

การใช้โมเดลสมการโครงสร้างเพื่อประเมินปัจจัยที่มีผลต่อการใช้แก๊สโซฮอล์ 91 ของรถยนต์ส่วนบุคคล

Using Structural Equation Modeling for Assessing the Factors Affecting Gasohol 91 Consumption on the Personal Car

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การศึกษานี้มีวัตถุประสงค์เพื่อประเมินหาปัจจัยที่มีผลต่อการใช้แก๊สโซฮอล์ 91 ของรถยนต์ส่วนบุคคล ด้วยเทคนิคโมเดลสมการโครงสร้าง โดยอาศัยแบบสอบถามเป็นเครื่องมือในการเก็บรวบรวมข้อมูลจากกลุ่มตัวอย่างผู้ใช้รถยนต์ส่วนบุคคล ในเขตอำเภอเมือง จังหวัดนครราชสีมา จำนวน 558 ราย จากผลการวิเคราะห์โมเดลสมการโครงสร้างสุดท้ายของปัจจัยที่มีอิทธิพลต่อการใช้แก๊สโซฮอล์ 91 ของรถยนต์ส่วนบุคคล พบว่า โมเดลโดยรวมมีความสอดคล้องกับข้อมูลเชิงประจักษ์ ส่วนสำหรับปัจจัยที่มีอิทธิพลต่อปริมาณการใช้แก๊สโซฮอล์ 91 ของรถยนต์ส่วนบุคคลมากที่สุดคือ ผลิตภัณฑ์ รองลงมาได้แก่ ช่องทางการจัดจำหน่าย การค้นหาข้อมูลและประเมินผลทางเลือก พฤติกรรมหลังการซื้อ ราคา การส่งเสริมการขาย การตัดสินใจซื้อ การรับรู้ปัญหา และการซ่อมและบำรุงรักษา ตามลำดับ โดยทุกปัจจัยที่มีอิทธิพลสามารถร่วมอธิบายความผันแปรของปริมาณการใช้แก๊สโซฮอล์ 91 ได้ร้อยละ 83.20

คำสำคัญ: โมเดลสมการโครงสร้าง ปัจจัยที่มีผล แก๊สโซฮอล์ 91 รถยนต์ส่วนบุคคล

ABSTRACT

The objective of this study was to assess the factors affecting gasohol 91 consumption of the personal car. The Structural Equation Modeling (SEM) is the statistical technique that is utilized to analyze the data. The data were obtained from the amount of the 558 personal car users in Muang District, Nakhon Ratchasima Province, utilizing the questionnaire as a tool to collect the data. The results of the final SEM indicated that the overall model is consistent with the empirical data. The most influential factor in the consumption of gasohol 91 on a personal car was the product, followed by the place, information search and pre-purchase evaluation of alternatives, post-purchase, price, promotion, purchase decision, problem recognition, and repair-maintenance, respectively. All influential factors could explain variation in gasohol 91 consumption by 83.20%.

Keywords: Structural equation modeling, Factor affecting, Gasohol 91, Personal car

1. Introduction

The Ministry of Energy sets national energy policy and plan under the name of the Thailand Integrated Energy Blueprint (TIEB). The Blueprint comprises of the five master plans for energy development as follows: Power Development Plan of Thailand (PDP), Energy Efficiency Development Plan (EEDP), Alternative Energy Development Plan (AEDP), Natural Gas Supplying Plan (Gas Plan), and Oil Management Plan (Oil Plan).

According to the report of the final energy consumption by type of energy in Thailand between 2007 and 2016, the petroleum products consumption played the greatest proportion 47.99% of the total final energy consumption, followed by electricity, traditional renewable energy, coal & its products, renewable energy, and natural gas in shared 18.81%, 11.30%, 8.77%, 6.81%, and 6.33% respectively, as shown in Figure 1. In addition, total final energy consumption increased by 2.36% per year [1].

