Women's Modal Switching Behavior Since Driving Is Allowed in Saudi Arabia

ABSTRACT

The objective of this paper is to explore if and how the primary transport mode of women in Saudi Arabia changed since they are allowed to issue a driving license and drive, and what the factors affecting modal switch behavior are. A survey was launched as part of the national project She Drives KSA a year after the activation of the decree on allowing women drive. 20,504 women participated in the survey. Data analysis shows that modal shifts happened to several directions. A significant percentage of women (22.7%) has switched from "household car-as a passenger" to "household car-as a driver". In total, 37.7% of the participants have switched to household car-as a driver. A nested logit model is developed and the model estimation results indicate that employed women, women in the age groups of 18 to 29 and 30 to 39, women with high educational level, and single women are more likely to change from "household private car-as a passenger", "ridehailing" and "other" to "household private car-as a driver". Women who are unemployed, with low educational level and from households with low monthly income, are more likely to not change their primary transport mode. To our knowledge, this is the first research investigating such a unique and sensitive topic that is expected to significantly affect women's travel behavior.

Keywords: modal switch, women, travel behavior, nested logit

1. INTRODUCTION

The published literature has studied numerous events that affect modal switching behavior. Such events -among a plethora of others- are indicatively, the introduction of new mobility services such as ridehailing, car sharing or bike-sharing (*Martin and Shaheen, 2014; Kamargianni et al., 2016; Henao and Marshall, 2019; Tsirimpa et al., 2019; Alemi et al., 2018; Young and Farber, 2019; Becker et al., 2017; Liao et al., 2020; Ma et al., 2020; Tsouros and Polydoropoulou, 2020*), the COVID-19 pandemic (*De Vos, 2020; Ivanov, 2020*), the economic crisis (*Papagianakis et al., 2018*), the construction of new corridors (*Fuji and Gärling, 2003*), relocation of individuals (*Klinger and Lanzendorf 2016; Rashidi et al., 2011; Aditjandra et al., 2016; Titheridge and Hall, 2006*), Information and Communication Technologies (*Kitamura et al., 2008; Kamargianni and Polydoropoulou, 2014; Varghese and Jana, 2018; Choi and Mokhtarian, 2020*).

In 2018, a unique event happened in Saudi Arabia that -to our knowledge- the literature has not captured yet. Women in Saudi Arabia were not allowed to drive until 2018, when a royal decree was published reinstating their right to drive. As the situation was before the date women allowed to drive, in case a woman needed to leave the house, either the husband or an adult male household member had to accompany her, or alternatively the household had to employ a driver. Culturally, taxi is generally not an option, unless a woman is accompanied by a household's adult male. In addition, public transport that is mainly available in the big Saudi cities, is not a culturally acceptable transport mode. Hiring a driver poses no problems in wealthy households, but it is a significant financial burden to the great majority of households which relies on an ordinary (mainly public sector) salary. As such, transport becomes a significant problem for the households.

Transporting a woman takes two persons' time, and the time involved is significant taking into account the traffic congestion problems in most of the Saudi cities. Furthermore, in households without drivers, the husband was socially obliged to leave work to drive his wife if she needs to go to the doctor or other matters deemed important. Most employers, at least in the public sector, accept this cultural norm, implying that driving one's wife is a legitimate reason not to be present at work. As such, households' women and young children relied on male drivers (either household members or household private employees) or taxis to meet their daily travel needs including travel for education, jobs, shopping or other leisure trips, and for acting in urgent situations (*Aldalbahi and Walker, 2015; Alotaibi and Potoglou, 2018; Elias et al., 2015*).

Allowing women to drive has a big impact on women's travel behavior and mode choices. The objective of this paper is to explore if and how the primary transport mode of women in Saudi Arabia changed since they are allowed to issue a driving license and drive, and what the factors affecting modal switch behavior are. Since no public data is available for investigating this topic, a survey was launched as part of the national project She Drives KSA, a year after the activation of the decree on allowing women drive. 20,504 women participated in the survey declaring the primary transport mode they used before and after the activation of the decree. To investigate modal switches, a Nested Logit and a Mixed Multinomial Logit models are developed having 12 alternatives about modal switches. Since driving is a right of every citizen in other countries, the case of KSA offers a unique opportunity to study what is the impact on modal switching when the female population of a country is suddenly allowed to drive. The paper contributes to the state-of-the-art of gender issues in transport, as well as to the transport related research in the Arab countries that is very limited.

The rest of the paper is structured as follows. Section 2 presents the survey design and the data used for analysis in this paper. Section 3 presents the model specification and the elaboration on the model estimation results. Section 4 concludes the paper.

