The empirical behavior of roads' edge betweenness in vulnerable flow organizations

– A case of Seoul –

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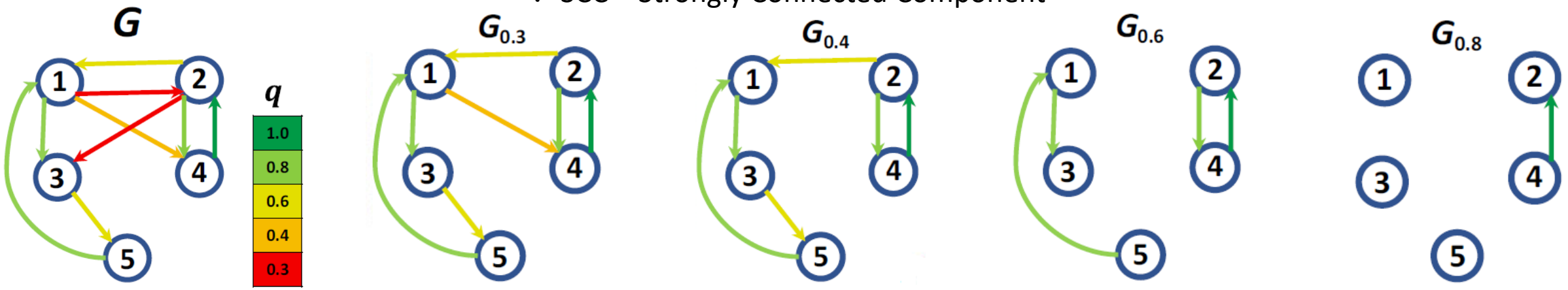
> A Challenging Problem: Traffic Congestion

> Understanding by Traffic Percolation

✻ SCC = Strongly Connected Component



Largest SCC size = 5

Average quality:
$\langle q \rangle = 0.622$

Largest SCC size = 5

Largest SCC size = 3

Largest SCC is fragmented!

q_c=0.4

Largest SCC size = 2

Largest SCC size = 1

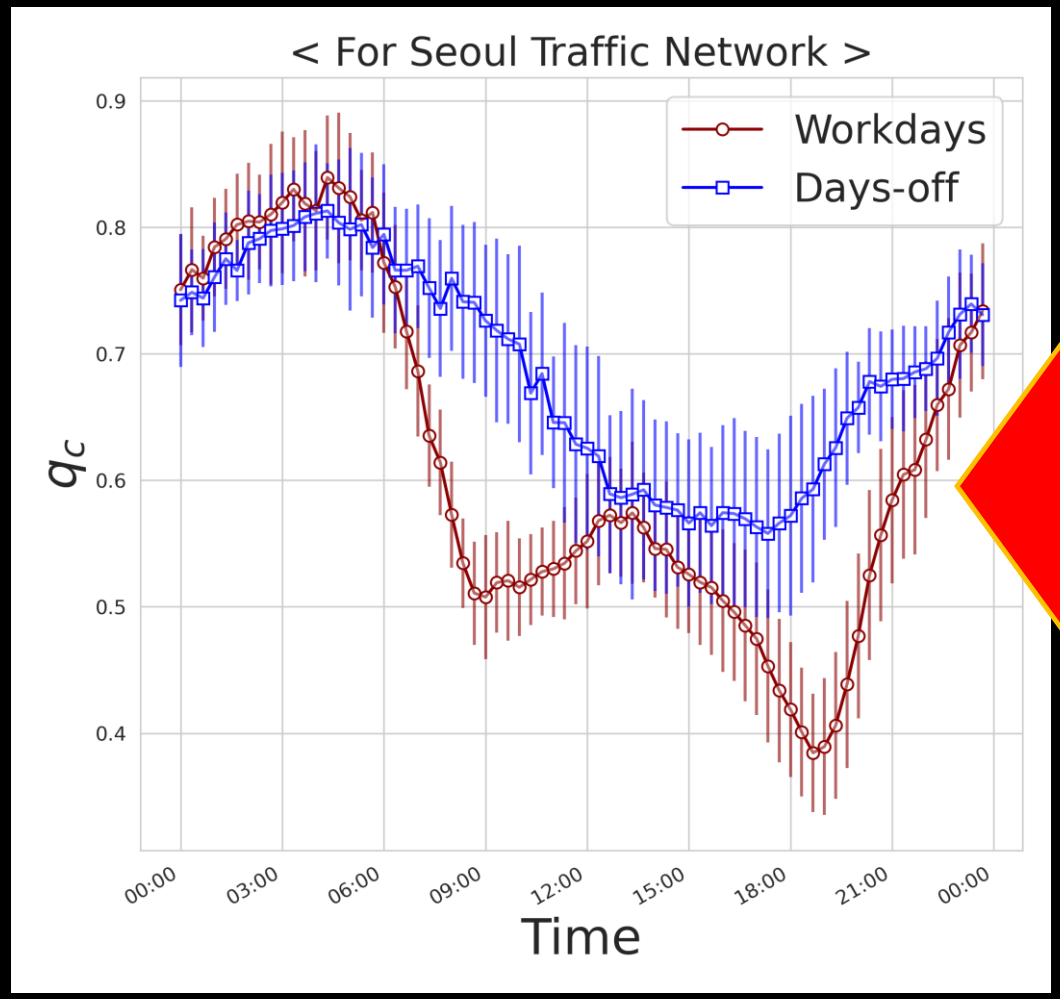
Image source: Hamedmoghadam, Jalili, Vu, & Stone (2021)

