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Toward Comprehensive Policies of Urban Freight Demand Management: Evidence, Necessary Conditions, and Micro-Simulation Results

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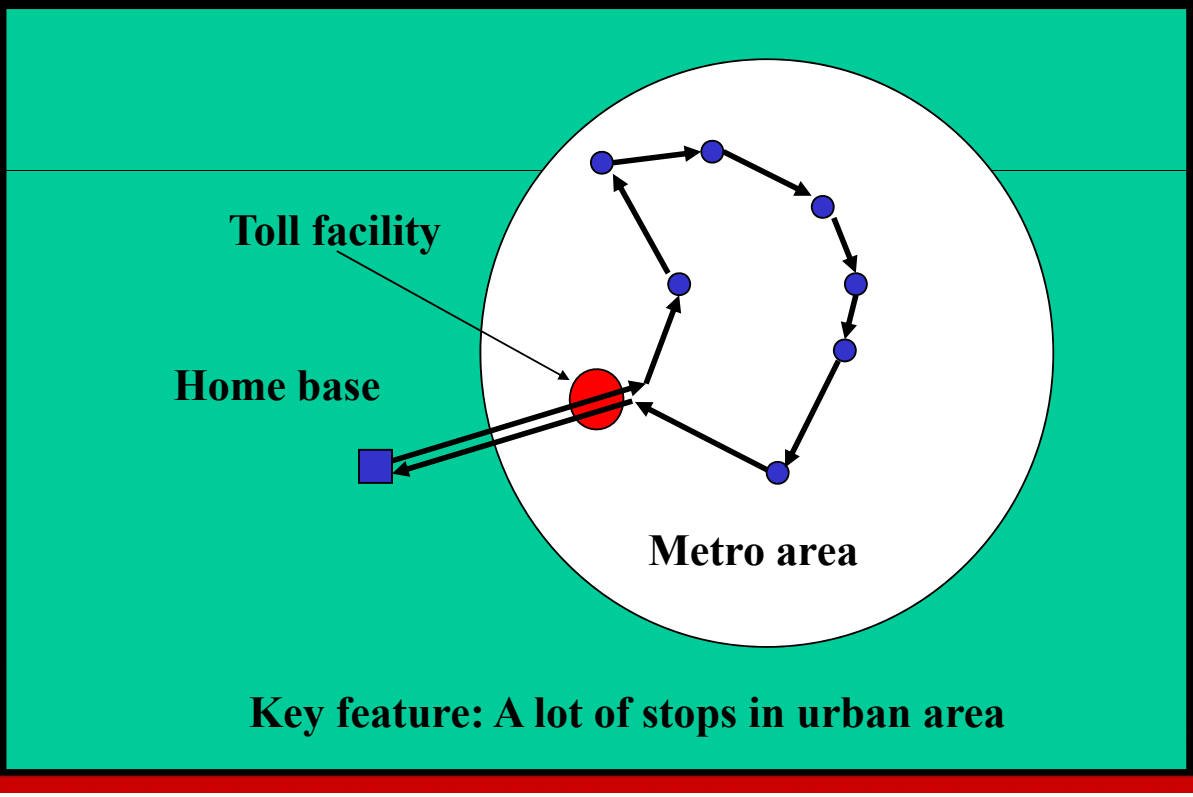
Objectives of the presentation

- To highlight the (not so well known) limitations of freight road pricing and the need for policies that go beyond road pricing
- To discuss alternative, and potentially more efficient, approaches to move truck traffic in congested urban areas
- To outline the necessary conditions for off-hour deliveries to be possible
- To discuss results of a behavioral micro-simulation of joint carrier-receiver behavior

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



Key feature: A lot of stops in urban area

Part I: Empirical Evidence

We all know...

- If price go up, transportation demand goes down
- In freight road pricing:
  - Tolls are imposed on truck traffic
  - Carriers pass the toll to the receivers / shippers
  - Receivers / shippers will react by moving their operations to the off peak hours
- Right?
- Not quite..... Reality is more complex than we think

This presentation is based on:

- A significant amount of outreach/data collection:
  - In depth Stated Preference surveys (receivers & carriers)
  - Revealed Preference data post pricing implementation
  - Dozens of in depth interviews with industry
  - Four focus groups with industry representatives
- Data and analyses come from:
  - "The Evaluation Study of the PANYNJ Time of Day Pricing Initiative"
  - "Potential for Off-Hour Deliveries on New York City"
- <u>These are the first projects on the subject that have collected behavioral data</u>

