

# The GTHA Commercial Vehicle Model and Applications

Tufayel Ahmed Chowdhury

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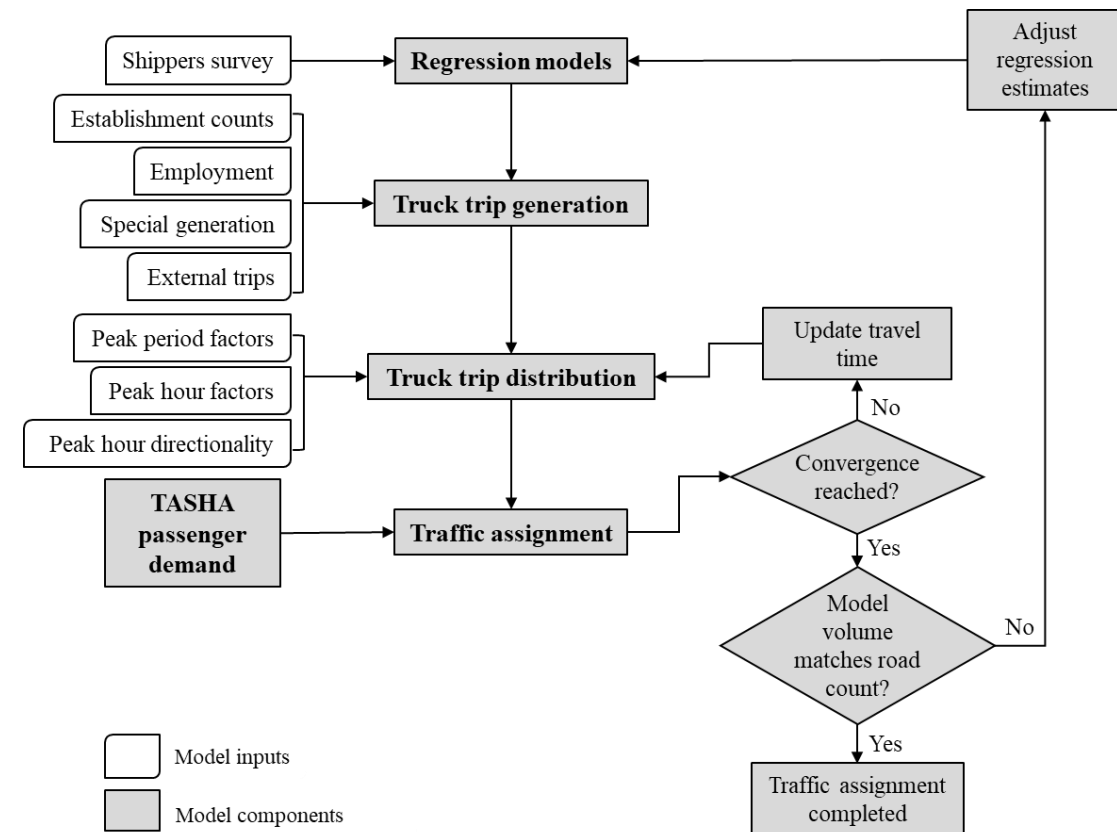
# Content

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- The GTHA Commercial Vehicle (CV) Model
- Two applications
  - Off-peak hour (OPHD) truck delivery
  - Freight automated vehicles

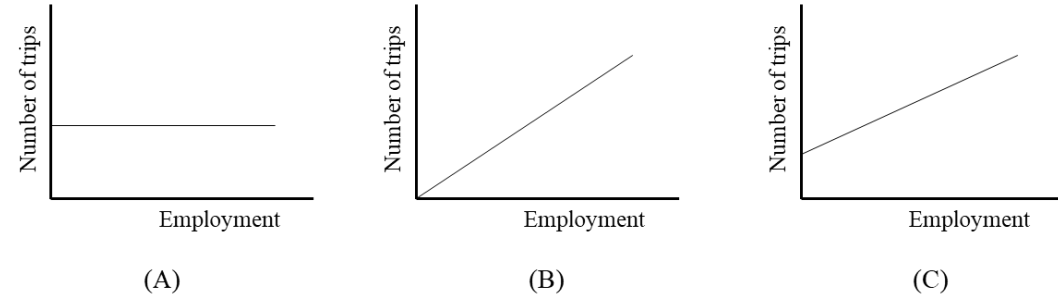
# The CV model overview

- A trip-based model with three components
- Base year – 2016
  - Trip generation input data 2016
  - Calibrated with 2016 road counts
- Has been integrated with the GTAModel V4



