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DETERMINANTS OF THE INTENTION TO USE A NATURAL GAS VEHICLE (NGV) AS AN ALTERNATIVE TO A PETROL CAR: THE CASE OF MALAYSIA

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Abstract: The objective of this paper is to examine the intention of vehicle owners to use NGVs as an alternative to petrol cars in Malaysia. Significant amounts of evaporated carbon dioxide (CO_2) cause global warming and the transport sector is one of the major contributing segments of the economy. The transport sector demand for petrol is increasing worldwide, which suggests the need for an alternative fuel vehicle (AFV). Among AFVs, the NGV has less CO_2 emission to the environment. For Malaysia, which is endowed with natural gas reserves, the use of NGV is a potential alternative policy strategy for reducing CO_2 emissions and reducing petrol usage. A total of 152 respondents who were either vehicle owners or car drivers were posed with combination of options for the usage of NGVs as an alternative to petrol cars and the experimentally designed questionnaire was adopted in the study to analyze the data using conjoint analysis for multidimensional scaling method. Results indicate that while a growing number of vehicle owners are willing to switch to NGV, their choice is influenced by an available government subsidy, safety and security measures and the availability of NGV refueling stations. The implication of the findings is that there is the need for the Malaysian government to implement decisive energy policies for NGV usage to lower the amount of pollution and minimize the impact of volatile global oil prices on the Malaysian economy.

Keywords: *Global warming, Carbon Dioxide (CO_2), Natural Gas Vehicle (NGV).*

Introduction

The debate regarding the relationship between carbon dioxide emission by vehicles and the impact of emissions on global warming has attracted increasing attention in recent years because of climatic changes worldwide. The average global temperature has risen since the mid 20th century, and it is likely to increase because of man-made greenhouse gas emission. The Intergovernmental Panel on Climate Change (IPCC) has commented that the concentration of greenhouse gases has exceeded the pre-industrial value since 1750, and carbon dioxide (CO_2) contents were the highest of the greenhouse gases (Baird & House, 2009). Although the debate on global warming has generated much literature in both developed and developing countries, the majority of the previous studies has concentrated in developed countries and very few have focused on developing countries. However, the recent global financial crisis and the associated spiraling oil prices are placing a great strain on economies in the developing world. In response, governments in developing countries have tended to develop sustainable energy conservation policies.

For instance, in Malaysia, CO_2 emission has increased dramatically from 23 million tons in 1980 to 138 million tons in 2005 (Timilsina & Shrestha, 2009), rising even further to 186 million tons in 2006 (Chance & Ahmad, 13 December 2009). The Economic Planning Unit of Malaysia (2006) stated that the energy demand in the transport sector has reached 41.1% of the total energy consumption in 2010. This result indicates that more than one third of the CO_2 emission in Malaysia is from the transport sector. For example, in 1980, CO_2 emission from the transportation section was 6.44 million tons, and this amount increased 500% in 25 years to reach a new record of 38.64 million tons in 2005 (Timilsina & Shrestha, 2009).

According to the World Bank, in 2010, Malaysia's CO_2 emission (metric tons per

capita) was estimated at 7.67. In 2001, the Malaysian government dedicated US$ 0.63 billion to finance environmental preservation projects. To promote and encourage the use of green technology, the Malaysian government has reduced import duty and excise duty on efficient cars. Although the Malaysian government is promoting the use of energy efficient vehicles, an important question is whether households are willing to use these energy efficient vehicles. The fuel reserve of Malaysia is declining at a rapid rate (Aslam *et al.*, 2006), and it is expected that the country would become a net importer of oil by 2013 (Gan & Li, 2008). A shift to the use of alternative fuel vehicles will enable Malaysia to reduce its dependence on petrol. In 2006, Malaysia discovered new natural gas reserves, which are expected to produce natural gas in commercial quantities for the next three decades. Thus, the focus of this study is to use the Theory of Reasoned Action (TRA) framework proposed by Ajzen and Fishbein (1980) to examine the willingness of households to use Natural Gas Vehicles (NGVs) as an alternative to petrol vehicles in Malaysia. In the Ninth Malaysia Plan 2006-2010, the transport sector recorded the highest percentage in commercial energy demand in 2010 (41.1%); other sectors such as industrial, residential, non-energy, and agricultural sectors consumed 38.8%, 12.8%, 6.5% and 0.8%, respectively, of the commercial energy in the country (Table 1).