2. SURVEY DESIGN & DATA

2.1 Survey design & Data Collection

An on-line questionnaire survey was designed specifically for the needs of the She Drives KSA project (*IAU, 2018*) to collect data right after one year of the activation of the decree on allowing women driving (survey launched on 25th of June 2019; the decree was activated on the 24th of June 2018). The period that the questionnaire was available on-line to be answered was four weeks.

Before we launch the official online survey, several focus groups, where both females and males participated, took place around the KSA. The topics discussed in the focus groups assisted us to derive the sections of the questionnaire and relevant questions. Once the online questionnaire was designed, we also did several rounds of tests to make sure that all the questions were clear to the participants. The final version of the questionnaire used for the survey was structured in seven main sections:

1. Personal information: questions about individual's socio-demographic characteristics; referred both to female and male participants
2. Household information: questions about participant's household socio-demographic characteristics; referred both to female and male participants
3. Household's privately employed drivers: questions about the number of privately employed drivers before and after women start driving as well as related expenses and satisfaction with them; referred both to female and male participants whose households employ(ed) private drivers;
4. Attitudes towards women driving: referred both to female and male participants; but there were some questions that were specific to males and some specific to females;
5. Current travel behaviour: referred to female participants;
6. Driving license: questions about the experience, the cost and the impact on their lives; referred to female participants; and
7. Policies to support women driving in the KSA: potential policies that KSA could apply to support women driving; referred both to female and male participants.

For this paper, we use data from sections 1, 2, and 5.

The link of the on-line questionnaire was sent via text messages with the support of the Imam Abdulrahman Bin Faisal University and two communications companies (the companies did this as in-kind contribution for the survey; the companies could not control of the characteristics of the participants to achieve a representative sample). The link of the on-line questionnaire was viewed by 42,096 individuals (both male and female). 33,828 started answering the survey, while 29,756 completed it. After cleaning the dataset, the final sample consists of 29,639 respondents; 20,543 (69.3%) women and 9,069 men (30.7%) men. The survey was addressed only to adults (over 18 years old). The survey was available to fill out in both Arabic and English; 87% of respondents chose to fill it out in Arabic. The survey participants who completed the questionnaire were awarded for their participation via a lottery system, where four of them won a city car (the four cars were sponsored by a KSA car seller).

Due to the fact that the survey was administered on-line, there are several limitations in terms of the sample. It is anticipated that not all women have access to the internet and as such our sample includes only women who have access to the internet and women who also have the ability/skills to answer to on-line questionnaires. In addition, although we invited people from all over the Kingdom, the response to our invitation was higher in Riyadh (the capital) followed by Eastern Province and Makkah provinces leading to 87.2% of our sample coming from these provinces. The participation of women was considerably higher than participation of men. As such, the sample used for this analysis is not representative of KSA's population and the results presented below refer only to our sample.

2.2 Sample characteristics

Table 1 presents the descriptive statistics of our sample as well as census statistics for the female population of KSA. Since the topic of this paper is about women's switching mode behavior now that they can issue a driving license, only the female participants (20,543 observations) are taken into account for our modelling. Our sample consists mainly of women up to 39 years old. Most of the participants have attended college, while most of them received their education in KSA. 45% of the participants are married, while 43% are single. 63.5% of the participants have issued a driving license. 32% of the participants' households employ at least one private driver. 63.5% of the participants have already issued a driving license.

Table 1: Sample Characteristics

Variables		Percentage (N=20,543)	Official Statistics for KSA's female population (GSA KSA, 2010)
Age	18 to 29	42%	31%*
	30 to 39	38%	30%*
	40 to 49	16%	21%*
	50 or more	4%	18%*
Educational level	Low (up to high school)	20%	59%
	Medium (College)	66%	28%
	High (University)	14%	13%
Place education received	Outside KSA	11%	N/A
	In KSA	89%	N/A
Employment status	Employed	52%	24%
	Student	15%	17%
	Unemployed	33%	59%
Marital status	Single	43%	22%
	Married	45%	63%
	Widow/Divorced	12%	4%
Nationality	Saudi Arabian	89%	78%
	Non-Saudi Arabian	11%	21%
Residential province	Riyadh (capital)	64%	24%
	Eastern Province	15.5%	15%
	Makkah	12%	25%
	Other	8.5%	36%
Position of a driving license	Yes	63.5%	N/A
	No	26.5%	N/A
Average number of household members	Males	2.3	N/A
	Females	2.9	N/A
Household monthly income*	Less than 10,000SAR	36%	N/A
	10,000SAR to 20,000SAR	34%	N/A
	20,000SAR to 30,000SAR	14%	N/A
	More than 30,000SAR	16%	N/A
Average number of privately-owned vehicles		2.14	N/A
Availability of private driver(s) at household	Yes	32%	N/A
	No	68%	N/A
**1 SAR = 0.27 USD (rate for July 2019)*			

