Chapter 1

Re-estimation of Energy Demand Formula

March 2018

This chapter should be cited as
Chapter 1
Re-estimating Energy Demand Formulas Using
ASEAN National Energy Data

This chapter discusses the national data improvement and uses this to estimate demand equations of some ASEAN countries to be able to assess the integrity of their historical national data as potential database to project energy demand. In the past, the East Asia Summit energy outlook and saving potential relied greatly on the International Energy Agency’s historical energy data. However, the working group of this study wanted to create its data by looking into each country data as prepared based on the practical knowledge of the experts involved in the preparation of country energy outlook. To start with, five countries were chosen to check the historical data correction for the energy outlook. In formulating statistical demand model using regression analysis, the national energy data improvement should be accurate, complete, and timely. The main database file for the 1990–2013 final energy consumption by major economic sectors and subsectors and the socio-economic parameters were established and exported to the forecasting tool. Assessment on the national energy data was made through regression analysis to estimate energy demand functions such as electricity demand in residential sector. At the end, the national energy data of two ASEAN countries were assessed and used for energy outlook modelling. The remaining three countries, however, need to improve their national energy data. In this regard, the working group deferred the use of their national energy data.
1A. Indonesia’s National Energy Data Estimations

1. Background

Developing the energy outlook and analysis of energy-saving potential in East Asia has always been based on the International Energy Agency’s energy balances for member countries of the Organisation for Economic Co-operation and Development (OECD) and non-OECD countries except that of the Lao PDR which came from its Department of Energy and Mines. The plan for the future is to use the energy statistics of the member countries of the Asia Pacific Economic Cooperation (APEC) instead of the International Energy Agency’s energy statistics. In this regard, for the fiscal year 2016–2017, the Energy Working from the ASEAN countries that are member of APEC (except Brunei Darussalam) was tasked to re-estimate the demand equation using APEC’s energy statistics. The Energy Statistics and Training Office of the Asia Pacific Energy Research Centre provided the historical energy data from 1970 to 2014 (only up to 2013 in the case of some countries). The Microfit software was used in re-estimating the energy demand function.

The Lao PDR was also tasked to re-estimate the energy demand function using its national energy statistics. The remaining ASEAN member countries were tasked to prepare and analyse their historical energy statistics.

The socio-economic data were obtained from the World Bank’s World Development Indicators. Where available, data on transportation, buildings, and industrial production indices were provided by the members of the working group.

The APEC energy statistics of Indonesia were only up to 2013. The final energy demand data provided the fuel consumption in the three main energy sectors: industrial; transport; and others, consisting of residential-commercial, agriculture, and other sectors. This report is the result of the re-estimation of the demand function for Indonesia.

2. Methodology

Indonesia’s energy demand function was estimated using the econometric approach, a top-down approach linking macroeconomic model with energy model. The macroeconomic model estimates macroeconomic activities such as gross domestic product (GDP), income distribution, commodity prices, labour, industrial production, number of vehicles, number of households, number of appliances, floor area of buildings, etc. with a given level of exogenous variables such as crude oil price, world trade, and governmental policies such as fiscal expenditure and interest rate.
Thus, in econometric approach, energy demand is modelled as a function of macroeconomic activities such as income, relative prices among sources of energy, and energy demand at previous period

\[ E = f(Y, \frac{Pe}{CPI}) \quad \text{or} \quad E = f(Y, \frac{Pe}{CPI}, E_{-1}) \]

where

- \( E \): Energy Demand
- \( Y \): Income
- \( Pe \): Energy Price
- \( CPI \): Consumer Price Index
- \( \frac{Pe}{CPI} \): Relative price
- \( E_{-1} \): Energy Demand at previous period

Such relationships among variables are derived by regression analysis using Microfit, a computer programme that offers an extensive choice of data analysis options and is a versatile aid in evaluating and designing advanced univariate and multivariate time series models. It is an interactive, menu-driven programme with a host of facilities for estimating and testing equations, forecasting, data processing, file management, and graphic display.

Not all consumption in each of the sectors or subsectors can be explained by a demand function. In cases where regression analysis is not applicable due to insufficient data or failure to derive a statistically sound equation, it is not necessary to estimate the demand function.

3. Industry Sector

The total final energy demand of the industry sector by subsector is shown in Figure 1A.1. As shown, the consumption data of the sub-sectors prior to 2004 do not add up to the total consumption of the sector. Since 2004, the total subsector data has been similar to the total industry data. However, majority of the demand is classified as consumption of non-specified industry. Further breakdown will be necessary and the subsectors data since 2004 have irregular trend that need to be further clarified.
By type of energy (Figure 1A.2), the total consumption each year since 1990 is the sum of the different types of fuels consumed by the sector, consisting of coal and coal products (briquette), petroleum products, gas, others (fuelwood, other biomass, etc.), and electricity.

Considering the data condition, the re-estimation of the demand function will be done only for total industry and by fuel type wherever possible.

4. Total Industry Energy Demand (INTT)

Total fuel consumption of industries was re-estimated using the manufacturing GDP (MFFGDP) and consumption of previous year as the independent variables. Imposing price variable resulted in a positive sign in the regression result. Dummy variable was included for 2001–2004 because without this, the result is statistically not a sound equation.

The result of the regression analysis is shown in Table 1A.1 while the plot of the actual and fitted
values is shown in Figure 1A.3. The re-estimated demand equation is:

\[
INTT = -24169.7 \times CONS + 0.4366 \times MFGGDPM + 0.15377 \times INTT(-1) + 4546.8 \times DUM0104
\]

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-24169.7</td>
<td>8408.8</td>
<td>-2.8743[.010]</td>
</tr>
<tr>
<td>MFGGDPM</td>
<td>.4366E-4</td>
<td>.1275E-4</td>
<td>3.4257[.003]</td>
</tr>
<tr>
<td>INTT(-1)</td>
<td>.15377</td>
<td>.26817</td>
<td>.57340[.573]</td>
</tr>
<tr>
<td>DUM0104</td>
<td>4546.8</td>
<td>3329.4</td>
<td>1.3657[.188]</td>
</tr>
</tbody>
</table>

R-Squared 0.94150
R-Bar-Squared 0.93227
Mean of Dependent Variable 33647.5
S.D. of Dependent Variable 18103.9
Residual Sum of Squares 4.22E+08
Akaike Info. Criterion -228.9676
Schwarz Bayesian Criterion -231.2386
DW-statistic 2.125
Durbin's h-statistic *NONE*

Source: Microfit regression analysis.
5. Total Coal Consumption (INCL)

Figure 1A.4 shows the total coal consumption (INCL) of the industrial sector. As before, the total consumption prior to 2004 does not equal the sum of the subsector consumption. Since 2004, coal consumption of the industries has increased significantly. In 2009, coal consumption experienced a steep decline but bounced back in 2010 onwards. Subsector’s consumption data of coal is not consistent so it is very difficult to re-estimate the coal demand function by subsector. Thus, the re-estimation was possible only for total coal consumption.

Re-estimation of the total industrial coal consumption also used the manufacturing GDP (MFFGDP) as the independent variables and the lag variable (previous year consumption). Inclusion of the price variable will also result in a positive sign for the regression result. The regression test was done with and without a dummy variable for 2007–2010. The regression result with the dummy variable is better so that the function to explain the coal consumption in the industrial sector is as follows:

\[
INCL = -7298.7*CONS + .1209E-4*MFGGDPM + .47196*INCL(-1) - 1885.8*DUM0710
\]

The result of the regression analysis is shown in Table 1A.2 while the plot of the actual and fitted values is shown in Figure 1A.5.
Table 1A.2. Ordinary Least Squares Estimation for INCL

Dependent variable is INTT
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-7298.7</td>
<td>4027.1</td>
<td>-1.8124[.086]</td>
</tr>
<tr>
<td>MFGGDPM</td>
<td>.1209W-4</td>
<td>.4192E-5</td>
<td>2.8849[.009]</td>
</tr>
<tr>
<td>INTT(-1)</td>
<td>.47196</td>
<td>.19693</td>
<td>2.3966[.027]</td>
</tr>
<tr>
<td>DUM0104</td>
<td>-1885.8</td>
<td>1974.9</td>
<td>.95486[.352]</td>
</tr>
<tr>
<td>R-Squared</td>
<td>.88290</td>
<td></td>
<td>.86441</td>
</tr>
<tr>
<td>S.E. of Regression</td>
<td>3089.2</td>
<td>F-stat. F( 3, 19)</td>
<td>47.7502[.000]</td>
</tr>
<tr>
<td>Mean of Dependent Variable</td>
<td>8151.7</td>
<td>S.D. of Dependent Variable</td>
<td>8389.4</td>
</tr>
<tr>
<td>Residual Sum of Squares</td>
<td>1.81E+08</td>
<td>Equation Log-likelihood</td>
<td>-215.2590</td>
</tr>
<tr>
<td>Akaike Info. Criterion</td>
<td>-215.2590</td>
<td>Schwarz Bayesian Criterion</td>
<td>-221.5300</td>
</tr>
<tr>
<td>DW-statistic</td>
<td>2.2254</td>
<td>Durbin’s h-statistic</td>
<td>-1.6446[.100]</td>
</tr>
</tbody>
</table>

Source: Microfit regression analysis.

Figure 1A.5. Plot of Actual and Fitted Values for INCL

Source: APEC Energy Statistic of Indonesia.

6. Total Petroleum Product Consumption (INPP)

As shown in Figure 1A.6, summation of the industrial subsector consumption of petroleum product prior to 2004 does not equal the total consumption. From 2004 onwards, this has been possible because there was only one subsector for the breakdown of industry in the Indonesian data of APEC, which was the non-specified industries.
Since the data is not complete to conduct re-estimation of demand function for each of the petroleum products, the estimated function will only be for total petroleum product consumption. As with coal, the independent variable explaining the total petroleum product consumption of industries is the MFFGDP and the lag variable INPP(-1). In the case of petroleum product consumption, the price variable also contributes to the consumption as it results in a negative sign for the regression analysis. The re-estimated demand equation for INPP is:

\[
INPP = 2775.6 \times CONS + 0.8315E^{-5} \times MFFGDP - 0.71444 \times RPOIL + 0.27885 \times INPP(-1)
\]

The result of the regression analysis is shown in Table 1A.3 while the plot of the actual and fitted values is shown in Figure 1A.7.
Table 1A.3. Ordinary Least Squares Estimation for INPP

Dependent variable is INTT
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>2775.6</td>
<td>1983.1</td>
<td>1.3996[.178]</td>
</tr>
<tr>
<td>MFGGDPM</td>
<td>8.32E-06</td>
<td>2.84E-06</td>
<td>2.9283[.009]</td>
</tr>
<tr>
<td>INTT(-1)</td>
<td>.71444</td>
<td>.35838</td>
<td>2.0135[.061]</td>
</tr>
<tr>
<td>DUM0104</td>
<td>.27885</td>
<td>.21329</td>
<td>1.3074[.207]</td>
</tr>
</tbody>
</table>

R-Squared .48642  R-Bar-Squared .40533
S.E. of Regression 2280.5  F-stat. F( 3, 19) 5.9984[.005]
Mean of Dependent Variable 9904.9  S.D. of Dependent Variable 2957.2
Residual Sum of Squares 9.88E+07  Equation Log-likelihood 208.2776
Akaike Info. Criterion 212.2776  Schwarz Bayesian Criterion 214.5486
DW-statistic 2.3736  Durbin’s h-statistic *NONE*

Source: Microfit regression analysis.

Figure 1A.7. Plot of Actual and Fitted Valued for INPP

Source: Microfit regression analysis.

7. Total Electricity Consumption of Industries (INED)

The subsector data of electricity consumption is not reliable and needs further clarification (Figure 1A.8). As such it is not possible to estimate the demand function for electricity in each subsector.
In the case of total electricity consumption, the data for 1994–2004 showed irregularity. There was no explanation for this irregularity. Although a dummy variable is not appropriate for smoothing unexplained irregularity of data, the result of the regression analysis shows a better fit than that without the dummy. The re-estimated demand equation for INEL from the regression analysis is:

\[ \text{INEL} = 1390.9^*\text{CONS} + .1976^*\text{MFGGDPM} - .095445^*\text{RPOIL} + .45469^*\text{INEL}(-1) - 975.4261^*\text{DUM9404} \]

**Figure 1A.8. Power Generation by Type of Fuel (TWh)**

ktoe = kilotonne of oil equivalent, TWh = terawatt hour.

Source: Author’s calculations.

The result of the regression analysis is shown in Table 1A.4 while the plot of the actual and fitted values is shown in Figure 1A.9.
Table 1A.4. Ordinary Least Squares Estimation for INEL

Dependent variable is INTT
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>1390.9</td>
<td>706.8747</td>
<td>1.9677 [.065]</td>
</tr>
<tr>
<td>MFGGDPM</td>
<td>.1976E-5</td>
<td>.1029E-5</td>
<td>1.9208 [.071]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.095445</td>
<td>.14716</td>
<td>-.64857 [.525]</td>
</tr>
<tr>
<td>INEL(-1)</td>
<td>.45469</td>
<td>.22146</td>
<td>2.0531 [.055]</td>
</tr>
<tr>
<td>DUM9404</td>
<td>-975.4261</td>
<td>712.3919</td>
<td>-.3692 [.188]</td>
</tr>
</tbody>
</table>

R-Squared .72534 R-Bar-Squared .66431
S.E. of Regression 796.5824 F-stat. F(3, 19) 11.8841 [.000]
Mean of Dependent Variable 4362.3 S.D. of Dependent Variable 1374.9
Residual Sum of Squares 1.14E+07 Equation Log-likelihood -183.4643
Akaike Info. Criterion -188.4643 Schwarz Bayesian Criterion -191.3030
DW-statistic 2.3656 Durbin’s h-statistic *NONE*

Source: Microfit regression analysis.

Figure 1A.9. Plot of Actual and Fitted Valued for INEL

Source: Microfit regression analysis.

11. Transport Sector

The total energy demand of the transport sector by subsector is shown in Figure 1A.10. The data by subsectors are available only since 2004. However, as shown, the subsector data are inconsistent and need to be verified further.
The majority of the fuel consumed by the transport sector are petroleum products (Figure 1A.11) consisting of motor gasoline, gas/diesel oil, jet fuel, kerosene, and fuel oil. Motor gasoline is used by the road sector while jet fuel is for aviation purposes. Gas/diesel oil can be used in the road, rail, and inland waterways. Fuel oil is consumed in inland waterways.

The regression analysis will be done to estimate the demand function for the jet fuel, the petroleum product for road transport, and the fuel oil.
12. Total Jet Fuel (TSJET)

The jet fuel (TSJF) data for the transport sector is shown in Figure 1A.12. The data shows an increasing trend and that the function could be estimated linearly.

Figure 1A.12. Total Jet Fuel (TSJF) Consumption (Ktoe)

ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

The APEC energy data for the transport sector, however, also includes kerosene data (TSOK) as shown in Figure 1A.13. Since kerosene is not commonly consumed by the transport sector, it is assumed that this is some inconsistent data.

Figure 1A.13. Transport Sector Kerosene (TSOK) Consumption (Ktoe)

Source: APEC Energy Statistic of Indonesia
Considering that jet kerosene has similar specification for kerosene, the kerosene data is assumed to be part of the aviation fuel. Thus, total jet fuel (TSJET) will be the sum of TSJF and TSOK (Figure 1A.14).

**Figure 1A.14. Total Jet Fuel (TSJET) Consumption (Ktoe)**

ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

The re-estimated demand equation for TSJET from the regression analysis is:

\[
TSJET = -677.5099*CONS + 0.4632*GDPMIL - 0.058392*RPOIL + 0.3141*TSJET(-1)
\]

The result of the regression analysis is shown in Table 1A.5 while the plot of the actual and fitted values is shown in Figure 1A.15.

**Table 1A.5. Ordinary Least Squares Estimation for TSJET**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-677.5099</td>
<td>189.3916</td>
<td>-3.5773[.002]</td>
</tr>
<tr>
<td>GDPMIL</td>
<td>0.4632*10^-6</td>
<td>0.1036*10^-6</td>
<td>4.4716[.000]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-0.058392</td>
<td>0.027203</td>
<td>-2.1465[.045]</td>
</tr>
<tr>
<td>TSJET(-1)</td>
<td>0.31410</td>
<td>0.17675</td>
<td>1.7771[.092]</td>
</tr>
</tbody>
</table>

R-Squared         .95376   R-Bar-Squared        .94646
S.E. of Regression 188.8635   F-stat.     F( 3, 19)  130.6399[.000]
Mean of Dependent Variable 1765.6   S.D. of Dependent Variable 816.2348
Residual Sum of Squares 677719.0   Equation Log-likelihood -150.9820
Akaike Info. Criterion -154.9820  Schwarz Bayesian Criterion -157.2530
DW-statistic      1.6757    Durbin's h-statistic 1.4658[.143]

Source: Microfit regression analysis.
13. Road Transport

The road sector consumed majority of the petroleum product consumption of the transport sector. There was no data on road consumption prior to 2004 (Figure 1A.16). In 2004, the data shows only for motor gasoline, while the total consumption of the road sector is not available.