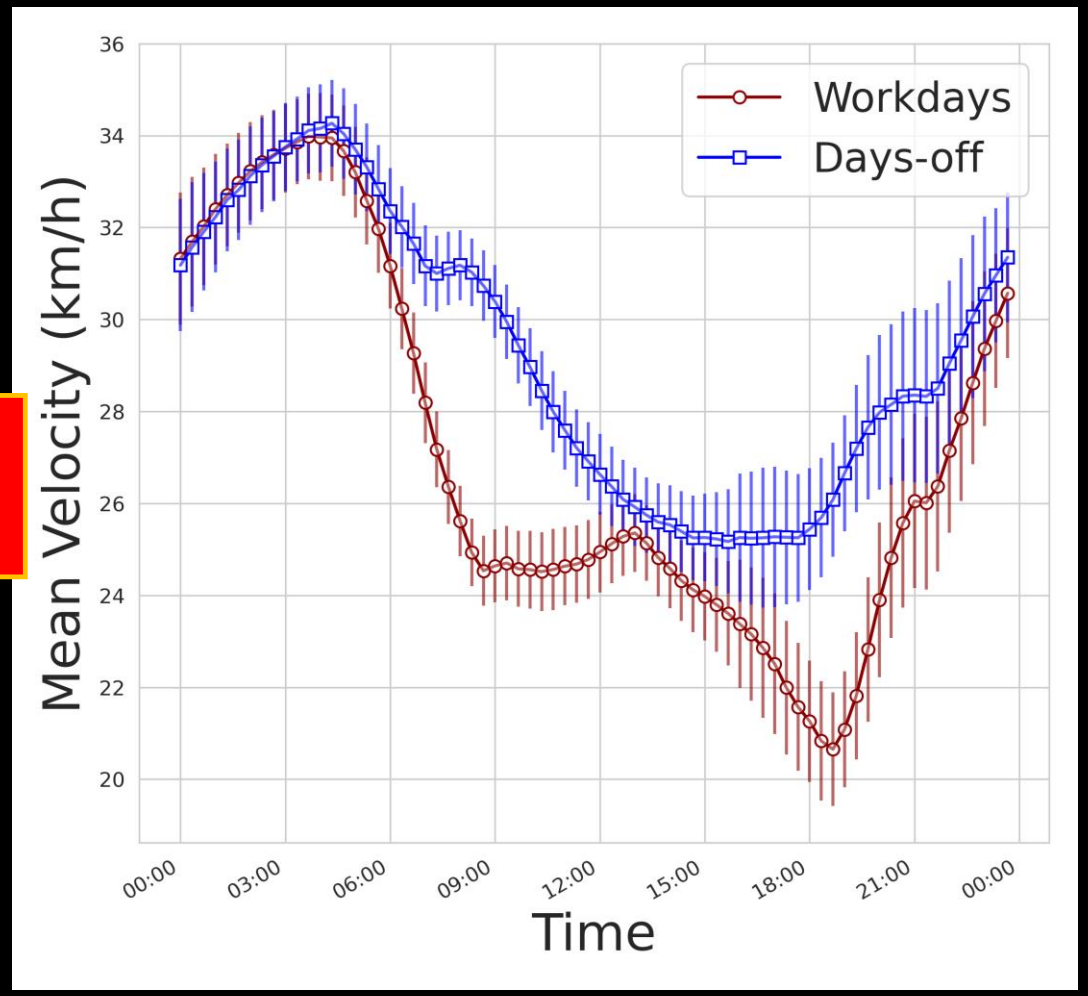
- A Global Efficiency (q_c) -

= The threshold at which the global connectivity is fragmented

= The maximal velocity at which one can travel over the most part of the network.

> What drives the global efficiency q_c to be High or Low ?

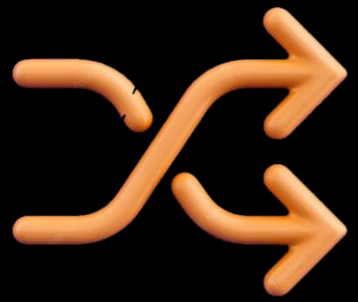


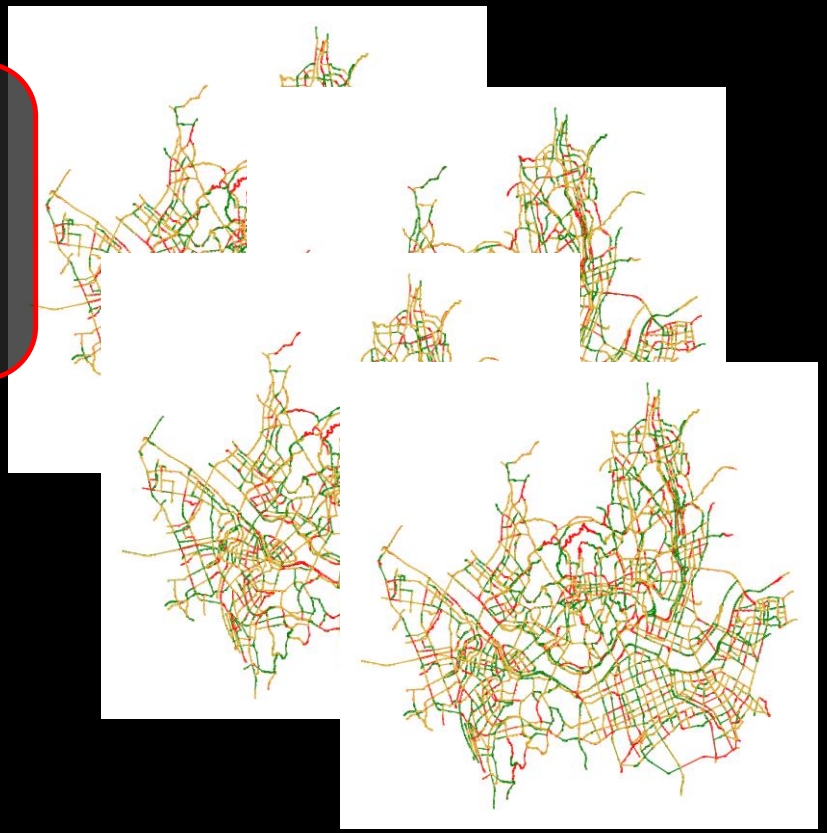


Let's check this out.