Empirical evidence: PANYNJ experience

- 20.2% of the sample changed behavior (implementing productivity increases, changes in facility use, and cost transfers)
- 69.8% of the carriers that did not change behavior indicated it was due to "customer requirements"
- Only 9.0% of the sample increased rates
  → cost transfers were relatively small, about 15%
  - Reflecting a competitive market, marginal cost pricing (carriers that passed costs have oligopoly power)
  - Cordon tolls are a fixed cost
  - Implication: Use toll schemes like GPS based systems that depend on the unit of output

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Breakdown of carriers that passed toll costs

Commodity type transported	% of carriers that passed costs	% of overall sample	Representation ratio	Average increase in rates (%)
Stone/concrete	28.69%	3.29%	8.725	15%
Wood / lumber	6.56%	1.82%	3.598	20%
Food	38.52%	15.35%	2.510	5%
Electronics	9.02%	4.10%	2.201	n.a.
Beverages	4.10%	3.03%	1.355	n.a.
Plastics / rubber	1.64%	2.25%	0.727	20%
Household goods/various	4.92%	19.00%	0.259	10%
Machinery	2.46%	11.14%	0.221	7%
Metal	0.82%	4.11%	0.200	10%
Paper	0.82%	4.87%	0.168	5%
Textiles / clothing	2.46%	17.00%	0.145	7%
Other, specify	0.00%	5.22%	0.000	n.a.
Furniture	0.00%	3.59%	0.000	n.a.
Chemicals	0.00%	2.78%	0.000	n.a.
Agriculture, Forestry, Fishing	0.00%	1.39%	0.000	n.a.
Alcohol	0.00%	0.67%	0.000	n.a.
Tobacco	0.00%	0.26%	0.000	n.a.
Petroleum / coal	0.00%	0.13%	0.000	n.a.

All these industry segments have market power

Part II: Need for comprehensive policies

These research projects concluded that:

- Carriers have limited ability to:
  - Pass tolls to receivers because in competitive markets rates equal marginal costs, and cordon tolls are fixed costs (that vanish from marginal costs)
  - Unilaterally change delivery times
- Delivery times jointly set by carriers and receivers
  - Part of the “Battle of the Sexes” game
  - Receivers playing the dominant role
- For these reasons, comprehensive policies targeting both receivers and carriers are needed

Why?

- Because it is the only way to move the equilibrium solution from quadrant I to quadrant IV

		Receiver	
	Strategy	Regular hours	Off-hours
Carrier	Regular hours	(-,+) (I)	(-,-) (II)
	Off-hours	(-,-) (III)	(+,-) (IV)

(This is the original solution)

(If proper incentives are provided to receivers, this will be the solution)

Part III: Necessary conditions

For off-hour deliveries to be feasible:

- Carrier and receivers must be better of because of policies targeting carriers (π_C) and receivers (π_R)
- Mathematically: Marginal Revenues > Costs

$$\Delta G_j(\pi_C) \geq \Delta C_j(\pi_C)$$ **Carrier is better off**

$$\Delta G_i(\pi_R) \geq \Delta C_i(\pi_R) \quad \forall i \in \Omega^O_j$$ **Receiver s are better off**

$$\tau^O_i \geq \tau^O_{\min} \quad \forall i \in \Omega^O_j$$ **Technical condition to ensure minimum duration**

NOTE: Cost savings are negative, cost increases are positive

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Implications

- In terms of truck-trips generated:
  - Only if **ALL** receivers switch to the off-hours, the number of trips before/after would be the same
  - In all other cases, there may be an additional trip
- In terms of toll impacts:
  - Single tour carriers (33%): An extra trip is likely needed → toll surcharge plays no role
  - Multi tour case: Total trips could be equal to original one, or increase by one → the impact of the toll is reduced
- In most cases, carriers pay double tolls (reducing profits) though it does not provide incentive for them to move to off-hours

