



Emergence of Application Based Transportation and its Impacts on Travelling Trends: A Case Study of Lahore

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Abstract

The urban transportation system impacts the sustainable development of a country. Ride sourcing is a transportation model that operates under the notion of sharing economy. This study attempts to identify the changes in travel patterns of the users, particularly female users and their access to space. Focusing on how for the women in Lahore, the mobility has changed? The data for this research has been collected from passengers and drivers of ride-sourcing in Lahore through structured questionnaires. Structural equation modelling (SEM) was used to do the econometric analysis of consumers and drivers. Main findings indicate that for females, there is a significant shift in travel patterns from conventional modes (family car, public transportation) towards ride-sourcing. The results indicate that Uber and Careem has improved mobility as women feel secure in ride-sourcing services compared to public transportation. The female population of Lahore have started taking more trips because of car availability. The paper also tries to calculate the carbon emissions of ride-sourcing. The increasing number of cars is contributing to the city's worsening air pollution as the concept of 'one person in one car' prevails. The social impacts are positive, where women have become more mobile and independent because of app-based transportation.

Key Words: App Based Transportation, On-Demand Ride Service, Online Taxi, Ride Sharing, Ride-Hailing and Transportation Network Companies

Introduction

Pakistan's economy is exposed to new emerging trends and transportation, which is one of the major areas that is evolving. In developing countries, people spend approximately 16% of their household incomes on transport, which is expected to rise (World Bank, 2014). The increasing population and economic growth put excessive pressure on environmental resources, affecting the quality of human life (Mittal 2013; Guria, 2015). As the population grows, transportation pattern changes (Lindau, 2015). In Pakistan, the government is unable to develop a transport system that provides mobility and sustainability (Faiz, 1993, Aziz & Bajwa, 2007; Imran, 2009; Jamal et al., 2012). Developing countries like Pakistan are struggling with the economy, but currently, a shift is taking place in technological advancements through the emerging idea of sharing economy. Sharing or Gig economy means to transform underused products or assets into productive use (Bocker & Meelen, 2016). In the existing system of transportation, the addition of Ride sourcing or Ride sharing services, i.e. Uber/Careem etc., is the new trend. These services provide convenient mobility and travelling solution; however, this service is becoming a cause of traffic congestion and resulting in competition with public transportation (Kampa & Castanas, 2008). In Pakistan, ride-sourcing is functional since 2015 and is expanding in various cities. They provide customers with ease, but people have concerns about inconsistent pricing (Hordepal, 2015).

There is advancement in the mobility sector because of app-based services, but how it has impacted gender equality in commuting, this phenomenon needs investigation. According to a survey as per the psychology of users, economic and time benefits along with trust serve as factors that lead towards strong intentions of using

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ride-sourcing services ([Amirkiace & Evangelopoulos, 2018](#)). Uber has expanded to more than 450 cities globally. In the west, car-sharing removes 9 to 23 vehicles from the road, but at the same time, these are supposed to have altered transit patterns and drawing people away from the use of public transportation. People are taking more trips because of the easy availability of cars, which results in additional trips on roads. If those trips are not based on ridesharing, that ultimately have an impact on the environment ([Badger, 2017](#); [Rayle et al., 2016](#)).

Gender accessibility and mobility are major tools of women empowerment. Startups like resourcing should consider these factors. Pakistan's urban environment is gender-biased. Travelling in public transportation, ill-treatment is one of the major concerns for women. In the west, a woman travelling by bus is considered a widely accepted form of commuting along with a shared taxi. Reserved taxis for women are operational in UK, Mexico, Russia, Dubai, Iran (Duchène, 2011). According to ADB (2015), in Pakistan, women do not feel safe while using public transportation. Women have to face harassment, verbal jibes and offensive language frequently. Women harassment in public transportation is a major concern in countries like Pakistan, UK, Malaysia, Japan, Mexico and India ([SADAQA, 2018](#)). Studies indicate that women worldwide are hesitant of using public transportation because of lack of surveillance whereas, the feeling of security influences the frequency of public transport use ([Bhatt et al., 2015](#); [Gardner, 2017](#)).

