Rensselaer | SCHOOL OF ENGINEERING

A Simulation-Optimization Formulation for Design of Off-Peak Delivery Policies

Michael A. Silas, MS
Ph.D Student
Rensselaer Polytechnic Institute
The Department of Civil and Environmental Engineering

Outline

- Introduction
- What exactly are Off-Peak Deliveries (OPD)
- New York City study on OPD
- Simulation-Optimization Framework
- Findings
- Conclusions
- Questions

Introduction

- Urban vehicle traffic congestion is a serious problem
- Another method is to control delivery times on the business and corporate levels of operations.
  - Specifically having carriers shift part of their shipping operations to the *off-peak hours*
  - *Ex: One seventy foot truck occupies about 3 car lengths*
    - *Parking and Interstate space are scarce in congested areas*
- Shifting delivery times has the potential to reduce traffic congestion and improve environmental quality

What exactly are Off-Peak Deliveries (OPD)?

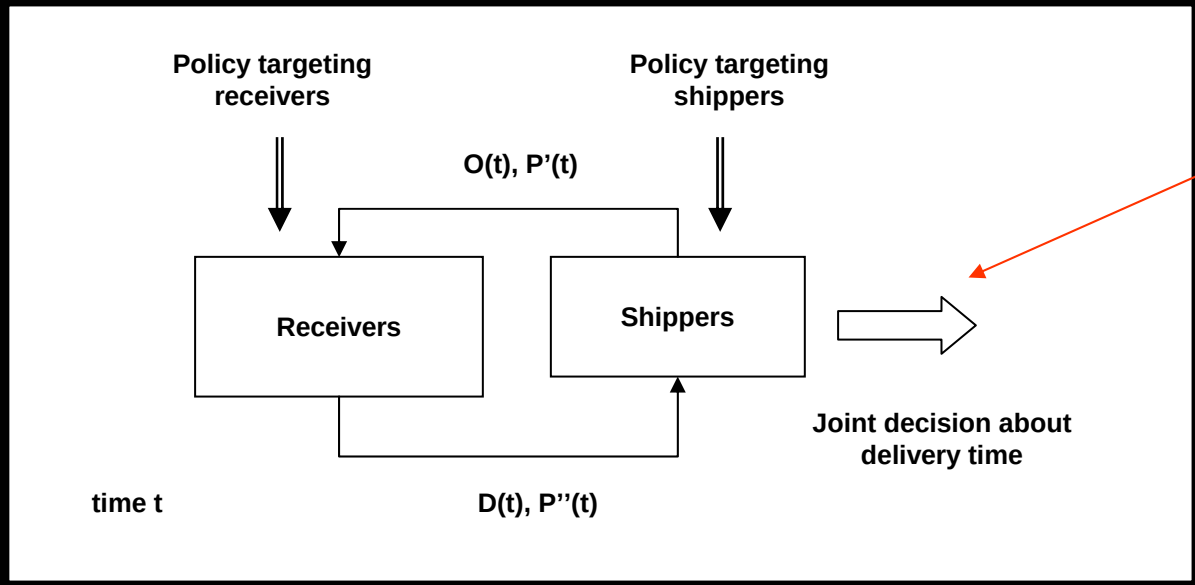
- Off-Peak Deliveries (OPD) is the receiving and shipping of goods outside of regular business hours (6PM and 6AM)
  - OPD needs the two major stakeholders to agree about delivery times: **Receivers and Carriers**
  - Incentives for participation
    - Receivers – tax deductions
    - Carriers – toll discounts, financial rewards
- Policy analysis techniques are needed to understand how to increase the participation in OPD

Studies on OPD

- New York City
- NYSDOT initiative
  - Two phases: Manhattan and Brooklyn
  - Outreach efforts
    - Focus Groups
    - In depth Interviews
    - Surveys
- Key Findings
  - Receivers are the main stumbling block to OPD
  - Tax deductions would foster OPD
  - Carriers are most likely to participate in OPD