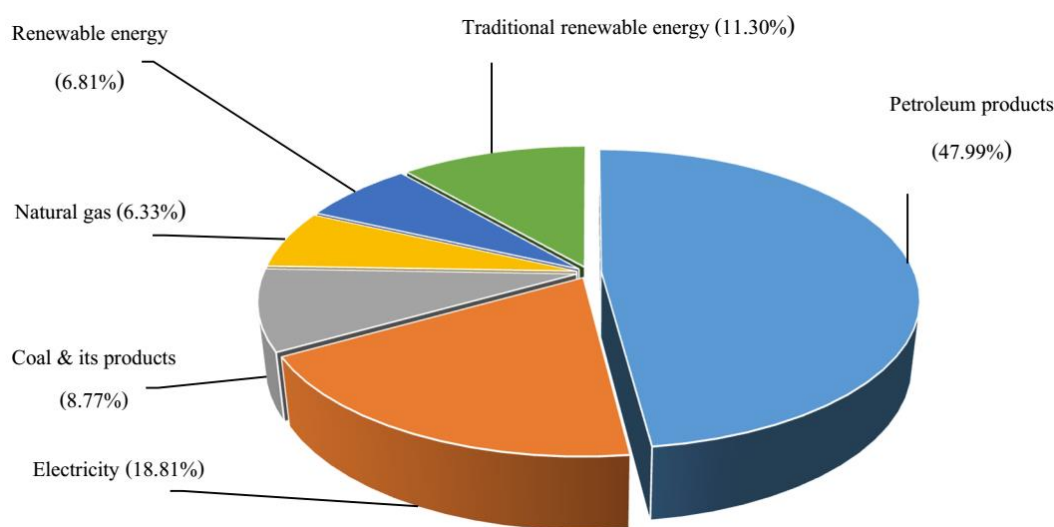


Figure 1: Final energy consumption by type of energy in Thailand, 2007 to 2016 [1]

From total petroleum products consumption, the greatest share of 69.82% was from energy consumed in the transportation sector, followed by industrial sector,

agricultural sector, residential sector, and commercial sector in shared 16.52%, 7.46%, 4.68%, and 1.52% respectively [2], as shown Figure 2.

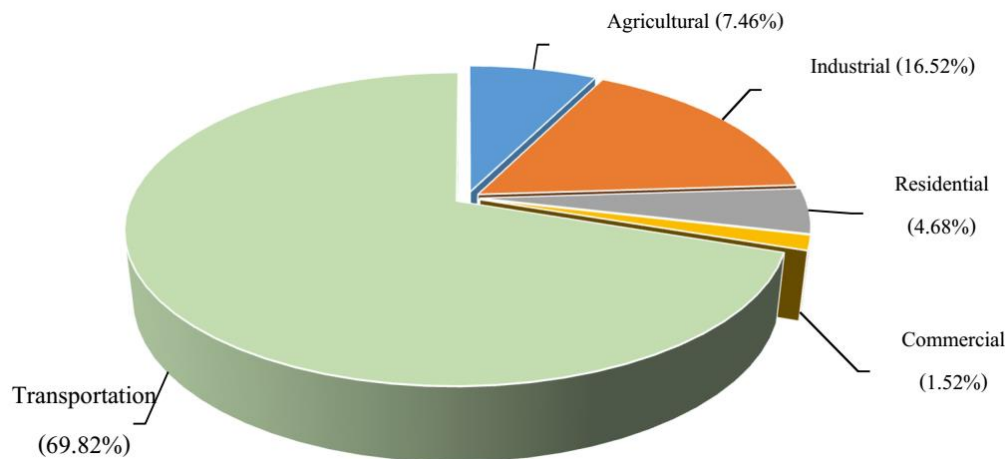


Figure 2: Petroleum products consumption by economic sectors, 2016 [2]

The Oil Plan is a long-term plan for the period 2015-2036 to support fuel management in line with the goal of EEDP which targets on reducing 30% of the Energy Intensity (EI) in 2036 compared to 2010 and also the AEDP, which aims to use 30% renewable energy in 2036 [3]. It is the framework for managing future fuels, taking into account the environment and risks that may impact both directly and indirectly in the development of the country's energy.

