Transport Energy Consumption Model for Thailand Provinces

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Abstract

The objective of this study is to formulate the transport energy consumption model in Thailand Provincial and to define the factors that affect to the amount of provincial energy consumption in Thailand. The study develops log-linear regression model and linear regression model using as independent variables transport energy consumption for Thailand provinces (in 1,000,000 liters). The models were developed using historical data in 2007. The cross sectional data include Gross Provincial Product (in 1,000,000,000 baht, billion), Total No. of Sedans that not more than 7 Pass (in 1,000 vehicle) and Total No. of Gas Stations all each province in Thailand. In order to eliminate appearance of outliers and influential observations in our data set, Bangkok data has been excluded from model development due to the remarkable variations in variables figures between Bangkok as federal territory and capital city with different socio – economic characteristics and the other rest provinces.

Keyword: transportation energy consumption, regression analysis, log-linear model, cross sectional data

1. Introduction

In Thailand almost the total amount of energy demand is mainly consumed by the transport sector. Population and economic development in Thailand provinces in the past few decades have caused a growing demand for personal travel and freight transport. People in the provinces have progressively changed their travel behavior by relying more on private vehicles, and using them more frequently than ever before for travelling. Moreover, the road network and public transit are developed as well making higher demand of travelling. When incomes rise due to the economic growth, people are able to afford a vehicle or an additional vehicle for the convenience of themselves and their family members, in order to access various places at any time, instead of taking public transit, which is often limited in coverage area and service time. In good economic conditions, travel demand increases due to higher purchasing power and growing needs for entertainment and social activities. These cause an increase in the amount of gasoline consumption from personal travel. For freight transport, the growing economy has stimulated more goods transport activities nationwide. It involves the transporting of goods from one location to other parts of the country as well as to the rest of the world, and vice versa. Thus, the number of freight trips has risen; therefore, we have also witnessed a large increase in the amount of diesel consumption. The combination of increases in personal travel and goods transport has resulted in a growth in transport energy consumption in Thailand, similar to the growing motorization trend in most developing countries in the world. According to the cross sectional data in 2007, the total energy consumption is 22,241.37 million liters.

However, population growth and economic development increase unequally in each province in Thailand cause the total amount of energy consumption in each province are unequal too. They have many factors that associate with the transport demand. Due to the cross sectional data in 2007, the big cities typically have more demand of energy than rural cities.

The amount of energy consumption is related to many factors. So, modeling all these factors in regression structure can make the government more understandable to the characteristics of the transport energy demand in each province. Accurate estimation of energy demands for each province perhaps the first and crucial step for the government to plan and develop the useful new policies for each province. Because of different in amount of individual provincial energy consumption parameters, the government has concerns about how to develop the country in the appropriate way for each province. Energy planning requires an understanding of the variables that affect to the amount of energy consumption. Accurate estimating tools are needed in order to correctly predict the provincial fuel demand of the country according to each province economic activities.

The objective of this study is to develop suitable provincial transport energy demand models for Thailand using a statistical approach and to identify the factors that affect the amount of provincial energy consumption in Thailand. In this study, a linear regression and log-linear regression analysis were developed to model provincial transport energy consumption, using Gross Provincial Product (in 1,000,000,000 baht, billion), Total No. of Sedans that not more than 7 Pass (in 1,000 vehicle) and Total No. of Gas Stations all each province in Thailand. The input data in 2007 are used for the development of the models in this study.

2. Literature review

A perfect projection and forecasting techniques are essential for accurate investment planning in energy production, generation and distribution for each nation.

A wide range of modeling techniques have been utilized in transport energy projection worldwide, also the relationship between energy consumption and many socio - economic and demographic indicators has been very well studied and reviewed in energy economic context. In literature considerable efforts have been made for energy demand and consumption forecasting, part of them stated by A. Akinar et al.(2010) including Box - Jenkins models, regression models, econometric models, and artificial neural networks models, while these and other transport energy model structures has been summarized by Limanond et al.(2011) in a tabulation form as shown in table 1 covering all recent studies that developed energy demand models specific to the transport sector for a country or a city.

