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# Impacts on Pricing on the Behavior of Freight Traffic: Review and Implications

**José Holguín-Veras, Ph.D., P.E.**

Professor

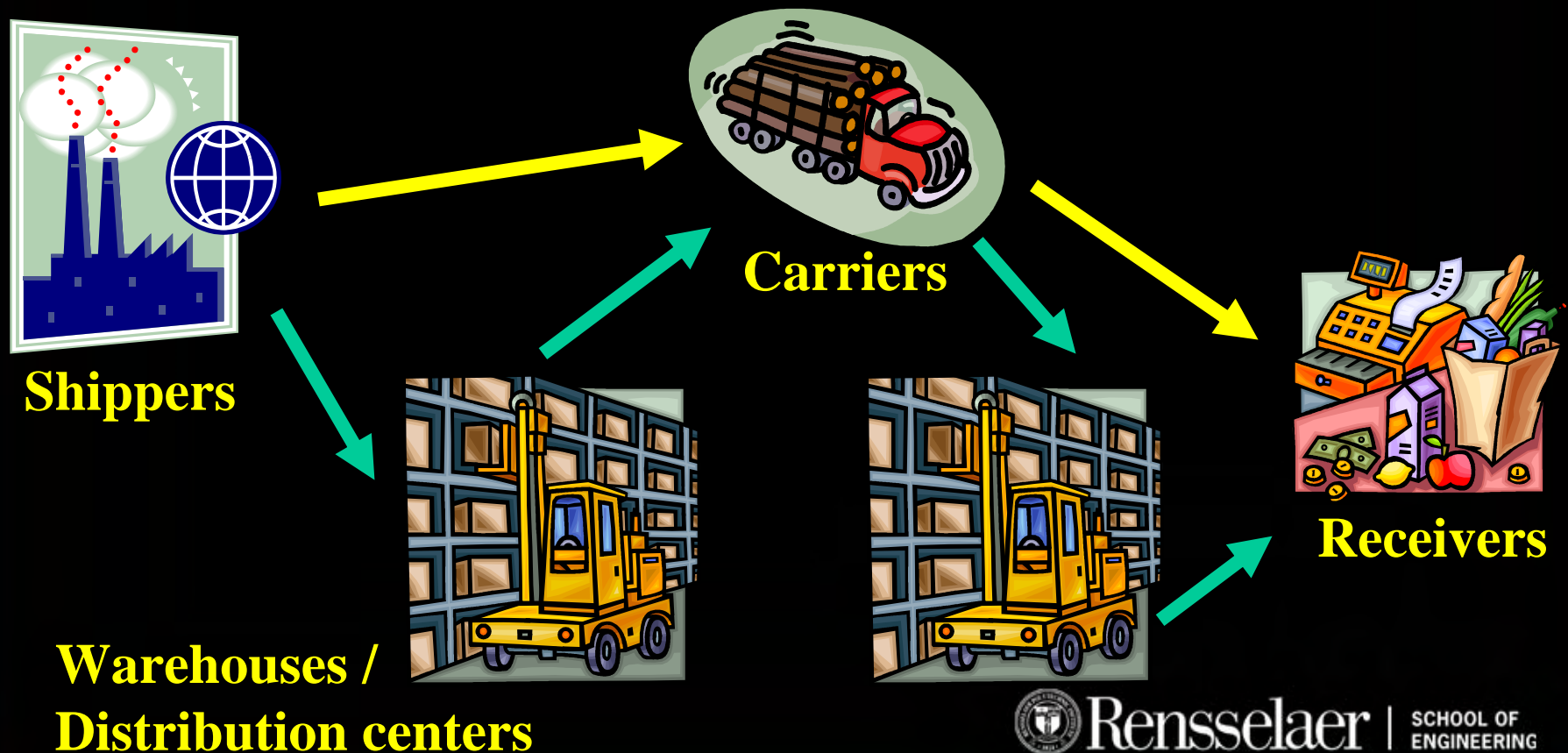
Phone: 518-276-6221

Email: [jhv@rpi.edu](mailto:jhv@rpi.edu)



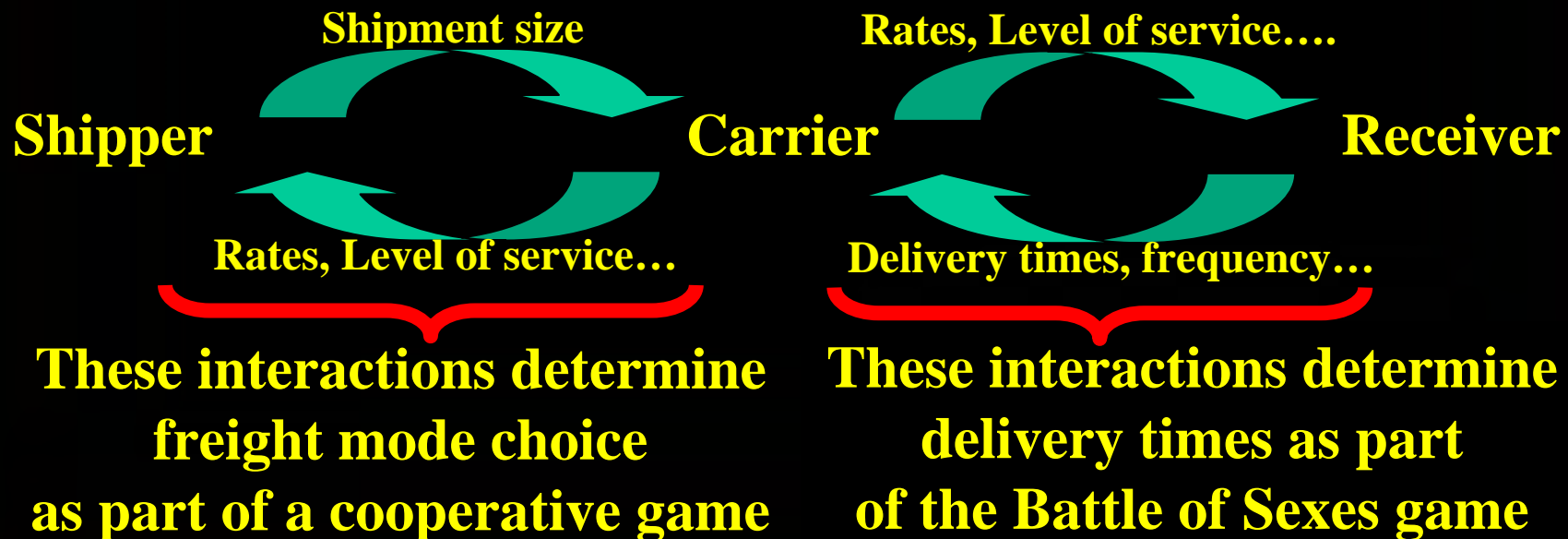
# Supply chain 101

- ❖ Interactions among players determine truck traffic patterns (Shippers, warehouses, distribution centers, carriers and receivers, 3PLs, 4PLs)