The gasoline is the fuel group which the five products of the highest distribution in Thailand are gasoline 95, gasohol 91, gasohol 95, gasohol E20, and gasohol E85. It also is the second largest market share after diesel. The consumption amount of the gasoline in Thailand indicated that all four types of gasohol have the 95.38% consume proportion, the rest 4.62% is the gasoline 95. Out of the four types of gasohol portion, the 79.45% is the consumption of gasohol 91 and gasohol 95 (low percentage-ethanol group). The rest 20.55% is the consumption of gasohol E20 and gasohol E85 (high percentage-ethanol group) [4]. The consumption of gasohol in both groups is very different (58.90%). It is the risk that may affect the management according to the TIEB; i.e. not achieve the given target, especially with

the EEDP, the AEDP, and the Oil Plan. Since ethanol is a component of gasohol, it is another type of renewable energy that needs to increase from 3.50 million liters per day in 2015 to 11.30 million liters per day in 2036 [5].

Researchers have focused on this issue, so this research proposed the analysis of the structural equation model of the factors affecting the consumption gasohol of the personal car. In this study, gasohol 91 is the fuel type used as the case study because of the highest amount of usage (about 40% of total gasohol consumption) [4]. Nakhon Ratchasima is a study area because it is a large province with continuous economic growth. In addition, the number of personal cars registered in Nakhon Ratchasima Province is highest in the Northeastern of Thailand (210,277 cars) [6].

2. Objectives

The research aims to assess the factors affecting gasohol 91 consumption of the personal car.

3. Benefits

The expected benefits of this study are to understand the factors that influence the gasohol 91 consumption on the personal car. In the future research, the results of this

study can be brought to analyze the risk factor and the risk management of factors affecting the usage of the gasohol on the personal car.

4. Hypothesis

In this study, the conceptual framework was developed based on the results of “Factor analysis to use gasohol of personal car” [7]. It was hypothesized that product factor (F1), price factor (F2), place factor (F3), promotion factor (F4), problem recognition factor (F5), information search and pre-purchase evaluation of alternatives factor (F6), purchase decision factor (F7), post-purchase factor (F8), and repair-maintenance factor (F9) collectively affecting the gasohol consumption (Y) of the personal car.

The hypothetical diagram of the structural equation model consists of nine factors (F1-F9) and 48 X indicators, collectively affecting Y, as shown in Figure 3. The corresponding hypotheses were as follows:

- Hypothesis 1: F1 influences overall impact on Y.
- Hypothesis 2: F2 influences overall impact on Y.
- Hypothesis 3: F3 influences overall impact on Y.
- Hypothesis 4: F4 influences overall impact on Y.
- Hypothesis 5: F5 influences overall impact on Y.
- Hypothesis 6: F6 influences overall impact on Y.
- Hypothesis 7: F7 influences overall impact on Y.
- Hypothesis 8: F8 influences overall impact on Y.
- Hypothesis 9: F9 influences overall impact on Y.

