Chapter 1

Re-estimation of Energy Demand Formula

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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

$$E = f(Y, Pe/CPI) \quad \text{or} \quad E = f(Y, Pe/CPI, E_{-1})$$

where

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

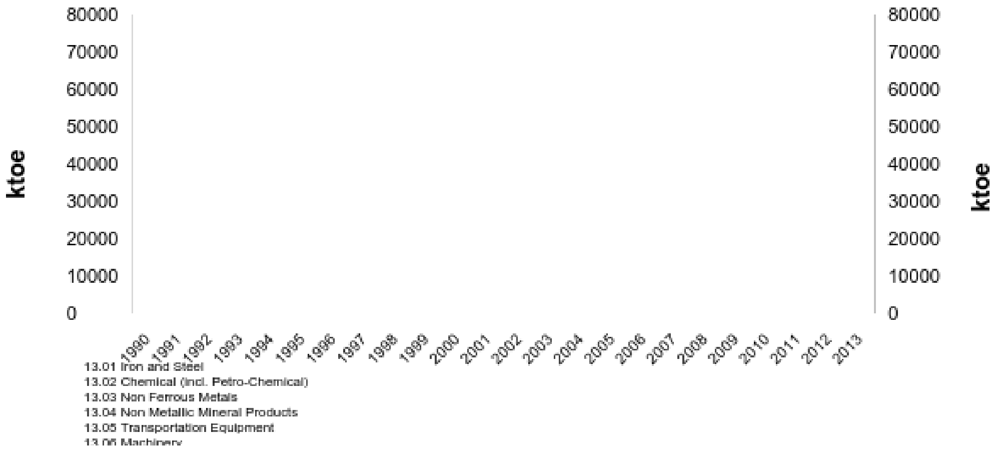
Such relationships among variables are derived by regression analysis using Microfit, a computer programme that offers an extensive choice of data analysis options and is a versatile aid in evaluating and designing advanced univariate and multivariate time series models. It is an interactive, menu-driven 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 subsectors 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.

Figure 1A.1. Industrial Energy Demand by Sector

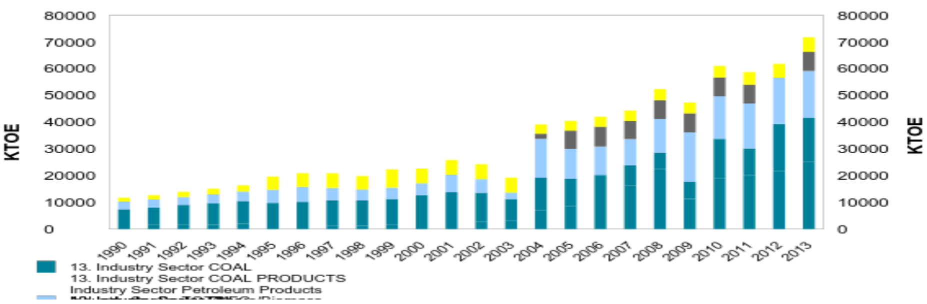


ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

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.

Figure 1A.2. Industrial Energy Demand by Fuel Type



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

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*CONS + .4366E-4*MFGGDPM + .15377*INTT(-1) + 4546.8*DUM0104

Table 1A.1. Ordinary Least Squares Estimation Total Industry (INTT)

Dependent variable is INTT 23 observations used for estimation from 1991 to 2013			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-24169.7	8408.8	-2.8743[.010]
MFGGDPM	.4366E-4	.1275E-4	.1275E-4 3.4257[.003]
INTT(-1)	.15377	.26817	.57340[.573]
DUM0104	4546.8	3329.4	1.3657[.188]
R-Squared	.94150	R-Bar-Squared	.93227
S.E. of Regression	4711.6	F-stat. F(3, 19)	101.9352[.000]
Mean of Dependent Variable	33647.5		
S.D. of Dependent Variable	18103.9		
Residual Sum of Squares	4.22E+08	Equation Log-likelihood	-224.9676
Akaike Info. Criterion	-228.9676	Schwarz Bayesian Criterion	-231.2386
DW-statistic	2.125	Durbin's h-statistic	*NONE*

Source: Microfit regression analysis.

Figure 1A.3. Industrial Energy Demand by Sector

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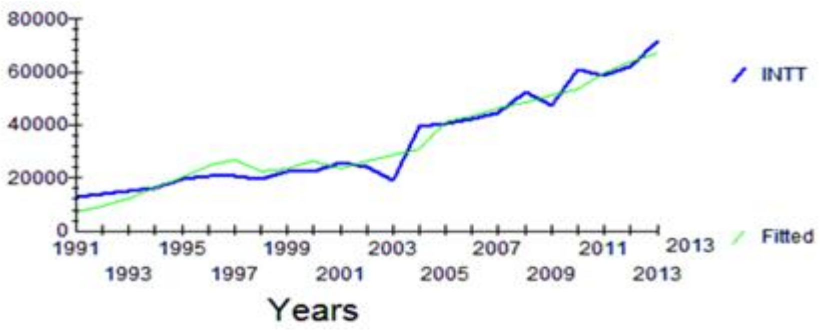
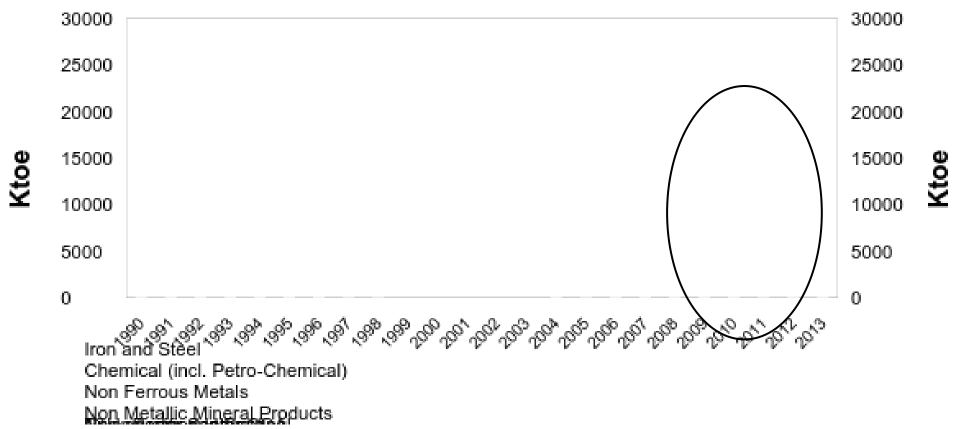


5. Total Coal Consumption (INCL)

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.

