

# Approximation Model to Estimate Joint Market Share in Off-Hour Deliveries

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# Rationale of Off-Hour Deliveries policies

- ❖ Empirical evidence and theory indicate that freight road pricing in urban areas is not likely to switch deliveries to the off-hours. The reasons are many:
  - ❖ Time of day cordon tolls are a fixed cost (in economic terms) that carriers cannot pass in competitive markets
  - ❖ Even if the carrier can pass the tolls, its impact is diluted among the multiple receivers
  - ❖ Time-distance tolls could be passed to receivers, though they would have to be humongous to be effective



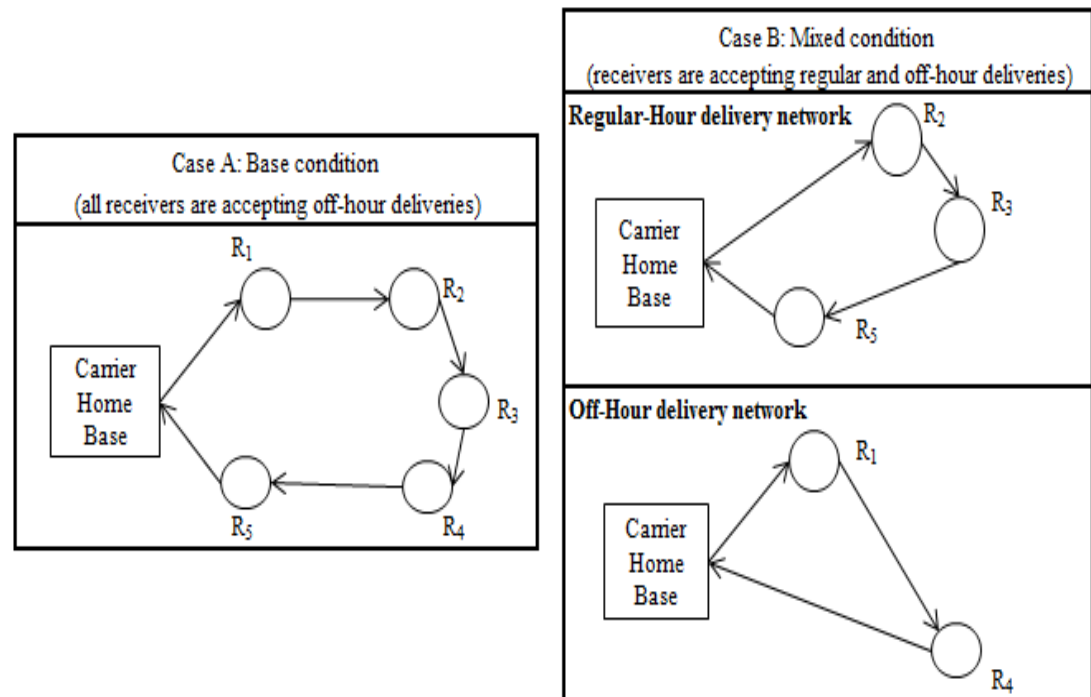
- ❖ Providing financial incentives to receivers would:
  - ❖ Induce a switch to the off-hours because the carriers would follow suit (it is 30% cheaper to deliver at night)
  - ❖ Improve the economic competitiveness of urban areas
  - ❖ Improve environmental and traffic conditions
  - ❖ Increase overall welfare because of its voluntary nature



- ❖ Holguin-Veras et al. (2006a and b) used a sequence of Logit models to estimate:
  - ❖ The behavior of receivers in response to policies encouraging them to switch to the off-hours, e.g., tax incentives; and
  - ❖ The behavior of carriers in response to: (a) the receivers' response; and (b) carrier-centered policies such as time of day tolls
- ❖ Limitations:
  - ❖ Its sequential nature does not consider interactions
  - ❖ Require behavioral data and models
  - ❖ Does not explicitly consider routing and other costs



- ❖ Silas and Holguin-Veras (2008) developed a Behavioral Micro-Simulation (BMS) that, based on the behavioral models of Holguin-Veras et al. (2006 a and b) simulates the behavior of carriers and receivers



