IS CAR-SHARING A SUSTAINABLE TRAVEL OPTION IN SAUDI ARABIA?

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ABSTRACT

Purpose: The purpose of this paper is to investigate car sharing schemes in Tabuk in the Kingdom of Saudi Arabia and feasibility of this option.

Methodology: In this context, this paper investigates car-sharing as a mode for travel for work trips in Tabuk city. Investigation of the characteristics of trip makers which impact on the decision of selecting car-sharing as a mode of travel is presented. The paper investigates the factors which affect the decisions of car sharing in the Kingdom of Saudi Arabia using the household survey data. Discrete choice modelling techniques have been adopted in this research to investigate behaviour and attitudes to car sharing and the binary logit model has been utilised.

Findings: From the results, the most popular mode of transportation which was used 2–3 times per week by males was an informal car share. This was accounting for 15.1% of all male responders. For the seldom (one or less times per week) option it was seen that the informal car share was the most common option selected by the male responders selecting this option accounting for 23.2% of all male responses within this questionnaire.

Originality: Investigation of car-sharing schemes in Saudi Arabia as a sustainable mode of transport.

Keywords: car-sharing; sustainable modes of travel; Saudi Arabia; Tabuk.

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INTRODUCTION

Car sharing is membership-based, shared-use access to an automobile fleet for as little as an hour at a time. Vehicles are located in reserved parking spaces in neighbourhoods close to where members live and work. After reserving the car share vehicle by phone, members typically walk, bike or take public transit to the vehicle, and gain access by using a special code or proximity card. The hourly fee covers use of the vehicle as well as gas, insurance maintenance, cleaning and insurance. Car-sharing is a system in which individuals have access to a car from a fleet on an hourly basis (Scott et al., 2003). The growing popularity of car-sharing is reflected by a continuous increase in the number of users worldwide. However, the estimation of travel demand for this mode has only sporadically been addressed by researchers and not in a completely satisfactory way. In the USA the share of trips by car is similar for men and women (87%), while Germany displays a larger gender gap with 65% of trips by car for males compared to only 57% for women. In Germany, the share of trips by car in the lowest density category is smaller than the share of car trips in the second highest density category in the USA. For example, European retirees are more likely to walk, bike or ride public transport, while the share of trips by car increases with retirement age in the USA (Buehler, 2011).

Scott et al. (2003) explained that car sharing is now being offered in about 30 cities in North America, and through about 50 organisations throughout Europe, while private autos are typically used only 2% of the time they are available, car share vehicles are used 30–40% of the time. This makes for a more effective use of resources. Instead of high fixed costs of ownership (for payment/ depreciation, insurance and sometimes registration) which approach 80% of the total costs of owning a car, car share members pay the incremental cost of vehicle ownership and operation, and only when they are actually using a vehicle. For people who drive less than about 12,000 km per year (7500 mi), car sharing is less expensive than owning a new car. This provides an economic incentive not to drive that would be overlooked by private car owners. Car share members can estimate the cost of an auto trip in advance, and can weigh it against the convenience, comfort or carrying capacity desired. Members may then consider alternative transportation modes such as public transit, bicycling and walking. A number of studies indicate that car sharing members use public transit, walk and bicycle at higher rates that the general population (Scott et al., 2003).

In Kingdom of Saudi Arabia, Tabuk city has typical travel characteristics of a medium size Saudi city. It should be noted here that for cultural reasons women do not drive in the Saudi Arabia. Moreover, workplaces as well as schools for men are separate than work places for women. Travel behaviour research indicates that travel decisions are usually influenced by accessibility as well as characteristics of the transport systems. Factors such as travel times, travel costs, waiting times, walking times have the most significant contributions in mode choice and travel decisions. In the case of developing countries however, most influencing factors for travel behaviour and decisions are the social factors (Attiyah and Saleh, 2014). Because of the social factors in Saudi Arabia, most male members of the family drive cars, while the female mainly rely on car sharing, hiring a private driver or using a taxi. The aim of this paper is to investigate the factors which affect the decisions of car sharing in the Kingdom of Saudi Arabia. The data has been collected using a household survey in Tabuk city (see Al-Atawi and Saleh, 2013) for a detailed description of the survey.

