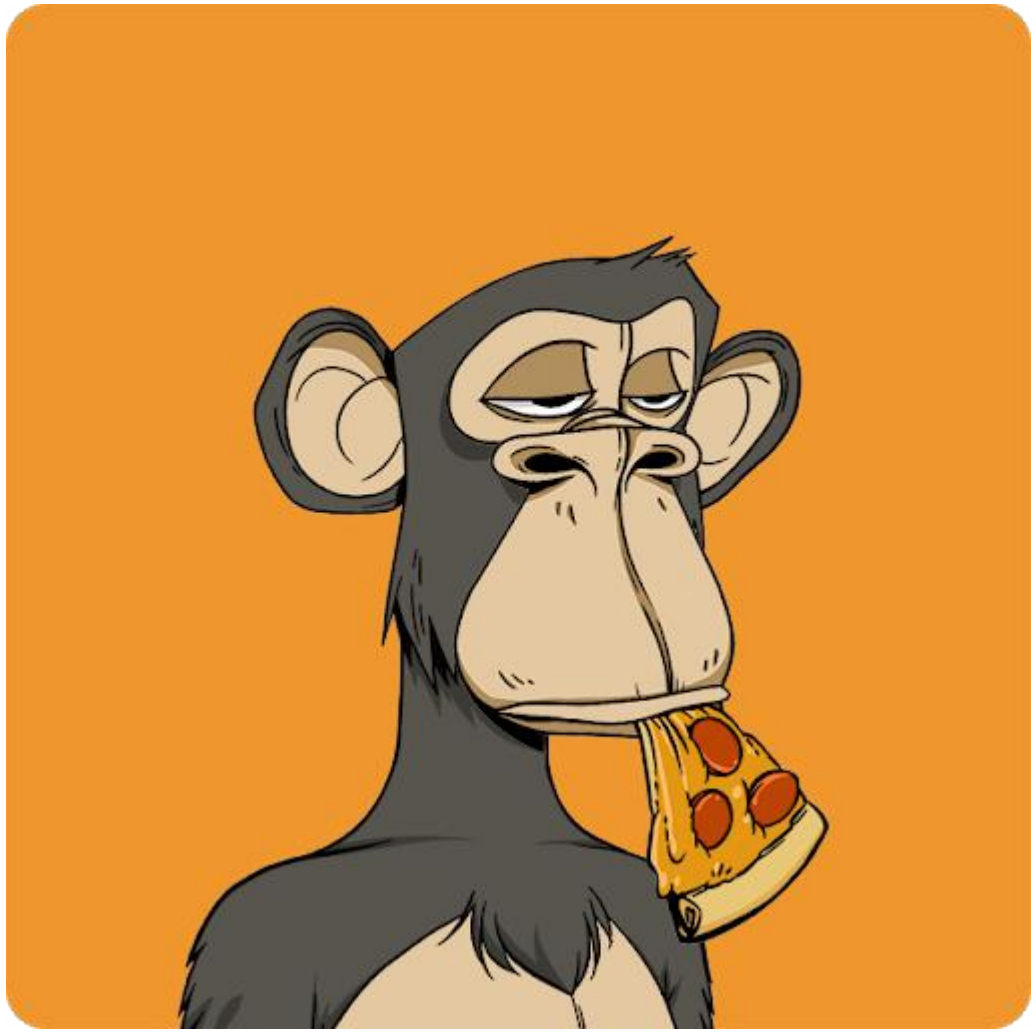
"The one thing that most people don't realize is that the role of delivery doesn't begin when someone places the order, but as soon as they open the app."

