EXPLORING THE FACTORS AFFECTING WOMEN'S INTENTION TO DRIVE IN SAUDI ARABIA

ABSTRACT

Women's choice to drive is a topic that has not attracted much interest in the academic literature, due to the fact that this is every citizens' right around the world. Saudi Arabia was the only country left, where women were not allowed to drive. In September 2017, a royal decree was issued, which reinstated the right for women to drive (activated in June 2018). This research aims to identify the key characteristics of women that affect their choice to drive, in order to seek policy inspirations for encouraging more women to drive. To our knowledge, this is the first research, exploring such a sensitive topic. An advanced behavioural econometric model, integrated choice and latent variable (ICLV) model, is developed to take into account both directly observable and unobservable characteristics of women to yield broader insights. Specifically, two latent variables, "Current mobility satisfaction" and "Driving importance for women", are studied, and the policy opportunities attached on them are explored. The data come from the national project SHE Drives KSA, and the sample used for analysis consists of 10,508 women from all over the Kingdom. The model estimation results show that younger and single women, those who have studied abroad and are employed, and those who live in provinces that are more affluent and have more economic opportunities are more willing to drive.

Keywords: Women; Driving intention; ICLV model; Latent variables; Saudi Arabia

1. INTRODUCTION

The Vision 2030 of the Kingdom of Saudi Arabia (KSA) envisages diversifying the country's economy away from oil, thus placing the Saudi economy on a more solid and economically sustainable footing (Hvidt, 2018). One of the drivers behind the reform proposed in the Vision 2030 is that the era of "plentiful oil incomes" is grinding to a halt as income from oil is significantly challenged in the long run (Economou and Agnoluci, 2016), while the KSA population steeply increases. The old model, where the government through high oil incomes was able to secure the population high salaries seems to not be sustainable (Goldstone, 2018). Through reforms, the economy needs to be diversified and more sources of income need to be brought into balance. A key factor in this reform is that larger segments of the population need to work, migrant labour force needs to be reduced, and job creation for Saudi-nationals should not take place only in the public sector (Hvidt, 2018). The private sector needs to be revitalized, so it can be attractive for Saudis to work there as well.

KSA has a total population of more than 33 million people, while more than 12 million of the population are non-Saudis (GAS KSA, 2019). In the third quarter of 2018, approximately 12.6 million of the population was employed (GAS KSA, 2019), with 3.1 million to be Saudis, while 9.5 million being non-Saudis. Analysing this from a gender perspective, 2 million employed persons are Saudi males, 1 million are Saudi females, 8.6 million are non-Saudi males, and 955 thousand are non-Saudi females (GAS KSA, 2019). In other words, out of the 21 million Saudis, only the 9.5% of the males and only 4.5% of the female Saudi population are employed. By international standards these numbers are extremely low. In an effort to increase the total number of Saudis working, Vision 2030 makes a considerable effort to increase the percentage of women in the workforce. The government has requested various entities in the public sector to post jobs targeting women. However, one of the most significant initiatives that the KSA aims to bring more women into the job market and change their status in the society is the royal decree issued in September 2017, which reinstated the right of women to drive.

KSA is a society, where the role of women is restricted in all the facets of daily life (Al-Alhareth et al., 2015). Recently some changes have started to give some rights to women (i.e. going to stadiums or attend concerts) to make the society more equal, and one of these is allowing women driving. However, besides the strong symbolic statement of change embedded in this initiative, lifting the ban on women's driving (which was instituted in the early 1980s) serves important interests related to bringing more women into the labour force and to increase work-related productivity (Hvidt, 2018). 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 both for the households and for the work-related productivity.

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 is 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 rely 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 (Aldalbahi and Walker, 2015; Alotaibi and Potoglou, 2018).

Against this background, it is expected that, now that the ban on women driving has been lifted, women but also households' daily life, activities and travel behaviour will change (Al-Garawi et al., 2019). Specifically, it would be desirable to see more women being willing to drive when they are allowed, as an important way to revitalize the labour market. Therefore, we present this research that aims to identify the key characteristics/factors that would affect women's intention to drive, in order to seek policy inspirations for encouraging more women to drive in the future. An advanced behavioural econometric model, an integrated choice and latent variable (ICLV) model, is developed to take into account both directly observable and unobservable characteristics of women to yield broader insights. Specifically, two latent variables, "Current mobility satisfaction" and "Driving importance for women", are studied, and the policy opportunities attached to them are explored. The data come from the national project "SHE Drives KSA" (IAU, 2018) and they were collected before the royal decree of allowing women driving was activated (before the 24th of June 2018; however, women were allowed to have driving lessons or convert their foreign driving licenses when the survey took place). The sample used for the analysis in this paper consists of 10,508 women from all over the Kingdom. Due to our survey approach (data collected via on-line questionnaires), most of the sampled women have good educational background (i.e. college and above). Although such a bias may limit the implications to the general population, the sample would fit the context of this project as such a population segment could have more access to private vehicles and potentially contribute the most to labour productivity once the driving ban is lifted.

To our knowledge, this is the first research exploring such a sensitive topic. Although there had once been a wide interest of research in 'women and transport' (Law, 1999), such as topics on commute travel or daily mobility in general, women's intention to drive or get a driving license is a specific topic that has not attracted very much interest in the academic literature, due to the fact that this is every citizens' legal right in other countries around the world, even though there are also cases where women could tend to travel by car less as drivers compared to men (Elias et al., 2015). Hence, the case of the Kingdom of Saudi Arabia offers transport-researchers a unique opportunity to study the characteristics of the women who intend to drive. Although in other countries both males and females grow up having in mind that one day when they are adults, they will be able to issue a driving license and drive, in Saudi Arabia women grow up knowing that they will not drive. Now that suddenly, they are allowed to drive, it is worthwhile to investigate what factors are there affecting women's intention to drive.

The rest of the paper is structured as follows. Section 2 presents the survey design and the data used for analysis in this paper. Following that is the description of the model development (section 3). The model estimation results are elaborated in section 4, with a projection analysis and policy discussions followed in section 5. In section 6, we conclude the paper.

2. SURVEY DESIGN AND DATA

2.1 Survey Design and Data Collection

An on-line questionnaire survey was designed specifically for the needs of the "SHE Drive KSA" project (IAU, 2018) to collect data before the decree on allowing women driving was activated (before the 24th of June 2018). The questionnaire was structured in seven main sections:

1. *Personal information* (presented to women and men): including socio-demographic characteristics of the respondent, such as age, gender, employment, education, residence, income and health conditions preventing them from driving.
2. *Household information* (presented to women and men): including questions related to household size, role, income, car ownership and parking spaces.

3. *Household's privately employed drivers* (presented to women and men): number of drivers, nationality of drivers, length of employment of drivers, incidents with drivers, satisfaction with drivers, planned status of drivers following the lift of the ban on women driving.
4. *Attitudes towards women driving* (presented to women and men): social, economic, environmental, road traffic safety statements that were rated on a 5-point Likert scale.
5. *Current travel behaviour* (presented only to women): transport mode usage, travel cost, accidents, satisfaction.
6. *Women driving* (presented only to women): intention to drive, get a license and purchase a vehicle.
7. *Policies to support women driving in the KSA* (presented to women and men): a range of policies aimed at supporting women who drive.

The link of the on-line questionnaire was viewed by 77,197 individuals, who received it via text messages on their mobile phones. The period that the questionnaire was available on-line to be answered was one week, while it was deactivated on the 23rd of June 2018, before the royal decree of allowing women drive was activated. 63,749 started answering the survey, but 31,594 completed it. After cleaning the dataset, the final sample consists of 31,426 respondents; 11,464 (36.5%) women and 19,930 (63.5%) men. The survey was mainly addressed to adults (over 18 years old); however, few people close to the adult age/the age that are allowed to drive (16-17 years old) were also invited. The survey was available to fill out in both Arabic and English; although 95% of respondents chose to fill it out in Arabic. Individuals from all the 13 provinces of Saudi Arabia were invited to participate in the survey, while at the same time we tried to secure a representativeness of our sample based on the KSA population. Respondents were awarded via a lottery system, where they could receive transport related awards (i.e. four city cars).

2.2 Sample Socio-demographic Characteristics

For this research, we select only the women respondents from the full sample of the "SHE Drives KSA" dataset (Al-Garawi and Kamargianni, 2018); while after a further cleaning of the data (removing missing observations), we end up with a sample consisting of 10,508 women. Table 1 offers a comparison between the selected sample and the full sample, as well as a comparison to the available census data for selected characteristics (for the missing: either this information was not available in the census data, or it was recorded in a different format that could not be compared to our data).