The travelling behaviour and needs of women are significantly different than those of men. Woman travel more, and non-work-related trips are also a part of their routine; this trend prevails in developed and developing countries (Utang, 2011). There is less attention paid to how the smart mobility and digitalization of transportation has affected the ease, access and safety concerns for women. In Saudi Arabia, currently, 70% of passengers of Careem are women. Careem has recently started training sessions for female drivers, and where more than 2000 females have participated in the initiative to work as captains in Saudi Arabia. In Pakistan, Careem introduced women drivers in 2016 in areas of Karachi, Lahore and Islamabad for providing safe transportation to females. Working for these ride-sourcing services, women are earning flexible, easy and extra money.

In the city of Lahore, the population has increased, so has the traffic. The number of vehicles has increased by 16.5 times since 1980 and is a prominent cause of urban emissions ([Han & Naeher, 2006](#); [Javid et al., 2014](#)). According to Pakistan Economic Survey (2016-17), Pakistan's energy consumption by the transportation sector is 57%, which is expected to double by 2050 as people will become more dependent on private vehicles ([Imran & Low, 2003](#), [Amjid, 2011](#)). Private cars are responsible for emitting three times more greenhouse gases than public transportation ([Wright & Fjellstrom, 2003](#)). Countries like Mexico, China, Columbia etc., have introduced bus rapid transit projects to reduce climate impacts. Brazil plans to reduce 38% of emissions by 2020 through investment in urban transportation infrastructure (Brazil INDC, 2015; [Lindau, 2015](#)). A study in Lahore shows that nearly 72% of people are satisfied with the use of ridesourcing based on comfort, security and ease ([Rasheed et al., 2018](#)).

According to the World Health Organization (2006), in Lahore, the level of Particulate Matter 2.5 is two to fourteen times higher than the prescribed limits of US NEQS, and vehicular emissions are one of the substantial causes of it. Moreover, nearly 1250 people die annually from air pollution in Lahore (World Bank, 2014). The ratio of particulate matter is going to increase because it is anticipated that around 60% of the population will live in urban centers by 2050 ([WHO, 2006](#)). Over the last twenty years, the number of vehicles in Pakistan has increased from 2 to 10.6 Million. The US EPA (2010) states, the average passenger vehicle emit about 4.7 metric tons of carbon dioxide. In 3 years, Uber contributed about 94,000 metric tons of carbon dioxide in New York City alone, which is equal to 101 Million pounds of coal-burning (World Bank, 2014; [Emerson, 2016](#)). More cars on the roads mean more fuel consumption and air pollution, which leads to 50% mortalities in Pakistan (World Bank, 2014; [Mirza, 2013](#)). Traffic congestion, old engines and low-quality fuel are some of the major causes of air pollution in Lahore.

Pakistan is one of the lowest emitters in the world, with 0.2% of total emissions in terms of global contribution. It is expected that the emissions in Pakistan will increase by about 295.73% by 2030 ([Zeb, 2017](#)). Pakistan Clean Air Program states that vehicular emissions are a prime source of urban air pollution. Lahore has experienced smog for the last few years. As the number of cars is increasing continuously, Lahore could fall in the category of Beijing and New Delhi because of their bad air quality. In this research, we primarily focus on how to ride sourcing is linked with changing transit patterns in developing country like Pakistan. Moreover, how

the phenomenon of additional trips is a cause of pollution. Emphasis is made on a social parameter, i.e. the influence of ride-sourcing upon the women’s access to space, their mobility and satisfaction.

The main objectives of this research work are:

1. To investigate that how travelling patterns of people are changing because of ride-sourcing
2. To identify women’s mobility and satisfaction with respect to ride-sourcing services
3. To identify the status of the additional trip of users

The following hypotheses were developed in order to examine the research problems:

- H1:** Uber and Careem usage (UCU) has significant and positive impacts upon travelling pattern changes (TP)
- H2:** Women’s satisfaction (WMS) is significant and positively linked with Uber and Careem usage (UCU)
- H3:** Women’s access to space (WMA) is significant and positively linked with Uber and Careem usage (UCU).
- H4:** Additional trips and pollution (ATP) are significant and positively linked with Uber and Careem usage (UCU)

This paper makes an attempt to identify the environmental impacts in terms of physical and social characteristics of ride-sourcing services, including Uber and Careem and to highlight and map that how the transit/commuting patterns are being changed. Physical parameters focus on the environmental sustainability issue, whereas; social parameters incorporate women access to space and satisfaction.

Methodology

The data was collected from the users of resourcing and drivers through structured interviews. The customers were accessed through snowball sampling, and questionnaire was circulated via Emails, WhatsApp and in-person meetings. In order to get data from drivers, random sampling was done. Rides were booked, and questions were asked during and after the ride ended. In order to test the hypothesis and analyze the results, structural equation modelling was done.