Studies on OPD

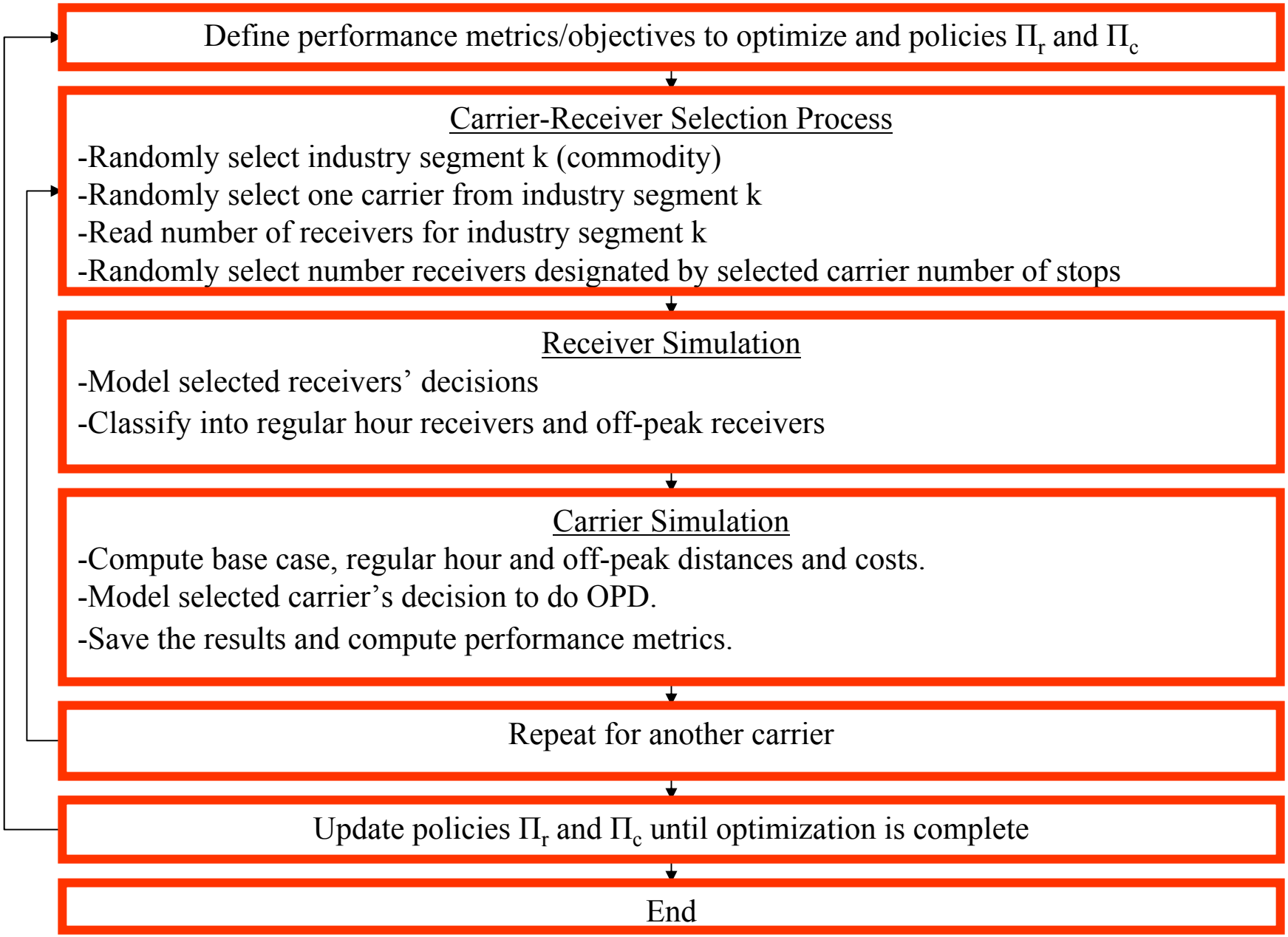
- Schematic of decision making process



- Further work is needed to understand how to foster more OPD

Simulation-Optimization Framework

- **September 11th Program** funded research
- ”A Simulation-Optimization formulation for the design of OPD”
- Using Economic Incentives to foster more participation
  - Receivers: Tax deductions
  - Carriers: Toll Savings, Financial Rewards
- Randomly select a commodity, a carrier, and a set of receivers.
  - Simulate receivers’ and carrier behaviors towards OPD
  - Optimize OPD participation, budget constraints

