The Influence of Rainfall on the Mode Shifting Behavior of Commuters: The Case of Ortigas CBD Workers

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Abstract: This paper presents an analysis of how rainfall influences the mode shifting behavior of CBD work-to-home commuters in Metro Manila, Philippines. After collecting data using a questionnaire survey, the analysis shows that the fare, travel time, walking time, waiting time, reliability, comfort and safety of the modes servicing the CBD significantly changes during heavy and intense rainfall. The level of switching to other alternative public transport modes is at 17.67%, 39.33% and 44.67% during light rain, heavy rain and intense rain respectively. GrabCar/Uber gains the most patronage while FX/van loses the most as rainfall intensity increases. The binary logistic regression analysis done shows that the decrease in reliability in public transport modes trigger mode shifting.

Keywords: rainfall, trip decisions, mode shifting behavior

1. INTRODUCTION

The Philippines is a typhoon-prone country due to its proximity to the Pacific Ocean. With the prevailing weather conditions and the worsening effects of climate change, Filipinos are exposed to varying intensities of rainfall. These adverse weather conditions caused by typhoons and frequent, short-lived thunderstorms continue to disrupt major urban activities especially transportation services. While heavy rainfall is nothing new in the metropolis, efforts should be made to make the transportation system climate resilient.

The effects of heavy rainfall are greatly felt by the commuters. According to the study conducted by JICA in 2015, 48.8% of the trips made in the metropolis utilize the existing public transportation system. This issues a pressing need to raise the quality of public transport services because many commuters rely on to take them to their respective destinations. This quality of services is particularly tested during occurrences of rainfall. Commuters then tend to adjust to the effects of rainfall by modifying their typical travel behavior.

This research aims to understand how rainfall affects the attributes of different public transport modes and consequently the mode shifting behavior of commuters. The understanding of the disruptions cause by rainfall on the commuters will serve as a valuable input in the evaluation of appropriate transport system improvement measures in the future. The Ortigas Central Business District (CBD) was chosen as the study area due to its strategic location at the center of the metropolis and the availability of various public transport modes such as the MRT, buses, jeepneys, FX/vans and taxis. CBD workers who commute to their homes during the afternoon peak hours were chosen as the respondents because they have relatively more flexibility in travel-related decision making. A survey was conducted to obtain information on the mode choices of workers during different rainfall intensities and the corresponding changes in their perception of important transit attributes.

2. LITERATURE REVIEW

One of the commonalities of prior researches tackling the relationship of weather and transportation is that the intensity of rain was considered essential in understanding the effects of adverse weather in transport demand and behavior. The US Highway Capacity Manual 2000 differentiates the reduction in capacities and speeds depending whether the occurrence of rain is light or heavy. According to the manual, the reduction in capacity during rainfall can reach up to 15% while the speed is reduced from 2% to 14% during light rains and between 5% and 17% during heavy rains. The study of CTRE (2005) even includes trace rainfall in its analysis although the effects were not found to be significant, compared to light and heavy rains. Eisenberg (2004) also related the intensity of precipitation with the probability of traffic crash accidents happening. Considering this commonality in previous studies, this research will also adopt such concept in which the travel decisions of commuters will also differ according to the rainfall intensity they encounter such as no rainfall, light rainfall, heavy rainfall and intense rainfall.

A number of researches have focused on the influence of weather on travel behavior specifically mode choices. The results of Sabir *et al*. (2010) in the Netherlands show that the substitution between different modes varies according to the intensity of precipitation. During average precipitation, there is a strong substitution from bicycle to bus, tram or metros but during extreme precipitation people prefer to use their private cars. The research of Liu *et al*. (2015) further asserts that the differences in the perceptions and expectations of people on intensities influence their mode choices, what is cold to one may be normal to another and these also vary depending on the study area. Changes in travel behavior in response to the weather condition found in prior studies may not be applicable due to variances in the characteristics of transportation systems, trip makers' decision making considerations and the respective climates of two or more different localities. This is exemplified by varying results from literatures coming from two different locations. In the study of Tao *et al*. (2016) in Brisbane, Australia heavy rain increases bus ridership while in the research of Stover *et al*. (2012) in Pierce County, Washington bus ridership has decreased because of rainfall.

A study that determines the influence of rainfall on both mode choice and departure time is that of Khattak *et al*. (1997) which addresses the need to understand the response of commuters to weather conditions especially in a country experiencing frequent adverse weather. Using the questionnaire method and ordered probit models, it was discovered that weather has a stronger influence on departure time compared to mode choice and route choice. Cools *et al*. (2010) also provides evidence that heavy rain has an effect on the timing of commuting trips in which people will postpone their trips until weather becomes better more than changing the transport mode, trip cancellations or changing the routes being taken.