## ❖ Pros:

- ❖ Detailed consideration of decision maker behavior
- ❖ Very accurate

## ❖ Cons:

- ❖ Require significant development time



# Fundamental objective of this paper

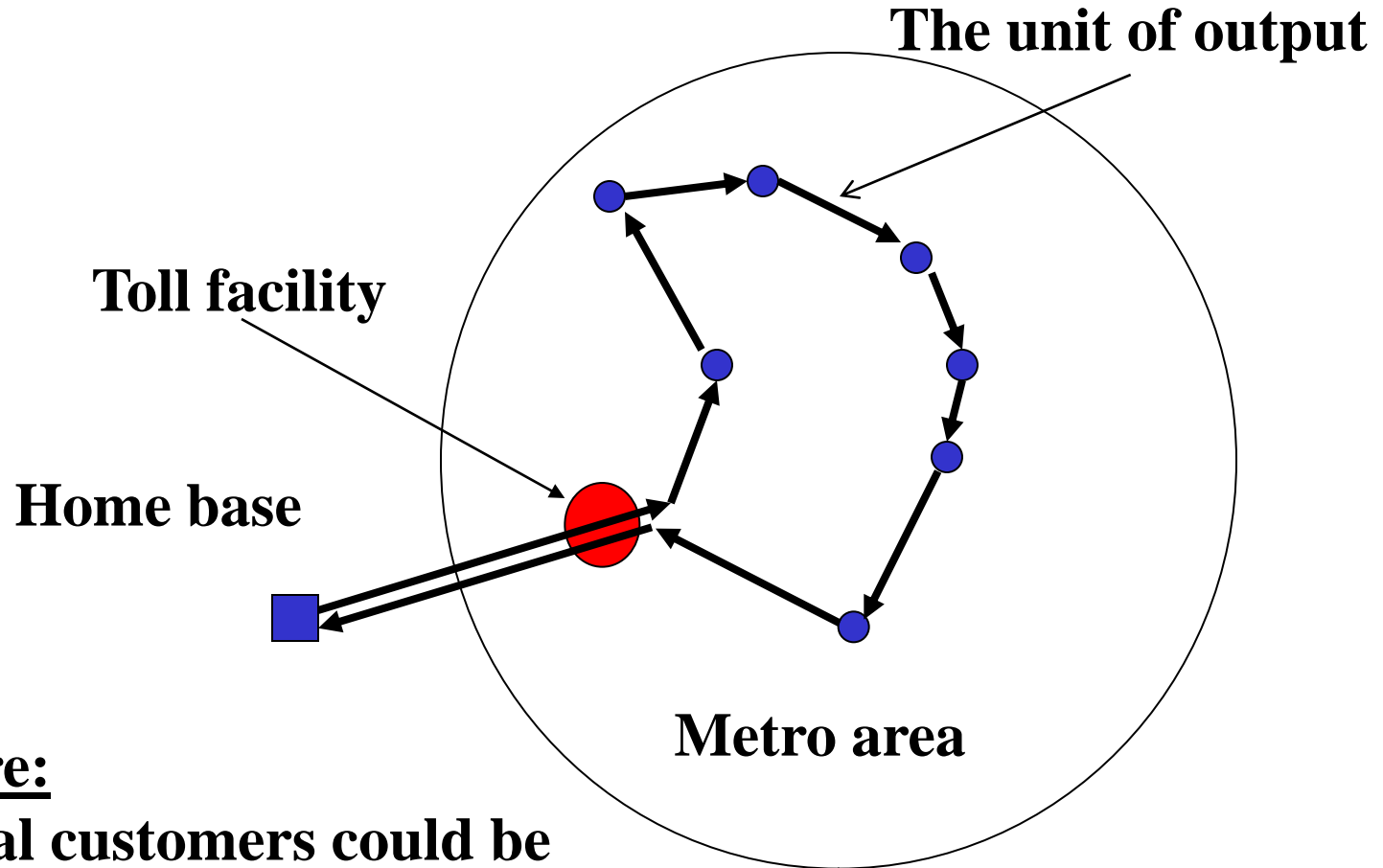
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- ❖ To develop an “easy to use” formulation to estimate the market share of OHD policies
  - ❖ That bypass the need to use more complex methodologies, such as the ones discussed before
  - ❖ That reduces the need for expensive data collection