Part IV: Behavioral Micro-Simulation Results

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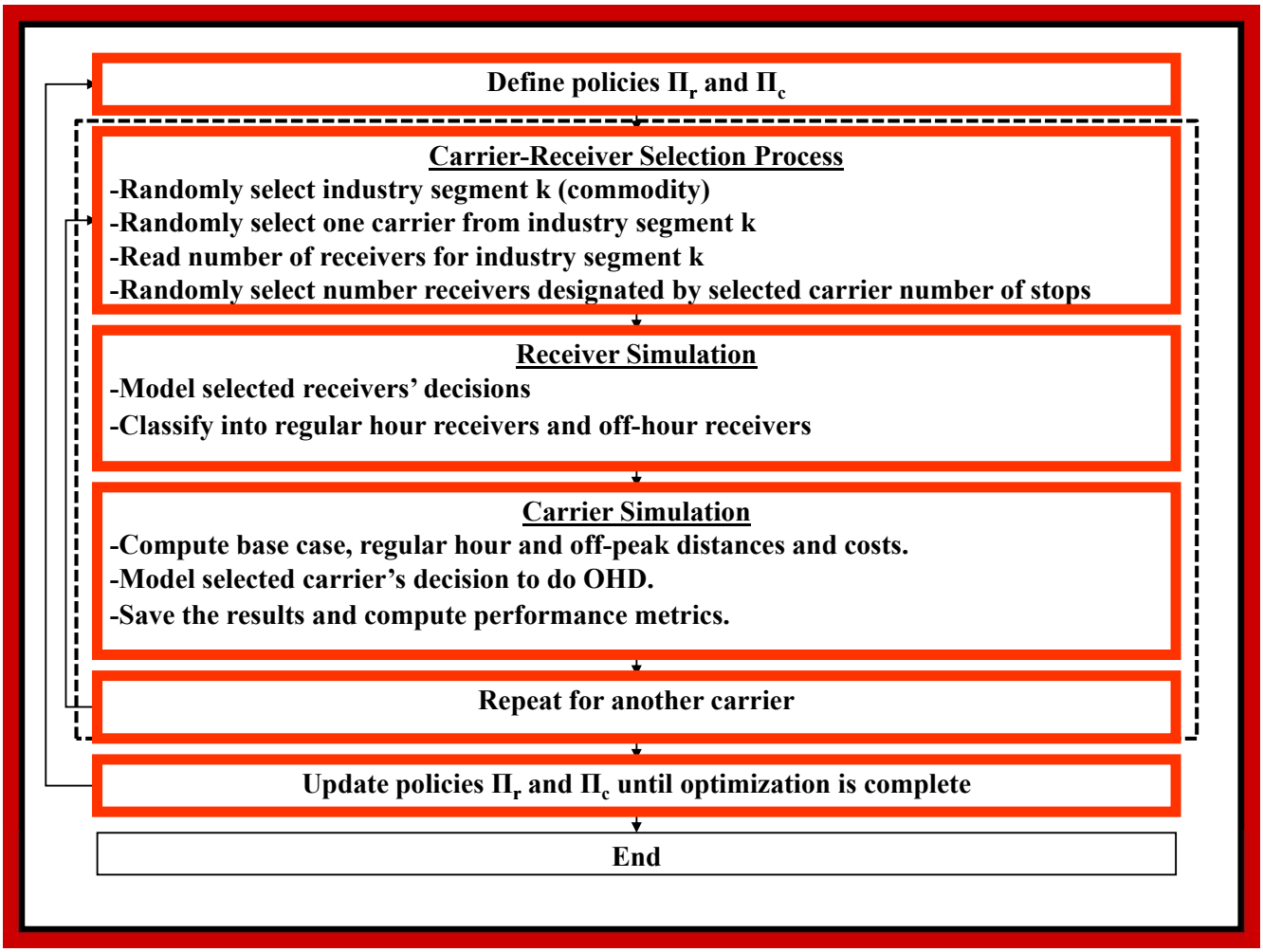