While there is a lot of research around the world regarding the relationship of rainfall and transportation, it is striking that the Philippines which is a typhoon prone country lacks literature on the matter. On the macro scale Abad *et al*. (2016) relates the accessibility of transportation and housing affordability using data from household interview surveys in Metro Manila. The study takes into consideration the effect of flooding in the access of transportation services under three scenarios namely normal conditions, flooded with terminated transport services and flooded with shortened transport services. It assumes that operators of transport services will either not run their fleet due to disruptions along their route or they will shorten their services when they reach flooded areas.

Another study in the local setting is Ibasco *et al.* (2016) which focuses on the travel behavior of students during heavy rainfall and flooding. Using a questionnaire, college students were asked regarding their commuting trips under normal conditions and bad weather specifically with strong rains and flooding. The study concluded that increased flood levels cause corresponding increase in travel time, waiting time and cost. Around 74% of the respondents also stated that they tried alternative routes to avoid flooded areas. However, mode switching due to rainfall was not tackled in the study.

3. DEFINITION OF TERMS

The following are the definitions of the terminologies found in this research:

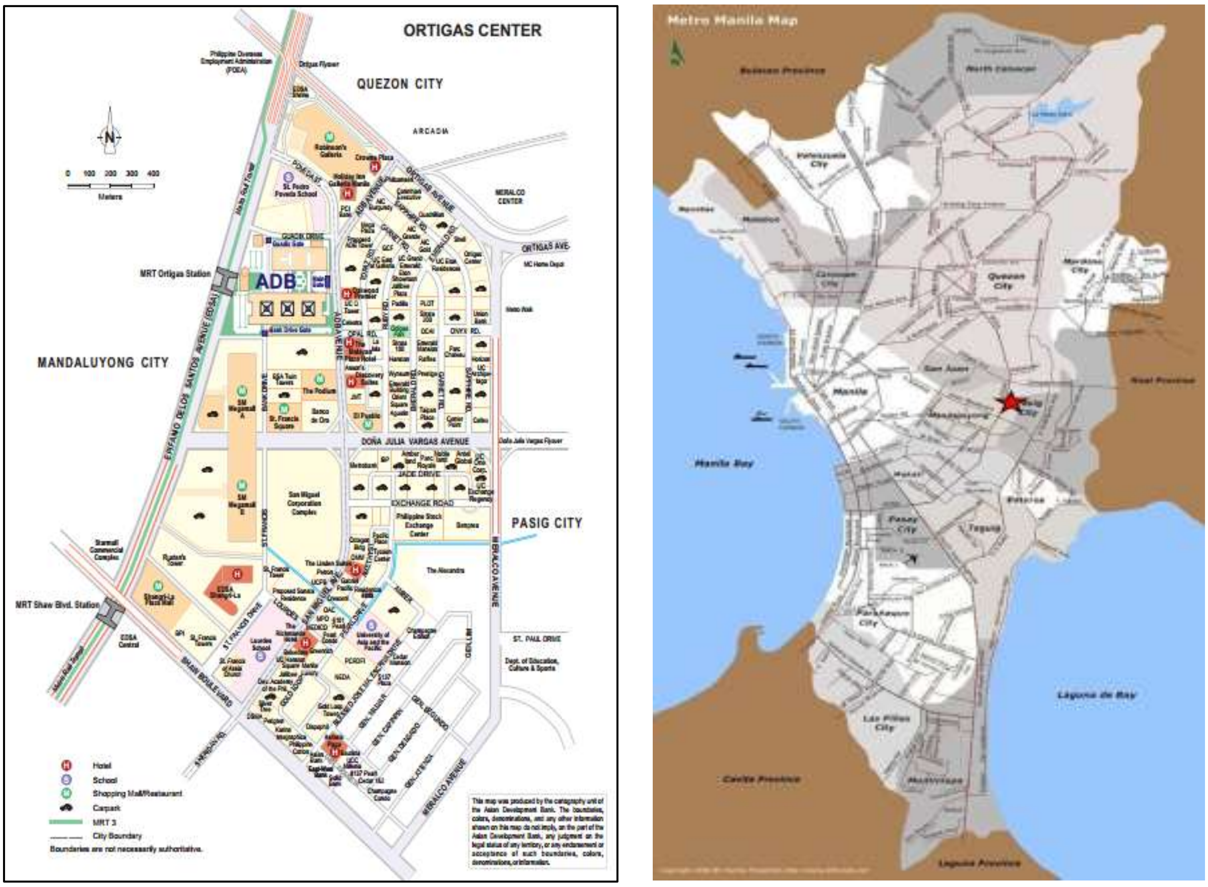
a. Commuter – term widely used in the Philippines to refer to users of the public transportation system.
b. Light rainfall – intensity of rainfall visualized as ambon or drizzle.
c. Heavy rainfall – intensity of rainfall illustrated as using an umbrella without getting wet.
d. Intense rainfall – intensity of rainfall explained as getting wet outside even while using an umbrella.
e. Fare – amount a passenger on public transportation has to pay.
f. Travel time – time spent by the passenger inside the vehicle.
g. Walking time - time spent by the passenger walking from the office building to the transport terminal or stop.
h. Waiting time – amount of time spent by the passenger from arrival at the transport terminal or stop to the departure of the vehicle used.
i. Service reliability – perception of the regularity of headways and consistency of arrival time of the fleet by the respondent.
j. Comfort – perception of the level of relaxation of the passenger while using transit.
k. Safety – perception of the potential of being injured while using transit by the respondent.
l. Security - perception of the potential of being a victim of a crime while using transit by the respondent.