A growing number of studies have provided a critical analysis and review of several *well-to-wheel* fuel chains for particular types of AFV that exist in the market place and those expected to be available in the near future (Hekkert, Hendriks, Faaij & Neelis, 2005; Holden & Hoyer, 2005; Matsumoto, Inaba & Yanagisawa, 1997; Pascoli, Femia & Luzzati, 2001). The *well-to-wheel* fuel chain method is used to analyze the CO_2 emission from the source, such as a mining process, to the combustion of the vehicle to power the wheel (Hekkert, *et al.,* 2005). The results have shown that the natural gas fuel chain has less CO_2 emission, including CO_2 from the process of fuel production (Hekkert *et al.,* 2005; Matsumoto *et al.,* 1997). However, Hekkert *et al.,* (2005) noted that the data might be different if renewable energy was used. Renewable energy in Malaysia is still at its infancy. Consequently, more research is needed to reduce the massive investment costs associated with renewable energy production to make it economically viable.

The importance of using renewable energy in Malaysia has been recoginsed by the government and this is highlighted in the Water Minister Datuk Seri Peter Chin Fah Kui in the renewable energy framework outlined in the 10th Malaysia Plan (2011-2015) (Leong, 2010). In the 2011 budget, the Malaysian government established the Green Technology Financing Scheme of US$0.63 billion to

Table 1: Commercial energy demand in Malaysia by sector, 2000-2010

Source	Petajoules			% of Total		
	2000	2005	2010	2000	2005	2010
Industrial[1]	477.6	630.7	859.9	38.4	38.6	38.8
Transport	505.5	661.3	911.7	40.6	40.5	41.1
Residential and commercial	162	213	284.9	13.0	13.1	12.8
Non-Energy[2]	94.2	118.7	144.7	7.6	7.3	6.5
Agriculture and Forestry	4.4	8.0	16.7	0.4	0.5	0.8
Total	1,243.7	1,631.7	2,217.9	100.0	100.0	100.0

Notes

1 Includes manufacturing, construction and mining.

2 Includes natural gas, bitumen, asphalt, lubricants, industrial feedstock and grease.

Source: Ministry of Energy, Water and communications and Economic Planning Unit

provide soft loans to producers and users of green technology ("Budget 2011", 16 October 2010). This scheme included the introduction of a Feed-in Tariff (FiT) of 1%, which is an incentive structure to enhance the adoption of renewable energy through government legislation (Leong, 2010). A FiT of 1% will be incorporated in the electricity tariff of consumers and establish a Renewable Energy Fund under the Energy, Green Technology and Water Ministry (KeTTHA) support the development of renewable energy.

Clearly, one of the ideal alternative methods for reducing dependency on petrol is to use NGV. A new natural gas field was discovered in Malaysia that increased the country's gas reserves from 84.3 trillion cubic feet (tcf) in 2000 to 85.2 tcf in 2005. This new reserve is expected to last for 33 years. Thus, the average production of natural gas has increased from 4,367 million standard cubic feet per day to 5,800 mscfd *EPU (Economic Planning Unit Malaysia, 2006), Ninth Malaysia Plan 2006-2010*, 2006). In 1995, PETRONAS NGV Sdn Bhd (PNGV), a wholly owned subsidiary of PETRONAS, was established to develop and commercialize NGV in Malaysia ("Malaysia - Country Report May 05"). According to CIA World Fact Book, as of 1 January 2013, the natural gas reserves of PNGV stands at 2.35 trillion cubic meters. The primary task for the PNGV is to construct NGV refueling stations in targeted urban areas where piped natural gas is available. To encourage more NGV users, the Malaysian government has provided a number of incentive programs, such as exempting the import duty and sales tax on NGV conversion kits that ultimately reduces the capital cost to the owner and reduces the payback period for the conversion. Moreover, all the NGV users with bi-fuel NGVs will be entitled to a 25% road tax rebate, and NGV users will receive a 50% road tax rebate because they use 100% natural gas ("Malaysia - Country Report May 05").

Despite abundant natural gas, less pollution to the environment and an increasing number of refueling stations of natural gas, NGVs do not seem to be popular in Malaysia. There were only 44,156 NGVs recorded in 2010, and 97% of them are taxis (Rohani, 2010). NGVs in Malaysia are still dominated by bi-fuel vehicles in which the petrol car is converted to an NGV, and the car is allowed to run either with petrol or natural gas based on the driver's choice. The conversion cost for a petrol car to NGV ranged from RM3,000 to RM7,000 depending on the capacity of the selected gas cylinder ("Estimated: NGV Installation Price", 2008). There was an increasing number of NGVs when the price of petrol surged in 2008, while the price of natural gas remained cheaper than that of petrol. However, the demand for NGVs has decreased dramatically after the government increased the subsidy for petrol in 2009 ("Asia NGV Communications, 2009").

Although previous studies have examined the features and benefits of using NGVs, to the knowledge of the authors no previous study has specifically examined the determinants of the consumers' intention to use NGV as an alternative to petrol cars. This study is aimed to investigate the influence of NGV refueling station availability, the payback period for the initial conversion cost, the fluctuation in petrol price and refueling time on demand for NGVs.