The total consumption of the road sector equals the sum of the different fuels since 2005. However, in 2012 and 2013, the sum of the fuels was lower than the total. In addition, data of the gas/diesel oil is only available from 2010 onwards and that there is other petroleum product (OOP) data which also needs to be clarified. The irregularity of the data by fuel type makes it difficult to estimate the demand function for each of the petroleum product in the road transport.
Considering the data limitation, a demand function analysis was still conducted for total petroleum product consumption of the road transport. The regression analysis shows a better result if the period is from 1991 as compared from 2005. The re-estimated demand equation for RDPP from the regression analysis is:

\[ RDPP = -13144.7*CONS + .3582E-5*GDPMIL - .14432*RPOIL + .81835*RDPP(-1) \]

The result of the regression analysis is shown in Table 1A.6 while the plot of the actual and fitted values is shown in Figure 1A.17.

**Table 1A.6. Ordinary Least Squares Estimation for RDPP**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
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<tbody>
<tr>
<td>CONS</td>
<td>-13144.7</td>
<td>5896.6</td>
<td>-2.2292[.038]</td>
</tr>
<tr>
<td>GDPMIL</td>
<td>.3582E-5</td>
<td>.1739E-5</td>
<td>2.0602[.053]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.14432</td>
<td>.54429</td>
<td>-.26515[.794]</td>
</tr>
<tr>
<td>RDPP(-1)</td>
<td>.81835</td>
<td>.14256</td>
<td>5.7406[.000]</td>
</tr>
</tbody>
</table>

R-Squared                     .95735   R-Bar-Squared   .95062
S.E. of Regression            3769.0   F-stat. F(3, 19) 142.1645[.000]
Mean of Dependent Variable    10956.5   S.D. of Dependent Variable 16960.4
Residual Sum of Squares      2.70E+08   Equation Log-likelihood -219.8335
Akaike Info. Criterion        -223.8335  Schwarz Bayesian Criterion -226.1045
DW-statistic                 2.0417    Durbin’s h-statistic -.13709[.891]

Source: Microfit regression analysis

**Figure 1A.17. Plot of Actual and Fitted Values for RDPP**

Source: Microfit regression analysis.

14. Road Motor Gasoline (RDMG)

The road sector motor gasoline consumption has been analysed as a function of GDP, domestic relative price of gasoline, and previous year consumption. The re-estimated demand equation for RDMG from the regression analysis is:
RD MG = -3370.5*CONS + .3795E-5*GDP MIL - 112.9137*RPPREM + .18479*RD MG(-1)

The result of the regression analysis is shown in Table 1A.7 while the plot of the actual and fitted values is shown in Figure 1A.18.

Table 1A.7. Ordinary Least Squares Estimation for RD MG

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
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</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-3370.5</td>
<td>5827.5</td>
<td>-0.57838[.584]</td>
</tr>
<tr>
<td>GDPMIL</td>
<td>.3795E-5</td>
<td>.94518-6</td>
<td>4.0159[.007]</td>
</tr>
<tr>
<td>RPPREM</td>
<td>-112.9137</td>
<td>55.2232</td>
<td>-2.0447[.087]</td>
</tr>
<tr>
<td>RD MG(-1)</td>
<td>.18479</td>
<td>.16017</td>
<td>1.1537[.292]</td>
</tr>
</tbody>
</table>

Source: Microfit regression analysis.

Figure 1A.18. Plot of Actual and Fitted Values for RD MG

Source: Microfit regression analysis.

15. Road Diesel Transport (RD GD)

As with motor gasoline, the road sector motor gas/diesel consumption has been analysed as a function of GDP, domestic relative price of gas/diesel oil, and previous year consumption. The re-estimated demand equation for RD GD from the regression analysis is:

RD GD = -12737.1*CONS + .4483E-5*GDP MIL - 371.6183*RP DSLS + .43108*RD MG(-1)
The result of the regression analysis is shown in Table 1A.8 while the plot of the actual and fitted values is shown in Figure 1A.19.

### Table 1A.8. Ordinary Least Squares Estimation for RDGD

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-23995.0</td>
<td>9816.3</td>
<td>-2.4444 [.050]</td>
</tr>
<tr>
<td>GDEMD</td>
<td>6424E-5</td>
<td>2006E-5</td>
<td>3.2020 [.019]</td>
</tr>
<tr>
<td>RFGDS</td>
<td>-254.7739</td>
<td>134.8292</td>
<td>-1.8896 [.108]</td>
</tr>
<tr>
<td>RDGD(-1)</td>
<td>.087633</td>
<td>.32024</td>
<td>.27364 [.794]</td>
</tr>
</tbody>
</table>

R-Squared                     .90763   R-Bar-Squared                   .86145
S.E. of Regression            2928.8   F-stat.     F( 3, 6)          19.6530 [.002]
Mean of Dependent Variable    6000.0   S.D. of Dependent Variable       7868.5
Residual Sum of Squares      5.15E+07  Equation Log-likelihood      -91.4588
Akaike Info. Criterion       -95.4588  Schwarz Bayesian Criterion   -96.0640
DW-statistic                2.3243   Durbin's h-statistic            *NONE*

Source: Microfit regression analysis.

### Figure 1A.19. Plot of Actual and Fitted Valued for RDGD

Source: Microfit regression analysis.

16. Transport Fuel Oil

The transport sector fuel oil consumption has been analysed as a function of GDP, relative price of crude oil, and previous year consumption. The re-estimated demand equation for TSFO from the regression analysis is:

\[TSFO = 96.5251 \times CONS + 0.1138E-7 \times GDEMD - 0.017440 \times RFGDS + 0.76634 \times TSFO(-1)\]

The result of the regression analysis is shown in Table 1A.9 while the plot of the actual and fitted values is shown in Figure 1A.20.
17. Residential and Commercial Sector

By type of fuel, the residential and commercial (ResCom) sector consumption covers LPG, electricity, biomass (fuelwood and charcoal), coal product (briquette), and gas/diesel. As with the industry and transport sector, the subsector consumption is not complete and unreliable.

For example, for the LPG consumption of the ResCom sector shown in Figure 1-4.21, the subsector data is available only from 2004 and only for commercial sector. In 2005, the data is only for the residential sector. From 2007 onward, both subsector data are available, but the commercial sector data is significantly lower than 2004. Under this data condition, it would be better to estimate total sector LPG consumption rather than the subsector consumption.
In the case of electricity consumption (Figure 1A.22), the sum of the subsectors is similar to the total consumption data although only from 2004 onward. Prior to 2004, the available data is only for total consumption. It is possible to estimate demand function for electricity consumption in each of the subsectors, but the regression analysis would be best if done for total ResCom consumption of electricity.

Figure 1A.22. Residential and Commercial (ResCom) Electricity Consumption (RECSEL)

ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.
The coal product consumed by the ResCom sector is actually briquette. Thus, the data shown in Figure 1A.23 is the briquette consumption (RECSCL). The data, however, needs to be clarified and revised because it seems there are missing data in 2001 and 2007 onwards. The subsector data seems also to be incorrect. Under this condition, no estimation of the demand function will be done.

**Figure 1A.23. Coal Product Consumption by Sector (CS)**

\begin{center}
\includegraphics[width=0.8\textwidth]{figure1.png}
\end{center}

\textit{ktoe = kilotonne of oil equivalent.}
\textit{Source: APEC Energy Statistic of Indonesia.}

Similarly, for natural gas consumption of the ResCom sector, the data available in the APEC statistic is unreliable. No explanation for the reason why the data is as it is. Therefore, no demand function was estimated for natural gas consumption in the ResCom sector (see Figure 1A.24).

**Figure 1A.24. Natural Gas Consumption by Sector (Ktoe)**

\begin{center}
\includegraphics[width=0.8\textwidth]{figure2.png}
\end{center}

\textit{ktoe = kilotonne of oil equivalent.}
\textit{Source: APEC Energy Statistic of Indonesia.}
18. Total LPG consumption (RECSOILP)

The ResCom consumption of oil covers not only LPG but kerosene and gas/diesel oil as well. Kerosene consumption is decreasing in line with the government programme to switch to LPG. The gas/diesel oil consumption data for ResCom is not reliable (Figure 1A.25), making it difficult to estimate the demand function. As a result, the demand equation will be estimated only for total LPG consumption of the ResCom sector.

Figure 1A.25. Residential and Commercial (ResCom) Sector Gas/Diesel Oil Consumption (Ktoe)

ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

The total LPG consumption of the ResCom sector has been analysed as a function of GDP, relative price of oil, and previous year consumption. The re-estimated demand equation for RECSLP from the regression analysis is:

\[ RECSLP = -2707.0 \times CONS - .11164 \times RPOIL + .6136 \times GDPMIL + .74018 \times RECSLP(-1) + 1087.2 \times DUM01 \]

The result of the regression analysis is shown in Table 1A.10 while the plot of the actual and fitted values is shown in Figure 1A.26.
Table 1A.10. Ordinary Least Squares Estimation for RECSLP

Dependent variable is RECSLP
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-2707.0</td>
<td>674.3900</td>
<td>-4.0139[.001]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.11164</td>
<td>.071735</td>
<td>-1.5563[.137]</td>
</tr>
<tr>
<td>GDPMIL</td>
<td>.6136E-6</td>
<td>.2229E-6</td>
<td>2.7523[.013]</td>
</tr>
<tr>
<td>RECSLP(-1)</td>
<td>.74018</td>
<td>.13736</td>
<td>5.3888[.000]</td>
</tr>
<tr>
<td>DUM01</td>
<td>1087.2</td>
<td>450.9640</td>
<td>2.4108[.027]</td>
</tr>
</tbody>
</table>

R-Squared                     .96279   R-Bar-Squared                   .95452
S.E. of Regression          430.1381   F-stat.    F( 4, 18) 116.4411[.000]
Mean of Dependent Variable   1708.1     S.D. of Dependent Variable 2017.0
Residual Sum of Squares      3330338   Equation Log-likelihood   -169.2911
Akaike Info. Criterion       -174.2911   Schwarz Bayesian Criterion -177.1299
DW-statistic                  1.6535   Durbin's h-statistic       1.1042[.270]

Source: Microfit regression analysis.

Figure 1A.26: Plot of Actual and Fitted Valued for RECSOILC

Source: Microfit regression analysis.

19. Total electricity consumption (RECSEL)

Demand function for electricity consumption will be estimated for total ResCom sector. It is not broken down by subsector (Figure 1A.27).
The re-estimated demand equation for RECSEL from the regression analysis is:

\[ \text{RECSEL} = -653.9821 \times \text{CONS} + 0.4125E^{-6} \times \text{GDPMIL} - 25.8784 \times \text{RPELCC} + 0.83281 \times \text{RECSEL}(-1) \]

The result of the regression analysis is shown in Table 1A.11 while the plot of the actual and fitted values is shown in Figure 1A.28.

**Table 1A.11. Ordinary Least Squares Estimation for RECSEL**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-653.9821</td>
<td>426.9971</td>
<td>-1.5316[.142]</td>
</tr>
<tr>
<td>GDPMIL</td>
<td>.4125E^{-6}</td>
<td>.1631E^{-6}</td>
<td>2.5294[.020]</td>
</tr>
<tr>
<td>RPELCC</td>
<td>-25.8784</td>
<td>24.2586</td>
<td>-1.0668[.299]</td>
</tr>
<tr>
<td>RECSEL(-1)</td>
<td>.83281</td>
<td>.095520</td>
<td>8.7187[.000]</td>
</tr>
</tbody>
</table>

*******************************************************************************
Dependent variable is RECSEL
23 observations used for estimation from 1991 to 2013
*******************************************************************************

R-Squared                     .99627   R-Bar-Squared     .99568
S.E. of Regression           193.3224   F-stat. F( 3, 19)  1693.0[.000]
Mean of Dependent Variable   4654.2     S.D. of Dependent Variable 2942.8
Residual Sum of Squares     710097.6    Equation Log-likelihood -151.5187
Akaike Info. Criterion      -155.5187   Schwarz Bayesian Criterion -157.7897
DW-statistic                2.7034     Durbin's h-statistic -1.8974[.058]
*******************************************************************************

Source: Microfit regression analysis.
20. Conclusion and Recommendation

The re-estimation of the demand function using APEC data is not as sound as with the energy statistics of the International Energy Agency. The Indonesian data in the APEC energy statistics still need to be analysed in detail due to data irregularity and inconsistency. Nevertheless, some demand equations have been re-estimated for each of the demand sector.

In the industrial sector, re-estimation has been done for total final energy consumption (INTT), total coal consumption (INCL), total petroleum product consumption (INPP), and total electricity consumption (INEL). In the transport sector, the re-estimated demand function is for total aviation fuel (TSJET) consisting of jet fuel (TSJF) and kerosene (TSOK), total petroleum product of road transport (RDPP), total motor gasoline and gas/diesel oil consumption of road transport (RDMG and RDGD), and total fuel oil consumption (TSFO). In the residential and commercial sector, the demand equation has been re-estimated only for the LPG and electricity consumption of total residential and commercial sector (RECSLP and RECSEL).

A better APEC energy statistics of Indonesia can be developed by further communication with Pusdatin (the Centre of Data and Information) of the Ministry of Energy and Mineral Resources of Indonesia which supplies data.
1B. Malaysia’s National Energy Data Estimations

1. Introduction

Malaysia’s energy demand projections up to 2040 were estimated using the econometric approach. Historical energy demand data were taken from the National Energy Balance of the Energy Commission of Malaysia. The economic indicators used in energy modelling such as gross domestic products (GDP) were taken from the World Bank’s World Development Indicators. Energy modelling involved the estimation of final energy consumption and the corresponding primary energy requirements or supply. Figure 1B.1 shows the model structure from final energy demand projection and estimation of transformation inputs to arrive at the primary energy requirements.

The econometric approach was used in forecasting Malaysia’s final energy demand. The historical correlation between energy demand as well as macroeconomic and activity indicators were derived by regression analysis using Microfit, an interactive software for microcomputers designed especially for the econometric modelling of time series data. It has powerful features for data processing, file management, graphic display, estimation, hypothesis testing, and forecasting under a variety of univariate and multivariate model specifications.

The future energy demand for various energy sources were estimated using assumed values of the macroeconomic and activity indicators. Future values of these indicators were also derived using historical data depending on their sufficiency for such analysis. In the model structure, energy demand was modelled as a function of activity such as income, industrial production, number of vehicles, number of households, number of appliances, floor area of buildings, etc. In the residential sector, for example, the demand for electricity could be a function of number of households, disposable income, and penetration rate of electrical appliances. In the commercial sector, energy consumption could be driven by building floor areas, private consumption, and other factors that encourage commercial activities. However, due to unavailable information on the activity indicators, macroeconomic data, i.e. GDP, was the best variable to search for the relationship with the energy demand trend. The GDP information was broken down into industry GDP, commercial GDP, agriculture GDP, and manufacturing GDP. These macroeconomic indicators were mainly used to generate the model equations. In some cases, where regression analysis was not applicable due to insufficiency of data or failure to derive a statistically sound equation, other methods such as share of percentage approach were used. Figure 1B.1 describes the flow of modelling structure of the energy demand outlook.
2. Industry Sector

Total Industry Sector

\[(\text{INTTC}): 1105.5*\text{CONST} + 27.4371*\text{MNGDP} - 986.1141*\text{RPOIL} + 0.76655*\text{INTTC}(-1)\]

Average Annual Growth Rate (2013–2040): 3.16 %
Table 1B.1. Coefficient Estimates of Total Industry Sector

Ordinary Least Squares Estimation

Dependent variable is INTTC
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>1105.5</td>
<td>948.1395</td>
<td>1.1660 [.258]</td>
</tr>
<tr>
<td>MNGDP</td>
<td>27.4371</td>
<td>16.6577</td>
<td>1.6471 [.116]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-986.1141</td>
<td>851.0325</td>
<td>-1.1587 [.261]</td>
</tr>
<tr>
<td>INTTC(-1)</td>
<td>.76655</td>
<td>.13197</td>
<td>5.8087 [.000]</td>
</tr>
</tbody>
</table>

R-Squared .89417 R-Bar-Squared .87746
S.E. of Regression 1316.1 F-stat. F( 3, 19) 53.5127 [.000]
Mean of Dependent Variable 12023.5 S.D. of Dependent Variable 3759.6
Residual Sum of Squares 3.298+07 Equation Log-likelihood -195.6336
Akaike Info. Criterion -199.6336 Schwarz Bayesian Criterion -201.9046
DW-statistic 1.1141 Durbin's h-statistic 2.7436 [.006]

Source: Microfit result.