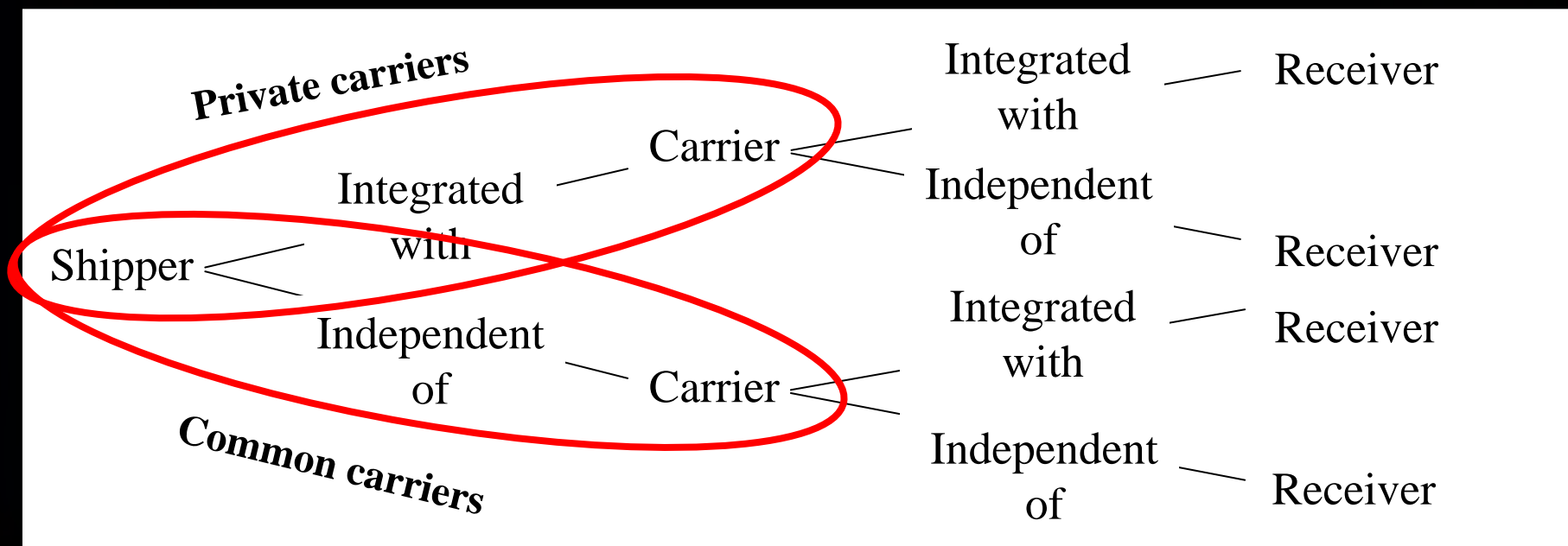
# In a simplistic view: Three key players

- ❖ The shipper, the one who ships
- ❖ The carrier: the conduit between shipper/receiver
- ❖ The receiver, the one who consumes/receives
- ❖ The nature of their interactions determine their response to pricing, freight mode choice, etc. etc.



# The role of industry structure

- ❖ It determines the nature of the interactions between the participating economic agents
- ❖ Integrated: Agents are part of the same company
- ❖ Independent: Different companies

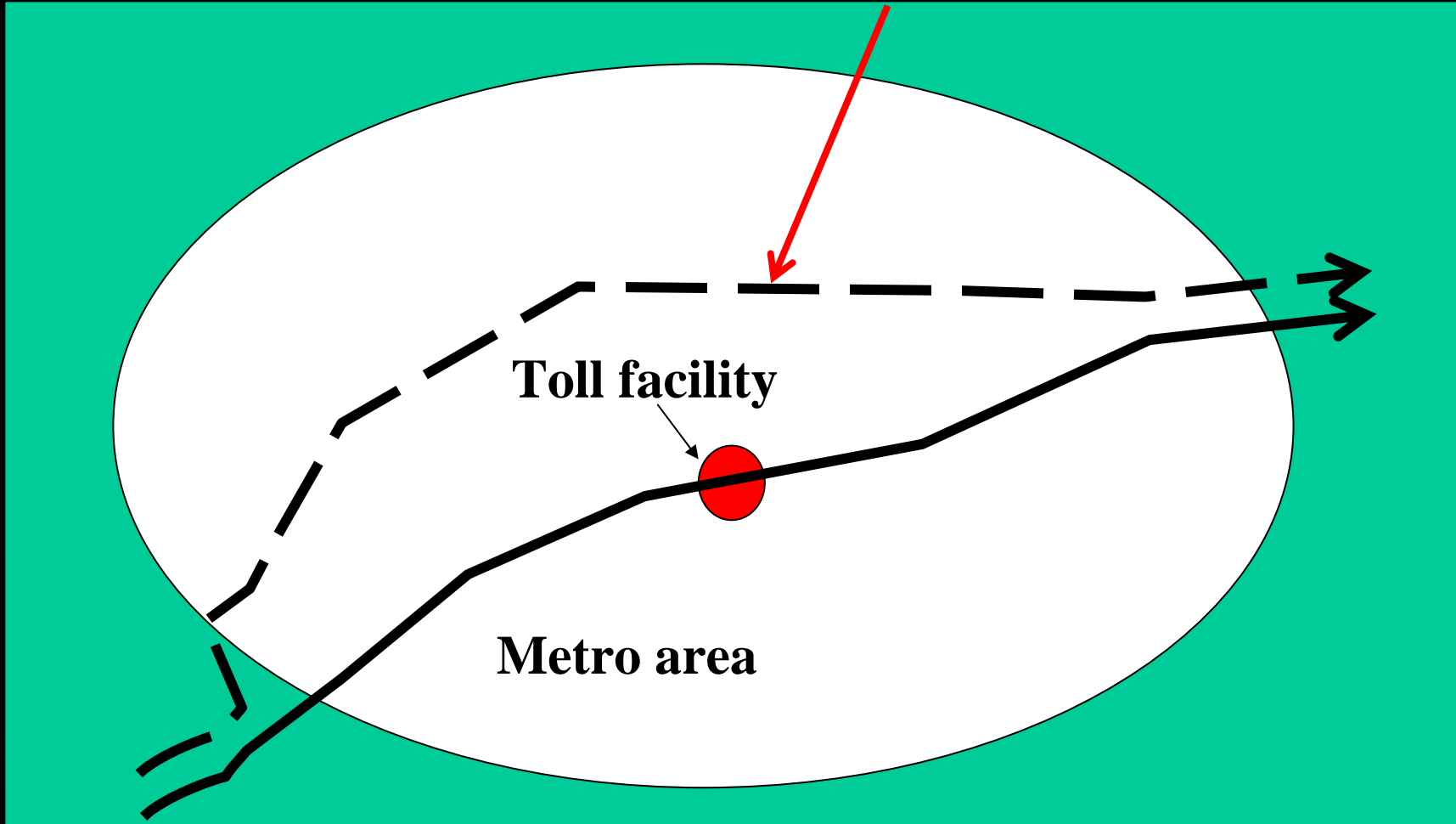


## In a typical urban area

- ❖ Intra-regional trips represent the vast majority of truck trips (70-80%)
- ❖ Inter-regional trips (with origin or destination in metro area) represent 20-25% of truck trips
- ❖ Thru trips (traversing metro area en route to other destinations): 1-3%
  
- ❖ Not all truck trips are transporting cargoes, maybe as much as 20% are service related trips
- ❖ Another 20-30% are empty trips

Thru trips (1-3%)