Discrete choice modelling techniques have been adopted in this research to investigate behaviour and attitudes to car sharing (see Cervero et al., 2007; Fallon et al., 2004; Habib et al., 2011; for further discussions) of car sharing behaviour of traveller and the structural modelling equations.

PREVIOUS RESEARCH/LITERATURE REVIEW

The Sefage development project in Zurich, which started in 1948, is known as the first implementation of the concept of car sharing (Harms and Truffer, 1998). Various other schemes were implemented in the 1970s and 1980s, but most of them operated at a very small scale and none of them survived (Shaheen et al., 1998). The modern era of car-sharing started in the late 1980s, when new schemes, most of them still in operation today, entered the market. Since then, the basic concept of car-sharing has evolved in slightly different ways throughout the world but 'neighbourhood car-sharing' (Barth and Shaheen, 2002) is still the predominant operational model, especially in Europe. In recent years, several new developments further modified the world of car-sharing. In many countries, the existing operators, experience substantial growth rates. Among motorised modes, if Single Occupancy Vehicle (SOV) is at one end of the spectrum for efficiency, comfort, and flexibility and transit is at the other end of the spectrum for pro-environmentalism, carpool falls somewhere in between – it can offer more efficiency, comfort and flexibility than transit and it is a more socially desirable mode than SOV in reducing congestion and pollution.

In US after experiencing a peak 20% mode share in 1980, the current share of carpooling for work trips is about 10% and the majority of these carpooling trips are made by intra-household members. Casting the choice between SOV and carpool as a social dilemma in which driving SOV is a no cooperative choice and carpool is a cooperative one, we propose to test two hypotheses. Firstly, the switch from SOV to carpool and the reverse choice are attributed to different factors – structural factors, or those factors altering the objective features of a decision scenario such as travel time and travel cost, play a dominant role in the switch from carpool to SOV while psychosocial factors (attitudes and beliefs) play a critical role in the switch from SOV to carpool. Secondly, the two choices are underlayed by different behavioural mechanisms. In particular, self-justification is expected by carpool-to-SOV switchers – after they switch from carpool to SOV, they adjusted their attitudes towards carpool accordingly to match their behaviour.

Fallon et al. (2004) investigated constraints affecting mode choices by morning car commuters. They found that in Auckland carpooling was less common with trips of 20 km or less. In Auckland, reflecting the generally lower levels of public transport service provision, busier streets and more dispersed population, more car drivers viewed Carpooling with someone else as a viable alternative to driving their own car or using public transport. They used The Christchurch model which is a nested logit model, chosen from a number of tree structures. It has one branch consisting of the drive, walk and catch public transport (walk PT) and cycle mode choices whereas the other branch incorporates the carpooling, (car) passenger, drive-park and ride (drive PT) and 'all other' mode choices. The nested logit model has inclusive value parameters lying in the 0–1 range, thus meeting the condition for consistency with utility maximisation (Louviere et al., 2000).

Cervero et al. (2007) investigated Longer-Term Travel Demand and Car Ownership Impacts for 79 vehicles Four years after the introduction of City CarShare in the San Francisco, Bay area in California, 29% of carshare members had gotten rid of one or more cars, and 4.8% of members' trips and 5.4% of their vehicle miles travelled were in carshare vehicles. Matched-pair comparisons with a statistical control group suggest that, over time, members have reduced total vehicular travel. However, most declines occurred during the first 1 to 2 years of the program; 3 to 4 years after City CarShare's inauguration, earlier declines had levelled off. Because many carshare vehicles are small and fuel-efficient but can carry several people, the trend in per capita gasoline consumption also is downward. Mindful of the cumulative costs of driving, carshare members appear to have become more judicious and selective when deciding whether to drive, take public transit, walk, bike or even forgo a trip. Coupled with reduced personal car ownership, these factors have given

rise to a resourceful form of automobility in the San Francisco Bay area. Evidence from study of Caevero et al. shows results of five surveys of City CarShare members and non-members clearly indicates a net reduction in the VMT and fuel consumption of carshare members. Matched-pair comparisons reveal that mean VMT and fuel consumption of members decreased faster than those of non-members from 2001 to 2005, in an era of rising fuel prices. Reduced travel was matched by increased accessibility afforded to those who joined City CarShare. Increased personal benefits matched by decreased social costs (reflected in VMT and fuel consumption) suggest that carsharing is a win–win proposition – benefiting users and non-users alike. Even though net longer-term benefits appear to be associated with carsharing in the San Francisco Bay Area, the largest reductions in members' average VMT and fuel consumption accrued during the first several years of the program.