Literature Review

The transport sector generates approximately 26% of the global CO_2 emission and is one of the industries that causes CO_2 emission to continue to increase (Chapman, 2007). The increases in population and globalized businesses have encouraged the use of transportation via air freight, cars, trucks, rails and ships (Gunasingham, 2009). According to the UN report, marine ecosystems store up to 1.6 billion tons of CO_2 every year, which is roughly equivalent to half the yearly emissions of the entire global transport sector" (Gunasingham, 2009). From this report, we can observe three important points. First, the oceans are also important in absorbing CO_2 in addition to forests. Second, CO_2 emission

from the transport sector is approximately 3.2 billion tons per year, and the most critical part is the CO_2 emission rate of the transport sector, which is 50% faster than CO_2 absorption by oceans. CO_2 emission is also affecting the sea ecosystem, which ultimately impinges on human food sources. Thus, actions to reduce CO_2 emission are highly desirable, especially in the transport sector. Timilsina & Shrestha (2009) have pointed out that CO_2 emission from the transport sector in Malaysia is the major issue of concern. Petrol and diesel are the primary fuels used for vehicles in Malaysia. The total fuel consumption was 39.5% diesel and 60.5% petrol in 1980.

After 25 years, petrol is still the main fuel source for the transport sector, with 38.2% diesel and 61.7% petrol in 2005. Although NGVs are an ideal AFV in Malaysia with respect to environmental impact and reducing the dependency on petrol, the consumers' perception of NGVs is the most important factor (Ahn, Jeong & Kim, 2008). Nevertheless, estimating the preference of real-world consumer choices is difficult because it is expensive to conduct such research. Instead, a stated-preference approach has been deployed in market research to estimate the demand for new products (Ewing & Sarigöllü, 1998). Thus, researchers have used a discrete choice model and stated preference data to study consumer preference with regard to AFVs (Ahn *et al.,* 2008; Dagsvik & Liu, 2009; Ewing & Sarigollu, 1998; Noblet, Teisl & Rubin, 2006; Rouwendal & de Vries, 1999). In the preference choice model, researchers are free to test as many attributes as alternatives to be measured. However, each attribute must not only focus on primary interest, such as economic instruments, but also other major influences on choice and trade-offs against these economic instruments (Ewing & Sarigollu, 1998).

Ewing and Sarigollu (1998) have stated three types of vehicles, Conventional, AFV and electric, which were used in a discrete choice experiment for car drivers to choose their preference. In addition to purchase price, repair and maintenance cost, performance characteristics such as range, refueling time and acceleration were also included in the experiment. Factorial design has been used to determine the combinations of cases for respondents to choose their preference. The results show that vehicle price and performance are perceived to be important by the consumers when they are making their preferred choice. Refueling time was not statistically significant for half an hour or less, which suggests that refueling stations are widely available. Similar research on forecasting the consumer demand for AFVs uses a multiple-discrete-continuous choice model and conjoint analysis (Ahn *et al.,* 2008). The advantage of using the multiple-discrete-continuous choice model is that the consumer can choose more than one option from a set of mutually exclusive options. The results show that petrol-fueled cars are still preferred by most consumers, and the results differ from the findings of Ewing and Sarigollu (1998).

However, Ahn *et al.,* (2008) suggest that the results were different due to the effect of omitted fuel-related variables, such as vehicle availability, fuel station availability, and refueling time. Thus, the fuel-related variables influence the consumers' decision when selecting an AFV. Consequently, it is important to include fuel-related variables in the case study of Malaysia in addition to economic factors such as initial modification cost and fuel price. It is worthwhile to mention that Ewing and Sarigollu (1998) and Ahn *et al.,* (2008) have investigated consumer preference between petrol cars and AFVs using a discrete choice model and a multiple-discrete choice model, respectively. However, none of these studies investigated the values of the discrete levels of each attribute that are used in NGVs. Thus, in this study, factorial design and conjoint analysis are used to study Malaysian consumers' preference in selecting an NGV by employing the economic factors (payback period for the initial modification cost and changes in petrol price) and fuel-related variables (NGV station availability and refueling time for an NGV).

In the present study, the purchase price used in Ewing and Sarigollu (1998) has been replaced by modification cost because the NGVs in Malaysia are bi-fuel vehicles, which are converted from petrol cars to NGVs (Aslam, *et al.*, (2006). The modification cost for Malaysian cars is between RM3,200 and RM5,200 ("Estimated: NGV Installation Price ", 2008). For this study, RM5,000 has been selected as an attribute to develop the option available to the consumer. The trade-offs between high fix price and low operation cost may be used to calculate the consumer payback period (Rouwendal & de Vries, 1999), and the payback period was found to be significant by Goedecke, Therdthianwong & Gheewala (2007). In this study, two discrete levels of payback period were used: more than one year and less than one year. The global economic fluctuations significantly influence the daily variations in petrol prices.