4. STUDY AREA

Ortigas Central Business District (CBD) is arguably the second most important business district second to Makati CBD. It is bounded by EDSA to the west, Ortigas Avenue to the north, Meralco Avenue to the east and Shaw Boulevard to the south. The map of Ortigas CBD and its location with respect to Metro Manila is shown in Figure 1. The area is chosen for its strategic location in the metropolis and the availability of different transport modes to serve the commuters.

Public transportation services are available at the surrounding thoroughfares of Ortigas CBD specifically EDSA, Ortigas Avenue, Shaw Boulevard and Meralco Avenue. One of the most prominent modes of public transport along EDSA is the MRT-3. Two stations service the CBD namely Ortigas Avenue station beside the offices of ADB and Shaw Boulevard Station adjacent to Shangri-la mall. On the other hand, road-based transport modes that are available at the CBD are buses, jeepneys, FX/vans and taxis. Public utility buses (PUBs) ply both EDSA and Ortigas Avenue. Northbound buses terminate at various locations in Valenzuela, Malabon, Navotas, Caloocan, Quezon City, Rizal and Bulacan while the routes of southbound buses end in Muntinlupa, Pasay, Taguig, Laguna and Cavite. Point-to-point (P2P) bus services can also be found in the Ortigas CBD. As of September 2016, there are two routes for these premium services: Robinson's Galleria (Ortigas) to Park Square Makati (Makati) and SM North EDSA (Quezon City) to SM Megamall (Ortigas).

Public transportation terminals are mainly located at shopping malls in the CBD. Common observations on terminals and stops located in Ortigas CBD include lack of covered areas and absence of defined queuing and seating areas for waiting passengers. The bus stops especially along EDSA are cramped with vendors adding to the pedestrian traffic. Covered pedestrian walkways leading to these terminals are also almost non-existent. Even some sidewalks in Ortigas CBD are not in good condition.



Source: ADB

Figure 1. Map of Ortigas CBD and Location

5. METHODOLOGY

The primary data gathering method used for this study is the questionnaire survey conducted in December 2016. The survey gathered the following information from the respondents: socio-economic characteristics (gender, age, civil status, income) and working conditions (years of working in Ortigas CBD, work hours), travel behavior during no rain conditions in terms of total travel time, total fare, departure time and available choices in mode, evaluation of most preferred modes in terms of fare, travel time, walking time, waiting time, service reliability, comfort and safety and security during the four different rainfall intensities (no rain, light rain, heavy rain, intense rain), mode switching considering the three with-rain conditions and prioritization of mode attributes. Service reliability, comfort and safety and security were evaluated using a Likert scale from 1 to 5 with 1 as very bad and 5 as very good.

