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Effect of City size on Mode-choice behaviour: Before and After COVID-19

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Introduction and Background

- The substantial impact of COVID-19 restrictions was seen in the daily travel patterns of individuals and households, including the mode of travel.
- **Beck & Hensher [3]** reported an increase of 20% from 14% in walking and cycling, whereas public transport share fell to 7% from 14% in Australia.
- **Bucsky [4]** found an increase in car usage to 65 % and a reduction in public transport from 43% to 18% in Budapest, Hungary.
- **Paul et al. [2]** found that individuals were found to prefer walking, private vehicles, and rickshaws over public transportation in Dhaka, Bangladesh.
- **Srikanth et al. [8]** found that the share of public transportation for work trips was 31.89%, 5.83%, and 21.31% before, during, and after COVID-19, respectively, in Bangalore. Whereas the share of private modes for work trips increased to 45.43 % (after) and 56.07% (during) from before COVID-19 level of 38.35%.
- Based on a stated preference survey, a study in Delhi, Bangalore, and Kolkata found that the largest decrease in the modal share would be seen in the metro (9%), followed by the bus (4%). In contrast, the share of private cars and two-wheelers would increase by 10% in post COVID-19 period [9].

- It was believed that the changes witnessed due to COVID-19 would be temporary, and the travel pattern of individuals will resume to pre-COVID-19 times due to multiple reasons [10].

However, the argument remains a subject of examination if city size is considered.

- As the **city size increases**; the **commuting distance increases** due to work opportunities nearby and in the city.
- **Bigger cities** tend to have extensive networks of **public transport** and have a presence of **ride-sharing services**
- The variations in the travel opportunities in different-sized cities might have had different effects on travel behavior under COVID-19 restrictions and during the new normal.
- The present study aims to compare the change in mode choice behavior for work and non-work trips before, during, and after COVID-19 circumstances, by modelling the city size (i.e., population).

Descriptives

Variable	Levels	% Share
Gender	Male	58.4
	Female	41.6
Age (years)	18-24	23.8
	25-34	67.7
	35-44	4.7
	Above 45	3.8
Reasons to buy a vehicle	No purchase	78.8
	COVID-related	8.1
	Independence	9.0
	Wish to buy	2.3
	Other	1.7
City Class (population in million)	More than 10 Lakh	43.9
	10 Lakh- 5, Lakh	14.8
	5 Lakh- 1 Lakh	29.4
	1 Lakh- 50,000	1.2
	50,000- 20,000	5.8
	20,000- 5,000	3.5
	< 5,000	1.5
Education	Secondary	8.4
	Sr. Secondary	5.8
	Diploma	3.5
	Graduate	45.9
	Above graduate	36.3

Variable	Levels	Pre-COVID-19 % share	Post-COVID-19 % share
Income (in thousands)	< 10	25.6	27
	10-30	25.9	20.3
	30-50	21.2	21.8
	50-100	20.9	23.3
	>100	6.4	7.6
Household Size	1	0.9	0.9
	2	8.7	7.6
	3	23.8	24.1
	4	41.0	38.1
	5	13.4	14
	6	12.2	15.4
No. of Bicycle	0	45.6	45.1
	1	40.1	39
	2	12.8	14.5
	3	1.5	1.5
Motorized 2-wheeler	0	29.7	22.4
	1	39.2	42.7
	2	24.7	26.5
	3	6.1	8.1
	4	0.3	0.3
Car	0	64.2	59.6
	1	28.5	31.7
	2	5.2	6.1
	3	2	2.6