> Need to compare with Random Flow Model

, but **shuffling the flow organization**





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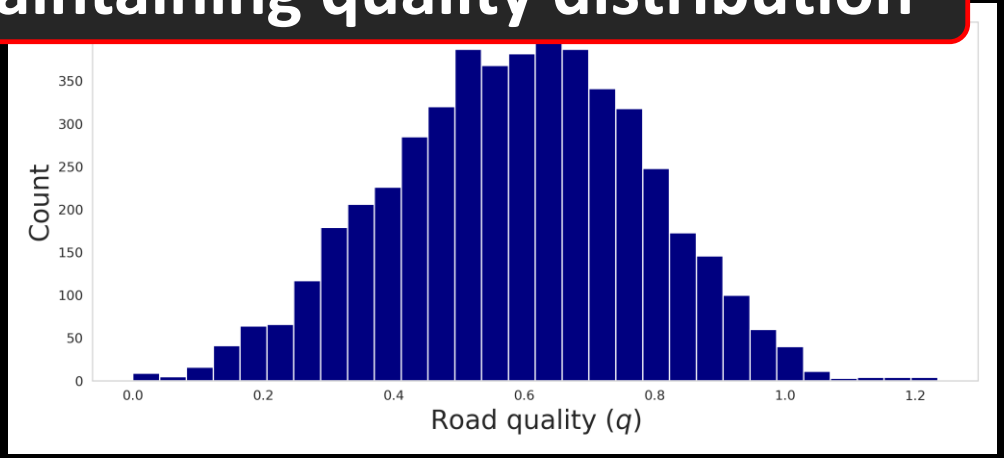
Maintaining quality distribution

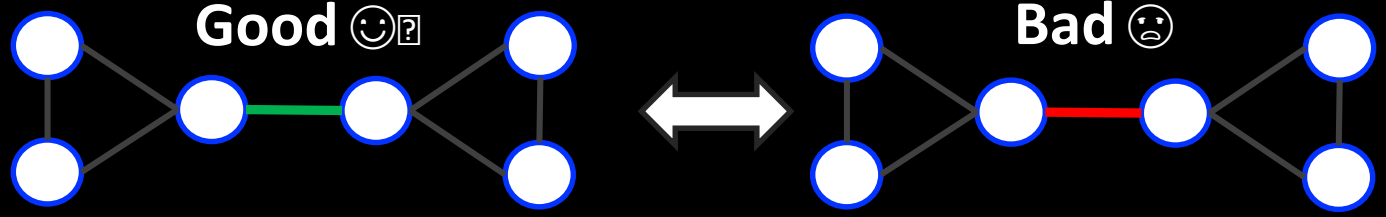


Reveals **the characteristic organizations of traffic flow** affecting its global efficiency.

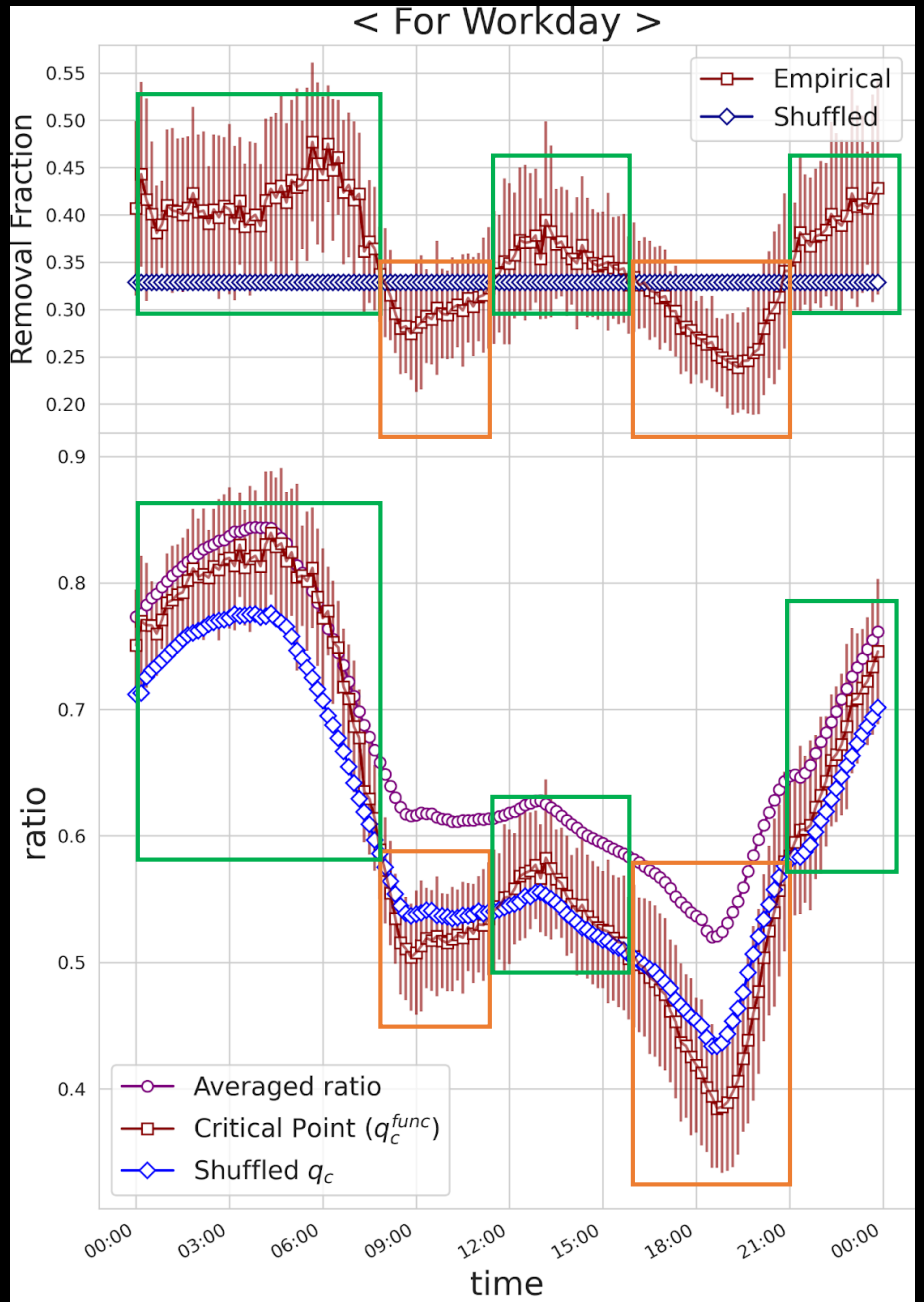
> Real vs. Shuffled flow organization

- **We can discriminate from its random counterpart.**
  - **Rush hours: $q_c^{real} < q_c^{shuffled}$ regimes**
  - **Non-rush hours: $q_c^{real} > q_c^{shuffled}$ regimes**
- **What makes such a qualitative difference?**
  - Our conjecture: **Local flows keeping the global connectivity** have ***low quality in rush hour***, whereas they have ***high-quality in non-rush hour***.

