

# Sustainable travel modes in Saudi Arabia: is there a potential for formal car-sharing scheme?

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## Abstract

**Purpose** – The purpose of this paper is to investigate the actual demand on formal car-sharing scheme in Saudi Arabia as a means of public modes of transport in order to assess the potential future of this mode in Saudi Arabia as a policy measure.

**Design/methodology/approach** – In this context, this paper investigates the potential feasibility of introducing formal car-sharing scheme as a means of public modes of transport in Tabuk city. Investigation of the characteristics of trip makers, which impact on the decision of selecting the currently available informal 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, in the case of Tabuk, the main factor in selection of the transport mode is the social role, and specifically the role inside the family. Results showed that about 49 per cent of total respondents drive to work, while about 20 per cent reported that they use car-sharing. About 8 per cent of respondents reported that they use a private driver, while other 8 per cent reported that they use a contracted driver.

**Originality/value** – Investigation of the potential of introducing formal car-sharing scheme in Saudi Arabia as a means of public modes of transport in Saudi Arabia which is a more sustainable mode of transport.

**Keywords** Saudi Arabia, Formal car-sharing, Sustainable modes of travel, Tabuk

**Paper type** Research paper

## 1. Introduction

Formal car-sharing scheme as well as 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 (Shaheen *et al.*, 1998). 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 per cent), while Germany displays a larger gender gap with 65 per cent of trips by car for males compared to only 57 per cent 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).

Shaheen *et al.* (1998) 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 per cent of the time they are available, car share vehicles are used 30-40 per cent 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 per cent 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 (7,500 mi), car-sharing is less expensive than owning a new car. This provides an economic incentive not to drive and 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 than the general population (Shaheen *et al.*, 1998).

In the 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 Saudi Arabia. Moreover, workplaces as well as schools for men are separate from 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 (Al-Atawi 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 and the potential of operating formal car-sharing schemes there. The data have 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 Habib *et al.*, 2011; Cervero *et al.*, 2007, Fallon *et al.*, for further discussions) behaviour of traveller and the structural modelling equations.

## 2. 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 (Wang and Chen, 2012).

In the USA after experiencing a peak 20 per cent mode share in 1980, the current share of carpooling for work trips is about 10 per cent 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 SOV driving is a no cooperative choice and carpool is a cooperative one, we propose to test two hypotheses:

- H1.* 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.
- H2.* The two choices are underplayed 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 per cent of car share members had gotten rid of one or more cars, and 4.8 per cent of members’ trips and 5.4 per cent of their vehicle miles travelled were in car share 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 1-2 years of the programme; 3-4 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, car share 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 auto mobility in the San Francisco Bay area. Evidence from study of Cervero *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 car share 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

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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 car-sharing is a win-win proposition – benefiting users and non-users alike. Even though net longer-term benefits appear to be associated with car-sharing in the San Francisco Bay Area, the largest reductions in members' average VMT and fuel consumption accrued during the first several years of the programme.

Ciari *et al.* 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 data set 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 recommending developing programs and policies that aim at influencing people's subjective assessments of carpooling, in addition to the existing ones that mostly focus on incentivizing 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 choose 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 work related, shopping, personal business, and recreational and others. The mode choice behaviour of car share members were considered using five modes in the choice set: transit, bicycle, walk, taxi, and 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 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. Al-Atawi 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.

**3. General description of survey and car-sharing in Tabuk**

The data presented in this paper were collected from a household survey in Tabuk city in 2012 (see Al-Atawi and Saleh, 2013, for detailed description of the survey). In total 527 completed surveys forms were obtained from a total of 1,226 distributed surveys throughout the city of Tabuk, which is an overall response rate of about 42.0 per cent 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 the characteristics of modes, 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 socio economic and household structure of respondents.

From the household data, it has been reported that 70 per cent of all responders were males, while about 30 per cent were females. It was also reported that car driving is the most common mode of travel to work. All female respondents did not drive, although few of them had a driving licence which were obtained from other countries (for example other Gulf countries, UK or USA). With respect to gender, it was seen that the majority of both males and females had obtained a level of education up to receiving a university graduate level with 51.1 per cent of males and 57.1 per cent of females achieving this level. Females achieved a higher level of education overall when compared to males with a further 23.6 per cent of females achieving a post graduate degree while only 7.3 per cent of males had obtained this level of education.