Figure 1B.2. Plot of actual and fitted values of total industry sector

3. Coal Demand in Industry Sector

\[ \text{INLB} = -5.5412 + 4.0091 \times \text{MNGDP} + 0.52011 \times \text{INLB} (-1) \]

Average Annual Growth Rate (2013–2040): 2.87 %
Table 1B.2. Coefficient Estimates of Coal Demand in Industry Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio(Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>-5.5411</td>
<td>87.0944</td>
<td>-.063623(.950)</td>
</tr>
<tr>
<td>MNGDP</td>
<td>4.0091</td>
<td>1.6053</td>
<td>2.4974 (.021)</td>
</tr>
<tr>
<td>INLB(-1)</td>
<td>.52011</td>
<td>.17588</td>
<td>2.9572 (.008)</td>
</tr>
</tbody>
</table>

Dependent variable is INLB
23 observations used for estimation from 1991 to 2013

Source: Microfit result.

Figure 1B.3. Plot of actual and fitted values of coal demand
4. Natural Gas Demand in Industry Sector

\[
INNG = -507.5752 + 5.5600*INGDP - 2519.1*RPRNG + 0.80290*INNG (-1)
\]

Table 1B.3. Coefficient Estimates of Gas Demand in Industry Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>-507.5752</td>
<td>594.2775</td>
<td>-.8541[.404]</td>
</tr>
<tr>
<td>INGDP</td>
<td>5.5600</td>
<td>3.8590</td>
<td>1.4408[.166]</td>
</tr>
<tr>
<td>RPRNG</td>
<td>-2519.1</td>
<td>3160.2</td>
<td>-.7971[.435]</td>
</tr>
<tr>
<td>INNG(-1)</td>
<td>.80290</td>
<td>.11943</td>
<td>6.7229[.000]</td>
</tr>
</tbody>
</table>

Source: Microfit result.

5. Electricity Demand in Industry Sector

\[
INEL = 18.0327 + 9.4470*MNGDP - 169.9169*RPOIL + 0.68847*INEL (-1)
\]

Average Annual Growth Rate (2013–2040): 3.20 %
Table 1B.4. Coefficient Estimates of Electricity Demand

Ordinary Least Squares Estimation

Dependent variable is INEL
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>18.0327</td>
<td>74.7523</td>
<td>.24123 [.812]</td>
</tr>
<tr>
<td>MWGDP</td>
<td>9.4470</td>
<td>2.7063</td>
<td>3.4882 [.002]</td>
</tr>
<tr>
<td>INEL(-1)</td>
<td>-169.9169</td>
<td>66.3959</td>
<td>-2.5591 [.019]</td>
</tr>
<tr>
<td></td>
<td>.09847</td>
<td>.099358</td>
<td>6.9292 [.000]</td>
</tr>
</tbody>
</table>

R-Squared .99290 R-Bar-Squared .99178
S.E. of Regression 96.9606 F-stat. F(3, 19) 885.5087 [.000]
Mean of Dependent Variable 2904.0 S.D. of Dependent Variable 1069.3
Residual Sum of Squares 178625.8 Equation Log-likelihood -135.6475
Akaike Info. Criterion -139.6475 Schwarz Bayesian Criterion -141.9185
DW-statistic 1.5416 Durbin's h-statistic 1.2503 [.211]

Source: Microfit result.

Figure 1B.5. Plot of actual and fitted values of electricity demand
6. Transport Sector

Jet Kerosene Demand in Transport Sector

\[ TRJK = -87.3853 + 2.2125 \times GDP - 165.5858 \times RPOIL + 0.51359 \times TRJK \ (-1) \]

Average Annual Growth Rate (2013–2040): 3.55 %

Table 1B.5. Coefficient Estimates of Jet Kerosene Demand

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>-87.3853</td>
<td>81.9289</td>
<td>-1.0666 [.300]</td>
</tr>
<tr>
<td>GDP</td>
<td>2.2125</td>
<td>.57156</td>
<td>3.8709 [.001]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-165.5858</td>
<td>70.8858</td>
<td>-2.3360 [.031]</td>
</tr>
<tr>
<td>TRJK(-1)</td>
<td>.51359</td>
<td>.15524</td>
<td>3.3083 [.004]</td>
</tr>
</tbody>
</table>

Average Annual Growth Rate (2013–2040): 3.55 %

Motor Gasoline Demand in Transport Sector

\[ TSMG = -246.4996 + 10.8371 \times GDP - 989.7284 \times RPOIL + 0.39919 \times TSMG \ (-1) \]

Average Annual Growth Rate (2013–2040): 3.51 %
Table 1B.6. Coefficient Estimates of Motor Gasoline Demand

Ordinary Least Squares Estimation

Dependent variable is TSMG
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>-246.4996</td>
<td>556.3996</td>
<td>-0.44303 [.663]</td>
</tr>
<tr>
<td>GDP</td>
<td>10.8371</td>
<td>2.7401</td>
<td>3.9551 [.001]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-989.7284</td>
<td>469.3141</td>
<td>-2.1089 [.048]</td>
</tr>
<tr>
<td>TSMG(-1)</td>
<td>.39919</td>
<td>.20797</td>
<td>1.9155 [.070]</td>
</tr>
</tbody>
</table>

R-Squared: .91353  R-Bar-Squared: .89987
S.E. of Regression: 705.3982  F-stat: F(3,19) 66.9081 [.000]
Mean of Dependent Variable: 6841.3  S.D. of Dependent Variable: 2229.3
Residual Sum of Squares: 945446  Equation Log-Likelihood: -181.2900
Akaike Info. Criterion: -185.2900  Schwarz Bayesian Criterion: -187.5610
DW-statistic: 1.5664  Durbin's h-statistic: 14.3911 [.000]

Source: Microfit result.

Figure 1B.7. Plot of actual and fitted value of motor gasoline demand
Diesel Demand in Transport Sector

\[ TRGD = -90.1833 + 17.8414 \times \text{MNGDP} - 5900.6 \times \text{RPRGD} + 0.43692 \times \text{TRGD} (\cdot 1) \]

Average Annual Growth Rate (2013–2040): 2.82 %

Table 1B.7. Coefficient Estimates of Diesel Demand

<table>
<thead>
<tr>
<th>Dependent Variable is TRGD</th>
<th>23 observations used for estimation from 1991 to 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regressor</td>
<td>Coefficient</td>
</tr>
<tr>
<td>CONST</td>
<td>-90.1833</td>
</tr>
<tr>
<td>MNGDP</td>
<td>17.8414</td>
</tr>
<tr>
<td>RPRGD</td>
<td>-5900.6</td>
</tr>
<tr>
<td>TRGD(-1)</td>
<td>.43692</td>
</tr>
</tbody>
</table>

Ordinary Least Squares Estimation

| R-Squared                  | .90274       | R-Bar-Squared  | .90823       |
| S.E. of Regression        | 456.1234     | F-stat. F(3,19) | 73.5773 [.000] |
| Mean of Dependent Variable| 4064.0       | S.D. of Dependent Variable | 1505.7 |
| Residual Sum of Squares   | 3952923      | Equation Log-Likelihood | -171.2620 |
| Akaike Info. Criterion    | -175.2620    | Schwarz Bayesian Criterion | -177.5330 |
| DW-statistic              | 2.0617       | Durbin's h-statistic | -.29569 [.767] |

Source: Microfit result.

Figure 1B.8. Plot of actual and fitted value of diesel demand

Plot of Actual and Fitted Values

7. Others Sector

Total Energy Demand in Others Sector

\[ OSTT = 220.6223 + 17.5420 \times \text{CSGDP} - 43.6012 \times \text{RRPOIL} + 0.025252 \times \text{OSTT} (\cdot 1) \]

Average Annual Growth Rate (2013–2040): 3.52 %

34
Table 1B.8. Coefficient Estimates of Others Sector Demand

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSGDP</td>
<td>129.6223</td>
<td>146.3524</td>
<td>0.8709[0.449]</td>
</tr>
<tr>
<td>RRPOIL</td>
<td>-17.5420</td>
<td>4.2622</td>
<td>4.0158[0.001]</td>
</tr>
<tr>
<td>OSPP(-1)</td>
<td>+43.4612</td>
<td>17.8712</td>
<td>-2.4522[0.04]</td>
</tr>
</tbody>
</table>

Source: Microfit result.

Figure 1B.9. Plot of actual and fitted values of other sectors demand

Total Energy Demand of Petroleum Products in Others Sector

\[
OSPP = 610.1269 + 6.6199*CSGDP - 265.9463*RRPOIL - 0.036547*OSPP(-1)
\]

Average Annual Growth Rate (2013–2040): 3.32 %
Table 1B.9. Coefficient Estimates of Petroleum Products in Others Sector Demand

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST</td>
<td>116.1268</td>
<td>157.5910</td>
<td>0.735</td>
<td>0.465</td>
</tr>
<tr>
<td>GDP</td>
<td>6.5199</td>
<td>1.2822</td>
<td>4.950</td>
<td>0.000</td>
</tr>
<tr>
<td>RPRLP</td>
<td>-205.9463</td>
<td>157.4980</td>
<td>-1.307</td>
<td>0.192</td>
</tr>
<tr>
<td>OSPP(-1)</td>
<td>-0.35247</td>
<td>0.30854</td>
<td>-1.146</td>
<td>0.261</td>
</tr>
</tbody>
</table>

R-Squared    : 0.29597
F-Stat.      : 229.5971
D.W. Stat.   : 1.7418
Durbin's Test: NA

Source: Microfit result.

Figure 1B.10. Plot of actual and fitted value of petroleum products in other sectors demand

LPG Demand in the Others Sector

\[ \text{OSLP} = 871.4548 + 0.82150*\text{CSGDP} - 24571.4*\text{RPRLP} + 0.45162*\text{OSLP}(-1) \]

Average Annual Growth Rate (2013–2040): 2.04 %
Table 1B.10. Coefficient Estimates of LPG Demand

Ordinary Least Squares Estimation

Dependent variable is OSEL
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSEL(-1)</td>
<td>0.45162</td>
<td>0.20244</td>
<td>2.2308</td>
<td>0.038</td>
</tr>
<tr>
<td>R^2-Squared</td>
<td>0.92173</td>
<td>R-Bar-Squared</td>
<td>0.90937</td>
<td></td>
</tr>
<tr>
<td>S.E. of Regression</td>
<td>64.0227</td>
<td>F-stat.</td>
<td>F( 3, 19)</td>
<td>74.5861</td>
</tr>
<tr>
<td>Mean of Dependent Variable</td>
<td>1056.7</td>
<td>S.E. of Dependent Variable</td>
<td>279.1079</td>
<td></td>
</tr>
<tr>
<td>Residual Sum of Squares</td>
<td>134136.4</td>
<td>Equation Log-Likelihood</td>
<td>-132.3534</td>
<td></td>
</tr>
<tr>
<td>Akaike Info. Criterion</td>
<td>-136.3534</td>
<td>Schwarz Bayesian Criterion</td>
<td>-138.6244</td>
<td></td>
</tr>
<tr>
<td>DW-statistic</td>
<td>2.2691</td>
<td>Durbin's h-statistic</td>
<td>-2.6934</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Source: Microfit result.

Figure 1B.11. Plot of actual and fitted value of LPG demand

Electricity Demand in the Others Sector

\[
OSEL = 298.2890 + 1.2677*CGDP - 732.9436*RPREL + 0.93157*OSEL(-1)
\]

Average Annual Growth Rate (2013–2040): 3.91 %
Table 1B.11. Coefficient Estimates of Electricity Demand in Other Sectors

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Fprob]</th>
</tr>
</thead>
<tbody>
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<td>217.5719</td>
<td>1.310[.186]</td>
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<tr>
<td>CSGDP</td>
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<td>.99305</td>
<td>1.2765[.217]</td>
</tr>
<tr>
<td>RHREL</td>
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<td>675.1614</td>
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</tr>
<tr>
<td>OSEL(-1)</td>
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<td>.081069</td>
<td>11.4910[.000]</td>
</tr>
</tbody>
</table>

R-Squared .99849 R-Bar-Squared .99925
S.E. of Regression 62.4854 F-stat. F( 3, 19) 4174.6[.000]
Mean of Dependent Variable 3054.0 S.D. of Dependent Variable 1492.0
Residual Sum of Squares 74194.2 Equation Log-Likelihood -125.5419
Akaike Info. Criterion -129.5419 Schwarz Bayesian Criterion -131.8129
DW-statistic 2.2865 Durbin’s h-statistic -.74565[.456]

Source: Microfit result.

Figure 1B.12. Plot of actual and fitted value of electricity demand in other sectors

Conclusions

By using national energy data from 1990 to 2013, major energy demand functions can be generated using the Microfit software. However, due to non-linear historical energy data for some parameters, the software was unable to generate satisfactory outcome. To overcome this problem, other methodologies, such as fuel share proportion or targeted growth rate, can be applied. Further improvement of historical data needs to be done to ensure that the time series data provide a good trend without any outliers.

In this exercise, other parameters, such as energy prices, were also chosen to determine the energy demand for the future. However, current information or data on future energy prices data are very limited due to uncertain economic situation. Information on short-term periods (less than 5 years) might be available but might be very hard to predict for long-term periods (until 2040).
Overall, some improvements need to be considered for the future development of the demand functions for Malaysia, mainly issues on historical energy time series data and other useful parameters for analysis.
1C. National Energy Data Estimations of the Philippines

1. Introduction

Based on the energy database of the Asia-Pacific Economic Cooperation, the total final energy consumption (TFEC) of the Philippines was 26.3 metric tonnes of oil equivalent (Mtoe) in 2013, growing by 1.3% from its 1990 level of 19.5 Mtoe (see Figures 1C.1 and 1C.2). The residential sector recorded the highest level of energy demand with an annual average share of 35.4% to TFEC. In terms of rate of increase, however, the sector’s share in the demand mix was decreasing to a rate of 0.5% per year of the demand level during the period. On the other hand, the transport and industry sectors, with considerably significant annual average shares of 32.2% and 24%, respectively, to the demand mix, registered yearly increase of 3% and 1.1%, respectively. Nevertheless, the fact that the main driver of growth in the country was the services sector, which is composed of essentially lesser energy-intensive establishments, commercial sectors grew the highest at 5.8% per year with an annual average share of 7.8%.

Figure 1C.1. Total Final Energy Consumption by Sector, 1990–2013

In terms of TFEC by fuel, oil dominated the demand mix during the period with an annual average share of 49.3%. Likewise, biomass has a significant share in the demand mix with an annual average share of around 30% to TFEC. However, its share to the demand mix was decreasing as its energy demand level declined at a rate of 1.2% per year. Meanwhile, the demand levels of electricity and coal grew the fastest at 4.7% and 4.9%, respectively, with annual average shares of 14.7% and 5.1%, respectively, to TFEC.
2. Estimation of Energy Demand Equation by Sector

In simulating the dataset to formulate the demand equation by fuel for each sector, linear regression was applied for the sample data covering the period 1990–2013. The Microfit forecasting tool was used to estimate the demand model for each fuel by sector.

Industry demand model

The fuels utilised in the industry sector include coal, electricity, diesel oil, fuel oil, liquefied petroleum gas (LPG), kerosene, biomass, and natural gas (Table 1C.1).

Table 1C.1. Industry Demand Mix, 2013

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>33.1%</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.2%</td>
</tr>
<tr>
<td>Diesel</td>
<td>10.4%</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>7.9%</td>
</tr>
<tr>
<td>LPG</td>
<td>1.8%</td>
</tr>
<tr>
<td>Biomass</td>
<td>17.3%</td>
</tr>
<tr>
<td>Electricity</td>
<td>28.2%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>1.0%</td>
</tr>
<tr>
<td>Total Demand</td>
<td>6.3 Mtoe</td>
</tr>
</tbody>
</table>

LPG = liquefied petroleum gas, Mtoe = million tonne of oil equivalent.
Source: Department of Energy, Philippines.
The following are the variables used to define the demand model for each fuel utilised in the industry sector:

1) Coal (CL):

1.1 Non-metallic minerals (NM): NMCL constant BNMMFGVA RCOILPR

Coal is mostly utilised in cement production which is within the non-metallic minerals subsector of the manufacturing sector. The explanatory variables used in the equation are GVA of the manufacturing sector and ratio of coal and crude oil prices.