Delivery Time Components

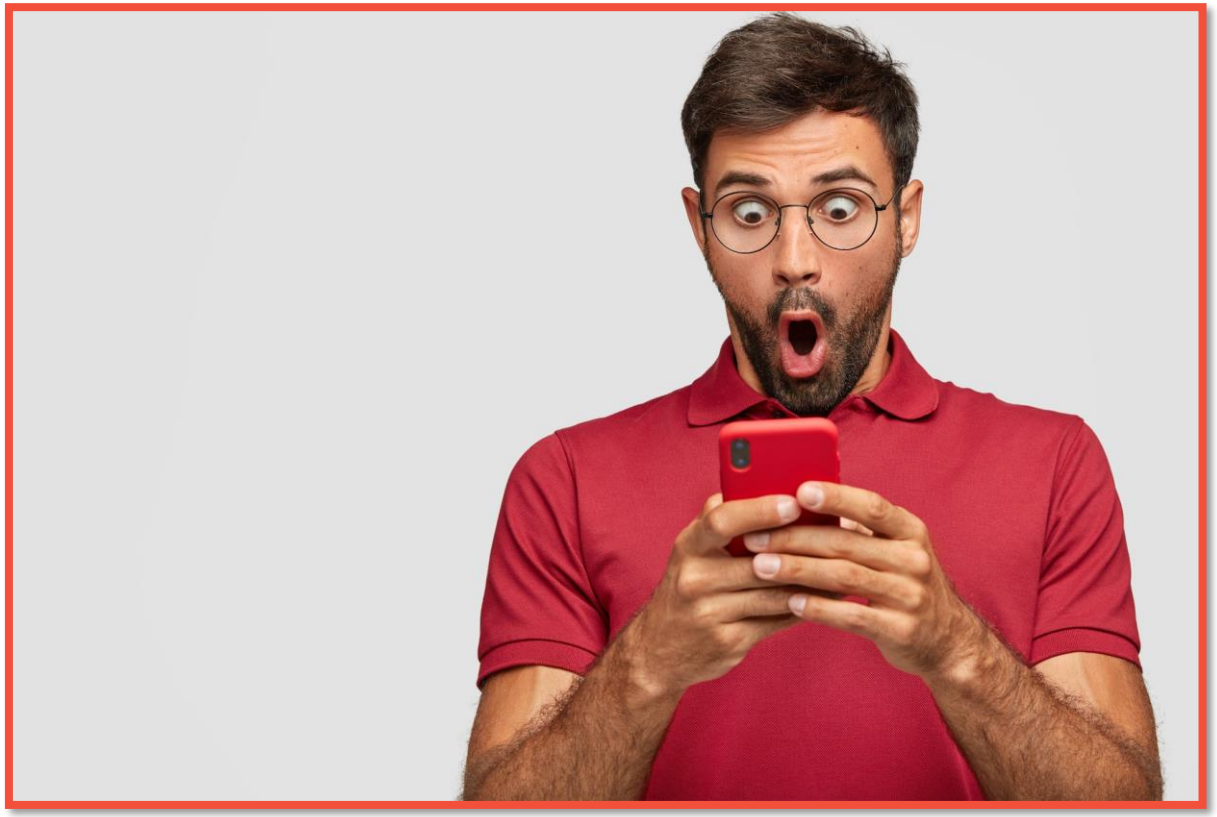


- **Assignment Delay:** How long before we can find a Delivery Executive who can fulfil this order*?*
- **First Mile:** How long before they arrive at the Restaurant?
- **Prep Time:** How much time is required for the Restaurant to prepare the food?
- **Last Mile:** How much time is required for the Delivery Executive to reach the customer from the Restaurant?

Why is on time delivery important?