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# The case considered: Urban deliveries (70-80%)



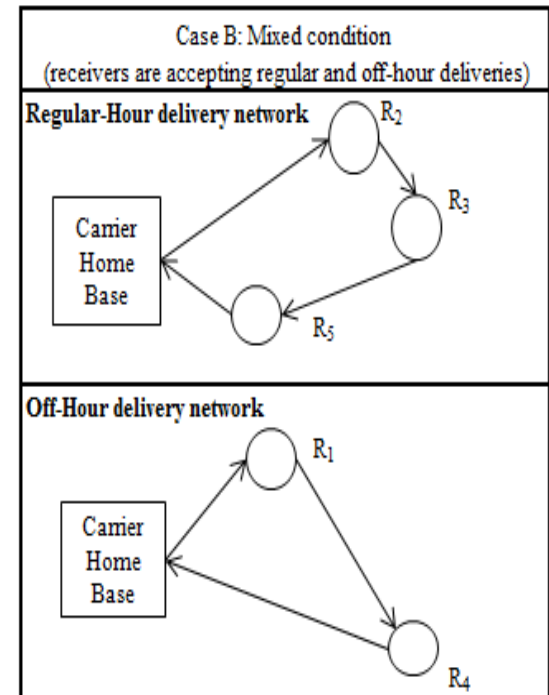
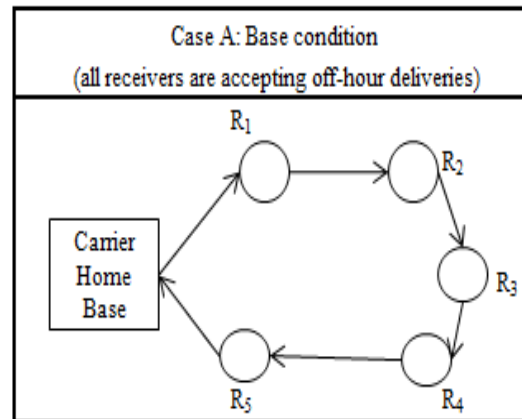
## Key feature:

- Additional customers could be accommodated into existing tours
- A cordon toll is a fixed cost



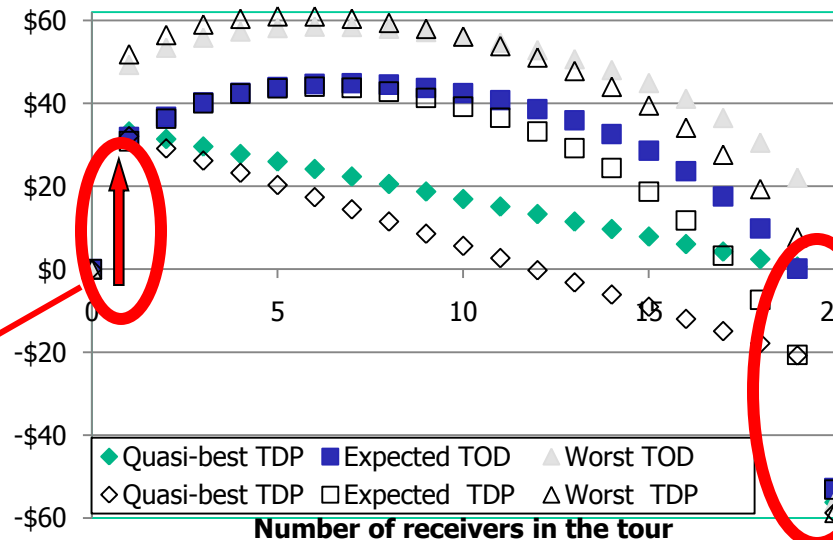
# In response to an incentive:

- ❖ Receivers may switch to the off-hours:
  - ❖ If all switch, the carrier will switch (it would save money)
  - ❖ If not all receivers switch, the carrier has to decide if the extra trip is compensated by the cost savings in off hours