1.2 Coal demand in industry (IN): INCL constant LINGDP INCL(-1)

Total coal demand of industry was defined as the function of industry GVA in logarithm and its previous year’s total demand. This equation has been formulated just to cover coal consumptions in other subsectors of manufacturing other than in non-metallic mineral subsector, which are insignificant in terms of demand level.

2) Electricity (EL): INEL constant LBINGDP

Total electricity consumption’s explanatory variable identified as industry GVA in billion and logarithm.

3) Diesel (GD):

3.1 Diesel for mining and construction: OTHGD CONSTANT LOTINGDP OTHGD(-1)

OTHGD is the diesel oil demand in the mining and construction subsectors of the industry sector. Diesel oil in these subsectors was significant in terms of its level of consumption. Its explanatory variables identified as mining and construction GVA in logarithm and its previous year’s demand level.

3.2 Diesel demand in industry (INGD): INGD CONSTANT LINGDP DUM939578

Total diesel oil demand equation was also derived to cover the diesel oil utilisation in the manufacturing subsector, which was defined as a function of industry GVA in logarithm.

4) Fuel oil (INFO): INFO CONSTANT RPOIL INFO(-1) DUM935770

The total fuel oil consumption was equated with the crude oil price and its previous year’s demand level.

5) Petroleum products: INPP CONSTANT RPOIL INPP(-1) DUM935778

The total petroleum products demand equation was derived with its relationship with the price of crude oil and its previous year’s demand level. Its equation was derived to estimate the percentage shares of LPG and kerosene consumption as the difference of the total petroleum products consumption and diesel plus fuel oil consumption, which are small portion of the industry demand mix.
6) LPG and kerosene:
LPG and kerosene will be projected with their percentage shares in the total petroleum products demand (not fit for linear regression).

7) Other (biomass) and natural gas:
Biomass and natural gas will be projected using energy intensity (not fit for linear regression)

3. Transport demand model

The transport sector is comprised of road transport (including rail), air transport, and water transport. The derivation of demand equation for transport sector was formulated by mode of transport as follows:

Road transport (RD)
1) Motor gasoline (MG): $R_{DMG} \text{constant } RR_{POILJ} RN_{OMGV90} R_{DMg(-1)}$
   The motor gasoline demand equation was derived from the relationship of motor gasoline with the relative growth rate of crude oil (1990=1) and relative growth rate of number of gasoline motor vehicles (1990=1).
2) Diesel (GD): $R_{DG} \text{constant } RR_{POILJ} RN_{ODSLVE}$
   The diesel oil demand equation was also derived from the relationship of diesel oil with the relative growth rate of crude oil (1990=1) and relative growth rate of number of diesel motor vehicles (1990=1).
3) LPG and natural gas
   LPG and natural gas will be projected based on the number of their demand technology. LPG consumption in road transport is very small and started being utilised only in 2000 while the current demand for natural gas is negligible.
4) Electricity (EL): $R_{AE} \text{constant } TR_{DGVA} RA_{E(-1)} DUM2003$
   Electricity consumption demand equation was derived from the relationship of electricity used in rail (RA) transport with the transport GVA and its previous year’s demand level.

Air transport (DA)
Air transport demand: $D_{APP} \text{constant } TG_{DPCAP} DUM989078$
Jet fuel equation was derived with its relationship with GDP per capita in thousand units.
Water transport (IW)

1) Fuel oil: IWFO constant LGDP RPOIL DUM0937

Fuel oil for inland waterways was defined as a function of GDP in logarithm and price of crude oil.

2) Diesel: IWGD constant LGDP RPOIL IWGD(-1)

Diesel oil was defined as a function of GDP in logarithm, price of crude oil, and its previous year’s demand level.

3) Motor gasoline: IWMG constant LCSGDP RPOIL IWMG(-1)

Motor gasoline consumption for inland waterways was defined as a function of services sector GVA, price of crude oil, and its previous year’s demand level.

4. Other sectors demand model

Other sectors include commercial, residential, and agriculture sectors. The formulation of demand equation for other sectors was disaggregated based on the specified sectors as follows:

Commercial (CS)

1) LPG: CSLP constant LCSGDP RPOIL CSLP(-1)

LPG demand equation was derived from its relationship with commercial sector GVA in logarithm, price of crude oil, and its previous year’s demand level.

2) Diesel: CSGD constant MCSGDP RDSLPR CSGD(-1)

Diesel oil used variables such as commercial sector GVA, diesel oil price, and its previous year’s demand level.

3) Electricity: CSEL constant LBCSGDP CSEL(-1)

Electricity for commercial sector was defined as being correlated with commercial GVA in logarithm and its previous year’s demand level.

4) Biomass and fuel oil: Projection using energy intensity (no regression)

Biomass and fuel oil as part of the demand mix of commercial sector will be projected using energy intensity (not fit for linear regression).

Residential (RE)

1) LPG: RELP constant LHEXP RPOIL RELP(-1)

LPG demand equation was derived using variables such as household final consumption expenditure in log, crude oil price, and its previous year’s demand level.
2) Kerosene (OK): REOK constant R2KERPR \( \text{REOK}(-1) \)

Kerosene demand equation was derived using variables such as local price of kerosene and its previous year’s demand level.

3) Electricity: REEL constant LBHEXP R2REELPR

Electricity was defined as a function of household final consumption expenditure in billion and log and local electricity price in residential sector.

4) Others (biomass): REOTH constant BPOPR \( \text{REOTH}(-1) \)

Biomass demand equation was derived using population of rural areas in billion and its previous year’s demand level.

Agriculture (AG)

1) Diesel: TAGGD constant RPOIL \( \text{TAGGD}(-1) \) DUM07

Diesel oil consumption in agriculture sector was defined as a function of crude oil price and its previous year’s demand level.

2) Other petroleum products: OTAGPP constant RPOIL DUM978347

The petroleum products demand equation was formulated to get the percentage shares of motor gasoline, fuel oil, and kerosene as the difference of the total petroleum products and diesel oil demand in the agriculture demand mix.

3) Motor gasoline, fuel oil, and kerosene:

Motor gasoline, fuel oil, and kerosene consumption in agriculture will be projected using their proportion to the total petroleum products consumption.

4) Electricity: TAGEL constant laggdp \( \text{tagel}(-1) \)

Electricity demand equation in agriculture was derived from its relationship with agriculture GVA in log and its previous year’s demand level.

5. Data and Estimations of Regression Results

Final energy consumption
Table 1C.2. Final Energy Consumption by Sector, 1990–2013, ktoe

<table>
<thead>
<tr>
<th>Year</th>
<th>Industry</th>
<th>Transport</th>
<th>Commercial</th>
<th>Residential</th>
<th>Agriculture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>4,896</td>
<td>4,290</td>
<td>841</td>
<td>9,164</td>
<td>283</td>
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<td>4,341</td>
<td>877</td>
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<td>261</td>
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<td>4,943</td>
<td>887</td>
<td>8,863</td>
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<td>875</td>
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<td>5,278</td>
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<td>358</td>
<td>26,276</td>
</tr>
</tbody>
</table>

ktoe = kilotonne of oil equivalent.

Source: Department of Energy, Philippines.
<table>
<thead>
<tr>
<th>Year</th>
<th>Oil</th>
<th>Coal</th>
<th>Electricity</th>
<th>Others</th>
<th>Total</th>
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<tr>
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<td>5,295</td>
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<td>26,276</td>
</tr>
</tbody>
</table>

ktoe = kilotonne of oil equivalent.

Source: Department of Energy, Philippines.

6. **Industry demand model**

1) Coal

1.1 Non-metallic minerals:

NMCL constant BNMMFGVA RCOILPR
### Table 1C.4. Coefficient Estimates of Non-metallic Mineral Demand in Industry

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
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<td>171.476</td>
<td>4.261 [.000]</td>
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<td>5.601 [.000]</td>
</tr>
<tr>
<td>RCOILPR</td>
<td>-1370.5</td>
<td>223.1813</td>
<td>-6.1406 [.000]</td>
</tr>
</tbody>
</table>

---

**R-Squared**: 0.80531  
**R-Bar-Squared**: 0.78677  
**F-stat. F(2,21)**: 43.4322 [.000]  
**S.E. of Regression**: 198.5057  
**Mean of Dependent Variable**: 962.1444  
**S.D. of Dependent Variable**: 429.8807  
**Residual Sum of Squares**: 827494.9  
**Equation Log-likelihood**: -159.4318  
**Akaike Info. Criterion**: -162.4318  
**Schwarz Bayesian Criterion**: -164.1989  
**DW-statistic**: 1.7217

Source: Author’s calculations.

### Figure 1C.3. Plot of Actual and Fitted Values of Non-metallic Mineral Demand in Industry

![Plot of Actual and Fitted Values](source)

Source: Author’s calculations.

NMCL = 730.6747*CONSTANT + 29.7715*BNMMFGVA - 1370.5*RCOILPR

1.2 Coal industry

INCL constant BINGDP INCL(-1)
Table 1C.5. Coefficient Estimates of Coal Demand in Industry

Ordinary Least Squares Estimation

Dependent variable is INCL
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-271.5342</td>
<td>114.1237</td>
<td>-2.3793[.027]</td>
</tr>
<tr>
<td>BINGDP</td>
<td>.63547</td>
<td>.18277</td>
<td>3.4769[.002]</td>
</tr>
<tr>
<td>INCL(-1)</td>
<td>.50380</td>
<td>.16312</td>
<td>3.0884[.006]</td>
</tr>
</tbody>
</table>

R-Squared                     .93351   R-Bar-Squared                   .92686
S.E. of Regression           121.1182   F-stat.   F( 2, 20) 140.3907[.000]
Mean of Dependent Variable  1174.8   S.D. of Dependent Variable  447.8409
Residual Sum of Squares     293392.5   Equation Log-likelihood -141.3540
Akaike Info. Criterion      -144.3540   Schwarz Bayesian Criterion -146.0572
DW-statistic                1.9066   Durbin's h-statistic         .35953[.719]

Source: Author’s calculations.

Figure 1C.4. Plot of Actual and Fitted Values of Coal Demand in Industry

INCL = -271.5342*CONSTANT + 0.63547*BINGDP + 0.50380*INCL(-1)

2) Electricity

INEL constant LBINGDP
Table 1C.6. Coefficient Estimates of Electricity Demand in Industry

Ordinary Least Squares Estimation

Dependent variable is INEL
24 observations used for estimation from 1990 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-6985.9</td>
<td>206.1562</td>
<td>-33.8866[.000]</td>
</tr>
<tr>
<td>LBINGDP</td>
<td>1140.6</td>
<td>28.6448</td>
<td>39.8176[.000]</td>
</tr>
</tbody>
</table>

R-Squared                     .98631   R-Bar-Squared                   .98569
S.E. of Regression           35.8191   F-stat.    F(  1,  22)    1585.4[.000]
Mean of Dependent Variable    1217.6   S.D. of Dependent Variable    299.4462
Residual Sum of Squares      28226.2   Equation Log-likelihood      -118.8940
Akaike Info. Criterion       -120.8940  Schwarz Bayesian Criterion   -122.0720
DW-statistic                  1.7414

Figure 1C.5. Plot of Actual and Fitted Values of Electricity Demand in Industry

INEL = -6985.9*CONSTANT + 1140.6*LBINGDP

3) Diesel

3.1 Diesel for mining and construction sector

OTHGD CONSTANT LOTINGDP OTHGD(-1)
Table 1C.7. Coefficient Estimates of Diesel for Mining and Construction Demand

Ordinary Least Squares Estimation
*******************************************************************************
Dependent variable is OTHGD
23 observations used for estimation from 1991 to 2013
*******************************************************************************
Regressor              Coefficient       Standard Error         T-Ratio[Prob]
CONSTANT               -1337.9           608.6225      -2.1983[.040]
LOTINGDP               50.8158            23.2980         2.1811[.041]
OTHGD(-1)              .94589             .13607          6.9518[.000]
*******************************************************************************
R-Squared               .84398   R-Bar-Squared   .82838
S.E. of Regression      25.2109   F-stat.          F( 2, 20) 54.0953[.000]
Mean of Dependent Variable 181.4092   S.D. of Dependent Variable 60.8561
Residual Sum of Squares 12711.7
Akaike Info. Criterion -108.2556
Schwarz Bayesian Criterion -109.9589
Durbin's h-statistic    .34859[.727]
*******************************************************************************

OTHGD = -1337.9*CONSTANT + 50.8158*LOTINGDP + .94589*OTHGD(-1)

3.2 Diesel demand in industry

INGD CONSTANT LINGDP DUM939578
Table 1C.8. Coefficient Estimates of Diesel Demand in Industry

Ordinary Least Squares Estimation
Dependent variable is INGD
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-7389.8</td>
<td>1075.6</td>
<td>-6.8706[.000]</td>
</tr>
<tr>
<td>LINGDP</td>
<td>284.1724</td>
<td>38.5950</td>
<td>7.3629[.000]</td>
</tr>
<tr>
<td>DUM939578</td>
<td>-77.3006</td>
<td>21.0673</td>
<td>-3.6692[.002]</td>
</tr>
</tbody>
</table>

R-Squared                     .75047   R-Bar-Squared                   .72552
S.E. of Regression           45.7941   F-stat.   F( 2, 20)   30.0759[.000]
Mean of Dependent Variable   493.3329   S.D. of Dependent Variable    87.4087
Residual Sum of Squares      41942.0    Equation Log-likelihood       -118.9839
Akaike Info. Criterion       -121.9839  Schwarz Bayesian Criterion   -123.6871
DW-statistic                 1.9550

Figure 1C.7. Plot of Actual and Fitted Values of Diesel Demand in Industry

INGD = -7389.8*CONSTANT + 284.1724*LINGDP - 77.3006*DUM939578

4) Fuel oil

INFO CONSTANT RPOIL INFO(-1) DUM935770
Table 1C.9. Coefficient Estimates of Fuel Oil Demand in Industry

Ordinary Least Squares Estimation

Dependent variable is INFO
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>1140.9</td>
<td>307.7944</td>
<td>3.7065 [.001]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-19.8698</td>
<td>8.9321</td>
<td>-2.2245 [.038]</td>
</tr>
<tr>
<td>INFO(-1)</td>
<td>.63875</td>
<td>.13994</td>
<td>4.5644 [.000]</td>
</tr>
<tr>
<td>DUM935770</td>
<td>-483.5952</td>
<td>116.5109</td>
<td>-4.1506 [.001]</td>
</tr>
</tbody>
</table>

R-Squared: .86595  R-Bar-Squared: .84479
S.E. of Regression: 219.6716  F-stat: F(3, 19) 40.9131 [.000]
Mean of Dependent Variable: 1306.4  S.D. of Dependent Variable: 557.5808
Residual Sum of Squares: 916856.4  Equation Log-likelihood: -154.4575
Akaike Info. Criterion: -158.4575  Schwarz Bayesian Criterion: -160.7285
DW-statistic: 1.6433  Durbin's h-statistic: 1.1536 [.249]

Figure 1C.8. Plot of Actual and Fitted Values of Fuel Oil Demand in Industry

INFO = 1140.9*CONSTANT -19.8698*RPOIL + .63875*INFO(-1) -483.5952*DUM935770

5) Petroleum products

INPP CONSTANT RPOIL INPP(-1) DUM935778
### Table 1C.10. Coefficient Estimates of Petroleum Products Demand in Industry

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>2043.8</td>
<td>463.6495</td>
<td>4.4081[.000]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-28.9752</td>
<td>10.0196</td>
<td>-2.8919[.009]</td>
</tr>
<tr>
<td>INPP(-1)</td>
<td>.40690</td>
<td>.15800</td>
<td>2.5752[.019]</td>
</tr>
<tr>
<td>DUM935778</td>
<td>-512.6589</td>
<td>143.3941</td>
<td>-3.5752[.002]</td>
</tr>
</tbody>
</table>