Receiver Simulation: Tax deduction logit models

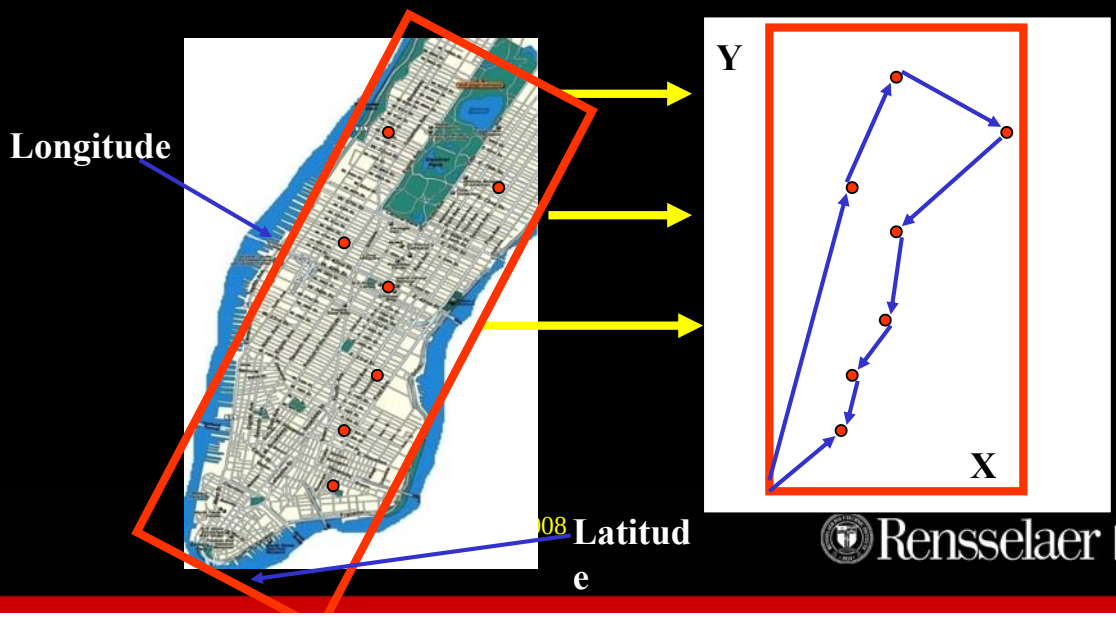
All receivers are moderately sensitive to tax deductions

Variable	Name	Coefficient	t-value
Utility of off-peak deliveries:	C1CHOICE		
A tax deduction for an employee assigned to OPD	TDEDUCT	8.392E-05	1.410
Reasons for not receiving OPD			
No access to building/freight entrance after hours	REASON1	-1.234	-1.571
Additional costs to the business if accepting more OPD	COST	-0.888	-3.232
Interferes with normal business	REASON2	-0.591	-1.208
Policy interaction terms			
Tax deduction for receivers of Wood/lumber	TDCOM8	6.968E-04	2.219
Tax deduction for receivers of Alcohol	TDCOM4	4.356E-04	2.209
Tax deduction for receivers of Paper	TDCOM9	2.627E-04	2.988
Tax deduction for receivers of Medical supplies	TDCOM22	2.598E-04	3.188
Tax deduction for receivers of Food	TDCOM2	1.875E-04	3.973
Tax deduction for receivers of Printed Material	TDCOM21	1.652E-04	1.802
Tax deduction for receivers of Metal	TDCOM13	1.415E-04	1.410
Other interaction terms			
Number of employees in a branch facility	BRANEMP	9.867E-03	1.612
Utility of no off-peak deliveries:			
Alternative specific constant	CONSTANT	1.599	4.151
R^2	0.172		
Adjusted R^2	0.140		

These industry segments are more sensitive than the rest

Behavioral Micro-Simulation: Carrier Simulation

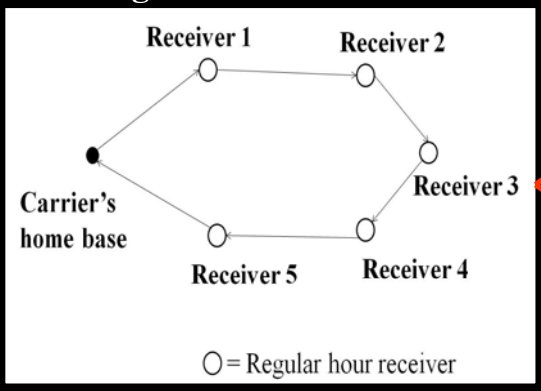
- Based on the cost impacts to the carrier
  - Requires solving a set of vehicle routing problems for two problems: Base case, and Mixed operation



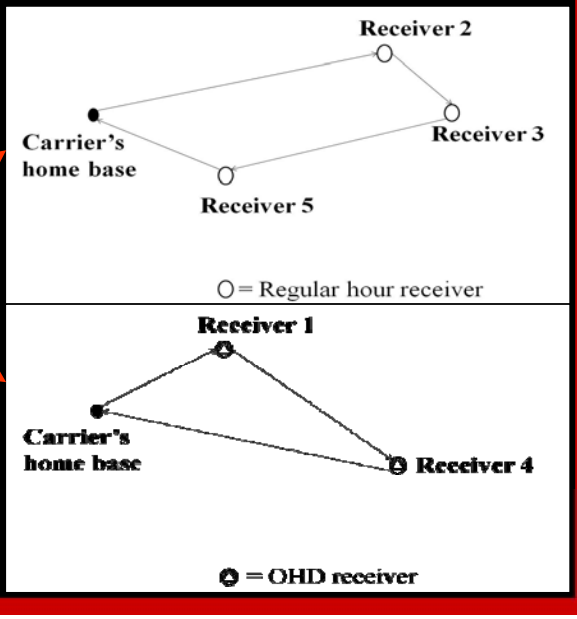
Behavioral Micro-Simulation: Carrier Simulation