2.3 Modal shift statistics

Table 2 presents the modal shifts that have been identified in our sample. The lower part of the table presents the statistics for our dependent variable in the modelling exercise (Section 3). Women were asked what the primary transport mode for their trips was before and after the activation of the decree on allowing women driving. In our survey, we only included questions about the transport mode they use the most for any type of activity (we did not make it specific to trip purposes; apart from work trip purpose). In the "before" period, the vast majority of women (61.4%) declared that their primary transport mode was "household's private vehicle-as a passenger", followed by ridehailing (28.4%). Public transport modes are not that popular in the KSA and especially for women; the same applies for walking.

After the activation of the decree, we notice that modal shifts have happened to several directions. 37.7% of the participants declared that their primary transport mode is now "household's private vehicle – as driver". Although 63.5% of the participants issued a driving license, only 37.7% of the participants switched their primary transport mode into private vehicle driver. 39.7% of the sample are driven by a household member/staff. Allowing women driving had a big impact on ridehailing services (Uber and Kareem). In the "before women driving" period, 28.4% of women declared that they mainly used ridehailing, while in the "after women driving" period only 14.5%. It is also worth noting that 5% of our sample has switched to private cars-as a passenger. This may have happened because now that women are allowed to drive, they can escort other female household members as well.

Table 2: Modal Shifts: Primary Transport Mode Used Before and After Women Drive

Before women drive			**After women drive**		
	Freq.	Percent. (Obs.=20540)		Freq.	Percent. (Obs.=20540)
Household's private car - as driver	0	0%	Household's private car - as driver	7745	37.7%
Household's private car - as a passenger	12611	61.4%	Household's private car - as a passenger	8146	39.7%
Taxi	1207	5.9%	Taxi	820	4.0%
Ridehailing (Uber, Kareem)	5838	28.4%	Ridehailing (Uber, Kareem)	2974	14.5%
Bus	412	2.0%	Bus	322	1.6%
Walking	141	0.7%	Walking	127	0.6%
Other	334	1.6%	Other	409	2.0%
Shift to specific modes *(dependent variable)*					
From			**To**		
Household's private car - as a passenger	12611	61.40%	Household's private car - as driver [Alt. 1]	4667	22.72%
			Ridehailing & Taxi [Alt. 4]	563	2.74%
			Other [Alt. 5]	187	1.25%
			Has not changed [Alt.10]	*7194*	*35.0%*
Ridehailing & Taxi	7045	34.30%	Household's private car - as driver [Alt. 2]	2872	14.0%
			Household's private car - as a passenger [Alt. 8]	822	4.00%
			Other [Alt. 6]	219	1.07%
			Has not changed [Alt. 11]	*3132*	*13.9%*

Other	887	4.32%	Household's private car - as driver [Alt. 3]	206	1.00%
			Household's private car - as a passenger [Alt. 9]	130	1.63%
			Ridehailing & Taxi [Alt. 7]	99	0.48%
			Has not changed [Alt. 12]	*452*	*2.20%*

2.3 Male's attitudes towards women driving

Although this paper focuses on women's modal shifts, it is worth providing statistics about how this change affected males' daily life as well. The male participants that have at least one woman in their household owning a driving license, were asked to indicate their level of agreement or disagreement (5-point Likert Scale) to the statements presented in Table 3. 2,271 out of the 9,069 male participants in the survey have at least one women in their household owning a driving license. In general, it is seen that women driving has affected positively the daily life of males as well as the relationships among the family members. 34% of the participants agree and 27% completely agree with the statement that their daily trips number has been reduced. In addition, the majority of the participants positively perceived the statement that there is no need now to interrupt their activities to escort other household members. In addition, 26% of the participants agree and 20% completely agree with the statement that allowing women driving has improved the relationship in their households.

Table 3: Impact of allowing women drive on male's daily life

	Completely disagree	Disagree	Neutral	Agree	Completely agree
I have reduced the number of my daily trips	10%	9%	20%	34%	27%
I have more free time now	9%	9%	19%	35%	29%
There is no need now to interrupt my activities to escort the women from my household	9%	8%	17%	33%	33%
There is no need now to interrupt my activities to escort other household members	13%	13%	21%	26%	27%
The expenses of transporting my household's women have been reduced	13%	12%	20%	27%	28%
It has created tension in the household's relationships	51%	21%	18%	7%	3%
It has improved the relationships in my household	10%	8%	36%	26%	20%