R-Squared: .77237  R-Bar-Squared: .73643
S.E. of Regression: 282.5306  F-stat. F( 3, 19) 21.4894[.000]
Mean of Dependent Variable: 1999.5  S.D. of Dependent Variable: 550.3191
Residual Sum of Squares: 1516647  Equation Log-likelihood: -160.2455
Akaike Info. Criterion: -164.2455  Schwarz Bayesian Criterion: -166.5165
DW-statistic: 1.5512  Durbin’s h-statistic: 1.6491[.099]

#### Figure 1C.9. Plot of Actual and Fitted Values of Petroleum Products Demand in Industry

**Plot of Actual and Fitted Values**

```
INPP = 2043.8*CONSTANT -28.9752*RPOIL + .40690*INPP(-1) -512.6589*DUM935778
```

**Transport demand model**

1. **Road Transport**

1.1 **Motor gasoline**

   RDMG constant RRPOILJ RNOMGVE90 RDMg(-1)
Table 1C.11. Coefficient Estimates of Motor Gasoline Demand in Transport

Ordinary Least Squares Estimation

Dependent variable is RDMG
22 observations used for estimation from 1991 to 2012

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>433.7545</td>
<td>133.7149</td>
<td>3.2439[.005]</td>
</tr>
<tr>
<td>RRPOILJ</td>
<td>-285.7495</td>
<td>79.2469</td>
<td>-3.6058[.002]</td>
</tr>
<tr>
<td>RNOMGVE90</td>
<td>494.1055</td>
<td>137.3021</td>
<td>3.5987[.002]</td>
</tr>
<tr>
<td>RDMG(-1)</td>
<td>.51980</td>
<td>.13246</td>
<td>3.9241[.001]</td>
</tr>
</tbody>
</table>

R-Squared                      .95816   R-Bar-Squared       .95118
S.E. of Regression            116.3466  F-stat.  F( 3, 18) 137.3897[.000]
Mean of Dependent Variable    2404.4    S.D. of Dependent Variable 526.5792
Residual Sum of Squares       243657.6  Equation Log-likelihood -133.6539
Akaike Info. Criterion        -137.6539  Schwarz Bayesian Criterion -139.8360
DW-statistic                  1.6514    Durbin's h-statistic      1.0433[.297]

Figure 1C.10. Plot of Actual and Fitted Values of Motor Gasoline Demand in Transport

Plot of Actual and Fitted Values

RDMG = 433.7545*CONSTANT - 285.7495*RRPOILJ + 494.1055*RNOMGVE90 + .51980*RDMG(-1)

1.2 Diesel

RDGD constant RRPOILJ RNODSLVE
### Table 1C.12. Coefficient Estimates of Diesel Demand in Transport

**Ordinary Least Squares Estimation**

Dependent variable is RDGD
24 observations used for estimation from 1990 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>1604.5</td>
<td>128.5955</td>
<td>12.4772[.000]</td>
</tr>
<tr>
<td>RRPOILJ</td>
<td>-343.4349</td>
<td>42.1219</td>
<td>-8.1534[.000]</td>
</tr>
<tr>
<td>RNODSLVE</td>
<td>1079.4</td>
<td>72.5288</td>
<td>14.8826[.000]</td>
</tr>
</tbody>
</table>

R-Squared                    .93167   R-Bar-Squared               .92516
S.E. of Regression           167.5537  F-stat. F( 2, 21)  143.1707[.000]
Mean of Dependent Variable   3689.4    S.D. of Dependent Variable 612.4921
Residual Sum of Squares      589558.9  Equation Log-likelihood    -155.3634
Akaike Info. Criterion       -158.3634  Schwarz Bayesian Criterion -160.1305
DW-statistic                 1.2356  

Figure 1C.11. Plot of Actual and Fitted Values of Diesel Demand in Transport

**Plot of Actual and Fitted Values**

RDGD = 1604.5*CONSTANT -343.4349*RRPOILJ + 1079.4*RNODSLVE

1.3 Road transport total

RDPP constant RRPOILJ RNTOOVE
Table 1C.13. Coefficient Estimates of Road Transport Total

Ordinary Least Squares Estimation

Dependent variable is RDPP
23 observations used for estimation from 1990 to 2012

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>2621.6</td>
<td>209.9990</td>
<td>12.4838 [.000]</td>
</tr>
<tr>
<td>RRPOILJ</td>
<td>-1033.4</td>
<td>112.8145</td>
<td>-9.1606 [.000]</td>
</tr>
<tr>
<td>RNOTOOVE</td>
<td>2102.7</td>
<td>147.1657</td>
<td>14.2882 [.000]</td>
</tr>
</tbody>
</table>

R-Squared: .93750, R-Bar-Squared: .93125
S.E. of Regression: 306.4042, F-stat: F( 2, 20) = 150.0002 [.000]
Mean of Dependent Variable: 6047.0, S.D. of Dependent Variable: 1168.6
Residual Sum of Squares: 1877671, Equation Log-likelihood: -162.7011
Akaike Info. Criterion: -165.7011, Schwarz Bayesian Criterion: -167.4044
DW-statistic: 1.6201

Figure 1C.12. Plot of Actual and Fitted Values of Road Transport Total

RDPP = 2621.6*CONSTANT -1033.4*RRPOILJ + 2102.7*RNOTOOVE

1.4 Rail: Electricity

RAEL constant TRDGVA RAEL[-1] DUM2003
Table 1C.14. Coefficient Estimates of Electricity in Rail Transport

Ordinary Least Squares Estimation
*******************************************************************************
Dependent variable is RAEL
22 observations used for estimation from 1991 to 2012
*******************************************************************************
<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-6.7225</td>
<td>1.4360</td>
<td>-4.6814[.000]</td>
</tr>
<tr>
<td>TRDGVA</td>
<td>62.5306</td>
<td>15.4766</td>
<td>4.0403[.001]</td>
</tr>
<tr>
<td>RAEL(-1)</td>
<td>.60962</td>
<td>.094718</td>
<td>6.4362[.000]</td>
</tr>
<tr>
<td>DUM2003</td>
<td>3.0153</td>
<td>.66363</td>
<td>4.5436[.000]</td>
</tr>
</tbody>
</table>
*******************************************************************************
R-Squared       | .96655      | R-Bar-Squared  | .96097          |
S.E. of Regression | .63033    | F-stat.        | F( 3, 18) 173.3573[.000] |
Mean of Dependent Variable | 5.3504  | S.D. of Dependent Variable | 3.1906 |
Residual Sum of Squares | 7.1516  | Equation Log-likelihood | -18.8559 |
Akaike Info. Criterion | -22.8559 | Schwarz Bayesian Criterion | -25.0380 |
DW-statistic    | 1.3356      | Durbin's h-statistic | 1.7391[.082] |
*******************************************************************************

RAEL = -6.7225*CONSTANT + 62.5306*TRDGVA + .60962*RAEL(-1) +3.0153*DUM2003

2) Air transport
2.1 Air transport demand (jet fuel)

DAPP constant TGDPCAP DUM989078
Table 1C.15. Coefficient Estimates of Jet Fuel

Ordinary Least Squares Estimation

Dependent variable is DAPP
12 observations used for estimation from 2002 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-343.5947</td>
<td>130.9274</td>
<td>-2.6243 [.028]</td>
</tr>
<tr>
<td>TGDPCAP</td>
<td>7.9071</td>
<td>2.1992</td>
<td>3.5955 [.006]</td>
</tr>
<tr>
<td>DUM989078</td>
<td>168.4262</td>
<td>39.0732</td>
<td>4.3105 [.002]</td>
</tr>
</tbody>
</table>

R-Squared                     .77354
R-Bar-Squared                 .72321
S.E. of Regression            50.4271
F-stat. F( 2, 9)              15.3709 [.001]
Mean of Dependent Variable 246.7468
S.D. of Dependent Variable  95.8499
Residual Sum of Squares      22886.0
Equation Log-likelihood      -62.3475
Akaike Info. Criterion       -65.3475
Schwarz Bayesian Criterion   -66.0749
DW-statistic                 1.5879

Figure 1C.14. Plot of Actual and Fitted Values of Jet Fuel

DAPP = -343.5947*CONSTANT +7.9071*TGDPCAP +168.4262*DUM989078

3) Water transport

3.1 Fuel oil

IWFO constant LGDP RPOIL DUM0937
Table 1C.16. Coefficient Estimates of Fuel Oil in Water Transport

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-33808.1</td>
<td>9569.8</td>
<td>-3.5328[.002]</td>
</tr>
<tr>
<td>LGDP</td>
<td>1221.1</td>
<td>335.9026</td>
<td>3.6352[.002]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-75.3265</td>
<td>11.4034</td>
<td>-6.6056[.000]</td>
</tr>
<tr>
<td>DUM0937</td>
<td>295.0693</td>
<td>105.9703</td>
<td>2.7845[.012]</td>
</tr>
</tbody>
</table>

R-Squared: .80290   R-Bar-Squared: .77178
S.E. of Regression: 192.3839   F-stat.: F( 3, 19) = 25.7988[.000]
Mean of Dependent Variable: 627.4025   S.D. of Dependent Variable: 402.7060
Residual Sum of Squares: 703219.9   Equation Log-likelihood: -151.4068
Akaike Info. Criterion: -155.4068   Schwarz Bayesian Criterion: -157.6778
DW-statistic: 1.2301

Figure 1C.15. Plot of Actual and Fitted Values of Fuel Oil in Water Transport

IWFO = -33808.1*CONSTANT + 1221.1*LGDP -75.3265*RPOIL + 295.0693*DUM0937

3.2 Diesel

IWGD constant LGDP RPOIL IWGD(-1)
Table 1C.17. Coefficient Estimates of Diesel in Water Transport

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-6504.7</td>
<td>2070.8</td>
<td>-3.1411 [.005]</td>
</tr>
<tr>
<td>LGDP</td>
<td>232.8977</td>
<td>73.4121</td>
<td>3.1725 [.005]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-6.9632</td>
<td>2.1778</td>
<td>-3.1974 [.005]</td>
</tr>
<tr>
<td>IWGD(-1)</td>
<td>.59340</td>
<td>.10939</td>
<td>5.4246 [.000]</td>
</tr>
</tbody>
</table>

R-Squared                     .89115   R-Bar-Squared                   .87397
S.E. of Regression           25.6908   F-stat.  F( 3, 19) 51.8528 [.000]
Mean of Dependent Variable  327.5296   S.D. of Dependent Variable     72.3663
Residual Sum of Squares      12540.3   Equation Log-likelihood        -105.0995
Akaike Info. Criterion       -109.0995  Schwarz Bayesian Criterion   -111.3705
DW-statistic                 1.8800    Durbin’s h-statistic            .33800 [.735]

Figure 1C.16. Plot of Actual and Fitted Values of Diesel in Water Transport

IWGD = -6504.7*CONSTANT + 232.8977*LGDP -6.9632*RPOIL + .59340*IWGD(-1)

3.3 Motor gasoline

IWMG constant LCSGDPS RPOIL IWMTG(-1)
Table 1C.18. Coefficient Estimates of Motor Gasoline in Water Transport

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-458.7576</td>
<td>165.0077</td>
<td>-2.7802 [0.012]</td>
</tr>
<tr>
<td>LCSGDP</td>
<td>16.9625</td>
<td>5.9733</td>
<td>2.8397 [0.011]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.99224</td>
<td>.22169</td>
<td>-4.4758 [0.000]</td>
</tr>
<tr>
<td>IWMG(-1)</td>
<td>.89065</td>
<td>.055098</td>
<td>16.1648 [0.000]</td>
</tr>
</tbody>
</table>

- R-Squared: .95159
- R-Bar-Squared: .94352
- S.E. of Regression: 3.0909
- F-stat. F(3, 18) = 117.9448 [0.000]
- S.D. of Dependent Variable: 13.0064
- Residual Sum of Squares: 171.9705
- Equation Log-likelihood: -53.8357
- Akaike Info. Criterion: -57.8357
- Schwarz Bayesian Criterion: -60.0178
- DW-statistic: 2.2789
- Durbin's h-statistic: -.67703 [0.498]

\[ \text{IWMG} = -458.7576 \times \text{CONSTANT} + 16.9625 \times \text{LCSGDP} - 0.99224 \times \text{RPOIL} + 0.89065 \times \text{IWMG}(-1) \]

B.3 Other sector demand model

Commercial sector demand model

1) LPG

\[ \text{CSLP constant LCSGDP RPOIL CSLP(-1)} \]
### Table 1C.19. Coefficient Estimates of LPG in Commercial Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-1008.6</td>
<td>389.1156</td>
<td>-2.5921[.018]</td>
</tr>
<tr>
<td>LCSGDP</td>
<td>73.7462</td>
<td>27.9569</td>
<td>2.6379[.016]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-2.9345</td>
<td>.94410</td>
<td>3.1083[.006]</td>
</tr>
<tr>
<td>CSLP(-1)</td>
<td>.93630</td>
<td>.095899</td>
<td>9.7634[.000]</td>
</tr>
</tbody>
</table>

**Ordinary Least Squares Estimation**

Dependent variable is CSLP
23 observations used for estimation from 1991 to 2013

**Figure 1C.18. Plot of Actual and Fitted Values of LPG in Commercial Sector**

CSLP = -1008.6*CONSTANT + 73.7462*LCSDGP -2.9345*RPOIL + .93630*CSLP(-1)

2) Diesel

CSGD constant MCSGD P ROIL CSGD(-1)
Table 1C.20. Coefficient Estimates of Diesel in Commercial Sector

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-262.7964</td>
<td>67.2700</td>
<td>-3.9066[.001]</td>
</tr>
<tr>
<td>MCGDP</td>
<td>259.9314</td>
<td>59.8464</td>
<td>4.3433[.000]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-13.1069</td>
<td>3.7415</td>
<td>-3.5301[.002]</td>
</tr>
<tr>
<td>CSGD(-1)</td>
<td>.63577</td>
<td>.13134</td>
<td>4.8407[.000]</td>
</tr>
</tbody>
</table>

R-Squared                      .95687  R- Bar-Squared   .95007  
S.E. of Regression             51.5839  F-stat.        F( 3, 19)  140.5256[.000]  
Mean of Dependent Variable     222.4543  S.D. of Dependent Variable  230.8415  
Residual Sum of Squares        50557.1   Equation Log-likelihood -121.1323  
Akaike Info. Criterion         -125.1323  Schwarz Bayesian Criterion -127.4033  
DW-statistic                   1.6488    Durbin’s h-statistic     1.0843[.278]  

Figure 1C.19. Plot of Actual and Fitted Values of Diesel in Commercial Sector

CSGD = -262.7964*CONSTANT + 259.9314*MCGDP -13.1069*RPOIL + .63577*CSGD(-1)

3) Electricity

CSEL constant LBCSGDP CSEL(-1)
Table 1C.21. Coefficient Estimates of Electricity in Commercial Sector

Ordinary Least Squares Estimation

Dependent variable is CSEL
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-3991.6</td>
<td>1383.4</td>
<td>-2.8853[.009]</td>
</tr>
<tr>
<td>LBCSGDP</td>
<td>594.5959</td>
<td>204.3727</td>
<td>2.9094[.009]</td>
</tr>
<tr>
<td>CSEL(-1)</td>
<td>.44499</td>
<td>.19831</td>
<td>2.2439[.036]</td>
</tr>
</tbody>
</table>

R-Squared .98907  R-Bar-Squared .98797
S.E. of Regression 38.5880  F-stat. F( 2, 20) 904.5527[.000]
Mean of Dependent Variable 973.7839  S.D. of Dependent Variable 351.8522
Residual Sum of Squares 29780.7  Equation Log-likelihood -115.0460
Akaike Info. Criterion -118.0460  Schwarz Bayesian Criterion -119.7492
DW-statistic 1.5973  Durbin's h-statistic 3.1258[.002]

Figure 1C.20. Plot of Actual and Fitted Values of Electricity in Commercial Sector

CSEL = -3991.6*CONSTANT + 594.5959*LBCSGDP + .44499*CSEL(-1)

Residential sector demand model

1) LPG
RELP constant LHEXP RPOIL RELP(-1)
**Table 1C.22. Coefficient Estimates of LPG in Residential Sector**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-12791.2</td>
<td>3792.3</td>
<td>-3.3730[.003]</td>
</tr>
<tr>
<td>LHEXP</td>
<td>465.0721</td>
<td>136.2398</td>
<td>3.4136[.003]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-16.0292</td>
<td>4.0443</td>
<td>-3.9634[.001]</td>
</tr>
<tr>
<td>RELP(-1)</td>
<td>.63293</td>
<td>.092144</td>
<td>6.8690[.000]</td>
</tr>
</tbody>
</table>