Figure 1A.4. Industrial Coal Consumption



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

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

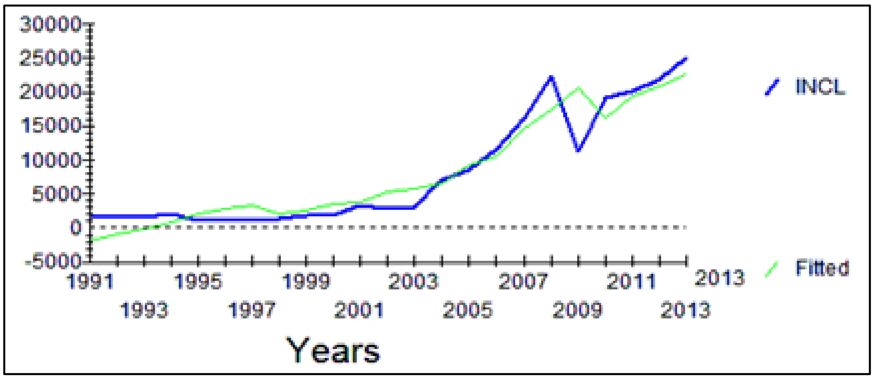
The result of the regression analysis is shown in Table 1A.2 while the plot of the actual and fitted values is shown in Figure 1A.5.

Table 1A.2. Ordinary Least Squares Estimation for INCL

Dependent variable is INTT 23 observations used for estimation from 1991 to 2013				
Regressor	Coefficient	Standard Error		T-Ratio[Prob]
CONS	-7298.7		4027.1	-1.8124[.086]
MFGGDPM	.1209W-4		.4192E-5	2.8849[.009]
INTT(-1)	.47196		.19693	2.3966[.027]
DUM0104	-1885.8		1974.9	'.95486[.352]
R-Squared	.88290	R-Bar-Squared		.86441
S.E. of Regression	3089.2	F-stat. F(3, 19)		47.7502[.000]
Mean of Dependent Variable	8151.7	S.D. of Dependent Variable		8389.4
Residual Sum of Squares	1.81E+08	Equation Log-likelihood		-215.2590
Akaike Info. Criterion	-215.2590	Schwarz Bayesian Criterion		-221.5300
DW-statistic	2.2254	Durbin's h-statistic		-1.6446[.100]

Source: Microfit regression analysis.

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

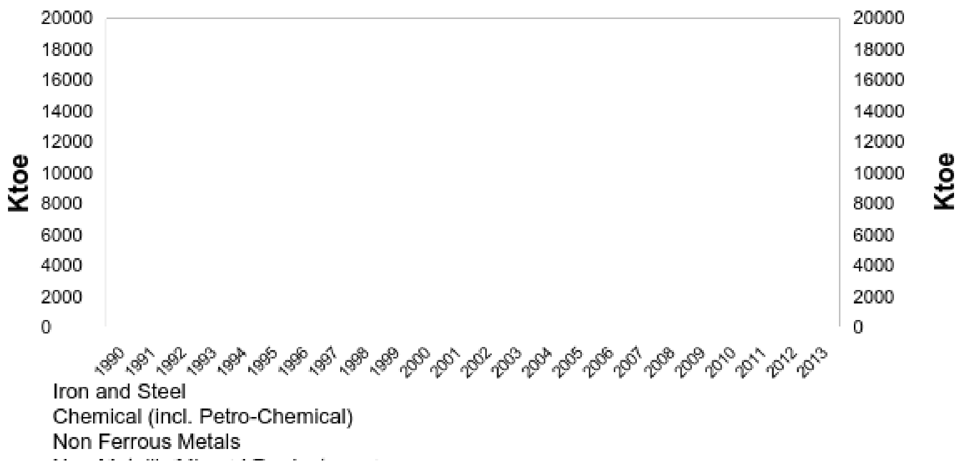


Source: APEC Energy Statistic of Indonesia.

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.

Figure 1A.6. Industrial Petroleum Product Consumption (INPP)



ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

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*CONS + .8315E-5*MFGGDPM - .71444*RPOIL + .27885*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

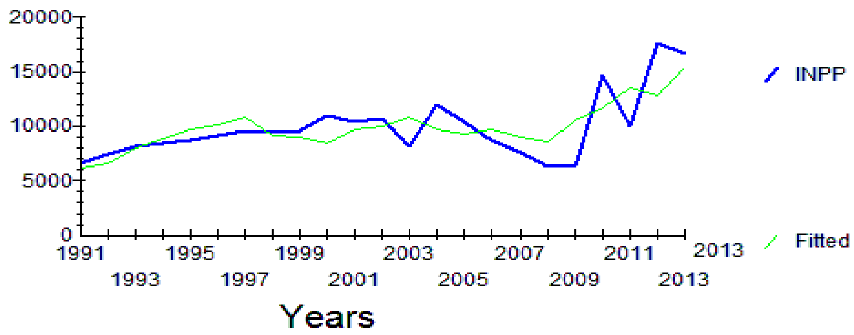
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	2775.6	1983.1	1.3996[.178]
MFGGDPM	8.32E-06	2.84E-06	2.9283[.009]
INTT(-1)	.71444	.35838	1.9935[.061]
DUM0104	.27885	.21329	1.3074[.207]

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.

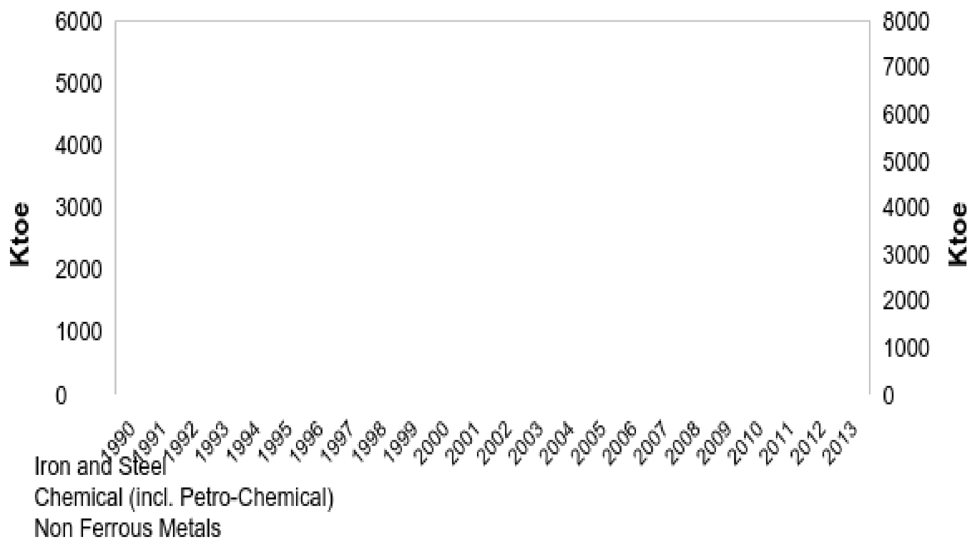
7. Total Electricity Consumption of Industries (INEL)

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:

*INEL = 1390.9*CONS + .1976E-5*MFGGDPM - .095445*RPOIL + .45469*INEL(-1) - 975.4261*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.