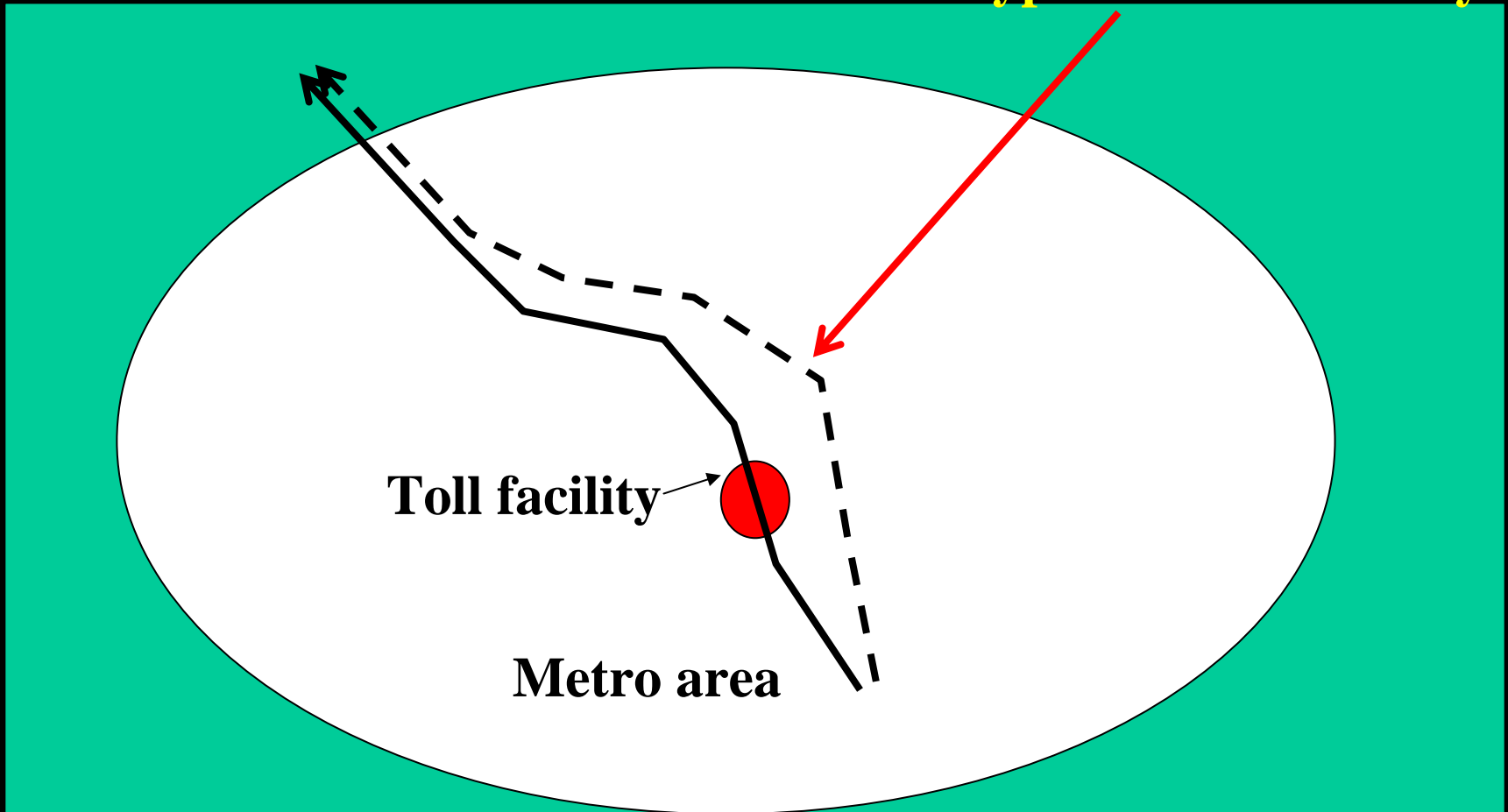
They could bypass the toll facility as long as they meet delivery constraints



Key feature: No stops in urban area

# Inter-regional trips (20-25%)

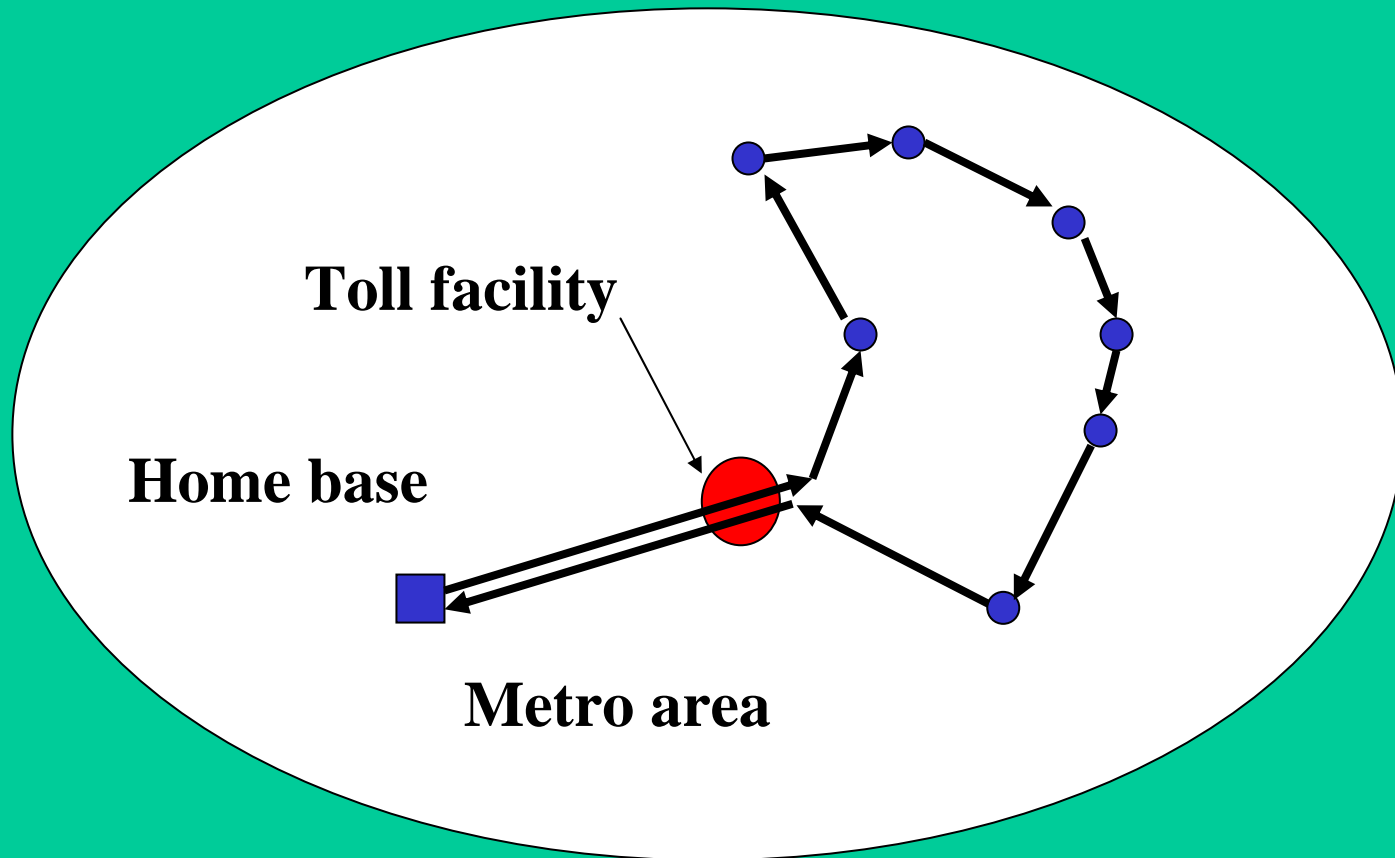
**They may have some ability to bypass the toll facility**



**Key feature: Very few stops in urban area**

# Intra-regional trips (70-80%)

Typically not possible to bypass the toll facility



Key feature: A lot of stops in urban area

## We all know....

- ❖ If prices go up, demand for transportation services go 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 that

## Analyses supported by:

- ❖ Two in depth surveys (400 receivers, 400 carriers)
- ❖ Data about post pricing behavior (200 carriers)
- ❖ 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 Peak Deliveries on New York City"
- ❖ The first projects, in the world, on these subjects
- ❖ Reported in ten peer reviewed journals

# Myth #1: All carriers are created equal

- ❖ Private carriers, i.e., those that provide transportation service to a parent company, operate in a “less” constrained environment
- ❖ For-hire carriers, i.e., those that sell transportation service to the open market, are far more constrained to switch to off peak hours

Carriers	Late Arrival Flexibility	Early Arrival Flexibility
Private Carriers	79.0	55.1
For-Hire Carriers	26.1	23.7
All Current Regular Users	48.8	37.3



# Carriers that changed behavior vs. that did not<sup>12</sup>

<b>Characteristic:</b>	<b>Carriers that changed behavior</b>	<b>Carriers that did not change behavior</b>	<b>Statistically different at 5% level?</b>
% of FTL operators	73.6%	25.3%	Yes
Interstate drivers (mean)	34.2 drivers	39.3 drivers	Yes
% of carriers transporting shipments from areas other than New Jersey and New York	28.0%	9.9%	Yes
% of carriers transporting shipments to areas other than the Mid-Atlantic region	30.4%	16.2%	Yes
Fleet size (mean)	51.6 trucks	54.5 trucks	No
Interstate drivers/truck (mean)	0.7 drivers/truck	0.7 drivers/truck	No



