Allocation of Freight Externalities Among Agents in the Supply Chain

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Research Areas

- Background and Motivation
- Objective of this Research
- Urban Freight Issues
- Initiatives to Improve Freight Systems
- Externalities in Urban Freight
- Allocation of Externalities using Shapley Value
- Concluding Remarks



Is Freight in my neighbor?



Fundamental Tenets

- Freight activity takes place at all levels (global, national/regional, and metropolitan/urban)
- Freight activity = physical manifestation of economy

The shippers The carriers The receivers The Economy

We need to recognize that in complex cities...

- Simple approaches don't usually work...(JHV's principle)
- We need to use all policy weapons to reduce congestion and improve environmental conditions
- ✤ It is not enough to:
 - Build infrastructure (in some cases, it is not even possible)
 - Manage traffic (it has limits, cannot solve the root problem)
 - Use ITS (it has limits, cannot solve the root problem)
 - etc.

It is better to:

- Use comprehensive approaches
- Manage demand (to reduce the number of deliveries made), in combination with other initiatives

Objective

- This research is related to the impacts of the decisions made by agents in a supply chain on the generation of externalities
- We focus on the role of the main agents (suppliers, carriers and receivers) involved in the transport of cargo, but also consider the role of other agents that influence decision indirectly (i.e., city governments, real estate sector, land-use planners)
- ✤ To analyze the effects of externalities, the inclusion of these in the costs of transportation is crucial → costs of operation + externalities



Objective

- Who should pay for such increments?
- We propose a methodology based on cooperative game theory to obtain a fair allocation of the social cost generated by such decisions
- Social Costs = Private costs + externalities (CO2 emissions)





Urban Freight Issues





NYC, 3rd most congested city in the world!

Issues are all over the world

Effect of Large Trucks Ban in Sao Paulo

Initiatives to Improve Freight Systems

NCFRP Report 33 "Improving Freight System..."

Parking/Loading Area Management: On-Street

STAKEHOLDER ENGAGEMENT **ON-STREET PARKING** AND LOADING Freight Parking and Loading Zones Loading and Parking Restrictions Peak-Hour Clearways PARKING / LOADING AREAS Vehicle Parking MANAGEMENT **Reservation Systems** OFF-STREET PARKING AND LOADING Enhanced Building Codes Timeshare of Parking Space Upgrade Parking Areas and Loading Docks Improved Staging Areas Truck Stops/ Parking Outside of Metropolitan Areas

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On-Street Parking and Loading

Freight Parking and Loading Zones

See P2P Webinars 15 and 16

Are we allocating enough parking space for freight activities?

3.30-8.30pm

Off-Street Parking and Loading

Enhanced Building Codes

Land use	Floor area	Minimum number of bays	Land use	Floor area	Minimum number of bays
Office	General Minimum	1/5000 m ² 1 LR	Dept Store General Minimum		1/1000 m ² 1 HR
	e.g., 5000 m ² e.g., 20000 m ²	1 HR 4 HR		e.g., 2000 m ² e.g., 4000 m ²	2 HR or 1A+1HR 1 A + 3HR
Shop	General Minimum e.g., 2000 m ² e.g., 10000 m ²	1/2000 m ² 1 LR 1 HR 2 HR + 3 LR	Showrooms	General Minimum e.g., 5000 m ² e.g., 10000 m ²	1/2000 m ² 1 HR 3 HR 4 HR + 1A
Supermarket	General Minimum e.g., 1000 m ² e.g., 2000 m ² e.g., 4000 m ²	1/1000 m ² 1 HR 1 HR 1 A + 1 HR 2 A + 2 HR	Warehouse and Industry	General Minimum e.g., 5000 m ² e.g., 10000 m ²	1/1000 m ² 1A 1 A + 1 HR 2 A + 1 HR
			Others	General	1/2000 m ²

Improved Staging Areas

Upgrade Parking Areas and Loading Docks

Timeshare of Parking Space

Free Spaces
IOS Floor 4
54 Floor 3
Floor 2
FULL Floor 1

Demand/Land Use Management

Focuses on modifying the demand, instead of modifying the logistical activities or the traffic

Voluntary Off-Hour Delivery Program

- Objective: To induce a shift to deliveries made during the off-hours (7PM to 6AM), by providing incentives to receivers for their commitment to accept off-hours deliveries (OHD)
- Purpose: reduce congestion and pollution during daytime hours
- Examples in USA:
- PierPass Program, California
- ♦ OHD, New York City

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Impacts of Freight Demand Management

Externalities in Urban Freight

Externalities

- ♦ When an action of one or more agents impacts other agent not involved in the economic transaction → an externality
- Freight is a result of an economic transaction from suppliers, freight carriers, and receivers
- ◆ Congestion Pricing (Pigou, 1920) → charging a tax to the generators of the externality
- Substantial research is passenger related, very little on freight research
- ◆ Port Authority of New York and New Jersey's Time of Day Pricing Initiative and the resulting publications provide a direction to this research (Holguín-Veras and others) → congestion pricing is <u>not</u> a behavior changer
- Why? Because <u>carriers</u> are taxed but the ones who make decision on the time of delivery are the <u>receivers</u>.

Is OHD easy to implement?

- The answer is <u>no</u>.
- ☆ Markets find efficient outcomes, if they do not, there is a market failure → public sector intervention
- The market failure is the result of the unwillingness of receivers to accept OHD
- Increasing off-hour deliveries is beneficial to Society
- The solution is to either:
 - Compensate the receivers for additional costs, or
 - Develop technologies/systems to allow receivers to do OHD at lower costs (so that compensation could work)
- Quantifying externalities and allocating them among stakeholders is necessary

Role of Externalities – Who is responsible?