For instance, in Malaysian automobile industry, many consumers converted their petrol cars to NGVs during the price surge of Ron 97 in 2008. Thus, modification cost and changing petrol prices have been used as economic factors in this study. For this purpose, two discrete levels of petrol Ron 95 price were used: 'more than RM1.85/liter' and 'maintained at RM1.85/liter'. The importance of NGV refueling station availability has been stated by researchers such as Yang, Kraft-Oliver, Yan and Min (1997), Pascoli *et al.,* (2001), Byrne and Polonsky (2001) and Goedecke *et al.,* (2007) among others. Following these studies, two discrete levels of NGV refueling station availability have been used: 'many NGV refueling stations' and 'no NGV refueling stations'. Refueling time for an NGV in public refueling stations is expected to be the same as that for a petrol car unless there is high demand that causes the pressure to drop, which may increase the time ("Refueling," 2011). In Malaysia, public refueling stations are commonly available and the refueling time is expected to vary between 3 and 15 minutes. Thus, two discrete levels of refueling time are considered for this study: 'less than or equal to 3 minutes' and 'between 4 and 15 minutes'. Factors such as safety and support from the government are used as assumptions in the experimental design of the questionnaire survey because these factors are believed to have some influence on the consumers' decision when changing their petrol car to a NGV.

Methodology

The present study includes respondents who are car owners in Malaysia, regardless of whether they are petrol users or NGV users or both. According to the International Association for Natural Gas Vehicles (IANGV), there are 8,506,080 passenger cars that were registered in Malaysia in 2009, of which 42,617 (0.5%) use NGV. The NGV stations are located in three regions: the center, south, and northern regions of West Malaysia. Furthermore, there is no NGV station in east Malaysia, although Miri and Sarawak in Eastern part of the country are where the natural gas deposits are located. These facts motivated the study to focus on West Malaysia. For ease of collecting data, a non-probability sampling method, namely, convenience sampling, was used to elicit information from respondents who drive cars in Malaysia. This study follows the approach of Sekaran and Bougie (2010) who suggested that a sample size larger than 30 and less than 500 will be appropriate for survey and experimental research design.

Experimental Design: An Illustration

A questionnaire was administered to each respondent in the survey with the underlying assumption that the respondent is using a Proton Saga car, cc 1,500 (National car of Malaysia), which is still under warranty, and is using Ron 95 petrol. The respondent are aware that the government is encouraging car owners to convert their petrol vehicle to a NGV. NGV car owner will be eligible to enjoy a 25% rebate on road tax. The respondent is also aware of the safety benefits and that a NGV will reduce carbon dioxide emission and thus foster a cleaner environment. As part of

this experiment, the respondent needs to make a decision whether to convert a petrol car to an NGV and has the following conditions to consider before making the decision:

Combination-1 (out of the possible 16 combinations)

a. There are no NGV stations in your residential area.
b. The modification cost is approximately RM5,000 and more than one year is required to pay back the cost.
c. The Ron 95 petrol price will be maintained at RM 2.10 / liter.
d. Approximately 15 minutes is needed to fill an NGV, which is 12 minutes more than that are required to fill a petrol car.

The respondent's opinion will be measured on the following 10-point rating scale:

1	2	3	4	5	6	7	8	9	10

Least Likely → Most Likely

Research Framework

The theory of reasoned action (TRA) proposed by Ajzen and Fishbein (1980) has been used to develop a research framework to determine the influence of preference and the intention of the respondents to switch over from a petrol car to a NGV. The research framework has been constructed to conceptualize the intension of using NGV as an alternative to a petrol car based on the four selected factors (independent variables): availability of NGV stations, the payback period for the initial modification cost, change in petrol price and refueling time. The conceptual model for the intention of consumers to switch over from a petrol car to an NGV (dependent variable) is shown in Figure 1.

A complete factorial design including all the possible combinations of two discrete levels of each of the four independent variables (IVs) contains 2^4 or 16 combinations (Table 3). The 2^4 factorial design has been used to study the effects of 16 combinations to understand customer preferences. Each combination of IVs has been measured on a 10-point scale to estimate the effect of the discrete level of the IVs on the intention of consumers to change a petrol car to a NGV.

Hypotheses Construction

For the research framework depicted in Figure 1, the following four hypotheses (Table 2) have been developed to test the relationship between each of the independent variables (IVs) and the dependent variable (DV).