# Myth #2: "All commodities are created equal" <sup>13</sup>

Variable	Name	Coefficient	T-value
<b>Utility of off-peak deliveries:</b>	C4CHOICE		
Percentage (25%, 50%, or 75%) of customers requesting OPD	PCUST	0.019	3.090
<b>Number of employees</b>	DBSEM	0.006	1.626
<b>Primary line of business</b>			
Shipper	SHIPPER	1.537	4.109
Third Party Logistic Provider	THIRDPL	3.424	4.380
Trucking companies	TRUCKING	1.717	4.809
Warehouse	WAREHOUS	0.879	2.144
Mover	MOVER	1.591	2.620
<b>Number of truck drivers</b>	TRUCKD	0.027	2.716
<b>Total trips to Manhattan</b>	TTRIPS	0.070	1.519
<b>Reasons for not making OPD</b>			
Overtime costs	REASON1	-0.786	-1.281
Union regulations	REASON2	-0.866	-1.838
No access to buildings at that time	REASON5	-1.115	-2.250
<b>Parking infractions in Manhattan per driver per month</b>			
Nothing, \$0	FINE0	-1.178	-2.768
From \$1 - \$100	FINE100	-0.637	-1.948
From \$401 - \$700	FINE700	-0.379	-1.087
<b>Interaction terms</b>			
Toll savings for Petroleum/coal	TOLCOM10	0.418	1.526
Toll savings for Wood/lumber	TOLCOM8	0.347	1.902
Toll savings for Food	TOLCOM2	0.211	2.737
Toll savings for Textiles/clothing	TOLCOM6	0.203	1.878
Total Trips for Furniture	TTCOM7	-0.064	-1.107
Total Trips for Food	TTCOM2	-0.118	-1.770
Total Trips for Machinery	TTCOM14	-0.144	-1.989
Total Trips for Households goods/various	TTCOM16	-0.191	-1.617
Total Trips for Alcohol	TTCOM4	-0.486	-3.188
<b>Utility of no off-peak deliveries:</b>			
Alternative specific constant	CONSTANT	2.334	4.726
<b>Adjusted R<sup>2</sup></b>	0.146		
<b>R<sup>2</sup></b>	0.198		

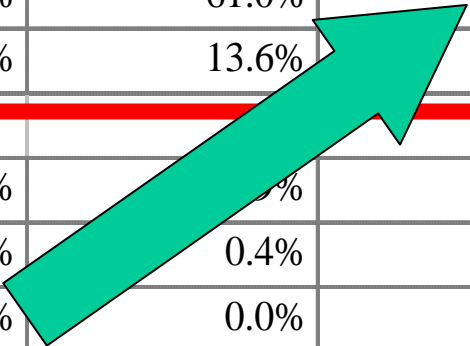
**Toll savings are only attractive to the segment of the trucking industry transporting low valued goods and non-perishables**

**This is because the commodity type is a proxy for the industry segment.**

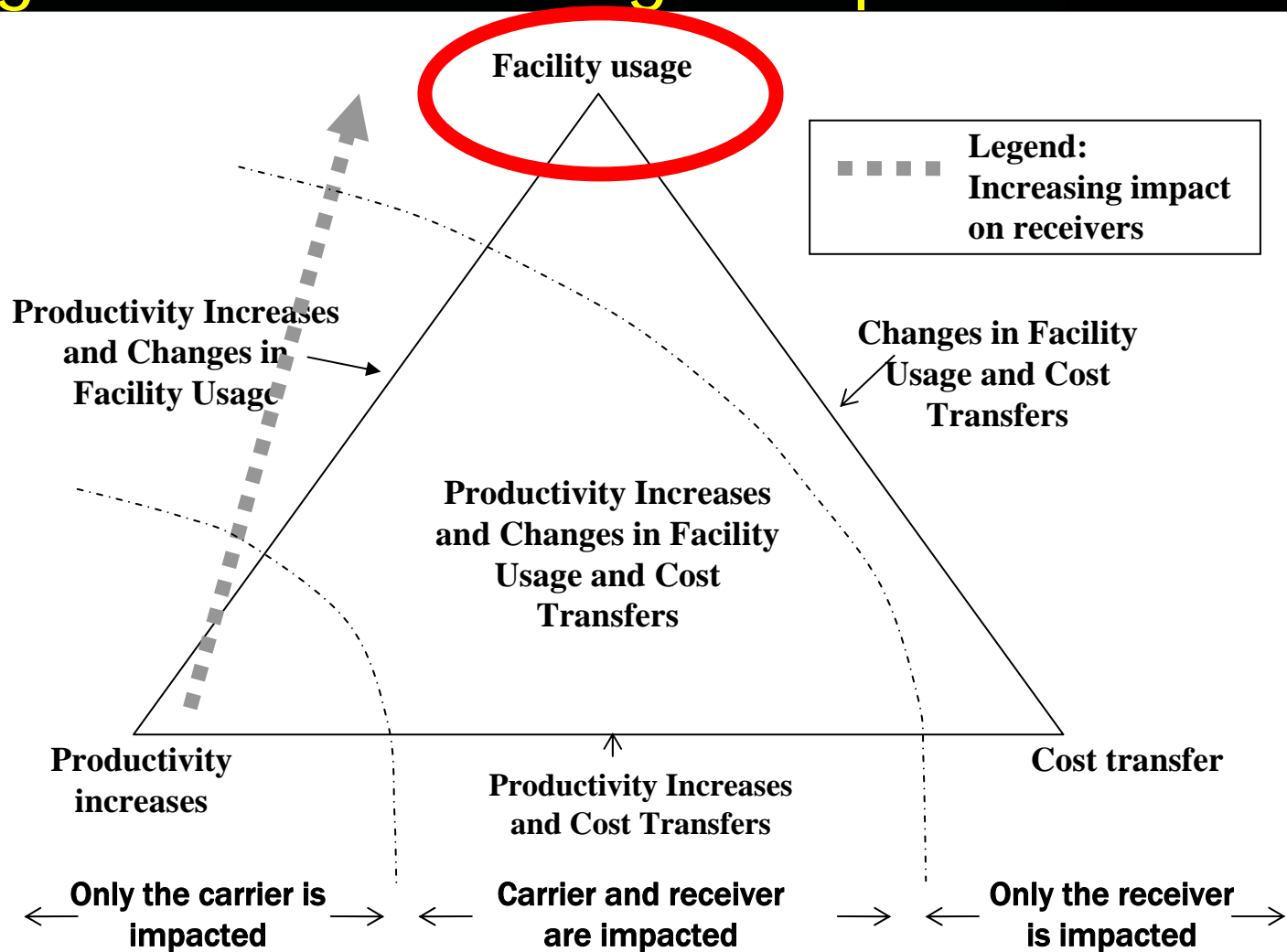
# Myth #3: "Truckers love to drive in congestion"<sup>14</sup>