3. MODEL SPECIFICATION & ESTIMATION RESULTS

3.1 Model specification

The main objective of this paper and the according models is to identify which variables are most likely to affect mode switching behavior of women in Saudi Arabia now that they can issue a driving license. Given our data and the transport modes available, 12 alternatives have been identified for mode switching/or not. As such, our choice set (dependent variable) consists of the below alternatives (i):

1. **From** household car as passenger **to** household car as a driver
2. **From** ridehailing/taxi **to** household car as a driver
3. **From** other **to** household car as a driver
4. **From** household car as passenger **to** ridehailing / taxi
5. **From** household car as passenger **to** other
6. **From** ridehailing **to** other
7. **From** other **to** ridehailing
8. **From** ridehailing **to** household car as passenger
9. **From** other **to** household car as a passenger
10. **No change**: Household car as passenger
11. **No change**: Ridehailing / taxi
12. **No change**: Other

The alternatives that are referred to switching to drivers (*1,2,3*), are not available to the women who do not have a driving license. In addition, the alternatives that include private household vehicles are not available to the women whom their household does not have any car. As a first step, a multinomial logit (MNL) model is developed and it is used as the base model. In an MNL model, the probability of an individual selecting an alternative *i* out of *j* number of alternatives is estimated by *Eq. (1):*

$$P_{(i)} = \frac{e^{(V_i)}}{\sum_{j}^{J=10} e^{V_j}} \qquad (1)$$

where $P_{(i)}$ represents the probability of choosing alternative *i*. V_i is the systematic part of utility function for alternative *i*. *J* is the total number of available alternatives in the choice set for the individual. However, MNL models suffer from IIA (independence of irrelevant alternatives) assumption leading to equal cross elasticity, meaning that any alternative draws equally from all the others (*Ben-Akiva and Lerman, 1985; Ortúzar and Willumsen, 2002; Hensher and Greene, 2002; Hess et al., 2012; Hess et al., 2005; Santos et al., 2013; Papola, 2016; Li and Kamargianni, 2020*). Initial IIA tests indicated that a multinomial logit structure is not appropriate for our case, as the IIA assumption is not met. As such, nests of alternatives can be formed that are closely correlated to each other (*Polydoropoulou and Ben-Akiva, 2001; Sekhar, 2016; Li and Kamargianni, 2018*). Consequently, a Nested Logit (NL) model is developed to model women's mode switching behavior. Such a model structure relaxes the identically and independently distributed (IID) assumption among the different alternative modes by allowing for correlation to exist among certain alternatives (*Ben-Akiva and Lerman, 1985*). The probability of choosing alternative *i* (where *i* is contained in nest *k*) in a NL with *M* different nests, where $j \in S_m$ defines the set of alternatives contained in nest m, is given by Eq. (2):

$$P_i = \frac{e^{\lambda_k I_k}}{\sum_{m=1}^{M} e^{\lambda_m I_m}} \frac{e^{V_j/\lambda_k}}{\sum_{j \in S_k} e^{V_j/\lambda_k}} \text{ with } I_k = ln \sum_{j \in S_k} e^{V_j/\lambda_k} \quad (2)$$

where λ is the nesting coefficient or the logsum parameter, which estimates the scale parameter of the Gumbel distribution for the nested alternatives.

After testing several nested structures (i.e. NL with two nests about "switched" and "not switched mode"; NL with 4 nests about "switched mode" and under this nest, the nests about "switched to drivers" and "switched to non-drivers", and another nest about "not switched mode"), we concluded to the NL structure presented in Fig. 1. Our NL consists of four levels and 6 nests. We first nest by if the women have switched or not their primary transport mode since women have been allowed to issue a driving license. Then for those who have switched primary transport mode, we create a nest for those who have switched to drivers and another nest for those who have not switched to drivers. Under the nest "switched to non-drivers", we create two more nests about if they switched to private or non-private modes.

Since, for those who have not switched modes the "driver" option is not available (women were not allowed to drive before this time), there is no nest about this under the "not switched mode" nest. We tested two further nests under the "not switched mode" for private and non-private modes, but the nest collapsed. The modelling structure that we concluded in, is presented in Fig. 1 and allows for correlation between those who have switched primary mode and those who have not. It allows for even higher correlation between those who switched primary transport mode and became drivers and those who have switched mode, but still they are not drivers. Even more, for those who switched mode to non-drivers, correlation is captured for those who switched to private and non-private modes.