As an overview, our women sample mainly captures young and middle age groups (i.e. from 18 to 45); more than half of the sample are married and holding a college degree; the wealth of respondents spreads, with more women living in a household with monthly income under 10,000SAR; more than 90% of women have at least one household owned car, and most of them also have available parking spaces at home. Rising incomes have allowed most households to own private vehicles, while economic development has delivered large cities with extensive road infrastructure and a vast network of highways that connect the numerous cities scattered across KSA. The need for private vehicles to travel is reinforced by the current lack of public transportation systems within most of the Saudi cities (Atala et al., 2018). Regarding the residential location of our sample, most households (85.6%) are in the four most affluent provinces of KSA as listed in the table (i.e. Riyadh, Eastern Province, Medina and Mecca), and the rest 9 provinces in the KSA altogether capture 14.4% of the sampled women.

On the one hand, many characteristics of the women-only sample are close to those from the full sample, such as the distribution of age groups, marital status, educational level, household monthly income, number of cars owned by the household, number of parking spaces available to the household, and residential location by province. On the other hand, differences are found with some of the other characteristics. For instance, in the women sample, there are fewer foreigners (14.8%) compared to the

full sample that consists of both genders (27.0%); but we consider this plausible because given the census statistics the non-Saudi females are less than the non-Saudi males (GSA KSA, 2019). Similar conclusions can be drawn for employment status and educational place, as there must be more males employed and received education abroad which made the female numbers (40.7% for employment rate and 17.3% for overseas education rate) significantly lower than the full sample statistics (64.8% for employment rate and 26.0% for overseas education rate). At last, household driver hire rate is higher in the women sample than in the full sample. The difference directly reflects the fact that men are allowed to drive whereas women have to rely on drivers when using household owned cars.

Comparing the "SHE Drives KSA" sample to the national statistics (GSA KSA, 2019), differences are noticed. The biggest difference in the sample is related to the educational level. Our sample mainly consists of individuals who have received high education (college and higher education), while a significant percentage of the whole population (43.8%) has received elementary or no education. It is assumed that this is related to the way our survey was disseminated to the public; through text messages to mobile phones. People who have received higher education, are usually more likely to have a smartphone that could be used to access the survey link, while it is also easier for them to navigate through the link (Sax et al., 2003; Sinclair et al., 2012; Matyas and Kamargianni, 2018). In addition, there is a difference in the age, as the "SHE Drives KSA" survey was addressed more to adults (more than 18 years old), while included only few individuals under 18 years old (close to the driving age).

TABLE 1 Socio-economic Characteristics and Comparisons across Datasets

		SHE Drives KSA survey-women only N=10,508 obs*	**SHE Drives KSA survey-full sample** N=31,426 obs	**Official Statistics (GSA KSA, 2019)**
Gender	Male	-	63.5%	57.0%
	Female	100%	36.5%	43.0%
Age	under 18	1.7%	1.6%	13.1%
	18-25	27.9%	20.7%	13.8%
	26-35	38.6%	40.2%	30.4%
	36-45	22.5%	26.0%	21.8%
	46-55	7.6%	9.2%	12.3%
	56-65	1.6%	2.2%	5.2%
	over 65	0.1%	0.3%	3.4%
Nationality	Saudi	85.2%	73.0%	68.9%
	Non-Saudi	14.8%	27.0%	31.1%
Marital status	Single	38.9%	33.7%	33.3%
	Married	51.8%	61.9%	62.0%
	Divorced or widowed	9.2%	4.3%	4.7%
Employment status	Employed	40.7%	64.8%	53.5%
	Not employed	59.3%	35.2%	46.5%
Educational level	Elementary or no education	1.2%	1.9%	43.8%
	Intermediate	3.4%	4.6%	19.1%
	Secondary / High school	23.8%	28.4%	21.6%
	College	58.5%	53.8%	14.7%
	Higher studies	13.1%	11.2%	0.8%
Educational place	In the KSA	82.7%	74.0%	-
	Overseas	17.3%	26.0%	-
	No income	5.8%	10.3%	-

Household monthly income in SAR (including tax)**	Under 10,000	40.7%	42.0%	-
	10,000 - 20,000	30.0%	28.7%	-
	20,000 - 30,000	11.1%	9.6%	-
	Over 30,000	12.4%	9.4%	-
Household number of cars owned	No car	7.3%	10.3%	-
	One car	43.0%	45.8%	-
	Two cars	24.7%	21.8%	-
	More than two cars	25.1%	22.1%	-
Household number of parking spaces available	No space	29.1%	36.7%	-
	One space	39.9%	36.7%	-
	Two spaces	15.3%	12.4%	-
	More than two spaces	15.6%	14.2%	-
If household employ any drivers	Yes	26.8%	17.3%	-
	No	73.2%	82.7%	-
Household residential location (province)	Riyadh	30.7%	31.0%	-
	Eastern Province	31.0%	23.8%	-
	Medina	6.5%	7.2%	-
	Mecca	17.4%	20.0%	-
	Other provinces	14.4%	18.0%	-

* This number is slightly smaller than the number of women in the full sample due to the removal of some missing observations associated with attitudinal information.
** 1 SAR ≈ 0.27 USD

Table 2 presents the information regarding women's plans to drive, that is the key interest of this research, and statistics on women's current travel behaviour. We can see a massive difference between the number of women saying "Yes, I intend to drive" (66.3%) and those saying a strict "No" (7.8%), showing the importance of analysing such a behaviour, as it could potentially make a significant impact not only on Saudi's transport network and mode choices, but also on the society and economy in the near future.

Regarding the transport mode that women use the most, more than 70% of the surveyed respondents use a household private car as passengers (driving is not an option), followed by taxi (22.4%), while bus (2.2%) and walking (1.8%) seem to be quite unpopular. As explained in the introduction, bus is not a culturally accepted option and exists only in major Saudi cities. As such, the low percentage of bus usage is expected. Even more, the bus companies with the widest coverage in Riyadh and Jeddah till recently did not allow women at all (PTA, 2019). In 2018, this has changed, and women shall use a separate entrance and sit in a back section reserved for women. The Public Transport Authority of Saudi Arabia also plans to initiate buses dedicated only to women in an effort to increase the use of public transport modes in the future.

Over 60% of women have their current transport cost covered by other household members rather than themselves. Such a trend is possibly a result of the relatively low women employment rate, as presented earlier. In the end, we analysed some common activities that women tend to do during their trips. A wide range of activities are observed; although the majority of the respondents would still like most of the times to focus on the road (78.8%). Other collected information such as women's commute time, number of weekly commute trips, etc. are not studied in this research due to relatively poor data quality.

TABLE 2 Women's Intention to Drive and Current Travel Behaviour

	SHE Drives KSA survey-women only N=10,508 obs.

Intention to drive	Yes	66.3%
	No	7.8%
	Unsure	25.9%
Current transport mode that is mostly used	Private car	70.8%
	Taxi	22.4%
	Bus	2.2%
	Walking	1.8%
	Others	2.9%
Who covers the current transport cost?	By the user	28.7%
	By the user' household	63.2%
	By others	3.4%
	Not applicable	4.7%
Preferred activity during a journey	Talking on phone	15.2%
	Surfing the internet	23.4%
	Using social media	29.8%
	Listening to music	21.0%
	Work	14.5%
	Playing video games	6.1%
	Reading books/magazines	5.9%
	Reading Holy Quran	22.2%
	Eating	5.8%
	Sleeping	6.7%
	Relaxing	13.1%
	Focus on the road	78.8%

2.3 Attitudinal Indicators

To capture attitudinal information, the survey also presented to respondents a list of statements that are related to social, economic, environmental, and safety aspects of women driving in the KSA. Respondents were asked to indicate to what extent they agree with each of the statements. The levels of agreement were measured using a traditional 5-point Likert-scale (Likert, 1932) where: 1. Completely disagree; 2. Disagree; 3. Neutral; 4. Agree and 5. Completely agree.