**Ordinary Least Squares Estimation**

Dependent variable is RELP

23 observations used for estimation from 1991 to 2013

---

**Figure 1C.21. Plot of Actual and Fitted Values of LPG in Residential Sector**

RELP = -12791.2*CONSTANT + 465.0721*LHEXP -16.0292*RPOIL + .63293*RELP(-1)

2) Kerosene

REOK constant R2KERPR REOK(-1)
Table 1C.23. Coefficient Estimates of Kerosene in Residential Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>335.6263</td>
<td>100.3275</td>
<td>3.3453 [.003]</td>
</tr>
<tr>
<td>R2KERPR</td>
<td>-1023.6</td>
<td>283.1607</td>
<td>-3.6148 [.002]</td>
</tr>
<tr>
<td>REOK(-1)</td>
<td>.55251</td>
<td>.13559</td>
<td>4.0749 [.001]</td>
</tr>
</tbody>
</table>

R-Squared: .97460  R-Bar-Squared: .97206
S.E. of Regression: 29.8784  F-stat.: F(2, 20) = 383.7111 [.000]
Mean of Dependent Variable: 352.8924  S.D. of Dependent Variable: 178.7514
Residual Sum of Squares: 17854.4  Equation Log-likelihood: -109.1624
Akaike Info. Criterion: -112.1624  Schwarz Bayesian Criterion: -113.8657
DW-statistic: .84749  Durbin's h-statistic: 3.6377 [.000]

Figure 1C.22. Plot of Actual and Fitted Values of Kerosene in Residential Sector

REOK = 335.6263*CONSTANT -1023.6*R2KERPR + .55251*REOK(-1)

3) Electricity

REEL constant LBHEXP R2REELPR
Table 1C.24. Coefficient Estimates of Electricity in Residential Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-9987.0</td>
<td>270.3355</td>
<td>-36.9429[.000]</td>
</tr>
<tr>
<td>LBHEXP</td>
<td>1454.5</td>
<td>39.8506</td>
<td>36.4982[.000]</td>
</tr>
<tr>
<td>R2REELPR</td>
<td>-7975.9</td>
<td>1526.3</td>
<td>-5.2255[.000]</td>
</tr>
</tbody>
</table>

Dependent variable is REEL
24 observations used for estimation from 1990 to 2013

R-Squared         .98925  R-Bar-Squared  .98823
S.E. of Regression 44.2744  F-stat.  F( 2, 21)  966.2599[.000]
Mean of Dependent Variable 1128.4  S.D. of Dependent Variable 408.0348
Residual Sum of Squares 41164.6  Equation Log-likelihood -123.4219
Akaike Info. Criterion -126.4219  Schwarz Bayesian Criterion -128.1890
DW-statistic       1.7034

Figure 1C.23. Plot of Actual and Fitted Values of Electricity in Residential Sector

Plot of Actual and Fitted Values

REEL = -9987.0*CONSTANT + 1454.5*LBHEXP -7975.9*R2REELPR

4) Others (biomass)

REOTH constant MPOPR REOTH(-1)
### Table 1C.25. Coefficient Estimates of Biomass in Residential Sector

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-19278.0</td>
<td>8942.8</td>
<td>-2.1557[.043]</td>
</tr>
<tr>
<td>MPOPFR</td>
<td>291.2535</td>
<td>131.2575</td>
<td>2.2189[.038]</td>
</tr>
<tr>
<td>REOTH(-1)</td>
<td>2.2082</td>
<td>.60150</td>
<td>3.6711[.002]</td>
</tr>
</tbody>
</table>

- R-Squared: 0.91282
- R-Bar-Squared: 0.90410
- S.E. of Regression: 420.6040
- F-stat.: F(2, 20) = 104.7040[.000]
- Mean of Dependent Variable: 5397.1
- S.D. of Dependent Variable: 1358.2
- Akaike Info. Criterion: -172.9872
- Schwarz Bayesian Criterion: -174.6905
- DW-statistic: 1.6807
- Durbin’s h-statistic: *NONE*

### Figure 1C.24. Plot of Actual and Fitted Values of Biomass in Residential Sector

**Plot of Actual and Fitted Values**

```
REOTH = -19278.0*CONSTANT + 291.2535*MPOPFR + 2.2082*REOTH(-1)
```

**Agriculture demand model**

1) **Total diesel demand**

   TAGGD constant RPOIL TAGGD(-1) DUM07
Table 1C.26. Coefficient Estimates of Diesel Demand in Agricultural Sector

Ordinary Least Squares Estimation

Dependent variable is TAGGD
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>310.1387</td>
<td>35.5129</td>
<td>8.7331 [.000]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-2.3767</td>
<td>.51289</td>
<td>-4.6340 [.000]</td>
</tr>
<tr>
<td>TAGGD(-1)</td>
<td>.41622</td>
<td>.10829</td>
<td>3.8435 [.001]</td>
</tr>
<tr>
<td>DUM07</td>
<td>-140.6408</td>
<td>19.6104</td>
<td>-7.1717 [.000]</td>
</tr>
</tbody>
</table>

R-Squared .81787  R-Bracketed .78911
S.E. of Regression 18.5351  F-stat. F( 3, 19) 28.4398 [.000]
Mean of Dependent Variable 234.7599  S.D. of Dependent Variable 40.3613
Residual Sum of Squares 6527.4  Equation Log-likelihood -97.5907
Akaike Info. Criterion -101.5907  Schwarz Bayesian Criterion -103.8617
Durbin's h-statistic .74003 [.459]

Figure 1C.25. Plot of Actual and Fitted Values of Diesel Demand in Agricultural Sector

Plot of Actual and Fitted Values

TAGGD = 310.1387*CONSTANT -2.3767*RPOIL +.41622*TAGGD(-1) -140.6408*DUM07

2) Total petroleum products demand
Table 1C.27. Coefficient Estimates of Petroleum Products Demand in Agricultural Sector

Ordinary Least Squares Estimation

Dependent variable is TAGGD
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>292.6657</td>
<td>35.5636</td>
<td>8.2294[.000]</td>
</tr>
<tr>
<td>RDSLPR</td>
<td>-170.0127</td>
<td>40.4258</td>
<td>-4.2055[.000]</td>
</tr>
<tr>
<td>TAGGD(-1)</td>
<td>.48173</td>
<td>.10996</td>
<td>4.3809[.000]</td>
</tr>
<tr>
<td>DUM07</td>
<td>-141.0179</td>
<td>20.6702</td>
<td>-6.8223[.000]</td>
</tr>
</tbody>
</table>

R-Squared .79907  R-Bar-Squared .76734
S.E. of Regression 19.4682  F-stat. F( 3, 19) 25.1861[.000]
Mean of Dependent Variable 234.7599  S.D. of Dependent Variable 40.3613
Residual Sum of Squares 7201.2  Equation Log-likelihood -98.7205
Akaike Info. Criterion -102.7205  Schwarz Bayesian Criterion -104.9915
DW-statistic 1.5131  Durbin's h-statistic 1.3740[.169]

3) Other petroleum products

OTAGPP constant RPOIL DUM978347

Table 1C.28. Coefficient Estimates of Other Petroleum Products Demand in Agricultural Sector

Ordinary Least Squares Estimation

Dependent variable is OTAGPP
24 observations used for estimation from 1990 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>52.7772</td>
<td>2.8628</td>
<td>18.4354[.000]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.71568</td>
<td>.12594</td>
<td>-5.6827[.000]</td>
</tr>
<tr>
<td>DUM978347</td>
<td>-17.7046</td>
<td>2.5114</td>
<td>-7.0496[.000]</td>
</tr>
</tbody>
</table>

R-Squared .81659  R-Bar-Squared .79912
S.E. of Regression 4.9572  F-stat. F( 2, 21) 46.7479[.000]
Mean of Dependent Variable 27.0524  S.D. of Dependent Variable 11.0604
Residual Sum of Squares 516.0563  Equation Log-likelihood -70.8725
Akaike Info. Criterion -73.8725  Schwarz Bayesian Criterion -75.6396
DW-statistic 1.5459
Figure 1C.26. Plot of Actual and Fitted Values of Other Petroleum Products Demand in Agricultural Sector

![Plot of Actual and Fitted Values](image)

OTAGPP = 52.7772*CONSTANT - 0.71568*RPOIL - 17.7046*DUM978347

4) Electricity

TAGEL constant laggdp tagel(-1)

Table 1C.29. Coefficient Estimates of Electricity Demand in Agricultural Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-1587.0</td>
<td>623.1709</td>
<td>-2.5467[.019]</td>
</tr>
<tr>
<td>LAGGDP</td>
<td>59.1806</td>
<td>23.2243</td>
<td>2.5482[.019]</td>
</tr>
<tr>
<td>TAGEL(-1)</td>
<td>.87320</td>
<td>.11529</td>
<td>7.5742[.000]</td>
</tr>
</tbody>
</table>

Dependent variable is TAGEL
23 observations used for estimation from 1991 to 2013

Ordinary Least Squares Estimation

R-Squared: .89976
R-Bar-Squared: .88974
S.E. of Regression: 14.5869
F-stat.: F( 2, 20) = 89.7601[.000]
Mean of Dependent Variable: 57.5314
S.D. of Dependent Variable: 43.9283
Residual Sum of Squares: 4255.5
Equation Log-likelihood: -92.6712
Akaike Info. Criterion: -95.6712
Schwarz Bayesian Criterion: -97.3744
Durbin’s h-statistic: -0.023745[.981]

72
Figure 1C.27. Plot of Actual and Fitted Values of Electricity Demand in Agricultural Sector

Plot of Actual and Fitted Values

<table>
<thead>
<tr>
<th>Years</th>
<th>1991</th>
<th>1993</th>
<th>1995</th>
<th>1997</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
<th>2009</th>
<th>2011</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAGEL</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>175</td>
<td>150</td>
<td>125</td>
<td>100</td>
<td>75</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Fitted</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>175</td>
<td>150</td>
<td>125</td>
<td>100</td>
<td>75</td>
<td>50</td>
<td>25</td>
</tr>
</tbody>
</table>

TAGEL = -1587.0*CONSTANT + 59.1806*LAGGDP + .87320*TAGEL(-1)

Conclusion

The national energy data of the Philippines used in estimating the demand equation and as established by the Asia Pacific Energy Research Centre through its Asia-Pacific Economic Cooperation’s energy database is comparable with the International Energy Agency’s database in terms of its reliability and responsiveness in formulating statistical demand model using regression analysis to project final energy consumption by sector. The annual historical data of most dominant fuels by sector have a good linear trend in which regression analysis through ordinary least squares is applicable. It is assumed there are no significant differences between the use of the International Energy Agency’s energy database and the Asia-Pacific Economic Cooperation’s energy database in formulating energy demand equations through linear regression analysis for the Philippines.

References


Department of Energy, ‘Energy Supply and Demand Situation FY 2014 – Philippines’
1D. Thailand’s National Energy Data Estimations

The national energy statistics in Thailand are compiled mainly and separately by the Department of Alternative Energy Department and Efficiency (DEDE) and the Energy Policy and Planning Office under the Ministry of Energy. DEDE provides detailed statistics while the Energy Policy and Planning Office focuses more on energy policy. Thus, to make more detailed energy model outlook, divided into subsectors, the data in Thailand’s time series will rely on DEDE’s data. For example, DEDE’s time series data in industrial sector can be broken down into smaller industrial types, such as non-metallic, paper and pulp, and food and tobacco, in every energy type of use.

Characteristic of Data

This study uses DEDE data series to make the estimates for the energy outlook modelling, which is input into LEAP Application. The energy consumption statistics by sector, by subsector, and by energy type have been collected since 1970 but only up to 2015.

Using National Energy Data to Make Energy Model

Econometric equations use statistical data to estimate the results as compared to the actual figures and to see how the data will fit the estimations as forecast. The transport, industry, and others sectors and subsectors use national energy data for estimations. The industrial sector has 11 subsectors: iron and steel, chemical and petrochemical, non-metallic products, machinery, mining and quarrying, food and tobacco, paper, pulp and printing, wood and wood products, construction, textile and leather, and non-specified products. The transport sector has four subsectors: road, water, rail, and aviation. The others sector covers residential, commercial, agricultural, non-specific, and non-energy sectors.

\[ Q = f(GDP, P) \]

The consumption of each energy type in subsector relates to income as represented by GDP and energy price. The demand function is applied to estimate the future consumption. For example, food and tobacco consume electricity in their production process. Their electricity consumption will depend upon their production and sales, which are finally derived from the growth of GDP. This is how the equation looks in terms of ordinary least square, with statistical confidence of 95%.

Electricity consumption in food industry \[ = -310.4871 + .1607E-3*GDP \]

As mentioned, all the equations of energy consumption in every subsector are based on national energy statistical data. The quality of the data is very significant for the estimation. Some problems in the statistics might cause the model not to work properly. Different results can be driven by different data sets.
**National Energy Data Incident**

Using national energy statistics for outlook remains on bumpy road. Some problems need to be solved in running econometric equations. Some data show fluctuations that cause uncertainty as they swing up and down at times (see Figure 1D.1).

**Figure 1D.1 Energy Consumption in Iron and Steel**

ISHC = iron and steel hard coal, ISCP = iron and steel coal product, ISHCN; ISHC + ISCP
Source: Author’ data generated from LEAP.

Moreover, many data are missing in the time series. Although missing data within a short period of time can be solved statistically, this can be hard when a longer period of time is involved. A good example is the electricity consumption in cement industry. We realise that cement is consistently produced every year. What is hard to believe is that they stopped the process for a certain period (see Figure 1D.2)
As some products tend to fade away in the market while new ones are introduced, certain period is needed to learn its behaviour. Although not directly concerned with data problem, it can cause confusion. An example for this is fabricated metal (see Figure 1D.3).

Thailand’s energy statistics data provide details in time series in sectors and in subsectors that are adequate to make energy model. However, double checking dates for accuracy is important as original sources tend to change them.
Data Treatment

Sometimes, statistical problems in data information can be statistically treated by dummy and irregular terms and some problems can be ignored. But such is not always the case. Although many statistical tools are available for solving matters, some data are really hard to be treated statistically as they tend to make matters worse. When faced with too many missing and inconsistent data, several definitions on the same set of data, too many uncertainties in observation, and too many irregularities, we have no choice but to reset all data.
1E. Viet Nam’s National Energy Data Estimations

Introduction

This chapter aims to use Viet Nam’s national energy data for estimation of energy demand formulas for 2018 and 2019 instead of the energy data from the International Energy Agency’s energy balances.

Energy demand equations were based on national data such as historical energy and socio-economic data obtained from the Asia Pacific Energy Research Centre.

Real price of international oil (RPOIL) was used as main drivers of energy demand. Where RPOIL did not affect the demand equations, estimates were made based on domestic energyfuel prices obtained from domestic or other study sources in Viet Nam.

Estimation Results

The estimation results of energy demand formulas by each fuel in each sector are presented as follows:

Industrial sector model

- Coal

\[ \text{INHC} = -362.4500\times \text{CONS} + 0.0030152\times \text{INGDP} - 0.0057528\times \text{RPOIL} + 0.80775\times \text{INHC}(-1) \]

Table 1E.1. Coefficient Estimates of Coal Demand in Industrial Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-362.4500</td>
<td>409.0371</td>
<td>-.88611[.398]</td>
</tr>
<tr>
<td>INGD</td>
<td>0.0030152</td>
<td>0.0018658</td>
<td>1.6160[.124]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0057528</td>
<td>.062197</td>
<td>-.092493[.927]</td>
</tr>
<tr>
<td>INHC(-1)</td>
<td>.80775</td>
<td>.12337</td>
<td>6.5471[.000]</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.
Figure 1E.1. Plot of Actual and Fitted Values of Coal Demand in Industrial Sector

![Plot of Actual and Fitted Values](image)

Source: Author’s calculation.