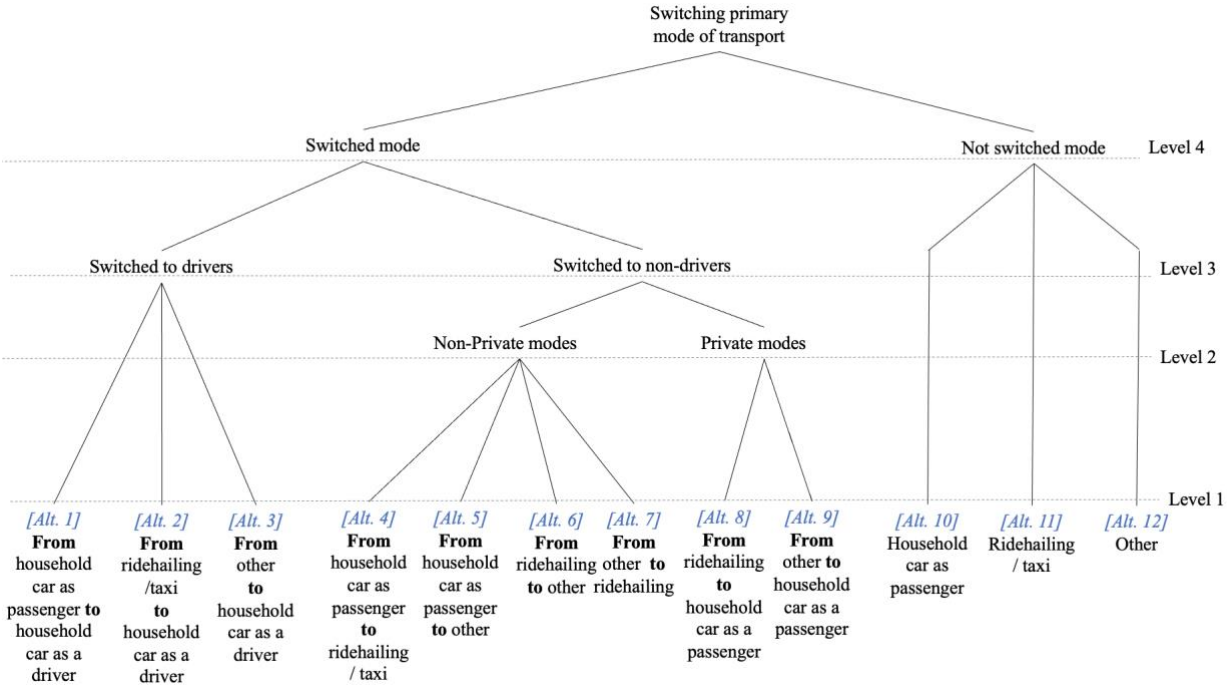

Figure 1:The NL model structure

We would like also to acknowledge that lately, there has been an increasing focus on the use of mixed multinomial logit (MMNL) models, which can also be used to allow for correlation between alternatives, with the use of a so called error components logit (ECL) specification (*Walker, 2001; Tsirimpa et al., 2007*). In fact, McFadden and Train (*2000*) discuss how the MMNL model can approximate any other random utility model arbitrarily closely. In the present context, we do not see any advantage in replacing our closed form Generalised extreme value (GEV) structures by a ECL specification, which, with 12 alternatives and 6 nests, would entail the estimation of a model with a very high dimensional integral, leading to impractically high estimation costs (*Bowman, 2005; Walker et al., 2004*). However, due to the fact that MMNL models obviously have the additional advantage of allowing for random taste heterogeneity alongside any correlation accommodated through error components, we also estimate an MMNL model that has parameters to capture the taste heterogeneity of the nests presented in Fig. 1.

Several variables were tested before we conclude to the results presented in Table 4. For example, we tested in which business sector employed women work for, their personal monthly income, the number of female and male household members that have driving licenses, who covers their transport expenses etc. However, these variables did not turn out significant or they did not have a plausible coefficient sign. At this point we would like also to acknowledge that in the majority of the modal switching models in the literature, variables about travel time

and travel cost are included. In our case, the dataset has travel time information only for the commute trip and the main trip that unemployed women conduct. It also has information about the transport monthly expenses of the participants. The cost variable was tested, but it did not turn out significant. Our final decision was to exclude travel time and travel cost variables. The reason is that this modal switch is due to a unique event in the history. We assume that the driving forces for women to switch their primary mode are not just travel time and cost, but something latent such as their freedom (however, in this paper we do not incorporate any latent constructs to validate this assumption; this is part of future work). In addition, the transport mode alternatives for women in KSA even in the capital, are mainly car-based (i.e. private cars, taxi, ridehailing), while the public transport system is now under development (only some buses are available). As such, since most of the alternatives are car-based, travel times or travel time savings do not considerably vary among the alternatives.