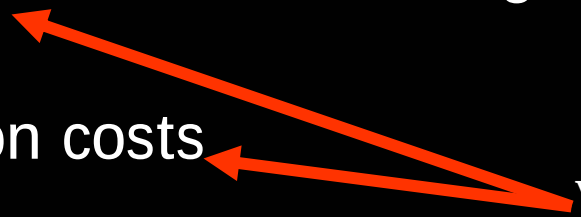

Define performance metrics/objectives to optimize and policies Π_r and Π_c
Carrier-Receiver Selection Process
-Randomly select industry segment k (commodity)
-Randomly select one carrier from industry segment k
-Read number of receivers for industry segment k
-Randomly select number receivers designated by selected carrier number of stops
Receiver Simulation
-Model selected receivers' decisions
-Classify into regular hour receivers and off-peak receivers
Carrier Simulation
-Compute base case, regular hour and off-peak distances and costs.
-Model selected carrier's decision to do OPD.
-Save the results and compute performance metrics.
Repeat for another carrier
Update policies Π_r and Π_c until optimization is complete
End

Receiver Simulation

- Use Discrete Choice Modeling with Tax Deduction as policy variable to model the Receivers' decision about the delivery time of goods and services.
- Monte Carlo Simulation is used as a platform to model the receivers' decision.

