# Structural Equation Modeling for Investigating Factors Analysis of Gasohol 95 and E85 Consumption of Personal Cars

# แบบจำลองสมการโครงสร้างเพื่อหาปัจจัยที่ส่งผลต่อการใช้แก๊สโซฮอล์ 95 และ E85 ของรถยนต์ส่วนบุคคล

**Chainikorn Kunlawong[1], Sanguan Vongchavalitkul[2], Marut Khodphan[3]**
Faculty of Engineering, Vongchavalitkul University
**ชัยนิกร กุลวงษ์[1], สงวน วงษ์ชวลิตกุล[2], มารุต โคตรพันธ์[3]**
คณะวิศวกรรมศาสตร์ มหาวิทยาลัยวงชวลิตกุล
E-mail: chainikorn_kun@vu.ac.th[1]
E-mail: sanguan@vu.ac.th[2]
E-mail: marut_kho@vu.ac.th[3]

***Received:*** *July 9, 2018;* ***Revised:*** *October 8, 2018;* ***Accepted:*** *November 1, 2018*

ABSTRACT

The objective of this study was to analyze factors affecting gasohol 95 and E85 consumption of personal cars. The Structural Equation Modeling (SEM) was a statistical technique used to analyze data. The sample group for data collection was 558 personal car users (per gasohol type) in Muang District, Nakhon Ratchasima Province. According to the final SEM results of factors affecting gasohol 95 consumption of a personal car, it was found that the overall model was consistent with the empirical data at CMIN/DF = 2.286, IFI = 0.967, TLI = 0.964, CFI = 0.966, RMSEA = 0.049, and HOELTER (0.05) = 255. The most important factor affecting gasohol 95 consumption of a personal car was product. The latter consisted of place, information search and pre-purchase evaluation of alternatives, post-purchase, price, problem recognition, purchase decision, repair-maintenance, and promotion, respectively with $R^2$ = 0.836. For gasohol E85, the results showed that the overall model was consistent with the empirical data at CMIN/DF = 2.326, IFI = 0.965, TLI = 0.963, CFI = 0.965, RMSEA = 0.049, and HOELTER (0.05) = 252. The most important factors affecting gasohol E85 consumption of a personal car were price, place, product, information search and pre-purchase evaluation of alternatives, repair-maintenance, problem recognition, purchase decision, post-purchase, and promotion, respectively with $R^2$ = 0.833.

**KEYWORDS:** Structural Equation Modeling, Gasohol 95, Gasohol E85

**บทคัดย่อ**

การศึกษานี้มีวัตถุประสงค์เพื่อประเมินหาปัจจัยที่ส่งผลต่อการใช้แก๊สโซฮอล์ 95 และ E85 ของรถยนต์ส่วนบุคคล โดยอาศัยเทคนิคโมเดลสมการโครงสร้างในการวิเคราะห์ข้อมูลที่เก็บรวบรวมจากกลุ่มตัวอย่างผู้ใช้รถยนต์ส่วนบุคคลในเขตอำเภอเมือง จังหวัดนครราชสีมา จำนวน 558 ราย (ต่อชนิดเชื้อเพลิง) จากผลการวิเคราะห์โมเดลสมการโครงสร้างสุดท้ายของปัจจัยที่ส่งผลต่อการใช้แก๊สโซฮอล์ 95 ของรถยนต์ส่วนบุคคล พบว่า โมเดลโดยรวมมีความสอดคล้องกับข้อมูลเชิงประจักษ์ เมื่อ CMIN/DF = 2.286, IFI = 0.967, TLI = 0.964, CFI = 0.966, RMSEA = 0.049 และ HOELTER (0.05) = 255 โดยปัจจัยที่มีอิทธิพลต่อปริมาณการใช้แก๊สโซฮอล์ 95 มากที่สุด คือ ด้านผลิตภัณฑ์ รองลงมาได้แก่ ช่องทางการจัดจำหน่าย การค้นหาข้อมูลและประเมินผลทางเลือก พฤติกรรมหลังการซื้อ ราคา การรับรู้ปัญหา การตัดสินใจซื้อ การซ่อมและบำรุงรักษา และการส่งเสริมการขาย ตามลำดับ โดยมีค่าสัมประสิทธิ์การตัดสินใจ ($R^2$) เท่ากับ 0.836 ส่วนสำหรับผลการวิเคราะห์โมเดลสมการโครงสร้างสุดท้ายของปัจจัยที่ส่งผลต่อการใช้แก๊สโซฮอล์ E85 ของรถยนต์ส่วนบุคคล พบว่า โมเดลโดยรวมมีความสอดคล้องกับข้อมูลเชิงประจักษ์ เมื่อ CMIN/DF = 2.326, IFI = 0.965, TLI = 0.963,CFI = 0.965, RMSEA = 0.049 และ HOELTER (0.05) = 252 โดยปัจจัยด้านราคามีอิทธิพลมากที่สุดต่อปริมาณการใช้แก๊สโซฮอล์ E85 รองลงมาได้แก่ ช่องทางการจัดจำหน่าย ผลิตภัณฑ์ การค้นหาข้อมูลและประเมินผลทางเลือก การซ่อมและบำรุงรักษา การรับรู้ปัญหา การตัดสินใจซื้อ พฤติกรรมหลังการซื้อ และการส่งเสริมการขาย โดยมีค่าสัมประสิทธิ์การตัดสินใจ ($R^2$) เท่ากับ 0.833