 Consider a single carrier that makes a delivery to a receiver at a congested Central Business District under 2 different scenarios of time-of-delivery, and availability of suitable parking or loading areas

		Time of Delive	ery Selected
		Off-Hour Deliveries (OHD)	Regular-Hour Deliveries (RHD)
Suitable Parking/Loading Areas	Available	Scenario I: OHD with Sufficient Space Base Externalities: Noise, congestion, emis- sions, infrastructure damage, and accidents produced (NCEIDA) by the freight vehicle	Scenario II: RHD with Sufficient Space Incremental Extendities = (the additional NCEIDA effect of the freight vehicle on the traffic stream) + (the additional NCEIDA pro- duced by freight vehicle as it responds to the congestion)
	Not Available	Scenario III: OHD without Sufficient Space Incremental Externalities = Incremental NCEIDA produced by the lack of a suitable space to make pickaps and deliveries	Scenario IV: RHD without Sefficient Space Incremental Externalities – Incremental NCEIDA produced by the effects of receiver's decision of time of delivery and the inability of building owners and city government to provide auitable space for freight activity

Allocation of Externalities using Shapley Value

Allocation of Externalities using Shapley Value

- Our most recent research aims at considering the externalities involved and being able to distribute these among the responsible actors, that is, those who are responsible for that incremental change
- Cooperative Game theory offers an efficient way of allocating externalities
- Shapley Value is used as the solution concept

$$\varphi_{i} = \sum_{\{S \in N: i \in S\}} \frac{(S-1)!(n-S)!}{n!} \left(v(S) - v(S-\{i\}) \right)$$

Linear City Case

Consider a linear city and the following decisions:

- O1-RH: Supplier locates farther from receivers and delivery takes place during regular hours
- O2-RH: Supplier locates closer to receivers and delivery takes place during regular hours
- O1-OH: Supplier locates farther from receivers and delivery takes place during off-hours
- O2-OH: Supplier locates closer to receivers and delivery takes place during off-hours

		Private Costs + Externalities						
Receiver	O1-RH	01-ОН	∆ RH	O2-RH	02-ОН	∆ RH		
#1	\$64.16	\$40.94	\$23.22	\$30.07	\$18.21	\$11.86		
#2	\$67.23	\$44.11	\$23.12	\$33.13	\$21.38	\$11.75		
#3	\$78.59	\$51.69	\$26.91	\$44.50	\$28.96	\$15.54		
#4	\$105.84	\$68.72	\$37.12	\$71.74	\$45.99	\$25.75		
Total	\$315.82	\$205.45	\$110.37	\$179.43	\$114.53	\$64.90		
01-02	\$136.39	\$90.92						
	Private Costs							
Receiver	O1-RH	01-ОН	Δ RH	O2-RH	02-ОН	Δ RH		
#1	\$45.15	\$32.41	\$12.74	\$22.46	\$14.80	\$7.66		
#2	\$45.68	\$34.44	\$11.24	\$22.99	\$16.83	\$6.16		
#3	\$53.24	\$40.31	\$12.93	\$30.55	\$22.70	\$7.85		
#4	\$72.88	\$53.93	\$18.95	\$50.19	\$36.32	\$13.87		
Total	\$216.95	\$161.10	\$55.85	\$126.19	\$90.65	\$35.54		
01-02	\$90.76	\$70.45						
			Extern	alities				
Receiver	O1-RH	01-ОН	∆ RH	O2-RH	02-ОН	∆ RH		
#1	\$19.01	\$8.53	\$10.49	\$7.61	\$3.41	\$4.19		
#2	\$21.55	\$9.67	\$11.88	\$10.14	\$4.55	\$5.59		
#3	\$25.35	\$11.37	\$13.98	\$13.94	\$6.25	\$7.69		
#4	\$32.96	\$14.78	\$18.17	\$21.55	\$9.67	\$11.88		
Total	\$98.87	\$44.35	\$54.52	\$53.24	\$23.88	\$29.36		
01-02	\$45.63	\$20.47		11				

Results of Shapley Value

Concluding Remarks

- Urban freight takes place at all levels and involves the interaction of multiple stakeholders
- Externalities in urban freight are caused by the interaction of stakeholders and identifying responsible actors is the key to change
- This research intends to quantify the use of initiatives by calculating the incremental costs of these, from the social cost perspective
- The test case provided an initial attempt to this methodology, by using Shapley Value as a way of allocating externalities among the responsible actors

Thanks! Any Questions?

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Initiative Selector Tool for Improving Freight System Performance

Software available at COE-SUFS webpage

https://coe-sufs.org/wordpress/software/

NCFRP Report 33 "Improving Freight System..."

Initiative Selector				Initiative 26: Restricted Multi-Use Lance Entrative Multi-Use Lance Entrative Multi-Use Lance Entrative Multi-Use Lance Description: Premotes the use of oradiation road capacity by allocating motivated has tight-of-way to reach, bases, and occursmally high-occupanty vehicles. The take usage case the allocated to in different users using time reaches, marked mong designated overs all day, or revision a user all. Targeoid and/or multi-User tracks Targeoid and/or Multi-User tracks Targeoid and/or Multi-User Targeoid multi-Use Multi-User				
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