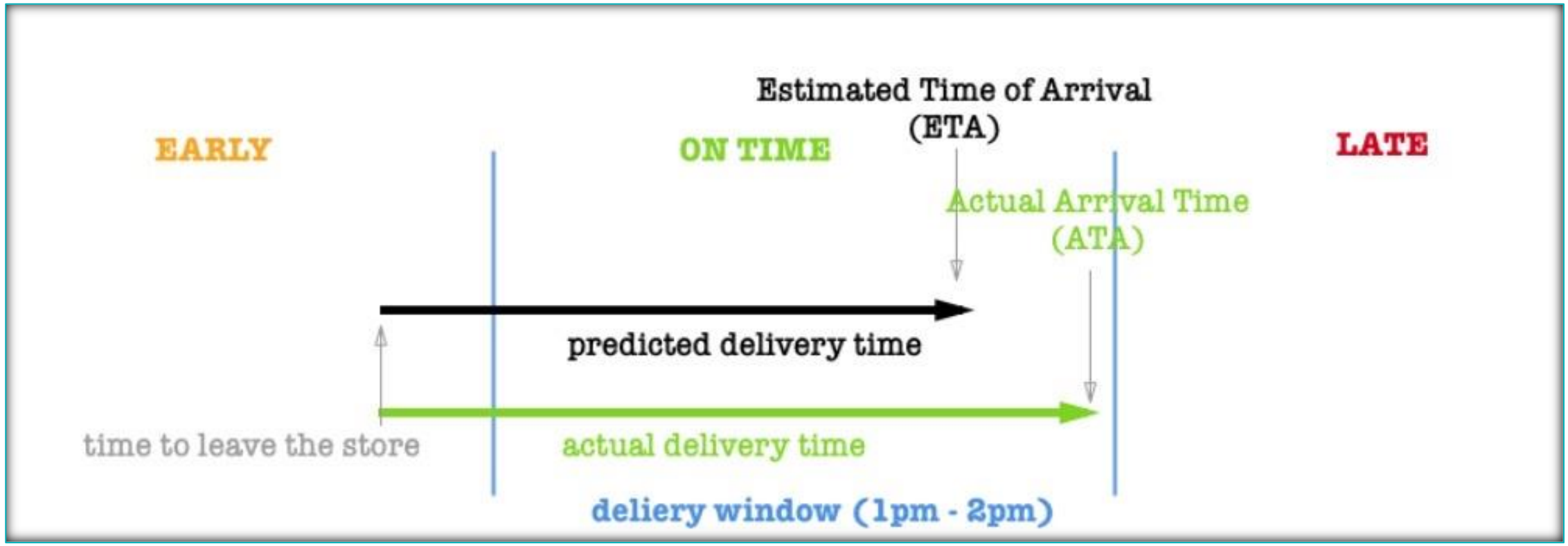
Because no one likes cold pizza!!



“When your food delivery partner reaches your location AFTER the promised time”