**คำสำคัญ:** การสร้างโมเดลสมการโครงสร้าง แก๊สโซฮอล์ 95 แก๊สโซฮอล์ E85

## Introduction

The Thailand Oil Plan 2015 - 2036 is one of the five long-term master plans of Thailand's Integrated Energy Blueprint (TIEB). The fuel products in this plan are gasoline, diesel, jet fuel, fuel oil, Liquefied Petroleum Gas (LPG), and Natural Gas for Vehicles (NGV). The plan focuses on the management of fuel in the transportation sector because of the most fuel consumption. The purpose is to identify the direction of the fuel management plan in line with the goals in the other sub-plans; especially with the Energy Efficiency Development Plan (EEDP). This plan is targeted to reduce 30% of the Energy Intensity (EI) in 2036 compared to the plan in 2010 and the Alternative Energy Development Plan (AEDP), which aims to use 30% renewable energy in 2036 (Ministry of Energy, Department of Energy Business, 2015).

The five fuel products having the highest distribution in Thailand are gasoline 95, gasohol 91, gasohol 95, gasohol E20, and gasohol E85. It also has the second largest market share compared with diesel.

The consumption of the gasoline in Thailand indicated that all four types of gasohol had 95.38% consume proportion, the rest of 4.62% was the gasoline 95. Apart from the four types of gasohol portion, 79.45%

consumption was gasohol 91 and gasohol 95. The rest of 20.55% was the consumption of gasohol E20 and gasohol E85 (Ministry of Energy, Department of Energy Business, 2016). Although gasohol E20 and E85 are cheaper than gasohol 91 and 95 because they received subsidies from the oil fund to encourage more use of biofuel, the consumption of them is low. The low consumption of the gasohol E20 and gasohol E85 is a risk that may affect the management according to the TIEB, because it does not achieve the given target; especially in the EEDP, the AEDP, and the Oil Plan. Since the ethanol used as an ingredient in gasohol is another type of renewable energy that aimed to increase consumption with the average of 3.50 million liters per day in 2015 to the average of 11.30 million liters per day in 2036 (Ministry of Energy, Department of Alternative Energy Development and Efficiency, 2015). The cause or factor that gasohol E20 and gasohol E85 are consumed in low quantity may come from the wrong type of gasohol uses on some users, or not consistent with the technology of the engine. However, the true reason is unclear since there is not clear research that covers all areas of use. Nakhon Ratchasima Province is a big city and also has continuously grown in the economy. The personal cars that registered there are 210,277 vehicles, the largest amount in the northeastern area of Thailand (Ministry of Energy, Department of Land Transport, 2017). The researchers concentrate on the stated problem. So, this study was aimed to the concept to analyze the factors of the Structural Equation Modeling (SEM) affecting gasohol consumption of personal cars. The gasohol E85 was chosen from the gasohol group which contained low consumption (20.55%). Also, gasohol 95 was chosen from the gasohol group which contained high consumption (79.45%) to analyze the factors affecting gasohol consumption of personal cars.

**Purpose**

The research was aimed to analyze factors affecting gasohol 95 and E85 consumption of personal cars.

**Hypothesis**

The results of the "Factor Analysis to Use Gasohol of Personal Car" (Kunlawong, Vongchavalitkul, & Khodphan, 2018) were employed to develop the conceptual framework for this study. 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 affected the gasohol consumption (Y) of personal cars.

The hypothetical diagram of the SEM was presented in Figure 1. The correspondence hypothesis were as follows:

Hypothesis 1: F1 (indicators listed: X1, X2, X3, X4, X5) influences on Y.

Hypothesis 2: F2 (indicators listed: X6, X7, X8, X9, X10) influences on Y.

Hypothesis 3: F3 (indicators listed: X11, X12, X13, X14, X15) influences on Y.

Hypothesis 4: F4 (indicators listed: X16, X17, X18, X19, X20) influences on Y.

Hypothesis 5: F5 (indicators listed: X21, X23, X24, X25) influences on Y.

Hypothesis 6: F6 (indicators listed: X26 to X35) influences on Y.

Hypothesis 7: F7 (indicators listed: X36, X37, X38, X39, X40) influences on Y.

Hypothesis 8: F8 (indicators listed: X41, X42, X43, X44, X45) influences on Y.

Hypothesis 9: F9 (indicators listed: X47, X48, X49, X50) influences on Y.

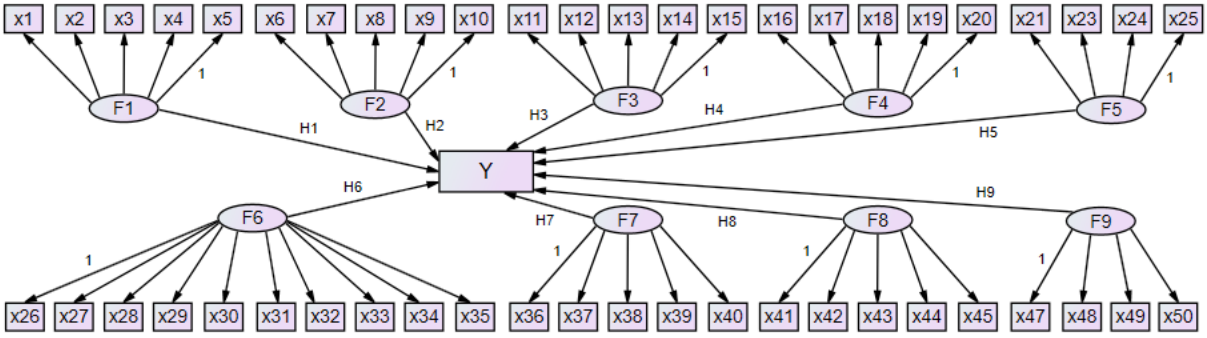


**Figure 1** Hypothetical model of the factors affecting gasohol consumption of a personal car

## Benefit of Research

The benefits expected from this study are to identify and understand influential factors in the consumption of gasohol 95 and E85 of personal cars. After, the research results can be brought to analyze the risk factor and the risk management of factors affecting the usage of the gasohol on personal cars for the future research.