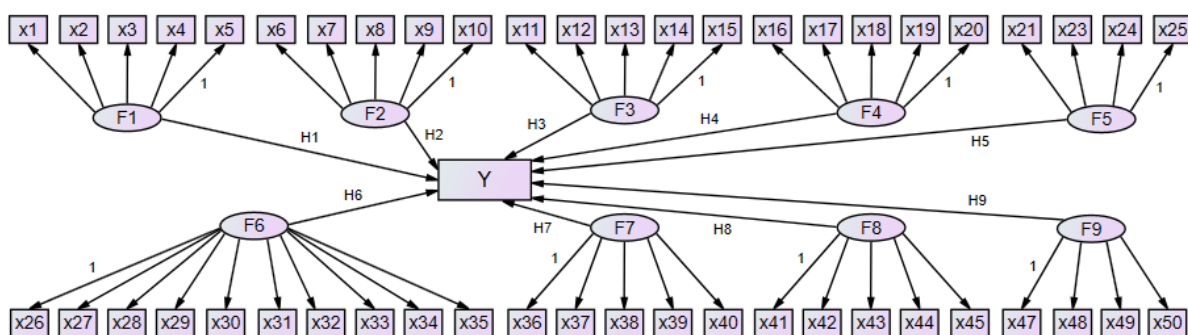


Figure 3: The hypothetical model of the factors affecting gasohol 91 consumption of the personal car

5. Concept and Theory

The Structural Equation Modeling (SEM) is a multivariate statistical analysis technique that is used for analyzing the structural relationships. This technique is the combination of factor analysis and multiple regression analysis which is used to analyze the structural relationship between indicators and latent variables (factors). The statistics are used to evaluate two model: a measurement model and a structural model [8].

To specify the details of the questions in the questionnaire, the researchers relied on the review of the relevant theories and concepts, including:

- The marketing mix (4 Ps) that manufacturers want to share. To meet the needs of the target market includes product, price, place, and promotion. Consumer behavior involves buying, using, disposing of goods, and services. The behavior of any person seeking, buying, evaluating, and spending any goods and services was expected to meet their own needs. The consumer buying decision process includes problem recognition, information search, evaluation of alternatives, purchase decision, and post-purchase behavior [9-17].
- The properties of gasohol, which may differ from gasoline, could affect long-term used, as well as repair-maintenance of the engine after use [18].

6. Methodology

6.1 Population and Sample

The population in this study was personal car users in Muang District, Nakhon Ratchasima Province. The size of the sample is important in the SEM which there are many different opinions and rules of thumb as follows: minimum sample size should be in the range of 100 to 200 [19][20][21][22], sample size should be above 200 or 300 [23][24], and sample size should be 5 to 10 times of the number of variables [22][25][26][27][28].

This study consisted of 49 indicators (48 variables X and one variable Y) to prevent incompleteness of data from the survey, so the researchers set the sample size to 558. The purposive sampling was used to select the study area from the top six most populated Sub-district of Muang District, Nakhon Ratchasima Province as follows: Nai Muang Sub-district, Cho Ho Sub-district, Pho Klang Sub-district, Hua Thale Sub-district, Nong Bua Sala Sub-district, and Khok Kruat Sub-district. It also used a convenient sampling method to collect data from samples by collecting data amount 93 samples per Sub-district.

6.2 Instrument

This study was a survey using the questionnaire as a research tool to collect data. The questions had nine factors (F1 - F9), consisted of 48 items [7], collectively affecting gasohol consumption of the personal car. The questions were grouped as follows: F1 (questions X1 to X5), F2 (questions X6 to X10), F3 (questions X11 to X15), F4 (questions X16 to X20), F5 (questions X21 and X23 to X25), F6 (questions X26 to X35), F7 (questions X36 to X40), F8 (questions X41 to X45), F9 (questions X47 to X50), and the gasohol consumption (Y). All X questions were measured with a 5-likert scale.

Quality testing of the instrument, the content validity was checked by three experts based on the index of Item-Objective Congruence (IOC) and adjusted the

questionnaire according to the recommendations of the experts. The reliability was checked by Cronbach's alpha coefficient. The quality test showed that the IOC score ranged from 0.67 to 1 (greater than 0.50) [27] and the overall Cronbach's alpha coefficient was 0.96 (higher than 0.70) [30-37]. The details of the questions on the questionnaire are shown in Appendix A.