- Diesel oil
  \[
  \text{INGD} = 16.4679 \times \text{CONS} + .6956E^{-3} \times \text{INGDP} + .4128E^{-3} \times \text{RPOIL} + .52806 \times \text{INGD}(-1)
  \]

Table 1E.2. Coefficient Estimates of Diesel Oil Demand in Industrial Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>16.4679</td>
<td>73.3551</td>
<td>.22450 [.825]</td>
</tr>
<tr>
<td>INGDP</td>
<td>.6956E-3</td>
<td>.3935E-3</td>
<td>1.7677 [.093]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>.4128E-3</td>
<td>.0080159</td>
<td>.051498 [.959]</td>
</tr>
<tr>
<td>INGD(-1)</td>
<td>.52806</td>
<td>.26463</td>
<td>1.9955 [.061]</td>
</tr>
</tbody>
</table>

Ordinary Least Squares Estimation

Dependent variable is INGD
23 observations used for estimation from 1991 to 2013

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-Squared</td>
<td>.93672</td>
</tr>
<tr>
<td>S.E. of Regression</td>
<td>98.8770</td>
</tr>
<tr>
<td>Mean of Dependent Variable</td>
<td>720.9526</td>
</tr>
<tr>
<td>Residual Sum of Squares</td>
<td>185756.5</td>
</tr>
<tr>
<td>Akaike Info. Criterion</td>
<td>-140.0976</td>
</tr>
<tr>
<td>DW-statistic</td>
<td>1.9433</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.
The sign of coefficient of RPOIL is positive. This is irrational that the demand increases when oil price increases. It proves that RPOIL does not affect the demand of diesel oil. In this case, RPDOIL (real price of domestic diesel oil of Viet Nam) would be used. The revised result is presented as follows:

\[ \text{INGD} = 217.5275 \times \text{CONS} + .0012868 \times \text{INGDP} - 343.7591 \times \text{RPDOIL} + .41609 \times \text{INGD}(-1) - 268.0025 \times \text{DUM05} \]

Table 1E.3. Coefficient Estimates of Diesel Oil Demand in Industrial Sector (Revised Estimates)

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio(Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>217.5275</td>
<td>107.3368</td>
<td>2.0266(0.062)</td>
</tr>
<tr>
<td>INGDP</td>
<td>.0012868</td>
<td>.4162E-3</td>
<td>3.0919(0.008)</td>
</tr>
<tr>
<td>RPDOIL</td>
<td>-343.7591</td>
<td>146.7815</td>
<td>-2.3420(0.034)</td>
</tr>
<tr>
<td>INGD(-1)</td>
<td>.41609</td>
<td>.17294</td>
<td>2.4060(0.031)</td>
</tr>
<tr>
<td>DUM05</td>
<td>-268.0025</td>
<td>71.1519</td>
<td>-3.7666(0.002)</td>
</tr>
</tbody>
</table>

R-Squared: .96763, R-Bar-Squared: .95859
S.E. of Regression: 65.2559; F-stat: F( 4, 14) 104.6356(0.000)
Mean of Dependent Variable: 820.9137; S.D. of Dependent Variable: 319.0891
Residual Sum of Squares: 59616.7; Equation Log-Likelihood: -103.4467
Akaikes Info. Criterion: -108.4467; Schwarz Bayesian Criterion: -110.8078
DW-statistic: 2.6658; Durbin’s h-statistic: -.21939(0.827)

Source: Author’s calculation.

Figure 1E.2. Plot of Actual and Fitted Values of Diesel Oil Demand in Industrial Sector

Plot of Actual and Fitted Values

Source: Author’s calculation.

- Liquefied petroleum gas (LPG)

\[ \text{INLP} = -38.5632 \times \text{CONS} + .1757E-3 \times \text{INGDP} -.1279E-3 \times \text{RPOIL} + .55283 \times \text{INLP}(-1) \]
Table 1E.4. Coefficient Estimates of LPG Demand in Industrial Sector

Ordinary Least Squares Estimation
---------------------------------------------------------------------------------------------------------------------
Dependent variable is INLP
21 observations used for estimation from 1993 to 2013
---------------------------------------------------------------------------------------------------------------------
<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-38.5632</td>
<td>19.7526</td>
<td>-1.9523 [.068]</td>
</tr>
<tr>
<td>INGDP</td>
<td>.1757E-3</td>
<td>.6671E-4</td>
<td>2.6344 [.017]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.1279E-3</td>
<td>.0020865</td>
<td>-.061295 [.952]</td>
</tr>
<tr>
<td>INLP(-1)</td>
<td>.55283</td>
<td>.16718</td>
<td>3.3069 [.004]</td>
</tr>
</tbody>
</table>
---------------------------------------------------------------------------------------------------------------------
R-Squared  | .95144       | R-Bar-Squared  | .94287        |
S.E. of Regression | 19.2518 | F-stat. | F(3, 17) | 111.0290 [.000]|
Mean of Dependent Variable | 99.6233 | S.D. of Dependent Variable | 80.5461 |
Residual Sum of Squares | 6300.8 | Equation Log-likelihood | -89.6887 |
Akaike Info. Criterion | -93.6887 | Schwarz Bayesian Criterion | -95.7777 |
DW-statistic | 2.6067 | Durbin's h-statistic | -2.1628 [.031]|
---------------------------------------------------------------------------------------------------------------------

Source: Author’s calculation.

Figure 1E.3. Plot of Actual and Fitted Values of LPG Demand in Industrial Sector

<table>
<thead>
<tr>
<th>Years</th>
<th>1993</th>
<th>1995</th>
<th>1997</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
<th>2009</th>
<th>2011</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>INL</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>INLP</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fitted</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Electricity

\[ \text{INEL} = -166.7921*\text{CONS} + .6872E-3*\text{INGDP} + 1.0552*\text{RPEL} + 1.0198*\text{INEL}(-1) \]

The real price of electricity (RPEL) in Viet Nam (VPBank, 2013) was used. However, the sign of coefficient of RPEL is still positive. It proves that RPEL also does not affect the electricity demand. In this case, only INGDP would be used as variable to drive electricity demand as follows:

\[ \text{INEL} = -140.4502*\text{CONS} + .6697E-3*\text{INGDP} + 1.0194*\text{INEL}(-1) \]
Table 1E.5. Coefficient Estimates of Electricity Demand in Industrial Sector

Ordinary Least Squares Estimation

Dependent variable is INEL
20 observations used for estimation from 1994 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-140.4502</td>
<td>59.3963</td>
<td>-2.3648</td>
<td>.030</td>
</tr>
<tr>
<td>INGDP</td>
<td>0.66972E-3</td>
<td>0.1826E-3</td>
<td>3.6680</td>
<td>.002</td>
</tr>
<tr>
<td>INEL(-1)</td>
<td>1.0194</td>
<td>0.025530</td>
<td>39.9279</td>
<td>.000</td>
</tr>
</tbody>
</table>

R-Squared: .99073  R-Bar-Squared: .99058
S.E. of Regression: 60.5687  F-stat.: F(2, 17): 6686.3000
Mean of Dependent Variable: 2014.0  S.D. of Dependent Variable: 1607.9
Residual Sum of Squares: 62365.7  Equation Log-likelihood: -108.8291
Akaike Info. Criterion: -111.8291  Schwarz Bayesian Criterion: -113.3227
Durbin's h-statistic: 1.8747  Durbin's h-statistic: 0.28200000000000003

Source: Author’s calculation.

Figure 1E.4. Plot of Actual and Fitted Values of Electricity Demand in Industrial Sector

Plot of Actual and Fitted Values

INEL

Fitted

Years


Source: Author’s calculation.

- Natural gas

\[ \text{INNG} = -3191.6 \times \text{CONS} + 0.0041153 \times \text{INGDP} + 0.044366 \times \text{RPOIL} + 0.31736 \times \text{INNG}(-1) \]

The sign of coefficient of RPOIL is positive. It proves that RPOIL also does not affect the natural gas demand. In this case, INGDP would be used as variable to drive natural gas demand as follows:

\[ \text{INNG} = -2244.3 \times \text{CONS} + 0.0035561 \times \text{INGDP} + 0.42423 \times \text{INNG}(-1) + 157.5739 \times \text{DUM10} \]
### Table 1E.6. Coefficient Estimates of Natural Gas Demand in Industrial Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-2244.3</td>
<td>1640.1</td>
<td>-1.3684 [.229]</td>
</tr>
<tr>
<td>INGDP</td>
<td>.0035561</td>
<td>.0027523</td>
<td>1.2921 [.253]</td>
</tr>
<tr>
<td>INNG(-1)</td>
<td>.42423</td>
<td>.47668</td>
<td>.88996 [.414]</td>
</tr>
<tr>
<td>DUM10</td>
<td>157.5739</td>
<td>259.7540</td>
<td>.60663 [.571]</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.

### Figure 1E.5. Plot of Actual and Fitted Values of Natural Gas Demand in Industrial Sector

The sign of coefficient of INGDP is negative. It proves that fuel oil demand decreases when INGDP increases. In this case, the above demand function should not be used and suppose that

```
INHF = 304.2015*CONS - .3610E-3*INGDP -.0064430*RPOIL + .95001*INHF(-1)
```
fuel oil used in industry would reach zero by 2020 based on the trend of fuel oil used in the past (see Figure 1E.6).

**Figure 1E.6. Plot of Actual and Fitted Values of Fuel Oil Demand in Industrial Sector**

![Plot of Actual and Fitted Values](image)

Source: Author’s calculation.

**Transport sector demand model**

- Air/jet kerosene
  
  \[
  TSKJ = -72.0365\times CONS + .1548E-3\times GDP -.0012082\times RPOIL + .72335\times TSKJ(-1)
  \]

**Table 1E.7. Coefficient Estimates of Jet Kerosene Demand in Air Transport**

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-72.0365</td>
<td>52.5324</td>
<td>-1.3713 [.186]</td>
</tr>
<tr>
<td>GDP</td>
<td>.1548E-3</td>
<td>.7756E-4</td>
<td>1.9958 [.060]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0012082</td>
<td>.0049970</td>
<td>-.24179 [.812]</td>
</tr>
<tr>
<td>TSKJ(-1)</td>
<td>.72335</td>
<td>.20351</td>
<td>3.5544 [.002]</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.
Figure 1E.7. Plot of Actual and Fitted Values of Jet Kerosene in Air Transport

Source: Author’s calculation.

- Road/Gasoline

\[
\text{TSMG} = -522.1186 \times \text{CONS} + .0010506 \times \text{GDP} + .013665 \times \text{RPOIL} + .54695 \times \text{TSMG}(-1)
\]

The sign of coefficient of RPOIL is positive. This is irrational that the demand increases when oil price increases. It proves that RPOIL (or international oil price) does not affect the domestic demand of diesel oil. In this case, ERIA commented that the RPGOIL (price of gasoline of Viet Nam) should be used. The result is presented as follows:

\[
\text{TSMG} = -967.5575 \times \text{CONS} + .0018675 \times \text{GDP} - 356.2257 \times \text{RPGOIL} + .34983 \times \text{TSMG}(-1)
\]
Table 1E.8. Coefficient Estimates of Gasoline Demand in Road Transport

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-967.5575</td>
<td>340.0138</td>
<td>-2.8456 [.012]</td>
</tr>
<tr>
<td>GDP</td>
<td>.0018675</td>
<td>.5540E-3</td>
<td>3.3709 [.004]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-356.2257</td>
<td>696.5289</td>
<td>-.51143 [.616]</td>
</tr>
<tr>
<td>TSMG(-1)</td>
<td>.34983</td>
<td>.25415</td>
<td>1.3765 [.189]</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.

Figure 1E.8. Plot of Actual and Fitted Values of Gasoline in Road Transport

Plot of Actual and Fitted Values

Source: Author’s calculation.

- Road/Diesel

  \[\text{TSGD} = -155.7043*\text{CONS} + .8473E-3*\text{GDP} + .012516*\text{RPOIL} + .61874*\text{TSGD}(-1)\]

The sign of coefficient of RPOIL is positive. It proves that RPOIL (or international oil price) does not affect the domestic demand of diesel oil. In this case, RPDOIL should be used. The result is presented as follows:

\[\text{TSGD} = -56.0251*\text{CONS} + .7703E-3*\text{GDP} - 416.9328*\text{RPOIL} + .74988*\text{TSGD}(-1)\]
**Table 1E.9. Coefficient Estimates of Diesel Demand in Road Transport**

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-56.0251</td>
<td>441.5668</td>
<td>-.12688[.901]</td>
</tr>
<tr>
<td>GDP</td>
<td>.77035E-3</td>
<td>.8761E-3</td>
<td>.87923[.393]</td>
</tr>
<tr>
<td>RPDOIL</td>
<td>-416.9328</td>
<td>1083.1</td>
<td>-.38494[.706]</td>
</tr>
<tr>
<td>TSGD(-1)</td>
<td>.74988</td>
<td>.33622</td>
<td>2.2303[.041]</td>
</tr>
</tbody>
</table>

| R-Squared     | .94997      | R-Bar-Squared  | .93996        |
| S.E. of Regression | 340.0748 | F-stat. F(3, 15) 94.9306[.000] |
| Mean of Dependent Variable | 3218.5   | S.D. of Dependent Variable 1387.9 |
| Residual Sum of Squares | 1734763 | Equation Log-likelihood -135.4683 |
| Akaike Info. Criterion  | -139.4683 | Schwarz Bayesian Criterion -141.3572 |
| DW-statistic         | 2.0760     | Durbin’s h-statistic *NONE* |

Source: Author’s calculation.

**Figure 1E.9. Plot of Actual and Fitted Values of Diesel in Road Transport**

Plot of Actual and Fitted Values

![Plot of Actual and Fitted Values](image)

Source: Author’s calculation.

- Other/Fuel oil

\[ TSHF = 38.2912 \times CONS + 0.1623 \times GDP - 150.1930 \times RPDOIL + 1.0713 \times TSHF(-1) \]
Table 1E.10. Coefficient Estimates of Fuel Oil Demand in Transport

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>38.2912</td>
<td>45.8308</td>
<td>.83549[.417]</td>
</tr>
<tr>
<td>GDP</td>
<td>.1623E-4</td>
<td>.7519E-4</td>
<td>.21590[.832]</td>
</tr>
<tr>
<td>REHC</td>
<td>-150.1930</td>
<td>124.2344</td>
<td>-1.2089[.245]</td>
</tr>
<tr>
<td>TSHF(-1)</td>
<td>1.0713</td>
<td>.13667</td>
<td>7.8388[.000]</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.

Figure 1E.10. Plot of Actual and Fitted Values of Fuel Oil in Transport

Plot of Actual and Fitted Values

Source: Author’s calculation.

Residential sector demand model

- Coal

\[
\text{REHC} = 69.6896 \times \text{CONS} + 0.1602 \times 3 \times \text{GDP} + 0.64842 \times \text{REHC}(-1)
\]
Table 1E.11. Coefficient Estimates of Coal Demand in Residential Sector

Ordinary Least Squares Estimation
***********************************************************************************************************************************************
Dependent variable is REHC
23 observations used for estimation from 1991 to 2013
***********************************************************************************************************************************************

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>69.6896</td>
<td>31.3586</td>
<td>2.2223 [.030]</td>
</tr>
<tr>
<td>GDP</td>
<td>1.602E-3</td>
<td>.9146E-4</td>
<td>1.7517 [.095]</td>
</tr>
<tr>
<td>REHC(-1)</td>
<td>.64842</td>
<td>.18290</td>
<td>3.5452 [.002]</td>
</tr>
</tbody>
</table>

***********************************************************************************************************************************************

R-Squared .96602 R-Bar-Squared .96263
S.E. of Regression 57.3717 F-stat. F( 2, 20) 284.3337 [.000]
Mean of Dependent Variable 760.0035 S.D. of Dependent Variable 296.7707
Residual Sum of Squares 65830.1 Equation Log-likelihood -124.1680
Akaike Info. Criterion -127.1680 Schwarz Bayesian Criterion -128.8712
DW-statistic 1.7442 Durbin’s h-statistic 1.2776 [.201]

***********************************************************************************************************************************************

Source: Author’s calculation.

Figure 1E.11. Plot of Actual and Fitted Values of Coal in Residential Sector

Plot of Actual and Fitted Values

Source: Author’s calculation.

- Diesel oil
  
  \[ \text{REGD} = -6.8421 \times \text{CONS} + .7572E-5 \times \text{GDP} + .46540 \times \text{REGD}(-1) + 12.7738 \times \text{DUM05} \]
Table 1E.12. Coefficient Estimates of Diesel Demand in Residential Sector

Ordinary Least Squares Estimation  
******************************************************************************
Dependent variable is REGD  
23 observations used for estimation from 1991 to 2013  
******************************************************************************

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-6.8421</td>
<td>10.9403</td>
<td>- .6254 [.539]</td>
</tr>
<tr>
<td>GDP</td>
<td>.7572E-5</td>
<td>.4826E-5</td>
<td>1.5690 [.133]</td>
</tr>
<tr>
<td>REGD(-1)</td>
<td>.46540</td>
<td>.20521</td>
<td>2.2679 [.035]</td>
</tr>
<tr>
<td>DXMO5</td>
<td>12.7738</td>
<td>10.1240</td>
<td>1.2617 [.222]</td>
</tr>
</tbody>
</table>

******************************************************************************

Source: Author’s calculation.