# Truck trip generation

- Linear regression at the scale of business establishment
  - Rate-based (type B) is not suitable for most industry classes
  - Zonal trip generation inputs 2016: establishment counts & employment
- Special generators
  - CP & CN intermodal terminals and Pearson Airport
  - Reported values are used instead of regression models
- External trips
  - Road counts at gateway zones



Three types of regression specifications

Number of industry classes by preferred model

Model Type	Light Truck	Medium Truck	Heavy Truck	Total
Intercept-only (A)	9	6	7	22
Slope-only (B)	0	0	3	3
Intercept and slope (C)	6	9	5	20
<b>Total</b>	<b>15</b>	<b>15</b>	<b>15</b>	<b>45</b>

# Other model components

## Truck trip distribution

- Trip generations are converted from 24-hr to 13-hr vectors
- A doubly-constrained gravity model is applied to estimate zone-to-zone 13-hr trips
- The 13-hour matrices are converted to peak-hour matrices for AM, MD, PM, EV periods by applying period and PHFs
- Directionality matrices are applied to AM & PM light & medium truck matrices

## Traffic assignment

- Multiclass user-equilibrium of auto, light, medium and heavy trucks
- Updated travel times are fed back to trip distribution until convergence is reached

# Model calibration

- Regression model parameters are calibrated by
  - Industry-specific factors
  - Zone land use type
- Gravity model  $\beta$  parameters are calibrated by adjusting modeled vs observed volumes in E/W and N/S directions
- Toll perception factors (\$/hour) are adjusted to match Hwy 407 modeled vs observed volumes

# Calibration results

- Model volumes are within 0.2% of road counts across various screenlines in the GTHA
- Volumes match relatively well in E/W and N/S directions

Direction	Modeled volume	Count volume	Difference	Percent difference
Light Trucks				
E/W	311,466	325,880	-14,414	-4.4%
N/S	233,743	218,678	15,065	6.9%
Total	545,208	544,558	650	0.1%
Medium Trucks				
E/W	118,620	121,387	-2,767	-2.3%
N/S	83,289	80,207	3,082	3.8%
Total	201,909	201,594	315	0.2%
Heavy Trucks				
E/W	220,262	227,045	-6,783	-3.0%
N/S	140,634	133,414	7,220	5.4%
Total	360,896	360,459	437	0.1%

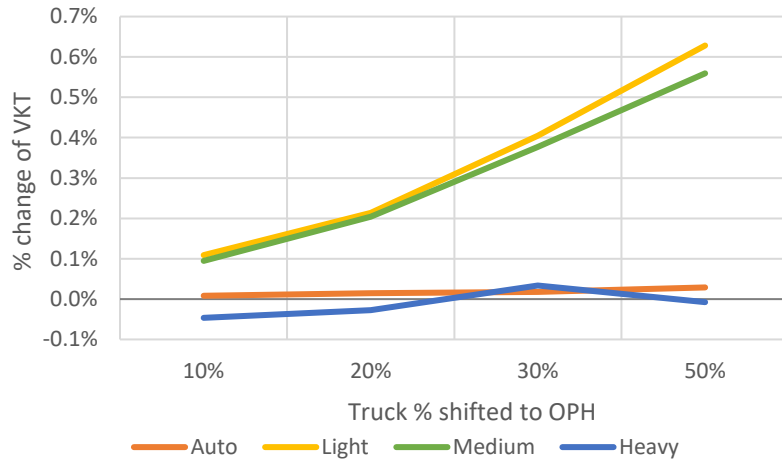
Calibration results across screen lines (total of AM, MD, PM periods)

