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

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Outline

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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

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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 $\Pi_r$ and $\Pi_c$

**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 $\Pi_r$ and $\Pi_c$ 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 to 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

Longitude

Latitude

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Carrier Simulation

- **Cost Estimations:**

\[ C = C_d \times D + C_t \times T + 15 \times C_t \times \text{Stops} \]

\[ C_d \] = 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.

![Graph showing the relationship between Tax Deduction given to Receivers ($) and % of OPD Participation.]
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.
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Questions???