In a nutshell, they seem like…



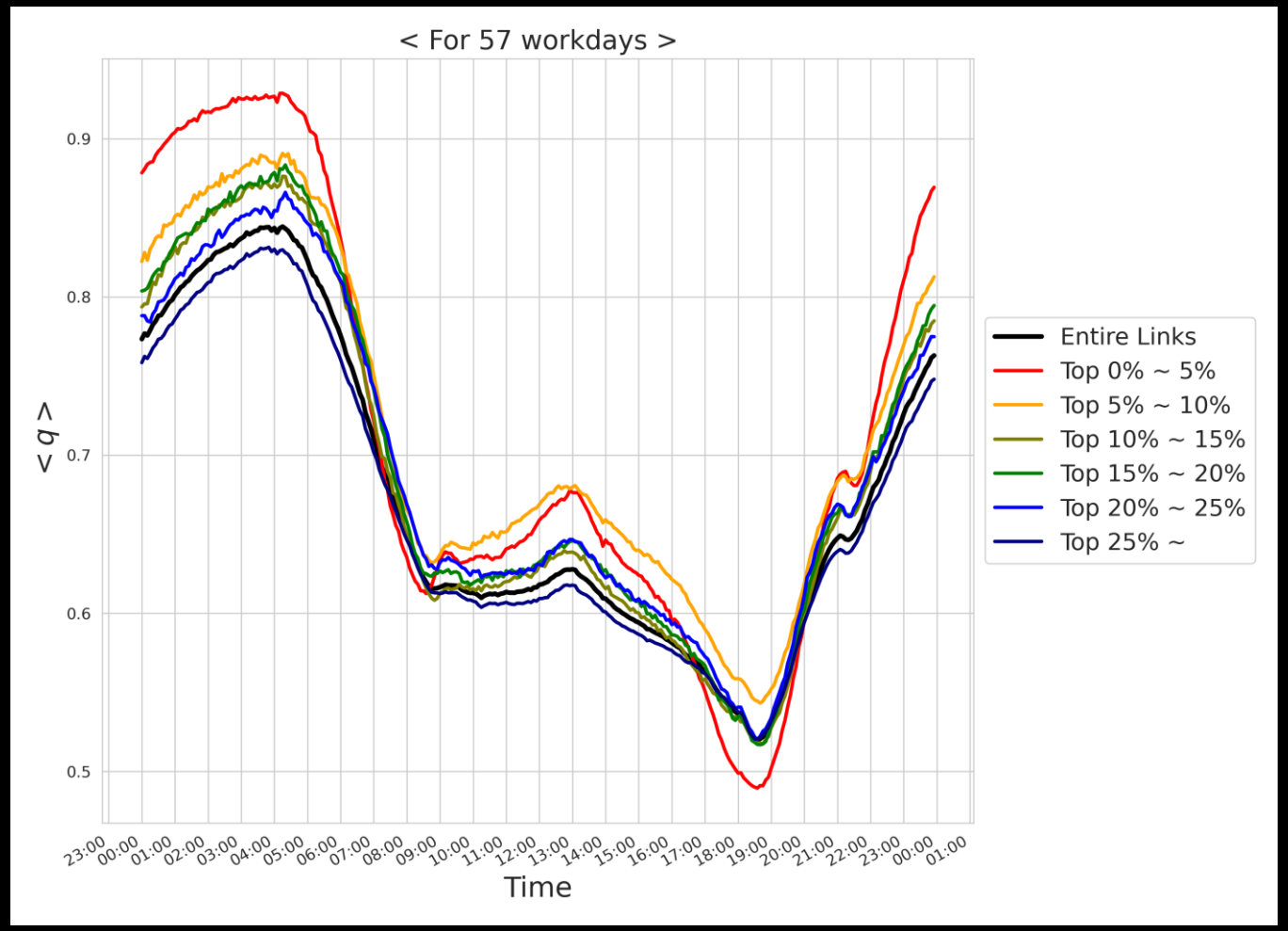
Flow Organization in Non-rush hours **in Rush hours**