3.2 Model Estimation Results

The model estimations reported in this paper were carried out in Python BIOGEME (*Bierlaire, 2016*). Table 4 presents the parameters of explanatory variables used in the model. The variables used are presented in the first column, while it is stated in the parenthesis to which alternatives these variables are specific to. The NL gives us an improvement in model fit over the MNL model by 21.38 units in log-likelihood (LL), which is statistically significant. The nesting parameter for the nest "Switching to drivers" is statistically significant and much lower than 1 indicating that there is high correlation among these women who changed their primary transport to private vehicle drivers. High correlation is also observed for women who have not changed mode and for the women who have switched to non-drivers and to private modes. The value for the nesting parameter non-private modes under the nest switched to non-drivers, is close to 1 and not significantly different from 1, suggesting that only low levels of correlation arise in this context. The MMNL model further corrects correlation effects and shows the best performance among the three models. The MMNL has also a significant improvement over the MNL and NL specifications as inferred from the log-likelihood ratio test. The error components of the MMNL have the same coefficient signs as the nesting parameters of the NL verifying the taste heterogeneity among these alternatives. The MMNL model results will be used for the elaboration of the estimation results (however, there is no considerable difference from the NL estimation results in terms of interpretation).

Low level of education (parameter is generic for Alt. 10,11,12) is positively associated with women not switching modes, while high educational level is positively associated with women switching modes and more specifically becoming drivers. Women with high education seem to prefer switching from private cars-as passengers, ridehailing and other transport modes to private cars-as a driver. In addition, women who have received their education abroad seem to also have switched from private cars-as passengers, ridehailing and other transport modes to private cars-as a driver.

If a woman is employed positively affects the switching from any transport mode to private car-as a driver, while this is one of the most statistically significant variables. It seems that now that women drive in KSA, they can travel to work by themselves without requiring from any other household member to escort them. This is a promising finding, because women employment rates in KSA are quite low. If more women start driving, then this may also result in increasing women employment rates in the country. It has also been found that if a woman is employed affects positively the switch from household car-as a passenger and from "other" modes to ridehailing. These women may not have a car available for them at their household and since they have their own personal income, they may be able to cover this expense.

If a woman is unemployed positively affects the probability of not switching modes, as well as the option of switching from ridehailing to a household's car-as a passenger. Although women who are unemployed, do not have to commute to work, we assume that they may have several household errands to run. So, we expected that even unemployed women, they would switch to drivers in order to share some of the household errands. However, it seems that they stick to their travel behavior habits. For unemployed women who have switched from ridehailing to private car-as a passenger, it can be hypothesised that some of the female household members may have started driving, so they can escort them.

Younger women in the age group 18 to 29 and 30 to 39 years old seem to prefer switching modes and more specifically becoming drivers, as these two variables are positively associated with the Alt.1, Alt.2 and Alt.3. In addition, women belonging to the age group of 18 to 29 have also higher probability of switching from private car-as a passenger and from other modes to ridehailing. This age group is probably quite tech-savvy and smartphone-based transport options are quite attractive to them. The age group of 40 to 49 seem to prefer not to switch their primary transport mode. Older women have probably crystallised their travel behavior and it is difficult for them to change modes; so, they probably stick to their habits.

Single women are also more likely to switch their primary transport mode, as the generic coefficient that is specific to the alternatives switched from private car-as a passenger, ridehailing and other to private car drivers is positive. The marital status variable follows the same pattern as the variable of the age group 18-29 years, and this is plausible as probably younger women are also single. We tried to interact these two variables, but the results were not plausibly interpretable.

As the number of male household members who hold a driving license increases, women do not prefer to change their transport and they stick to private cars-as a passenger. The same happens for the number of female drivers in the household; as their number increases women prefer not to change modes and stick to household cars-as a passenger. In addition, when as the number of female drivers in the household increases, women tend to switch from ridehailing to private cars-as passengers. These validate also the assumption that women drivers have started escorting other female household members.

Although our expectation was that household income would have a significant role on modal switch behavior, our model indicates that the impact of the household income-related variables is not that high. Women from low income households (less than 10,000SAR) seem to have not changed their primary transport mode. And this is absolutely plausible, as for them it may be unaffordable to issue a driving license or for them or their household to purchase extra cars. For the other household income categories that we tested, the results were not statistically significant and as such, we did not include them in the models.

As the number of households' vehicles increases, women tend to switch from private car-as a passenger to drivers. Finally, as the number of the private drivers that a household employs increases, women prefer to not switch modes, and more specifically to not drive.