## Research Process

### Population and Sample

The population in this study consisted of all personal cars used in Muang Nakhon Ratchasima District, Nakhon Ratchasima Province.

The sample size was important in SEM. There were various opinions and several guiding rules of thumb as follows:

- Minimum sample size should be 100 to 200 (Anderson & Gerbing, 1988; Boomsma, 1985; Ding, Velicer, & Harlow, 1995; Kline, 1998).

- Sample size should be above 200 (Hoe, 2008) or 300 (Gunning, 2015).

- Sample size should be 5 to 10 times of the number of variables (Bentler & Chou, 1987; Bollen, 1989; Hair, Black, Babin, & Anderson, 2010; Kline, 1998; Schumacher & Lomax, 2010).

Exogenous variables are variables that are not influenced by other variables in the model and not determined by the model (Carvalho & Chima, 2014). This study consisted of 49 indicators, 48 exogenous variables (X), and one output variable (Y). To prevent incomplete data from the survey, so the researchers set the sample size to 558 samples per model (gasohol type). The purposive sampling was used to select the study area from the top of the six most populated Sub-district of Muang Nakhon Ratchasima 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. Moreover, the convenience sampling was used for data collection from 93 samples per Sub-district per model.

**Instruments**

This study was a survey research. The questionnaire was used as a tool to collect data from the sample group. The questions contained nine factors (F1 - F9) and consisted of 48 items (X) (Kunlawong, Vongchavalitkul, & Khodphan, 2018), collectively affecting gasohol consumption of personal cars (Y). The questions were grouped as follows: F1 (questions X1 to X5, 5-likert scale), F2 (questions X6 to X10, 5-likert scale), F3 (questions X11 to X15, 5-likert scale), F4 (questions X16 to X20, 5-likert scale), F5 (questions X21 and X23 to X25, 5-likert scale), F6 (questions X26 to X35, 5-likert scale), F7 (questions X36 to X40, 5-likert scale), F8 (questions X41 to X45, 5-likert scale), F9 (questions X47 to X50, 5-likert scale), and gasohol consumption (Y, open end).

To identify the details of questions in the questionnaire, the researchers relied on the results of the review from relevant theories and research including:

- The marketing mix (4Ps) that manufacturers want to share. To meet the needs of the target market, it includes product, price, place, and promotion. Consumer's behavior involves buying, using, disposing of goods, and services. The behavior of a person who was seeking, buying, evaluating, and spending any goods and services was expected to meet their own needs. The decision-making process when a consumer was buying a product includes problem recognition, information search, evaluation of alternatives, purchase decision, and post-purchase behavior (Bovee, Houston, & Thill, 1995; Isoraite, 2016; Kotler, 2002; McCarthy & Perreault, 1990; Pimonsompong, 2005; Pourdehghan, 2015; Riaz, 2011; Serirat, 2007; Singh, 2009).

- The properties of gasohol, which differ from gasoline, could affect long-term use, as well as repair-maintenance of the engine after use (Ministry of Energy, Energy Policy and Planning Office, 2008).

According to the quality testing of the instrument, the content validity was checked by three experts based on the index of Item-Objective Congruence (IOC) and the reliability was checked by Cronbach's alpha coefficient. These questions consisted of IOC scores between 0.67 and 1 (above 0.50) (Chakatit, 2013). The overall Cronbach's alpha coefficient was 0.96 (above 0.70) (Awang, 2012; Bagozzi & Yi, 2012; Doloi, Iyer, & Sawhney, 2011; Koo, Ruihley, & Dittmore, 2012; Rusuli, Tasmin, Takala, & Hashim, 2014; Streiner, 2003; Tavakol & Dennick, 2011; Vanichbuncha, 2014). The reliability and construct validity of the models were shown in the results. The details of the questions in the questionnaire were shown in Appendix A.

**Data Analysis**

SEM is a multivariate statistical analysis technique used to analyze structural relationships. This technique is the combination of factor analysis and multiple regression analysis, and it is used to analyze the structural relationship between indicators and latent variables (factors). SEM is divided into two parts: a measurement model and a structural model. The measurement model involves the relationship between indicators and latent variable, but the structural model involves the relationships among latent variables only (Carvalho & Chima, 2014).

SEM was used in this research to investigate the factors affecting gasohol consumption of personal cars. The procedures of this study used a two-step approach, which the measurement model was initially generated and then the structural model was built. The initial hypothesized model in Figure 1 was analyzed using AMOS based on Maximum Likelihood (ML) to estimate parameters. Thus, the variables must have a multivariate normal distribution.