The target sample size for this study was initially set at 1000 since mode choice modelling using multinomial logistic regression was intended to be the method of analysis. However, this kind of analysis will require a detailed questionnaire for the respondents to answer. Pilot testing revealed that respondents did not answer the questionnaire fully due to busy work schedules. The questionnaires were modified to fit one page and the target size was reduced to 500 since choice modelling would not be done anymore. Survey forms were first distributed in various offices in Ortigas Center. Due to logistical limitations, only a total of 352 survey forms were distributed through acquaintances working in Ortigas, but finally only 200 forms were returned and completely answered corresponding to a response rate of 56.82%. Surveyors were also hired to interview at public transport terminals within the study area. They were deployed from 5 pm to 8 pm last December 9 and 16, 2016 and were given 500 forms to use. The surveyors found it difficult to interview commuters since they were always in a hurry to go home. Only 181 survey forms were filled out but only 32.54% or 59 forms were answered completely. To further supplement the survey, an online form, similar to the questionnaire, was posted in social media. This online survey was able to gather a total of 41 responses. In summary, the survey generated a total of 300 respondents.

Basic descriptive statistics is used to characterize the results of the conducted survey. The Shapiro – Wilk test was used to test the normality of the data since the sample size is less than 2000. Since the tests show that the responses to all mode attributes are not normally distributed, the Wilcoxon test was used to compare the mode attributes during no rain conditions and with rain conditions using the mode they usually prefer to ride on their work-to-home trip. The null hypothesis was there is no significant difference between two or more variables. The confidence level was set at 95% such that if p value < 0.05, the difference between the mode attributes during the two rainfall intensities being compared was considered significant. Binomial logistic regression was also used to identify the variables that influence mode shifting. The Nagelkerke R squared and the p value were reported to determine the goodness of fit of the model and the significance of each variable respectively.

6. RESULTS

6.1. Profile of the Respondents

The attributes of the tripmaker may affect the travel behavior of the respondents. The influence of the socio-economic characteristics of the respondents to their mode shifting behavior were taken into consideration in the binomial logistic regression analysis. More than half of the respondents were female at 57%. Most are within the 21 to 30 years old age group with the frequency declining as age increases. This is expected as older workers are more possible to be able to afford a car to be used in their work-to-home trips compared to younger people who just entered the workforce. With majority of the respondents belonging to a younger age group, 76.67% are still single while the rest are married and have families of their own. Workers with families are inclined to choose the mode with the least travel time for them to be able to attend to their children. Income is also a factor because it indicates the spending capability of the respondent. Commuters with low income may choose the mode with the least fare despite the discomfort and longer travel time. With respect to average monthly income of the respondents, 38% were found to earn around 25,000 pesos per month.

6.2. Mode Preferences during No Rain Conditions

The focus of this study is the mode chosen by the commuter to depart from the Ortigas CBD. Nine (9) public transport modes have been identified to be servicing the CBD namely the aircon bus, non aircon bus, P2P bus, jeepney, FX/van, MRT, ordinary taxi, GrabTaxi and GrabCar/Uber. Table 1 shows the preferences in mode of the respondents grouped according to their home addresses. From the table,majority of the respondents also come from the north of Ortigas CBD followed by those going to the east. The most preferred mode at 33.33% is the FX/van commonly known as the UV Express followed by the aircon bus at 25.33% and the MRT-3 at 17.33%. The users of P2P bus and GrabCar/Uber are only at 4% and 6% during normal weather conditions.

Table 1. Mode Preferences of Respondents

Destination Zone	Aircon bus	Non aircon bus	P2P bus	Jeep	FX/van/ UV Express	MRT	Ordinary Taxi	GrabTaxi	GrabCar/ Uber	SUM
1 - Pasig , San Juan, Mandaluyong	2.00%	0.00%	0.00%	7.00%	7.33%	0.67%	0.33%	0.00%	1.33%	***18.67%***
2 - Marikina, Rizal	1.67%	0.00%	0.00%	2.67%	14.67%	0.00%	0.00%	0.00%	0.67%	***19.67%***
3 - Quezon City, Caloocan City, Navotas, Malabon, Valenzuela	12.67%	1.33%	3.67%	1.00%	5.67%	7.33%	0.33%	0.00%	2.00%	***34.00%***
4 - Makati , Pasay, Taguig, Pateros, Las Pinas, Paranaque, Muntinlupa	4.33%	0.67%	0.00%	0.33%	1.33%	4.67%	0.33%	0.00%	1.33%	***13.00%***
5 – Manila	1.33%	0.00%	0.00%	0.00%	2.00%	0.67%	0.00%	0.00%	0.33%	***4.33%***
6 – Bulacan	1.00%	0.00%	0.33%	0.00%	0.33%	1.33%	0.00%	0.00%	0.33%	***3.33%***
7 - Cavite, Laguna	2.33%	0.00%	0.00%	0.00%	2.00%	2.67%	0.00%	0.00%	0.00%	***7.00%***
SUM	***25.33%***	***2.00%***	***4.00%***	***11.00%***	***33.33%***	***17.33%***	***1.00%***	***0.00%***	***6.00%***	***100.00%***