# Key insight/result

- ❖ Numerical experiments conducted using the formulation of Holguin-Veras (2009) and the BMS (Silas and Holguin-Veras, 2009) indicated that:
  - ❖ In order for the carrier to do off-hour deliveries in a mixed mode operation (regular and off-hour deliveries) that almost all receivers must switch to the off-hours



The receivers' probability of accepting off-hour deliveries in response to incentive  $F$ :

$$P(R_i \in \Omega_j^O) = P(F)$$

The probability that  $M$  receivers accept off-hour deliveries:

$$P(R_1 \in \Omega_j^O \cap R_2 \in \Omega_j^O \cap R_3 \in \Omega_j^O \cap \dots R_M \in \Omega_j^O / M' = |\Omega_j^{BC}|) = \mathbf{P}(F)^M$$

The probability that such operation with  $M$  receivers is profitable to the carrier:

$$P(j \in \Gamma^O) = \mathbf{P}(F)^M P(G_M > C_M / M)$$

The expected value of the number of tours that would be switched to the off-hours is equal to the number of tours of length  $M$ , times the probability that these tours switch to the off-hours:

$$E(Q) = \sum_{M=1}^{M^*} Q_M \mathbf{P}(F)^M$$



# Mathematical derivation

Defining, the total number of tours as  $Q_*$ , and  $f_M$  as the relative frequency:

$$Q_* = \sum_{M=1}^{M^*} Q_M \quad f_M = \frac{Q_M}{Q_*}$$

The market share of off-hour deliveries could be obtained as:

$$MS^O = \sum_{M=1}^{M^*} f_M \mathbf{P}(F)^M$$



$$MS^O = \sum_{M=1}^{M^*} f_M [P(F)]^M$$

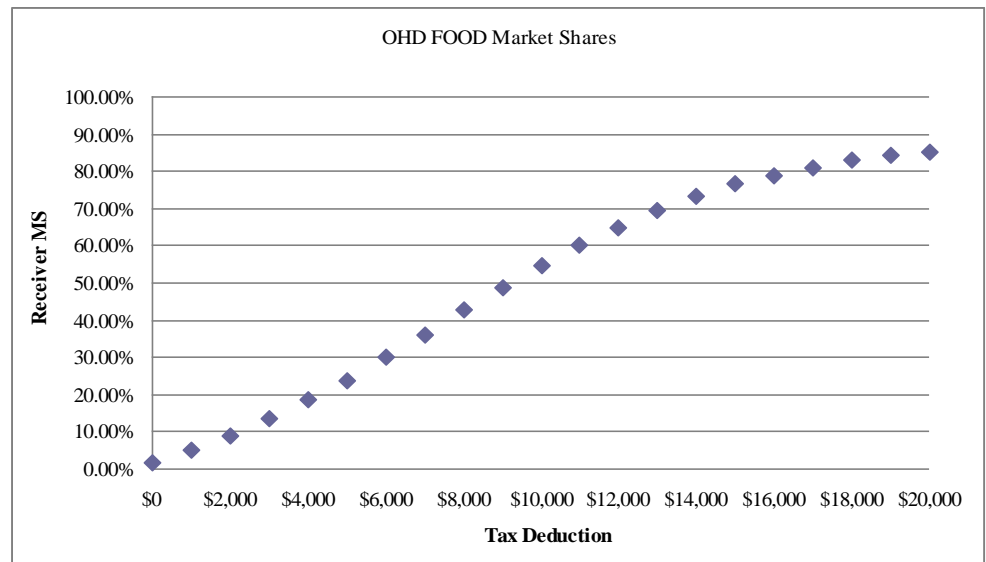
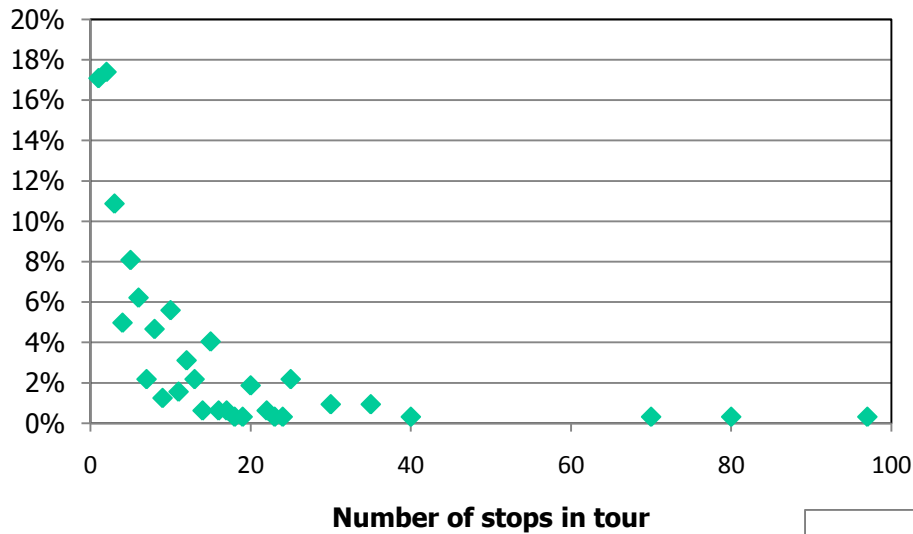
The contribution of a tour of length M rapidly decreases with tour length

