LABORATOIRE AMÉNAGEMENT ÉCONOMIE TRANSPORTS | TRANSPORT URBAN PLANNING ECONOMICS LABORATORY

Spatio-temporal patterns of the impact of COVID-19 on public transit: an exploratory analysis from Lyon, France

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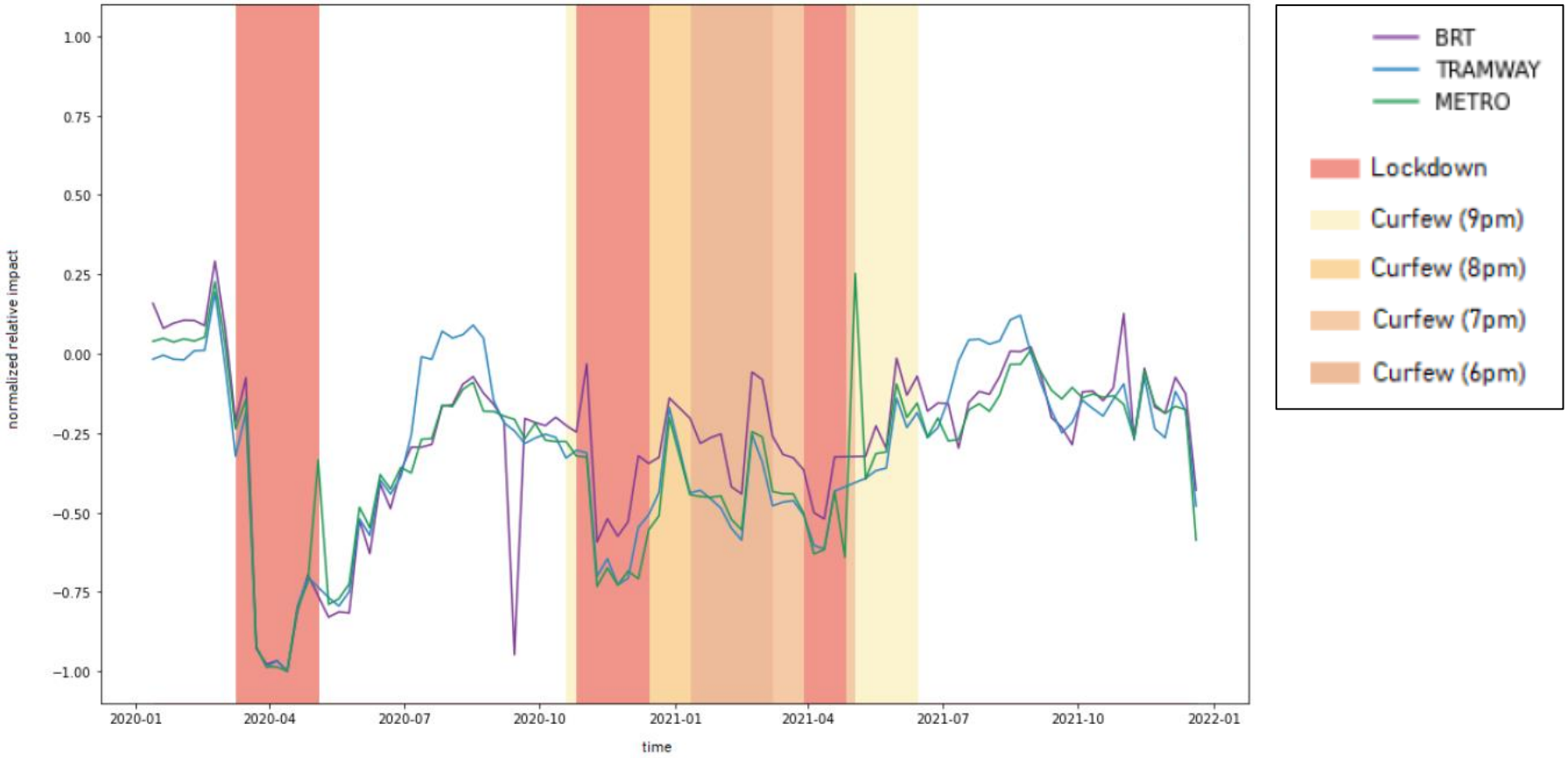
(1) Context: COVID-19 mitigation measures in France

(Fig1): Relative evolution of public transit ridership in Lyon in 2020 and 2021 (ref. :2019) per transit mode



(2) Data

- Automatic Fare Collection (AFC) data recorded **from January 1st 2019 to December 31st 2021**:
  - Spatial resolution : **stop level**
  - Temporal resolution : **day level**

- For each week, if there is at least one day without data, **the whole week is deleted**.