Nowadays, to study attitudinal effects on choice behaviour it is generally not recommended to follow traditional practices such as directly treating statements from the survey as explanatory variables or using a sequential estimation approach that relies on factor analysis to identify latent variables which then contribute as input to choice model (Ortúzar and Willumsen, 2011), but a simultaneously-estimated integrated choice and latent variable (ICLV) model should be preferred as the best available technique (details of the model structure will be given in Section 3). Simultaneous estimation would allow the use of information on observed choices to inform the derivation of latent attitudes, as opposed to simply using attitudes as input to choice model (Bolduc and Alvarez-Daziano, 2010; Daly et al., 2012). However, rather than directly using an ICLV model to determine which of the many statements as the indicators to be used to form latent attitudes, a factor analysis could serve as a preliminary step to narrow down data dimension, especially as researchers are increasingly finding model computation time could easily surge when capturing more than one latent variable in an ICLV analysis (Raveau et al., 2010; Bhat and Dubey, 2014; Kamargianni et al., 2015; Bierlaire, 2016a; Li and Kamargianni, 2019).

A standard principal component factor analysis (Jolliffe, 2002) is conducted to assess the loadings of these survey statements on any potential attitudes that may help explain women's intention to drive. Among a number of attitudes that are detected, we are interested the most in women's "Current mobility

satisfaction" and their attitudes towards "Driving importance for women". Based on the literature (Abou-Zeid and Fujii, 2016; De Vos et al., 2016; Ye and Titheridge, 2017; Kamargianni and Dimakopoulos, 2018), the current satisfaction with a transport mode plays an important role in a mode choice or switching behaviour. Although in our case, we do not study the factors affecting mode choice and due to the fact that there is no previous literature on women's choice to drive, we hypothesise that women who are not satisfied with their current mobility, they would choose to change it; and since the transport mode alternatives in KSA are limited the most prominent option seems to become car drivers. Regarding "Driving importance for women", we believe that this is also a very important unobservable attitude that could affect the decision of women to drive, as well as a factor through which policy intervention may have opportunity to step in to encourage more women to choose self-driving, i.e. by influencing their awareness and consciousness towards the importance of being allowed to drive (more details will be discussed in section 5.2). In addition, there is a practical constraint for us deciding to focus on two attitudinal variables in this research, as the model estimation time substantially increased when trying to test with more attitudinal variables, given the current sample size.[1] Figure 1 and Figure 2 list the statements as indicators through which the two attitudes are manifested, and also show the percentages of women agreeing/disagreeing with the different measurement levels.

There are five statements selected as the indicators of "Current mobility satisfaction". For the first statement regarding if the surveyed respondents are generally happy with their current transport modes, there is a relatively equal split between the positive and negative responses; however, for the second statement which is also about happiness but looking instead on travel expenses, the statistics skew towards having more negative responses, highlighting an aspect that most people are not satisfied right now. The next two statements begin to touch upon the issue of being driven. Although many women agree with the fact that by being driven, they can do other activities thus spending their travel time more productively, they still have a strong negative attitude towards being driven per se (as we can see nearly 60% women completely disagree that they are happy with being driven). The last statement could also reflect such an issue as there are more people not feeling independent at the current state when making a transport mode choice. Finally, three other statements are evaluated alongside the five selected statements in the factor analysis due to their relevance to current mobility satisfaction; they are "I feel a need to change my daily transport mode", "My daily life is too busy and I want my trips to be convenient and relaxing" and "The transport mode I chose makes me worry". However, these statements are found to have significantly lower factor loadings (in terms of absolute value) in the varimax rotation test with Kaiser normalization (Kaiser, 1958). Although this is a preliminary step for indicator selection, the same results are confirmed while we formally testing the indicators for "Current mobility satisfaction" in the simultaneously-estimated ICLV framework in the next stage. Thus, our analysis ends up with five indicators as shown in Figure 1.

[1] For ICLV models, there is however a relatively novel estimation approach that could help cut down the lengthy computation time with multiple latent variables (see an application in Kamargianni et al., 2015) compared to the commonly used maximum likelihood estimator as we adopted here. However, for the "SHE Drives KSA" project, we do not have the resources needed to apply again the new approach, since it works with a specific modelling tool (i.e. GAUSS programming language) and would require complex coding inputs.

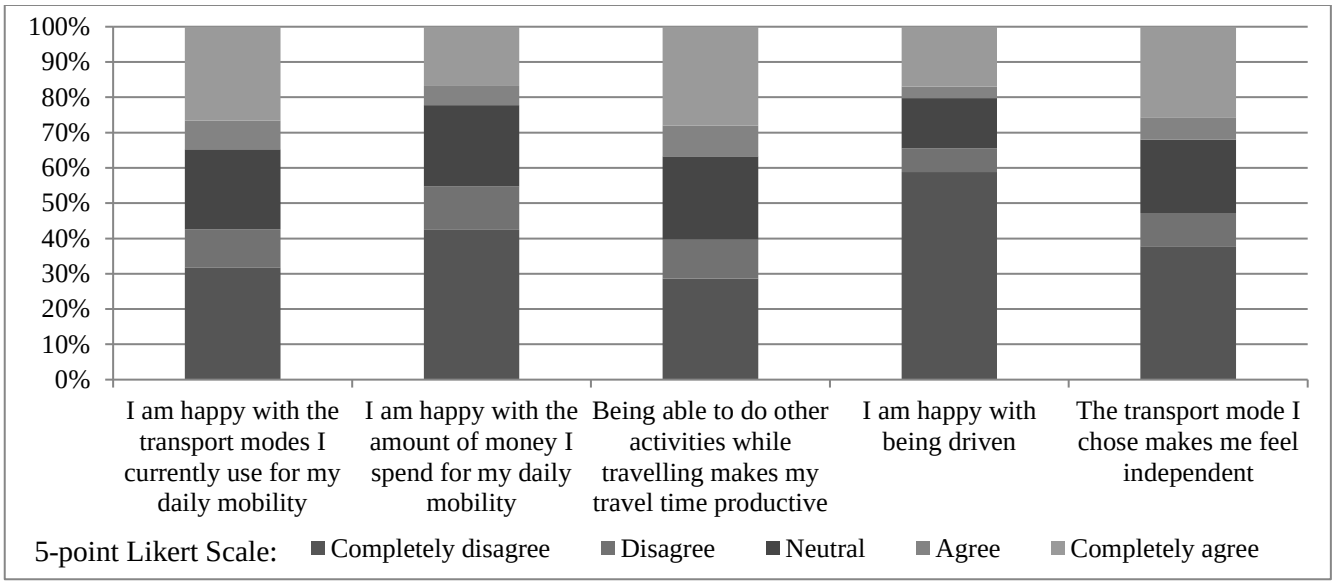

FIGURE 1 The Indicators of "*Current Mobility Satisfaction*" (N = 10,508 obs.)

For the attitudes concerning "Driving importance for women", we identified seven statements as the indicators, which are given in Figure 2. The key impression from the statistics is that "Completely agree" dominates the responses to all seven statements, which implies a consensus amongst women in the KSA that driving should be permitted. Nevertheless, it is also noteworthy that there are two statements, regarding social acceptance and status symbol, to which the proportion of "Completely agree" responses are significantly lower. The corresponding implications could be that many women may still have worries upon if women driving can be accepted by the society, and women's preference on self-driving could be more associated with their perceptions of real-life benefits rather than taking it as a status symbol. Similar to above, two more statements are also tested but eventually avoided from serving as the driving importance indicators; they are "Women might be afraid to drive" and "I am afraid that women will be abused while driving".