Ciari et al. (2010) estimated Car-Sharing Demand Using an Activity-Based using Micro simulation Approach. How precise this tool can estimate the demand for car sharing is, however, yet to be answered. This can be achieved only by testing different modelling options and scenarios. Hitherto, it was important to show that an activity- and agent-based tool is a realistic option for the modelling of car-sharing.

Habib et al. (2011) investigated the carpool mode choice option in the context of overall commuting mode choice preferences using hybrid discrete choice modelling technique. They modelled considering carpooling in the choice set formation as well as commuting mode choice together with the response bias corrections through the accommodation of measurement equations. A cross-nested error structure for the econometric formulation is used to capture correlations among various commuting modes and carpool consideration in the choice set. Empirical models are estimated using a dataset collected through a week-long commuter survey in Edmonton, Alberta. The empirical model reveals many behavioural details of commuting mode choice and carpooling.

The study done by Wang and Chen (2012) resulted into recommend developing programs and policies that aim at influencing people's subjective assessments of carpooling, in addition to the existing ones that mostly focus on incentivising carpooling, and differentiating between programs seeking to encourage SOV users to switch to carpool and those aiming to maintain existing car-poolers (Wang and Chen, 2012). They used Structure Equations Modelling (SEM) to capture the interdependence between changes in attitudes and mode switching behaviour between SOV and carpool. SEM has the advantage of inferring relative causality (regression effects) between multiple endogenous variables. The three endogenous variables in their model were: change in the perceived difficulty of carpool (Component 1), change in the feelings of carpool (Component 2) and demand for the mode switch between SOV and carpool. Demand for the mode switch is a latent variable related to the observed mode switching behaviour.

Fatmi and Habib (2014) modelled use of car share services for different trip purposes in Halifax, Canada. Their investigation also included the modes car share members who chooses trip purposes, in absence of the car share service. Latent class modelling techniques were utilised with data from a web-based travel survey of existing car share member. The purpose of accessing car share, considered

1. work related,
2. shopping,
3. personal business and
4. recreational and others.

The mode choice behaviour of car share members were considered using five modes in the choice set:

1. transit,
2. bicycle,
3. walk,
4. taxi and
5. other (carpool and rental car).

The parameter estimates of the trip purpose model suggested that socio-economic characteristics, location of accessing car share, membership plans, travel attributes and neighbourhood characteristics are highly significant in explaining the purpose of accessing car share services. In case of the mode choice model, socio-economic characteristics, travel attributes, and neighbourhood characteristics are the major predictors of mode choices in absence of the car share services.

The above review has essentially looked at a very broad definitions and operations of car sharing schemes and their assessment. In the case of Saudi Arabia however, the formal operation of car sharing is not recognised as such, instead there are informal arrangements of car sharing, mainly within each household. Therefore, the assessment and investigation of this kind of transport have not been explored previously. Attiyah and Saleh (2014) investigated the modal share and the extent of car sharing in Tabuk city. This paper presents further investigation of car sharing in the city of Tabuk.

GENERAL DESCRIPTION OF CAR SHARING IN TABAUK

Kunieda and Gauthier (2007) reported that men travelled more than women in certain stages of life (usually older) and mainly in cities in Islamic countries. This suggests that cultural factors, including religion, influence travel behaviour. In the case of Tabuk, the main factor in selection of mode of the transport mode is the social role, and specifically the role inside the family. The majority of the people who drive are the family heads. Then it is followed by older, Son/Daughter and at last finally wife. Women are less likely than men to use bicycles or other intermediate means of transport, but are more dependent on feeder services and door-to-door transport provision (Kunieda and Gauthier, 2007). Wives are more likely passenger either informal or using contractor drivers or using private vehicles in Tabuk. These results are similar to IIesa, Nigeria where more than 70% of the women depend on public transport for their day-to-day transactions. Also, 65% of the men depend on their own personal means of transport to commute to different activity centres (Adetunji, 2013).

