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What make consumer sign up to PHEVs? Predicting Malaysian consumer behavior in adoption of PHEVs

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ABSTRACT

Malaysia is amongst the major energy intense countries and is under an excessive burden to advance its energy efficiency and to also work towards the reduction of its carbon emission. Plug-in Hybrid Electric Vehicles (PHEVs) have the potential to lessen the carbon emission and gasoline consumption in order to alleviate environmental problems. Consequently, attempts are being initiated to popularise the use of PHEVs as the main mode of transportation. The diffusion of PHEV adoption is a positive initiative. A sample of 403 respondents has been collected from Malaysia in order to forecast the customer's intention to adopt PHEVs by using the extended theory of planned behaviour. The empirical outcome using the PLS investigation exposed that all four constructs, subjective norm, personal moral norm, perceived behavioural control, and attitude ominously shows an indirect effect which has inclined towards the Malaysian consumers' intention to adopt PHEVs. All these four major constructs were significantly predetermined by their respective environmental concern. Whereas, hyperbolic discounting moderated the relationship between intention and adoption. The fostering result verifies that the relevance of the extended TPB had a good explanatory power in the line of predicting the Malaysian consumers' intention to adopt PHEVs. For future study, grounded by the observed outcome, authors explain the implication aimed at promoting the PHEV adoption.

1. Introduction

The world is going through crucial issues like energy scarcity, air pollution, and the emission of greenhouse gas (GHG) (Sang and Bekhet, 2015). Vehicles which use both electrical and internal combustion engines for propulsion purposes, appear to be a very promising prospect (Millo et al., 2014). There are 3 types of road transports powered by electricity such as electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in-electric vehicles (PHEVs). These vehicles offset foreign petroleum usage and cost less to refuel per mile than conventional vehicles. EVs are propelled by a battery-powered motor, and the battery is charged by plugging the vehicle into the electric grid either at home or at a public charging station (Ahmadi et al., 2015). EVs do not have an internal combustion engine and therefore do not use petroleum. HEVs are powered by conventional or alternative fuels as well as electric power stored in a battery. The charging of a battery is performed through the internal combustion engine and regenerative braking. Alternatively, the captured battery energy generally lost during braking by the use of electric motor acted as a generator. Contrasting

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Nomenclature

GHG	greenhouse gas
EVs	electric vehicles
HEVs	hybrid electric vehicles
PHEVs	plug-in hybrid electric vehicles
BEVs	battery electric vehicles
AFVs	alternative fuel vehicles
ICEVs	internal combustion engine vehicles
AEVs	all-electric vehicles
HEVs	hybrid electric vehicles
TRA	theory of reasoned action
TPB	theory of planned behaviour
PN	personal norm
PBC	perceived behavioural control
EC	environment concern
SN	subjective norm

EVs and PHEVs, HEVs are not plugged into charge (Adnan et al., 2017a). However, HEVs use both petroleum and electricity and a good mean for long distance driving. PHEVs are powered by alternative or conventional fuels as well as electric power stored in a battery. The battery can be charged by plugging it into an outside power source, by the internal combustion engine, or by re-generative breaking (Adnan et al., 2017a). Unlike HEVs, which still depend on petroleum, it is possible for PHEVs to run on only electricity when fully charged. Because PHEVs can run off petroleum or electricity, they are a good option for driving long distance if you are uncertain about charging station availability.