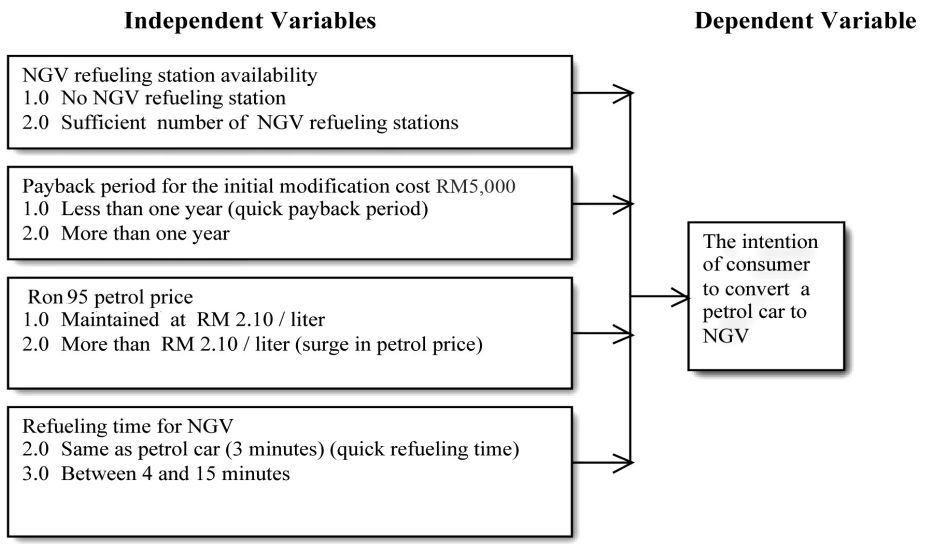

Figure 1: Conceptual model to convert a petrol car to a NGV

Table 2: Hypotheses testing for main effects and interaction effects

	Main effects	References
H1	If the number of NGV refueling stations in the market increases or there is a quick payback period, surge in petrol price or quick refueling time, then the intention to change a petrol car to a NGV increases.	Yang, *et al.,* 1997; Romm, 2006; Rohani, 2010; Pascoli, *et al.,* 2001; Goedecke, *et al.,* 2007; Ewing & Sarigöllü, 1998; Refueling, 2011.
	Two-way interaction effects	**References**
H2	The interaction between any two Independent variables will lead to an intention to change from a petrol car to a NGV.	Goedecke, *et al.,* 2007; Rouwendal & de Vries, 1999; Pascoli, *et al.,* 200 ; Ewing & Sarigöllü, 1998; Refueling, 2011; Turrentine & Kurani, 2007; Byrne & Polonsky, 2001.
	Three-way interaction effects	**References**
H3	Three-way interaction among three independent variables will lead to an intention to change from a petrol car to a NGV.	Yang, *et al.,* 1997; Goedecke, *et al.,* 2007; Ahn, *et al.,* 2008; Ewing & Sarigöllü, 1998; Rouwendal & de Vries, 1999; Byrne & Polonsky, 2001.
	Four-way interaction effects	**References**
H4	Four-way interaction among the availability of NGV stations, quick payback period, surge in petrol price and quick refueling time will increase the intention to change a petrol car to a NGV.	Romm, 2006; Byrne & Polonsky, 2001; Goedecke, *et al.,* 2007; Pascoli, *et al.,* 2001; Ewing & Sarigöllü, 1998; Ahn, *et al.,* 2008.

Results

The respondents are those who are filling their cars with petrol at the petrol stations. The data collection was executed for the duration of two months and about 180 questionnaires were administered at different petrol stations in Malaysia during that period. About 168 positive responses were received at the end of the data collection period. However, during the process of cleaning the data, 16 responses were omitted due to incomplete information; therefore, 152 (84.5%) valid respondents were considered for the study with 78 (51.3%) males and 74 (48.7%) females. A total of 81 (53.3%) respondents are married, and 66 (43.4%) are single. The respondents are mostly between 26 and 45 years old (75%) with a total of 149 (98%) respondents from West Malaysia, and only 3 (2%) respondents from East Malaysia. In addition to the above information, the occupational status and the income distribution of the respondents are presented in Appendix I. The majority of the respondents was clustered at the average income of RM2,001- RM5,000 per month.

Respondent's Preference for NGV

The research question arises here is that "whether the availability of NGV refueling station, fast payback period, surged petrol price and fast refueling time will influence intention to use NGV or not?". For this purpose, the respondents were posed with combination of options for the usage of NGVs as an alternative to petrol cars and the experimental design was conducted. Also, the respondents have been asked about their willingness to convert their petrol car to a NGV within a year, given that the government provides a subsidy and safety security measures. The results show that 52 (34.2%) respondents are willing to change their petrol cars to a NGV, while 93 (61.2%) respondents are not willing to change. Additionally, there were 7 (4.6%) respondents who did not make any comments. Although the respondents are willing to use NGV cars they

have inhibition on safety concerns, no clarity on the sustainability of NGV and performance of NGV- speed, engine durability and lack of information on conversion kits.

Best Preferred Combinations

In the current study, 16 combinations have been constructed to test the intention of the respondents to change their petrol car to a NGV. The explanation for combination 1 is provided in section 3.1 and similarly we can define the remaining 15 combinations. The respondents must rate their preference for each combination on a 10-point scale. Table 3 provides the average mean value for each combination. Combination 16 has the highest average rating score of 6.49 on a 10-point scale, followed by combination 13 (6.07), combination 14 (5.63), combination 8 (5.51) and combination 12 (5.22) as the top five preferred combinations.