Last Mile Time Prediction

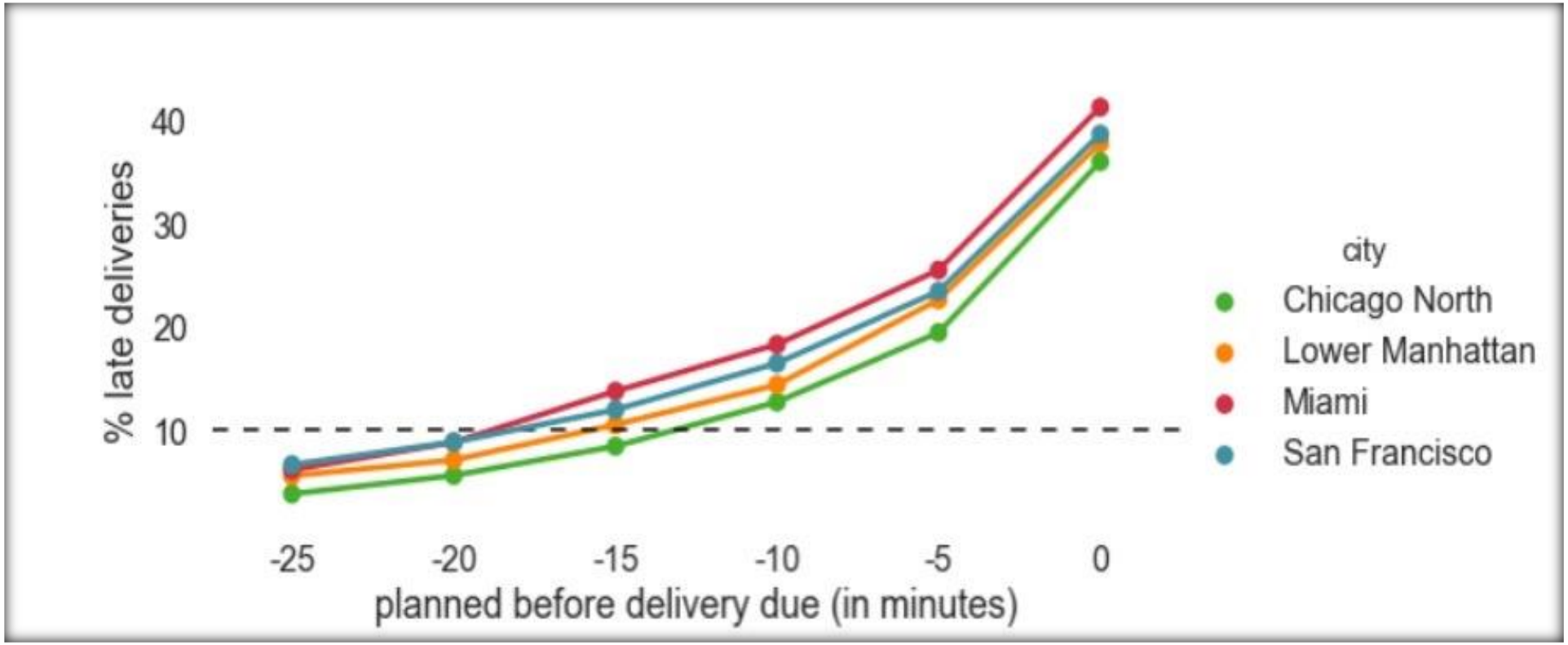
Last Mile Time Prediction



- **Actual Arrival Time = ETA + Prediction Error < Due Time**
- **ETA + Buffer < Due Time**

Statistical Approach

How to choose buffer?



"There are some issues with keeping a fixed buffer. A fixed buffer may have higher risk of lateness and sometimes leads to loss of efficiency as well."

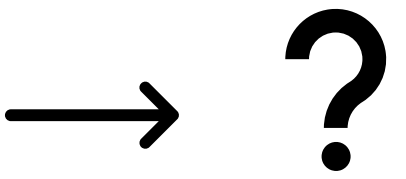
ML Approach

Why not any typical regression?

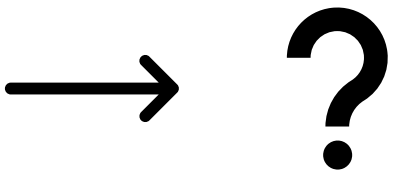
Linear Regression Overview – A Little Math

- *A typical regression aims to fit the mean of the distribution. We try to approximate the conditional mean of the response variable Y given certain values of the predictor variables X. In this context the objective is to minimize is the sum of the squared errors.*

$$y_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_p x_{ip} \quad i = 1, \ldots, n$$



$$\sum_{i=0} (y_i - \hat{y}_i)^2$$



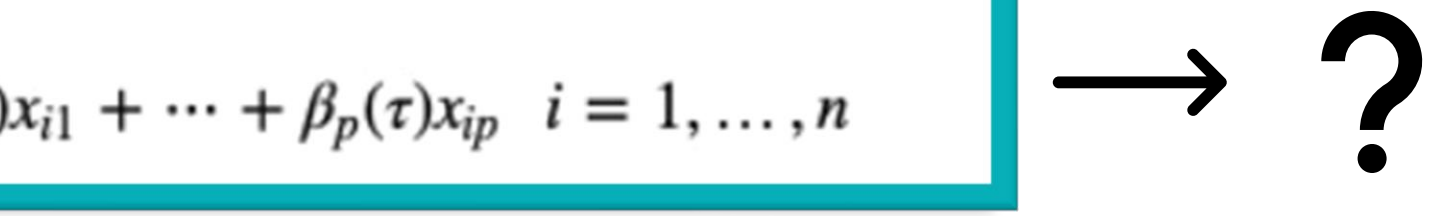
Confidence Intervals

Quantile Regression

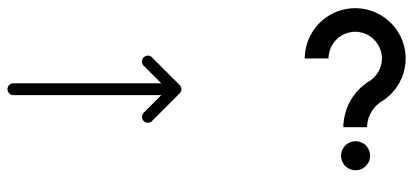
Quantile Regression – A Little More Math

- In quantile regression, we want to make a set of predictions Q so that, for a given quantile q, q% of the true values are less than Q. In this case, we try to minimize the below loss function:

$$Q_\tau(y_i) = \beta_0(\tau) + \beta_1(\tau)x_{i1} + \cdots + \beta_p(\tau)x_{ip} \quad i = 1, \ldots, n$$