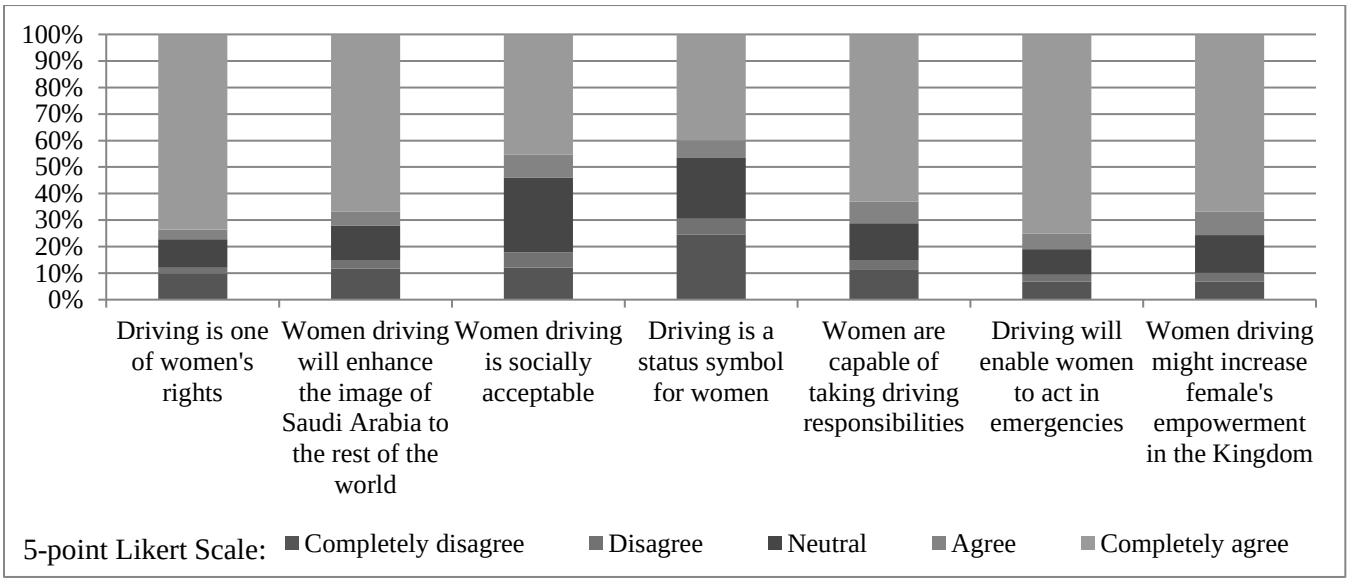

FIGURE 2 The Indicators of "*Driving Importance for Women*" (N = 10,508 obs.)

3. MODEL DEVELOPMENT

This paper aims at exploring the directly observable and unobservable (latent) factors that affect women's intention to drive in KSA. Identifying the factors that influence this decision-making process is important to understand what decisions are made and by which socio-demographic groups (Dietrich, 2010). In fact, many of women's socio-economic and current travel characteristics presented in Section 2 may help explain such a behaviour. These characteristics may not only pose a direct influence, but they can also yield the unique attitudes of individuals which further affect the observed behaviour. In such a case, an ICLV model can help to simultaneously capture the joint effects (Ben-Akiva et al., 2002; Walker and Ben-Akiva, 2002; Bolduc and Alvarez-Daziano, 2010; Kamargianni and Polydoropoulou, 2013; Sarkar and Mallikarjuna, 2018; Li and Kamargianni, 2019). The model provides an integrated modelling framework which consists of a latent variable model and a discrete choice model (La Paix et al., 2013; Kamargianni et al., 2015; Enam et al., 2018). The latent variable model studies the determinants of any latent variables (e.g. attitudes) via a structural equation system and also analyses via a set of measurement equations the observed indicators through which the latent variables are manifested. The discrete choice model evaluates as usual the utilities of alternatives in a given choice set while taking into account the effects of any latent variables alongside other explanatory variables.

Figure 3 shows a complete modelling framework for the case of this paper. The dependent variable (choice set) has three discrete alternatives: 1. intend to drive, 2. not intend to drive, and 3. unsure (see also Table 2 for the statistics), so that logistic regression is used for the analysis. The choice is affected by a number of directly observed Explanatory Variables (X_k) and - as explained earlier- by the two latent variables (LV_j) "Current mobility satisfaction" and "Driving importance for women". The LVs are further affected by the Explanatory Variables (X_k) via the structural model, while are constructed based on the observed psychological indicators (I_{jh}) presented in section 2.3 via the measurement model. A mathematical presentation of this framework is given by Eq. 1-4.

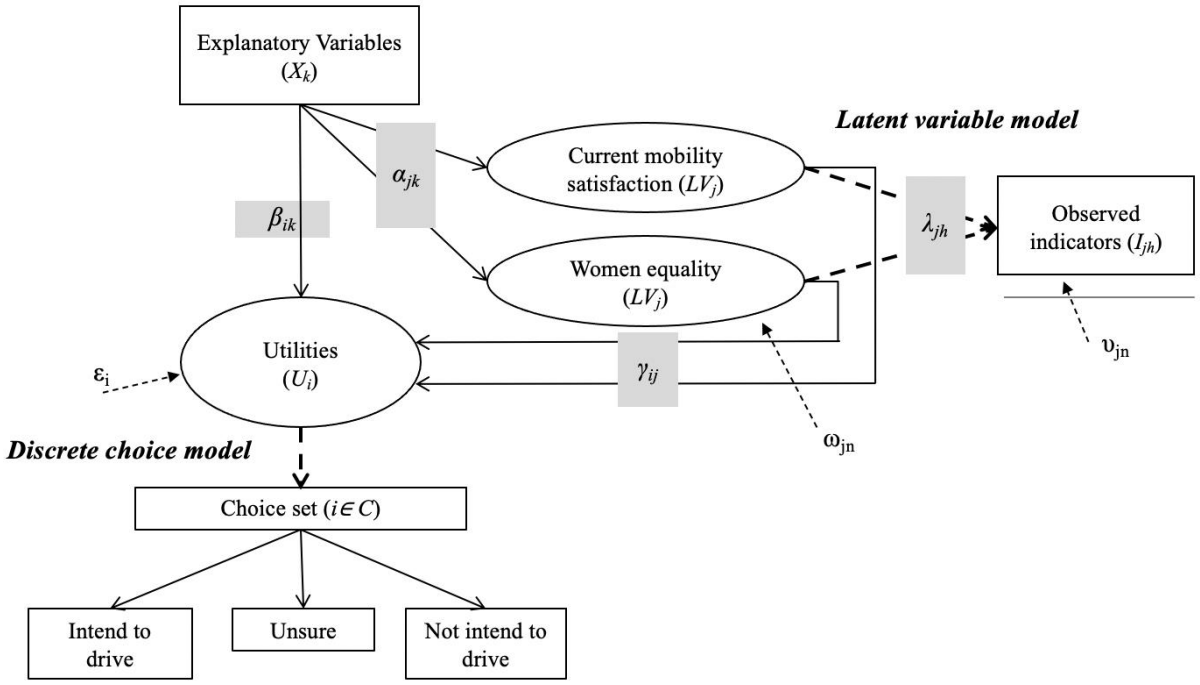

FIGURE 3 The ICLV Modelling Framework with Two Latent Variables

Structural equation (latent variable model):

$$LV_j = \mathrm{A}_j + \sum_{k=1}^{K} \alpha_{jk} X_k + \sigma_j \omega_{jn} \quad \text{(Eq.1)}$$

Measurement equation (latent variable model):

$$I_{jh} = \Lambda_{jh} + \lambda_{jh} LV_j + \sigma_{jh} \upsilon_{jhn} \quad \text{(Eq.2)}$$

where LV_j is the vector of latent variables, X_k is the vector of explanatory variables and α_{jk} is the vector of estimated coefficients (A_j is the vector of intercepts). I_{jh} is the vector of indicators through which the attitudinal factors are manifested and their effects on the indicators are revealed by the parameter vector λ_{jh} (Λ_{jh} is the vector of intercepts). ω_{jn} and υ_{jhn} are the error components normally distributed across individuals with mean 0 and variance 1, $\sim N(0,1)$, and σ_j and σ_{jh} are their effects (standard deviation) respectively.

Utility function (discrete choice model):

$$U_i = \mathrm{B}_i + \sum_{k=1}^{K} \beta_{ik} X_k + \sum_{j=1}^{J} \gamma_{ij} LV_j + \varepsilon_i + \upsilon_{\mathrm{jhn}} \quad \text{(Eq.3)}$$

where U_i is the utility associated with each of the three alternatives in our case, X_k is the vector of explanatory variables, and β_{ik} is the vector of estimated coefficients (B_i is the vector of alternative specific constants). The effects of latent variables are revealed by the parameter vector γ_{ij}. ε_i is the error component i.i.d. extreme value distributed and υ_{jhn} is the error component from the measurment model.

The likelihood function for an observation:

$$f(y, I_{jh} \mid X_k; \alpha_{jk}, \beta_{ik}, \lambda_{jh}) = \int_{LV_j} P(y \mid X_k, LV_j; \beta_{ik}) \, f_{me}(I_{jh} \mid LV_j; \lambda_{jh}) \, f_{se}(LV_j \mid X_k; \alpha_{jk}) dLV_j \quad \text{(Eq.4)}$$

which is a joint probability of having the observed intention to drive choice and the observed indicator levels, where y is the observed choice, P, f_{me} and f_{se} are the probability density functions for the mode choice model, latent variable measurement model and structural model respectively.