They are variety of techniques have been used which can be broadly classified into three groups. The first group uses the Long Range Alternative Energy Planning System or a “LEAP” models. LEAP is commercial software developed by the US Centre of the Stockholm Environment Institute in 1980, and has gained popularity as the most commonly used software packages for projecting future conditions and evaluating energy and environment polices. The second group is based on econometric approaches, including multiple linear regression, partial least square regression, time series (ARIMA), etc, while the third group is in the field of artificial intelligence, including artificial neural networks, ant colony optimization, generic algorithms, Bayesian combination, swarm intelligence and Meta - heuristic harmony search algorithm.

Transport energy demand models have various independent variables; Haldenbilen and Ceylan(2005 developed a genetic algorithm model with GDP, population and transport amount (vehicle - kilometer); Murat and Ceylan (2006) developed an ANN model with GDP, population and transport amount (vehicle - kilometer) for Turkey's transport energy forecasting; Ceylan et al.(2008) developed a harmony search model with GDP, population and transport amount(vehicle - kilometer); Zhang et al.(2009) developed a partial least square regression model with GDP, urbanization rate, passenger transport amount(person - kilometer) and freight transport amount(ton - kilometer) for China's transport energy forecasting; Limanond et al.(2011) developed a log - linear regression and feed - forward neural network model with GDP, population, and number of vehicles registered for Thailand transport energy demand projection and Z.W.Geem(2011) developed artificial neural network model using GDP, population, oil price, number of vehicle registrations and passenger transport amount (person - kilometer) as predictors.

As we can see from table 1 the inputs of the transport energy demand models include a number of factors (predictors) depending on the methodology. In this study and according to the data set available multi linear regression technique capable of modeling provisional transport energy consumption in simplified mathematical expressions using fewer data. The chosen approaches require only less number of independent variables, and data concerning such variables are commonly available from the related government agencies Limanond et al. (2011). Details about linear regression analysis techniques we are explain in metrology.

Table 1 Summary of previous studies on transport energy modeling

Referenced study/study area	**Dependent variables (Forecasting years)**	**Methodology**	**Independent variables (period of data used for model development)**
Z.W.Geem (2011) /South Korea	Transport energy demand (2007 - 2025)	Artificial neural networks(ANN)	Gross domestic product, population, oil price, number of vehicle registration & passenger transport amount (1990 - 2007)
Limanond et al. (2011) /Thailand	Transport energy consumption (2010 - 2030)	Log - linear regression & feed - forward neural networks models	National gross domestic product, population and the numbers of registered vehicles (1998 - 2008)
Ceylan et al. (2008)/Turkey	Transport energy consumption (2006 -2025)	Linear, exponential &quadratic expression through Harmonic search	Population, gross domestic product, vehicle kilometers (1970 - 2005)
Bose and Srinivaschary (1997)/Delhi, India	Passenger transport energy demand (1990 - 2010)	LEAP	Vehicle population, average distance traveled, occupancy level, along with people travel mode split, mode occupancy and fuel efficiency (1981-1989)
Dhakal (2003) /Kathmandu Valley, Nepal	Passenger transport energy demand (2005 - 2020)	LEAP	Vehicle population, annual average vehicle travel, fuel economy, occupancy rate (1998 - 2000)
Haldenbilen (2006)/Turkey	Transport energy demand (2004 -2020)	Linear time series, polynomial time series, genetic algorithm	Year, gross domestic product, population, annual vehicle kilometers (1990 - 2003)
Haldenbilen and Ceylan (2005)/Turkey	Transport energy demand (2002 – 2020)	Linear, exponential and quadratic expression through Harmonic search	Population, gross domestic product, vehicle kilometers (1990 - 2000)
Mazraati and Alyousif (2009) /OECD and developing countries	Aviation (jet) fuel demand (2006-2030)	Log - linear model through ordinary least square technique	Gross domestic product, jet fuel price, urban population, passenger kilometers performed (1980 - 2005)
Mazraati and Faquih(2008)/ US and China	Aviation (jet) fuel demand (2008-2025)	Log - linear model through ordinary least square technique	Passenger kilometers performed, tones kilometers performed, price of jet fuel, average passenger load factor, consumer price index, gross domestic product, population (1990 - 2007)
Lu et al. (2009)/Taiwan	Road transport energy consumption (2007 - 2025)	Grey forecasting model , GM (1,1)	Road transport energy consumption (1990 - 2006)
Murat and Ceylan (2006)/Turkey Polemis (2006)/Greece	Transport energy demand (2002 - 2020) Gasoline and diesel demand	Artificial neural networks ANN Log - linear model	Population, gross domestic product, vehicle kilometers (1970 - 2001) Per capita income, real energy price of gasoline and diesel and per capita vehicle fleet (1978 - 2003)
Shabbir and Ahmed (2010) /Rawalpindi and Islamabad, Pakistan	Urban passenger transport energy demand (2000-2030)	LEAP	Vehicle population, average distance traveled, occupancy level, along with people travel mode split, mode occupancy and fuel efficiency (2000)
Yan and Crookes (2009)/China	Road Transport energy demand (2005 - 2030)	LEAP	Vehicle population, annual average vehicle travel, fuel economy (2000 - 2005)
Zachariadis and Kouvaritakis (2003)/10 countries in Central and Eastern Europe	Transport energy demand (2000-2030)	Macro –economic and demographic forecast	Gross domestic product, population, real price of gasoline, car ownership, time - trend parameter, average vehicle kilometers, occupancy rate, new car fuel consumption, car renewal rate (1970 - 1999)
Zhang et al.(2009)/China	Transport energy demand (2010-2020)	Partial least square regression	Gross domestic product, urbanization rate, passenger - turnover and freight - turnover (1990 - 2004)