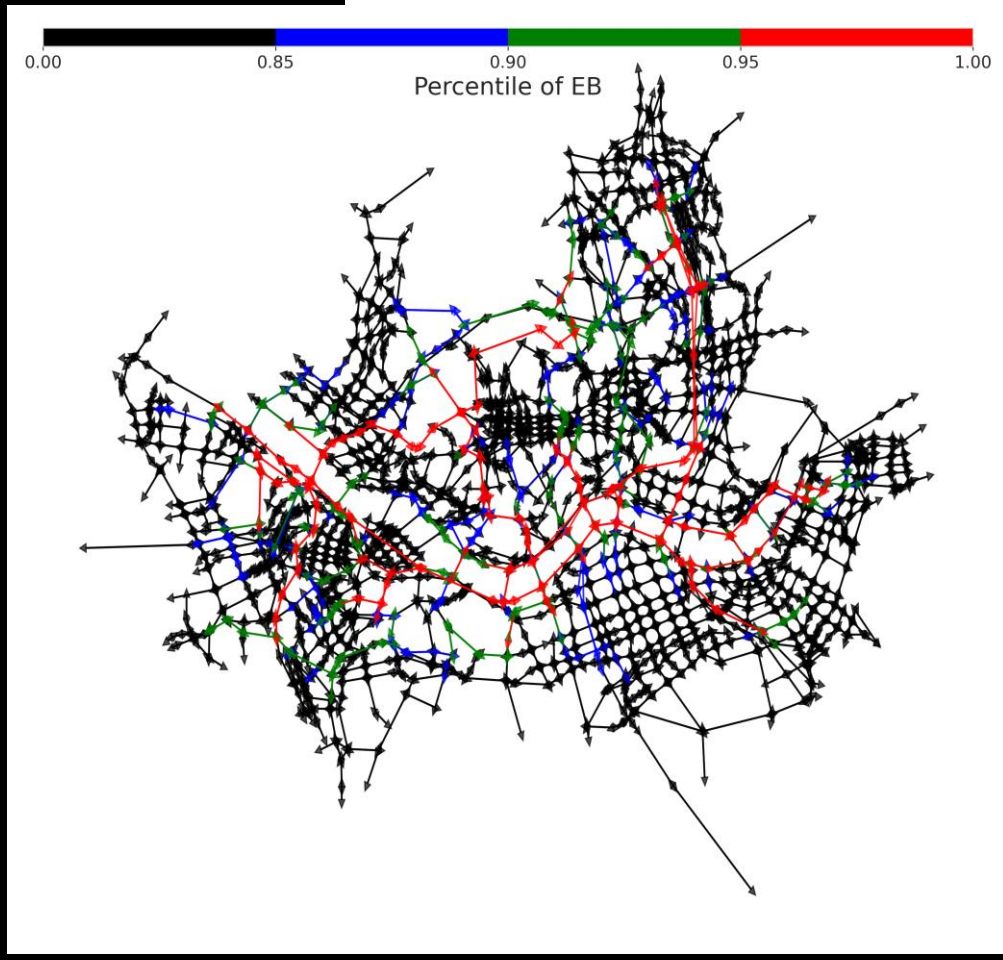


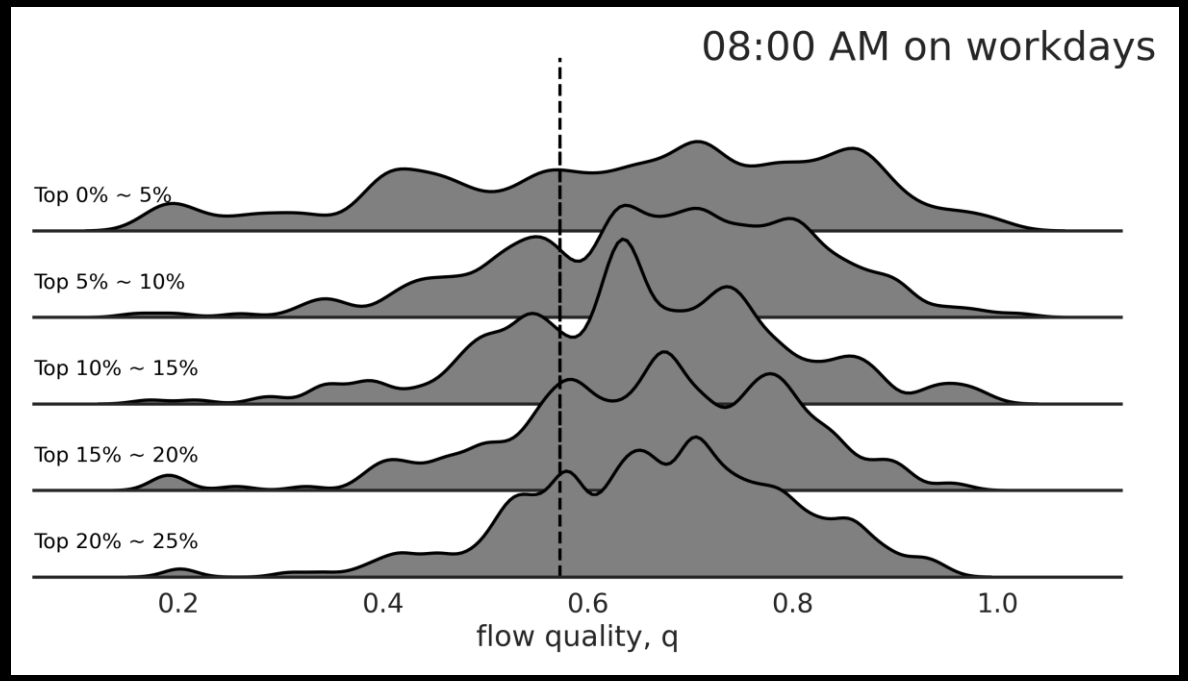
> Who is keeping the global connectivity ?

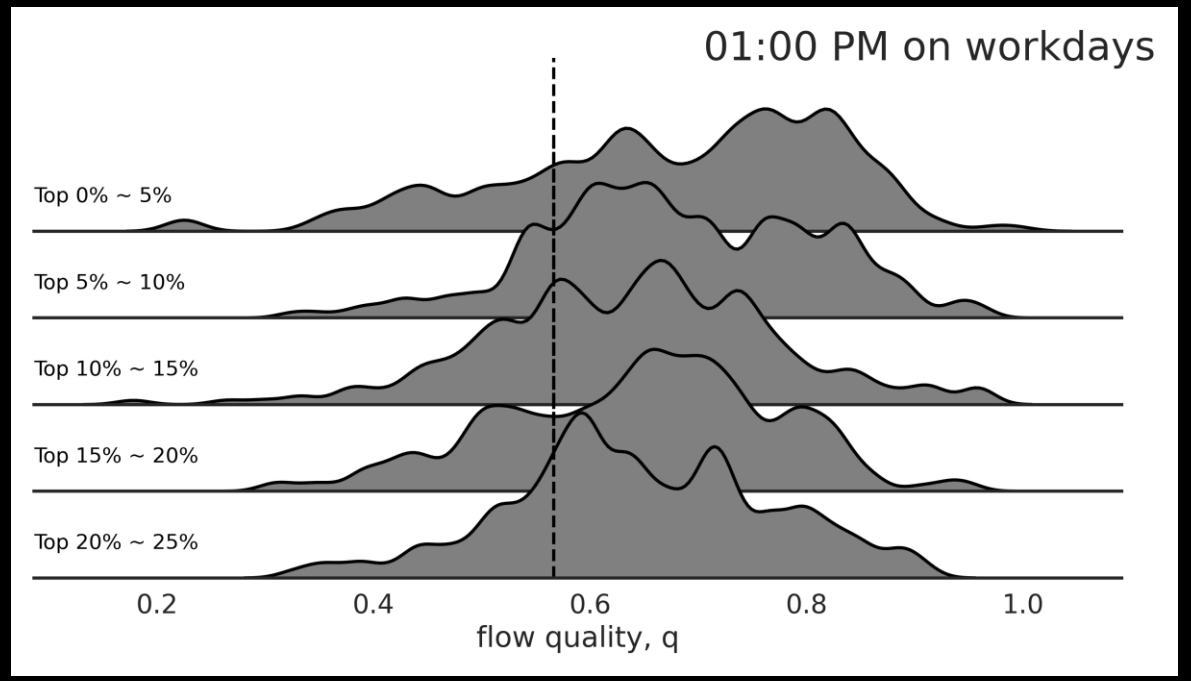
Edge Betweenness(EB) of an edge(e) is the sum of the fraction of all-pairs shortest paths that pass through e.