Conceptual Framework

Four leading constructs, i.e., travelling patterns, additional trips and pollution, women’s satisfaction regarding Uber and Careem and women’s access to space, were identified and highlighted, and their relation with Uber and Careem usage was analyzed in the research. Questions related to users before and after travelling trends, travelling frequency, additional trips etc., were inquired. In the case of women respondents, precise questions related to preference, family satisfaction, ease of travelling, security and reliance were asked. A diverse sample of Uber/Careem users was surveyed using a research questionnaire in order to analyze the travelling behaviors before and after ride-sourcing initiation. The derivative data was helpful in answering the research questions.

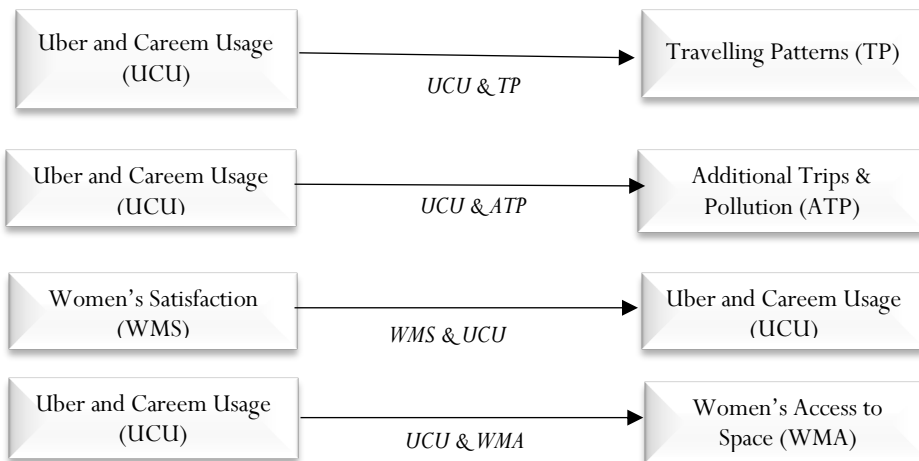


Figure 1: Theoretical Framework

Figure 1 diagram shows the conceptual framework model used for the study. Table 1 shows the regression equations which were used to test the model.

Table 1. Regression Equation

$$\begin{aligned}
 TP_i &= \alpha_0 + \alpha_1 UCU_i + \varepsilon_i \\
 ATP_i &= \delta_0 + \delta_1 UCU_i + \varepsilon_i \\
 UCU_i &= \gamma_0 + \gamma_1 WS_i + \varepsilon_i \\
 WMA_i &= \beta_0 + \beta_1 UCU_i + \varepsilon_i
 \end{aligned}$$

Data Sampling and Variables

The survey was conducted in Lahore due to its developing infrastructure in the transportation sector. In order to complete primary data collection, one questionnaire was developed for ride-sourcing users, and the other was for the drivers. Table 2 shows the variables on which data was measured.

Questionnaire for Users

Table 2. Variables

Independent	Dependent
Uber and Careem Usage (UCU)	Travelling pattern changes (TP) Additional trips and pollution (ATP) Women’s satisfaction with Uber & Careem (WMS) Women’s access to space (WMA)

A total of 621 respondents filled the survey, and the answers were gathered. 21 responses were discarded on the basis of incomplete information, and 600 responses were selected. The questionnaire includes dimensions like demographic information, travelling patterns and the trends of commuting before and after the phenomenon of ride-sourcing services.

Questionnaire for Drivers

A total of 60 drivers were interviewed using the structures questionnaire. Questions about demographics, travelling hours, kilometres are driven, and fuel consumption was asked. The information acquired through fuel consumption and kilometres is driven used for CO2 emission calculation.

Instrumentation

[Bianco and Lawson \(2011\)](#) identified certain components that indicate women’s mobility that can be affected because of Uber and Careem usage, making access to space easier for women. Henao (2017), [Dawes \(2016\)](#), [Rayle et al. \(2016\)](#) and [Zhen Chen \(2013\)](#) defined the independent variables along with the constructs which can measure changes in travel patterns and public preference and opinions on ridesharing. The questions on demographics and additional trips were also added (Er. et al., 2017). Tables 1(a) to 4(a) in Appendix A shows the variables and the associated questions.

Results

Descriptive Analysis

Table 3 (on next page) shows the demographic information and descriptive analysis of the users obtained using software SPSS 23.