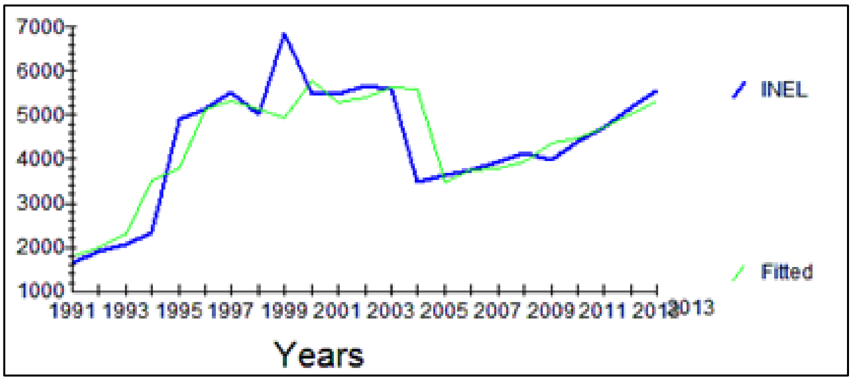
Table 1A.4. Ordinary Least Squares Estimation for INEL

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	1390.9	706.8747	1.9677[.065]
MFGGDPM	.1976E-5	.1029E-5	1.9208[.071]
RPOIL	-.095445	.14716	-.64857[.525]
INEL(-1)	.45469	.22146	2.0531[.055]
DUM9404	-975.4261	712.3919	-1.3692[.188]
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

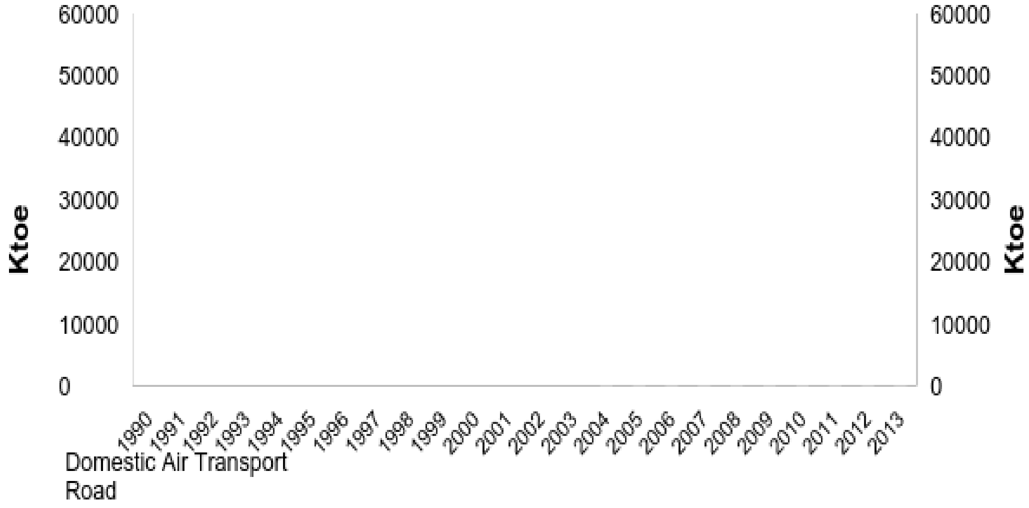


Source: Microfit regression analysis.

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.

Figure 1A.10. Transport Sector Final Energy Demand by Subsector

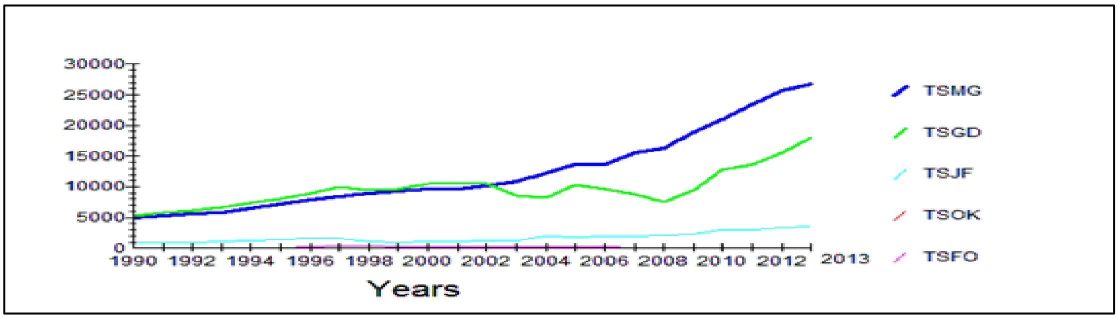


ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

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.

Figure 1A.11. Transport Sector Petroleum Product Consumption (Ktoe)



ktoe = kilotonne of oil equivalent.

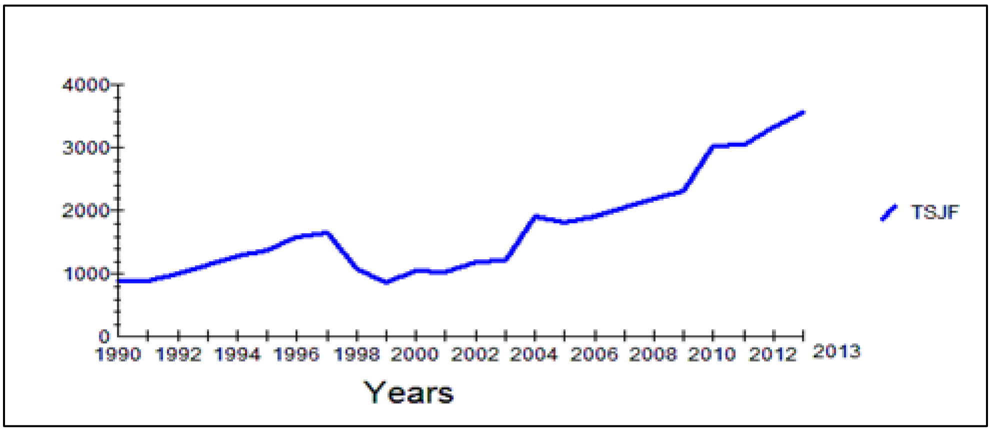
Source: APEC Energy Statistic of Indonesia.