6.3. Change in Prioritization of Mode Attributes

The prioritization of mode attributes may change depending on what is the important consideration of the respondent during a specific rainfall intensity and the corresponding perception of the traffic congestion on the road. Table 2 shows the ranking of attributes according to rainfall intensity based on their average rating. It can first be observed that the rankings of these attributes for no rain and light rain are exactly the same and heavy rain and intense rain are also the same. During the occurrence of no rain and light rain, travel time is the most important attribute to the commuter, followed by the affordability of fare and the last two are waiting time and walking time. However, these rankings change when heavy rain and intense rain occur in which comfort is considered most important, followed by service reliability and the last two being affordability of fare and walking time. The respondents acknowledge that rainfall increases travel time and waiting time across all modes especially during heavy and intense conditions. With that in mind, they might as well choose the mode which provides a better commuting experience in terms of the other mode attributes such as comfort and service reliability. These changes in prioritization may affect the mode choices of the commuters and may influence mode switching behavior as they choose the mode which provides them the most utility.

Table 2. Ranking of Mode Attributes

	No rain	Light rain	Heavy rain	Intense rain
Affordability of fare	2	2	6	6
Travel Time	1	1	3	3
Walking Time	7	7	7	7
Waiting Time	6	6	5	5
Service Reliability	4	4	2	2
Comfort	3	3	1	1
Safety	5	5	4	4

6.4. Mode Attributes during Different Rainfall Conditions

Table 3 shows the mean values of various mode attributes under four different rainfall conditions. It is seen all values increase as the intensity of the rain increase. Fare only increases for ordinary taxi, GrabTaxi and GrabCar/Uber depending on the traffic congestion caused by rainfall and in addition depending on the surge induced by high demand in the case of GrabTaxi and GrabCar/Uber. Average travel time increases 82.83% during intense rains compared to the average travel time when there is no rain. Respondents noted an average increase of 6.49 minutes in walking time during intense rains due to additional discomfort. Waiting time increases on the average by 5 minutes, 19 minutes and 35 minutes during light, heavy and intense rains respectively. Service reliability, comfort and safety were rated from 1 to 5 by the respondents with 1 being the lowest and 5 as the highest and these mode attributes all go down as the intensity of the rain goes up.

Table 3. Mean Values of Travel Mode Attributes

	No rain	**Light rain**	**Heavy rain**	**Intense rain**
Fare (pesos)	40.56	42.81	47.21	51.95
Travel Time (mins)	59.86	71.16	90.52	109.44
Walking Time (mins)	10.15	11.03	14.64	16.64
Waiting Time (mins)	15.85	20.83	34.93	51.31
Reliability rating	4.01	3.70	2.80	2.46
Comfort rating	3.69	3.41	2.76	2.55
Safety and security rating	3.60	3.40	3.04	2.89

The Wilcoxon test for significance was used to determine the significance of the difference between the means of the mode attributes during no rain conditions and with rain conditions. The test shows that there is no statistically significant change in fare during light rains compared to the no rain condition unlike the other pairings. Since fare rates do not change for most public transport services, the change may only come from ordinary taxis, GrabTaxi and GrabCar/ Uber services which only comprise of 7% of the preferred modes of the commuters during no rain conditions.

Since the deviations of responses is caused by the different preferences in modes, significance tests are also done for the five most preferred modes (aircon bus, jeep, FX/van, MRT and GrabCar/ Uber) and the results are summarized in Table 4. For aircon bus, and FXs, all attributes significantly change except for fare. Commuters using jeepneys noted significant changes in waiting time, reliability, comfort and safety for all rain conditions and travel time only during occurrence of heavy and intense rain. MRT users reported significant differences in waiting time and reliability for light rain conditions and all attributes except fare and travel time for the heavy and intense conditions. Since it is in rail and not affected by traffic congestion which may be caused by rainfall, travel time is constant. Meanwhile, changes in fare are consistent for all rain conditions for GrabCar and Uber users. These app-based vehicle subscribers also noted significant changes in travel time and waiting time only. It can also be observed that there are no significant changes in walking time noted by the respondents during light rains across all modes studied.