- Calculate delivery costs for the carrier depending on the decisions of receivers

Base Case: All Receivers Accept Regular-Hour Deliveries



Mixed Case: Regular-Hour and Off-Hour Receivers



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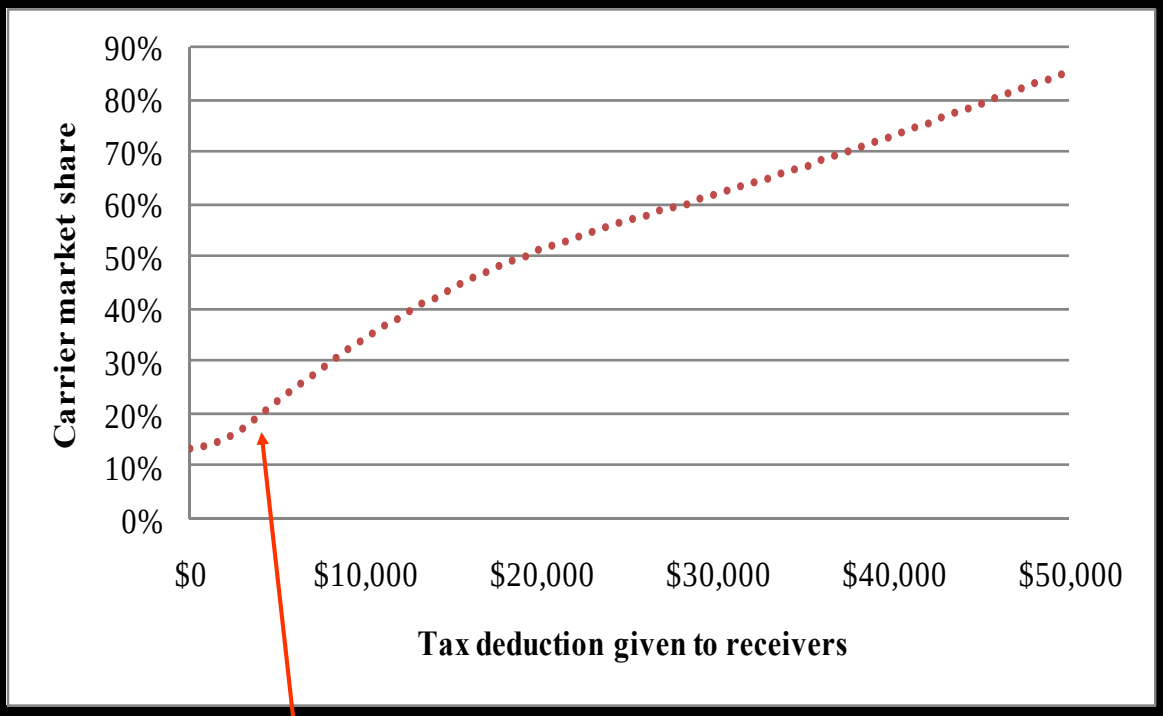
Impacts of Tax Deductions to receivers