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)

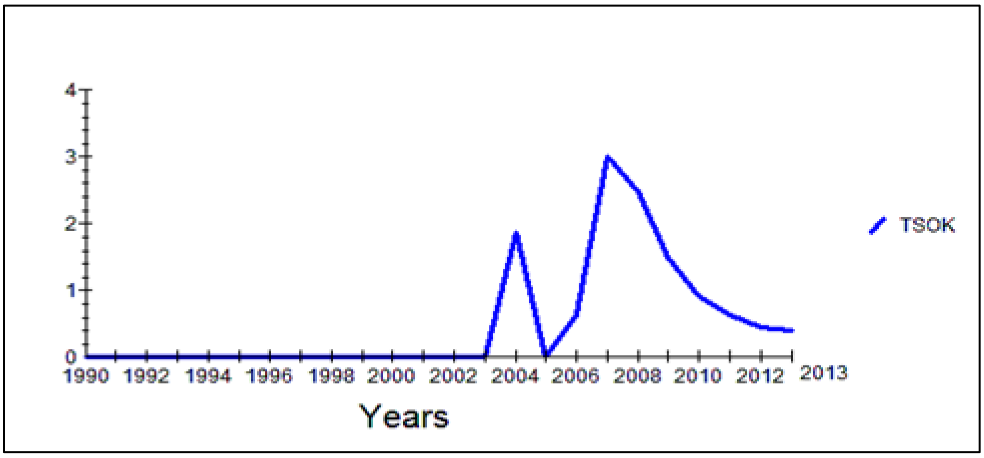


ktoe = kilotonne of oil equivalent.

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.

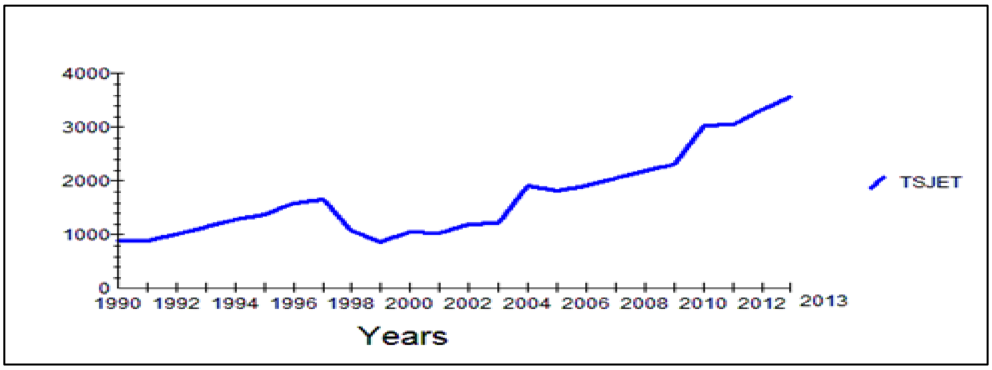
Figure 1A.13. Transport Sector Kerosene (TSOK) Consumption (Ktoe)



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 + .4632E-6*GDPMIL - .058392*RPOIL + .31410*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

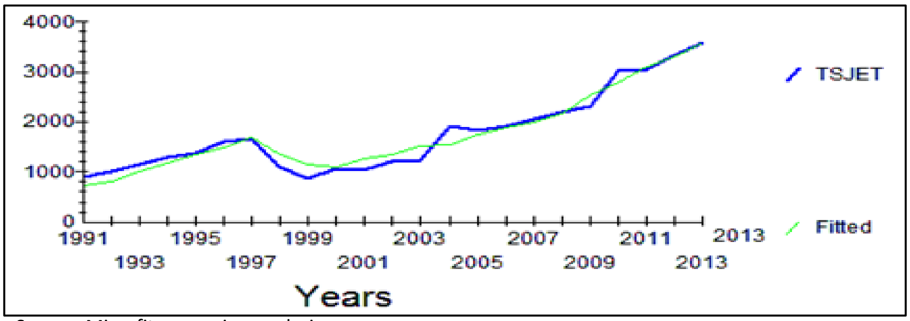
Dependent variable is TSJET
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-677.5099	189.3916	-3.5773[.002]
GDPMIL	.4632E-6	.1036E-6	4.4716[.000]
RPOIL	-.058392	.027203	-2.1465[.045]
TSJET(-1)	.31410	.17675	1.7771[.092]

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.

Figure 1A.15. Plot of Actual and Fitted Values for TSJET

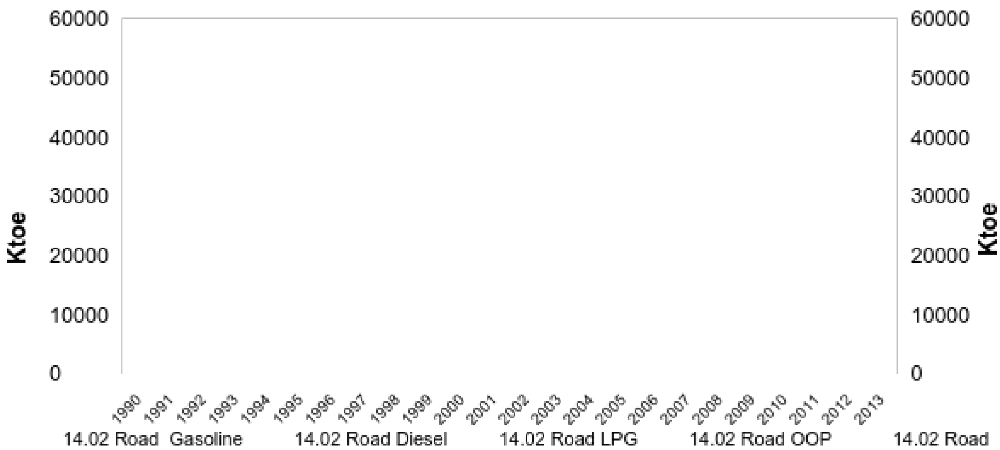


Source: Microfit regression analysis.

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.

Figure 1A.16. Road Sector Petroleum Product Consumption (RDPP)



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

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:

$$RDPP = -13144.7*CONS + .3582E\text{-}5*GDPMIL - .14432*RPOIL + .81835*RDPP(-1)$$

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

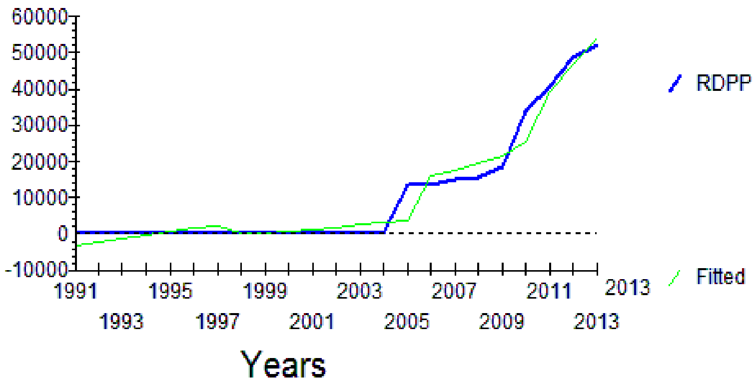
Dependent variable is RDPP
23 observations used for estimation from 1991 to 2013

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

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:

RDMG = -3370.5*CONS + .3795E-5*GDPMIL - 112.9137*RPPREM + .18479*RDMG(-1)

The result of the regression analysis is shown in Table 1-4.7 while the plot of the actual and fitted values is shown in Figure 1A.18.