After years of development and applications, merits of an ICLV framework are increasingly acknowledged, including for example that it can help eliminate endogeneity by explicitly modelling the unobserved factors in the latent variable model, rather than treating indicators from survey as direct measures of attitudes (Ortúzar and Willumsen, 2011; Daly et al., 2012). Nevertheless, recently, Vij and Walker (2016) made a further and more comprehensive evaluation regarding the values of ICLV model applications. In particular, they explained under what circumstances an ICLV model could bring tangible gains over a corresponding reduced form choice model that do not include latent variables. Important criteria were identified to help assess if the use of an ICLV framework ought to be justified. Thus, for our case, a multinomial logit (MNL) model without capturing the latent attitudes is also developed. In the

following sections, we will refer to the criteria proposed by Vij and Walker (2016) to assess the value of adopting an ICLV model in this research.

Table 3 lists the explanatory variables that are included in the aforementioned ICLV and MNL models. The variable selection is first driven by the hypotheses we made and next by data in terms of the extent to which their effects are significant. A broad range of socio-economic and current travel characteristics, as presented in Table 1 and Table 2, are tested to disclose their effects on women's intention to drive. Some variables (such as educational levels, driver hire, several activities women conduct while travelling etc.) turned out as insignificant, and hence are excluded from the final models. A few variables are further tested with their various possible forms that can be included in the utility functions, such as age and household number of cars owned. Both their continuous forms and dummy transformations (e.g. different age categories, and if a household owns a car) are studied, and we found the former can give a slightly better model fitness. For model estimation, weights are also calculated with respect to different age (above 18), employment status and nationality groups of people, to correct the differences between sample statistics and KSA's census data, as suggested by Table 1. Weighting is not applied to educational level as we are more interested to study the behaviour of more educated segment of the population.

TABLE 3 Explanatory Variables and Measurements

Variable	Measurement
Age	continuous
Nationality	dummy, 1 if Saudi, 0 if non-Saudi
Marital status	dummy, 1 if single, 0 if not (including married, divorced or widowed)
Employment status	dummy, 1 if employed, 0 if unemployed
Educational place	dummy, 1 if received education in the KSA, 0 if received abroad
Household monthly income	in 5 categories, dummy for each, i.e. no income, under 10,000SAR, 10,000 to 20,000SAR, 20,000 to 30,000SAR, over 30,000SAR
Household number of cars owned	continuous
Household residential location (province)	dummy for each province in the KSA
Currently most-used transport mode	dummy, 1 if private car, 0 if not (including taxi, bus, walking or any other modes)
Payment body of current transport cost	dummy, 1 if by the user' household, 0 if not (including by the user or by anyone else)
Preferred activity during a journey	dummy for each activity (see Table 2)

4. MODEL ESTIMATION RESULTS

4.1 Discrete Choice Models

As mentioned above, initially an MNL model has been developed and used as a basis to incorporate the latent variables. The models have been developed and estimated using Python Biogeme (Bierlaire, 2016b). Table 4 presents the results of the MNL and the ICLV choice models. Comparing the MNL and the ICLV choice models, it is noticed that the two choice models do not have exactly the same explanatory variables. The variables age, marital status and current most frequently used mode are used in the MNL choice model, while in the ICLV choice model not (instead they are used as explanatory variables in the structural equation models of the ICLV). We have removed these variables from the ICLV choice model as with the incorporation of the LVs these variables became highly insignificant (see section "Policy Insights Brought by the ICLV Analysis" for a further discussion). Moreover, the explanatory variables are only presented for their effects on two alternatives: "intend to drive" and "not intend to drive", where "unsure" is in fact

set to be the base for normalization purpose. This is not a subjective selection, but a result after testing the variables' effects on all three alternatives where the one on the "unsure" option is always detected with the minimum effect (in terms of absolute value).

Focusing on the ICLV choice model, it is noticed that the two LVs affect significantly the choice of women to drive or not. The LV "Current mobility satisfaction" affects negatively the choice of driving and positively the choice of not driving. As the "Current mobility satisfaction" increases women do not prefer to drive. It seems that the women who are satisfied with the transport mode they currently use, they prefer to not drive. The LV "Driving importance for women" affects positively the choice of driving, while negatively the choice of not driving. The more women believe in the importance of being allowed to drive, the stronger is their actual driving intention.

Regarding the socio-demographic variables, it is noticed that the place where women received their education plays a significant role in their choice to drive or not. Women who have received their education within KSA do not prefer to drive. These women probably have not been exposed to any other culture and by receiving their education in a country where the role of women is deprived, it is hard for them to change their behaviour. On the opposite side, women who have received their education outside the KSA, seem more likely to drive. These women have interacted with other cultures and have been in countries where women driving is not a privilege, but something like a given. These women would probably like to change the situation in their country and become more similar to the countries they studied in.

Another variable that affects the choice of women to drive is the employment status. Women who are employed are more likely to drive than those who are unemployed. This finding is completely in line with the rationale behind the decree of allowing women driving. As it was mentioned in the introduction, the Vision 2030 envisages bringing more women into employment as currently only about 20% of women in KSA are employed (although this percentage is 40.7% in our sample). One of the reasons that hinders women to find a job is the pain-points that this brings to the household in terms of driving women to the work place. As such, employed women deem necessary for them to drive to be able to go to work without imposing any further burden to other household members.

Household monthly income also affects the choice of women to drive. Women from households with low income (under 10,000SAR) seem to not prefer to drive, but this variable is statistically insignificant. Getting driving lessons to obtain a driving license costs from 2,000SAR up to 3,000SAR for women, while for men is only 450SAR (Saudi Gazette, 2018). This may be a considerable cost that low income households cannot afford. Women coming from households with monthly income more than 10,000SAR tend to be more likely to drive; especially women from more wealthy households with monthly income over 30,000SAR. Household car ownership seems to also affect the choice of driving. As the number of cars in the household increases, women prefer not to drive. Households with more privately-owned vehicles may employ private drivers, so for these women it is not necessary for them to drive.

Women who tend to do nothing while travelling and focus on the road, prefer to drive. Since they do not do any other activities to kill their travel time, they probably find it more interesting for them to drive. Women who usually read the Holy Quran while they travel, tend to prefer to not drive. This may probably be related to religious issues as some traditional and religious leaders in KSA believe that this decree is "bending the verses of Sharia" which is the religious law Muslims follow. However, the current leaders of KSA claim that whether women should drive is not religious nor a cultural issue. Someone could also assume, that by reading the Holy Quran, the women spend their travel time more productively. However, when we tested the other activities that women do while travelling (i.e. surfing the web, talking on the phone, checking social media etc. – see Table 2 for the activities that were tested in the model),

they came out as insignificant. As such, we assume that this result is related to the religious and to spending travel time more productively.

As far as the residential location, women who live in Riyadh, Eastern Province, Medina and Mecca provinces seem more willing to drive compared to women living in other provinces. These provinces are the most affluent and the most exposed to the Western civilisation as most of the expats live in these provinces. In addition, these provinces host several economic activities and offer more employment opportunities to women.

Focusing on the MNL and the variables that were used only for this model (in the ICLV model they were used as explanatory variables in the structural equation model of the LVs), we can see that as the age of women increases, they do not prefer to drive. The reasons behind this may be that for older women is like a habit to be driven to their activities, and it may be difficult for them to change this behaviour; or it may be difficult for them at an older age to go to a driving school and study for getting a driving license. On the opposite side, for younger women who would probably like to find a job or feel more independent, choosing to drive is more likely. Single women are also more likely to choose to drive compared to married ones. Married women shall be accompanied by a male household member to their activities and as such, there may be less motivation for them to drive. Furthermore, women who currently use a private car as their most frequently used mode and the cost of this is paid by the head of the household seem also unwilling to drive. Finally, the women in our sample with Saudi nationality seem to be more like to choose not to drive compared to the non-Saudi women who live in the KSA.