Moreover, PHEVs are extensively recognised as an answer that will reduce the harmful effect on the climate and lessen the carbon emission (Adnan et al., 2016). Hence, this sort of vehicle offers an advantage in the quest to reduce carbon emissions by as much as 30 percent to 50 percent and be able to attain 40 percent to 60 percent improvement in fuel efficiency. Though, Bonges and Lusk (2016) stated that in actual fact, they are going to be somewhat on the lower side. Several researchers have proved that a great amount of reduction in greenhouse gas emissions and in the increasing dependence on oil could be accomplished by the electrification of the transport sector, which further needs proper understanding and adoption from the consumer's point of view (Barbarossa et al., 2015; Bateman et al., 2013). Certainly, the emergence of Hybrid Electric Vehicles (HEVs) has received substantial industrial accomplish-ment starting from the last decade. However, all the vehicles are categorised into 3 major groups, such as Internal Combustion Engine Vehicles (ICEVs), Hybrid Electric Vehicles (HEVs), and All-Electric Vehicles (AEVs) (Adnan et al., 2016a; Boroojeni et al., 2017). Nonetheless et al. (2016) specified that a PHEV has less CO2 emission and it helps towards environmental sustainability. Schuitema et al. (2013) argued that the disadvantage of PHEV batteries is that they cannot offer the same mileage that a pure EV would offer as batteries are easily drained off for PHEVs. Furthermore, Hosseini et al. (2012) claimed that there are very few plug-in facilities that such vehicles may require. Rezvani et al. (2015) highlighted that the PHEV is the combination of a gasoline or diesel engine with an electric motor and it also carries a large rechargeable battery. Khooban et al. (2016) emphasised that since they use less gas, they also cost less to fuel: driving a PHEV can save hundreds of dollars a year in gasoline and diesel costs and help to save the environmental sustainability. In order to gain the main goal of this study, there is a need to resolve the shortcomings, i.e., limited mileage offered by the batteries as well as the inability to charge the batteries with the frequency required, that have hindered the acceptability of PHEVs (Chang et al., 2015). However, Johansson and Mattsson (2012) suggested that the adoption of plug-in hybrid electric vehicles is gaining popularity and increasing acceptability. Because of PHEVs being more practicable, they are becoming more popular in the developed nations, such as the U.S., Japan, and Europe (Fotouhi et al., 2016). However, in the context of the developing countries likewise, such as in Malaysia where the government has noted the advantages offered by PHEVs and has taken measures to promote their use (Luo et al., 2012).

The Malaysian higher authority had fixed the goal of 500,000 PHEVs being driven on Malaysian roads at the end of 2015 and around five million by the year 2020 (The National Council of Malaysia, 2012). In order to promote the usage of PHEVs, the government has initiated a number of policies, including subsidising the sale of PHEVs. The government has also paid special consideration to the advancement and manufacture of PHEVs in the eleventh 5 year-long Plan. The government has also planned to invest RM 100 billion ($ 16 billion) for the improvement of technologies in the 25 year-long planning (Sang and Bekhet, 2015; Zhang, Tolbert, and Ozpineci, 2011). The government did indicate in 2009 a 10 cities-thousand Vehicles initiative to give a boost to the growth of PHEVs and to popularise their use. However, the consumer reaction fell short of expectations (Richardson, 2013; Sang and Bekhet, 2015). According to the Malaysian Automobile Manufacturers Associations, the cumulative sales were 27,400 EVs in 2012. Of these, 23,000 were acquired by the governing agency and the community service sector whilst 4400 were bought by individuals. It was seen that the ordinary Malaysian considered the performance of the conventional vehicle to be superior to the PHEV (He and Zhan, 2017; Zhang et al., 2013). The consumer did, however, show his/her preference to have a PHEV as a second vehicle (Sang and Bekhet, 2015). Currently, it is estimated that 13% of households have a second PHEV type vehicles. Likewise, the PHEV technology may also improve and consumers may prefer the new innovations (Li and Loo, 2014). In any case, there are bright prospects for PHEVs gaining popularity in Malaysia.

The penetration of electric vehicles into the market of Malaysia has directed the vehicular industry to an entirely new dimension which is based on less dependency on fuel, and an improved fuel efficiency (Rezvani et al., 2015). Though Falvo et al. (2013) declared that electric vehicles may decrease the overall tailpipe emission, the benefits in the context of entire emissions are slightly marginal if the traditional power generation still uses coal as a primary source. So, the governing agency has substantially sponsored the vast usage of alternative energy like solar and biomass in order to lessen the dependency on coal (Adnan et al., 2016a). Although the use of PHEVs as a cleaner alternative is well sponsored by the government through many programs and policies, less information is provided from the social perspective regarding the PHEV's public acceptance (Danial et al., 2013). As the exposure to PHEVs is comparatively new in Malaysia, there has been no former research study or analysis carried out on Malaysian drivers to measure the