# Modeling Impacts of Off-peak Delivery in the GTHA

## Scenario definitions

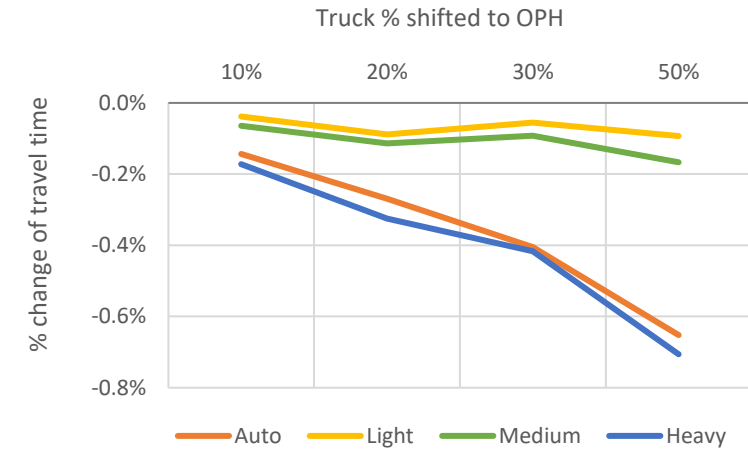
- Businesses to receive OPHD
  - Retail trade (RT)
  - Wholesale trade (WT)
  - Accommodation and food (AF)
- Participation rates: 10%, 20%, 30% and 50%
- Delivery time windows
  - 100% evening (7 pm – 11 pm)
  - 50% evening, 50% overnight (11 pm – 6 am)

# OPHD scenario results – daytime traffic



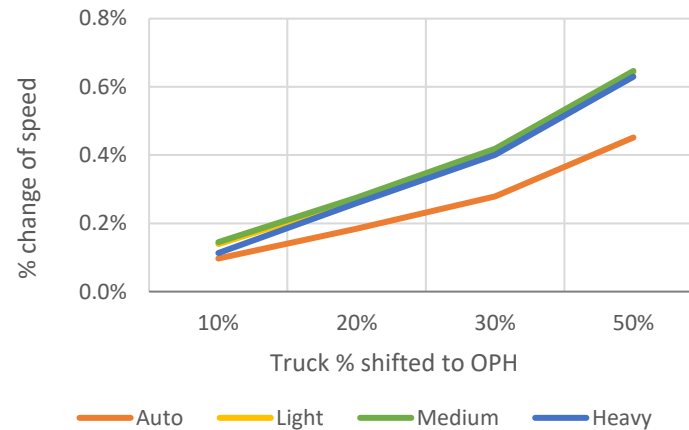
Change in average VKT

- Light and medium truck VKTs increase



Change in average travel time

- Speed changes uniformly



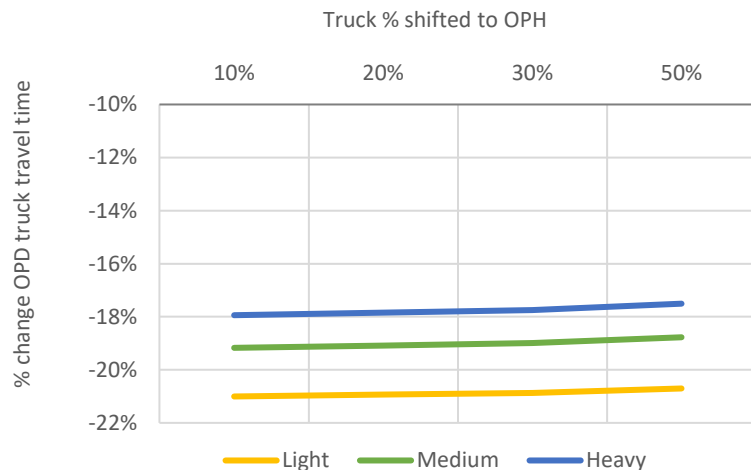
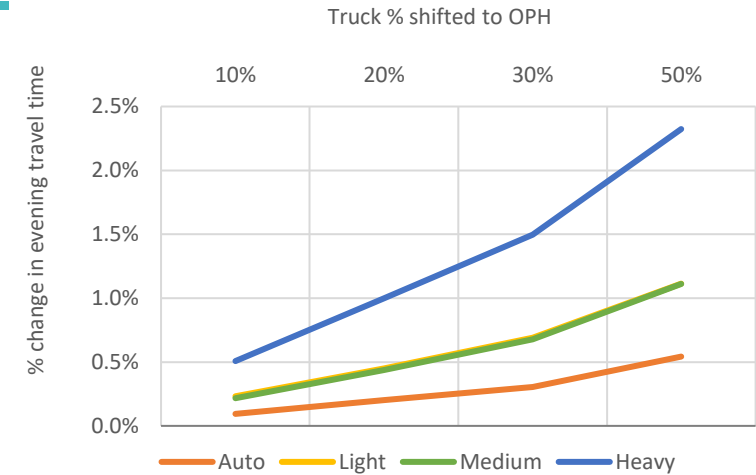
Change in average speed