However women in Tabuk city have different modes of choice as reported by Kunieda and Gauthier (2007) that men's and women's walking trip mode shares in Dhaka and Lima were roughly the same, while female walking trip shares were 52% higher than men's in Pune, 61% higher in Bamako and a 100% higher in Ashgabat (Kudat et al., 1996). There was no walking trip found in case of Tabuk for female however there were a few trips by head of family. Furthermore, the accessibility of a location from the perspective of a woman is likely to be different than that of a man in the same household because data suggests that women are less likely to own a vehicle or have a license to drive it. In Tabuk, women tend to have a lower proportion of trips involving personal vehicles like bicycles or personalised motorised modes as it was found in Chendgu and Chennai (Srinivasan and Rogers, 2005; Srinivasan, 2008).

DATA DESCRIPTION IN TABUK CITY

The data presented in this paper was collected from a household survey in Tabuk city in 2012 (see Al-Atawi and Saleh for detailed description of the survey). In total 516 completed surveys forms where obtained from a total of 1226 distributed surveys throughout the city of Tabuk, which is an overall response rate of 42.0% for the study. Questionnaires were distributed in different sectors covering broad spectrum of characteristics of different workplaces in Tabuk city (health services, educational services, military services, security, private, Tabuk Municipality and the water Authority.

The questionnaire comprised of five separate sections; the current travel patterns of the respondents including the mode of transportation which they use to reach their place of work as well as modes' characteristics, respondents' attitudes and preferences on alternate modes of transport, preferences and attitudes related to the times which individuals travelled to their place of work, information of respondents' preferences and attitudes to a number of traffic and travel transport policies and socioeconomic and household structure of respondents.

From the household data, it has been reported that 55.1% of all responders were male. It was also reported that the car drive is the most common mode of travel to work. A total of 233 males indicated that they held a valid driving licence which was 45.2% of total responders to the questionnaire. In terms of mode of travel to work, there were in total 221 male responders indicated that they drove 4–5 times per week to reach their place of work. Interestingly however, some of the male members of the households have specified more than two modes to be chosen including the private car as the preferred option while others indicated that they prefer informal car sharing and/or being a passenger with a contracted driver. Bus, taxi and other combinations have not shown significance in the modes chosen for male member. Therefore, there are a large percentage of travellers who are captive to the car as a mode of travel, while another large percentage are choosers (Tabuk Study Final Report, 2013).

The most popular mode of transportation which was used 2–3 times per week by males was an informal car share as was accounting for 15.1% of all male responders. For the seldom (one or less times per week) option it was seen that the informal car share was the most common option selected by the male responders selecting this option accounting for 23.2% of all male responses within this questionnaire. Driving was seen to have the lowest response rate in the never category with only 5.9% males indicated that they never drove to work. The most common response in this category was that of the use of public buses of which 62.6% individuals indicated that they never used buses in their commuter journey (see Table 1).

The responses of males in relation to using two modes of transportation during the week was a combination of driving and being a passenger in an informal car share which account for 44.4% of all male responders to the questionnaire. This was followed by utilising both walking and driving as was selected by 25.4% male respondents. The lowest combination which was a passenger in a car driven by a contracted driver and used another means of transportation accounting 2.1% of all male responders to the questionnaire. Male (18%) responses in relation to their income levels and the mode they use in reaching their place of work was seen an income between 8001 and 12,000 SAR and drove to work. The pay bracket which received the highest overall response rate from males was that of the 4000–8000 SAR pay range.

The males with respect to their place of work and mode used to reach their destination for all frequencies throughout the week it can be seen that the highest response rate was from individuals in education whom drove to work. This accounted for 19.8% of all male responses to the questionnaire. The second most popular combination was also seen to be from individuals

Transport_Mode	Count	Social_Role						Total
		Daughter	Head	Old	Other	Son	Wife	
	36	1	8	2	0	2	7	56
Bus	1	0	2	1	0	0	3	7
Car sharing	0	2	1	0	0	0	1	4
Cycling	1	1	17	5	0	5	3	32
Drive	34	16	145	38	4	33	9	279
Other	1	0	0	0	0	0	0	1
Pass CNT	3	8	2	0	0	2	20	35
Pass Informal	6	11	6	2	1	6	39	71
Pass PRV	1	8	0	2	1	0	16	28
Taxi	0	0	0	0	0	1	0	1
Walk	2	0	2	1	0	1	0	6
Total	85	47	183	51	6	50	98	520

Table 1 Transport_Mode × Social_Role cross tabulation

in the education sector indicating that they used an informal car share at some stage during the working week (Attiyah and Saleh, 2013).