## ❖ Reasons for not changing travel behavior

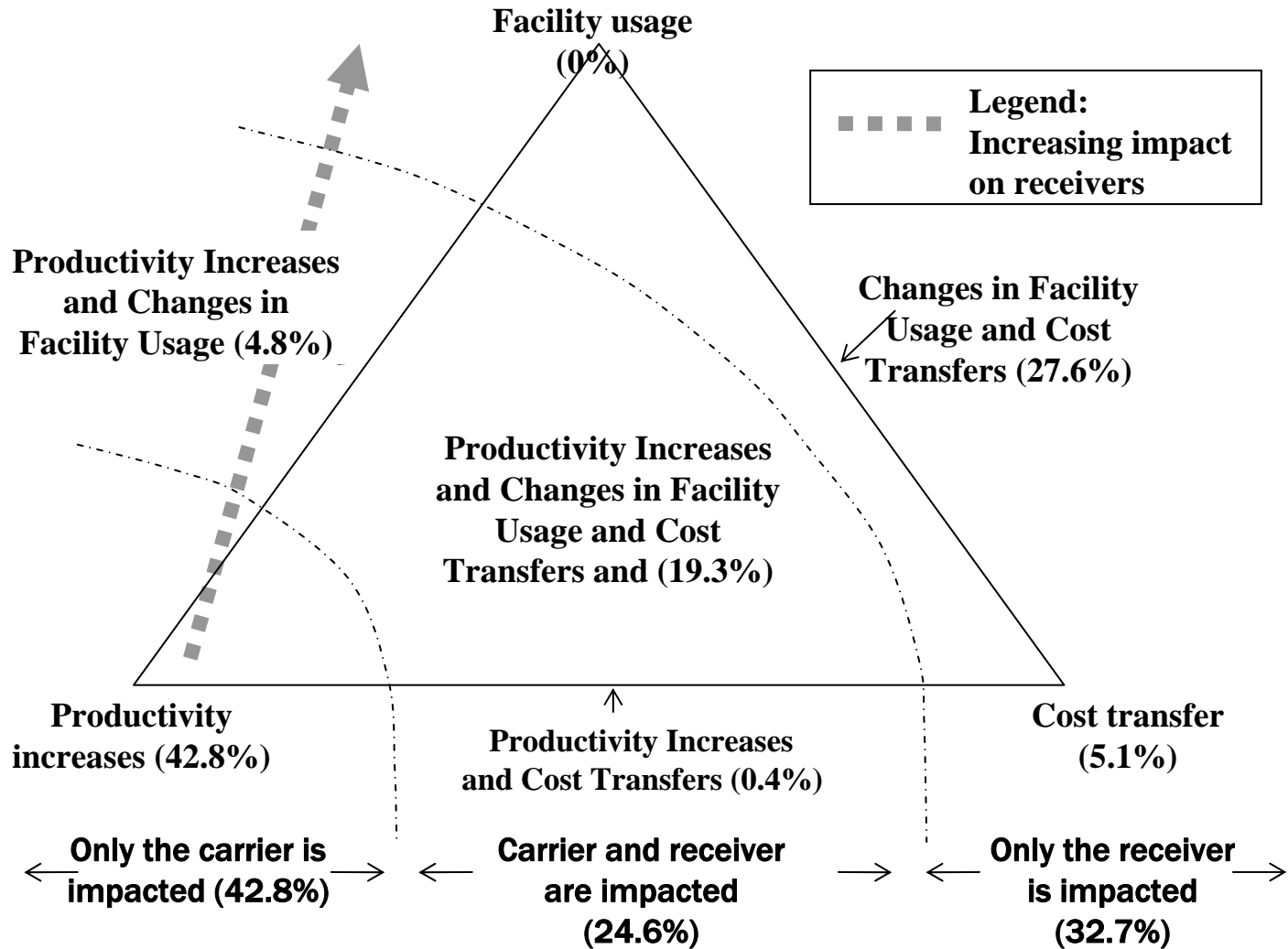
Reasons	For-hire carriers	Private carriers	Carriers that did not change
<b>No flexibility:</b>			
Cannot change schedule due to customer requirements	72.3%	61.0%	68.9%
Must use quickest route	3.3%	13.6%	6.4%
<b>Cost paid by others:</b>			
Customers absorb costs	19.1%	15.0%	18.2%
Cost paid by shippers	0.0%	0.4%	0.1%
Cost paid by receivers	2.1%	0.0%	1.5%
<b>Small price difference/can afford it</b>	0.2%	6.1%	2.0%
<b>No change in off-peak travel cost</b>	0.3%	0.4%	0.4%
Do not know/Refused	2.6%	2.5%	2.6%
<b>Total</b>	100.0%	100.0%	100.0%
<b>Total truck trips</b>	<b>573</b>	<b>245</b>	<b>817</b>




# Myth #4: Trucking companies cannot react to pricing: Behavioral Changes Reported



# Behavioral Changes Reported by Carriers (cont.)<sup>16</sup>



## Myth #5: Pricing trucks is THE solution

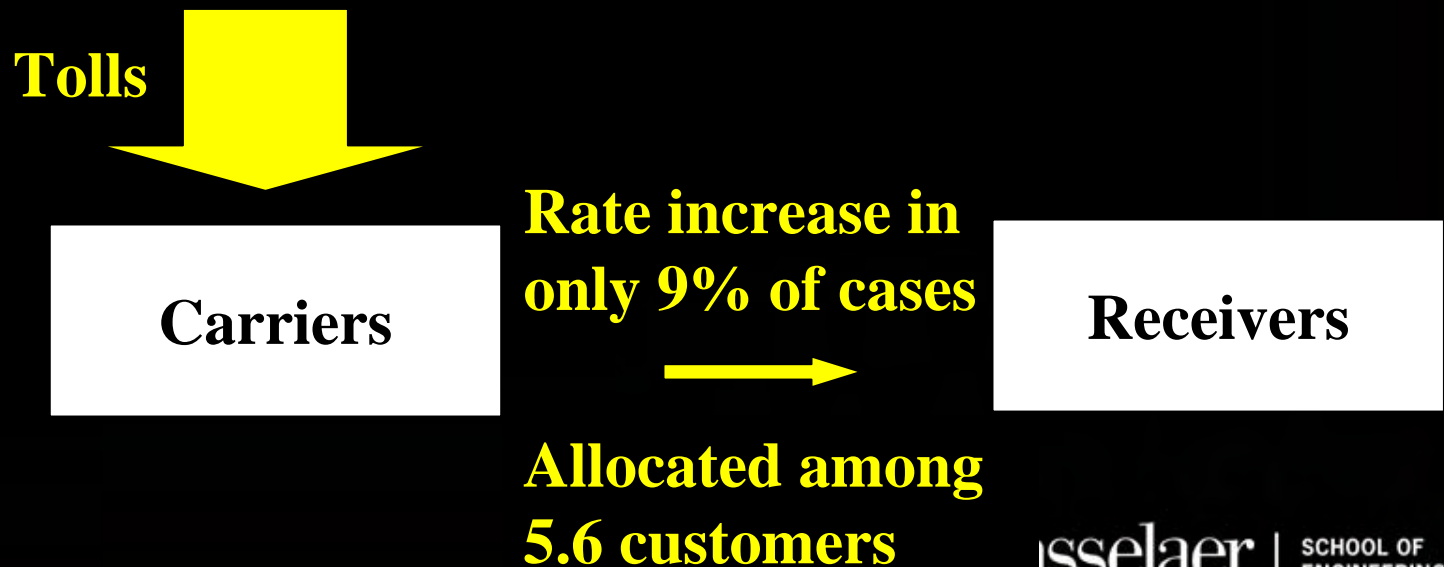
- ❖ Receivers are the key decision maker (they are the customers) when deciding delivery times
- ❖ 70% of the carriers that did not change behavior after the 2001 PANYNJ toll increase indicated “customer requirements” as the reason
- ❖ Market conditions:
  - ❖ Contractual constraints: Only 9% of carriers passed the toll increase to customers
  - ❖ The price signal is diluted because the carriers allocate it among multiple customers

# Graphically

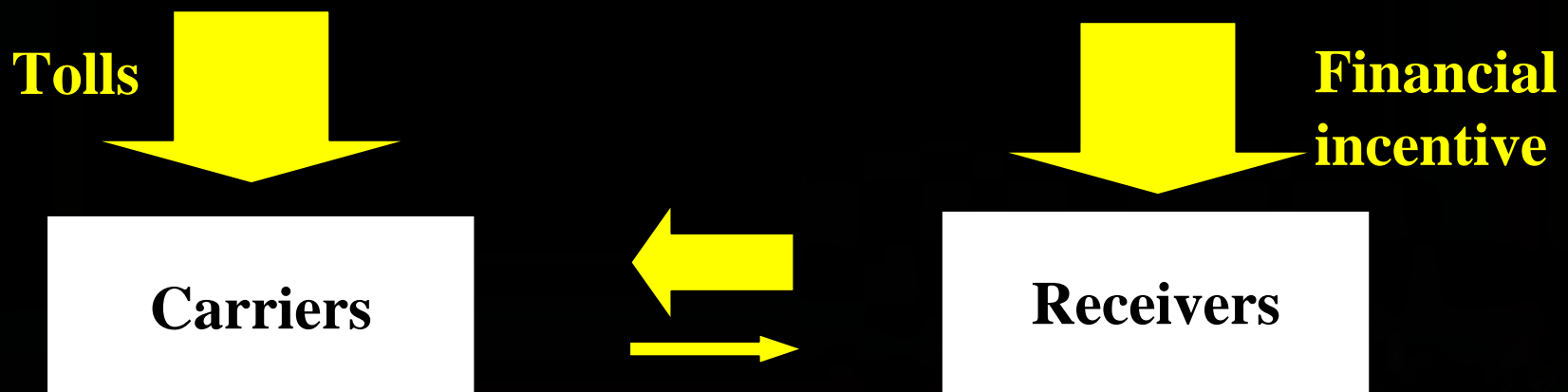
Ideal condition:  
strong price signal  
reaches receivers