Table 3. Demographics

Variables	Description	Frequency	Percentage
Age	18 to 25	459	76.4
	26 to 35	132	22.0
	36 to 45	6	1.0
	More than 46	3	0.5
Occupation	Self employed	39	6.5
	Part time employee	27	4.5
	Business owner	45	7.5
	Student	363	60.5
Monthly Income	House wife	27	4.5
	Full time employee	99	16.5
	Less than 20,000	267	44.5
	21,000 to 50,000	114	19.5
Car Ownership	51,000 to 80,000	66	11.0
	81,000 to one lac	30	5.0
	More than a lac	123	20.5
Gender	Yes	228	38.0
	No	372	62.0
Gender	Male	270	45.0
	Female	330	55.0

The results show that the majority of users of ride-sourcing services are youngsters between the age bracket of 18-25, which means they are more technology users, and the majority is students and employees. The majority of our respondents do not own a personal car, which means they have to rely on any significant and available mode of transport daily. The sample was almost equal with respect to gender, with a female respondents' rate of 55%. In the paper, 4 dependent variables were used WMA & WMS, TP and ATP.

Table 4. Dependent Variables (WMA and WMS)

Variables (Women's Mobility and Satisfaction)	Description	Percentage
Security	Agree	14.0
	Disagree	6.0
	Neutral	35.0
Reliance on ride sourcing for travelling	Agree	15.5
	Disagree	9.3
	Neutral	30.2
Preference of female driver	Agree	20.2
	Disagree	4.5
	Neutral	30.3
Freedom to travel	Agree	28.8
	Disagree	1.0
	Neutral	25.2
Family satisfaction	Agree	21.3
	Disagree	4.5
	Neutral	29.2
Travelling more because of ride-sourcing	Agree	19.0
	Disagree	8.8
	Neutral	27.2
Reported any driver	Agree	17.2
	Disagree	13.7

Will you work as a driver	Neutral	24.2
	Agree	6.2
	Disagree	22.8
	Neutral	26.2

Table 4 focuses on women's mobility and access to space; the following are the descriptive results. The result demonstrates that women have started travelling more because of the available services. They feel secure and satisfied with the use of ridesourcing, and it is helping them in being more mobile and independent. Their dependence on Uber and Careem is increasing significantly. The majority of respondents do prefer a female driver for their ride too, but being asked that will they be interested to work as a driver very few agreed. The variables TP and ATP show that the users of app-based transportation have shifted away from using the conventional modes. They find Uber and Careem as more reliable and convenient way of commuting. Because of car availability they take additional trips too, which they would not have taken otherwise. The phenomenon of additional trips can impact the environment resulting in additional pollution in the city. Since cars are available everywhere and people are relying on the use of cars, the previous means like buses, rikshaws, student vans are neglected. The results show that ridesourcing is serving people with easy and fast commuting solutions which are resulting in change in transit patterns.

Structural Equation Modelling

By using AMOS 23, Structural Equation Model (SEM) is used to examine the measurement model and the hypotheses which were proposed and to determine that how the independent variables like the travelling patterns, additional trips and pollution, women's mobility and satisfaction with respect to Uber and Careem are linked with the dependent variable i.e. Uber and Careem Usage as specified by Zhen Chen (2013), Dawes (2016), Ertz. et al. (2017) and Henao (2017). There were no missing values in the data. The table below shows the dependent and independent variables with their Cronbach's alpha and factor loading. A three stage approach is developed by Shah and Goldstein (2006) in order to confirm the reliability, uni-dimensionality and validity of the data. Factor loading can be seen in table 5.