6.3 Data Analysis

For this research used the SEM to assess factors affecting gasohol consumption of the personal car. The initial hypothesized model in Figure 3 was analyzed using AMOS based on Maximum Likelihood (ML) technique to estimate parameters. Thus, the variables must have a multivariate normality distribution.

7. Results and Discussions

The data from the survey revealed that the absolute values of Kurtosis Index (KI) were less than 7 and the absolute values of Skewness Index (SI) were less than 2, which were in the range of normal distribution [38]. The results of the analysis of factors affecting gasohol 91 consumption of the personal car can be shown in each section as follows.

7.1 Refinement of Model

Analysis of the factors affecting gasohol 91 consumption of the personal car, the X10 and X33 indicators showed that the standardized loadings were relatively low standardized loadings with their latent variables in the structural equation model (less than 0.50). Thus, both indicators were removed from the final structural equation model.

This research used the Goodness of Fit (GOF) indices to the refinement of the initial hypothesized model performed the improvement that fits to its recommended levels GOF indices. As shown in Table 1, all GOF indices were certainly acceptable. Thus, the final structural equation model was consistent with the empirical data.

Table 1 The GOF indices of final SEM and recommended levels of GOF indices

GOF Index	Recommended level of GOF index	GOF index of final SEM ^a	Source reference
CMIN/DF	≤ 3	2.287	[22][23][24]
IFI	≥ 0.90	0.965	[23][27][28][33][37]
TLI	≥ 0.90	0.962	
CFI	≥ 0.90	0.965	
RMSEA	≤ 0.05	0.048	[27][28][33]
HOELTER (0.05)	≥ 200	258	[28][39]

Note: ^a The indicators X10 and X33 were removed from the final structural equation model.

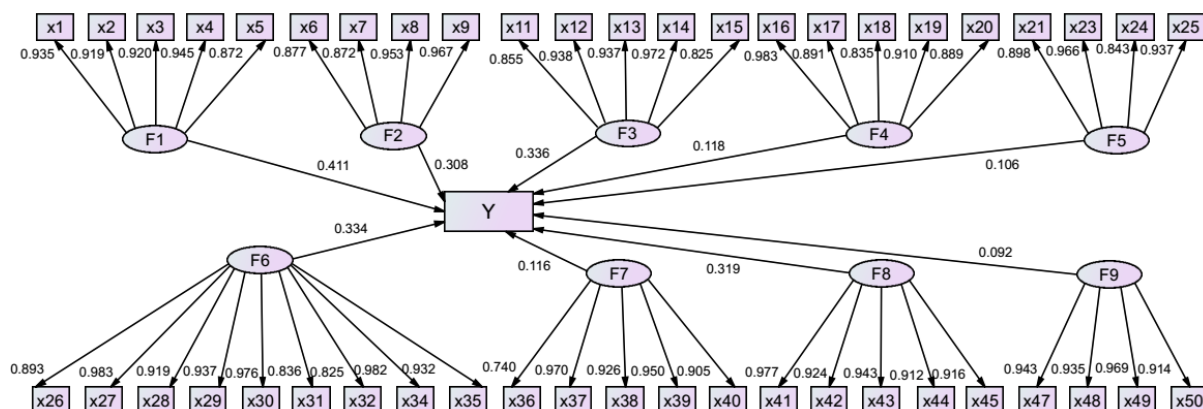
7.2 Reliability of Constructs

To evaluate the adequacy of the measurement model in terms of the relationship between indicators and latent variables, there were three different tests as follows:

- Reliability test base on Cronbach's alpha coefficient a cut-off value of 0.70 was used to indicate an acceptable level of initial consistency [40][41].

The results of reliability test of final structural equation model ranged from 0.949 to 0.981.

- Convergent validity test base on standardized loading of the measurement paths, the threshold of 0.50 was used to indicate an acceptable level [42]. However, standardized loading of 0.70 was widely used at an acceptable level [27][41]. Figure 4 show the final structural equation model with the standardized loadings and standardized path coefficients of structure path.