- **3 modes** accounting for 80-90% of the total amount of validations:

Subway **(SUB)**	Tramway **(TRA)**	Bus Rapid Transit **(BRT)**
• 40 stops • 6 105 daily records	• 88 stops • 13 199 daily records	• 520 stops • 76 475 daily records

(3) Methods

- **Intensity**: measurment of the magnitude of the impact of COVID :

$$X_{s,y,w,d} = \frac{dem[s,w,d]_{ref} - dem[s,w,d]_y}{max_{s,d}(|dem[s,d]_{ref} - dem[s,d]_y|)} \quad \textit{(Eq.1)}$$

$$I_{\mathrm{w,s}} = [X_{s,y,d=MON}, X_{s,y,d=TUE}, ..., X_{s,y,d=SUN}] \quad \textit{(Eq.2)}$$

- **Recovery**: ability for a stop to recover to pre-COVID-19 levels over time

- **Stability**: ability for a stop to belong to a same group of stops which share common properties over time

$$G_y(s) = \frac{dem[s]_y - dem[s]_{ref}}{dem[s]_{ref}} \quad \textit{(Eq.3)}$$

(3) Methods - Intensity

Reference demand data
(daily time serie 2019, stop level)

Current demand data
(daily time serie 2020, 2021, stop level)

Normalized difference stored in week vectors
(stop, weekdays)

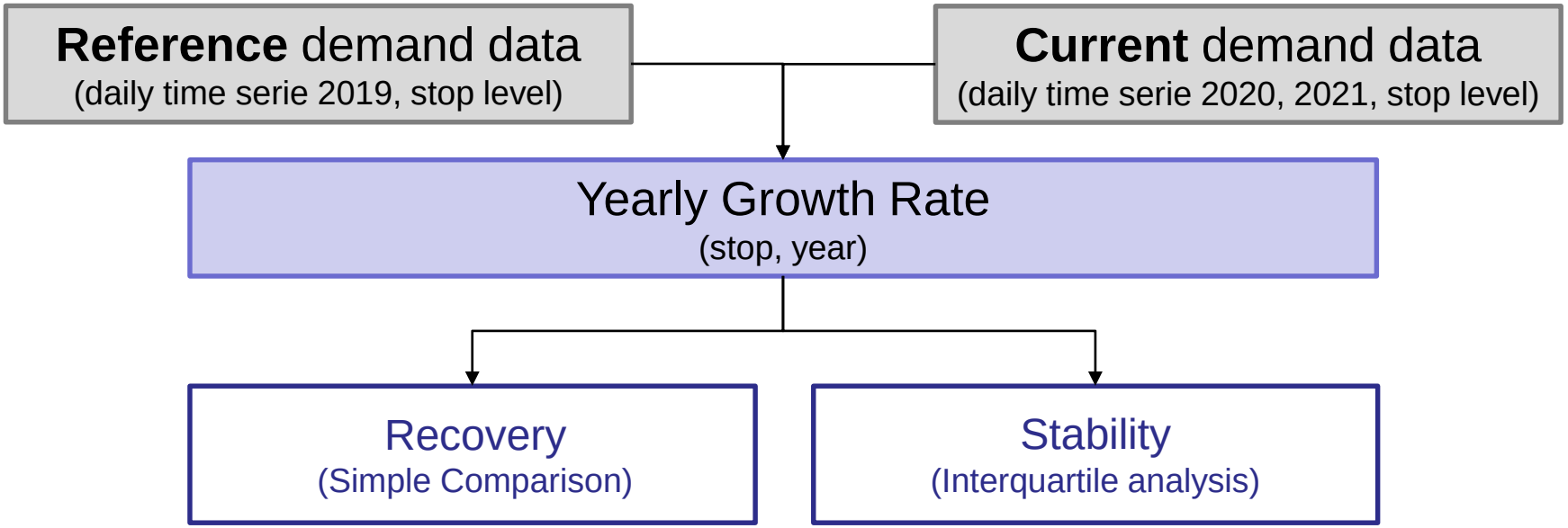
1st clustering: K-means + HC (Stop-week vectors)