Table 5. Factor Loading

Latent variables (Cronbach's Alpha)	Measured variables (items)	Item loading
Uber Careem Usage (0.824)		
UCU1	What is your frequency of usage of Uber and Careem for work, on a scale of 0 to 5?	0.494
UCU2	What is your frequency of usage of Uber and Careem for leisure/hangout on a scale of 0 to 5?	0.626
UCU3	What is your frequency of usage of Uber and Careem for medical reasons/ doctor's appointment on a scale of 0 to 5?	0.851
UCU4	What is your frequency of usage of Uber and Careem for visiting relatives on a scale of 0 to 5?	0.853
UCU5	What is your frequency of usage of Uber and Careem for going to college/university on a scale of 0 to 5?	0.605
Travelling Patterns (0.781)		
TP13	How often were you taking public transportation for travelling weekly, BEFORE ride-sourcing?	0.416
TP14	How often were you taking public transportation for travelling weekly, AFTER ride-sourcing?	0.405
TP17	How often do you take a family car for travelling, BEFORE ride-sourcing?	0.490
TP18	How often do you take family car for travelling, AFTER ride sourcing?	0.574
TP19	How often do you take rikshaw for travelling, BEFORE ride sourcing?	0.835
TP20	How often do you take rikshaw for travelling, AFTER ride sourcing?	0.875
Women's Access to Space (0.882)		
WM1	Is ride sourcing contributing to your increased freedom to travel?	0.875
WM2	Is ride sourcing providing you with sense of security?	0.714
WM3	Do you rely on ride sourcing for your daily travelling?	0.784
WM5	Have you started travelling more because of ride sourcing?	0.848

Latent variables (Cronbach's Alpha)	Measured variables (items)	Item loading
Women's Satisfaction with Uber and Careem (0.826)		
WM4	Is your family satisfied with your use of ride sourcing?	0.807
WM6	Have you ever reported any driver since you are using ride sourcing services?	0.789
WM7	Do you prefer and would feel safer with a female driver instead of male driver?	0.673
WM8	Will you be interested to work as a driver for ride sourcing?	0.693
Additional Trips and Pollution (0.674)		
ATP 1	In the past month, how many times you have taken a trip just because of ride sourcing (say additional trip) that you might not have taken otherwise? [You can see MY RIDES option in your app]	0.688
ATP2	Out of the additional trips you have taken, what was the approximate average kilometer distance traveled?	0.933
ATP7	Has ride sourcing reduced the travelling on your own private vehicle/ family vehicle?	0.206

Reliability Testing

The test of construct reliability (also composite reliability) by average variance extracted (convergent reliability) was done to check the reliability of the constructs. Usually, the acceptable levels of analysis show AVE greater than 0.5 and composite reliability of more than 0.7 (Salman et al., 2014). The given table 6 shows the reliability values for each construct.

Table 6. Reliability of Constructs

Constructs	Convergent Reliability (AVE)	Construct Reliability	Discriminant Validity
Uber Careem Usage	0.491	0.822	0.0045033 (holds)
Travelling Patterns	0.395	0.781	0.048034967 (holds)
Women's Access to Space	0.652	0.882	0.280459473 (holds)
Women's Satisfaction with Uber and Careem	0.552	0.830	0.283214593 (holds)
Additional Traveling Patterns	0.462	0.674	0.00047088 (holds)

Uni- Dimensionality Testing

The purpose of this test is to determine that whether the used items in the scale fit in a solitary underlying construct. There was no uni-dimensionality found from the results. (Chi-square p value= 0.000, X2/df= 2.008, GFI=0.773, NFI=0.716, TLI=0.810 and RMSEA= 0.79).

Validity Testing

The validity is analyzed using discriminate validity, which is defined as the extent to which the constructs are divergent from each other (John and Reve, 1982). The convergent reliability is equated with the average shared variance (which is the average squared correlation of all the constructs). This value is thought to be lesser than the value of AVE.

Confirmatory Factor Analysis (CFA)

Each item was loaded and analyzed for CFA. Only those were retained, which showed a significant relationship. There was no correlation between the error terms of the items. The model fit for all the variables can be seen in the given table. It is recommended by Hu & Bentler (1999) to use a mix of these values since each one has its own strengths and weaknesses. CFA can be seen in table 7.

Table 7. Confirmatory Factor Analysis

Index	Recommended Value	Observed Value
Chi-square/df	It should be between 1 to 3 (Segars & Grover, 1998)	2.008
NFI		0.716
GFI	It should be > than 0.8 (Segars & Grover, 1998)	0.773
CFI		0.830
TLI		0.810
RMSEA	It should be < than 0.10 (Hair et al., 2009)	0.079

Correlational Analysis

When the validity and reliability of all the constructs were identified, all the constructs were examined for the correlational analysis. The following figure shows the correlational matrix. It was found that traveling patterns changes, women’s access to space, women’s satisfaction and additional trips and pollution are positively correlated with the usage of Uber and Careem. When the validity and reliability of all the constructs were identified, all the constructs were examined for the correlational analysis.