The reality:  
carriers lack power



- ❖ Instead of this ineffective policy that fails to reach the intended target (the receivers)
- ❖ Provide tax incentives to receivers willing to accept deliveries during off-hours, possibly, combining it with time of day pricing
- ❖ Let the receivers (or a big chunk of them) pull the carriers to the off-hours



## A really dumb idea? ....

- ❖ The data show that this could generate a shift of 15-25% of truck traffic to the off-hours (several times the shift induced by the 2001 toll increases)
- ❖ Politically attractive/economically sound because:
  - ❖ It targets the key decision makers
  - ❖ It will improve economic competitiveness
  - ❖ It will reduce urban congestion
  - ❖ It will increase sustainability
  - ❖ The carriers will support it (28% cost savings if all operations are switched to off-hours)
- ❖ See NYSDOT "Potential for Off-Peak Deliveries" report

# Results from two stated preference surveys

## ❖ Targeting receivers

- ❖ Tax deductions
- ❖ Lower shipping rates

## ❖ Targeting carriers

- ❖ A request from a percentage of receivers
- ❖ A request from a percentage of receivers + providing parking during off peak hours
- ❖ A request from a percentage of receivers + security clearance at river crossings
- ❖ A request from a percentage of receivers + TOD Tolls
- ❖ A request from a percentage of receivers + Financial rewards
- ❖ A request from a percentage of receivers + OPD permit



# Receivers are sensitive to incentives

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

# Carriers are sensitive to receivers' wishes

Variable	Name	Coefficient	t-value
<b>Utility of off-peak deliveries:</b>	C4CHOICE		
Percentage of customers requesting OPD	PCUST	0.017	2.912
(Variables deleted)			
<b>Parking infractions in Manhattan per driver per month</b>			
Nothing	FINE0		
From \$1-\$100	FINE100		
<b>Policy interaction terms</b>			
Toll savings for Petroleum/coal	TOLCOM10	0.440	1.606
Toll savings for Wood/lumber	TOLCOM8	0.340	1.912
Toll savings for Food	TOLCOM2	0.209	2.733
Toll savings for Textiles/clothing	TOLCOM6	0.217	2.022
(Variables deleted)			
$R^2$	0.194		
Adjusted $R^2$	0.146		

**ALL truckers are sensitive to customers requesting OPD**

**ONLY some segments of the industry are sensitive to tolls**

# The Possible

- ❖ Myth: “There is no money to provide financial incentives to receivers”
- ❖ One possibility:
  - ❖ Use revenues from a toll surcharge (or general tax revenues) to provide financial incentives to receivers
    - ❖ To large traffic generators with central delivery/receiving stations
    - ❖ To industry segments prone to do Off Peak Deliveries under proper incentives

## Is this possible?

- ❖ A \$10,000 tax deduction to restaurants accepting off-peak deliveries would lead to 20% of the Manhattan restaurants switching from the regular to the off-peak hours
- ❖ This leads to a total truck traffic deduction in the day hours of 1.3 million trucks/year in the Manhattan network
- ❖ This idea will be tested as part of a USDOT pilot project in NYC

## In summary

- ❖ We need to rethink FRP in urban areas:
  - ❖ Carriers cannot change time of travel unilaterally
  - ❖ Carriers are constrained by contractual agreements
  - ❖ Carriers that could pass costs, pass a diluted price signal
  - ❖ Carriers that could react to tolls are either doing thru trips or transporting low value commodities
- ❖ Developing comprehensive policies targeting receivers and carriers seem the way to do it
  - ❖ If receivers decide to accept deliveries during the off peak hours, the carriers will (happily) follow suit

# Did I muddy the waters?

- ❖ Questions?

- ❖ Acknowledgments:

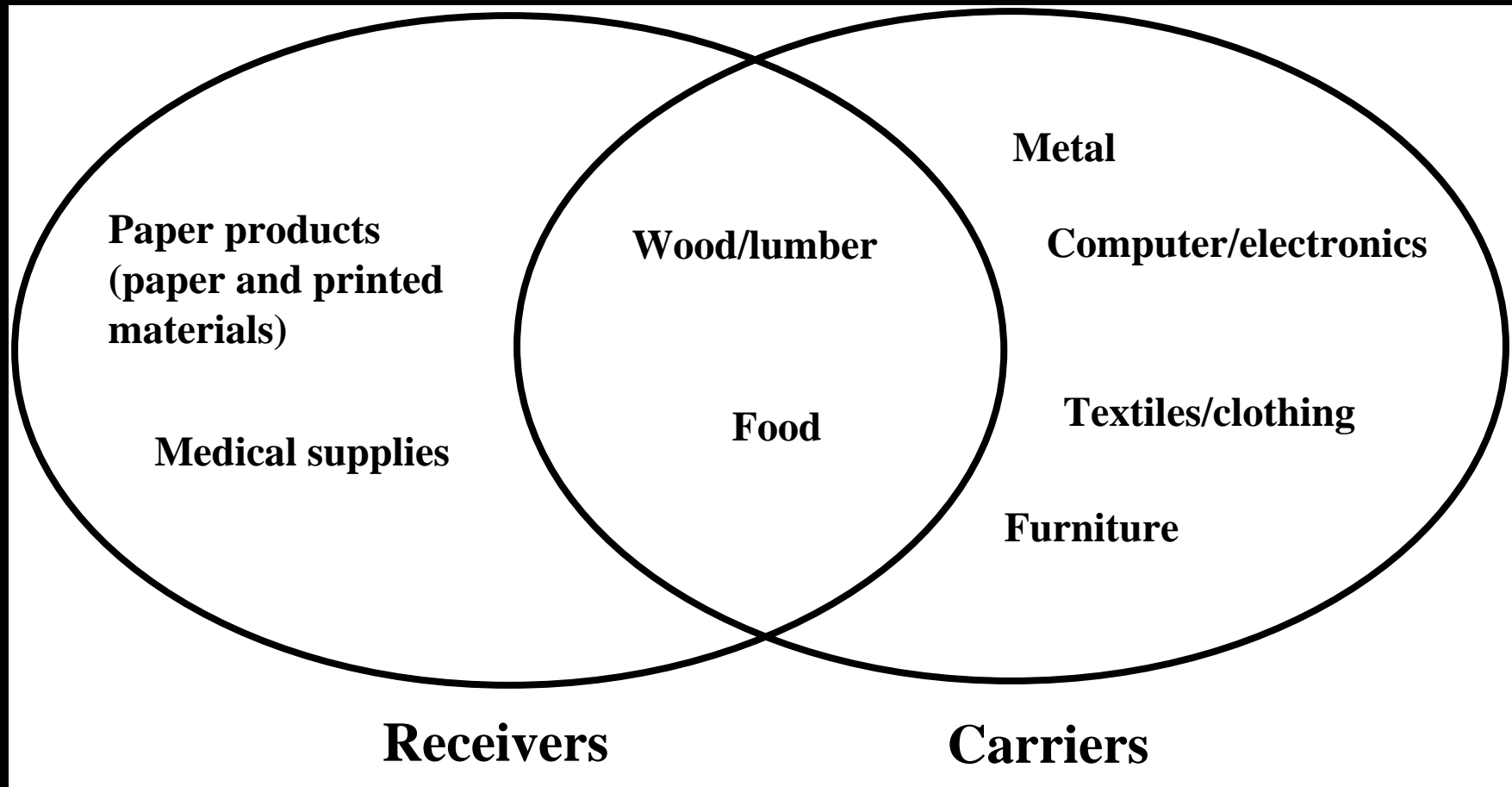
- ❖ Results from the Evaluation Study of the PANYNJ Time of Day Pricing Initiative and the NYSDOT Off Peak Delivery Study (in progress)