Multidimensional Scaling (MDS) for 16 Combinations

Multidimensional Scaling (MDS) has been performed to investigate the degree of similarity and dissimilarity between each of the 16 combinations (cases) discussed in Table 3. From the MDS map (Euclidean distance model), similarity may be viewed as the distance between two points. If the distance is short, the two cases are assumed to be relatively similar. If the two points are located far away from one another, then the two cases are assumed to be dissimilar. Generally, the most preferred combination is located far away from the other cases, which are relatively clustered. The MDS map for the 16 combinations is shown in Figure 2. Altogether, three clusters were formed: the first cluster has combinations 1, 2, 3 and 4; the second cluster has combinations 5, 6 and 7; and the third cluster has combinations 9, 10, 11 and 15. Combinations 16, 13, 14, 8 and 12 are located relatively far away from the others.

Table 3: Average scores for all 16 combinations (n=152)

Combination	Availability of NGV refueling station	Payback period for initial modification cost RM 5000	Petrol price / liter (Ron95)	Time (in minutes) required to fill NGV	Mean value on a 10-point scale
16	**Yes**	**< 1 year**	**> RM 2.10**	**3**	**6.49**
13	**Yes**	**< 1 year**	**RM 2.10**	**3**	**6.07**
14	**Yes**	**> 1 year**	**> RM 2.10**	**3**	**5.63**
8	**Yes**	**> 1 year**	**RM 2.10**	**3**	**5.51**
12	**Yes**	**< 1 year**	**> RM 2.10**	**15**	**5.22**
6	Yes	< 1 year	**RM 2.10**	15	5.05
7	Yes	> 1 year	**> RM 2.10**	15	4.93
5	Yes	> 1 year	**RM 2.10**	15	4.80
15	No	< 1 year	**> RM 2.10**	3	4.11
2	No	> 1 year	**RM 2.10**	3	3.74
11	No	> 1 year	**> RM 2.10**	3	3.74
10	No	< 1 year	**RM 2.10**	3	3.71
3	No	> 1 year	**> RM 2.10**	15	3.66
9	No	< 1 year	**> RM 2.10**	15	3.62
4	No	< 1 year	**RM 2.10**	15	3.61
1	No	> 1 year	**RM 2.10**	15	3.21