			$I_{y,w,s}$						
Stop (s)	Year (y)	Week (w)	$X_{s,y,MO}$	$X_{s,y,TU}$	$X_{s,y,WE}$	$X_{s,y,TH}$	$X_{s,y,FR}$	$X_{s,y,SA}$	$X_{s,y,SU}$
AMPERE	2020	2	-0.025	-0.060	-0.073	0.056	-0.017	0.126	0.095
AMPERE	2020	3	0.016	0.033	-0.020	0.098	0.015	-0.011	0.094
AMPERE	2020	4	0.052	0.086	0.044	0.023	0.055	-0.124	-0.007
...	...	...	...	...	...	...	...	...	...
VIEUX LYON	2021	50	-0.175	-0.361	-0.006	-0.068	-0.001	0.058	-0.050
VIEUX LYON	2021	51	-0.178	-0.260	-0.201	-0.173	-0.201	-0.219	-0.027

2nd clustering : K-means + HC (Stop vectors)

	P_s			
Stop (s)	$P_S(C_1)$	$P_S(C_i)$	...	$P_S(C_n)$
AMPERE	0.49	0.13	...	0.11
BELLECOUR	0.49	0.28	...	0.13
...	...	...	...	...
...	...	...	...	...
VIEUX LYON	0.66	0.27	...	0.06