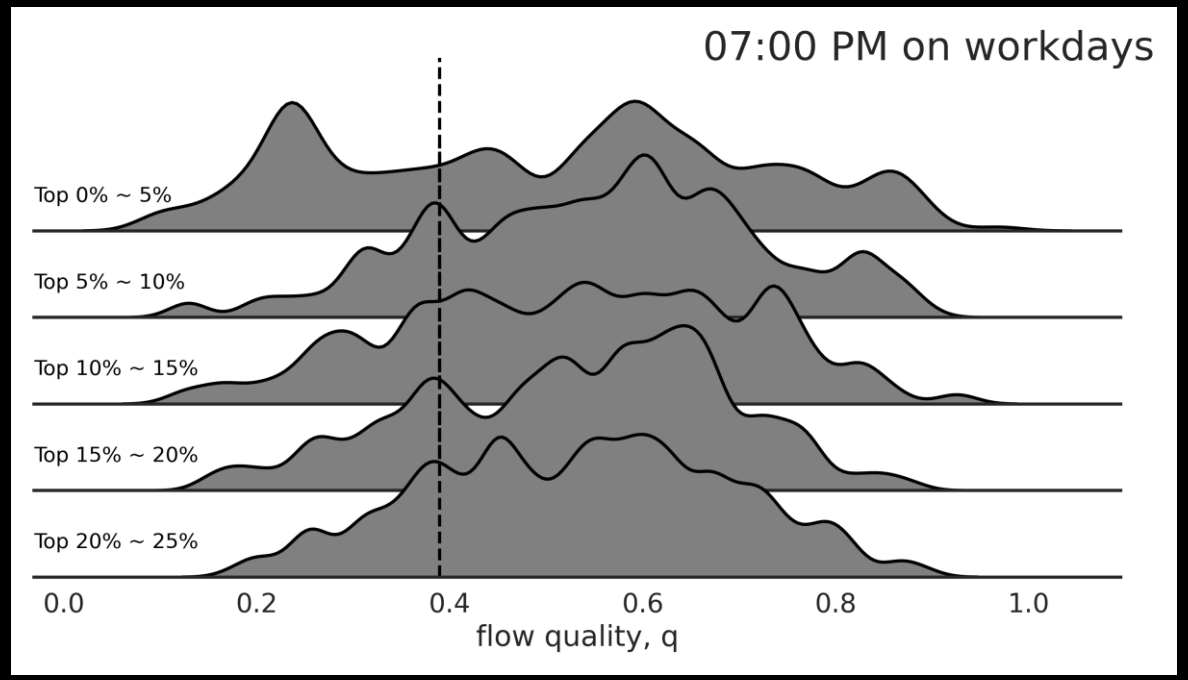
$$c_B(e) = \sum_{s,t \in V} \frac{\sigma(s,t|e)}{\sigma(s,t)}$$