- Heavy truck's travel time drops the most

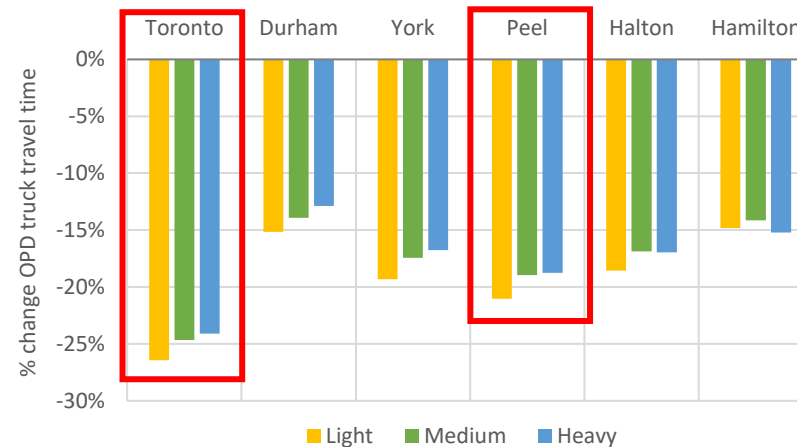
# OPHD results – off-peak traffic

- Travel time rises in the evening

## Travel time in evening



Travel time savings by OPHD trucks

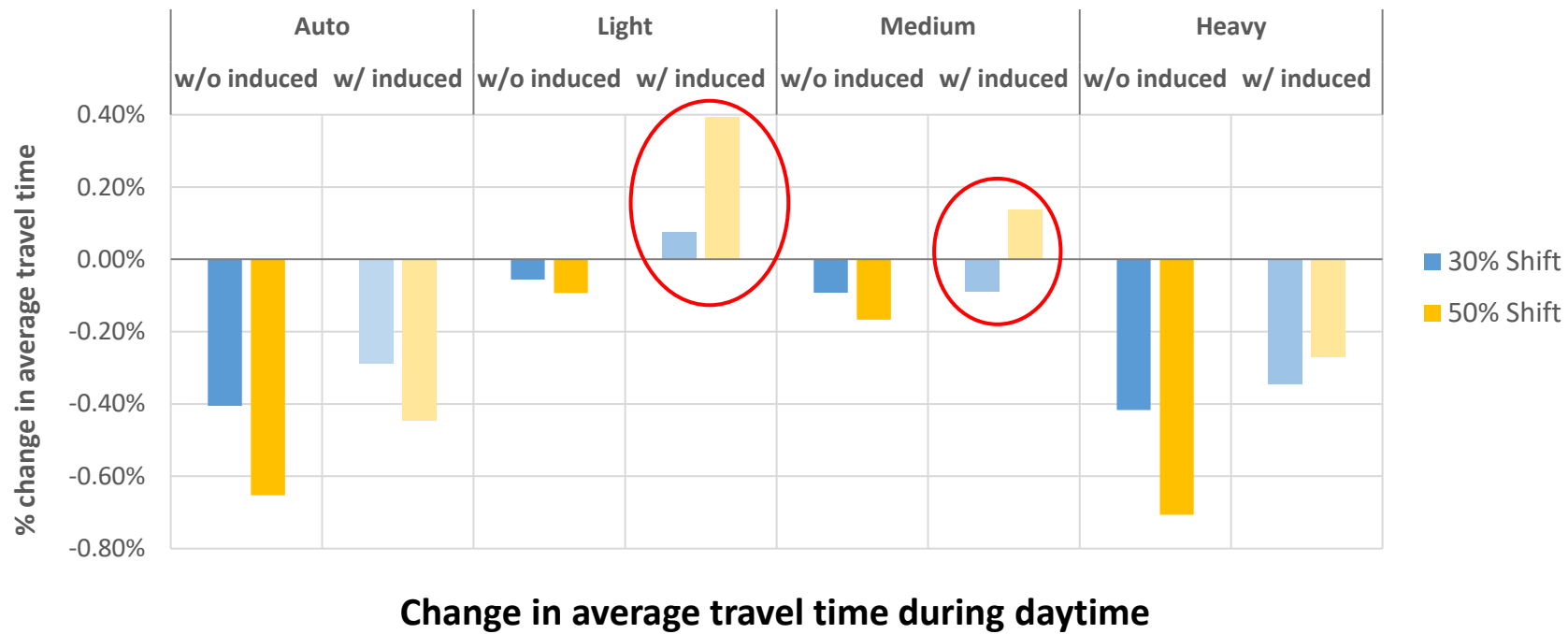


Travel time savings by OPHD trucks by region

- OPD trucks have substantially better travel times

# OPHD results – induced auto demand

- The impacts of induced auto demand is the highest on light trucks and the lowest on heavy trucks



# OPHD results – system-wide impacts

Change in total travel time (vehicle-hour) with a 30% participation rate

Vehicle type	Daytime traffic (6 am - 7 pm)		Evening traffic (7 pm - 11 pm)		Trucks participating in OPHD
	w/o induced	w/ induced	w/o induced	w/ induced	
Auto	-6,021	-3,426	157	135	-
Light	-78	201	90	-25	-1,499
Medium	-46	-12	32	-8	-170
Heavy	-304	-478	176	51	-297
<b>Total</b>	<b>-6,449</b>	<b>-3,715</b>	<b>454</b>	<b>153</b>	<b>-1,967</b>
<b>Total vehicle-hour saved</b>	<b>-7,962 (w/o induced)</b>		<b>-5,530 (w/ induced)</b>		

# Modeling Impacts of Freight AVs in the GTHA

## Scenario definitions

- Connected and automated trucks (CATs): Level 4 & 5 with V2V communications
- Market adoption
  - Partial automation (50% adoption)
  - Full automation (100% adoption)
- Expected changes
  - Changes in the headway
  - Rail-to-truck shift
- Partial adoption
  - CATs allowed on freeways only
  - CATs on the full network

# Scenario implementation

- New vehicle classes (light, medium, heavy CATs, auto CAVs) are defined in the model with **changed PCUs**
- **Freeway-only CATs** have trips between OD pairs that are
  - Located at least 30-km apart
  - Over 80% of medium and heavy truck trip distance is on freeways
- **Rail-to-truck shift** is represented by shifting heavy truck trip generation from CP and CN terminals to gateway zones

# Freight AV: scenario results

- Partial automation
  - When CATs are allowed only on freeways, network-wide travel time drops with smaller headways, while overall VKT increases
  - Freeway-only CATs + rail-to-truck shift results in increased travel time and VKT
  - Average travel time increases with higher headways (i.e., CAT manufacturers have higher safety settings)
- Full automation
  - Total travel time drops substantially when all trucks are automated and allowed on urban roads
  - If all passenger cars are AVs, the total travel time drops four times

AV adoption	Scenario	Change in total daily vehicle-hour
Partial Automation (50%)	Freeway CATs (lower PCU), rail-to-truck shift	218,759
	Freeway CATs (higher PCU), rail-to-truck shift	774,571
Full Automation (100%)	CATs on all roads, much lower PCU, rail-to-truck shift	-3,815,638
	CATs and passenger AVs on all roads, much lower PCU, rail-to-truck shift	-12,165,700

# Questions/comments

- Chowdhury, T. (Upcoming in Fall 2023). Freight Demand Model Development and Application at the National and Urban Scale. *PhD Dissertation*, Uoft TSpace Repository.
- Chowdhury, T., Vaughan, J., Saleh, M., Mousavi, K., Hatzopoulou, M., & Roorda, M. J. (2022). Modeling the Impacts of Off-Peak Delivery in the Greater Toronto and Hamilton Area. *Transportation Research Record*, 2676(10), 413-425
- Chowdhury, T., Vaughan, J., & Roorda, M. J. (Under review). Modeling Impacts of Freight Automated Vehicles in the Greater Toronto and Hamilton Area. *Transportation Research Part A: Policy and Practice*.