Table 4. Results of Tests of Significance of Change (per mode)

	LIGHT							HEAVY							INTENSE						
	Fare	Travel Time	Walking Time	Waiting Time	Reliability	Comfort	Safety	Fare	Travel Time	Walking Time	Waiting Time	Reliability	Comfort	Safety	Fare	Travel Time	Walking Time	Waiting Time	Reliability	Comfort	Safety
Aircon bus		✓		✓	✓	✓			✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Jeep				✓	✓	✓	✓		✓		✓	✓	✓	✓		✓		✓	✓	✓	✓
FX/van		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
MRT				✓	✓					✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
GrabCar/ Uber	✓							✓	✓		✓				✓	✓		✓			

6.5. Mode Switching during Different Rainfall Conditions

Tables 5 – 7 show the mode switching behavior of respondents according to the rainfall intensity. During light rain conditions, 30% of the respondents choose to ride the FX/van followed by the aircon bus at 24% and MRT at 15%. This ranking is similar to the mode choices during no rain conditions. However, for heavy rain conditions the top choice is still FX/van at 25% but now followed by GrabCar/Uber at 20% and the former second choice, the aircon bus, at 18%. The preferences change during intense rains as GrabCar/Uber is the first choice at 27% followed by FX/van and aircon bus.

Table 5. Mode Switching at Light Rain Conditions

		Preferred Mode Under Light Rain										
		Aircon bus	Nonaircon bus	P2P bus	Jeep	FX/ van	MRT	Ordinary Taxi	Grab Taxi	GrabCar/ Uber	SUM	% of Total
Preferred Mode Under No Rain	Aircon bus	63	0	1	1	2	0	3	2	4	76	25%
	Non aircon bus	1	3	0	0	0	1	1	0	0	6	2%
	P2P bus	0	0	12	0	0	0	0	0	0	12	4%
	Jeep	2	0	0	23	3	0	3	1	1	33	11%
	FX/van	1	0	1	1	84	0	4	2	7	100	33%
	MRT	4	0	2	0	0	44	0	0	2	52	17%
	Ordinary Taxi	0	0	0	0	0	0	2	0	1	3	1%
	GrabTaxi	0	0	0	0	0	0	0	0	0	0	0%
	GrabCar/ Uber	1	0	0	0	0	0	1	0	16	18	6%
	SUM	72	3	16	25	89	45	14	5	31	300	
	% of Total	24%	1%	5%	8%	30%	15%	5%	2%	10%		

Table 6. Mode Switching at Heavy Rain Conditions

		Preferred Mode Under Heavy Rain										
		Aircon bus	Nonaircon bus	P2P bus	Jeep	FX/ van	MRT	Ordinary Taxi	Grab Taxi	GrabCar/ Uber	SUM	% of Total
Preferred Mode under No Rain	Aircon bus	41	0	5	1	4	3	4	4	14	76	25%
	Non aircon bus	2	1	0	0	0	1	1	0	1	6	2%
	P2P bus	0	0	11	0	0	0	1	0	0	12	4%
	Jeep	3	0	0	13	7	0	5	2	3	33	11%
	FX/van	4	0	1	2	63	0	8	2	20	100	33%
	MRT	5	0	3	0	1	35	2	0	6	52	17%
	Ordinary Taxi	0	0	0	0	0	0	2	0	1	3	1%
	GrabTaxi	0	0	0	0	0	0	0	0	0	0	0%
	GrabCar/ Uber	0	0	1	0	0	1	0	0	16	18	6%
	SUM	55	1	21	16	75	40	23	8	61	300	
	% of Total	18%	0%	7%	5%	25%	13%	8%	3%	20%		

Table 7. Mode Switching at Intense Rain Conditions

		Preferred Mode Under Intense Rain										
		Aircon bus	Nonaircon bus	P2P bus	Jeep	FX/ van	MRT	Ordinary Taxi	Grab Taxi	GrabCar/ Uber	SUM	% of Total
Preferred Mode Under No Rain	Aircon bus	35	0	5	1	1	3	4	4	23	76	25%
	Non aircon bus	2	1	0	0	1	0	1	0	1	6	2%
	P2P bus	0	0	10	0	0	0	0	1	1	12	4%
	Jeep	2	0	0	12	6	0	6	2	5	33	11%
	FX/van	4	0	0	0	57	0	10	4	25	100	33%
	MRT	4	0	2	0	1	33	1	1	10	52	17%
	Ordinary Taxi	0	0	0	0	0	0	2	0	1	3	1%
	GrabTaxi	0	0	0	0	0	0	0	0	0	0	0%
	GrabCar/ Uber	1	0	1	0	0	0	0	0	16	18	6%
	SUM	48	1	18	13	66	36	24	12	82	300	
	% of Total	16%	0%	6%	4%	22%	12%	8%	4%	27%		