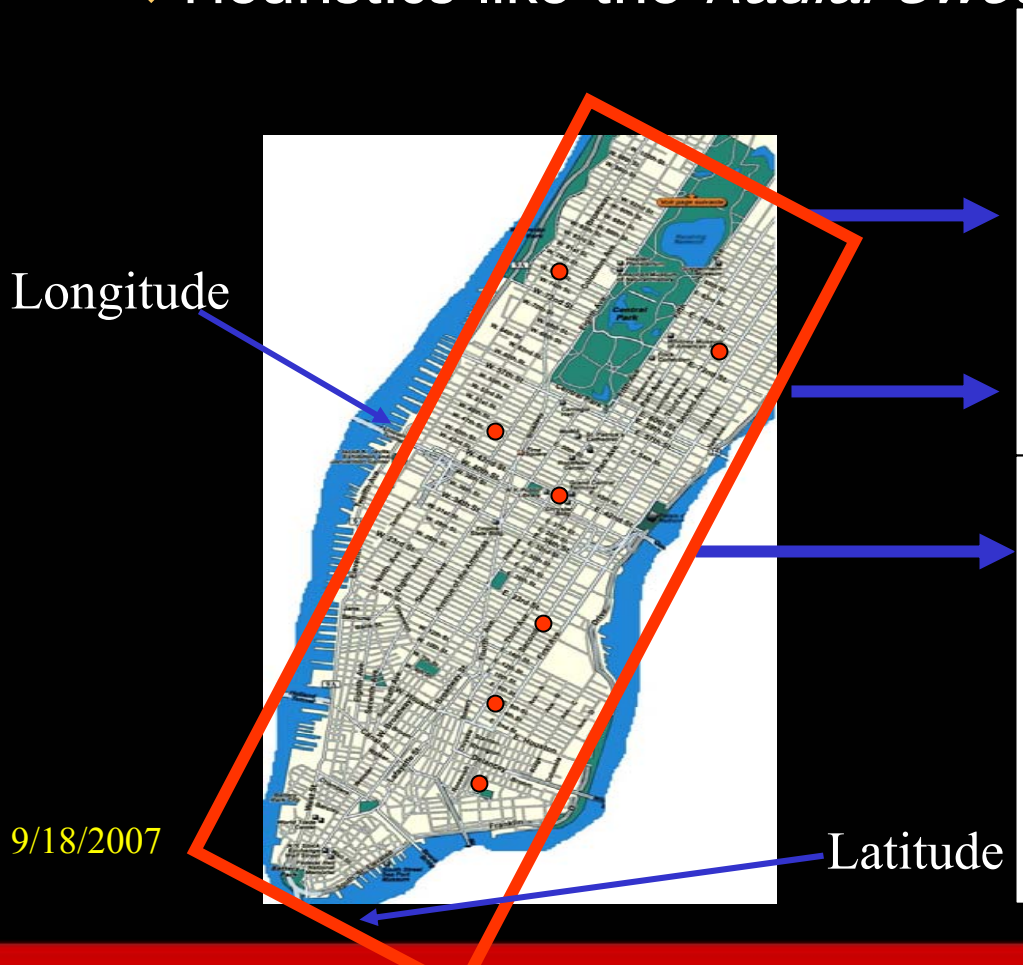
Carrier Simulation

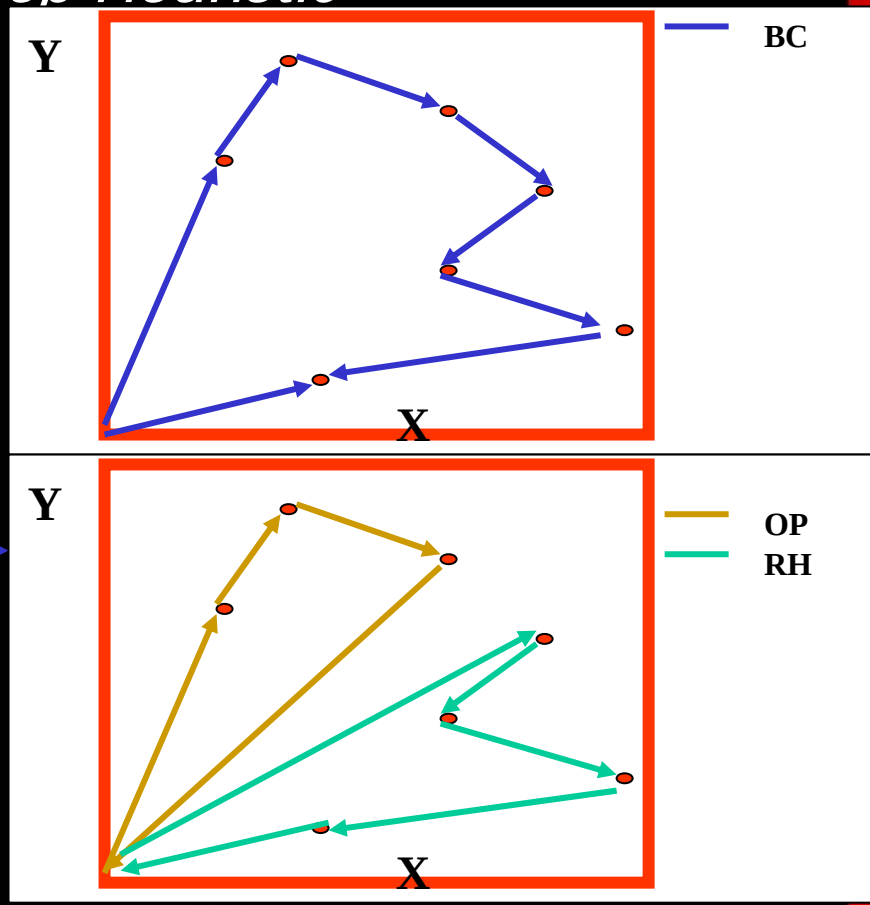
- Model the decisions of Carriers on whether or not make OPD based on:
  - Receivers' (Customer) decisions
  - Calculation of shortest route distances amongst Receivers
  - Calculation of transportation costs



Carrier Simulation

- Calculate shortest tour distance amongst the selected receivers
  - Heuristics like the *Radial Sweep Heuristic*