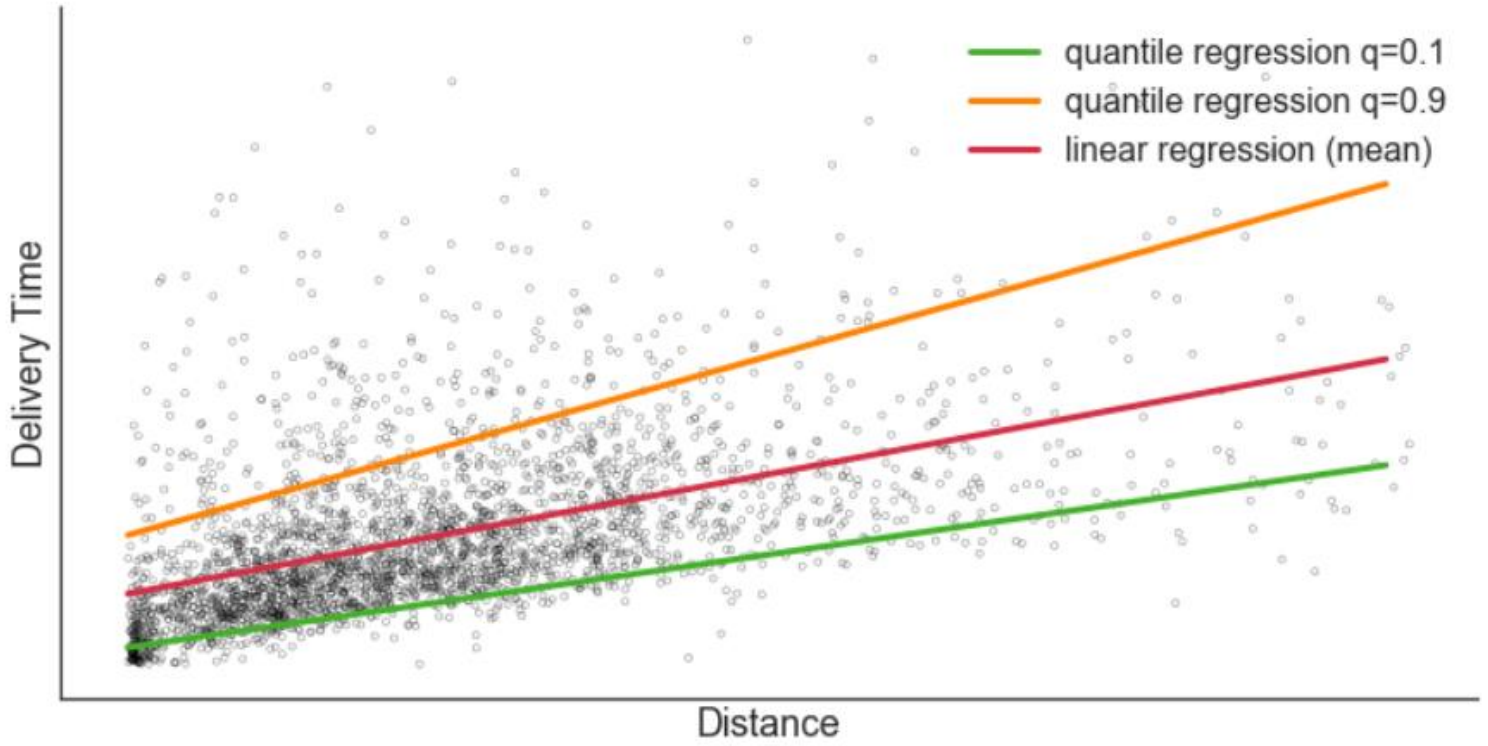


$$\sum_{i=0} \rho_q(y_i - \hat{y}_i)$$



$$\rho_\tau(u) = \tau \max(u, 0) + (1 - \tau) \max(-u, 0)$$

Quantile Regression Vs Linear Regression

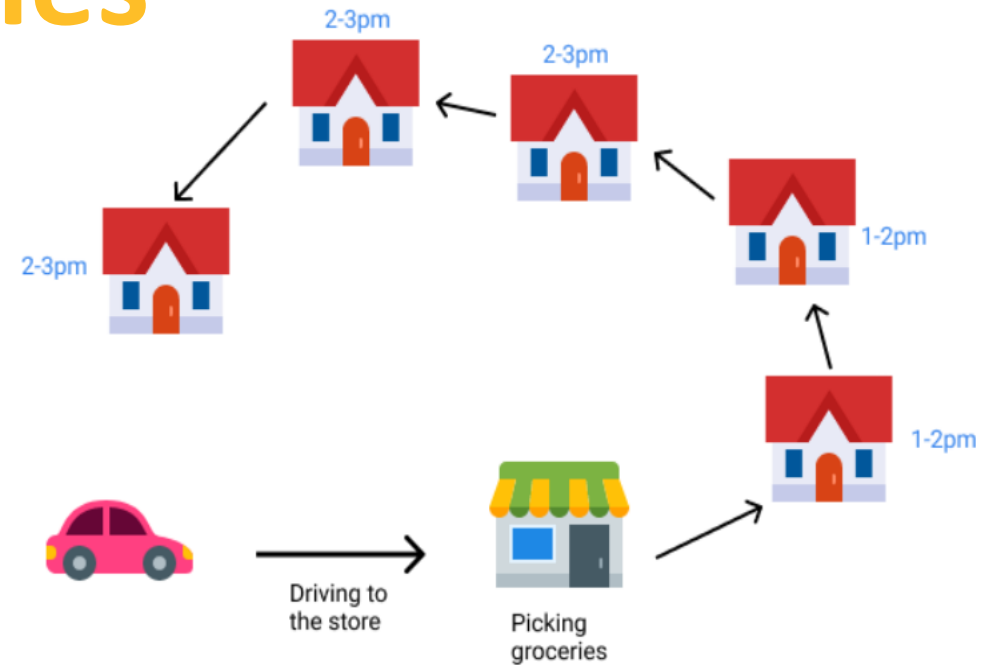


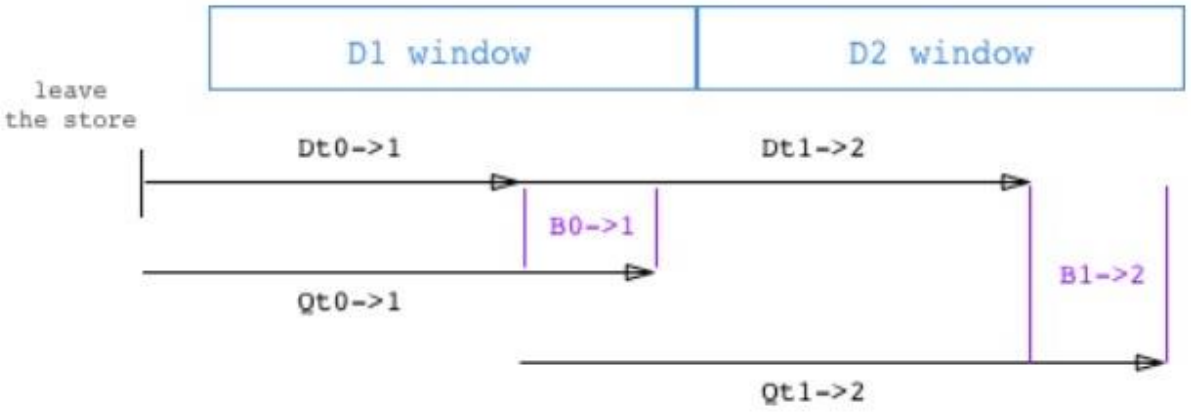
Prediction from 90th quantile < Due time

What about multiple deliveries?

Multiple Deliveries

If first delivery takes more time than estimated, that will impact the next one as well. Therefore, the risk associated with being late is cumulative over here





Dt0->1 = *Predicted delivery time from store to D1.*
Dt1->2 = *Predicted delivery time from D1 to D2.*
Qt0->1 = *90th percentile prediction from store to D1.*
Qt1->2 = *90th percentile prediction from D1 to D2.*
B0->1 = *Qt0->1 - Dt0->1 = Delivery Time Buffer from store to D1.*
B1->2 = *Qt1->2 - Dt1->2 = Delivery Time Buffer from D1 to D2.*
B0->2 = *Buffer that we need to use to make sure D2 will not be late.*

Dt01 + Dt12 + B02 < Due Time of D2

How to estimate B02?

$$B_{0->1} = z * \sigma_1$$
$$B_{1->2} = z * \sigma_2$$
$$B_{0->2} = z * \sqrt{\sigma_1^2 + \sigma_2^2} = \sqrt{B_{0->1}^2 + B_{1->2}^2}$$

→ ?

Next Steps:-

- Finally, compare statistical way and Quantile Regression Method to decide the better one.
- We can do A/B Testing with both the mentioned methods and finally conclude the results
- Another advancement, we can look into is ***"Conformalized Quantile Regression"*** which is a hybrid of conformal and quantile model predictions

“Delivery Partners after delivering all the orders on time be like: ”

Thank You for bearing with me!!

References

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