Data-driven quantification of the Resilience of enforcement policies on transportation systems: A Comparative study of two major winter storms in Buffalo, New York

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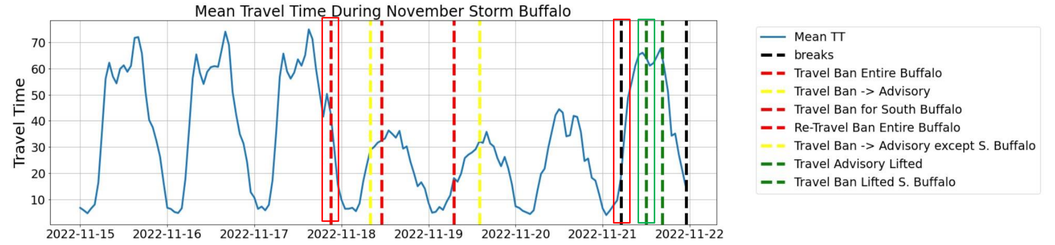
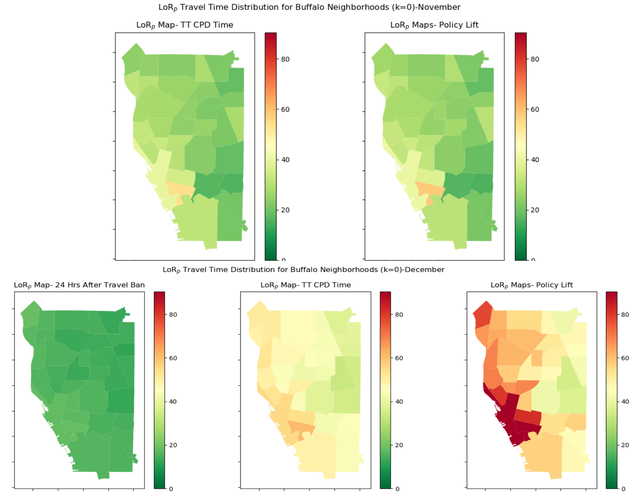
Abstract: This study aims to investigate the regulation power policies retain during disruptive and deadly winter storms, focusing on enforcement policies. A comparative study using the disruptive events of the November and December 2022 blizzards in Buffalo is conducted, aiming at pattern identification in travelers' responses during enforcement and recovery phases, using different time scales and reactions of various transportation system indicators. We introduce a new conceptual metric, **the Loss of Resilience of Policy (LoR_p)** drawing inspiration from the Loss of Resilience framework used in evacuation studies. Results based on these new performance indicators are analyzed using **a change detection and spatial modeling framework** on a neighborhood level to associate the calculated values with spatial and socioeconomic variables, to better understand the effect of these elements co-variated on LoR_p and study the factors affecting resilience of various policies. The model serves as a preemptive tool for policymakers to timely adjust enforcement policies, thereby improving responses to extreme weather events and reducing unnecessary delays.



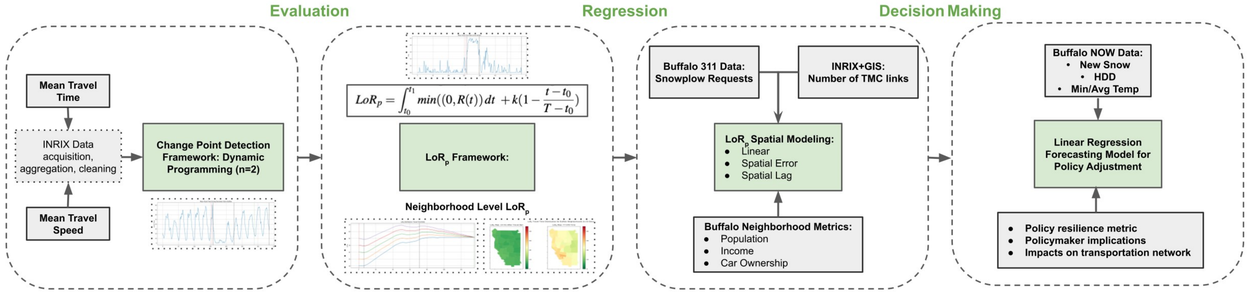


METHODOLOGY

- **Change Point Detection (CPD) Analysis** - CPD is designed to identify instances when the distribution of a stochastic process or time series undergoes a change.
- **LoR_p Design**- Inspiration for LoR_p term was influenced by the LoR term used in evacuation studies.

$$LoR_p = \int_{t_0}^{t_1} min((0,R(t))\,dt + k(1-\frac{t-t_0}{T-t_0})$$

- **Spatial Modeling of LoR_p** - Correlate the LoR_p values with socioeconomic, demographic and geographic variables to better understand the effect the co-variates have on LoR_p from a spatial perspective.



Main Takeaways

- Novel term is proposed to illustrate the loss of resilience of the policy (LoR_p) after its issuance by the authorities: **Measure the loss of the regulation power of a policy on the affected population**
- A Change Point Detection (CPD) based framework is devised to detect the decrease and increase of time points of the travel metrics: Time-stamps are used in the equation designed to calculate LoR_p
- Neighborhood level spatial analysis to correlate the LoR_p values calculated using the designed equation with key socioeconomic, demographic, and geographic covariates to understand their effect in a spatial sense.
- Findings display how variables such as number of snowplow requests, number of TMC links, car ownership rate, and employment rates provide statistically significant results in the prediction of LoR_p.
- The variables used in the spatial models display reasonable correlative results that are elaborated to provide lessons for policymakers regarding the power an enforcement policy holds before it is lifted and the factors that influence the resilience of the policy, providing them with future implications for enforcement policies.

Future Research:

- Calibrating the LoR_p equation,
- Using additional indicative variables in the regression, and, most importantly,
- Using LoR_p to identify the loss of resilience experienced for policies during different disruptive extreme events such as COVID-19 and other emergency circumstances should be investigated.

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