TABLE 4 Results of Discrete Choice Models about Driving Intention

	MNL model		**ICLV model**	
	Coef.	**t-stat**	**Coef.**	**t-stat**
α_{yes}	1.62	9.48	0.38	2.37
α_{no}	- 2.91	- 11.94	- 3.15	- 23.95
α_{unsure}	-	-	-	-
Variables specific to alternative: "Intend to drive"				
Age	- 0.01	- 3.79	-	-
Marital status (single)	0.23	3.79	-	-
Educational place (in the KSA)	- 0.81	- 11.93	- 0.55	- 6.80
Employment status (employed)	0.21	3.94	0.27	4.30
Household monthly income (under 10,000 SAR)	- 0.04	- 0.39*	- 0.11	- 0.95*
Household monthly income (10,000-20,000 SAR)	0.11	1.14*	0.16	1.26*
Household monthly income (20,000-30,000 SAR)	0.30	2.54	0.42	2.82
Household monthly income (over 30,000 SAR)	0.31	2.53	0.29	1.91*
Household number of cars owned	- 0.09	- 4.28	- 0.07	- 2.92
Household residential location (Riyadh)	0.34	4.88	0.32	3.65
Household residential location (Eastern Province)	0.38	5.48	0.31	3.61
Household residential location (Medina)	0.22	2.20	0.28	2.26
Household residential location (Mecca)	0.10	1.38*	0.23	2.38
Preferred activity during a journey (focus on the road)	0.30	5.68	0.28	4.21
Currently most-used transport mode (private car)	- 0.32	- 3.91	-	-
Currently most-used transport mode (private car) * Payment body of current transport cost (by household's head)	- 0.30	- 4.03	-	-
LV (current mobility satisfaction)	-	-	- 1.24	- 16.71
LV (driving importance for women)	-	-	1.45	26.01

Variables specific to alternative: "Not intend to drive"				
Age	0.01	2.16	-	-
Marital status (single)	- 0.34	- 2.93	-	-
Nationality (Saudi)	0.44	3.04	-	-
Household number of cars owned	0.15	4.71	0.14	3.74
Household residential location (Qassim)	0.77	5.20	-	-
Preferred activity during a journey (reading Holy Quran)	0.56	6.79	0.11	1.01*
Currently most-used transport mode (private car)	0.46	2.94	-	-
Currently most-used transport mode (private car) * Payment body of current transport cost (by household's head)	0.24	2.02	-	-
LV (current mobility satisfaction)	-	-	1.76	12.55
LV (driving importance for women)	-	-	- 1.58	- 18.23
Model fitness				
Initial log likelihood		- 11544.21		- 11544.21
Final log likelihood		- 8121.96		- 8120.36
Likelihood ratio test		6844.51		6847.72
Note: * parameter values not meeting the 95% significance level				

4.2 Latent Variable Model

The upper part of Table 5 presents the results of the structural models of the two LVs, while the lower part of the table presents the estimation results of the measurement models. The LVs' structural models describe attitudes in terms of observable socio-economic characteristics, exhibiting interesting relationships between respondent profiles. The LV "Current Mobility Satisfaction" seems to be strongly affected by the current transport mode women use the most, and this is the car. Since the alternative transport modes in the KSA are limited, the majority of women use private cars for their trips, and they seem to be satisfied with this. In fact, satisfaction can further increase when the cost of car usage is covered by the head of the household (not the women themselves). Since women do not have to worry about covering the costs of their mobility, it is plausible this to contribute positively to their satisfaction. Age also affects positively this LV. As age increases, women tend to be more satisfied with the transport mode they use. Women who have received their education in the KSA are also more satisfied with their current mobility compared to women who studied abroad and were exposed to different cultures and norms. Nevertheless, single women (who are usually younger in the age) seem to not be satisfied with their current mobility. The fact that they are not allowed to drive probably restricts their activities and their opportunities.

The second LV "Driving importance for women" is strongly affected by the marital status and the place of education. Single women and women who have received their education outside the KSA tend to be more conscious of the importance of being allowed to drive. As described above, young women are keener to support the changes in the KSA community to offer more and equal opportunities to women. Even more, women who have studied abroad and were exposed to other cultures, by returning back to their country, they would like to "import" some of the characteristics of the other cultures that offer equal opportunities to women and men. On the contrary, women who have been born and raised in the KSA and received their education in the country, seem to be more negative towards driving importance. In addition, Saudi women believe less to driving importance compared to the non-Saudi women of our sample who live in the KSA. The non-Saudi women probably have to give up several of the habits they had in their origin-countries (and one of this is driving), when they move to the KSA and this empowers even more their beliefs towards the right of self-driving. Finally, residential location also affects the attitudes towards driving importance for women. Women who live in the Riyadh and Eastern provinces believe more in this concept, while women who live in the Qassim province (a less affluent province) seem to believe less.

Finally, the coefficients of the measurement model are all highly significant and show the expected signs, confirming the results of the factor analysis regarding the interpretation of the LVs. Looking at the statements used as dependent variables for the first latent variable (Current mobility satisfaction), the consistent positive signs for all the five statements indicate that a higher value for the LV leads to a higher level of agreement with the five statements. This means that respondents with a higher value for "Current mobility satisfaction" are more satisfied with their current mobility. The same pattern is noticed for the second LV "Driving importance for women". The positive signs of all the seven statements indicate that a higher value for the LV leads to a higher level of agreement with the seven statements.

TABLE 5 Results of the Latent Variable Model

Structural equation		
	coefficient	**t-statistic**
Latent Variable: "Current mobility satisfaction"		
$A_{satisfaction}$	- 0.68	- 16.86
Age	0.01	8.11
Marital status (single)	- 0.06	- 4.05
Educational place (in the KSA)	0.09	5.13
Currently most-used transport mode (private car)	0.44	18.80
Currently most-used transport mode (private car) * Payment body of current transport cost (by household's head)	0.14	7.29
$\sigma_{satisfaction}$	0.55	38.13
Latent Variable: "Driving importance for women"		
$A_{equality}$	0.68	12.52
Age	- 0.01	- 6.74
Marital status (single)	0.23	9.23
Educational place (in the KSA)	- 0.28	- 9.05
Employment status (employed)	0.06	2.92
Nationality (Saudi)	- 0.09	- 2.65
Household residential location (Riyadh)	0.10	4.25
Household residential location (Eastern Province)	0.14	5.73
Household residential location (Qassim)	- 0.32	- 5.91
$\sigma_{equality}$	0.90	49.01
Measurement equation		
	coefficient	**t-statistic**
Latent Variable: "Current mobility satisfaction"		
$\Lambda_{satisfaction1}$	- 0.06	- 3.46
$\Lambda_{satisfaction2}$	- 0.44	- 27.69
$\Lambda_{satisfaction3}$	0	-
$\Lambda_{satisfaction4}$	- 1.01	- 33.32
$\Lambda_{satisfaction5}$	- 0.21	- 9.82
$\lambda_{satisfaction1}$ (I am happy with the transport modes I currently use for my daily mobility)	1.39	33.63
$\lambda_{satisfaction2}$ (I am happy with the amount of money I spend for my daily mobility)	0.95	28.98

$\lambda_{satisfaction3}$ (Being able to do other activities while travelling makes my travel time productive)	1	-
$\lambda_{satisfaction4}$ (I am happy with being driven)	1.63	26.49
$\lambda_{satisfaction5}$ (The transport mode I chose makes me feel independent)	1.69	32.78
$\sigma_{satisfaction1}$	0.84	55.49
$\sigma_{satisfaction2}$	0.96	60.45
$\sigma_{satisfaction3}$	1	-
$\sigma_{satisfaction4}$	1.46	48.20
$\sigma_{satisfaction5}$	0.89	49.92
Latent Variable: "Driving importance for women"		
$\Lambda_{equality1}$	1.46	36.83
$\Lambda_{equality2}$	0.88	32.56
$\Lambda_{equality3}$	0.30	22.74
$\Lambda_{equality4}$	0	-
$\Lambda_{equality5}$	0.72	32.39
$\Lambda_{equality6}$	1.29	41.46
$\Lambda_{equality7}$	0.84	42.55
$\lambda_{equality1}$ (Driving is one of women's rights)	1.50	31.07
$\lambda_{equality2}$ (Women driving will enhance the image of Saudi Arabia to the rest of the world)	1.58	37.68
$\lambda_{equality3}$ (Women driving is socially acceptable)	0.75	39.15
$\lambda_{equality4}$ (Driving is a status symbol for women)	1	-
$\lambda_{equality5}$ (Women are capable of taking driving responsibilities)	1.34	38.89
$\lambda_{equality6}$ (Driving will enable women to act in emergencies)	1.28	33.91
$\lambda_{equality7}$ (Women driving might increase female's empowerment in the Kingdom)	1.03	38.28
$\sigma_{equality1}$	1.40	41.69
$\sigma_{equality2}$	0.86	43.57
$\sigma_{equality3}$	0.74	60.50
$\sigma_{equality4}$	1	-
$\sigma_{equality5}$	0.76	46.28
$\sigma_{equality6}$	0.99	43.43
$\sigma_{equality7}$	0.72	49.41
Note: all parameter values meet the 95% significance level		

5. FURTHER ANALYSES AND DISCUSSIONS

5.1 Marginal Effects

Table 6 summarizes the direct marginal effects of the variables included in the ICLV choice model. This table shows estimates of the effect of the explanatory variables included in the model on the probability of the intention to issue a license or not, while taking into account the impact of the other explanatory factors (Abdel-Aty and Abdelwahab, 2004).