Table 4: Models' Estimation Results

	MNL		NL		MMNL	
Variables	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Constant – Alt. 1	0.965	3.12	0.738	3.86	0.721	1.99
Constant – Alt. 2	0.563	3.48	0.435	2.95	0.462	2.24
Constant – Alt. 3	0.230	8.65	1.040	8.48	1.540	5.79
Constant – Alt. 4	0.977	7.64	1.630	7.29	1.680	6.32
Constant – Alt. 5	0.679	9.73	0.607	10.49	0.578	8.23
Constant – Alt. 6	1.560	10.87	1.730	9.76	1.650	8.08
Constant – Alt. 7	-	-	-	-	-	-

Constant – Alt. 8	0.636	3.86	0.653	3.93	0.563	4.03
Constant – Alt. 10	0.503	2.86	0.516	2.21	0.643	2.12
Constant – Alt. 11	0.735	4.03	0.758	4.87	0.458	3.75
Constant – Alt. 12	0.370	3.28	0.421	3.78	0.359	3.53
Education level: Low *(specific to Alt.10, 11, 12)*	0.532	5.67	0.516	5.89	0.647	6.14
Education level: High *(specific to Alt. 1, 2, 3)*	0.268	4.72	0.202	4.42	0.649	5.73
Education received outside of the country *(specific to Alt. 1,2,3)*	0.503	7.83	0.487	8.65	0.583	9.65
Employment status: Employed *(specific to Alt.* 1, 2, 3, 4, 7)	0.678	9.63	0.697	10.62	0.569	12.54
Employment status: Unemployed *(specific to Alt.8, 10, 11, 12)*	0.859	7.95	0.867	8.03	0.976	9.45
Age: 18 to 29 *(specific to Alt. 1,2,3,4,7)*	0.153	2.64	0.102	2.38	0.274	2.08
Age: 30 to 39 *(specific to Alt. 1,2,3)*	0.205	2.42	0.194	2.45	0.258	3.17
Age: 40 to 49 *(specific to Alt. 10,11,12)*	0.274	1.98	0.297	1.96	0.189	1.23
Marital status: single *(specific to Alt. 1,2,3,4,6)*	0.793	3.65	0.829	3.96	0.634	5.96
Number of male household members *(specific to Alt. 10)*	1.775	5.32	1.85	5.14	2.118	3.87
Number of female household members *(specific to Alt.8, 10)*	2.632	2.08	2.962	2.01	2.673	2.75
Household income: less than 10,000 SAR *(specific to Alt.10,11,12)*	0.742	1.96	0.683	1.75	0.599	1.33
Number of privately-owned vehicles *(specific to Alt.1,11)*	2.461	3.07	2.870	2.96	2.78	2.99
Private driver available at household *(specific to Alt.1,2,3)*	-0.436	-2.75	-0.427	-2.54	-0.393	-3.85
Nesting parameters						
Switched mode	-	-	0.56	9.65	-	-
Not switched mode	-	-	0.68	9.48	-	-
Switched to drivers	-	-	0.48	10.85	-	-
Switched to non-drivers	-	-	0.61	9.87	-	-
Switched to non-drivers: non-private modes	-	-	0.91	2.04	-	-
Switched to non-drivers: private modes	-	-	0.57	8.93	-	-
Error components						
Switched mode	-	-	-	-	0.65	9.23
Not switched mode	-	-	-	-	0.59	9.21
Switched to drivers	-	-	-	-	0.53	7.45
Switched to non-drivers	-	-	-	-	0.34	8.63
Switched to non-drivers: non-private modes	-	-	-	-	0.82	3.84
Switched to non-drivers: private modes	-	-	-	-	0.66	12.34
Summary statistics						

Observations			20543
Log-Likelihood	-18823.542	-18802.162	-17923.553
Adj. ρ^2	0.403	0.415	0.422

Table 5 summarizes the direct marginal effects of the variables included in the NL model. This table shows estimates of the effect of the explanatory variables included in the model on the probability of a switching mode alternative, while taking into account the impact of the other explanatory factors (*Abdel-Aty and Abdelwahab, 2004*). Table 5 presents the marginal effects only for the Alt.1, Alt.2, and Alt.3 (the utility functions of them are the same apart from the constant), due to space limitations and due to higher interest in the women who have switched to drivers. For example, employed women are more likely to switch from private car-as a passenger to private car-as a driver. In addition, employed women are also likely to change from ridehailing to private car-as a driver.