Table 8. Correlational Analysis

Variables	Car owner ship	UCU	ATP	TP	WMA	WMS	Age	Occupation	Income	HHCAR
Car owner ship	1.000									
UCU	0.140***	1.000								
ATP	0.019	0.060	1.000							
TP	0.211***	0.022	-0.037	1.000						
WMA	0.442***	0.103**	-0.011	0.241***	1.000					
WMS	0.406***	0.074*	-0.001	0.273***	0.871***	1.000				
Age	0.076*	0.006	0.076*	0.010	-0.156***	-0.108***	1.000			
Occupation	0.208***	-0.020	0.136***	0.022	0.202***	0.153***	0.150***	1.000		
Income	0.356***	0.030	0.079*	0.113***	0.150***	0.165***	0.141***	0.056	1.000	
HHCAR	0.340***	0.152***	0.175***	-0.179***	0.227***	0.234***	0.097**	0.155***	-0.041	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8 shows that there is a significant positive correlation between car ownership and Travelling Patterns which shows that as an individual have their own car, their travelling pattern will change. Having a personal car also has a significant positive relation with women access to space and their sense of security. Implying that women feel secure in their personal car as compared to public transportation. Uber and Careem Usage also a positive significant relation with women sense of security. Furthermore, travelling patterns and access to space and security has a positive and significant relationship. Age seems to have a negative relation with women security and access to space, which is true in the Pakistan context which shows that as the women in Pakistan age, their sense of security in public transportation decreases and their access to space also decreases.

Result Estimation

Given is the summary of SEM in which hypotheses were tested based on one-on-one regressions.

Table 9. Hypothesis Testing (One on One Regression of Dependent and Independent Variables)

VARIABLES	(1) TP	(2) TP	(3) ATP	(4) ATP	(5) WMA	(6) WMA	(7) UCU	(8) UCU
UCU	0.0393*	0.0127	0.0471**	0.0678***	0.0253**	0.0607**		

VARIABLES	(1) TP	(2) TP	(3) ATP	(4) ATP	(5) WMA	(6) WMA	(7) UCU	(8) UCU
CarOwnerShip	(0.0233) -0.246***	(0.0235)	(0.0460) -0.118	(0.0460)	(0.0214) -0.568***	(0.0239)	0.342*** (0.120)	
Age	-0.00935 (0.056)		0.0853 (0.111)		-0.244*** (0.052)		-0.0251 (0.100)	
Occupation	0.0436* (0.0226)		0.119*** (0.0446)		-0.0480** (0.0207)		-0.0694* (0.0397)	
Income	0.0165 (0.0186)		0.049 (0.0368)		0.0156 (0.0171)		0.0701** (0.0328)	
HHCAR	-0.235*** (0.0724)		0.547*** (0.1430)		-0.0906 (0.0665)		0.340*** (0.1270)	
WMS							0.0267* -0.0714	-0.117* -0.065
Constant	3.512*** (0.154)	3.093*** (0.059)	1.433*** (0.304)	2.554*** (0.114)	3.864*** (0.141)	2.452*** (0.059)	1.435*** (0.371)	2.458*** (0.154)
Observations	600	600	600	600	600	600	600	600
R-squared	0.07	0	0.053	0.004	0.244	0.011	0.043	0.005

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

(HHCAR: if Household has a car. car ownership: if the respondent owns a car.)

Table 9 shows regression estimated for the four econometric equation. Column (1) and (2) show UCU impact on travel patterns. Column (1) shows that UCU has a positive and significant impact on the travelling patterns for our complete sample. Having your own personal car does not impact the travelling patterns change. In the questionnaire, the travelling pattern questionnaire was with respect to UCU, so is thus relation is negative; it again supports our relation that it because of Uber and Careem that travelling patterns have increased. Column (2) shows that without the control, UCU does not impact travelling patterns. Column (3) and (5) shows that UCU has a positive and significant impact on ATP and WMA. Column (4) and (6) show the same results; this shows that UCU has contributed toward pollution generation to an increased number of trips on the road. Also, that women mobility has improved due to ridesharing. One of the interesting results is the negative relation of women access to space and age. The results imply that as the women in Lahore grow, their access to space decreases. This could be due to the conservative thinking of Pakistan families. There is a significant positive impact of Household car and occupation on pollution. Column (7) and (8) of the regression table explain how the women’s sense of security about Uber and Careem impact its’ usage. The results show a positive relationship between women’s security and UCU.

Result Estimations for Women Sample

In table 10, regression analysis for a female sample is done only.