This study considers various independent variables such as gross domestic product, population, the number of vehicle registration, the road length for projecting transport energy demand for Thailand provinces

These key independent variables has direct relation with provisional transport energy consumption, that is because GDP represent the trend of the national economic growth and the influence of it positively or negatively on road transport energy consumption, also the population size indicates the number of energy users; the more the people the more energy a nation will consume. Similarly the number of vehicle registration as well as the road length both has strong impact on road transport energy demand, since making trips by motorized vehicles in extended road network definitely require energy. In Thailand historical cross - sectional data for one year about GDP, population, number of vehicle registration, road length and transport fuel consumption is available in Thailand from different government organizations and agencies mainly ministry of cabinet affairs Central Bureau of Statistics (CBS) for population data, ministry of petroleum for road transport fuel consumption data, ministry of finance and national economy for GDP data, traffic police department for number of vehicle registration data, while the road length data has been brought from ministry of road and transport.

3. Methodology

3.1 linear Regression Model

Multiple regression analysis is an econometric technique used for investigating the relationship between a dependent variable, or the effect, and an array of independent variables, or the causes (Neter et al, 1996). This technique allows the researchers to analyze the associations among the related variables based on a proven statistical theory. In addition, the developed regression model can be used to estimate and forecast the dependent variable under future scenarios, for given projections of the independent variables. Regression analysis has been used in various fields of study, such as transportation engineering, marketing and business, and social science.

A linear multiple regression models simply take the form of

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \varepsilon \quad (1)$$

Where: Y is a dependent variable
X_i is independent variables 1, 2, …, n.
β_0 is a y-intercept of the regression equation.
β_1 - β_n is the regression coefficient for the relevant independent variables 1 to n.

The regression coefficients of the model can be estimated using the ordinary least square method. The process tries to find the best set of the coefficients that minimizes the sum of squared errors between the predicted output ($\hat{Y}_i$) and the desired output (Y_i), as shown in Equation (2) (Neter et al, 1996):

$$\text{Min} \sum_{i=1}^{n}\left(Y_i - \hat{Y}_i\right)^2 = \min \sum_{i=1}^{n}\left(Y_i - \beta_0 - \beta_1 X_{i1} - ... - \beta_{p-1} X_{i,p-1}\right)^2 \quad (2)$$

Assumptions regarding the regression model:

1. each of the random error term ε_i has expectation zero
2. $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n$ are independent of each other
3. ε for a given setting of the independent variable x is normally distributed with a mean 0 and variance σ_ε^2. The variance σ_ε^2 is constant for all settings of x.