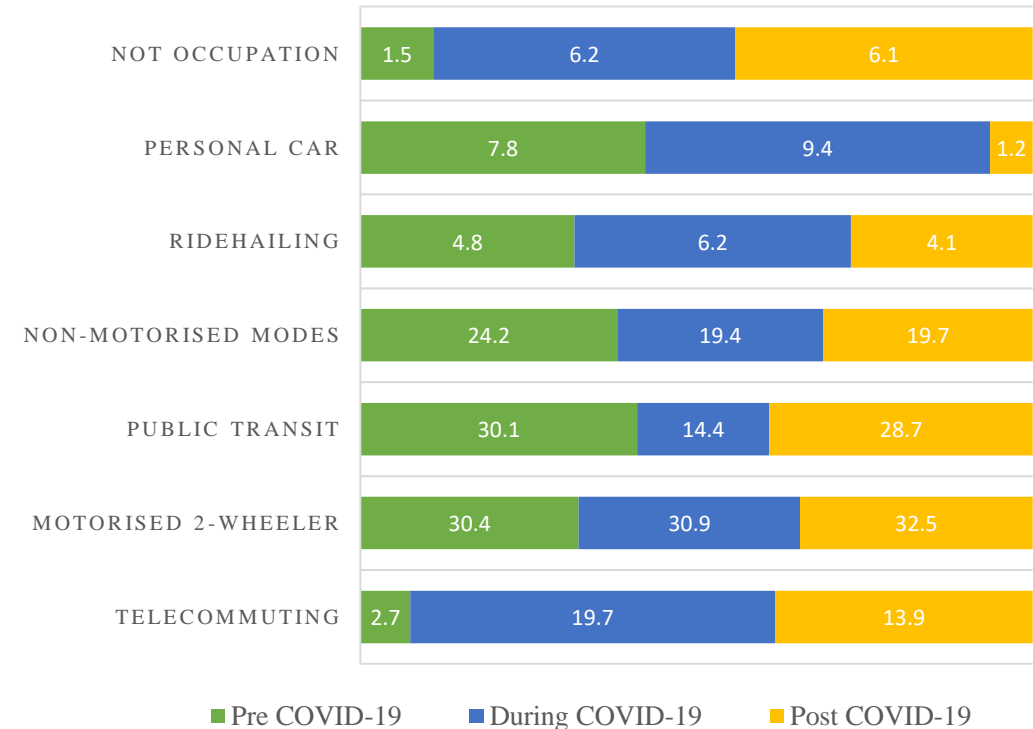
- **FIXED** Variables: Gender; Reason to buy vehicle; City Class; Education level.
- **CONTINUOUS** Variables: Income; Household size; No. of bike, Motorized 2-wheeler, Car.
- Age was recorded as age group. So, its transition over the COVID-19 period could not be known. Hence, AGE was taken to be a **FIXED** variable.

Results

- Paratransit (auto-rickshaw/ e-rickshaw) was predominantly used as an access mode for public transport modes. Hence, paratransit was merged with public transportation.
- Likely due to fear of infection and personal safety, **Public Transit** share reduced from 30% to 14%. After COVID-19, share again rose to 29%.
- *During COVID-19*, share of **Personal cars** increased from 7.8% to 9.4 %.
- *Post-COVID-19*, a share of 1.2 % suggests that individuals shifted to personal cars after restrictions were repealed.
- *During COVID-19*, share of **Private two-wheelers** increased by ~ 10%, with negligible reduction post-COVID-19.
- The share of ride-hailing services (**RHS**) during the whole analysis period is almost elastic.
- *During and post-COVID-19*, share of non-motorized transport (**NMT**) (walking and cycling) fell.