Less than a $10,000 tax deduction yields nearly 20% participation in OHD

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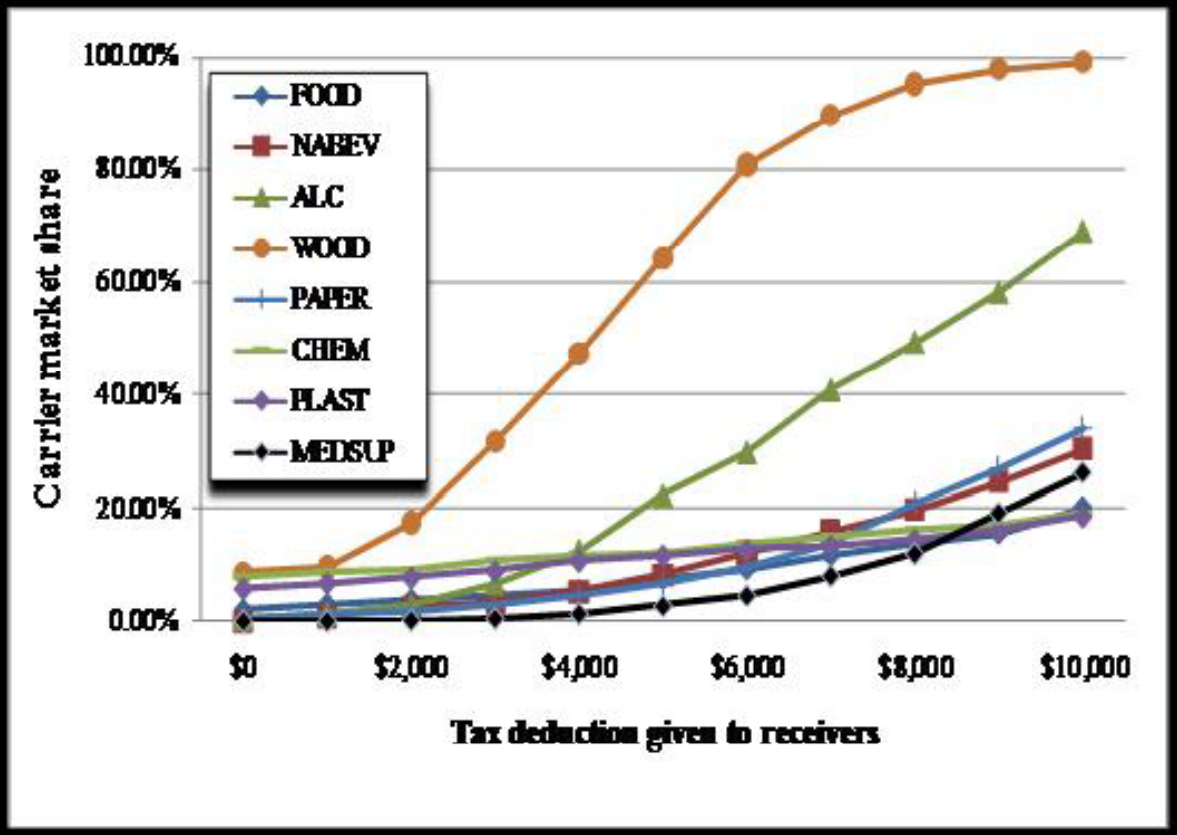