**Results and Discussion**

Survey data collection from the sample groups showed 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 (Curran, West, & Finch, 1996). The results of the analysis of the factors affecting gasohol 95 and E85 consumption of personal cars can be shown in each section as follows:

**Refinement of Models**

This research used the Goodness of Fit (GOF) indices for the refinement of the initial hypothesized model (Figure 1) to improve the fit to its recommended levels as follows:

- Chi-square per degree of freedom (CMIN/DF): the result should be $\leq 3$ (Gunning, 2015; Hoe, 2008; Kline, 1998).

- Incremental Fit Index (IFI), Comparative Fit Index (CFI), and Tucker - Lewis Index (TLI): the value should be ≥ 0.90 (Awang, 2012; Hair et al., 2010; Hoe, 2008; Schumacher & Lomax, 2010; Vanichbuncha, 2014).

- Root Mean Square Error of Approximation (RMSEA): the value should be ≤ 0.05 (Awang, 2012; Hair et al., 2010; Schumacher & Lomax, 2010).

- HOELTER: the value should be ≥200 (Hoelter, 1983; Schumacher & Lomax, 2010).

From the results of the initial SEM analysis, it was found that CMIN/DF, RMSEA, and HOELTER (0.05) were unacceptable as shown in Table 1. The initial models of gasohol 95 and E85 were revised according to the recommendations given by the Modification Index (MI) that estimates the effect on the chi-square statistic of adding path among error terms in the model.

Referring to the analysis of the factors affecting gasohol 95 consumption of a personal car, the two indicators were X10 and X33 which showed reasonably low standardized loadings with their latent variables in the SEM (less than 0.50). Thus, both indicators were removed from the final SEM. For the analysis of the factors affecting gasohol E85 consumption of a personal car, all indicators showed high standardized loadings with their latent variables in the SEM.

The essential GOF indices of the final SEM is shown in Table 1.

**Table 1** GOF indices of the final SEM

| Index | Recommended level of GOF index | Gasohol 95 | | Gasohol E85 | |
|---|---|---|---|---|---|
| | | Initial SEM | Final SEM [a] | Initial SEM | Final SEM |
| CMIN/DF | ≤ 3 | 3.447 | 2.286 | 3.368 | 2.326 |
| IFI | ≥ 0.90 | 0.931 | 0.967 | 0.937 | 0.965 |
| TLI | ≥ 0.90 | 0.927 | 0.964 | 0.933 | 0.963 |
| CFI | ≥ 0.90 | 0.931 | 0.966 | 0.937 | 0.965 |
| RMSEA | ≤ 0.05 | 0.067 | 0.049 | 0.066 | 0.049 |
| HOELTER (0.05) | ≥ 200 | 169 | 255 | 173 | 252 |

Note: [a] Indicators X10 and X33 were removed from the final SEM.

Table 1 showed that all GOF indices were certainly acceptable. Thus, the final SEM of the two sets were consistent with the empirical data.

**Reliability and Construct validity**

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 was estimated by Cronbach's alpha coefficient and Composite Reliability (CR). The value of Cronbach's alpha coefficient ≥0.70 (Doloi, Sawhney, & Iyer, 2012; Wong & Cheung, 2004) and CR ≥ 0.70 (Hair et al., 2010) were used for the indicative reliability. The reliability testing of the final SEM showed that the Cronbach's alpha coefficients was ranged from 0.946 to 0.986 and from 0.956 to 0.985 for gasohol 95 and gasohol E85, respectively. The CR ranged from 0.951 to 0.988 for gasohol 95 and ranged from 0.951 to 0.985 for gasohol E85 indicated that the final SEM were reliability.

- Convergent validity was assessed by standardized loading and the Average Variance Extracted (AVE). The value of standardized loading ≥0.50 and AVE ≥0.50 were used to indicate an acceptable level (Hair et al., 2010; Truong & McColl, 2011). However, a standardized loading of 0.70 was widely used at an acceptable level (Doloi et al., 2012; Hair et al., 2010). Figure 2 and Figure 3 showed the final SEM with the standardized loadings and standardized path coefficients of structure paths.