Table 10. Hypothesis Testing: Female Sample & Uber Careem Usage

VARIABLES	(1) WMA	(2) WMA	(3) UCU	(4) UCU
UCU	0.4230** (0.0194)	0.0244* (0.0186)		
CarOwnerShip	-0.162*** (0.062)		0.729*** (0.173)	
Age	-0.165*** (0.0456)		-0.106 (0.1300)	
Occupation	0.0620***		-0.200***	

VARIABLES	(1) WMA	(2) WMA	(3) UCU	(4) UCU
	(0.0188)		(0.0526)	
Income	0.00289		0.211***	
	(0.0181)		(0.0505)	
HHCar	0.00839		0.436***	
	(0.052)		(0.147)	
WMS			0.0868**	0.0664*
			(0.155)	(0.167)
Constant	2.565***	1.817***	0.791	2.178***
	(0.144)	(0.048)	(0.492)	(0.283)
Observations	330	330	330	330
R-squared	0.104	0.005	0.161	0
Standard errors in parentheses				

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Column (1) and (2) results show the women respondents agree that their mobility has improved due to the presence of Uber and Careem. The regression also shows that there is a significant positive relation between occupation and women mobility. This is supported by literature that as women start working, their mobility changes. Column (3) and (4) shows the factors that affect women sense of security and how secure do they feel about the services of Uber and Careem. There is a significant and positive relationship between women feeling safe about Uber and Careem and using their services. Only when women feel safe they would utilize the service. Furthermore, household car and their own income create a sense of security among the females of Lahore.

Result Estimations for Women Sample: Before and After Uber and Careem

The regression in table 11 estimates the women sample, which indicates that after ride-sourcing, their travelling patterns have changed.

Table 11. Hypothesis Testing: Female Sample & Ride Sourcing Impact

VARIABLES	(1) TP	(2) WMA
UCU	0.0138*	0.0123**
	(0.0418)	(0.0243)
CarOwnership	0.239*	0.0837**
	(0.134)	(0.0777)
Age	0.224**	-0.187***
	(0.0964)	(0.0560)
Occupation	0.0644	0.0534**
	(0.0416)	(0.0242)
Income	-0.0124	0.00562
	(0.0396)	(0.0230)
HHCar	-0.251**	-0.0111
	(0.114)	(0.0661)
Constant	2.261***	2.376***
	(0.307)	(0.178)

Observations	217	217
R-squared	0.070	0.091

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The results in column (1) indicate that after ride sourcing service women travelling patterns in Lahore have changed. Travelling patterns have increased by 0.0138. Also women access to space has shown a positive reaction to Uber/Careem, as the result shows that as UCU goes up WMA increase by 0.0123. The control on the other hand shows the same result as previous one .

The regression in table 12 estimates the women sample which indicates that after ride sourcing their use of Organization van has decreased.

Table 12. Hypothesis Testing: Female Sample & Organization Van Use

VARIABLES	(1) TP	(2) WMA
UCU	0.0119** (0.0384)	0.0172* (0.0217)
CarOwnerShip	0.122 (0.124)	-0.178** (0.0703)
Age	0.153* (0.0900)	-0.163*** (0.0510)
Occupation	0.0507 (0.0366)	-0.0633*** (0.0207)
Income	-0.0156 (0.0364)	0.00122 (0.0206)
HHCAR	-0.263*** (0.101)	-0.00736 (0.0572)
Constant	2.708*** (0.284)	2.606*** (0.161)
Observations	266	266
R-squared	0.043	0.111

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The results in column (1) indicate that after ride-sourcing service, women in Lahore rely more on Uber Careem rather than organization van. The wait time and travelling route is the reason for a change in. Travelling patterns to UCU have increased by 0.0119. Also, women access to space has shown a positive reaction to Uber Careem. As a result, it shows that as UCU goes up, WMA increase by 0.0172. The control, on the other hand, shows the same result as in the previous regression.

Impacts of Ride-Sourcing on Air Quality (Emissions Calculation)

The emission of CO_2 was calculated using data on fuel consumption and kilometres driven, using the emission calculation formula provided by (US Environmental Protection Agency, 2011).

$$CO_2 \text{ Emissions per mile (grams)} = CO_2 \text{ per gallon} / \text{Miles per gallon}$$

$$\text{Annual } CO_2 \text{ emissions} = (CO_2 \text{ per gallon} / \text{Miles per gallon}) * \text{Miles}$$

The values were converted in Liters and Kilometers instead of Gallons and Miles, according to Pakistani standards. In Pakistan, 1.65 kilometres are approximately equal to 1 US Mile, and 3.8 litres of petrol is approximately equal to 1 US gallon. Currently, the cars in Pakistan produce about 140-170 grams of CO_2 per

kilometre and 1 litre of petrol produces 2.34 kilograms of CO_2 (Rehan & Farhan, 2012). Emission estimation is shown based on average kilometres & days a car is driven. If an Uber/Careem car is driven for 7 days a week using the average distance travelled it gives out 19.7 Metric Tons of CO_2 whereas, if a car is driven for 6 days, it gives annual emissions of 16.89 Metric Tons of CO_2 .