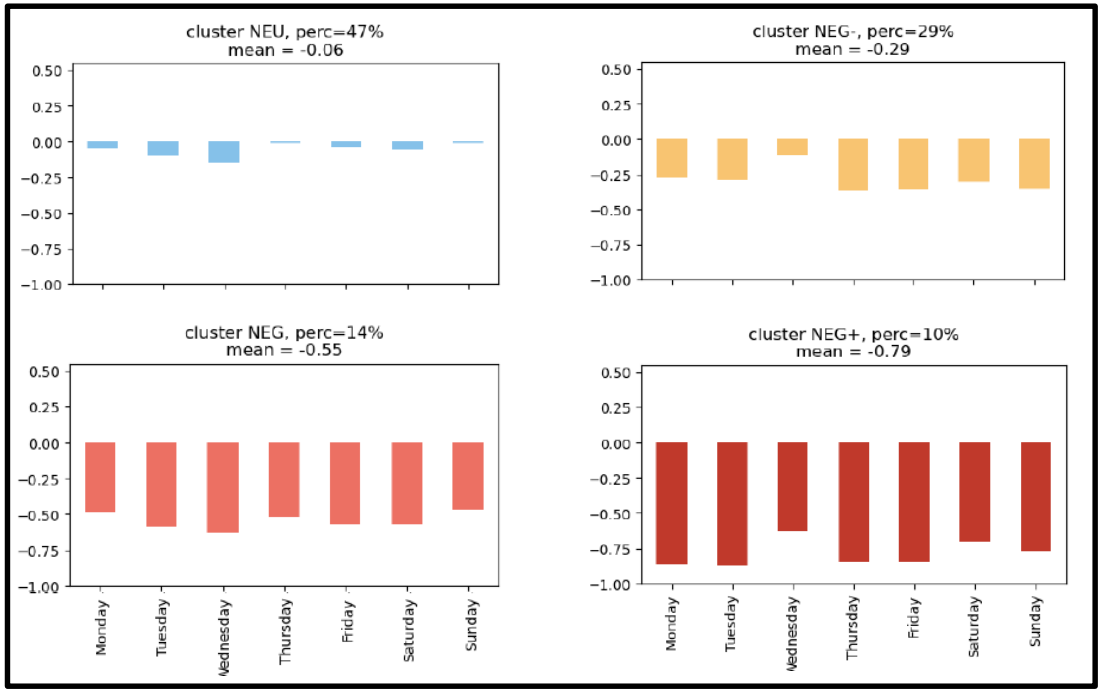
(3) Methods – Recovery and Stability



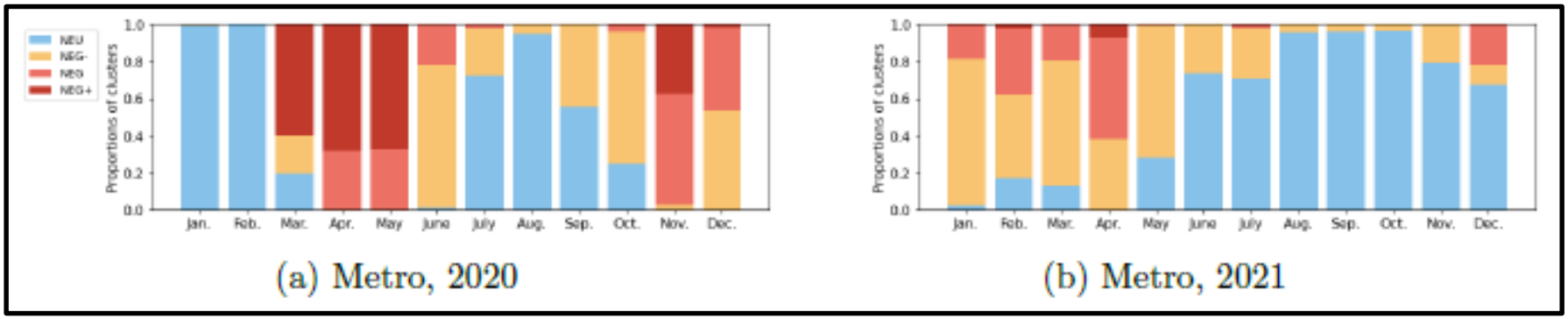
(4) Results – Intensity: temporal analysis **[SUB]**

- Intra-week variablity :
  - **NEG-,NEG+:** Difference between week-ends & wednesday / weekdays
  - **NEG** : Work-from-home effect ?
- Annual variability:
  - Follows mitigation measures
  - Apparition of **NEU** cluster when no mitigation measures are implemented