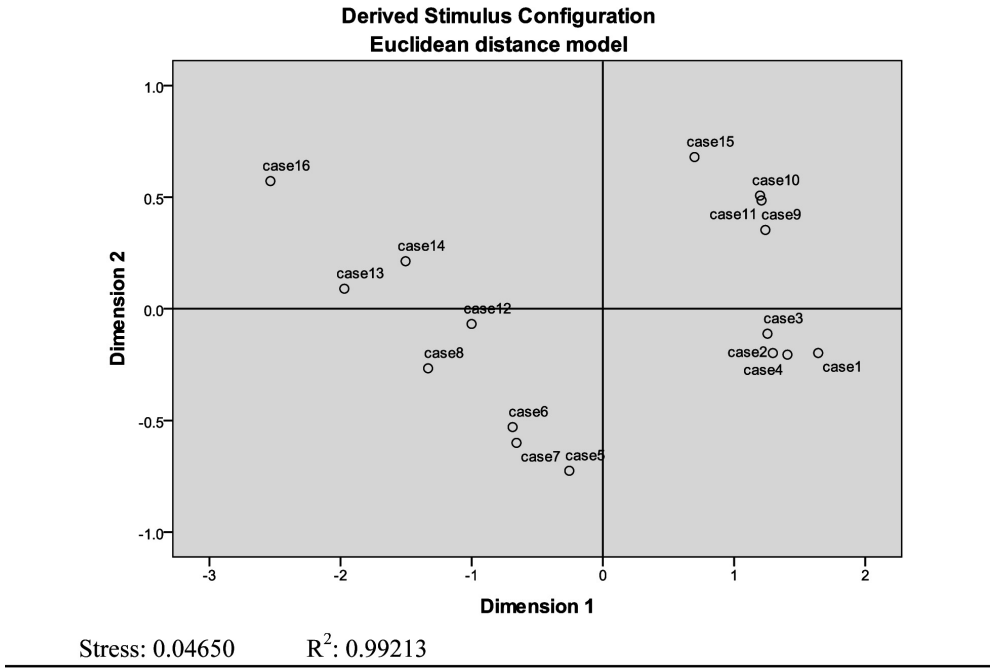

Figure 2: Euclidean Distance Model for the 16 combinations

Table 4: Summary of the significant best preferred combinations

				Top Five Combinations (Cases)				
				Influence of Socio Demographic Factors				
Socio Demographic Factors		**Stress**	**R^2**	**Case 16**	**Case 13**	**Case 14**	**Case 8**	**Case 12**
Gender	Male			Yes	Yes	Yes	Yes	Yes
	Female							
Marital status	Single	0.06901	0.98050	Yes	Yes	Yes	Yes[a]	Yes[a]
	Married	0.04737	0.99247					
Age (in years)	18-25	0.06302	0.98597	Yes	Yes	Yes	Yes[a]	Yes[a]
	26-35	0.05374	0.9887					
	36-65	0.04020	0.99451					
Family size	2 members	0.05228	0.99109	Yes	Yes	Yesa	Yes[a]	Yes[a]
	3-5 members	0.04650	0.99230					
	6 members and above	0.08302	0.97157					

Note: Only the top five combinations were presented; [a] partially significant.

Thus, these five combinations are viewed as dissimilar by the study respondents. Among these, combination 16 is located far away from the others. This indicates that combination 16 is the most preferred by the respondents and coincides with the results displayed in Table 3. The stress value is 0.047; the R^2 value is 0.99, which indicates that the model fits the data well.

Table 5: 2^4 Factorial experiment design results

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	**4**	**45.7111**	**45.7111**	**11.4278**	**31.18**	**0.000**
2-Way Interactions	6	1.7540	1.7540	0.2923	0.80	0.579
3-Way Interactions	4	0.7730	0.7730	0.1933	0.53	0.716
4-Way Interactions	1	0.1292	0.1292	0.1292	0.35	0.557
Residual Error	32	11.7293	11.7293	0.3665		
Pure Error	32	11.7293	11.7293	0.3665		
Total	47	60.0966				

The similar MDS analysis has been employed for social demographic factors such as gender, age, marital status and family size. The results are summarized in Table 4 and reveals that the combinations 16 and 13 are the most preferable options favoured by the respondents since the model fits well and is significant for each category of the socio demographic factors. On the other hand, for combinations 14, 8 and 12 the model fits well only for some categories of socio demographic factor and are called partially significant.

Region Wise Differences

The top five combinations have some similarities, and the availability of more NGV stations is the most common concern of the respondents. In Malaysia, the center and south regions of West Malaysia have a sufficient number of NGV stations. However, there are only a few stations in the northern region of West Malaysia. The relationship between the respondents from different regions and their preference is analyzed using the 2^4 Factorial experiment, and the results are presented in Tables 5. In the 2^4 Factorial experiment, the regions were selected as replicates, and the respondents' average scores for the four IVs were the main effects. There are 3 replicates for the north, center and south regions of West Malaysia. The output shows that the main effect is found to be statistically significant ($F= 31.18$; $p<0.001$). Among the main effects, the availability of NGV stations and quick refueling time were found to be highly statistically significant, with $t=10.62$ and $p< 0.001$ and $t=-2.97$ and $p< 0.01$, respectively. This result indicates that the respondents preferred to have more NGV refueling stations and a quick refueling time. The above results partially support hypothesis H1 in which the availability of more NGV refueling stations and quick refueling time positively influence consumers' intention to change from a petrol car to a NGV.

Discussion and Conclusion

The present study includes 152 respondents, of which 52 respondents (34.2%) reported that they were willing to change their petrol car to a NGV within a year provided that the government provides a subsidy and safety and security measures. The respondents are also concerned about other factors, such as car performance, maintenance cost, reliability of NGVs, conversion cost, conversion time, reliable NGV workshops and the sustainability of NGVs. These concerns have been raised by the respondents from the open-ended questions in the questionnaire. The NGV in Malaysia is a bi-fuel car in which a petrol car may be converted to a NGV car, and the driver has the option to use either petrol or natural gas. The conversion process requires time, a reliable workshop and a conversion cost. Some of the respondents were lack of information regarding the conversion kits and the compatibility for their petrol cars.

During the conversion process, car owners tend to rely exclusively on the NGV workshop. However, certified workshops and technicians in the NGV field were found not to be transparent enough for consumers to build their confidence in NGVs. Some respondents felt that the gas cylinder is bulky, making the boot of the car smaller than originally designed for and the trunk space will become limited

after installing the gas cylinder. However, some respondents are not satisfied with driving NGVs over long distances. Usually, the driving distance of the distance travelled by NGV cars is shorter than that of petrol cars due to their tank capacity. Further, as the frequency of refueling NGVs increases, and given limited availability of NGV refueling stations, car owners are reluctant to convert their cars to NGV. Notably, NGV cars are perceived to perform lower than those of petrol cars in terms of speed of the car, the engine performance and the durability of NGV car engines. The owners of NGV cars have expressed concern over the resale value of their cars given that those converted to NGV tend to loose their resale value. We find that respondents have very little knowledge about NGVs, much of which is obtained via media and newspapers. The implication is that there is the need for the Malysian government to educate the populace about the benefits of NGV cars. Further, there is the need to implement industry rules and regulations to ensure that workshops making the conversion offer customers the best service. These policy initiatives have the potential to encourage the use of NGVs in Malaysia.