Thus, the Transport energy consumption model for Thailand provinces in this study takes a form of:

$$(TOT) = \beta_0 + \beta_1(GPP) + \beta_2(SEDAN) + \beta_3(TF) + \beta_4(DN) + \beta_5(DNE) + \varepsilon \quad (3)$$

Where:
TOT is Transport energy consumption for Thailand provinces in 10^6 liters
GPP is Gross Provincial Product in 10^9 baht
SEDAN is Total No. of Sedans that not more than 7 Pass in 10^3 vehicles
TF is Total No. of Gas Stations
DN is Dummy for adjustment of North (North = 1, another = 0)
DNE is Dummy for adjustment of North East (North East = 1, another = 0)

3.2 Log-linear Regression Model

A log-linear model is a model that simply analyzes the dependent and the independent variables in logarithm form. The estimated coefficients illustrate the elasticity of the dependent variable with respect to the independent variables. The general form of a log-linear regression equation can write as:

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + ... + \beta_n \ln(X_n) + \varepsilon \quad (4)$$

Thus, the Transport energy consumption model for Thailand provinces in this study takes a form of:

$$\ln(TOT) = \beta_0 + \beta_1 \ln(GPP) + \beta_2 \ln(SEDAN) + \varepsilon \quad (5)$$

Where:
TOT is Transport energy consumption for Thailand provinces in 10^6 liters
GPP is Gross Provincial Product in 10^9 baht
SEDAN is Total No. of Sedans that not more than 7 Pass in 10^3 vehicles

3.3 Data Collection

The cross sectional historical data inventory in year 2007 was gathered for model development in this study. Data for the dependent variable, transport energy demand in units of megajoules was shown in the data.

The cross sectional data has been collected from different government departments. Total energy consumption data is given from department of energy. Total number of sedan registrations and total number of motorcycles data is given from land transport department. Total fuel station is given from department of statistic.

Variables that are used for the analysis in table 2, 3

TOT is Transport energy consumption for Thailand provinces in 10^6 liters
GPP is Gross Provincial Product in 10^9 baht
SEDAN is Total No. of Sedans that not more than 7 Pass in 10^3 vehicles
TF is Total No. of Gas Stations
DC is Dummy for adjustment of Central (Central = 1, another = 0)
DN is Dummy for adjustment of North (North = 1, another = 0)
DNE is Dummy for adjustment of North East (North East = 1, another = 0)
DS is Dummy for adjustment of South (South = 1, another = 0)

Table 2 The example of summarizes the historical data for all variables used in the study.

NO.	REGION	PROV_NAM	GPP (10^9 baht)	SEDAN (10^3 veh.)
1	Central	Bangkok	2,217.00	1,974.75
2	Central	Samut Prakan	614.12	13.57
3	Central	Nonthaburi	111.12	47.09
4	Central	Pathum Thani	192.95	19.55
5	Central	Ayutthaya	337.83	27.06
6	Central	Ang Thong	20.84	9.24
7	Central	Lop Buri	70.24	28.90
8	Central	Sing Buri	22.14	8.46
9	Central	Chai Nat	26.35	8.66
10	Central	Saraburi	134.03	26.52
11	Central	Chon Buri	453.89	97.75
12	Central	Rayong	604.90	41.51
13	Central	Chanthaburi	38.21	20.12
14	Central	Trat	20.31	5.10
15	Central	Chachoengsao	210.53	17.64
16	Central	Prachin Buri	70.29	12.91
17	Central	Nakhon Nayok	16.95	8.31
18	Central	Sa Kaeo	29.52	6.23
19	Central	Ratchaburi	102.90	27.05
20	Central	Kanchanaburi	69.26	22.15
21	Central	Suphan Buri	58.00	20.69
22	Central	Nakhon Pathom	126.14	27.68
23	Central	Samut Sakhon	315.47	4.15

Table 2(Cont.) The example of summarizes the historical data for all variables used in the study.