Carrier Simulation

- Cost Estimations:

$$C = C_d * D + C_t * T + 15 * C_t * Stops$$

C_d = cost per mile

D = delivery route distance

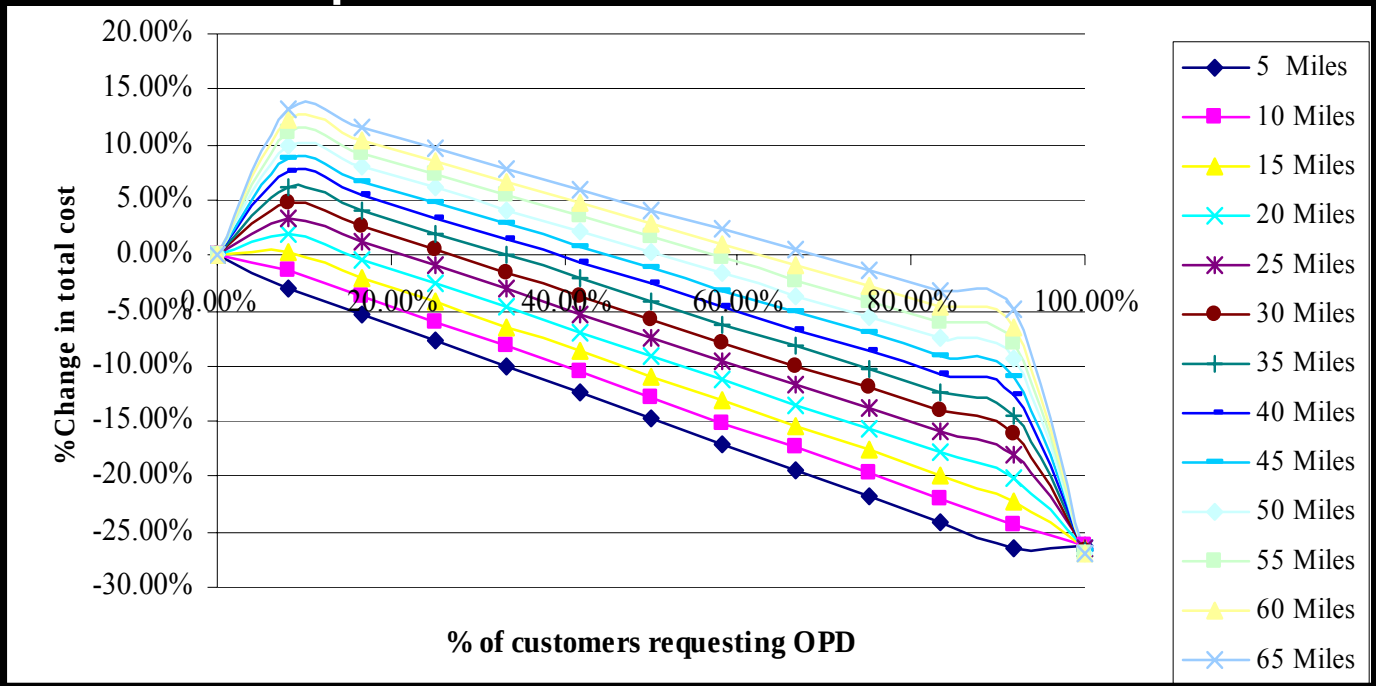
C_t = cost per minute

T = Travel time

- Assumption:
  - Carriers can travel twice the speed in the OP than in RH and BC