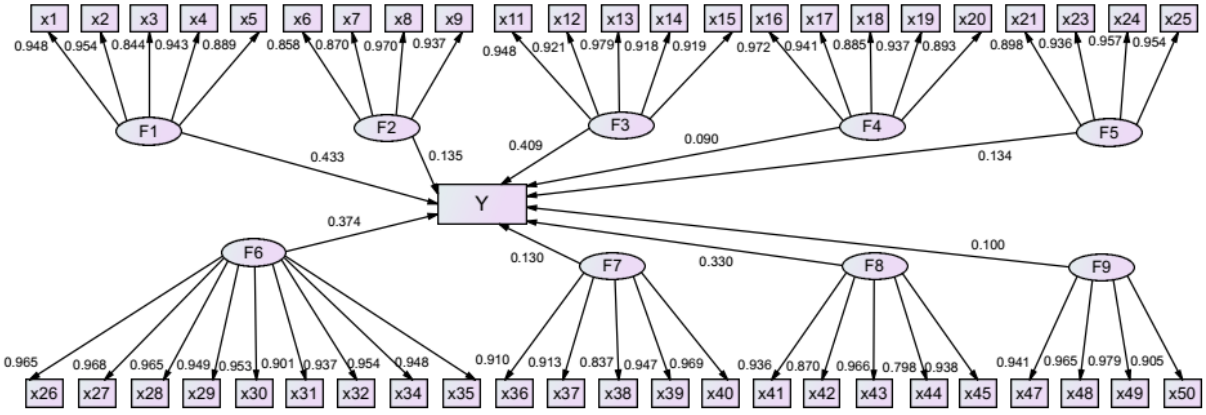


**Figure 2** Final SEM of gasohol 95

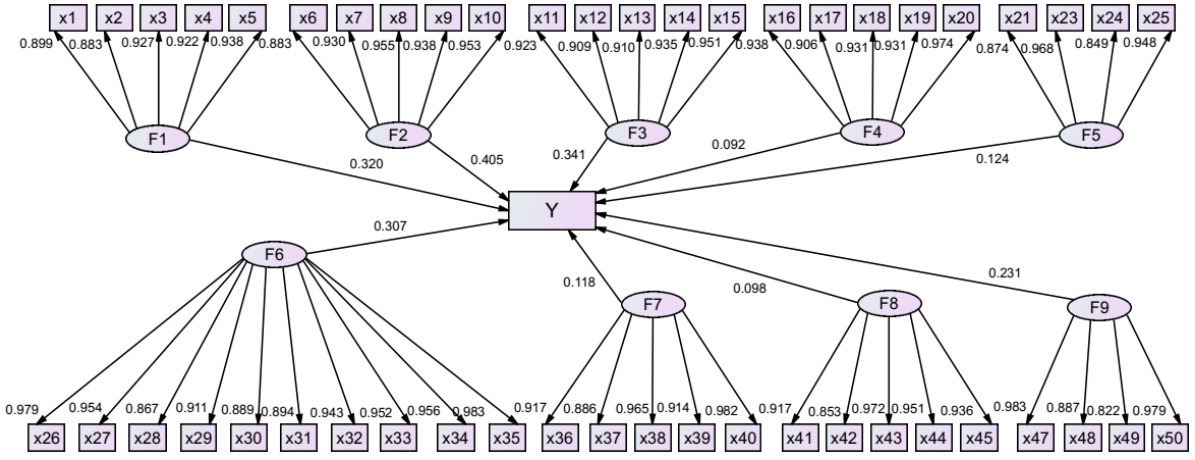


**Figure 3** Final SEM of gasohol E85

In Figure 2 and Figure 3, the standardized loadings of gasohol 95 and E85 were ranged from 0.798 to 0.979 and ranged from 0.822 to 0.983, respectively. In addition, for gasohol E85, the AVE was ranged from 0.817 to 0.901 for gasohol 95 and ranged from 0.830 to 0.877. This was a clear demonstration of the convergent validity of all indicators in the final SEM.

- Discriminant validity test with the assessment of cross-loadings: the items loadings (factor loadings) in the main factor must be higher than loadings in other factors (Doloi et al., 2012; Henseler, Ringle, & Sarstedt, 2015). The results of discriminant validity test of two sets of final SEM showed that all factor loadings in the main factor were higher than loadings in other factors and greater than 0.70 (Doloi et al., 2012; Hair et al., 2010). It was a clear demonstration of the discriminant validity of the nine latent variables in the final SEM.

**Hypothesis Testing**

The hypothesis test was significant when p-value was less than 0.05 and the critical ratio was greater than 1.96. (Hoe, 2008; Vanichbuncha, 2014). However, the critical ratio should be greater than 2.58 in order to provide adequate significant (Santos Neto, Dantas, & Machado, 2017). Table 2 and Table 3 showed standardized path coefficients of the final SEM.

**Table 2** Standardized path coefficients of final SEM for gasohol 95

| Path | | | Standardized path coefficient | Critical ratio | p-value |
|---|---|---|---|---|---|
| Y [a] | <--- | F1 | 0.433 | 21.554 | ***[b] |
| Y | <--- | F3 | 0.409 | 20.623 | *** |
| Y | <--- | F6 | 0.374 | 18.618 | *** |
| Y | <--- | F8 | 0.330 | 16.701 | *** |
| Y | <--- | F2 | 0.135 | 6.822 | *** |
| Y | <--- | F5 | 0.134 | 6.605 | *** |
| Y | <--- | F7 | 0.130 | 6.147 | *** |
| Y | <--- | F9 | 0.100 | 4.797 | *** |
| Y | <--- | F4 | 0.090 | 4.616 | *** |

Note: [a] Gasohol 95 consumption, [b] p-value less than 0.001

As shown in Table 2, all standardized path coefficients were positive and statistically significant (p-value < 0.05 and critical ratio > 1.96), therefore, all the hypotheses were accepted. The most influential factor in the gasohol 95 consumption of a personal car was F1, F3, F6, F8, F2, F5, F7, F9, and F4 respectively as well as $R^2$ was 0.836. The relationship as follows:

**Table 3** Standardized path coefficients of final SEM for gasohol E85

| Path | | | Standardized path coefficient | Critical ratio | p-value |
|---|---|---|---|---|---|
| Y [a] | <--- | F2 | 0.405 | 18.623 | ***[b] |
| Y | <--- | F3 | 0.341 | 16.877 | *** |
| Y | <--- | F1 | 0.320 | 15.409 | *** |
| Y | <--- | F6 | 0.307 | 15.600 | *** |
| Y | <--- | F9 | 0.231 | 11.111 | *** |
| Y | <--- | F5 | 0.124 | 6.106 | *** |
| Y | <--- | F7 | 0.118 | 5.583 | *** |
| Y | <--- | F8 | 0.098 | 5.113 | *** |
| Y | <--- | F4 | 0.092 | 4.638 | *** |