Table 1A.7. Ordinary Least Squares Estimation for RDMG

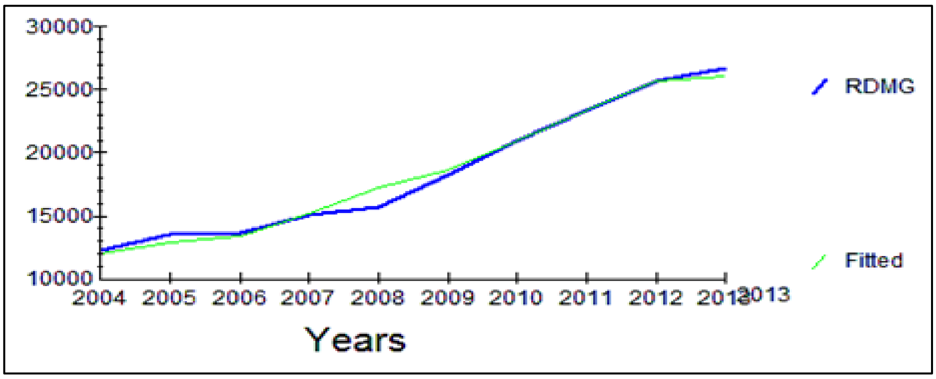
Dependent variable is RDMG
10 observations used for estimation from 2004 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-3370.5	5827.5	-.57838[.584]
GDPMIL	.3795E-5	.9451E-6	4.0159[.007]
RPPREM	-112.9137	55.2232	-2.0447[.087]
RDMG(-1)	.18479	.16017	1.1537[.292]

R-Squared	.98550	R-Bar-Squared	.97826
S.E. of Regression	783.7370	F-stat. F(3, 6)	135.9718[.000]
Mean of Dependent Variable	18550.0	S.D. of Dependent Variable	5315.0
Residual Sum of Squares	3685463	Equation Log-likelihood	-78.2760
Akaike Info. Criterion	-82.2760	Schwarz Bayesian Criterion	-82.8812
DW-statistic	1.2535	Durbin's h-statistic	1.3689[.171]

Source: Microfit regression analysis.

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



Source: Microfit regression analysis.

15. Road Diesel Transport (RDGD)

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 RDGD from the regression analysis is:

RDGD = -12737.1*CONS + .4483E-5*GDPMIL - 371.6183*RPDSLS + .43108*RDMG(-1)

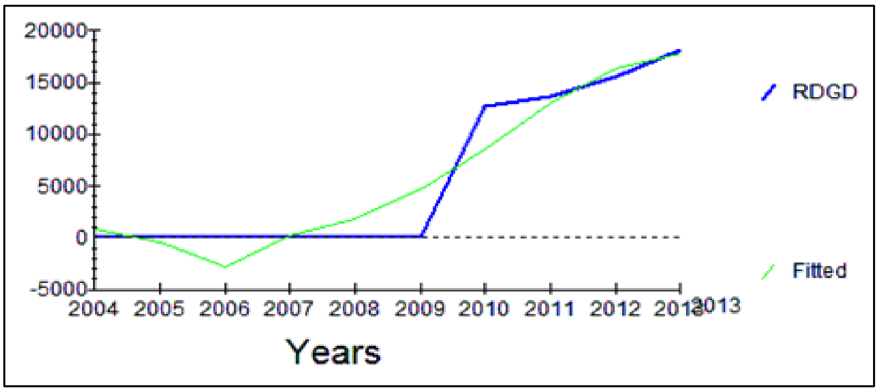
The result of the regression analysis is shown in Table 1-4.8 while the plot of the actual and fitted values is shown in Figure 1A.19.