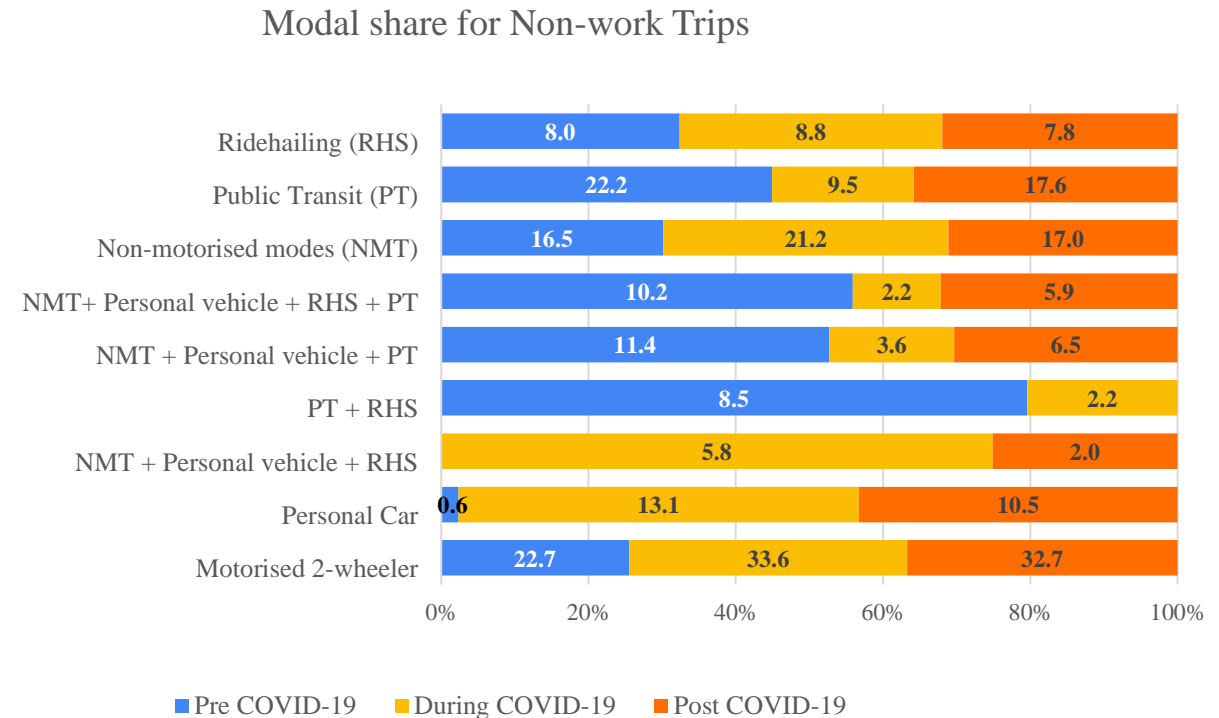
WORK Modal Share

MODE SHARE FOR WORK TRIPS



- For Non-Work (discretionary) purpose, people tend to use various modes depending upon the distance.
- *During COVID-19*, share of **Public Transit (PT)** reduced from 22% to 9.5 % - *Post COVID-19*, it could not reach early share levels.
- **Ride-hailing (RHS)**, **Personal cars**, and **Motorized 2-wheelers**, which increased by 0.8%, 12%, and 10% *during COVID-19*, and *post-COVID-19*, sustained growth of (-0.2%), 10%, 10%, respectively.
- Although there has been a decrease in the modal share of RHS alone, a large share of people selecting the combination of 'NMT, Personal vehicle, and PT' shifted to 'NMT, Personal vehicle, and RHS' (7%). Even after the relaxation of restrictions, the modal share of the former combination recuperated only by 3%.
- The increase in the modal share of Personal vehicles and Motorised 2-wheelers during and after COVID-19 suggests a possible increase in vehicle ownership during the period.

Non-WORK Modal Share



MNL model

- The Before and After COVID-19 mode choice models have McFadden R-square of **0.27** and **0.38** respectively. As per Louviere et al. (2012), this is an excellent fit.
- Mode choice for personal car for commuting post-COVID was not significant.
- The reason behind the drastic decrease in car commuting may be popularizing of Telecommuting and rapid increase in fuel price.

	Before COVID-19				After COVID-19			
	Non-Motorised modes	Ride hailing	Motorized Two-wheeler	Personal Car	Non-Motorised modes	Ride hailing	Motorised Two-wheeler	Telecommuting
ASC	-11.3	-24.25	-16.7	-13.9	-18.00	-15.7	-20.1	-18.35
Household members	-0.324 (0.1)	-1.3 (0.001)	-0.48 (0.02)	-2.3 (0.02)	-0.33 (0.09)	-0.53 (0.12)	-0.419 (0.04)	-0.31 (0.14)
No. of Bicycle			-0.39 (0.15)					0.87 (0.007)
No. of Motorized Two-wheeler			1.6 (0.00)	-3.4 (0.007)	0.65 (0.04)		2.28 (0.00)	0.558 (0.09)
No. of Personal cars		1.15 (0.06)	0.91 (0.007)	6.7 (0.002)	-0.83 (0.03)		-0.48 (0.12)	0.79 (0.03)
Male (w.r.t. Female)	0.624 (0.12)		1.09 (0.008)				0.989 (0.02)	
Age Group (ref. 45+ years old)								
18-24 years old				-4.85 (0.1)		-2.8 (0.18)		-1.96 (0.09)
25-34 years old				7.3 (0.06)				
35-44 years old								
Education (ref. post-Graduate and above)								
High-school	-2.9 (0.008)							2.36 (0.04)
Senior Secondary	2.8 (0.05)		3.5 (0.016)		1.64 (0.09)			1.49 (0.14)
Diploma					3.5 (0.03)			2.12 (0.09)
Graduate	-1.4 (0.003)				-0.85 (0.08)	1.4 (0.1)		
Income (ref. 100,000 and above)								
Less than 10,000						-3.64 (0.05)		-2.3 (0.008)
10,000- 30,000			1.11 (0.17)				1.74 (0.08)	-1.31 (0.15)
30,000- 50,000						-2.6 (0.13)		
50,000- 100,000		-2.01 (0.07)		5.06 (0.07)				-2.11 (0.01)
City class (ref. Class 5 cities)								
Class 1	-2.7 (0.001)		-2.04 (0.04)				1.7 (0.13)	
Class 2	-2.5 (0.02)		-2.55 (0.03)					
Class 3			-1.9 (0.11)		1.35 (0.13)		2.8 (0.02)	
Class 4								
McFadden R-square:	0.27				0.38			
-2 Log-likelihood (initial):	1067.793				1123.71			
-2 Log-likelihood (final):	774.286				688.12			