To further illustrate the changes in mode choices, Table 8 summarizes the modes that gain or lose passengers when compared to the no rain conditions. Aircon buses, non aircon buses, jeepneys, FX/van and MRT lose their passengers to P2P bus, ordinary taxi, GrabTaxi and GrabCar/Uber under all rainfall conditions. During light rain conditions, the differences in percentages to rain are minimal not exceeding 5%. The differences increase as rainfall intensity increases. Aircon buses and FX/van lose 7 to 8% during heavy rains which increase up to 11% during intense rain. The mode that gains the largest is GrabCar/Uber which preference increases by 14.33% and 21.33% during heavy rain and intense rain conditions respectively. Chi square tests reveal that the differences between mode choices is significant between no rain and light rain and between light rain and heavy rain at 97.5% and 95.0% respectively. However the difference between the mode choices between heavy rain and intense rain is not significant.

Table 8. Differences in Mode Choice (compared to no rain conditions)

	No rain	Light rain		Heavy rain		Intense rain	
	% of total	% of total	% diff to no rain	% of total	% diff to no rain	% of total	% diff to no rain
Aircon bus	25.33%	24.00%	-1.33%	18.33%	-7.00%	16.00%	-9.33%
Non aircon bus	2.00%	1.00%	-1.00%	0.33%	-1.67%	0.33%	-1.67%
P2P bus	4.00%	5.33%	1.33%	7.00%	3.00%	6.00%	2.00%
Jeep	11.00%	8.33%	-2.67%	5.33%	-5.67%	4.33%	-6.67%
FX/van	33.33%	29.67%	-3.67%	25.00%	-8.33%	22.00%	-11.33%
MRT	17.33%	15.00%	-2.33%	13.33%	-4.00%	12.00%	-5.33%
Ordinary Taxi	1.00%	4.67%	3.67%	7.67%	6.67%	8.00%	7.00%
GrabTaxi	0.00%	1.67%	1.67%	2.67%	2.67%	4.00%	4.00%
GrabCar/ Uber	6.00%	10.33%	4.33%	20.33%	14.33%	27.33%	21.33%
TOTAL	100%	100%		100%		100%	

The frequency of respondents opting to shift based from Tables 5 to 7 were summarized in Table 9 according to their mode choice during no rain conditions. Based from this table, the tendency to shift to other modes during the occurrence of rain increases as the rainfall intensity increases. The percentages of mode switching for light, heavy and intense rain are 17.67%, 39.33% and 44.67% respectively.

Table 9. Summary of Mode Switching per Mode

	Light Rain	Heavy Rain	Intense Rain
Aircon bus	13	35	41
Non aircon bus	3	5	5
P2P bus	0	1	2
Jeep	10	20	21
FX/van	16	37	43
MRT	8	17	19
Ordinary Taxi	1	1	1
GrabTaxi	0	0	0
GrabCar/ Uber	2	2	2
SUM	53	118	134
% of Total	17.67%	39.33%	44.67%

Binary logistic regression analyses were done to analyze which variables influence the mode switching behavior of the respondents. The independent variables used are the changes in the mode attributes of their chosen mode during no rain conditions compared to the with rain conditions and the socio-economic characteristics of the respondent such as gender, age, civil status and income. The models were first generated using one independent variable at a time as summarized in Table 10. The best fit models were then calculated considering the goodness of fit measured by the Nagelkerke R squared while maintaining the significance of all independent variables included such that the p value is less than 0.05. Comparing the three rainfall intensities, gender has always been a factor such that females are more inclined to shift modes compared to males. The change in mode attributes become significant for heavy and intense rain conditions.