From the data collected from the surveys carried it was found a total of 55.7% (287) of respondents indicating that they regularly drive to work, with 43 individuals indicated that they sometimes or seldom drove to work, while a further 14.5% indicated that they never drove to work. The second most common mode of transportation utilised was through informal car share schemes with 17% (88) of the respondents indicated that they utilised this method while formally organised car sharing schemes accounted for a further 3% (16) of regular work journeys. With regards to commuter journeys using a private vehicle in which the individual was a passenger with some forms of professional driver in place it was seen that a total of 42 (8.1%) individuals utilised a private driver on a regular basis while 46 (8.93%) individuals employed a contracted driver regularly.

Private bus and cycling accounted for 20% (107) journeys combined, with 3.5 and 6.4% of respondents indicating that they utilised each mode on a regular basis. About 54% of respondents indicated that they never used private buses with a further 55% of individuals never choosing to cycle to their destination. Within the private bus option it was seen that 2.7 and 5% of respondents chose to sometimes and seldom utilise this mode, while these frequency of use accounted for 1.4 and 1.7% of journeys through cycling.

When the use of a private driver is further examined it was seen that 32 (6.2%) and 39 (7.57%) individuals used these services on a less regular basis under the sometimes and seldom options, respectively. It was seen that the use of contracted drivers was identical in the seldom and regular categories at a level of uptake of 46 (8.39%) in each instance with 27 (5.24%) individuals indicating that they sometimes utilised these services. The use of taxis as a mode of transportation was seen to increase as the frequency of use decreased with 29 (5.6%) individuals indicating that they would sometimes use this means of transportation with this level rising to 53 (10.3%) on a seldom basis. A total of 235 (45.6%) individuals indicated that they never use taxis as a means of transportation to their place of work.

On the other hand, a total of 25 (4.85%) individuals indicated that they regularly walked to their place of employment with these levels rising to 32 (6.21%) and 42 (8.16%), respectively for the sometimes and seldom choices. A total of 244 or 47% or respondents indicated that they never walked to their place of work while a further 10 (2%) individuals indicated that they took a taxi to work on a regular basis. A further 18 (3.44%) individuals indicated that they commuted to their workplace by another means not mentioned within the questionnaire however these respondents failed to specify the specific mode by which they travelled. A summary of this data in relation to mode choice are in Table 2.

Interestingly when further analysis of this information are carried out, the results show that most people do use other modes than the private car, even though these other modes can involves the car as seen in Table 2 below. As can be seen from the table 91% of respondents take a private vehicle to work 4–5 times per week, there are 31% who use other modes than drive a car. Interestingly, the main factor to the selection of transport mode is the social role of each member of the family. From the following cross table we can see that the majority of the people which drive are the heads of families while it is seen that wives and daughters have the lowest rates of driving except for the other category which as it represented a small response rate is not statistically significant.

MODELLING FRAME WORK

The present study estimates the binary logit model to explore the effects of various characteristics which affect the choice and use of car sharing as the mode of transport. Other models have been calibrated using other modelling approaches such as least squares regression analysis, binary logit and binary probit models (see Al-Atawi and Saleh, 2013). In this research, each respondent was asked to report on the mode chosen, the reasons for the choice by him/herself as well as reporting on other household and travel characterises. The responses taken from each member of the family on behaviour of other members of his/her family have been assumed to be independent and hence the errors of each respondent's responses are not correlated. Therefore, a multinomial logit specification have been assumed to be appropriate to model this choice. In addition, different parameter such as education, cost to petrol and availability of taxi were also investigated. The dependent variable represents the choice of car sharing such as 1 is flexible and 0 otherwise. The description of the independent variables is given in Table 3.