The extensive study needs to be done at a larger scale in order to find the environmental burden. Traffic congestion adds to air pollution. The data obtained through public opinion on traffic congestion shows that these services are actually a cause of traffic congestion. Literature shows that the increase in traffic congestion can ultimately lead to exacerbated air pollution through tailpipe emissions (Beaton, 1995). Gorham (2002) states that carbon dioxide emissions via road traffic will increase up to 92% from 1990 to 2020. Ride-sourcing in this regard could make the situation worse. Kakouie (2012) shows that in the case of Tehran city, around 88% of all the anthropogenic carbon dioxide comes from private cars, whereas; the emissions from the public sector are significantly low. Cities where public transportation exists in an efficient manner produce less CO_2 .

Discussion & Conclusion

Pakistan has a low rank of indulgence, and in such economies, free and independent movement of women is not stress-free. This new business model of ride-sourcing is making women independent and providing them with ease of movement. This digitalization in the transport sector is altering the lives of women, and they are becoming empowered and more mobile (Yasin & Awan, 2018). The major aim of this research was to identify the impacts of ride-sourcing, including the change in public transit patterns with a special focus on women's access to space. Ridesourcing creates job opportunities and provides safe mobility for women. However, the number of cars on the roads has increased in terms of quantity and number of trips thus creating congestion problem along with CO_2 emissions. This economic model may prove profitable in monetary terms but may have negative impacts on the environment.

The paper shows that a maximum number of Careem and Uber users travel alone whereas, previously, people have been using the option of car-sharing, using organization's van or public bus. This has possibly little impacts on the environment as compared to the 'one person travelling in one car' approach. Careem and Uber are easy travelling solutions; the public opinion on the environmental situation in relation to Careem and Uber shows that many users disagree that this app-based transportation system is an environmentally friendly option. To share a ride (ridesharing) with unknown strangers is not considered a feasible mode of commuting in a traditional society like Pakistan, particularly for women. Henceforth, ridesharing is suppressed, and ridesourcing is widely used.

The results of this survey show that the majority of women agreed that ride-sourcing had increased their freedom to travel, and they feel secure. The female passengers have also agreed to the fact that their family is satisfied with their use of Uber or Careem. Ride sourcing has provided a platform for women's mobility. Women currently rely on ride-sourcing for their daily travelling, and it has become an important part of their routine. Women have started travelling more because of ride-sourcing, as a result of which their mobility is increased.

The findings also demonstrate that majority of the female riders would prefer having a ride with a female driver, but very few percentages are willing to opt to be a driver. Even though Careem has started hiring female drivers in Pakistan but the ratio is significantly low as compared to ladies working for the same platform in countries like India or UAE. The data shows that ride-sourcing has become a prominent feature of commuting for women in Lahore, making them independent. Yet again, more cars and more pollution phenomenon are prevailing.

Women contribute to urban mobility as much as men do, but their comfort concerns are often neglected while planning for transportation. The aggravating security risks for women in public transits are a societal fiasco. In order to make this business model successful, shared service should be available to people of all classes and gender groups (Stark & Meschik, 2018; Singh, 2019). Ridesourcing is serving for the time being need of people, and in spite of customer satisfaction majority respondents still plan to get a 'new car' but the irony is that public transportation is thought to be sustainable transportation system. Even though the mass transit options are available in the vicinity of Lahore, the results of this survey show that some percentage of people might not prefer to use public bus just because of the availability of Careem and Uber. The same trend is applicable to conventional

rickshaw services and even staff/student vans. People are moving away from the usage of traditional means and have adopted the new trend but no doubt women's mobility and access to space has increased making the model successful in the developing economy of Pakistan. Ridesourcing is limited scrutinized phenomenon which is expanding in Pakistan. This research proves the transit shift; however, the environmental along with the economic impacts of this transition needs further research.

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