Table 10. Binary Logistic Regression Results

	Light Rain Conditions		Heavy Rain Conditions		Intense Rain Conditions	
	p value	**R squared**	**p value**	**R squared**	**p value**	**R squared**
Increase in Fare	0.332	0.005	0.253	0.007	0.113	0.014
Increase in Travel Time	0.176	0.010	0.312	0.005	0.017	0.026
Increase in Walking Time	0.729	0.001	0.953	0.000	0.544	0.002
Increase in Waiting Time	0.092	0.015	0.417	0.003	0.467	0.002
Decrease in Reliability	0.232	0.007	0.000	0.106	0.000	0.217
Decrease in Comfort	0.074	0.017	0.000	0.061	0.000	0.065
Decrease in Safety	0.599	0.001	0.007	0.033	0.014	0.028
Gender	0.035	0.025	0.016	0.026	0.019	0.025
Age	0.285	0.007	0.031	0.022	0.003	0.040
Civil Status	0.925	0.005	0.264	0.012	0.037	0.031
Income	0.162	0.013	0.430	0.003	0.231	0.007

Table 11. Summary of Best Fitting Models

HEAVY RAINFALL				**INTENSE RAINFALL**			
Variable:	B	p-value	odds ratio	Variable:	B	p-value	odds ratio
Change in reliability	-0.550	0.000	0.577	Change in reliability	-0.659	0.000	0.517
Change in comfort	-0.378	0.003	0.685	Change in comfort	-0.291	0.008	0.748
Constant	-1.297	0.000	0.273	Age	-0.036	0.042	0.965
				Constant	-0.294	0.588	0.746
Nagelkerke R squared:	0.144			Nagelkerke R squared:	0.261		

The results of the best fit models as summarized in Table 11 show that change in reliability and change in comfort affects the mode shifting behavior of respondents. As the reliability and comfort of the mode decreases, the probability of shifting increases. This supports the conclusion of the change in prioritization wherein reliability and comfort are the most important considerations of commuters during heavy and intense rains. However when comparing the two mode attributes, change in reliability is more significant compared to change in comfort. Age also becomes a factor during intense rainfall as younger population tend to shift more compared to the older ones.

Opting to shift to another mode will change the fare, travel time, walking time, waiting time, reliability, comfort and safety experienced by the commuter. Table 12 shows the improvements experienced by the respondents after shifting to another mode. Many were compelled to pay higher fares when they have shifted in exchange for improvements in the other mode attributes. During light rains, their waiting time decreased by 5.53 minutes compared to the situation in which they did not change modes. Comfort level also improved but reliability and safety and security are the same. The respondents who shifted during heavy rain paid additional P143.49 but lessened their travel time and waiting time by 11.80 minutes and 9.63 minutes respectively. Those who have shifted during intense rain saved a total of 55 minutes due to decrease in travel time, walking time and waiting time. Their comfort level also increased by 3 levels but the average additional cost amounted to P209.10. It can also be observed for the three rainfall intensities that while the change in reliability triggered mode shifting, the improvements after shifting lean more toward increase in comfort level.

Table 12. Frequency of Respondents Noting Changes in Mode Attributes after Shifting

IMPROVEMENTS IN MODE ATTRIBUTES AFTER SHIFTING	LIGHT RAIN	HEAVY RAIN	INTENSE RAIN
Decrease in fare	(125.06)	(143.49)	(209.10)
Decrease in travel time (mins)	1.09	11.80	22.99
Decrease in walking time (mins)	4.00	6.28	9.49
Decrease in waiting time (mins)	5.53	9.63	22.21
Increase in reliability level	0	1	1
Increase in comfort level	2	2	3
Increase in safety and security level	0	1	0

7. CONCLUSION

This paper presented an analysis of data from survey among CBD commuters in Ortigas Center in Metro Manila, Philippines. The responses reveal that, when rainfall occurs, a significant number of work-to-home commuters shift to other public transport modes.

The changes in travel time, walking time, waiting time, service reliability, comfort and safety during light rains compared to no rain conditions are already statistically significant but these only induce 17.67% shifting. This percentage of shifting increases to 39.33% during heavy rains and 44.67% during intense rains. As rainfall intensity increases, respondents tend to shift toward point-to-point modes namely P2P bus, ordinary taxis, GrabTaxis and GrabCar/Uber services. GrabCar/Uber gains the most patronage while FX/van lose the most passengers. This shifting appears to be mostly brought about by the desire of commuters for a more comfortable and reliable mode of transportation even if it will cost them more. Therefore, public transport operators and policy makers should work on making public utility buses, jeepneys, FXs and the MRT more comfortable and reliable while retaining their affordability especially during the occurrences of rain if they do not want to lose their passengers. Measures to improve reliability include implementation of a schedule known to commuters and provision of information pertaining to estimated arrivals. Comfort may be improved by provision of comfortable seating, better ventilation and entertainment such as television, music or wifi connection to make the ride worthwhile. While the changes in demand during rainfall have been explored in this study, a further analysis on the supply side should also be undertaken to better understand the operational aspects related to the perceived change in service reliability and comfort of public transport modes.

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