(Fig2): Stop-week cluster centers

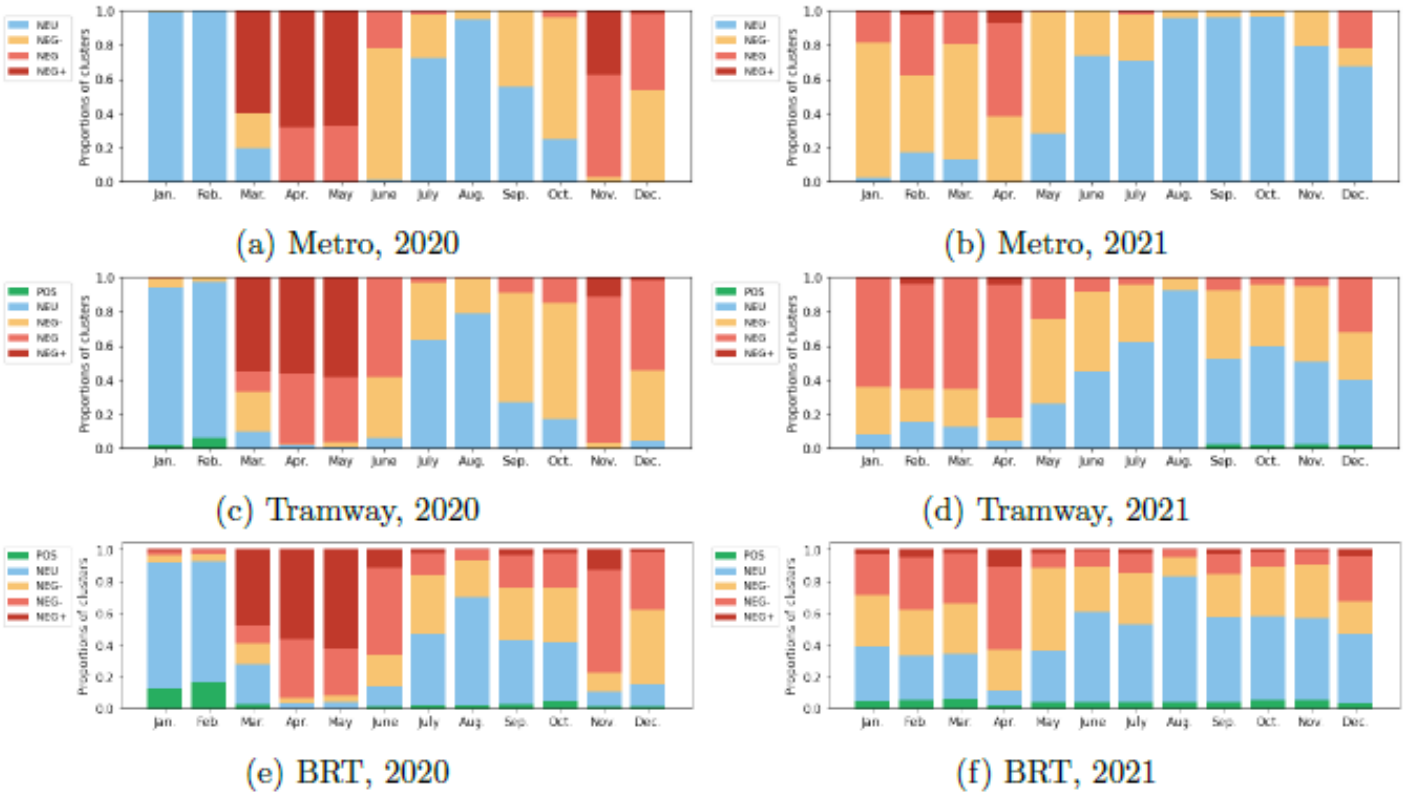


(Fig3a): Monthly cluster membership



(4) Results – Intensity: temporal analysis [SUB & TRA & BRT]

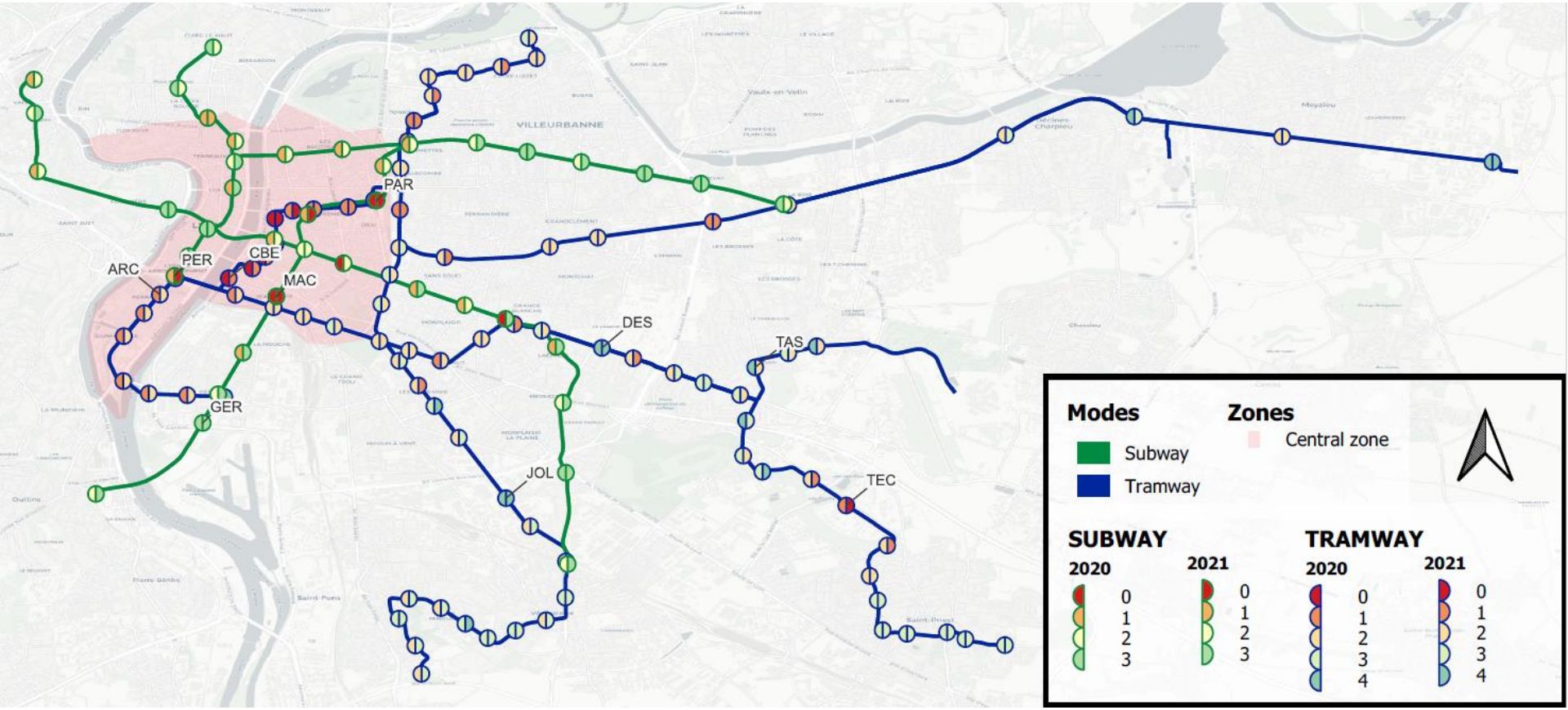
- Inter-modal variability :
  - **SUB** : short-lasting effects of COVID-19 (**NEU** represents >90% of weeks after summer holidays 2021)
  - **TRA & BRT** : long-lasting effects of COVID-19 (**NEU** represents between 40% and 60% of weeks after summer holidays 2021)