Reference mode is Public Transit; Numbers in parentheses represent respective p-values

Discussion

Age

- The likelihood to commute by Car is highest for 35-44 year age group.
 - Before COVID-19, relative to 45+ year aged individuals, 25-34 year individuals were 5 times less likely to commute by car; 35-44 year individuals were 7 times more likely to commute
 - After COVID-19, car commuting was negligible (too less to be estimated).
 - Telecommuting and RHS were found to be least likely for the 18-24 age group.
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City Class

City size is inversely related to the likelihood of NMT, Motorised 2-wheeler as commuting modes. i.e., the Larger the city, the lesser the likelihood of commuting by NMT.

- After COVID-19, As compared to Class 5 cities, NMT is 1.4 times more likely to be used as a commute mode in Class 3 cities. For other cities, no pattern could be found and the results were not significant.
- After COVID-19, As compared to Class 5 cities, Motorised 2-wheeler is 3 times and 1.7 times more likely to be used as a commute mode in Class 3 and Class 1 cities respectively cities.

Gender

- Male are more likely to commute by **NMT (0.6)** and **Motorised 2-wheeler (1.09)**.
- This may also reflect the **gender difference** in workforce participation and **mobility preference**.
- Male are more likely to commute by **Motorised 2-wheeler (0.99)** . However, there seems to be a small modal shift post-COVID

Household size

- As family size increases, the likelihood of commuting mode in **decreasing order** is: *Public transit, NMT, Motorized 2-wheeler, RHS, Personal Car*
- As **family size increases**, likelihood of telecommuting decreases.

Income

- Increase in income increases the likelihood of commuting by motorised 2-wheeler, and car.
- However, very high income group tends to refrain from using RHS.
- Lower income groups (< 30K per month) are less likely to opt Telecommuting, with the probability increasing with income.
- At the same time, very high income group are also less likely to opt for telecommuting.

Existing Motorised 2-wheeler

- Increase in motorised 2-wheeler ownership, **increases** likelihood of commuting by the **same mode**.
- At the same time, it **reduces** likelihood of **car commuting**
- At the same time, it increases likelihood (**0.6**) of **telecommuting**.

Existing Personal Car

- Car ownership generally implies high income, leading to the commute mode choice (in decreasing order):
Personal car, RHS, Motorised 2-wheeler.
- Increase in car ownership, **decreases** the likelihood of commuting by NMT and Motorised 2-wheeler
- Increase in car ownership, it increases likelihood (**0.8**) of **telecommuting**.

Conclusion

- The MNL model results indicate increased 2-wheeler commuting in smaller cities post-COVID. Smaller cities are more NMT-friendly, with less traffic making people feel safe and inclined to continue NMT use. This highlights the need for policies and infrastructure development to support NMT.
- During COVID-19, people turned to personal vehicles out of necessity. After restrictions eased, the continued use of personal vehicles suggests convenience, independence, and safety as factors. To promote sustainability, improving public transit is crucial.
- Smaller cities, limited in scale for full bus transit systems, can explore well-regulated paratransit services as a solution. In cities with bus transit, combining paratransit and buses through dynamic scheduling can create a mutually sustainable scenario, despite competition concerns.
- Motorized 2-wheelers gained popularity during COVID and continued as a preferred commute option afterward. Telecommuting can help alleviate peak-hour congestion, but strategies are needed to discourage vehicle ownership and enhance public transit.
- After COVID-19, increased car ownership led to more recreational trips. The increase in time spent at home during COVID, combined with reduced public transit availability, shifted "eating out" to online ordering, reducing household travel but increasing local delivery trips.

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