Note: [a] Gasohol E85 consumption, [b] p-value less than 0.001

Gasohol 95 consumption (Y) = (0.433) F1 + (0.409) F3 + (0.374) F6 + (0.330) F8 + (0.135) F2 + (0.134) F5 + (0.130) F7 + (0.100) F9 + (0.090) F4 ; $R^2$= 0.836

In Table 3, all standardized path coefficients were positive and statistically significant (p-value < 0.05 and critical ratio > 1.96), therefore, all the hypotheses were accepted. The most influential factor in the gasohol E85 consumption of a personal car was F2, F3, F1, F6, F9, F5, F7, F8, and F4 respectively as well as $R^2$ was 0.833. The relationship as follows:

Gasohol E85 consumption (Y) = (0.405) F2 + (0.341) F3 + (0.320) F1 + (0.307) F6 + (0.231) F9 + (0.124) F5 + (0.118) F7 + (0.098) F8 + (0.092) F4 ; $R^2$= 0.833

The final SEM of gasohol 95 and E85 results performed that all factors (F1-F9) influenced gasohol consumption of personal cars. Referring to other studies, it was found that the marketing mix factors which consisted of product, price, place, and promotion have a significant effect on consumer's buying decision-making process (Seenamngeon, 2005) and influenced their buying behavior (Jongjairak, 2014). It was also found that the cost, service stations and supply, and attitudes, were encouraged by the government policy, knowledge of the users, public relation, and technology and performance factors. They also influenced the success of car users who switched to gasohol (Lertharn, 2009).

The product factor is the most influential factor in the gasohol 95 consumption of a personal car. Due to the properties of gasohol 95, it was close to gasoline, making it was safe to use. It had good combustion properties, resulting in engine performance equivalent to gasoline. Also, it did not affect the operation of the engine, and could also be mixed with gasoline immediately. The results of this study were related to the properties of gasohol 95 that was very close to gasoline 95 (Ministry of Energy, Department of Energy Business, 2008).

For gasohol E85, the price factor was the most influential factor in the gasohol E85 consumption of a personal car because gasohol E85 price is significantly lower than gasoline, making it worthy for short-term and long-term use. Besides, the price was reasonable during the economic downturn. The results were consistent with the price of gasohol E85, which was lower than gasohol 95 at about 7 baht per liter (Ministry of Energy, Energy Policy and Planning Office, 2017). According to another study, the price factor had the most influence on the success of car users who switch to gasohol (Lertharn, 2009).

However, the final SEM results indicated that F4 has a little influence on the consumption of gasohol 95 and that F4 and F8 had a few effects on gasohol

E85 consumption, because of standardized path coefficients with less absolute values than 0.10 (Suhr, 2006). Focusing on these factors, it will have a few effects on the change in gasohol consumption. Therefore, in analyzing risk factors for future research, these factors should be excluded.

## Recommendation

Based on the research results, product and price are the most influential factors in the gasohol 95 and E85 consumption of a personal car respectively. The consumers choose to use gasohol 95 due to the consideration of the product quality such as safe to use and properties close to gasoline. For gasohol E85, the consumers choose to use it due to the consideration of the cheapest and reasonable price. For increasing ethanol consumption to achieve the given target in the Oil Plan, the government as well as the Ministry of Energy, or the other stakeholders should develop the product better and consistent with the technology of the engine as well as set price reasonable on its quality

The further research should consider an analysis of the factors affecting four types of gasohol consumption of personal cars all distributed in Thailand to obtain the analysis results comprehensive. It will lead to the analysis of risk factors and the management of risk factors that affect the use of gasohol 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 well 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 people in their organization to choose proper gasohol for vehicles.

## References


Anderson, J., & Gerbing, D. 1988. Structural Equation Modeling in practice: A review and recommended two-step approach. **Psychological Bulletin**, 103(3): 411 - 423.

Awang, Z. 2012. **Structural Equation Modeling Using Amos Graphic**. Kelantan: University Technology MARA Press.

Bagozzi, R. P., & Yi, Y. 2012. Specification evaluation and interpretation of structural equation models. **Journal of the Academy of Marketing Science**, 40(1): 8 - 34.

Bentler, P. M., & Chou, C. H. 1987. Practical Issues in Structural Modeling. **Journal of Sociological Methods & Research**, 16(1): 78 - 117.

Bollen, K. A. 1989. **Structural equations with latent variables**. New York: Wiley-Interscience.

Boomsma, A. 1985. Nonconvergence, improper solutions, and starting values in LISREL maximum likelihood estimation. **Journal of Psychometrika**, 50(2): 229 - 242.

Bovee, C. L., Houston, M. J., & Thill, J. V. 1995. **Marketing** (6th ed.). New York: McGraw-Hill.

Carvalho, J. D., & Chima, F.O. 2014. Applications of Structural Equation Modeling in social sciences research. **American International Journal of Contemporary Research**, 4(1): 6 - 11.

Chakatit, A. 2013. **The marketing factors effecting truck buyer's loyalty in the southern bordered provincial cluster.** Doctoral dissertation in Public and Private Management, Christian University.

Curran, P. J., West, S. G., & Finch, J. H. 1996. The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. **Psychological Methods**, 1(1): 16 - 29.

Ding, L., Velicer, W., & Harlow, L. 1995. Effect of estimation methods, number of indicators per factor and improper solutions on Structural Equation Modeling fit indices. **Structural Equation Modeling**, 2(2): 119 - 143.