(Fig3b): Monthly cluster membership (all modes)

(4) Results – Intensity: spatial analysis **[SUB & TRA]**

(Fig4): Map of clustered subway and tramway stops in 2020 (left-hand symbols) and 2021 (right-hand symbols)

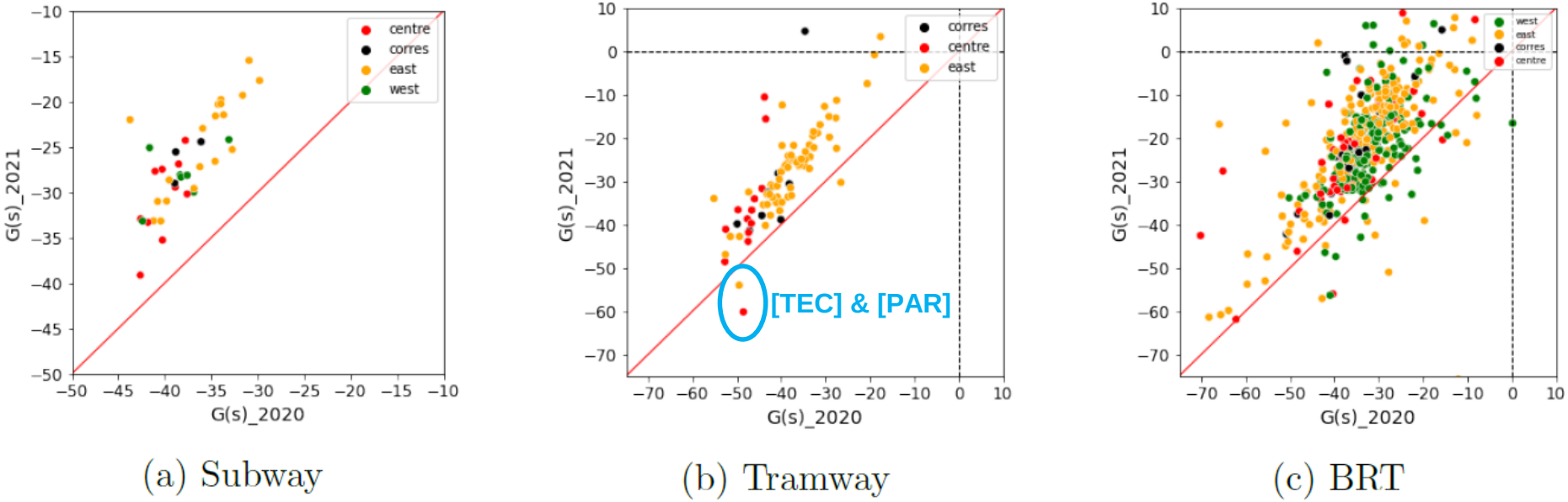


- Stop variability (examples):
  - Transfer stops with regional or national train lines (**[PER], [PAR]** and **[MAC]**) are more likely to be impacted
  - **[TEC]** shows a significant drop in 2020 and 2021. This stop serves mainly for commuting
  - Low decline in demand is observed near medical facilities **[DES]**, and supermarkets **[JOL]**

(4) Results – Recovery **[SUB & TRA & BRT]**

- Zonal variability:
  - central stops recover worse than peripheral stops
  - To a lesser extent, west stop recover worse than east stop