Figure 1E.12. Plot of Actual and Fitted Values of Diesel Demand in Residential Sector

Plot of Actual and Fitted Values

REGD  
Fitted

Source: Author’s calculation.

- LPG

RELP = -62.2959*CONS + .1330E-3*GDP -.0016185*RPOIL + .76858*RELP(-1)
Table 1E.13. Coefficient Estimates of LPG Demand in Residential Sector

Ordinary Least Squares Estimation
*******************************************************************************
Dependent variable is RELP
23 observations used for estimation from 1991 to 2013
*******************************************************************************

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-62.2959</td>
<td>135.2485</td>
<td>-.46060 [.650]</td>
</tr>
<tr>
<td>GDP</td>
<td>.1330E-3</td>
<td>.1242E-3</td>
<td>1.0709 [.298]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0016185</td>
<td>.0058828</td>
<td>-.27512 [.786]</td>
</tr>
<tr>
<td>RELP(-1)</td>
<td>.76858</td>
<td>.31460</td>
<td>2.4424 [.025]</td>
</tr>
</tbody>
</table>
*******************************************************************************

R-Squared .97832  R-Bar-Squared .97490
S.E. of Regression 47.4248  F-stat. F( 3, 19) 285.8473 [.000]
Mean of Dependent Variable 338.9857  S.D. of Dependent Variable 299.3505
Residual Sum of Squares 42733.0  Equation Log-likelihood -119.1988
Akaike Info. Criterion -123.1988  Schwarz Bayesian Criterion -125.4698
DW-statistic 1.6404  Durbin’s h-statistic *NOT* 1.0000
*******************************************************************************

Source: Author’s calculation.

Figure 1E.13. Plot of Actual and Fitted Values of LPG Demand in Residential Sector

Plot of Actual and Fitted Values

Source: Author’s calculation.

- Electricity

\[ \text{REEL} = -125.9780*\text{CONS} + .3589E-3*\text{GDP} - .0061136*\text{RPOIL} + .87991*\text{REEL(-1)} \]
Table 1E.14. Coefficient Estimates of Electricity Demand in Residential Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-125.970</td>
<td>120.157</td>
<td>-1.048</td>
<td>.308</td>
</tr>
<tr>
<td>GDP</td>
<td>.3589E-3</td>
<td>.1806E-3</td>
<td>1.9012</td>
<td>.073</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0061136</td>
<td>.0037420</td>
<td>-1.6338</td>
<td>.119</td>
</tr>
<tr>
<td>REEL(-1)</td>
<td>.87991</td>
<td>.12144</td>
<td>7.2456</td>
<td>.000</td>
</tr>
</tbody>
</table>

R-Squared: .99809  R-Bar-Squared: .99779
S.E. of Regression: 49.1702  F-stat: F( 3, 19) 3305.8 [0.000]
Mean of Dependent Variable: 1454.5  S.D. of Dependent Variable: 1045.0
Residual Sum of Squares: 45936.5  Equation Log-Likelihood: -120.0301
DW-statistic: 2.8031  Durbin’s h-statistic: -2.3690 [0.018]

Source: Author’s calculation.

Figure 1E.14. Plot of Actual and Fitted Values of Electricity Demand in Residential Sector

Source: Author’s calculation.

Commercial sector demand model

- Coal

CSHC = 22.9810*CONS + .0048148*GDPC -.0030803*RPOIL + .78805*CSHC(-1)
Table 1E.15. Coefficient Estimates of Coal Demand in Commercial Sector

Ordinary Least Squares Estimation
******************************************************************************
Dependent variable is CSHC
21 observations used for estimation from 1991 to 2011
******************************************************************************
<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>22.9810</td>
<td>18.2174</td>
<td>1.2615 [.224]</td>
</tr>
<tr>
<td>GDPc</td>
<td>.0048149</td>
<td>.0032558</td>
<td>1.4789 [.157]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0030803</td>
<td>.0020160</td>
<td>-1.5279 [.145]</td>
</tr>
<tr>
<td>CSHC(-1)</td>
<td>.79805</td>
<td>.11459</td>
<td>6.8771 [.000]</td>
</tr>
</tbody>
</table>
******************************************************************************
R-Squared   .96767
R-Bar-Squared .96196
S.E. of Regression 22.1023 F-stat. F(3,17) 169.5997 [.000]
Mean of Dependent Variable 247.3910 S.D. of Dependent Variable 113.7367
Residual Sum of Squares 8364.9 Equation Log-likelihood -92.6641
Akaike Info. Criterion -96.6641 Schwarz Bayesian Criterion -98.7532
DW-statistic 1.5768 Durbin’s h-statistic 1.1395 [.254]
******************************************************************************
Source: Author’s calculation.

Figure 1E.15. Plot of Actual and Fitted Values of Coal Demand in Commercial Sector

Plot of Actual and Fitted Values

- Diesel
  
  CSGD = 48.7576*CONS -.0010448*GDPC -.0012584*RPOIL + .95891*CSGD(-1)

Source: Author’s calculation.
Table 1E.16. Coefficient Estimates of Diesel Demand in Commercial Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>48.7576</td>
<td>19.8688</td>
<td>2.4540</td>
<td>.024</td>
</tr>
<tr>
<td>GDPC</td>
<td>-.0031048</td>
<td>.0018937</td>
<td>-.55173</td>
<td>.588</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0012584</td>
<td>.0020656</td>
<td>-.60923</td>
<td>.550</td>
</tr>
<tr>
<td>CSGD(-1)</td>
<td>.95891</td>
<td>.10182</td>
<td>9.4174</td>
<td>.000</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.

The sign of coefficient of GDPC (GDP per capita) is negative. It proves that diesel oil demand decreases when GDPC increases. In this case, the above demand function should not be used and suppose that diesel oil used in commercial sector would be reduced according to the past trend of diesel oil consumption in 2005–2013.

- Fuel oil

\[
\text{CSHF} = 38.1485*\text{CONS} - .0012298*\text{GDPC} - .6799E-3*\text{RPOIL} + .86958*\text{CSHF}(-1)
\]
The sign of coefficient of GDPC (GDP per capita) is negative. It proves that fuel oil demand decreases when GDPC increases. In this case, we do not need to use the above demand function and suppose that fuel oil used in commercial sector would reach to zero by 2018 based on the trend of fuel oil used in the past.
Table 1E.18. Coefficient Estimates of LPG Demand in Commercial Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-135.3638</td>
<td>61.5549</td>
<td>-2.0038</td>
<td>.060</td>
</tr>
<tr>
<td>GDPC</td>
<td>.015032</td>
<td>.0054312</td>
<td>2.7677</td>
<td>.012</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0011385</td>
<td>.0021789</td>
<td>-.52251</td>
<td>.607</td>
</tr>
<tr>
<td>CSLP(-1)</td>
<td>.44156</td>
<td>.25152</td>
<td>1.7556</td>
<td>.095</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.
Table 1E.19. Coefficient Estimates of Electricity Demand in Commercial Sector

Ordinary Least Squares Estimation
**********************************************
Dependent variable is CSEL
20 observations used for estimation from 1994 to 2013
**********************************************

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>-105.0106</td>
<td>58.1914</td>
<td>-1.8046 [.090]</td>
</tr>
<tr>
<td>CSGDP</td>
<td>.3768E-3</td>
<td>.1859E-3</td>
<td>2.0272 [.060]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.0030676</td>
<td>.0047521</td>
<td>-.64552 [.528]</td>
</tr>
<tr>
<td>CSEL(-1)</td>
<td>.35787</td>
<td>.12525</td>
<td>6.8490 [.000]</td>
</tr>
</tbody>
</table>

**********************************************

R-Squared       .98054     R-Bar-Squared       .97689
S.E. of Regression 43.0940   F-stat.       F( 3, 16) 268.2460 [.000]
Mean of Dependent Variable 353.4550  S.D. of Dependent Variable 283.4806
Residual Sum of Squares 29713.5  Equation Log-likelihood -101.4150
Akaike Info. Criterion   -105.4150  Schwarz Bayesian Criterion -107.4065
DW-statistic            2.2797    Durbin’s h-statistic -7.5502 [.450]

**********************************************

Source: Author’s calculation.

Figure 1E.19. Plot of Actual and Fitted Values of Electricity Demand in Commercial Sector

Plot of Actual and Fitted Values

Source: Author’s calculation.

Agricultural sector demand model

- Coal

\[ AGHC = 20.1040 \times CONS - .1350E-4 \times AGGDP - .6261E-4 \times RPOIL + .33333 \times AGHC(-1) \]

The sign of coefficient of AGGDP is negative. It proves that coal demand decreases when AGGDP increases. In this case, we do not need to use the above demand function and suppose that coal used in agriculture would be reduced based on the past trend of coal consumption in 2002–2012 (see figure below).
Table 1E.20. Coefficient Estimates of Coal Demand in Agricultural Sector

Ordinary Least Squares Estimation

Dependent variable is AGHC
16 observations used for estimation from 1998 to 2013

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>20.104</td>
<td>5.6359</td>
<td>3.5671[.004]</td>
</tr>
<tr>
<td>AGGDP</td>
<td>-.1358E-4</td>
<td>.1845E-4</td>
<td>-.7591[.479]</td>
</tr>
<tr>
<td>RPOIL</td>
<td>-.6261E-4</td>
<td>.2463E-3</td>
<td>-.2516[.804]</td>
</tr>
<tr>
<td>AGHC(-1)</td>
<td>.33333</td>
<td>.086149</td>
<td>4.1899[.001]</td>
</tr>
</tbody>
</table>

| R-Squared | .83661 | R-Bar-Squared | .79576 |
| S.E. of Regression | 1.8556 | F-stat. F( 3, 12) | 20.4813[.000] |
| Mean of Dependent Variable | 22.9175 | S.D. of Dependent Variable | 4.1059 |
| Residual Sum of Squares | 41.3172 | Equation Log-likelihood | -30.2923 |
| Akaike Info. Criterion | -34.2925 | Schwarz Bayesian Criterion | -35.8377 |
| DW-statistic | 2.4960 | Durbin’s h-statistic | -1.0473[.295] |

Source: Author’s calculation.

Figure 1E.20. Plot of Actual and Fitted Values of Coal Demand in Agricultural Sector

Plot of Actual and Fitted Values

- Diesel oil
  AGGD = 25.6198*CONS + .9438E-4*AGGDP - .2746E-3*RPOIL + .84035*AGGD(-1)
Table 1E.21. Coefficient Estimates of Diesel Demand in Agricultural Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>25.6198</td>
<td>30.9489</td>
<td>.8278</td>
<td>.410</td>
</tr>
<tr>
<td>AGGDP</td>
<td>.9430E-4</td>
<td>.2705E-3</td>
<td>.3390</td>
<td>.730</td>
</tr>
<tr>
<td>RPP01</td>
<td>-.2746E-3</td>
<td>.6013E54</td>
<td>-.1420</td>
<td>.888</td>
</tr>
<tr>
<td>AGGD(-1)</td>
<td>.84035</td>
<td>.19867</td>
<td>4.2299</td>
<td>.000</td>
</tr>
</tbody>
</table>


Source: Author’s calculation.

Figure 1E.21. Plot of Actual and Fitted Values of Diesel Demand in Agricultural Sector

Plot of Actual and Fitted Values

Source: Author’s calculation.

- Gasoline
AGMG = 19.8562*CONS + .2514E-3*AGGDP + .27416*AGMG(-1) -31.4888*DUM9799
Table 1E.22. Coefficient Estimates of Gasoline Demand in Agricultural Sector

Ordinary Least Squares Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>19.8562</td>
<td>10.9492</td>
<td>1.8135 [.086]</td>
</tr>
<tr>
<td>AGGDP</td>
<td>.2514E-3</td>
<td>.6623E-4</td>
<td>3.7961 [.001]</td>
</tr>
<tr>
<td>AGGMS(-1)</td>
<td>.27416</td>
<td>.16367</td>
<td>1.6751 [.110]</td>
</tr>
<tr>
<td>DUM9799</td>
<td>-31.4888</td>
<td>8.2874</td>
<td>-3.7996 [.001]</td>
</tr>
</tbody>
</table>

Mean of Dependent Variable: 95.3943  S.D. of Dependent Variable: 29.2421
Residual Sum of Squares: 2422.3  Equation Log-likelihood: -87.1030
Akaike Info. Criterion: -91.1030  Schwarz Bayesian Criterion: -93.3740
DW-statistic: 1.5621  Durbin’s h-statistic: 1.6948 [.090]

Source: Author’s calculation.

Figure 1E.22. Plot of Actual and Fitted Values of Gasoline Demand in Agricultural Sector

Plot of Actual and Fitted Values

Source: Author’s calculation.

Electricity

\[ AGEL = -14.3394 \times CONS + .1086E-3 \times AGGDP + 1.2218 \times RPEL + .71964 \times AGGMS(-1) - 24.6472 \times DUM1013 \]

The sign of coefficient of RPEL (domestic price of electricity) is positive. This is irrational (demand increases when price increases). It proves that RPEL does not affect the domestic demand of electricity. In this case, only AGGDP should be used as variable to drive electricity demand as follows:

\[ AGEL = 28.1367 \times CONS + .2999E-4 \times AGGDP + .75365 \times AGGMS(-1) - 24.5577 \times DUM1013 \]
Table 1E.23. Coefficient Estimates of Electricity Demand in Agricultural Sector

Ordinary Least Squares Estimation
*******************************************************************************
Dependent variable is AGEL
23 observations used for estimation from 1991 to 2013
*******************************************************************************

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio [Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>28.1367</td>
<td>11.2218</td>
<td>2.5073 [.021]</td>
</tr>
<tr>
<td>AGGDP</td>
<td>.2999E-4</td>
<td>.2427E-4</td>
<td>1.2354 [.232]</td>
</tr>
<tr>
<td>AGEL(-1)</td>
<td>.75365</td>
<td>.11958</td>
<td>6.3024 [.000]</td>
</tr>
<tr>
<td>DUM1013</td>
<td>-24.5577</td>
<td>5.9555</td>
<td>-4.1235 [.001]</td>
</tr>
</tbody>
</table>

*******************************************************************************

R-Squared    .95939 R-Bar-Squared .95298
S.E. of Regression 5.9076 F-stat. F(3, 19) 149.6367 [.000]
Mean of Dependent Variable 56.1926 S.D. of Dependent Variable 27.2449
Residual Sum of Squares 663.1057 Equation Log-likelihood -71.2921
Akaike Info. Criterion -75.2921 Schwarz Bayesian Criterion -77.5631
DW-statistic 2.6081 Durbin’s h-statistic -1.7799 [.075]
*******************************************************************************

Source: Author’s calculation.

Figure 1E.23. Plot of Actual and Fitted Values of Electricity Demand in Agricultural Sector

Plot of Actual and Fitted Values

Source: Author’s calculation.

- Fuel oil
  \[ \text{AGHF} = 4.5139*\text{CONS} - .8940E-5*\text{AGGDP} - .1423E-3*\text{RPOIL} + .99036*\text{AGHF(-1)} \]
Table 1E.24. Coefficient Estimates of Fuel Oil Demand in Agricultural Sector

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONS</td>
<td>4.5139</td>
<td>1.7634</td>
<td>2.5598[.019]</td>
</tr>
<tr>
<td>AGGDP</td>
<td>-.8940E-5</td>
<td>.8739E-5</td>
<td>-1.0230[.319]</td>
</tr>
<tr>
<td>RFOIL</td>
<td>-.1423E-3</td>
<td>.1462E-3</td>
<td>-.9733[.343]</td>
</tr>
<tr>
<td>AGHF(-1)</td>
<td>.99036</td>
<td>.081244</td>
<td>12.1900[.000]</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.

The sign of coefficient of AGGDP is negative. It proves that fuel oil demand decreases when AGGDP increases. In this case, we do not need to use the demand function above and suppose that fuel oil used in agriculture would reach zero by 2020 based on the trend of fuel oil used in the past.
Conclusion

The estimation results of energy demand formulas show that the data issue has become the most important factor affecting the energy demand in next periods. In the case of Viet Nam, the quality of data is still unsatisfactory, especially the existing unstable data chain and the inconsistency between the data source of the Asia Pacific Energy Research Centre and the energy balances of the International Energy Agency. Reasons for these include issues on data collection, data checking, and processing.

From the above findings, it is necessary that the Economic Research Institute for ASEAN and East Asia cooperate with the Asia Pacific Energy Research Centre to improve the energy data quality of Viet Nam.

Reference