Doloi, H., Iyer, K. C., & Sawhney, A. 2011. Structural equation model for assessing impacts of contractor's performance on project success. **International Journal of Project Management**, 29(6): 687 - 695.

Doloi, H., Sawhney, A., & Iyer, K. C. 2012. Structural equation model for investigating factors affecting delay in Indian construction projects. **Construction Management and Economics**, 30(4): 869 - 884.

Gunning, S. K. 2015. Identifying latent variables in nonprofit proposal writing: results of two structural equation models. In **Proceedings of the 33rd Annual International Conference on the Design of Communication**. Limerick: Ireland.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. 2010. **Multivariate data analysis** (7th ed.). New Jersey: Pearson Prentice Hall.

Henseler, J., Ringle, C. M., & Sarstedt, M. 2015. A new criterion for assessing discriminant validity in variance-based Structural Equation Modeling. **Journal of the Academy of Marketing Science**, 43(1): 115 - 135.

Hoe, S. L. 2008. Issues and procedures in adopting Structural Equation Modeling technique. **Journal of Applied Quantitative Methods**, 3(1): 76 - 83.

Hoelter, D. R. 1983. The analysis of covariance structures: Goodness of Fit indices. **Journal of Sociological Methods and Research**, 11(3): 325 - 344.

Isoraite, M. 2016. Marketing mix theoretical aspects. **International Journal of Research - Granthaalayah**, 4(6): 25 - 37.

Jongjairak, K. 2014. **Service marketing mix factors influencing consumer's buying behavior on air conditioning in northeastern region.** Master's Thesis in Marketing, Srinakharinwirot University.

Kline, R. B. 1998. **Principles and practice of structural equation modelling** (3rd ed.). New York: The Guilford Press.

Koo, G. Y., Ruihley, B. J. & Dittmore, S. W. 2012. Impact of perceived on-field performance on sport celebrity source credibility. **Sport Marketing Quarterly**, 21: 147 - 158.

Kotler, P. 2002. **Marketing management millenium edition.** Boston: Pearson Custom Publishing.

Kunlawong, C., Vongchavalitkul, S., & Khodphan, M. 2018. Factor analysis to use gasohol of personal car. In **Proceedings of the National Research Conference Northern College** (pp. 215 - 218). Tak: Northern College.

Lertharn, K. 2009. **Factors influencing a transition from mainstream energy to alternative energy. A case study of gasohol technology for passenger cars in Bangkok.** Master's Thesis Science in Technology Management College of Innovation, Thammasat University.

McCarthy, E. J., & Perreault, W. D. 1990. **Marketing: export marketing; management** (10th ed.). Boston: Irwin Press.

Ministry of Energy, Department of Alternative Energy Development and Efficiency. 2015. **Alternative energy development plan 2015 – 2036.** Retrieved January 7, 2017, from http://www.dede.go.th/ down-load/ files/AEDP2015_Final_ version.pdf

Ministry of Energy, Department of Energy Business. 2008. **Notification on characteristic and quality of gasohol, 2008**. Retrieved January 1, 2017, from http://www.dede.go.th /ewt_dl_link. php?nid=282

Ministry of Energy, Department of Energy Business. 2015. **Oil Plan 2015 – 2036**. Retrieved February 3, 2017, from http:// www.eppo.go.th /images/POLICY/ PDF/ oil_plan58-79.pdf

Ministry of Energy, Department of Energy Business. 2016. **The amount of fuel sold each day**. Retrieved February 3, 2017, from http:// www.doeb. go.th/2016 /stat.html#c

Ministry of transport, Department of Land Transport. 2017. **Number of vehicles registered (accumulated) as at 31 January 2017.** Retrieved February 3, 2017, from https://data.go.th

Ministry of Energy, Energy Policy and Planning Office. 2008. E20 clean energy: new alternative for Thai people. **EPPO Journal**, 79: 8-12.

Ministry of Energy, Energy Policy and Planning Office. 2017. **Oil prices between April and December 2017**. Retrieved April 10, 2018, from http:// 27.254.37.81/ epposite /index.php/th/petroleum/ price/oilprice?orders[publishUp] =publishUp& issearch=1

Pimonsompong, C. 2005. **Plan and develop the tourism market** (8th ed.). Bangkok: Kasetsart University.

Pourdehghan, A. 2015. The impact of marketing mix elements on brand loyalty: a case study of mobile phone industry. **Journal of Marketing and Branding Research**, 2(2015): 44 - 63.

Riaz, W. 2011. Marketing mix, not branding. **Asian Journal of Business and Management Sciences**, 1(11): 43 - 52.

Rusuli, M. S. C., Tasmin, R., Takala, J., & Hashim, N. 2014. A structural equation model of knowledge management practices and library users' satisfaction at Malaysian University libraries. In **the 8th International Conference on Knowledge Management in Organizations,** Netherlands: Springer.

Santos Neto, A. S., Dantas, M. J. P., & Machado, R. L. 2017. Structural Equation Modeling applied to assess industrial engineering students' satisfaction according to ENADE 2011. **Production Journal,** 27(spe): 1 - 13.

Schumacher, R. G., & Lomax, R. G. 2010. **Beginner's guide to Structural Equation Modeling** (3rd ed.). New York: Routledge.

Seenamngeon, P. 2005. **The decision-making process of the consumer in purchasing computer notebook in Bangkok**. Master's Thesis in Business Administration, Dhurakij Pundit University.