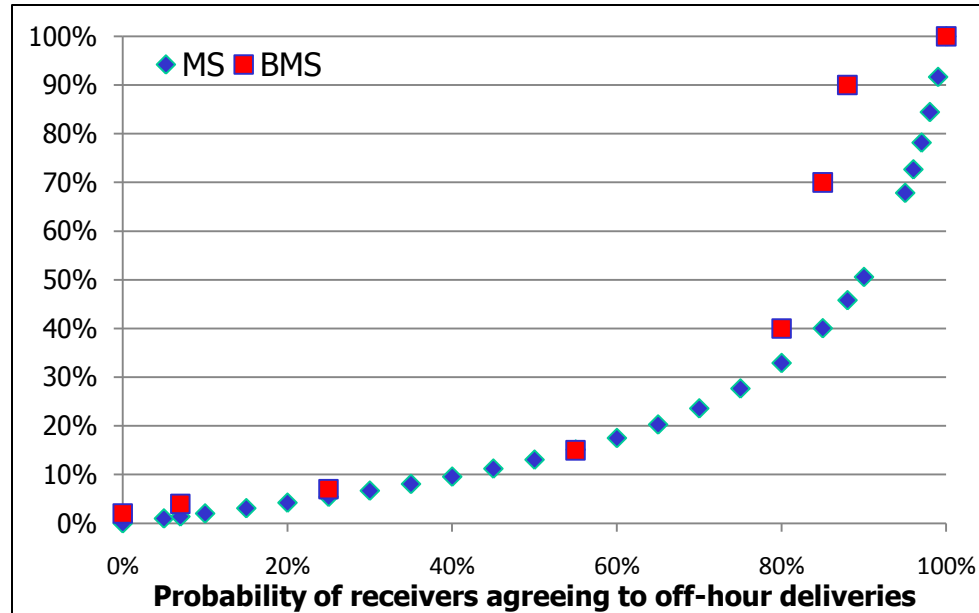
Urban areas with relatively high proportions of short tours will have larger market shares of off-hour deliveries



# Does this simple equation work?

## ❖ Data from New York City





- ❖ The approximation model (MS) works quite well
  - ❖ Almost identical results for  $P(F) < 80\%$
  - ❖ It underestimates for  $P(F) > 80\%$  (may be because in this range it is more likely to find profitable tours that do not require all receivers in it to agree to off-hour deliveries)

- ❖ The approximation model works quite well
- ❖ It only requires estimate of the participation of receivers in off-hours, and of the breakdown of tours by length
- ❖ Both could be obtained relatively easy through consultation with the industry



- ❖ The research was funded by the United States Department of Transportation's Cooperative Agreement DTOS59-07-H-0002 "Freight Demand Management in the New York City Metropolitan Area"
- ❖ The research presented here does not necessarily represent the view of the United States Department of Transportation.
- ❖ This support is both acknowledged and appreciated



Reactions?