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

```
*******************************************************************************
 Dependent variable is RDGD
 10 observations used for estimation from 2004 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     -23995.0            9816.3             -2.4444[.050]
 GDPMIL                   .6424E-5          .2006E-5              3.2020[.019]
 RPDSLS                  -254.7739          134.8292             -1.8896[.108]
 RDGD(-1)                  .087633            .32024               .27364[.794]
*******************************************************************************
 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*CONS + .1138E-7*GDPMIL - .017440*RPOIL + .76634*TSFO(-1)

The result of the regression analysis is shown in Table 1-4.9 while the plot of the actual and fitted values is shown in Figure 1A.20.

Table 1A.9. Ordinary Least Squares Estimation for TSFO

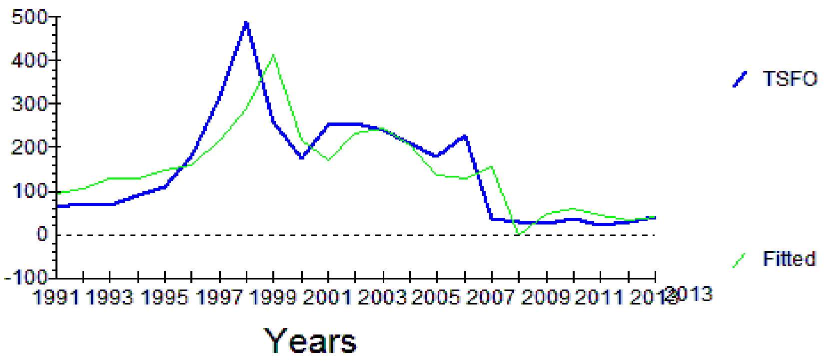
Dependent variable is TSFO
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	96.5251	77.5171	1.2452[.228]
GDPMIL	.1138E-7	.2163E-7	.52626[.605]
RPOIL	-.017440	.011672	-1.4942[.152]
TSFO(-1)	.76634	.16278	4.7078[.000]

R-Squared	.63262	R-Bar-Squared	.57462
S.E. of Regression	78.6495	F-stat. F(3, 19)	10.9060[.000]
Mean of Dependent Variable	147.8957	S.D. of Dependent Variable	120.5883
Residual Sum of Squares	117529.1	Equation Log-likelihood	-130.8335
Akaike Info. Criterion	-134.8335	Schwarz Bayesian Criterion	-137.1045
DW-statistic	2.1285	Durbin's h-statistic	-.49287[.622]

Source: Microfit regression analysis.

Figure 1A.20. Plot of Actual and Fitted Values for TSFO



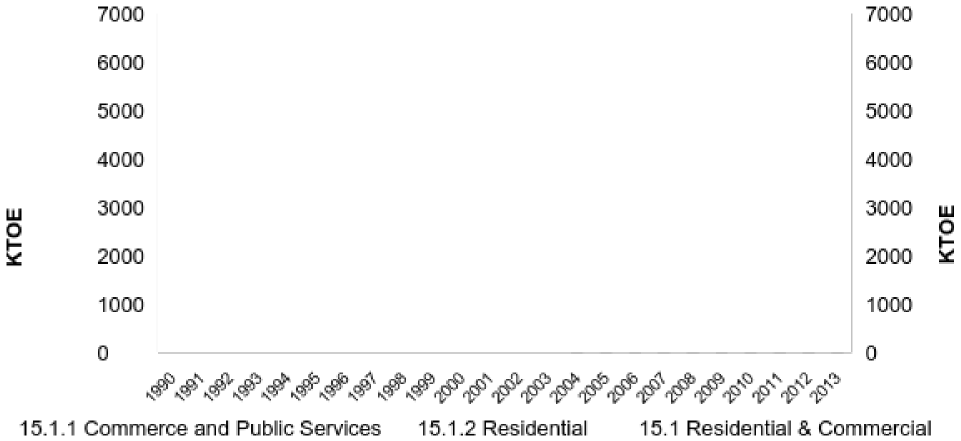
Source: Microfit regression analysis.

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.

Figure 1A.21. Residential and Commercial (ResCom) Sector LPG Consumption (RECSLP)

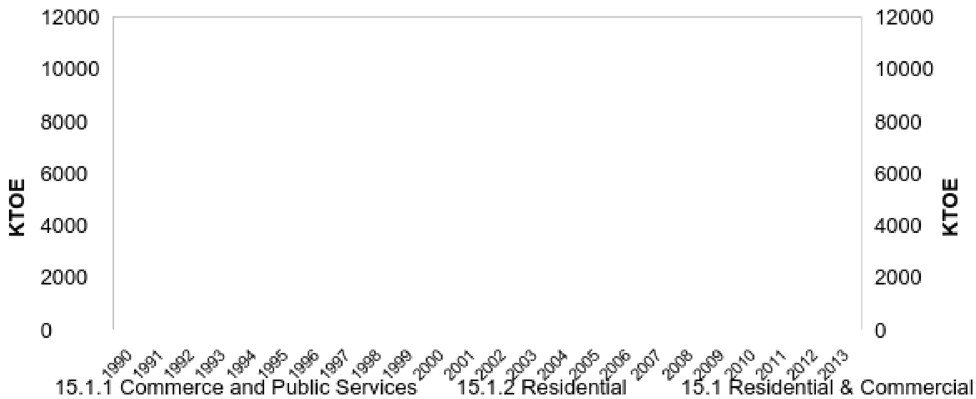


ktoe = kilotonne of oil equivalent.

Source: APEC Energy Statistic of Indonesia.

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.

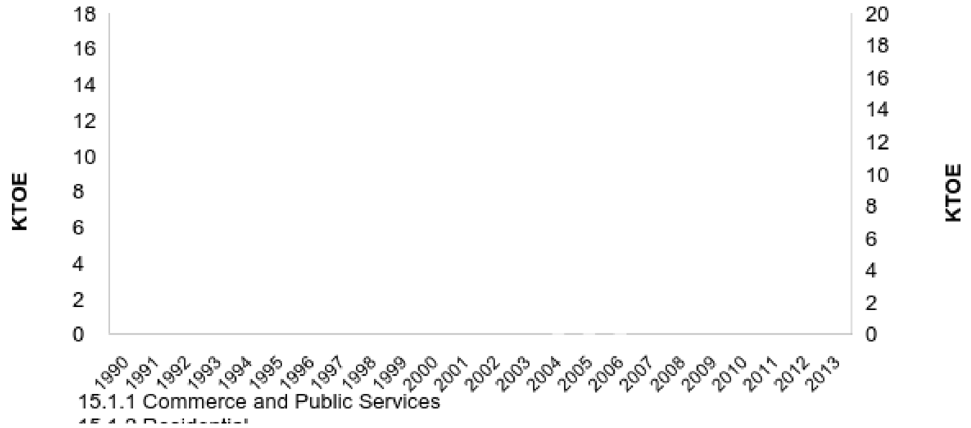
Figure 1A.22. Residential and Commercial (ResCom) Electricity Consumption (RECSEL)



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.

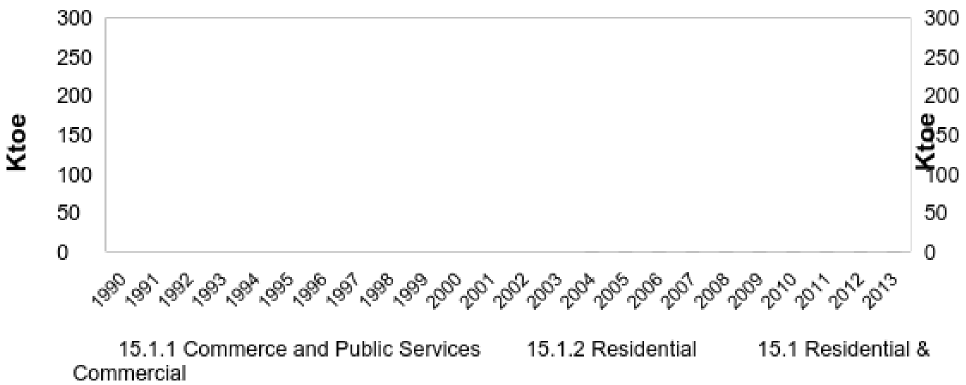
Figure 1A.23. Coal Product Consumption by Sector (CS)



ktoe = kilotonne of oil equivalent.
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)