NO.	TF (sta.)	DC	DN	DNE	DS	TOT(10^6 liters)
1	903	1	0	0	0	7,681.93
2	175	1	0	0	0	618.39
3	200	1	0	0	0	481.86
4	218	1	0	0	0	534.74
5	309	1	0	0	0	360.04
6	100	1	0	0	0	52.89
7	243	1	0	0	0	159.81
8	89	1	0	0	0	69.61
9	178	1	0	0	0	59.14
10	250	1	0	0	0	495.03
11	283	1	0	0	0	857.70
12	225	1	0	0	0	318.23
13	204	1	0	0	0	110.97
14	98	1	0	0	0	57.24
15	217	1	0	0	0	339.63
16	133	1	0	0	0	121.74
17	75	1	0	0	0	58.49
18	235	1	0	0	0	78.87
19	273	1	0	0	0	217.84
20	308	1	0	0	0	269.12
21	377	1	0	0	0	178.74
22	266	1	0	0	0	402.27
23	134	1	0	0	0	253.31

Table 3 Example of summarizes the historical data for all variables (in logarithm form).

NO.	REGION	PROV NAM	ln (GPP) (10^9 baht)	ln(SEDAN) (10^3 veh.)
1	Central	Bangkok	7.70	7.59
2	Central	Samut Prakan	6.42	2.61
3	Central	Nonthaburi	4.71	3.85
4	Central	Pathum Thani	5.26	2.97
5	Central	Ayutthaya	5.82	3.30
6	Central	Ang Thong	3.04	2.22
7	Central	Lop Buri	4.25	3.36
8	Central	Sing Buri	3.10	2.14
9	Central	Chai Nat	3.27	2.16
10	Central	Saraburi	4.90	3.28
11	Central	Chon Buri	6.12	4.58
12	Central	Rayong	6.41	3.73
13	Central	Chanthaburi	3.64	3.00
14	Central	Trat	3.01	1.63
15	Central	Chachoengsao	5.35	2.87
16	Central	Prachin Buri	4.25	2.56
17	Central	Nakhon Nayok	2.83	2.12
18	Central	Sa Kaeo	3.39	1.83
19	Central	Ratchaburi	4.63	3.30
20	Central	Kanchanaburi	4.24	3.10
21	Central	Suphan Buri	4.06	3.03
22	Central	Nakhon Pathom	4.84	3.32
23	Central	Samut Sakhon	7.70	7.59

Table 3(Cont.) The example of summarizes the historical data for all variables used in the study (in logarithm form).

NO.	ln(TF) (sta.)	DC	DN	DNE	DS	ln(TOT) (10^6 liters)
1	6.81	1	0	0	0	8.95
2	5.16	1	0	0	0	6.43
3	5.30	1	0	0	0	6.18
4	5.38	1	0	0	0	6.28
5	5.73	1	0	0	0	5.89
6	4.61	1	0	0	0	3.97
7	5.49	1	0	0	0	5.07
8	4.49	1	0	0	0	4.24
9	5.18	1	0	0	0	4.08
10	5.52	1	0	0	0	6.20
11	5.65	1	0	0	0	6.75
12	5.42	1	0	0	0	5.76
13	5.32	1	0	0	0	4.71
14	4.58	1	0	0	0	4.05
15	5.38	1	0	0	0	5.83
16	4.89	1	0	0	0	4.80
17	4.32	1	0	0	0	4.07
18	5.46	1	0	0	0	4.37
19	5.61	1	0	0	0	5.38
20	5.73	1	0	0	0	5.60
21	5.93	1	0	0	0	5.19
22	5.58	1	0	0	0	6.00
23	6.81	1	0	0	0	8.95

Bangkok's data was excluded from all provinces in simulation of regression model because Bangkok's data has the extreme difference in individual characteristic from other provinces.