Serirat, S. 2007. **Consumer Behavior.** Bangkok: Diamond In Business World.

Singh, R. 2009. Does my structural model represent the real phenomenon? A review of the appropriate use of Structural Equation Modelling (SEM) model fit indices. **The Marketing Review,** 9(3): 199 - 212.

Streiner, D. 2003. Starting at the beginning: an introduction to coefficient alpha and internal consistency. **Journal of Personality Assessment**, 80(1): 99 - 103.

Suhr, D. 2006. The Basics of Structural Equation Modeling. **Presented: SAS User Group of the Western Region of the United States**. Irvin: California.

Tavakol, M., & Dennick, R. 2011. Making sense of Cronbach's alpha. **International Journal of Medical Education**, 2: 53 - 55.

Truong, J., & McColl, R. 2011. Intrinsic motivations, self-esteem, and luxury goods consumption. **Journal of Retailing and Consumer Services,** 18(6): 555 - 561.

Vanichbuncha, K. 2014. **Structural Equation Modeling (SEM) by AMOS** (2nd ed.). Bangkok: Three Lada.

Wong, P. S. P., & Cheung, S. O. 2004. Structural equation model of trust and partnering success. **Journal of Management in Engineering,** 21(2): 70 - 80.

**Appendix A:** All 48 questions (indicators) grouped by constructions (F1-F9 factors)

| Question | Details of each question |
|---|---|
| **Product factor (F1)** | |
| X1 | Gasohol is safe to use. |
| X2 | Engine performance is equivalent to using gasoline. |
| X3 | Gasohol can be mixed with gasoline. |
| X4 | Gasohol has complete combustion properties. |
| X5 | Gasohol does not affect the operation of the engine. |
| **Price factor (F2)** | |
| X6 | Gasohol is cheaper than gasoline. |
| X7 | During the economic downturn, gasohol prices are reasonable. |
| X8 | The use of gasohol, instead of gasoline, is worth in the short-term. |
| X9 | The use of gasohol, instead of gasoline, is worth in the long-term. |
| X10 | The price of gasohol is different, so you decide to use gasohol with the lowest price. |
| **Place factor (F3)** | |
| X11 | There are several and enough gas stations to serve the consumers. |
| X12 | The gas station you are using is in your normal route. |
| X13 | The number of gas stations is likely to increase. |
| X14 | Gasohol has sufficient capacity for domestic use. |
| X15 | The gas stations have a good image. |
| **Promotion factor (F4)** | |
| X16 | Automobile manufacturers and related equipment have quality assurance and after sales service. |
| X17 | Gasohol dealers have been promoting and advertising the performance of gasohol. |
| X18 | Gas stations have promotional activities. |
| X19 | The government actively supports the use of gasohol. |
| X20 | Public relations and campaign increase the confidence for using gasohol from the government. |

**Appendix A:** (continued)

| Question | Details of each question |
|---|---|
| **Problem recognition factor (F5)** | |
| X21 | Using gasohol reduces the cost of importing methyl butyl ether (MTBE) of the country. |
| X23 | Gasohol is clean energy and does not affect the environment. |
| X24 | Using gasohol makes the country secure to energy. |
| X25 | The use of gasohol as a fuel substitute promotes and supports investment in agriculture and industry. |
| **Information search and pre-purchase evaluation of alternatives factor (F6)** | |
| X26 | Getting information from public relations have helped for the decision of gasohol use. |
| X27 | Getting information from the media helps for the decision of gasohol use. |
| X28 | Getting information from close friends have helped for the decision of gasohol use. |
| X29 | Getting information from trusted agencies have helped for the decision of gasohol use. |
| X30 | Getting information from experiences have helped for the decision of gasohol use. |
| X31 | Gasohol is cheaper than gasoline and supports the decision of gasohol use. |
| X32 | The efficiency of using gasohol is the same as the use of gasoline, supporting the use of gasohol. |
| X33 | It's worth to invest in tuning the engine to suit the application, supporting the use of gasohol. |
| X34 | Participation in family decision making supports the use of gasohol. |
| X35 | Participation in the decision of friends supports the use of gasohol. |
| **Purchase decision factor (F7)** | |
| X36 | There is the decision to use gasohol because it reduces air pollution. |
| X37 | There is the decision to use gasohol because it supports the government policy. |

**Appendix A:** (continued)

| Question | Details of each question |
|---|---|
| X38 | There is the decision to use gasohol because it supports increasing farmer income. |
| X39 | There is the decision to use gasohol because it reduces travel costs. |
| X40 | There is the decision to use gasohol because it is safe. |
| **Post-purchase factor (F8)** | |
| X41 | There is total satisfaction from using gasohol as it is expected. |
| X42 | The use of the same type of gasohol is repeated. |
| X43 | There is the recommendation for other people to use gasohol as you have used. |
| X44 | There is a switch to other types of gasohol that are expected to be better. |
| X45 | There is the recommendation for other people to use gasohol that is expected to be superior. |
| **Repair-maintenance factor (F9)** | |
| X47 | The engine that uses gasohol as fuel has the higher maintenance cost but, for economic value, gasohol is cheaper than gasoline. |
| X48 | There are many replacement spare parts and cheaper than genuine. |
| X49 | There are many replacement spare parts having the same quality as genuine but they are cheaper price. |
| X50 | The engine you use is designed to be compatible with gasohol. |