Religion influences travel behaviour. In the case of Tabuk, the main factor in selection the transport mode is the social role, and specifically the role inside the family. Table I shows summary statistics of family positions and mode chosen to work. In total, there seems to be about 49 per cent of total respondents drive to work, while

	Main mode of transport used in daily commute									
	Walk	Public bus	Cycling	Driving	Car share	Private driver	Contracted driver	Taxi	Others	
Head	9 (4.3)	9 (4.3)	18 (8.6)	148 (70.5)	12 (5.7)	4 (1.9)	4 (1.9)	3 (1.4)	3 (1.4)	
Wife	1 (1)	3 (3)	3 (3)	10 (9.9)	42 (41.6)	19 (18.8)	23 (22.8)	0	0	
Eldest Son	5 (7)	3 (4.2)	5 (7)	39 (54.9)	9 (12.7)	5 (7)	1 (1.4)	1 (1.4)	3 (4.2)	
Daughter	2 (3.2)	1 (1.6)	1 (1.6)	17 (27.4)	19 (30.7)	10 (16.1)	10 (16.1)	1 (1.6)	1 (1.6)	
Son	4 (6.2)	1 (1.5)	5 (7.7)	34 (52.3)	12 (18.5)	2 (3.1)	3 (4.6)	3 (4.6)	1 (1.5)	
Other	1 (12.5)	0	0	4 (50)	1 (12.5)	1 (12.5)	0	1(12.5)	0	
Total	22 (4.3)	17 (3.3)	32 (6.2)	252 (48.7)	105 (19.9)	41 (7.9)	41 (7.9)	9 (1.7)	8 (1.5)	

**Table I.**  
Family positions and mode of transport

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about 20 per cent reported that they use car-sharing. About 8 per cent of respondents reported that they use a private driver while another 8 per cent reported that they use a contracted driver.

The majority of the people, who drive, are the family heads (70.5 per cent of family heads). Then it is followed by older sons as 54.9 per cent of them reported that they drive to work, followed by son/daughter and finally wife. In the case of daughters and wives, this meant that they were driven to work rather than driving to work as women do not drive in the Kingdom. 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 passengers either informal, using contractor drivers or using private vehicles in Tabuk. These results are similar to Ilesa, Nigeria where more than 70 per cent of the women depend on public transport for their day-to-day transactions. Also, 65 per cent of the men depend on their own personal means of transport to commute to different activity centres (Adetunji, 2013). In terms of car-sharing, 30.7 and 41.6 per cent of daughters and wives reported that they use car-sharing to go to work (Table I).

However women in Tabuk city have different modes of choice as reported by Kunieda and Gauthier (2007) that men and women's walking trip mode shares in Dhaka and Lima were roughly the same, while female walking trip shares were 52 per cent higher than men's in Pune, 61 per cent higher in Bamako, and a 100 per cent higher in Ashgabat (Kudat *et al.*, 1996). In Tabuk, only 3 per cent of wives reported that they walk to work with only 1 per cent of daughters reported that walking was their mode of travel. Therefore, there was almost no walking trip found in case of Tabuk for female. However, there were a few trips by head of family as well as other members of the 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. Women in Tabuk 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).

Convenience and cost also rated highly with individuals whom partook in informal car share schemes with 24 and 21 per cent of all respondents indicating that these were factors which influenced their mode choice. Once more here, individuals, whom indicated that they are the passenger in a car sharing, state that they require their car either for work purposes or for other reasons before or after work.

With regards to commuters' journeys using a private vehicle in which the individual was a passenger with some form of professional driver in place, it was seen that a total of 7.9 per cent of respondents individuals utilised a private driver on a regular basis while another 7.9 per cent of them stated that they employed a contracted driver regularly while only 1.7 per cent of respondents indicated that they take a taxi to work on a regular basis.