# References

- ❖ Holguín-Veras, J. (2006). The Truth, the Myths, and the Possible in Freight Road Pricing in Congested Urban Areas. National Urban Freight Conference, Long Beach.
- ❖ Holguín-Veras, J., K. Ozbay and A. D. Cerreño (2005). Evaluation Study of Port Authority of New York and New Jersey's Time of Day Pricing Initiative.
- ❖ Holguín-Veras, J. and G. Patil (2005). "Observed Trip Chain Behavior of Commercial Vehicles." Transportation Research Record **1906**: 74-80.
- ❖ Holguín-Veras, J., N. Pérez, B. Cruz and J. Polimeni (2006a). "On the Effectiveness of Financial Incentives to Off Peak Deliveries to Manhattan Restaurants." Transportation Research Record: Journal of the Transportation Research Board. (in press).
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- ❖ Holguín-Veras, J., Q. Wang, N. Xu, M. C. K. Ozbay and J. Polimeni (2006d). "The Impacts of Time of Day Pricing on the Behavior of Freight Carriers in a Congested Urban Area: Implications to Road Pricing." Transportation Research Part A: Policy and Practice **40**: 744-766.
- ❖ Holguín-Veras, J., K. Ozbay and A. De Cerreño (2005) "Evaluation Study of Port Authority of New York and New Jersey's Time of Day Pricing Initiative" Final Report submitted to the Federal Highway Administration and the New Jersey Department of Transportation (accessible at <http://www.rpi.edu/~holguj2/PA/PANYNJ%20Final%20Report.pdf>)



# Industry segments most sensitive



# Myth #5: Pricing trucks is THE solution

- ❖ Pricing is part of the solution, hardly THE solution
- ❖ REASON #1: In congested urban areas (where pricing is needed), trucks' ability to unilaterally switch time of travel is VERY limited

Reasons offered about why could not change time of travel	For-hire carriers	Private carriers	Carriers that did not change
<b>No flexibility:</b>			
Cannot change schedule due to customer requirements	72.3%	61.0%	68.9%
Must use quickest route	3.3%	13.6%	6.4%
<b>Cost paid by others:</b>			
Customers absorb costs	19.1%	15.9%	18.2%
Cost paid by shippers	0.0%	0.4%	0.1%
Cost paid by receivers	2.1%	0.0%	1.5%
<b>Small price difference/can afford it</b>	0.2%	6.1%	2.0%
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<b>Total</b>	100.0%	100.0%	100.0%
<b>Total truck trips</b>	<b>573</b>	<b>245</b>	<b>817</b>

- ❖ REASON #2: The nature of the Urban Freight Market
- ❖ In only 9% of the cases, toll increases passed to receivers
- ❖ Average increase in shipping charges → 15.5% (less than original toll increase) → DILUTED PRICE SIGNAL
- ❖ Since they serve 6-8 different customers in one tour, it is very likely that some truckers are MAKING MONEY
- ❖ The magnitudes of the increases are significantly different:
  - ❖ Private carriers → 11.0%
  - ❖ For-hire carriers → 18.5%

# The decision about delivery time

- ❖ Is made jointly between receivers and carriers
  - ❖ 40% by receivers, 38% between receivers and carriers and 22% by carriers

- ❖ Let's take a look at the payoff matrix

- ❖ The first sign represents the impact on carrier and the second the impact on receiver

**(These are non-feasible solutions) (This is the solution preferred by most receivers)**

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

**(This is the solution preferred by most carriers)**

# Comprehensive policies are needed

## ❖ Why?

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

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

**(This is the original solution)**

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

# Myth #1: All trucks are created equal

- ❖ There are trucks that are more efficient (from the economic point of view) than others
- ❖ Truck toll policy should acknowledge this fact
- ❖ Unfortunately, the data show that the most efficient trucks from the economic point of view are charged proportionally more than their fair share with respect to the less efficient trucks and passenger cars (see "A Comparative Analysis of U.S. Toll Policy" Holguin-Veras, Cetin and Xia, Transportation Research Part A, in press)



# Load Equivalency Factors by Vehicle Type

FHWA	Description	Load Equivalency Factor (LEF)	Average Payload (metric tons)	LEF / Payload
<b>Passenger</b>				
1	Motorcycle	0.00002		
2	Passenger Car	0.0005		
4	Bus	0.9		
3	2 Axle-4 tire SUV	0.01	2.57	0.0038842
5	2 Axle-6 tire SUV	0.3	2.57	0.1165254
<b>Commercial</b>				
5	2 Axle SU truck	1.4	3.23	0.4333755
6	3 Axle SU truck	1.9	11.38	0.1669329
7	4 Axle SU truck	5.4	15.64	0.3452685
8	4 Axle – 1 Trailer truck	2.8	18.04	0.1552106
9	5 Axle – 1 Trailer truck	2.4	19.92	0.1205012
10	6 Axle – 1 Trailer truck	5.5	22.88	0.2403703
11	5 Axle - Multi-Trailer truck	2.3	19.30	0.1191906
12	6 Axle - Multi-Trailer truck	5.5	19.53	0.2815721



# Road space by Vehicle Type

FHWA Vehicle Class	Description	Vehicle length (m)	Average Payload (metric tons)	Length / Payload
<b>Passenger related vehicles</b>				
1	Motorcycle	2.0		
2	Passenger Car	5.8		
4	Bus	12.1		
<b>Commercial vehicles</b>				
5	2 Axle SU truck	9.1	3.23	2.8169410
9	5 Axle – 1 Trailer truck	16.7	19.92	0.8384873
12	6 Axle - Multi-Trailer truck	19.9	19.53	1.0187792



# Mathematically speaking

$$\Delta G_j \geq \Delta C_j$$

The carrier has to be better off

$$\Delta G_i \geq \Delta C_i \quad \forall i \in \Omega_j^{OP}$$

Each receiver has to be better off

$$\tau_i^{OP} \geq \tau_{\min}^{OP} \quad \forall i \in \Omega_j^{OP}$$

Technical constraint about off-peak time

Assuming that the financial incentive could be split between receivers and carriers, it could be proven that the necessary conditions become:

The carrier has to be better off

$$\Delta C_j \leq \sum_{i \in \Omega_j^{OP}} F_{ij} \leq \sum_{i \in \Omega_j^{OP}} (F - \Delta C_i)$$

$$\tau_i^{OP} \geq \tau_{\min}^{OP} \quad \forall i \in \Omega_j^{OP}$$

The receivers have to be better off

# In the case of Freight Road Pricing:

$$0 \geq \Delta C_j$$

The carrier has to be better off

$$\Delta G_i \geq \Delta C_i \quad \forall i \in \Omega_j^{OP}$$

Each receiver has to be better off

$$\tau_i^{OP} \geq \tau_{\min}^{OP} \quad \forall i \in \Omega_j^{OP}$$

Technical constraint about time during OP

Assuming that the carrier could split the cost savings with receivers, it could be proven that the necessary conditions are:

The toll surcharges

$$K^{OP} S^R \geq \sum_{i \in \Omega_j^{OP}} \Delta C_i + \Delta C_{-S} - \Delta C_{jj}$$

Total cost to receivers + carrier savings excluding tolls minus cost savings to carrier