Table 5: Marginal Effects of the NL Model

Variable	Marginal Effect	
	NL	MMNL
Education level: High *(specific to Alt. 1)*	0.177	0.169
Education level: High *(specific to Alt. 2)*	0.118	0.103
Education level: High *(specific to Alt. 3)*	0.026	0.019
Education received outside of the country *(specific to Alt. 1)*	0.152	0.163
Education received outside of the country *(specific to Alt. 2)*	0.095	0.102
Education received outside of the country *(specific to Alt.3)*	0.014	0.010
Employment status: Employed *(specific to Alt. 1)*	0.301	0.324
Employment status: Employed *(specific to Alt. 2)*	0.183	0.207
Employment status: Employed *(specific to Alt.* 3)	0.072	0.096
Age: 18 to 29 *(specific to Alt. 1)*	0.190	0.232
Age: 18 to 29 *(specific to Alt. 2)*	0.124	0.129
Age: 18 to 29 *(specific to Alt. 3)*	0.035	0.027
Age: 30 to 39 *(specific to Alt. 1)*	0.137	0.154
Age: 30 to 39 *(specific to Alt. 2)*	0.106	0.096
Age: 30 to 39 *(specific to Alt. 3)*	0.031	0.034
Marital status: single *(specific to Alt. 1)*	0.125	0.129
Marital status: single *(specific to Alt. 2)*	0.109	0.114
Marital status: single *(specific to Alt.3)*	0.065	0.048
Private driver available at household *(specific to Alt.1)*	0.103	0.101
Private driver available at household *(specific to Alt.2)*	0.086	0.092
Private driver available at household *(specific to Alt.3)*	0.029	0.009

4. CONCLUSIONS

The main objective of this paper was to explore if and how the primary transport mode of women in Saudi Arabia changed since they are allowed to issue a driving license and drive and what the factors affecting modal switch behavior are. The data (revealed preference) come from the national project SHE Drives KSA, and the sample used for analysis in this paper consists of 20,504 female individuals. To our knowledge, this is the first research investigating

such a unique and sensitive topic that is expected to significantly affect travel behavior in the country.

Data analysis shows that modal shifts happened to several directions. A significant percentage of women (22.7%) have switched from "household car-as a passenger" to "household car-as a driver". In total, 37.7% of the participants have switched to household car-as a driver. The impact of this decree on ridehailing and taxi seems to be negative, as before the activation of the decree 34.3% of the participants were using these options as their primary transport mode, while after the activation of the decree only 18.5% declared these options as their primary transport modes. Furthermore, these changes in travel behaviour have also affected positively the daily life of males as they state that the number of their daily trips has been reduced and there is no need now to interrupt their activities to escort a family member.

A nested logit model with six nests has been developed with 12 alternatives that represent all the potential modal shifts that happened. As a next step an MMNL model was developed incorporating six error components (similar to the six parameters incorporated for the nests) to capture the taste heterogeneity among the alternatives. The model estimation results indicate that employed women, women in the age groups of 18 to 29 and 30 to 39, women with high educational level, and single women are more likely to change from "household private car-as a passenger", "ridehailing" and "other" to "household private car-as a driver". Women who are unemployed, with low educational level and from households with low monthly income, are more likely to not change their primary transport mode.

One of the objectives of the country as stated in the Vision 2030[1], is to increase women in the labour. By promoting women to issue a driving license and drive, may increase the number of employed women in the KSA, as our results show that several employed women switched from "private car as a passenger" to "private car as a driver". To achieve this, authorities should focus particularly to younger women (under the age of 39 years old). Driving promotion campaigns can be organised targeted specifically these age groups. In addition, our results show that women with higher education is more likely to switch to driving a private car. As such, campaigns could be organised to the higher education institutes to further promote women issuing a driving license. Since several of the female driving training schools are located at universities, the driving schools can make special offers to the female students to issue a driving license. Furthermore, some female training schools are located in big companies; similarly, these schools can introduce special offers for their female employees or the adult daughters of their male and female employees. In addition, road safety courses can be introduced to high schools and universities to make sure that young women who want to issue a driving license develop the appropriate road safety culture to drive safely when the time comes. Since women in KSA grew up without having in mind that they will drive, priority should be given simultaneously both to assist them issuing a driving license, but also to support them driving safely to avoid rebound effects, such as increased road traffic accidents.

Although in most of the developed countries around the world, the authorities try to shift people away from private vehicles and driving, the activation of this decree seems to reinforce the use of them. However, this decree should not be explored by a sustainability-related perspective, as it has a deeper meaning about the society and women. Now that women can drive, they may have the opportunity to find a job and as such contribute to their household's income as well as to the economy of the country. At the same time, in the major cities of Saudi Arabia major public transport projects are about to be delivered and then it is also worthwhile to explore again the modal shifts. Nevertheless, the introduction of thousands of new unexperienced drivers to the network at the same time may have a negative impact on road safety and car accidents and this worths exploration. Our future work will focus on

[1] https://www.vision2030.gov.sa

reinforcing the model presented in this paper with latent constructs to test our hypothesis that such modal switches are also driven by not directly observed factors.

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