When the use of a private driver is further examined it was seen that 32 (6.2 per cent) and 39 (7.57 per cent) 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 44 (8.39 per cent) in each instance with 27 (5.24 per cent) 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 per cent) individuals indicating that they would sometimes use this means of transportation with this level

rising to 54 (10.3 per cent) on a seldom basis. A total of 240 (45.6 per cent) individuals indicated that they never use taxis as a means of transportation to their place of work.

**4. 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 has 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 II.

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 Train, 2003; Hensher *et al.*, 2005) 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,  $\beta_n$  is a vector of parameters associated with  $X_{in}$ ; and  $\varepsilon_{in}$  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 III presents model estimation results for the binary logit model. For determining whether a mixing

Code	Description
CAR_SHR	How do you usually travel to work (Regularly use car sharing (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
Daughter + WIFE	What is your status in your Household? Daughter or Wife
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

**Table II.**  
Description of variable

distribution is appropriate for specific variables within a mixed logit model, this could be further investigated.

The findings from the modelling of choices of car-sharing show that the cost of travel, the position in the family as well as the car availability do affect the decision of using car-sharing (all parameters have positive signs and are statistically significant). In terms of position in the family, the coefficient of daughter and wife has a larger value than the coefficient of the male members of the family. Taxi has a positive sign in the model, which might indicate that those members, who have a lower car ownership and use taxis to travel to work, are more frequent users to car-sharing. This is an indication of increasing the use of car-sharing when the income and the car ownership are lower. The results also show that those who are university graduates tend to use car-sharing more often.

These findings could assist decision-makers to develop a more attractive, competitive, and sustainable car share programme. 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.

## 5. Results and discussion

The data presented in this paper were 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 socio economic and household structure of respondents.

The purpose of this paper has been to investigate the demand on formal and informal car-sharing schemes in the city as modes of travel to work. This is in order to investigate the potential feasibility of introducing car-sharing scheme as a means of public modes of transport in Tabuk city. Investigation of the characteristics of trip makers, which impact on the decision of selecting the currently available informal 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 has also been utilised to assess the preferences

Variable	Coefficient	SE	z-Statistic	Prob.
CONSTANT	-1.315	0.191362	-5.25478	0
HED	0.76269	0.263736	2.560399	0.0105
OLD + SON	0.850666	0.312812	2.719416	0.0065
WIFE+DAUGHTER	1.3513	0.534812	2.719416	0.0034
OFT_PETR	0.096753	0.038174	2.53452612	0.0153
CHEAP	4.98794	1.31556	3.79149564	0.0007
UNI	0.789	0.218062	3.61823702	0.0069
TAXI	0.748136	0.243358	3.07421987	0.0046
McFadden $R^2$	0.1877685	Mean dependent var		0.573991
Obs. with Dep. = 0	422	Total obs.		527
Obs. with Dep. = 1	105			

**Table III.**  
Coefficient  
estimates for choice  
of mode of travel as  
a car sharing for  
Tabuk City

and attitudes to car-sharing as a mode of travel to work. From the results, in the case of Tabuk, the main factor in selection of the transport mode is the family position, and specifically the role inside the family. Results show that about 49 per cent of total respondents drove to work, while about 20 per cent reported that they use car-sharing. About 8 per cent of respondents reported that they use a private driver while another 8 per cent reported that they use a contracted driver.

Car-sharing is potentially an important mode of transport for policy makers. It can well be enhanced to be used more in order to increase the penetration of public modes of transport and reduce the share of the private modes. To answer the question adopted in this paper, it seems that car-sharing can indeed provide a sustainable option of travel; an option that is already accepted and implemented in the country. Therefore, it is very important to motivate this option of travel and complement it with other supportive measures. Otherwise, there could be unsustainable increase in the ownership and use of cars and decline in the use of car-sharing which is a sustainable mode of travel and already is a very popular option of travel in the country.

The findings from the modelling of choices of car-sharing show that the cost of travel, the position in the family as well as the car availability do affect the decision of using car-sharing. These findings will assist decision-makers to develop a more attractive, competitive, and sustainable car share programme. 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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