**Figure 4:** Final structural equation model of the factors affecting gasohol 91 consumption of the personal car

As depicted in Figure 4, all standardized loadings were above 0.70 which was a clear

demonstration of the convergent validity of all indicators in the final structural equation model.

- Discriminant validity test by the assessment of cross-loadings: the items loadings (factor loadings) in the main factor must higher than loadings in other factors [41][43]. The results of discriminant validity test of final structural equation model showed that all factor loadings in the main factor higher than loadings in other factors and greater than 0.70 [27][41], which a clear demonstration of the discriminant validity of the nine latent variables in the final structural equation model.

7.3 Hypothesis Testing

The hypothesis test of the path coefficient was significant when P-value less than 0.05 and the Critical Ratio (C.R.) greater than 1.96 [23][37]. However, the C.R. should be greater than 2.58 in order to provide for

an adequate significance [44]. Table 2 show standardized path coefficients of the final structural equation model. All standardized path coefficients were positive and statistically significant (P-value < 0.05 and C.R. > 1.96), therefore all the hypotheses were accepted. The most influential factor in the gasohol 91 consumption of the personal car (Y) was F1, followed by F3, F6, F8, F2, F4, F7, F5, and F9 as well as $R^2 = 0.832$. The relationship as follow:

$$\text{Gasohol 91 consumption (Y)} = (0.411)F1 + (0.336)F3 + (0.334)F6 + (0.319)F8 + (0.308)F2 + (0.118)F4 + (0.116)F7 + (0.106)F5 + (0.092)F9 ; R^2 = 0.832.$$

Table 2 The standardized path coefficients of the final structural equation model

Path			Standardized path coefficient	C.R.	P-value
Y ^a	<---	F1	0.411	20.047	*** ^b
Y	<---	F3	0.336	16.113	***
Y	<---	F6	0.334	15.983	***
Y	<---	F8	0.319	16.683	***
Y	<---	F2	0.308	14.641	***
Y	<---	F4	0.118	6.066	***
Y	<---	F7	0.116	5.414	***
Y	<---	F5	0.106	5.315	***
Y	<---	F9	0.092	4.370	***

Note: ^a Gasohol 91 consumption, ^b P-value less than 0.001

The results of this study are in line with other studies that found that the marketing mix comprised of products, prices, place, and promotions significantly influenced consumer buying decision-making process [45] and influencing buying behavior [46]. It also found that the cost, service stations and supply, attitudes, encouraged by government policy, knowledge of users, public relation, and technology and performance factors have influenced the success of car users who switch to gasohol [47].

The reason why the product factor is the most influential factor in the consumption of gasohol 91 of the personal car because it has similar properties to gasoline, which results in the engine burning complete (X4). It is safe to use (X1) and can be mixed with gasoline immediately (X3). In addition, the performance of the engine is equivalent to the use of gasoline (X2) and does not affect the operation of the engine (X5) [48].

8. Conclusion and Recommendation

The results of the final SEM showed that the overall model is consistent with the empirical data. The most influential factor in the consumption of gasohol 91 on a personal car was the product, followed by the place, information search and pre-purchase evaluation of alternatives, post-purchase, price, promotion, purchase decision, problem recognition, and repair-maintenance, respectively.

However, the final SEM results indicated that F9 has little influence on the consumption of gasohol 91, because of the standardized path coefficient with absolute values less than 0.10 [8]. Focusing on this factor (F9) will little affect the change in gasohol 91 consumption. Therefore, it should be ignored in considering F9. In defining risk factors, the absolute value of the standardized path coefficient should be greater than 0.30 [8][23]. Therefore, the risk factors that influence the consumption of gasohol 91 in a personal car for this study are F1, F3, F6, F8, and F2.