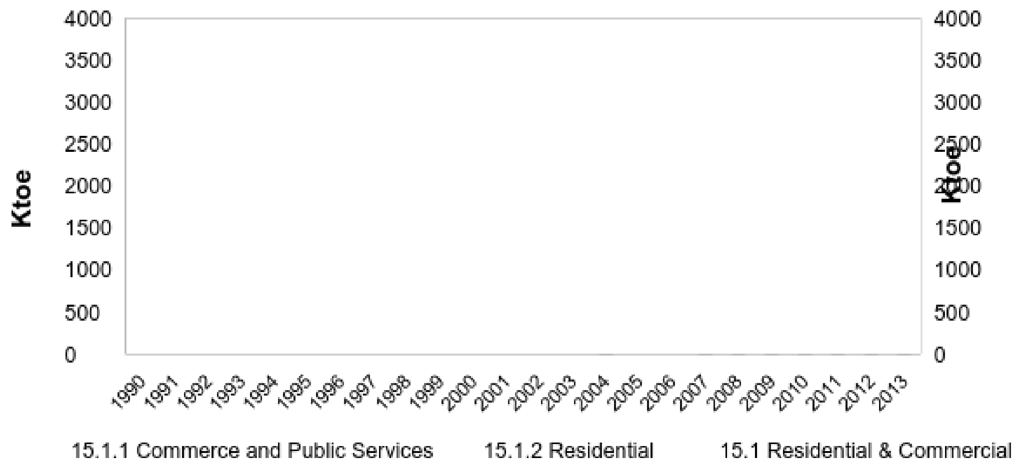


ktoe = kilotonne of oil equivalent.
Source: APEC Energy Statistic of Indonesia.

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*CONS - .11164*RPOIL + .6136E-6*GDPMIL + .74018*RECSLP(-1) + 1087.2*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

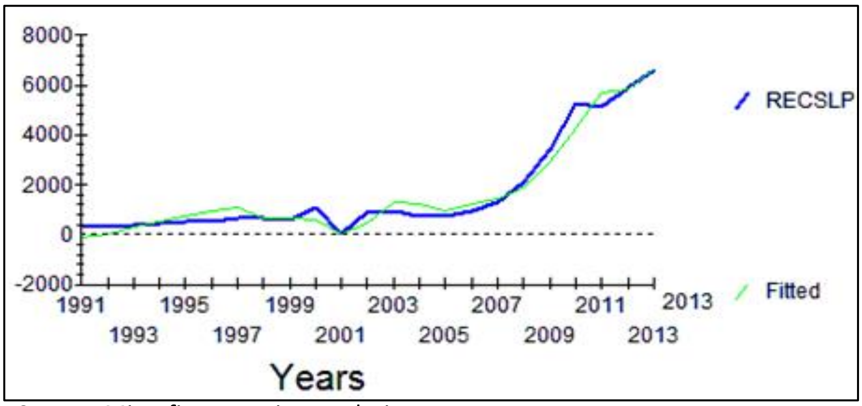
Dependent variable is RECSLP
23 observations used for estimation from 1991 to 2013

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

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

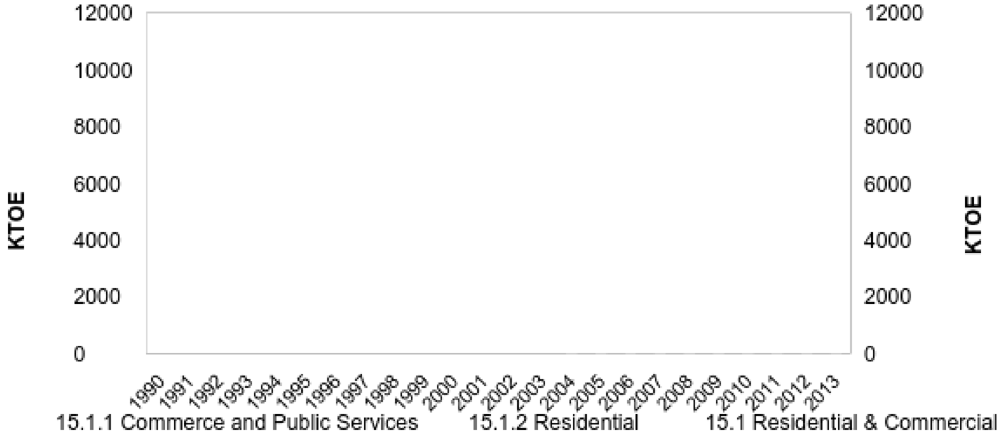


Source: Microfit regression analysis.

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).

Figure 1A.27. Total Electricity Consumption by Sector (Ktoe)



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

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

RECSEL = -653.9821*CONS + .4125E-6*GDPMIL - 25.8784*RPELCC + .83281*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

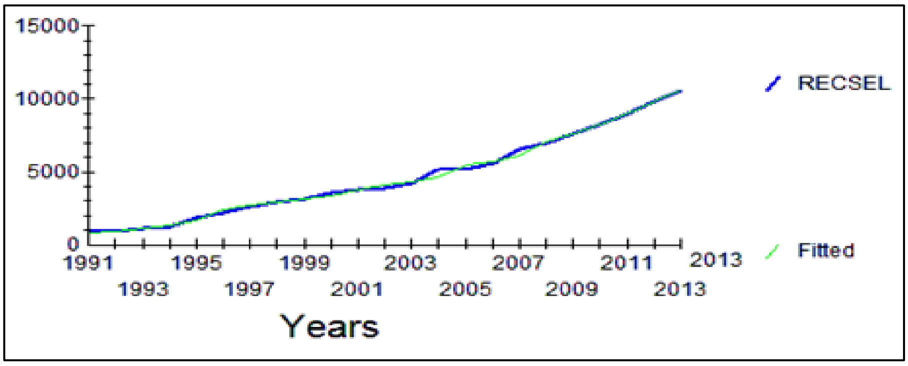
Dependent variable is RECSEL
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-653.9821	426.9971	-1.5316[.142]
GDPMIL	.4125E-6	.1631E-6	2.5294[.020]
RPELCC	-25.8784	24.2586	-1.0668[.299]
RECSEL(-1)	.83281	.095520	8.7187[.000]

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.

Figure 1A.28. Plot of Actual and Fitted Valued for RECSEL



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

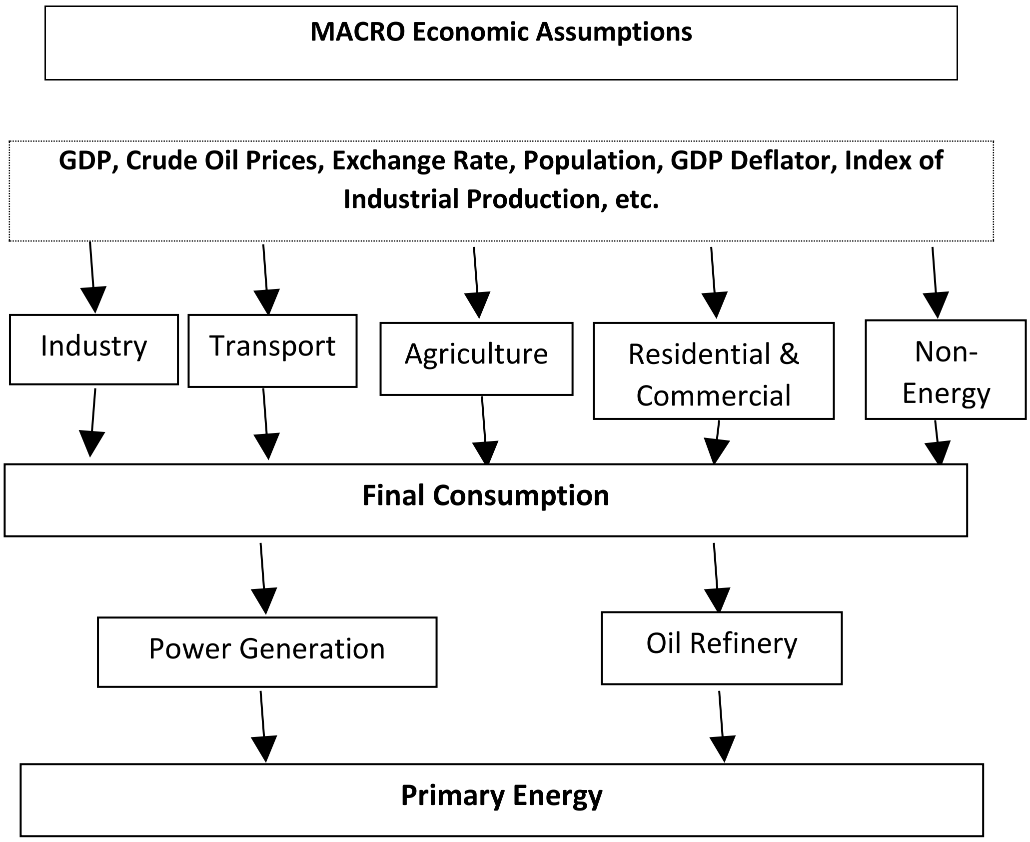
1. Introduction

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.

Figure 1B.1. Modelling Structure



GDP = gross domestic product.
Source: Author's llustration.

2. Industry Sector

Total Industry Sector

(INTTC): 1105.5*CONST + 27.4371*MNGDP -986.1141*RPOIL + 0.76655*INTTC (-1)

Average Annual Growth Rate (2013–2040): 3.16 %

Table 1B.1. Coefficient Estimates of Total Industry Sector

Ordinary Least Squares Estimation

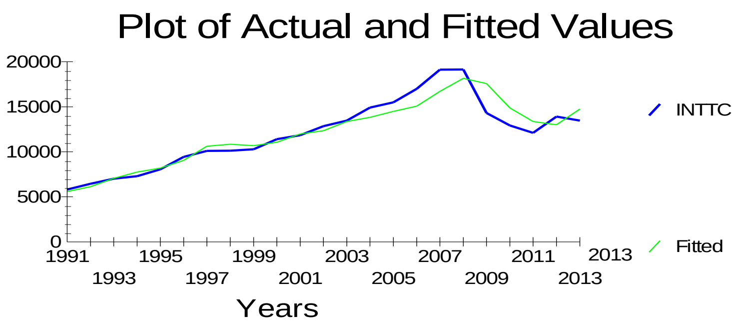
Dependent variable is INTTC
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	1105.5	948.1395	1.1660[.258]
MNGDP	27.4371	16.6577	1.6471[.116]
RPOIL	-986.1141	851.0325	-1.1587[.261]
INTTC(-1)	.76655	.13197	5.8087[.000]

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	3.29E+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

INLB = -5.5412 + 4.0091*MNGDP + 0.52011*INLB (-1)

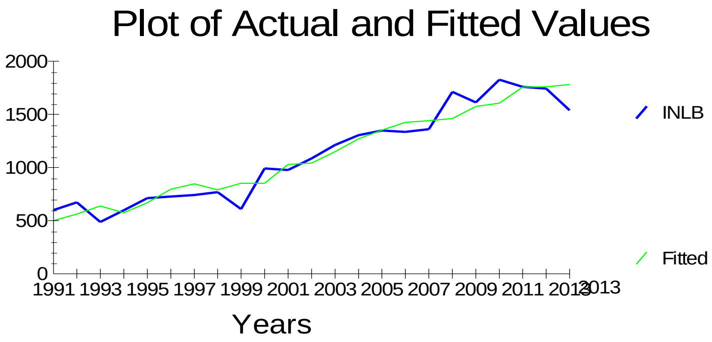
Average Annual Growth Rate (2013–2040): 2.87 %

Table 1B.2. Coefficient Estimates of Coal Demand in Industry Sector