Table 2 How respondents usually reach their place of work					
How do you usually travel to work?					
Mode	Never	Seldom (1 or less times per week)	Sometimes (2–3 times per week)	Regularly (4–5 times per week)	Total
Passenger Informal Car sharing	0.2	0.2	0.1	0.17	0.69
Passenger car sharing	0.5	0.1	0.0	0.03	0.63
Contractor driver	0.5	0.1	0.1	0.09	0.69
Private driver	0.5	0.1	0.1	0.08	0.68
Drive	0.1	0.0	0.0	0.54	0.75
Total	1.78	0.44	0.31	0.91	3.43

Table 3 Description of variable	
Code	*Description*
CAR_SHR	How do you usually travel to work (Regularly 4–5 times per week)?
HED	What is your status in your Household? Head
OLD+SON	What is your status in your Household? Oldest Son or Son
OFT_PETR	How often do you fill petrol in your car?
CHEAP	Why do you choose to travel (to work) by the mode(s) you have ticked in question 1?
	Is the sum up of all the scores assigned for the question 2 at the attribute CHEAP for every mode, divided by the total score assigned to every attribute to every mode plus one. This variable weights the importance the subject gives to 'CHEAP' against all the other attributes. Is the relative importance of been cheap for the subject. High values of this variable indicate subject for whom the cheapest transport mode everything else constant, is always preferred.
UNI	Level of education: University
TAXI	How would you make your journey to work if your current mode (most regularly used mode) was not available to you? With taxi

The formulation of the logit model begins by specifying a function that determines travellers' choice of the mode of travel. In this case, the utility function is written as (see also Hensher et al., 2005; Train, 2003) as shown in Equation 1:

$$U_{in} = \beta'_n X_{in} \varepsilon_{in} \tag{1}$$

where U_{in} is the propensity function that determines the probability of discrete adoption level *n* for individual traveller *i*; X_{in} is a vector of observed variables such as rider attributes, system characteristics, β_n is a vector of parameters associated with X_{in} and ε_{in} is error term. A number of models have been tried and there have been no evidence of superiority of any other model form over the logit model. Table 4 presents model estimation results for the binary logit model. For determining whether a mixing distribution is appropriate for specific variables within a mixed logit model, this could be further investigated.

Table 4 Car sharing model for Tabuk City				
Variable	*Coefficient*	*SE*	*z-Statistic*	*Prob.*
CONSTANT	−1.00557	0.191362	−5.25478	0
HED	0.675269	0.263736	2.560399	0.0105
OLD+SON	0.850666	0.312812	2.719416	0.0065
OFT_PETR	0.093553	0.038174	2.450718	0.0143
CHEAP	4.77794	1.41556	3.375301	0.0007
UNI	0.590054	0.218062	2.705899	0.0068
TAXI	0.738136	0.253358	2.913413	0.0036
McFadden *R*-squared	0.141185	Mean dependent var		0.573991
Obs with Dep=0	190	Total obs		446
Obs with Dep=1	256			

RESULTS AND DISCUSSION

The data presented in this paper was collected from a household survey in Tabuk city in 2012. The questionnaire collected data and information on respondents' current travel patterns of travel, their attitudes and preferences on alternate modes of transport, preferences and attitudes related to the times which individuals travelled to their place of work, information of respondents' preferences and attitudes to a number of traffic and travel transport policies and socioeconomic and household structure of respondents.

From the results, the most popular mode of transportation which was used 2–3 times per week by males was an informal car share. This was accounting for 15.1% of all male responders. For the seldom (one or less times per week) option it was seen that the informal car share was the most common option selected by the male responders selecting this option accounting for 23.2% of all male responses within this questionnaire. This paper investigates the factors which affect the decisions of car sharing in the Kingdom of Saudi Arabia using the household survey data. Discrete choice modelling techniques have been adopted in this research to investigate behaviour and attitudes to car sharing and the binary logit model has been utilised.

The findings of modelling travel behaviours of car share members will assist decision-makers to develop a more attractive, competitive and sustainable car share program. Thus implementing policies that increase population density and promote public transport access may initially have a more limited impact on the share of trips made by car. Over time, as regional population densities increase and public transport networks become more extensive, this may change, however.

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