The future research should consider the factors that affect the consumption of gasohol 91 of the personal car, covering all four types of gasohol distributed in Thailand. This will lead to the analysis and management of risk factors that affect the consumption of gasohol 91 in personal cars. These may be the framework for action to increase the proportion using ethanol to achieve the target of the Oil Plan from 3.50 million liters per day in 2015 as 11.30 million liters per day in 2036. Also, the plan is used as the framework or the operating guideline for various departments in public and private sectors that would like to invite or promote personal in their organization to choose proper gasohol appropriated to their automobiles.

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Appendix A. All 48 questions (indicators) grouped by constructs (F1-F9 factors)

Question	Details of each question
Product factor (F1)	
1	Gasohol is safe to use.
2	Engine performance is equivalent to using gasoline.
3	Gasohol can be mixed with gasoline.
4	Gasohol has complete combustion properties.
5	Gasohol does not affect the operation of the engine.
Price factor (F2)	
6	Gasohol is cheaper than gasoline.
7	During the economic downturn, gasohol prices are reasonable.
8	The use of gasohol instead of gasoline is worth it in the short-term.
9	The use of gasohol instead of gasoline is worth it in the long-term.
10	The price of gasohol is different, so you decide to use gasohol with the lowest price.
Place factor (F3)	
11	There are several gas stations and enough to serve.
12	The gas station you are using is in your normal route.
13	The number of gas stations used is likely to increase.
14	Gasohol has sufficient capacity for domestic use.
15	The gas stations have a good image.
Promotion factor (F4)	
16	Automobile manufacturers and related equipment have quality assurance and after sales service
17	Gasohol dealers have been promoting and advertising the performance of gasohol.
18	Gas stations have promotional activities.
19	The government actively supports the use of gasohol.
20	Public relations and campaign to build confidence in using gasohol from the government.
Problem recognition factor (F5)	
21	Using gasohol reduces the cost of importing methyl butyl ether (MTBE) of the country.
23	Gasohol is clean energy and does not affect the environment.
Question	Details of each question
24	Using gasohol makes the country secure in energy.
25	The use of gasohol as a fuel substitute promotes and supports investment in agriculture and industry.

Appendix A. (continued)

Information search and pre-purchase evaluation of alternatives factor (F6)	
26	Getting information from public relations have helped in the decision to use gasohol.
27	Getting information from the media helps in the decision to use gasohol.
28	Getting information from close friends have helped in the decision to use gasohol.
29	Getting information from trusted agencies have helped in the decision to use gasohol.
30	Getting information from experiences have helped in the decision to use gasohol.
31	Gasohol is cheaper than gasoline, supports the decision to use gasohol.
32	The efficiency of using gasohol is the same as the use of gasoline, supporting the use of gasohol.
33	It's worth to invest in tuning the engine to suit the application, supporting the use of gasohol.
34	Participation in family decision making, supporting the use of gasohol.
35	Participation in the decision of friends to support the use of gasohol.
Purchase decision factor (F7)	
36	Choosing gasohol because it wants to reduce air pollution.
37	Choosing gasohol because it wants to support government policy.
38	Choosing gasohol because they want to support and increase income for farmers.
39	Choosing gasohol because it wants to reduce travel costs.
40	Choosing gasohol because it is safe to use.
Post-purchase factor (F8)	
41	There is total satisfaction in using gasohol as expected.
42	There is the use of the same type of gasohol repeated.
43	There is the recommendation for other people to use gasohol as you have used.
44	There is a switch to other types of gasohol that are expected to improve if you have the opportunity.
45	There is the recommendation for other people to use gasohol that is expected to be superior.
Repair-maintenance factor (F9)	
47	The engine that uses gasohol as fuel has the higher maintenance cost but economic value because gasohol is cheaper than gasoline.
48	There are many replacement spare parts and cheaper than genuine.
49	There are many replacement spare parts with the same quality as genuine but cheaper prices.
50	The engine you use is designed to be compatible with gasohol.