Using the factorial design for the four factors (availability of NGV refueling stations, quick payback period for the initial modification cost, fluctuation of petrol price, and refueling time) with two levels, 16 combinations (Table 3) have been constructed. The descriptive analysis output shows that combination 16 is the most preferred by the respondents, followed by combination 13. Both of these combinations have the highest average score and received a score higher than 6.00 on a 10-point scale. The difference between combinations 16 and 13 is the petrol price. The difference may be due to the existence of the volatile petrol market in the globe and the fact that the price of natural gas is cheaper than the price of petrol. Apart from combinations 16 and 13, the respondents gave the next highest score to combination 14, which indicates that after petrol price, the payback period is the next factor of importance for the respondents. The cheaper natural gas will help commuters decrease the payback period, especially for those who drive frequently. The top four of the 16 combinations value the availability of NGV refueling stations and quick refueling time, which shows that the respondents were willing to trade off both fluctuations of petrol price and quick payback periods. The best combinations were further analyzed using Conjoint Analysis. From the Multidimensional Scaling-Euclidean Distance Model, combinations 16, 13, 14 and 8 were isolated from the remaining combinations, which support the earlier results.

From the factorial experiment, it is found that the main effects are statistically significant while the interaction effects were not. The availability of more NGV refueling stations and quick refueling time were the main concerns expressed by the respondents from the three regions in Malaysia. However, from the top five combinations, the respondents from the northern and southern regions rated combination 16 as the best, whereas the respondents from the center region prefer combination 13. This outcome indicates that the respondents from different regions have different opinions. The respondents from the northern and southern regions perceived the importance of all the factors prior to changing to NGV. However, the respondents from the center region were willing to switch from a petrol car to a NGV only when the petrol price remained at RM 2.10/liter. This result implies that center region respondents were being financially conscious in their selection of NGVs than those from other regions.

The NGVs are a relatively new concept for Malaysians when compared to the petrol car, which is well established in terms of technology and refueling network stations. The knowledge regarding safety issues, salient features and benefits of NGV, maintenance procedures for NGVs, certified workshop availability and NGV technology will increase the confidence of NGV car users. Given that much of the knowledge on NGVs are through media advertisements and newspapers, there is the need for the Malaysian government

to use these mediums for communicating to residents of the benefits of NGVs. Given that there are relatively few owners of NGV cars, but this will inevitably grow, encouraging them to share their experiences by word of mouth would be a powerful tool in encouraging more people to use NGVs. The NGVs have the lowest CO_2 emission to the environment based on the well-to-wheel analyses among the alternative fuel vehicles and petrol cars that are currently available on the market. Given that CO_2 emission is the main contributor to the greenhouse effect that causes climate change and global warming; it is pertinent that the Malaysian government promotes NGV cars as good for the environment.

In Malaysia, the number of cars registered at the Road Transport Department (JPJ) continues to increase. This is a consequence of the growth in cities and travel during holidays and festivals which increases congestion and consequently a rise in CO_2 emissions. The use of NGVs, therefore, can reduce the dependency on petrol. The establishment of NGV refueling stations is also important in ensuring that owners of NGVs have easy access to these outlets; currently, there are 144 outlets in Malaysia Rohani (2010). The lack of NGV refueling outlets are important because the lack of these stations would create inconvenience and thereby discourage potential owners of NGV cars in Malaysia.

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Appendix I: Demographic profile of the respondents (n = 152)

Profile	Description	Number of respondents	%
Gender	Male	78	51.3
	Female	74	48.7
Marital status	Single	66	43.4
	Married	81	53.3
	Divorced	4	2.6
	Widows	1	0.7
Age	18-25 years	21	13.8
	26-35 years	66	43.4
	36-45 years	48	31.6
	46-55 years	15	9.9
	56-65 years	2	1.3
Family size	2 members	31	20.4
	3-5 members	81	53.3
	6-7 members	29	19.1
	>8 members	7	4.6
	Unknown	4	2.6
Place of residence	Johor	17	11.2
	Perak	5	3.3
	Kedah	37	24.3
	Perlis	2	1.3
	Sarawak	3	2.0
	Pulau Pinang	51	33.6
	Selangor	27	17.
	Kuala Lumpur	9	5.9
	Pahang	1	0.7
Occupation	Education	34	22.4
	Manager/Management job	36	23.7
	Sales executive	14	9.2
	Self employed	14	9.2
	Non management job	12	7.9
	Others	42	27.6
Average monthly income	< RM 2000	31	20.4
	RM 2001- RM 5000	80	52.7
	RM 5001- RM 7000	16	10.5
	> RM 7000	13	8.6
	Unknown	12	7.8