Being an employed woman increases the probability of the intention to drive by 19%. This shows how important it is for employed women to be able to drive alone to their workplace without the need of a male to escort them. This also verifies that allowing women driving can contribute to the goal of Vision 2030 about increasing the number of employed women in the country. Being educated within KSA increases the probability of the intention to drive by almost 2%. Although this percentage may sound low, it is still a significant increase given that women in Saudi Arabia have been raised having in mind that they cannot drive. Coming from a household with monthly income less than 10,000 SAR decreases the probability of the indention to drive by 9.5%. It seems that for low income households, it is difficult to afford paying the training lessons and the fees for their female members to get a driving license; especially when the cost of women issuing a driving license is three times higher than this of males. On the contrary, coming from a household that is on the upper level of monthly income (over 30,000 SAR) increases the probability of the intention to drive by almost 18%. Women who live in the capital city -Riyadh- have the highest probability to get a driving licence compared to the other three provinces included in the model. Living in Riyadh increases the probability of the intention to drive by 18%; in Eastern province by 12%; in Medina by 3.5%; in Mecca by 3.7%. Most of the businesses in KSA are located in Riyadh and Eastern Province and this may be the reason that higher probabilities are noticed in these two provinces.

TABLE 6 Marginal Effects of the Model

Variable	Marginal Effect
Variables specific to alternative: "Intend to drive"	
Educational place (in the KSA)	0.026
Employment status (employed)	0.190
Household monthly income (under 10,000 SAR)	-0.095
Household monthly income (10,000-20,000 SAR)	0.014
Household monthly income (20,000-30,000 SAR)	0.101
Household monthly income (over 30,000 SAR)	0.181
Household number of cars owned	0.072
Household residential location (Riyadh)	0.182
Household residential location (Eastern Province)	0.124
Household residential location (Medina)	0.035
Household residential location (Mecca)	0.037
Preferred activity during a journey (focus on the road)	0.106
Variables specific to alternative: "Not intend to drive"	
Household number of cars owned	-0.034
Preferred activity during a journey (reading Holy Quran)	0.143

5.2 A Projection towards the Future

The modelling results above would allow us to perform a simulation analysis, which aims to investigate if there is a chance to have even more KSA women saying yes to drive in the future, compared to the current statistics. According to the Vision 2030 plan of the KSA (Hvidt, 2018), the country has been making constant progress in improving gender equality. Hence, for the future, we may see significantly narrowed gender gaps between men and women in various social aspects, which shall then pose a change on the currently observed pattern of driving intention. Taking employment rate as an example, our survey shows a vast difference between women's level (40.7%) and men's level (79.1%), which gives an index number of 0.51 as the female/male employment ratio (dividing 40.7% by 79.1%). This is a measure often used by the World Bank to compare the degree of female labour force participation across countries, and the 2018 figure for the KSA is 0.28 (World Bank, 2019), even lower than the statistics from our sample. The figure is also well below the world average of 0.67, highlighting a need and potential for the Kingdom to narrow the gap in the future. As proposed in the Vision 2030, more working opportunities are about to be opened up to females in the KSA (Hvidt, 2018), and hence an increase of their employment rate is highly expected. Since the factor can significantly affect women's intention to drive as per the model estimation results, the proportion of women who intend to drive could easily change, as a result of more women getting employed.

Apart from employment, currently there are also vast differences between women and men in the percentages of foreigners in the KSA (14.8% and 33.7% respectively) and being educated abroad (17.3% and 31.0% respectively). Both statistics for females are likely to increase in the future, as the royal decree of permitting women to drive may not only be a stand-alone regulation, but also a sign of women empowerment that could be followed by further improvements of women's rights in the country. Hence, for the future, we may expect more female foreigners that are willing to come to the KSA, and more Saudi females having opportunities to receive overseas education.

Table 7 presents the current differences between women and men on the aforementioned three aspects, i.e. employment, nationality and educational place. A simulation analysis is conducted to evaluate an optimistic scenario: what if females' demographic patterns converge to males. The gender differences concerning some other aspects are also presented in the table; however, they are not further analysed in simulation for two reasons. First, there are not significant differences between women and men, and second, there are not strong expectations for how females' current levels might evolve in the future.

The simulation uses the parameter values from the ICLV model. The way that the two latent attitudes ("Current mobility satisfaction" and "Driving importance for women") are formulated in the simulation follows the recommended approach in Vij and Walker (2016), i.e. using only the explanatory variables from the structural equations rather than introducing the measurement indicators at the same time (readers can find more information in their paper). The randomness in the latent attitudes is captured via simulation (Yáñez et al., 2010); different error component datasets are generated and tested, and no significant differences appear in the final forecasts. As a result, in Table 7, we have the predicted changes in the number of women that intend to drive, not intend to drive, and are unsure.

When females' current level converges to males' (females that incur a status change are randomly selected), the increases in both employment rate and percentage of overseas education are expected to yield around 3% more women saying "yes" to drive. Although this is not a large figure, the increase is even smaller with more female foreigners coming to the country (only 0.6%). Overall, it is possible to foresee that even if some key demographic indicators for women (e.g. employment, nationality and educational place) can catch up with men's in the future, this may not pose a significant difference to the current number of women that intend to drive.

TABLE 7 Simulation Results of Demographic Changes

				If females' demographic patterns converge to males'		
		Females' current level	Males' current level	% change in "yes"	% change in "no"	% change in "unsure"
Employment (employed)		40.7%	79.1%	↑ 3.2%	↓ 6.1%	↓ 6.6%
Nationality (foreigners)		14.8%	33.7%	↑ 0.6%	↓ 1.5%	↓ 0.7%
Educational place (overseas)		17.3%	31.0%	↑ 3.3%	↓ 7.6%	↓ 5.9%
Age		31.8 (avg.)	34.3 (avg.)	NA		
Marital status (single)		38.9%	31.1%			
Household monthly income	No income	5.8%	12.5%			
	Under 10,000	40.7%	42.6%			
	10,000 - 20,000	30.0%	28.1%			
	20,000 - 30,000	11.1%	8.9%			
	Over 30,000	12.4%	7.9%			
Household number of cars owned		1.9 (avg.)	1.7 (avg.)			
Household number of parking spaces available		1.4 (avg.)	1.2 (avg.)			

Note: % changes are presented in relative terms (i.e. $\Delta P_i = (P_i - P_i^0)/P_i^0$, where P_i and P_i^0 are the aggregate probabilities of choosing an alternative in the designed and base scenarios respectively) rather than absolute terms; a similar practice can be found in Yáñez et al. (2010).

5.3 Policy Insights Brought by the ICLV Analysis

Nevertheless, there are still opportunities where policy interventions could potentially step in and make more women willing to drive in the future. However, the inspirations sometimes hide behind an ICLV model until we well understand the true value of adopting such an analysis framework.