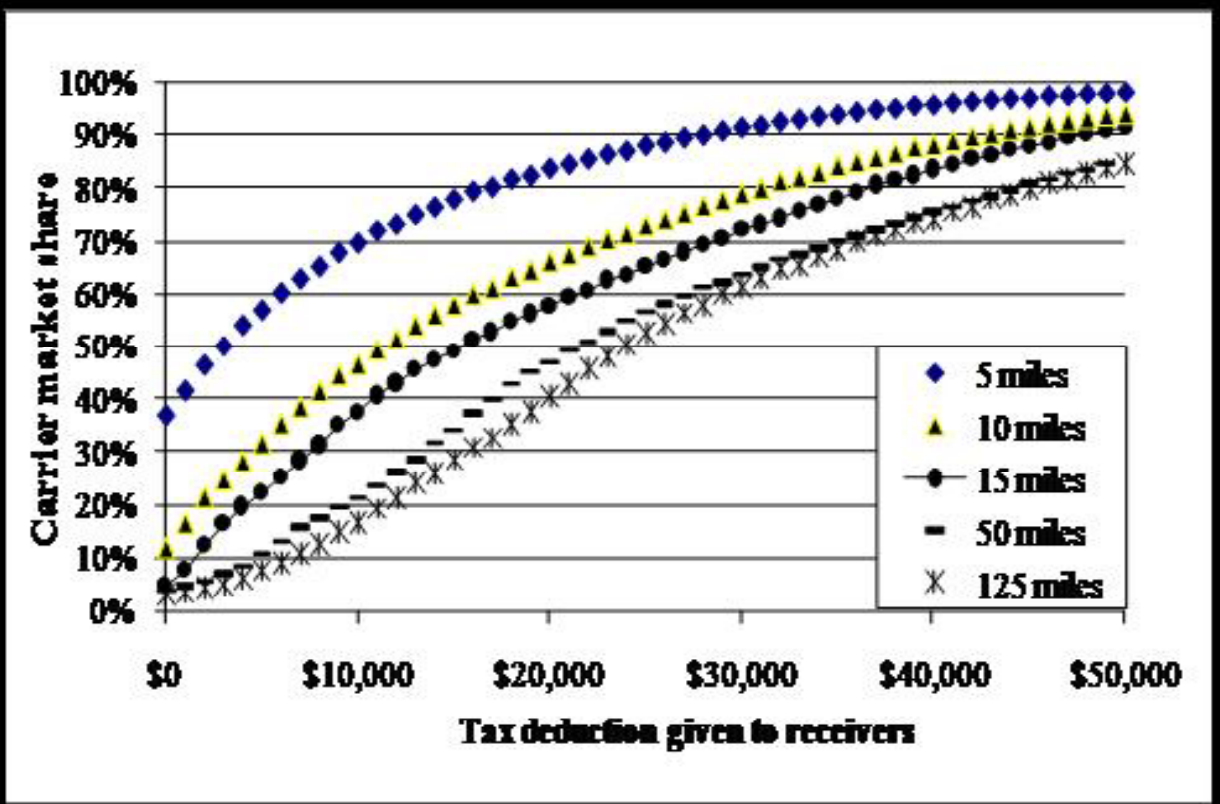
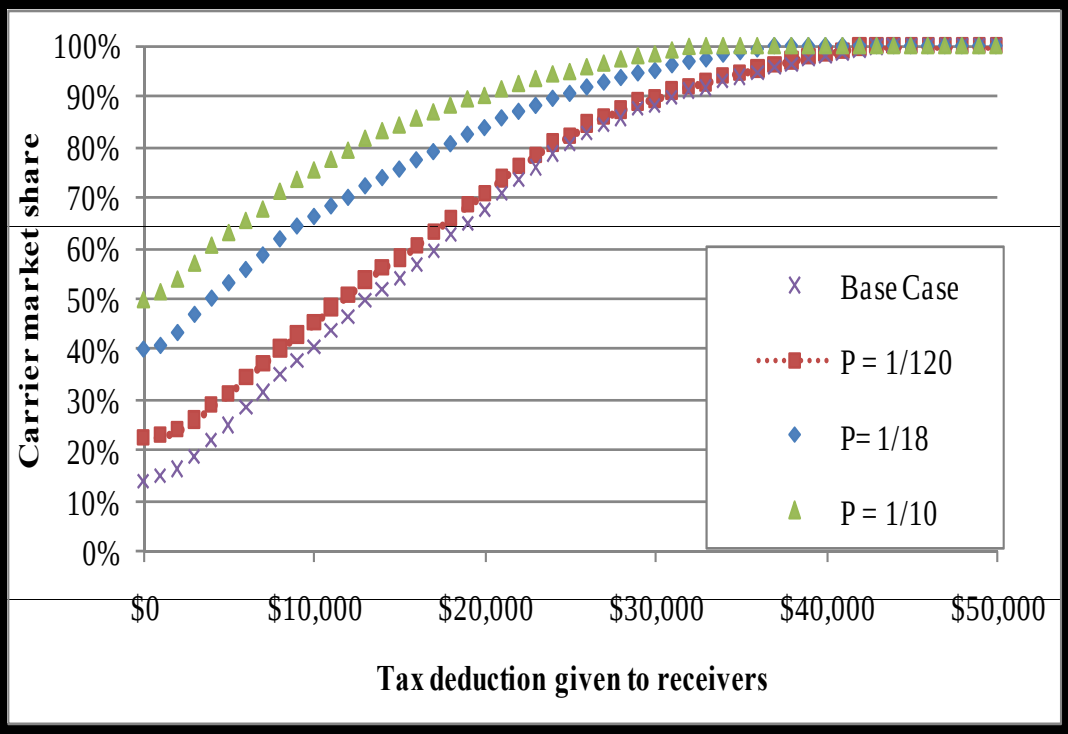
Impacts by Industry Segment: Most Sensitive



Impacts of distance to the first delivery stop



Impacts of parking fines



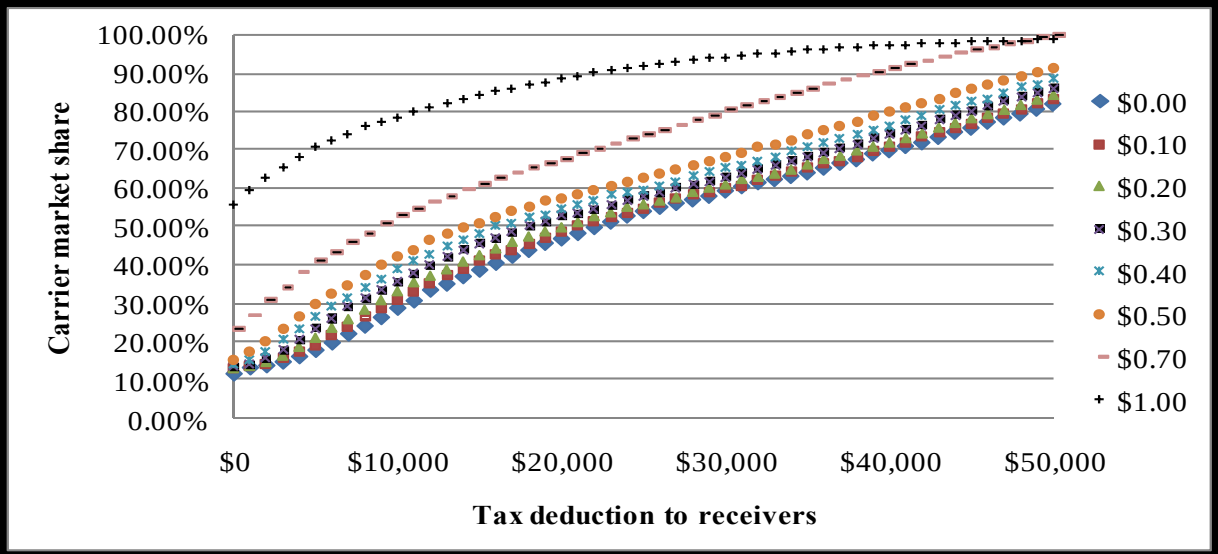
Impacts of Tax Deductions and Toll Surcharges

	Toll Surcharge Per Axle					
Tax Deduction	$0	$1	$2	$3	$4	$5
$0	11.71%	11.62%	11.65%	11.71%	11.70%	11.71%
$5,000	15.30%	15.28%	15.24%	15.29%	15.30%	15.32%
$10,000	25.05%	24.96%	25.07%	24.75%	25.05%	25.07%
$15,000	34.80%	35.22%	34.75%	34.99%	34.88%	34.78%
$20,000	43.43%	43.81%	43.36%	43.88%	43.55%	43.51%
$25,000	51.53%	51.11%	51.30%	51.47%	51.16%	51.56%
$30,000	57.38%	57.18%	57.36%	57.07%	57.36%	57.47%
$35,000	62.30%	63.00%	62.51%	62.57%	62.62%	62.21%
$40,000	68.04%	68.15%	67.91%	68.19%	67.91%	68.06%
$45,000	73.88%	73.66%	74.04%	74.04%	74.02%	73.88%
$50,000	80.16%	80.22%	80.19%	79.96%	80.45%	80.24%

What do we do?

- Cordon tolls will not achieve the objectives:
  - They are fixed costs that do not enter into marginal costs
  - Additional trips due to a split decision (the most likely) among receivers lead to **tolls not playing any role**...
- What about financial rewards/penalties for travel during off-hours/regular hours?
  - They are variable costs that could be passed on to the customers → will impact (though minimally) receivers
  - Will have a gradual impact on carrier behavior that will foster sustainable behavior
    - Financial penalties/rewards will provide a proper stimulus to the carriers regardless of the service network structure

Tax Deductions and Financial Rewards



Conclusions

- In competitive urban markets, most carriers cannot pass cordon toll costs to receivers
- Even when toll costs are passed on to receivers, they are of no consequence compared to the costs of extending operations to off-hours
- Since delivery times are jointly set, policies must target both receivers and carriers
- Financial incentives to receivers are the only way to change the equilibrium solution
- FRP could be used for revenue generation purposes

Conclusions

- A $10,000 tax incentive given to receivers can lead to a 20% shift to off-hour deliveries by carriers
- Food, Non-Alcoholic Beverages, Alcoholic Beverages, Wood/Lumber, Paper, Chemicals, Plastic, and Medical Supplies might be good targets for implementation of OHD policies
- Carriers located in close proximity to their urban customers might be good targets for OHD

Conclusions

- Regular Hour Parking Fine Enforcement could encourage OHD
- Regular Hour Toll Surcharges have no real influence on OHD
  - Financing purposes
- Financial rewards (or penalties) for OHD have more impact than toll surcharges

Thanks!

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