$$\tau_i^{OP} \geq \tau_{\min}^{OP} \quad \forall i \in \Omega_j^{OP}$$



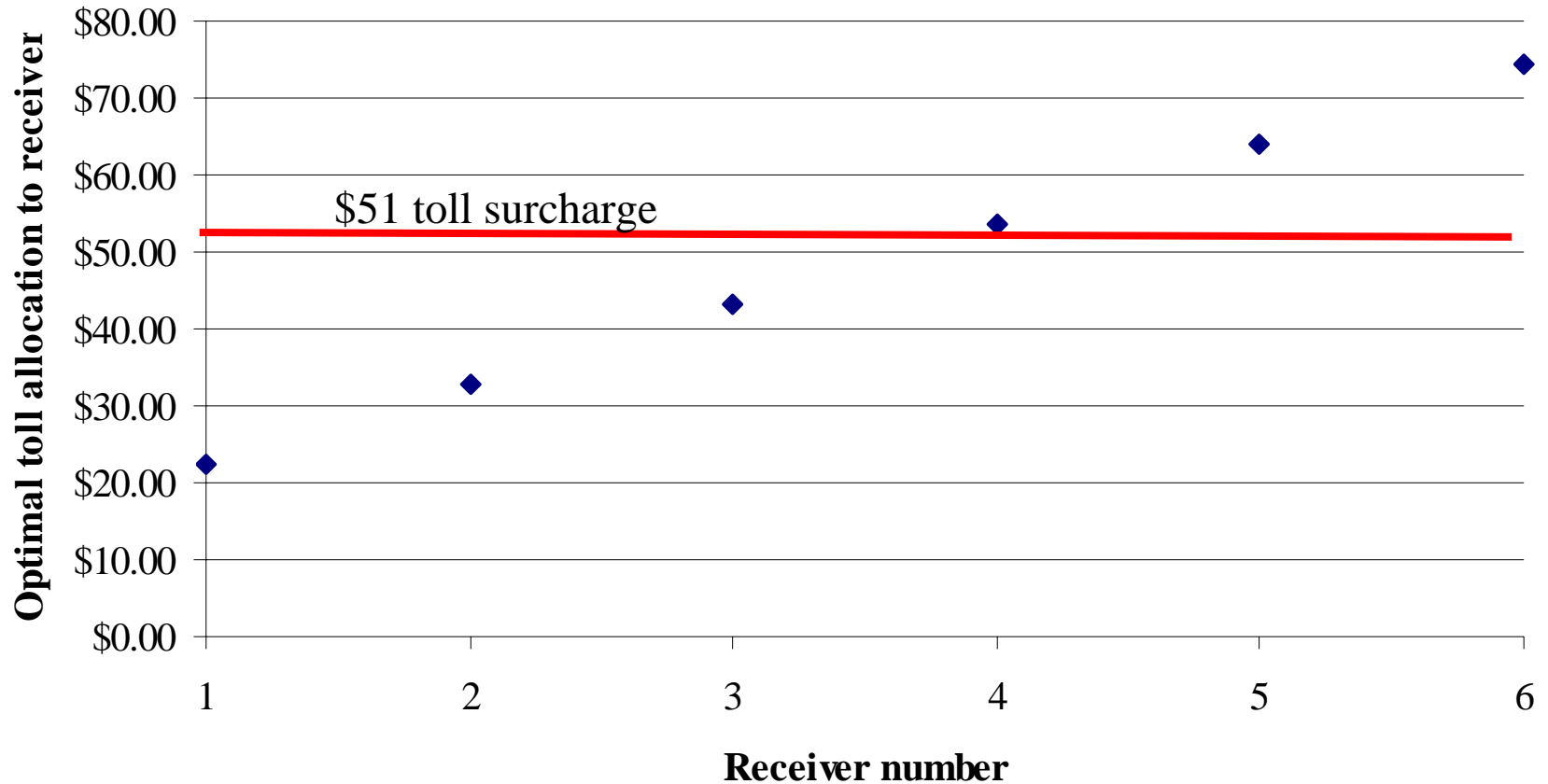
# Example: Consider a carrier with six customers<sup>39</sup>

- ❖ Assume that:
  - ❖ Travel time between customers is 10 minutes
  - ❖ Unloading time is 15 minutes
  - ❖ Minimum amount of time during off-peak = 1 hour
  - ❖ Original tour cost is \$300
  - ❖ Carrier cost savings during off-peak = 20%
  - ❖ The carrier split the savings in half with the receivers
  - ❖ Receiver's marginal costs = \$25/hour
- ❖ These assumptions come from NYC data

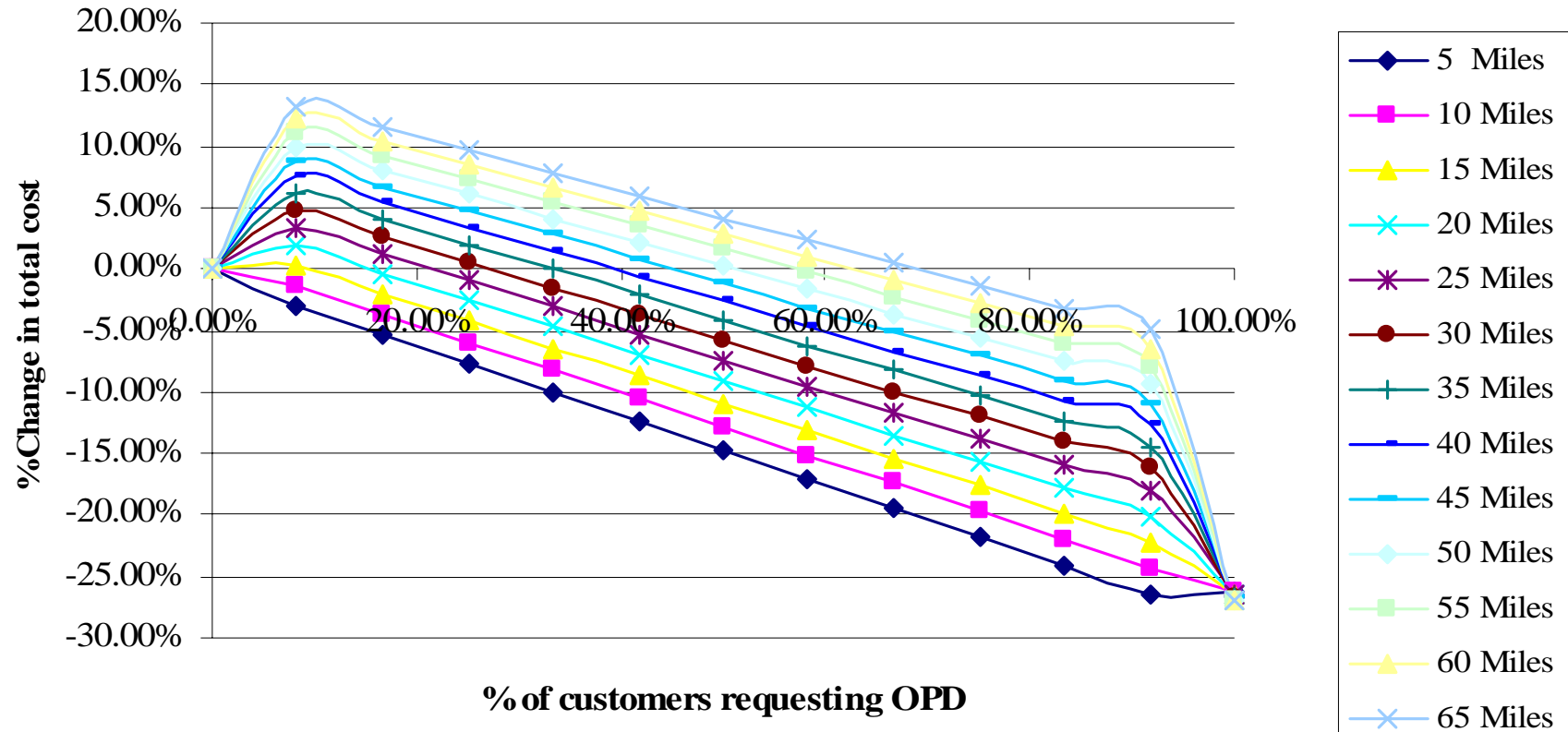
Receiver	Intercustomer travel time (mins)	Delivery time (mins)	Time into off-peak period ( $\tau$ ) (mins)	Savings passed to receivers	Marginal costs to receivers ( $m_i$ )	Optimal toll allocation to receiver $i$
1			60	-\$5.00	\$25.00	\$20.00
2	10	15	85	-\$5.00	\$35.42	\$30.42
3	10	15	110	-\$5.00	\$45.83	\$40.83
4	10	15	135	-\$5.00	\$56.25	\$51.25
5	10	15	160	-\$5.00	\$66.67	\$61.67
6	10	15	185	-\$5.00	\$77.08	\$72.08
Total	50	75	735	-\$30.00	\$306.25	\$276.25

**The total price signal reaching (receivers must be larger than \$276 (This is is the value of the toll required to force receivers to the off peak hours))**

# Another complexity



# Cost impact to carriers



**Most carriers transporting to NYC are located 15-20 miles from the first customer: if more than 20% of their receivers do off-peak deliveries they break even; if 50% they save 10% of total costs**