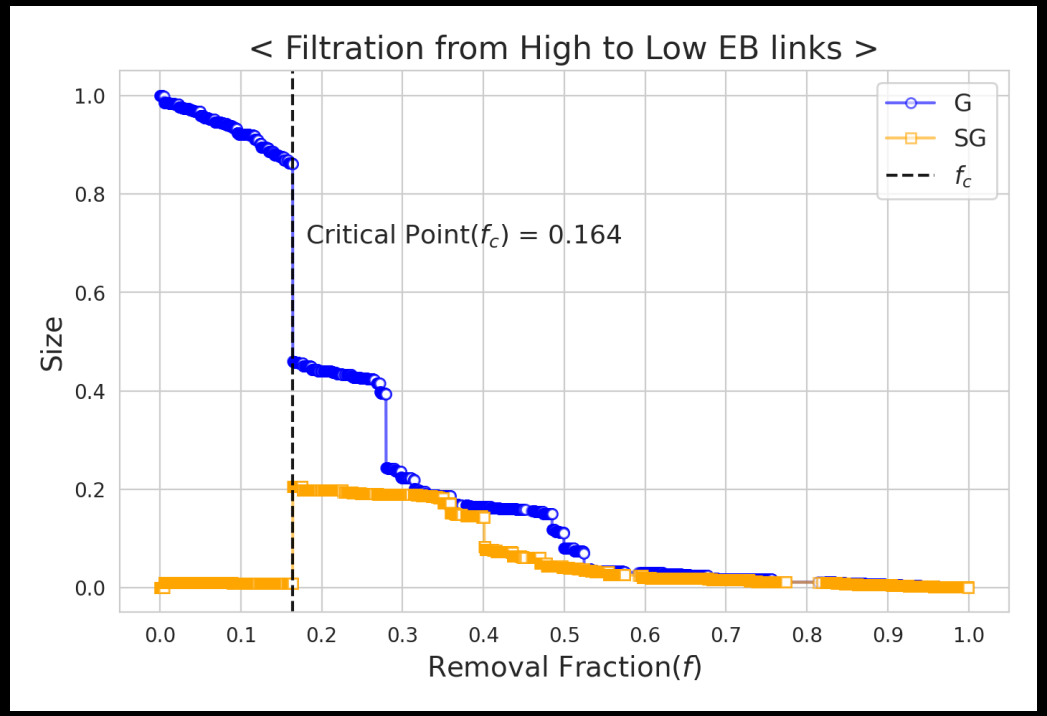


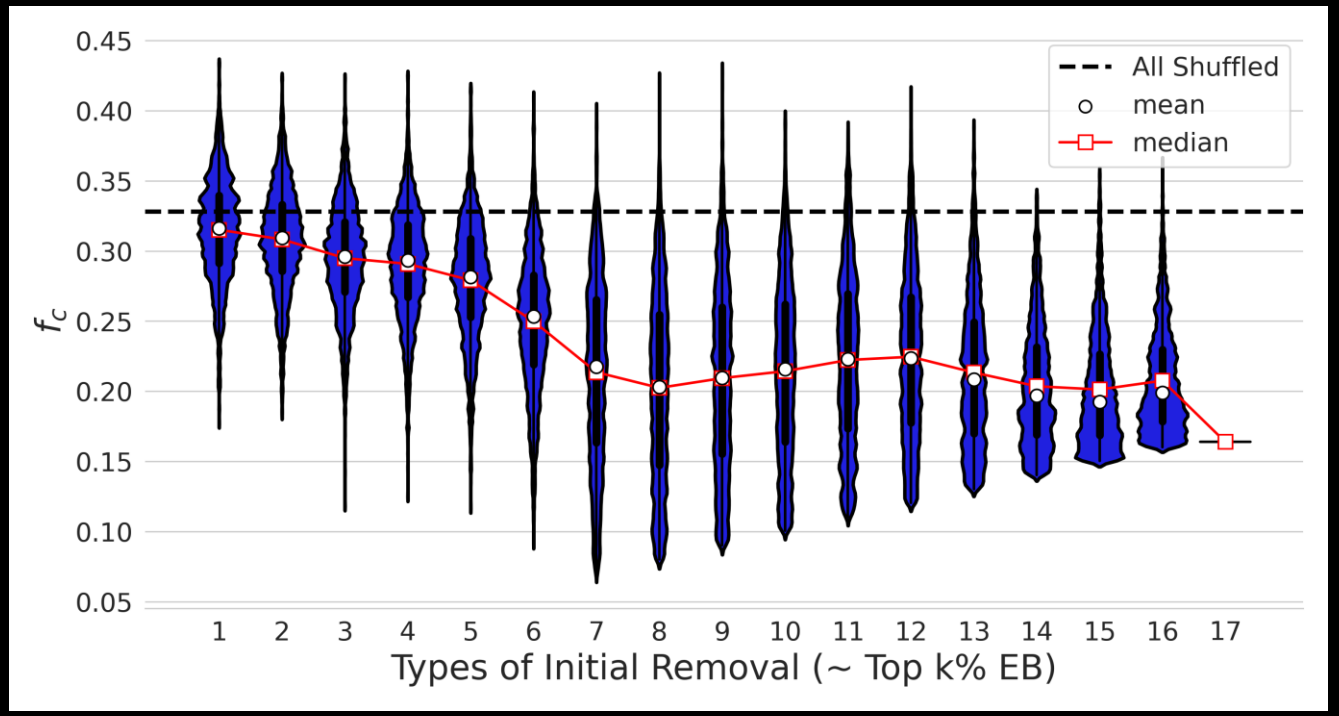


In (non-)rush hours,
the Highest EB flows
tend to be removed earlier(later)
during percolation processes.

> Highways vs. High EB roads

Zeng G, et al. (2019): Looking after the highways could be the aid of traffic management.





Our Management Viewpoint:
Not only fast on averaged(Highways),
but also **how Edge-Betweenness the roads** we should weigh on.

> Take-Home Messages

1. **Compared with appropriate null models,**
   the percolation approach to traffic gets more informative.
   >>> Disentangle the role of flow organization alone.
   >>> Get an explicit division b/w rush & non-rush hours.

2. **To enhance the global efficiency in traffic flows,**
   the highest EB roads would be a good starting point.

Many thanks for your attention.

> Appendix for Dataset : Seoul Traffic Network

- From the Seoul metropolitan government
- 1,813 intersection-nodes and 4,924 road-links
- Velocity record at 5-minute interval
  for each road segment (2020.12 ~ 2021.02)