```
                                 Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INLB
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor                Coefficient        Standard Error         T-Ratio[Prob]
 CONST                       -5.5412            87.0944            -.063623[.950]
 MNGDP                        4.0091             1.6053              2.4974[.021]
 INLB(-1)                     .52011             .17588              2.9572[.008]
*******************************************************************************
 R-Squared                        .92121   R-Bar-Squared                    .91333
 S.E. of Regression             130.1585   F-stat.    F(  2,  20)  116.9119[.000]
 Mean of Dependent Variable       1118.2   S.D. of Dependent Variable     442.1069
 Residual Sum of Squares        338824.6   Equation Log-likelihood       -143.0096
 Akaike Info. Criterion        -146.0096   Schwarz Bayesian Criterion    -147.7129
 DW-statistic                     1.9475   Durbin's h-statistic       .23458[.815]
*******************************************************************************
```

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

Ordinary Least Squares Estimation

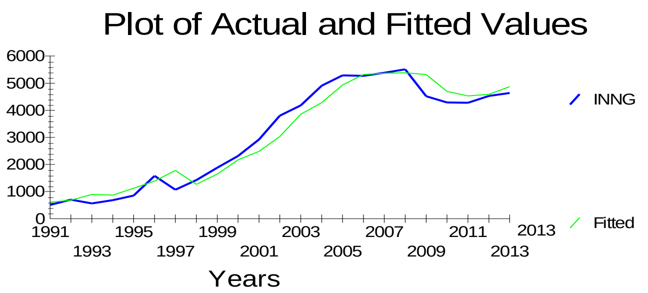
Dependent variable is INNG
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-507.5752	594.2775	-.85410[.404]
INGDP	5.5600	3.8590	1.4408[.166]
RPRNG	-2519.1	3160.2	-.79714[.435]
INNG(-1)	.80290	.11943	6.7229[.000]

R-Squared	.95728	R-Bar-Squared	.95054
S.E. of Regression	412.8358	F-stat. F(3, 19)	141.9263[.000]
Mean of Dependent Variable	3090.0	S.D. of Dependent Variable	1856.3
Residual Sum of Squares	3238234	Equation Log-likelihood	-168.9686
Akaike Info. Criterion	-172.9686	Schwarz Bayesian Criterion	-175.2396
DW-statistic	1.1700	Durbin's h-statistic	2.4279[.015]

Source: Microfit result.

Figure 1B.4. