Factors Influencing Freeway Traffic Upstream of an Incident

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Outline

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- Incident Effects on Freeways
- Scope
- Methodology
- Application and Results
- Conclusions

Incidents and Freeway Traffic

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Effect of Incidents

- On Freeway Traffic
  - ✓ Formation of increased density areas upstream of an incident
- On Road Safety
  - ✓ Increased density → high risk areas → Increased secondary incident likelihood

Previous Research

- Static effect of incidents to traffic
  - ✓ Setting thresholds e.g. 15 minutes in the future and 2 km upstream
  - ✓ Detect secondary accidents based on these thresholds
- Dynamic Approaches
  - ✓ Duration of incidents, secondary accidents detection

Scope of Work

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Examine the effects of incident occurrence on freeway traffic

- Define indicators to describe the evolution of a traffic disturbance related to an incident

- Develop explanatory relationships of the spatio-temporal extent of the incident's influence to traffic with
  - ✓ Geometry, incident and weather related factors

Methodology

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Problem Formulation

Every incident may create a disturbance on traffic flow propagated upstream of the incident's location.

Assumptions

- Disturbance as a Latent Variable
- Indicators
  - ✓ maximum length *Lmax* and duration *T* of a disturbance formed upstream of an incident
- Predictors
  - ✓ traffic, weather, geometry and incident specific factors

Methodology

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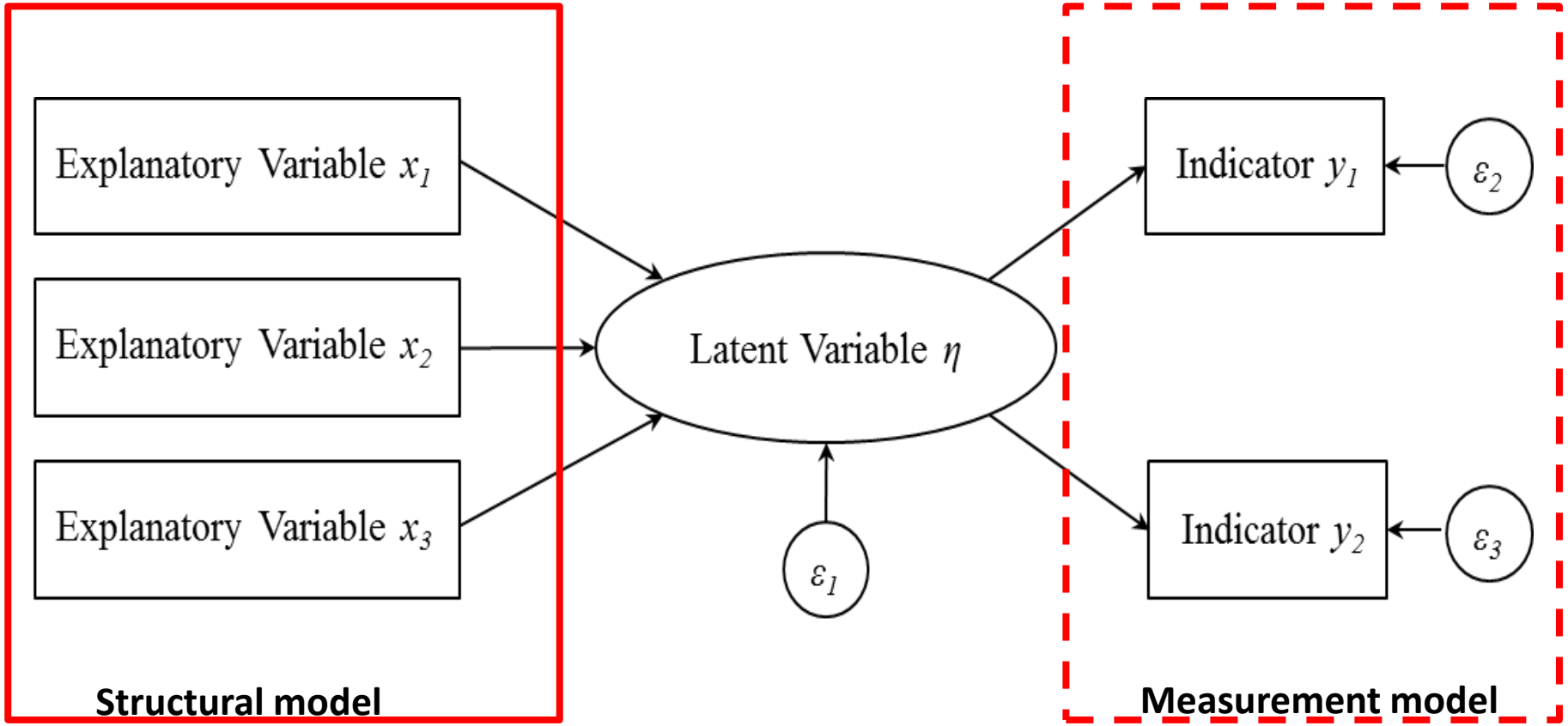
Structural Equation Model

Multiple Indicators-Multiple Causes (MIMIC) latent variable model



Description of Data

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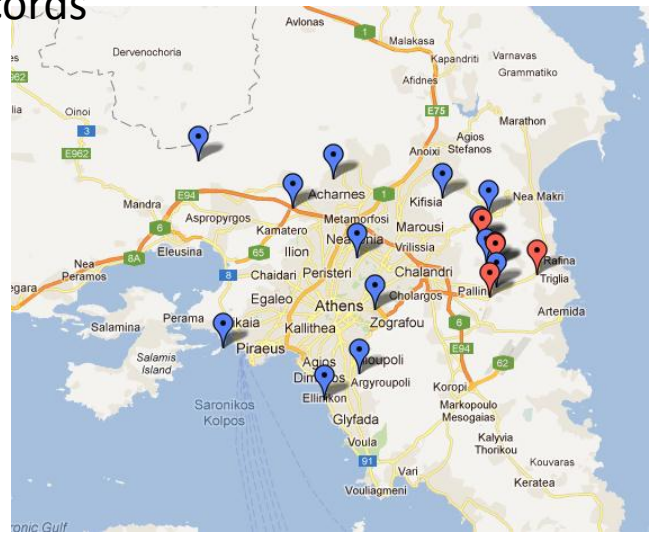
The available data

- Attica Tollway: a 65.2 km urban motorway.
  - ✓ 1287 accident records (2007-2010)
  - ✓ volume and speed from loop detectors
- METEONET network
  - ✓ (http://meteonet.chi.civil.ntua.gr/en/divs.html)
    - developed and operated by NTUA.
    - Rainfall episodes related to accident data records



Description of Data

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Variable	Type	Description
Clearance Time	Continuous	The incident duration in minutes
Collision Type	Categorical	0 to 4, from less to more severe
Nr. Lanes	Categorical	1 to 3, 1:1 lane, 2: two, 3: more than 2
Nr. Vehicles	Categorical	1 to 3, 1:one vehicle, 2: two vehicles, 3: more than 2 vehicles involved
Heavy Vehicle	Categorical	0 to 1(Heavy Vehicle involved)
Travel Speed	Continuous	Travel speed (km/h) at the occurrence of the incident
Hourly volume	Continuous	Hourly volume (veh/h/lane) at the occurrence of the incident
Rainfall Intensity	Continuous	Rainfall at the occurrence of the incident in mm/10min
Alignment	Categorical	0 to 1 (curve)
Downstream Geometry	Categorical	0 to 4, 0: no special geometry, 1: adjacent to tunnel, 2: adjacent to toll, 3: adjacent to entrance/exit, 4: more than one
Upstream Geometry	Categorical	0 to 4, 0: no special geometry, 1: adjacent to tunnel, 2: adjacent to toll, 3: adjacent to entrance/exit, 4: more than one

Description of Data

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Estimation of the temporal and spatial extend of incident's influence to traffic

$$x_{up}^{(jam)}(t) = L_{i+1} - \int_{t_0^{(i+1)}}^{t} \frac{q_0^{(i)}(t) - q_{min}}{\rho_{max} - \left(q_0^{(i)}(t)/w_0^{(i)}(t)\right)} dt$$

$$x_{down}^{(jam)}(t) = L_j - \int_{t_1^{(j)}}^{t} \frac{q_{out}^{(j)(jam)}(t) - q_{min}}{\rho_{max} - \left(q_{out}^{(j)(jam)}(t)/w_{max}^{(j)}(t)\right)} dt$$

ASDA Model

+

Empirical Speed Threshold Algorithms

→

Dynamic spatiotemporal boundaries of incident effect to traffic

Description of Data

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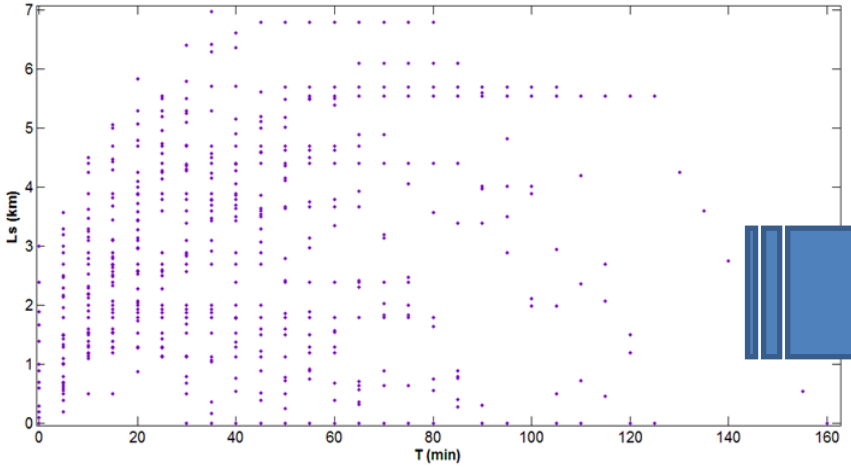
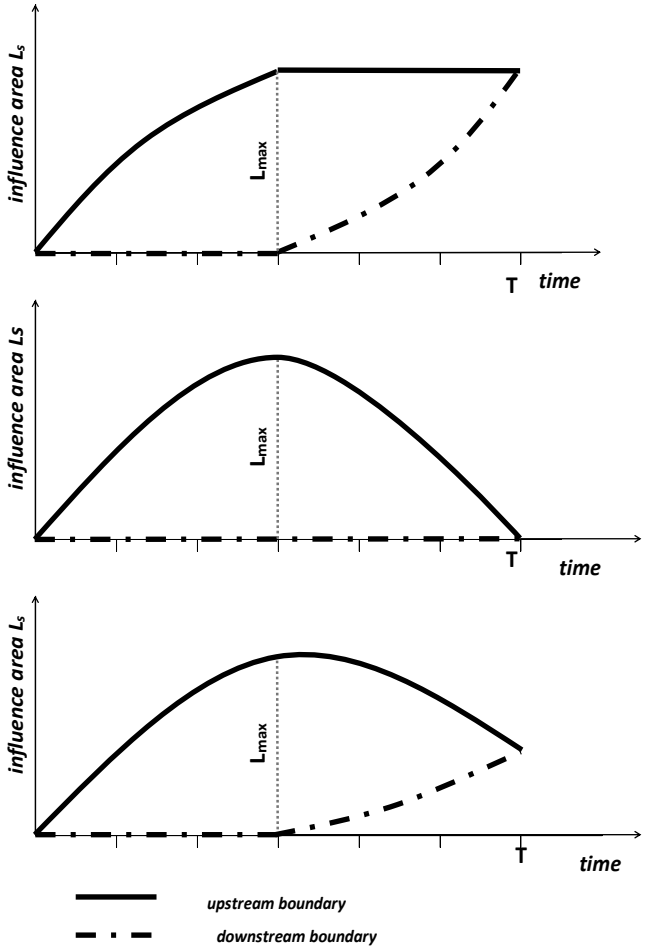


Typical propagation patterns



Information on:

1. the disturbance propagation length and duration
2. Secondary accident occurrence

Results

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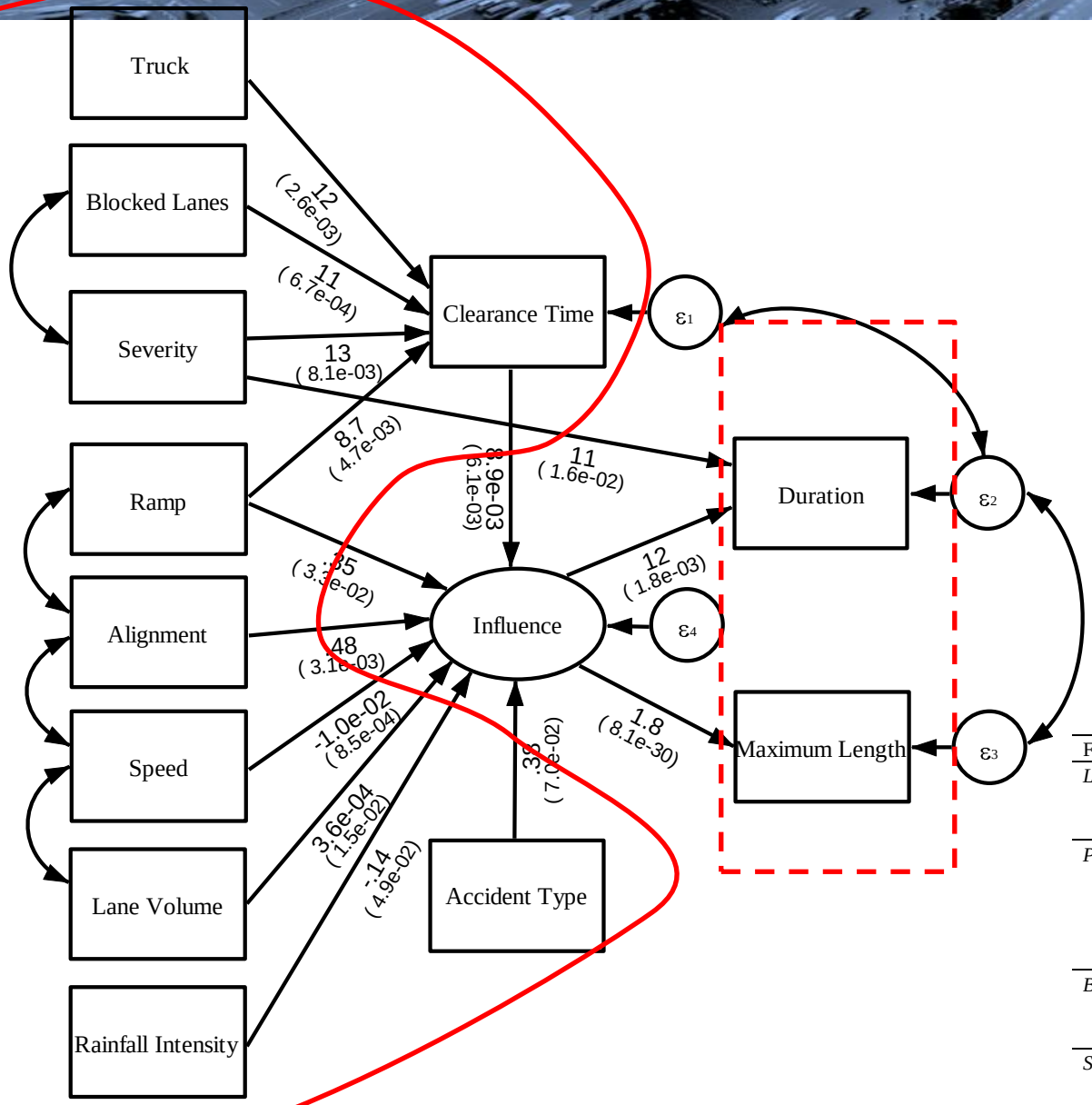

Fit statistic	Value
Likelihood ratio	
χ^2 ($p > \chi^2$) – Saturated	12.774 (0.689)
χ^2 ($p > \chi^2$) - Baseline	192.172 (0.00)
Population error	
RMSEA	0.000
90% CI, lower bound	0
90% CI,upper bound	0.025
Probability RMSEA <= 0.05	0.924
Baseline comparison	
CFI	1.00
TLI	1.037
Size of residuals	
SRMR	0.026
CD	0.408

Results

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- *T* is a stronger indicator than L_{max}.

- A negative relationship with the latent influence of the accident
  - ✓ Speed
  - ✓ rainfall intensity

- A strong positive relationship with the latent influence of the accident
  - ✓ Type of the accident (secondary or not)
  - ✓ Alignment (on a curve or not)
  - ✓ Entrance/exit ramps upstream of the accident location

- Weaker positive relationship
  - ✓ traffic volume and the clearance time of an accident.

Results

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- Predictors of Clearance Time
  - ✓ Involvement of trucks in the accident
  - ✓ Number of blocked lanes
  - ✓ Existence of tolls adjacent to the area of the accident

Conclusions

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- Quantitatively assess the effect of incidents to freeway traffic

- Methodology
  - ✓ Multivariate tool
  - ✓ Structural equation modeling
  - ✓ Traffic disturbance introduced as a latent variable

- Factors
  - ✓ Primary traffic flow conditions and rainfall intensity
  - ✓ Alignment and upstream geometry
  - ✓ Type of incident

Conclusions

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- Towards an online decision making mechanism to improve freeway operations with safety implications

  ✓ Traffic specific measures for filtering traffic and affecting short-term demand

  ✓ Online safety management
    - Predict high risk areas prone to secondary accidents occurrence
    - Informing road users on imminent high risk conditions on freeways

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