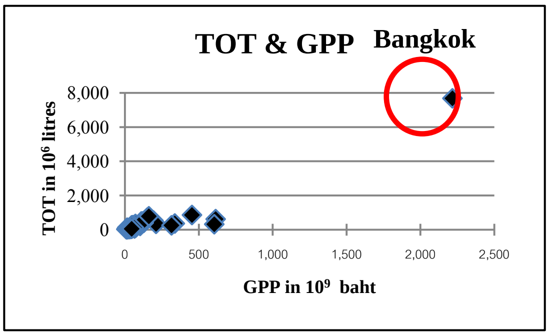

Fig 1 Represent relationship between TOT and GPP

From Fig 1, *Bangkok's data is considered to be an outlier. Hence, we exclude Bangkok's data in the model development

***Note:** Bangkok has different socio - economic characteristics in terms of gross domestic product, population, vehicle registrations and transport energy demand.

4. Model Development

4.1 linear regression models

The linear regression models are computed using SPSS software. Table 4 summarizes the model results. The final model structure is composed of four independent variables form: Gross Provincial Product (in 1,000,000,000 baht, billion), Total No. of Sedans that not more than 7 Pass (in 1,000 vehicle) and Total No. of Gas Stations all each province in Thailand. All of independent variable are with a p-value of less than 0.05 (see the Model in Table 4).

Table 4 Results of linear model development

Variable	Model			
	β	t-stat	p-value	VIF
GPP	0.604	5.619	0.000	1.342
SEDAN	3.933	6.499	0.000	1.508
TF	0.319	3.712	0.000	1.597
DN	-96.630	-3.349	0.001	1.282
DNE	-82.023	-2.718	0.008	1.513
Constant	28.246	1.307	0.196	
r^2	0.772			
Adj. r^2	0.755			

*** denotes significance at the 0.05 level**
**** denotes significance at the 0.01 level**

The final linear model takes the form of:

$$(TOT) = 28.246 + 0.604\,(GPP) + 3.933\,(SEDAN) + 0.319\,(TF) - 96.630\,(DN) - 82.023\,(DNE) \quad (6)$$

Where:

TOT is Transport energy consumption for Thailand provinces in 10^6 liters
GPP is Gross Provincial Product in 10^9 baht
SEDAN is Total No. of Sedans that not more than 7 Pass in 10^3 vehicles
TF is Total No. of Gas Stations
DN is Dummy for adjustment of North (North = 1, another = 0)
DNE is Dummy for adjustment of North East (North East = 1, another = 0)

The model has a high coefficient of correlation (r^2) of 0.772

The model has a high coefficient of correlation (r^2) of 0.772 this implies that for year

2007 national GPP information, SEDAN vehicles, total number of Gas stations, North and North East regions can explain the majority (77.2 percent) of the variability in transport energy consumption in Thailand provinces, while the remaining 32.8 percent of variability is left unknown. This shows that these five variables have a strong relationship with the energy used in transport in Thailand provinces.

When the national GPP rise, the economy prospers, which causes more people economic activity which will need extensive transportation in the nation; thus, it increases the use of fuel. The positive value of the GPP coefficient follows our commonsense assumption that GPP has a direct relationship with transport fuel consumption. The magnitude of the estimated coefficient indicates the elasticity of transport energy consumption with respect to GPP of 0.604. That is, for every 100 percent increase of GPP, transport energy demand is expected to rise by 60.4 percent holding the other variables equal to zero, this also reflects the strong relationship, and the same conclusion can be applied to the SEDAN vehicle & total number of Gas stations both with positive 3.93 and 0.319 estimated coefficients respectively, while the North and North East regions both has negatives estimated coefficients -96.63 and -82.023 respectively reflecting the variability among the regions characteristics

Multiple linear regression assumptions:

These include checking for the linearity assumption, normality assumption, presence of outliers and influential observations, multicolinearity and non - constant variance (heteroscedasticity) has been examined and verified using SPSS

4.2 log-linear regression models

The log-linear regression models are computed using SPSS software. Table 5 summarizes the model results. The final model structure is composed of five independent variables in a logarithm form: Gross Provincial Product (in 1,000,000,000 baht, billion), Total No. of Sedans that not more than 7 Pass (in 1,000 vehicle) and Total No. of Gas Stations all each province in Thailand. All of independent variable are with a p-value of less than 0.05 (see the Model in Table 5).