An ICLV model has a more complicated structure than an MNL model, and in turn, it requires additional effort to compute. However, unlike some other advanced forms of choice model, an ICLV analysis does not necessarily lead to goodness of fit improvement (Vij and Walker, 2016). This is also reflected by the results of this study where in Table 4 we only see trivial improvement in final log likelihood of the discrete choice model. In such a case, the real benefit of an ICLV model needs to be recognized to determine if it is worthwhile to afford the burden incurred in model estimation. As mentioned before, Vij and Walker (2016) proposed several criteria for justifying the use of an ICLV model. One of them is if the ICLV structure could offer greater insights to the choice-making process, by decomposing the influence of the explanatory variables into constituent effects, and hence to better inform policy making. This is exactly what the model in this research has detected. For educational place, employment status and household residential location in two of the provinces (Riyadh and Eastern Province), the ICLV model decomposes their influence on the intention to drive into two parts, i.e. the indirect influence through their effects on the two latent attitudes (educational place through both attitudes, while employment status and household residential location only through "Driving importance for women") and the direct influence that remains significant in the discrete choice model. The finding

suggests that not all parts of the variables' effects on the intention to drive can be attributed to the attitudes captured; there could be other intrinsic factors that may also be able to explain why these socio-economic groups prefer to drive or not (Vij and Walker, 2016). Moreover, for some variables like age, marital status, nationality, current transport mode and its payment body, as well as household residing in the Qassim province are all significantly correlated with the intention to drive in the MNL specification. However, their direct effects turned out as highly insignificant in the ICLV model (and thus dropped out) after introducing their indirect effects via the latent construct (i.e. the structural equations). Such a difference could imply the influence of these variables may be attributed mainly to their effects on the two latent attitudes (Vij and Walker, 2016). In particular, the effects of current transport mode and its payment body are manifested via the attitude "Current mobility satisfaction"; nationality and the province Qassim are via the attitude "Driving importance for women"; while age and marital status may affect the intention to drive via both attitudes.

Identifying the constituent effects, especially how the explanatory variables could pose their influence through the latent attitudes, may lead to useful insights to policy making. First of all, campaigns and advertisements may be developed as a direct way to promote changes to people's attitudes, which in turn could affect their choice-making outcomes. In our case, as there is an objective to encourage more women to drive, a women empowerment or information campaign that aims to strengthen women's awareness and consciousness towards the importance of being allowed to drive may be launched, given that the attitude "Driving importance for women" is shown to have a strong positive influence on the choice to drive. While the constituent effects are disclosed, i.e. we know which variables could pose their influence through "Driving importance for women", it also becomes clearer that the message should target at what segments of the population. For instance, as per the results of the structural equation, the campaign could focus more on changing the attitudes of people who tend to be negative towards "Driving importance for women", i.e. those already married, being educated in the KSA, unemployed, Saudi citizens (opposed to non-Saudi residents) and those from the Qassim province, which can be realised by adjusting relevant campaign strategies (see examples in Vij and Walker, 2016). The key take-away is, as a result of the campaign, if some of these socio-demographic groups could become less negative as they were before towards "Driving importance for women", the model estimation results of structural equations may no longer hold as they are originally discovered. As such, we expect to see more women showing their willingness to drive in the above projection study, just because those many that were ordinary or even reluctant to drive due to not being conscious enough towards the importance of being allowed to drive may start to behave differently.

There are also policy values attached to "Current mobility satisfaction", although the way to recognize such can be slightly different to above, as we shall not encourage driving by simply compromising people's satisfaction with their current transport modes. However, policy intervention could still step in by knowing from the structural equation the relationships between population segments and satisfaction level. It can be noticed the cost of travel plays a critical role in determining mobility satisfaction, such that even the current private car users (i.e. those women who have drivers) could be less satisfied if they need to afford the cost themselves. The importance of cost impact is also detected from Figure 1, where over 50% of women in the sample are in fact unhappy with the amount of money spent for their current daily mobility. Hence, a direct policy take-away would be to make sure car travel is a cost-effective option once women are allowed to drive. Various forms of cost-saving offers or subsidies may be used in practice; however, it is also important to target at specific population segments to give benefit to those who mostly need it. For instance, single women tend to be less satisfied with current mobility (Table 5), and a bespoke cost-saving offer could more effectively make them drive than trying to incentivise married women.

6. CONCLUSIONS

The main objective of this paper was to explore the factors that affect women's intention to drive in Saudi Arabia. The research combines a unique case study with an advanced behavioural choice model. An integrated choice and latent variable model was developed, where latent variables such as "Current mobility satisfaction" and "Driving importance for women" were constructed and incorporated in the choice model about women's decision to drive. The data come from the national project SHE Drives KSA (IAU, 2018), and the sample used for analysis in this paper consists of 10,508 women from all over the Kingdom. To our knowledge, this is the first research investigating such a unique and sensitive topic that is expected to significantly affect travel behaviour.

The model estimation results show that some of the most statistically significant factors that affect women's intention to drive are the country where women received their education, and their employment status. Women who have studied outside the KSA and have been exposed to other cultures and norms are more likely to choose to drive. In the same way, women who are employed seem that will choose to drive. As discussed in the introduction, commuting is not an easy task neither for the women per se nor for her household. In order a woman to get to her work place, she should be driven either by a male household member or by a household's privately employed driver. This imposes a huge burden to the household in terms of both time and income allocation, with many households to prefer women not to be employed. By lifting the ban on women driving, more women will be able to find a job as several of the time and budget constraints will be removed. Another factor that affects the choice of women to drive is the household's monthly income. Women from households with medium and high monthly incomes (more than 20,000 SAR) are willing to drive. Women from households with low monthly income seem unwilling to drive (although this is statistically insignificant) and this may be due to the high cost of driving lessons, which for women is between 2,000SAR to 3,000SAR, while for men is only 450SAR. The province, where women live also affects their choice to drive. Women who live in provinces that are more affluent and more job opportunities exist (i.e. Riyadh, Eastern Province, Medina, and Mecca) are more likely to start driving comparing to the women who live in other provinces.

Regarding the not directly observed variables, "Current mobility satisfaction" and "Driving importance for women" are the variables that significantly affect the choice of driving. The "Current mobility satisfaction" LV has been structured using five attitudinal indicators and affects the choice of driving in a negative way; as this LV increases, the propensity of women to choose to drive decreases. The "Current mobility satisfaction" is strongly affected by the current transport mode that women use and by whom covers the cost of women transport. Age also affects positively and significantly this LV, and this may be due to the habit developed through the years of using the specific transport mode (private car). Women who have studied in the KSA seem also to be more satisfied with their current mobility. The other LV, the "Driving importance for women" is constructed using seven attitudinal indicators and it affects the choice of women to drive in a positive way. As expected, the more the women participants agree with the importance of being allowed to drive, the more likely they would choose to drive. Younger and single women, those who have studied abroad and are employed, and those who leave in Riyadh and Eastern provinces seem to have the strongest attitudes towards driving importance.

Based on the model estimation results, a simulation analysis is conducted next to project the future pattern of women's driving intention, as some of the demographic indicators for females (e.g. employment, nationality and educational place) could possibly converge towards males' in future. However, the results did not show significant increases in the number of women that intend to drive, compared to the current statistics. With an aim to encourage more women to drive, we further explored the policy implications attached on the LVs. By unveiling the constituent effects (i.e. how the explanatory variables could pose their influence through the LVs), the ICLV analysis suggests a women empowerment or information

campaign could be launched and focus on changing the attitudes of people who tend to be less conscious or negative towards "Driving importance for women", such as those already married, being educated in the KSA, unemployed and Saudi citizens (opposed to non-Saudi residents). With respect to the findings associated with the LV "Current mobility satisfaction", we especially highlight the importance of making car travel cost-effective once women are allowed to drive.

This paper focused on developing an advanced behavioural econometric model combining it with a sensitive social issue that is expected to affect all the facets of daily life and sustainability of the KSA. The data used was collected before the 24th of June / before women starting driving. The SHE Drives KSA project continues to monitor the participant women in order to collect more data about their travel behaviour. Our future work will focus on comparing the travel patterns of women before and after they started driving to shed more light in mode choice behaviour and activity patterns not only of the women, but their households as well. However, due to the data collection approach that heavily relies on smart phones for accessing the survey, findings from the current and future studies of this project are more related and applicable to those who have a good educational background. More research on the rest part of the population is also needed to help present a comprehensive picture of women's behaviour in the Kingdom. Another limitation of the current study is so far only two attitudes are evaluated in terms of their effects on women's behaviour. As explained in section 2.3, this is largely due to a model computation constraint so that introducing more latent factors would be a great burden to a simultaneously-estimated ICLV model. When a wider range of attitudinal variables could be captured for example via adjusting model specification strategies (e.g. Kamargianni et al., 2015; however, trade-offs need to be assessed if not simultaneously estimating both parts of an ICLV model), it may yield broader insights to any traditional communities across the globe where accompanied travel rather than self-driving is also a social norm to a certain extent for women (even though not legally constrained). In such a case, attitudes towards driving ability, self-esteem, family norms and gender equality (rather than which partially reflected in "Driving importance for women") etc. are all worth to be explored in terms of their potential influence on women's driving-related behaviour.

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