- Inter-modal variablity:
  - SUB > TRA > BRT



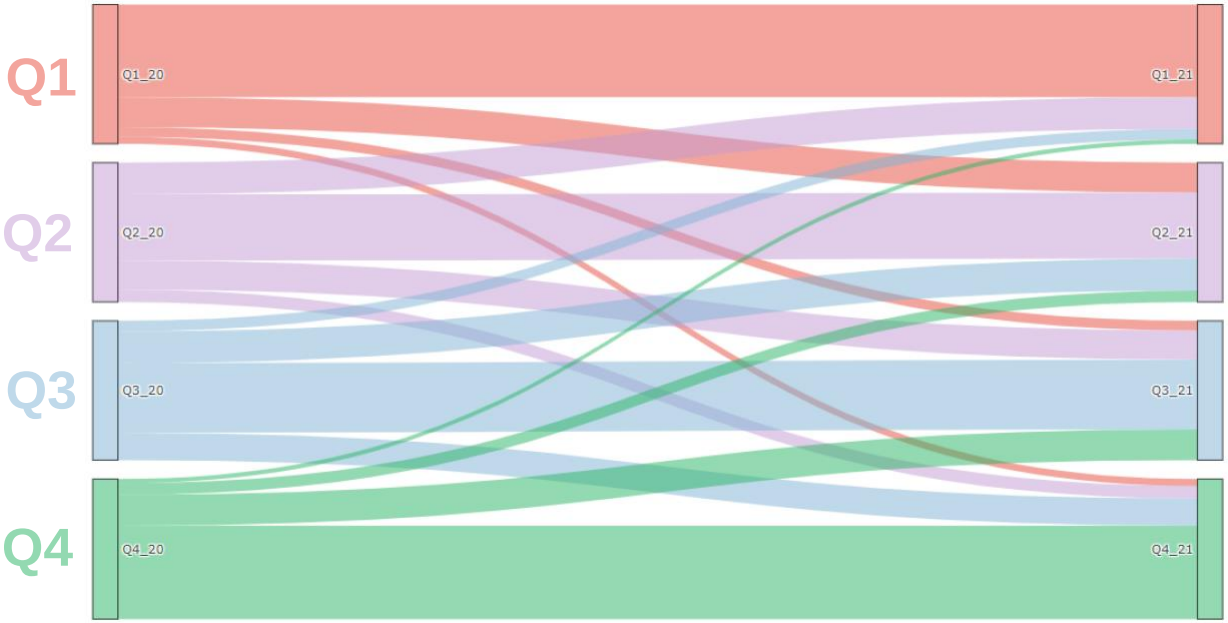
(a) Subway (b) Tramway (c) BRT

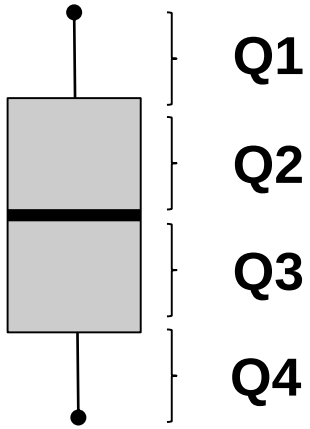
(Fig5): Evolution of the Growth Factor for each stop from the zone aggregation perspective

(4) Results – Stability **[SUB & TRA & BRT]**

- Stability analysis can give insights for public policies to take local actions on specific stops and or groups of stops.

- Tramway appears to be the most stable mode (73%), followed by subway (60%) and BRT (57%).





(Fig7): Sankey diagram showing the relation between groups of stops (interquartiles) in 2020 and 2021 for all modes

(5) Conclusion & Discussion

	SUBWAY	TRAMWAY	BRT
Intensity	Short-lasting (2^{nd})	Long-lasting (1^{st})	Long-lasting (3^{rd})
Recovery	Spatially consistent (1^{st})	Spatially consistent (2^{nd})	Few spatial consistency (3^{rd})
Stability	Stable (2^{nd})	Very stable (1^{st})	Stable (3^{rd})

- Provides insights on **where and when to focus ressources during or when overcoming a large-scale demand crisis** (spatial and temporal variability are observed)

- **PT stops are relatively stable** in their recovery trajectories

- Spatial analysis gives insights on the kind of activity that still need or need less public transport offers under crisis conditions. **This calls for an explanatory analysis based on territorial data** for further studies**.**

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Thank you! Any questions?

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