Table 5 Results of log-linear model development

Variable	Model			
	β	t-stat	p-value	VIF
GPP	0.617	8.609	0.000	1.892
SEDAN	0.392	5.136	0.000	1.892
Constant	1.377	6.534	0.000	
r^2	**0.809**			
Adj. r^2	**0.804**			

*** denotes significance at the 0.05 level.**
**** denotes significance at the 0.01 level.**

The final log-linear model takes the form of:

$$\ln(TOT) = 1.377 + 0.617\ln(GPP) + 0.392\ln(SEDAN) \quad (7)$$

Where:

TOT is Transport energy consumption for Thailand provinces in 10^6 liters
GPP is Gross Provincial Product in 10^9 baht
SEDAN is Total No. of Sedans that not more than 7 Pass in 10^3 vehicles

The model has a high coefficient of correlation (r^2) of 0.809. This implies that for year 2007 national GPP and total number of sedan vehicles information can explain the majority (80.9 percent) of the variability in transport energy consumption, while the remaining 19.1 percent of variability is left unknown. This shows that the national economy and the number of motorized vehicles have a strong relationship with the energy used in transport in Thailand provinces. When the national GPP and number of vehicles rise, the economy prospers, which causes more people activity as well as better transportation in the nation; thus, it increases the use of gasoline. The positive value of the GPP coefficient follows our commonsense assumption that GPP has a direct relationship with transport fuel consumption. The magnitude of the estimated coefficient indicates the elasticity of transport energy demand with respect to GPP of 0.617 That is, for every 100 percent increase of GPP, transport energy demand is expected to rise by 61.7 percent. Similarly, the positive value of the total Sedan number coefficient is also logical. The magnitude of the coefficient implies that for every 100 percent increase in the road length, road transport energy consumption is expected to increase by 39.2 percent.

It must be noticed that this kind of studies (at provisional level) has been conducted for the first time in Thailand offering very good disaggregation concept for transport energy models development. Nevertheless, the study yields two models possibly can be used in estimating transport energy consumption in the future. Thailand Government at all levels should benefit from this study in preparing future plans and policies regarding transport fuel consumption in terms of budget allocations, storage capacities and prices subsidies scenarios.

5. Conclusion

This study develops a linear and log-linear regression models to estimate transport energy consumption in Thailand provinces. The models are developed based on 0ne year cross sectional information about GPP, population, and number of Sedan vehicles and total gas stations. The final linear model composed of five independent variables these are gross provisional product the number of sedan vehicles, the total number of gas stations, the North and North East regions. The model capable to explain up to 77.2 percent of the variability in transport fuel demand, while the log - linear model comprises the two independent variables, gross provisional product and the total number of sedan vehicles. The model can explain up to 80.9 percent of the variability in road transport fuel demand. The two models can be used for estimating transport energy demand at provisional level in Thailand.

To summarize the findings in this study:

1. This study successfully develops a linear, log-linear regression models for estimating transport fuel consumption in Thailand.

2. The two models, using different approaches, has been developed including both two important predictor variables mainly GPP and SEDAN vehicles

3. Thailand Government at all levels should benefit from this study in preparing future plans and policies regarding transport fuel consumption in terms of budget allocations, storage capacities and prices subsidies scenarios.

In conclusion, there are a number of modeling techniques available that have been successfully developed to estimate energy consumption in many places. Each technique has its own advantages and disadvantages; the practitioner must select the techniques that are appropriate to the available data, and serve the purposes of estimating. It should be emphasized that transport energy consumption is one of the crucial issues facing a government. It can represent a threat to the energy and economic security of a nation, if a government does not reposition itself adequately.

It should be noted that most modeling approaches are based on historical data. We must recognize this as a potential major risk in estimating errors, especially when the world is in a transitional phase as it is now. During transition, future circumstances are likely to be vastly different from the past. Thus, constant monitoring of issues is required. Our claim here is that policy makers have to regularly monitor the transition, revisit demand estimates and improve policies and budget plans to reflect the change.

6. References

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