- For each road e_{ij}, one defines road quality as

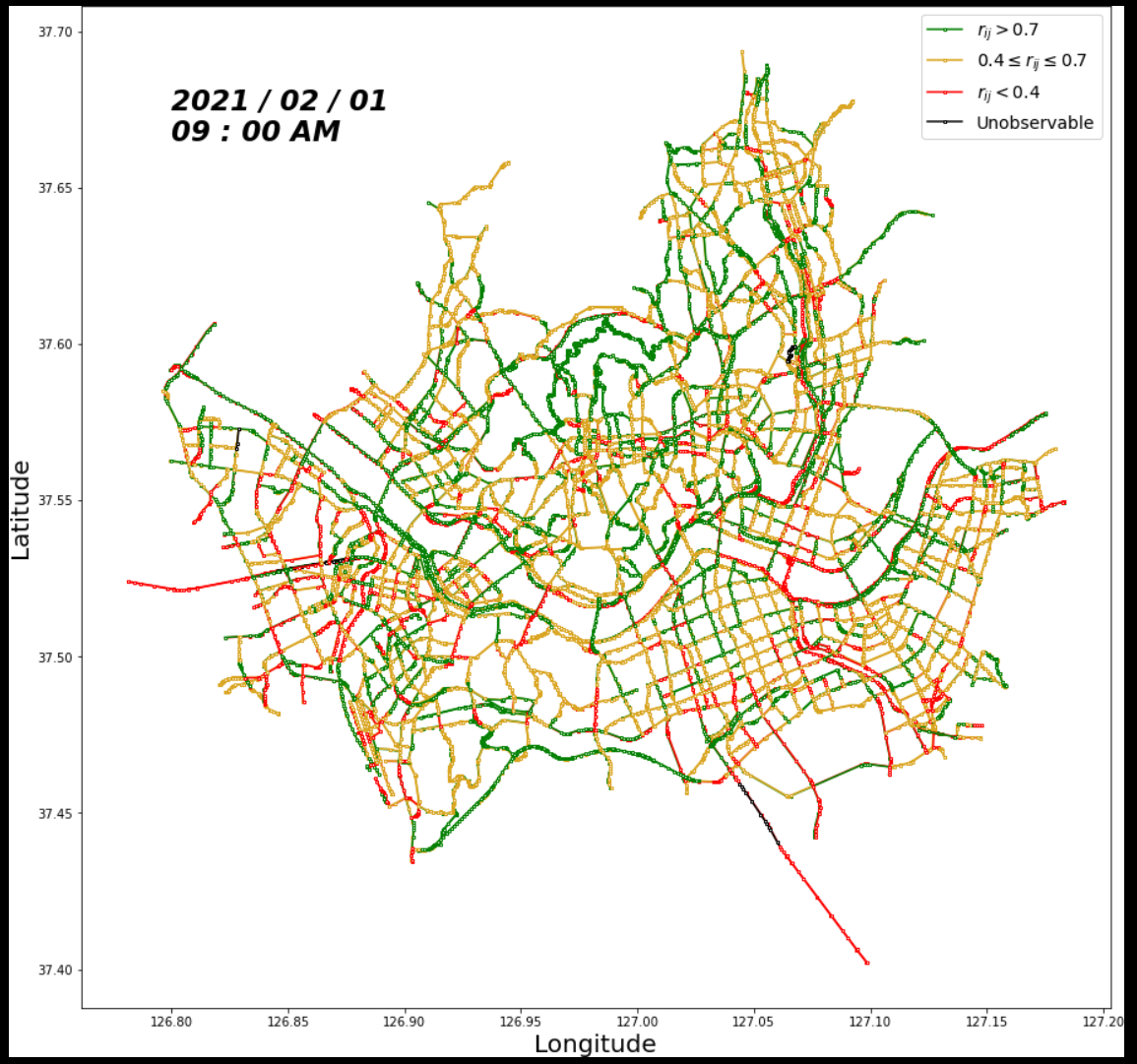
$$r_{ij}(t) = \frac{velocity\ at\ time\ t}{95th\ percentile\ of\ velocity\ at\ the\ day}$$

- For a given threshold q, road e_{ij} can be classified into two categories:

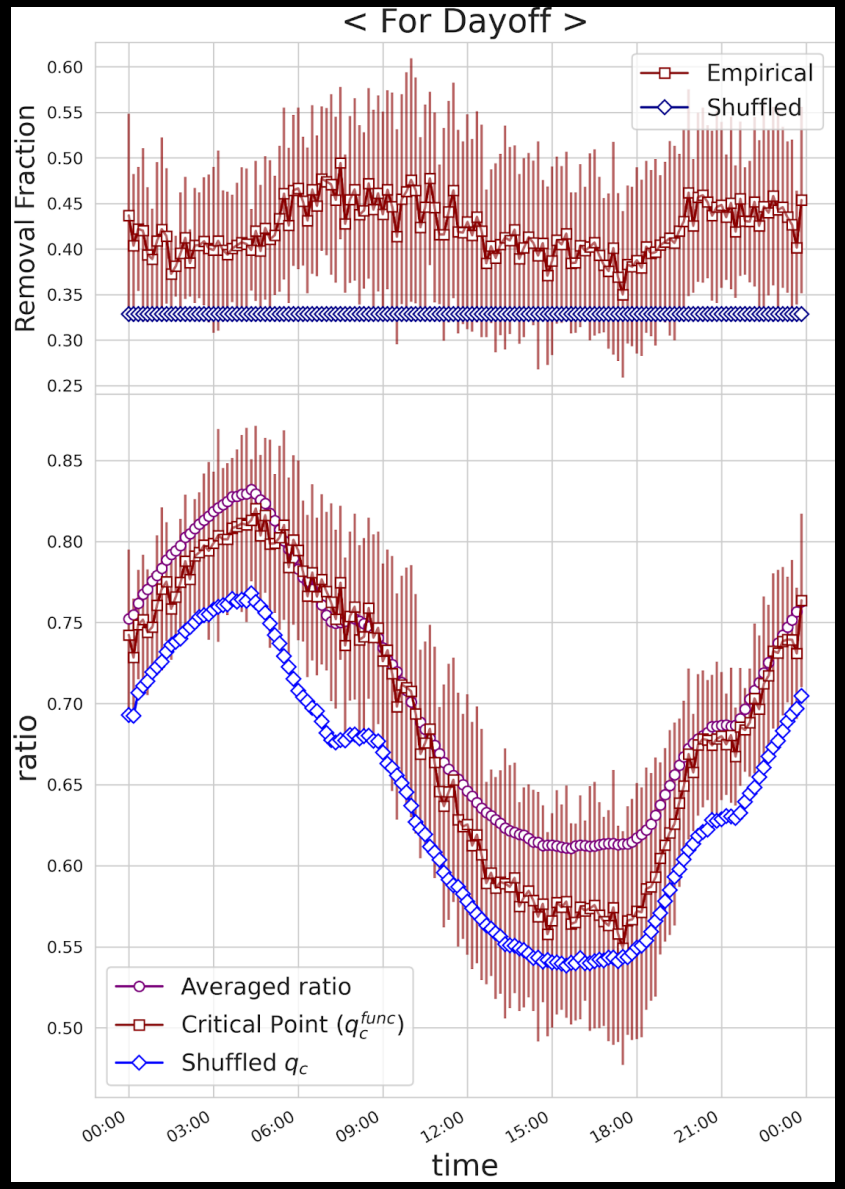
$$e_{ij} = \begin{cases} 1, & r_{ij} \geq q \\ 0, & r_{ij} < q \end{cases}$$

(Alive)

(Failure)



> Appendix for Days-off



> Appendix for other EB roads (Periphery roads)