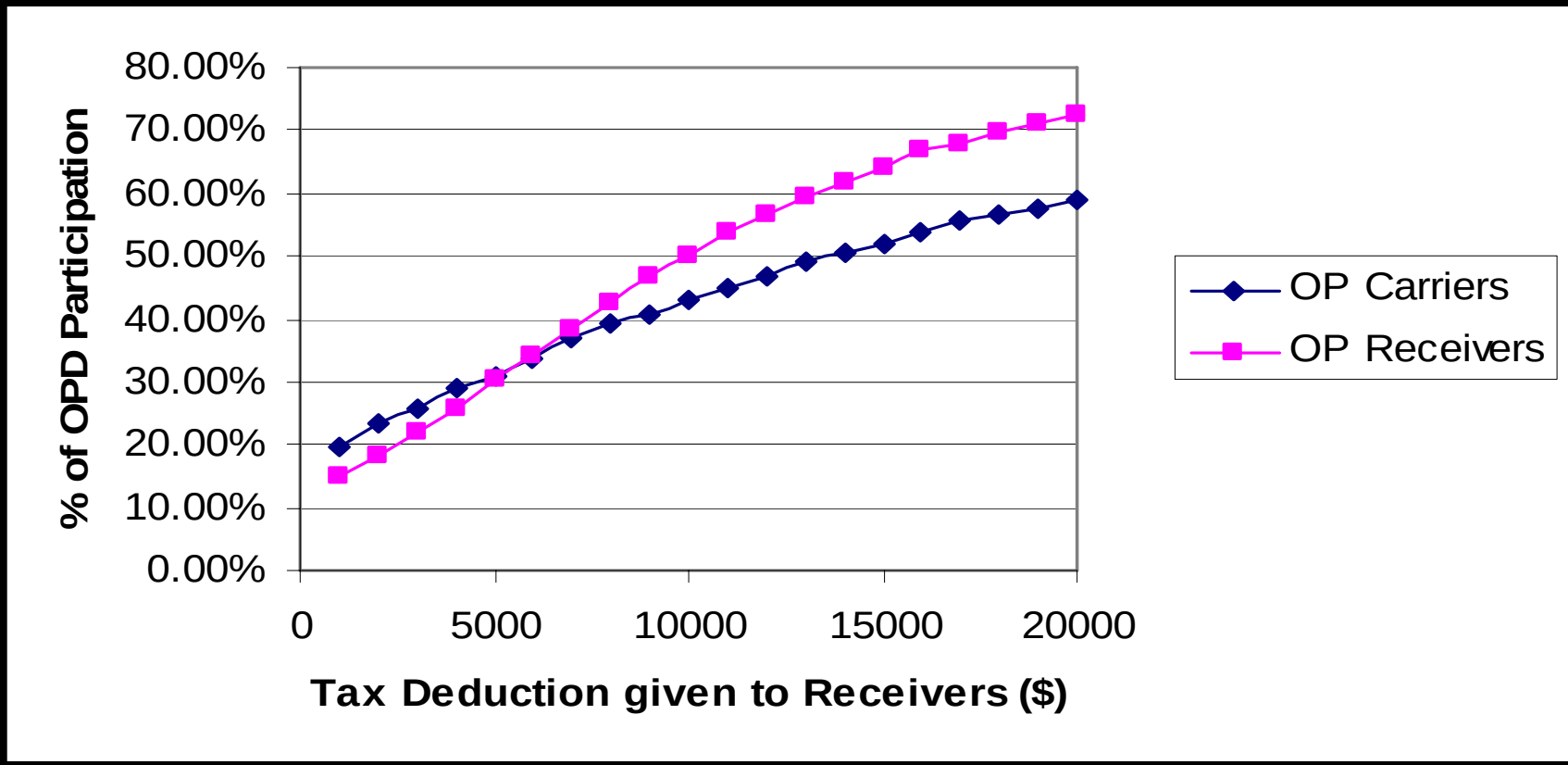
Findings

- The decision for Carriers to do OPD is driven by Receiver behaviors.
- Transportation costs are influenced by the distance to the first stop.



Findings

- Receiver and Carrier participation is increasing with respect to increases in the economic incentives given to Receivers



Findings

- Carrier route selection influences decisions on OPD
- Areas with higher densities of receivers influences OPD operations
- Industry Segments most receptive and sensitive to OPD
  - Food
  - Non-Alcoholic Beverages
  - Alcoholic Beverages
  - Printed Material
  - Paper
  - Medical Supplies
  - Metal
  - Wood/Lumber

Conclusions

- Simulation-Optimization framework is a valuable tool in identifying market segments (industry segments, areas, company characteristics, etc.) in the NYC region where OPD might be useful.
- Simulation-Optimization framework is a tool that can demonstrate the effectiveness of OPD, and its impact on the transportation market in urban areas.

Acknowledgements

- Dissertation Advisor: Jose Holguín-Veras, Ph.D., P.E. (Rensselaer Polytechnic Institute)
- Professional Advisor: Mr. Nathan Erlbaum (NYSDOT)
- September 11th Fellowship Program Director: Mr. Todd Goldman

Questions???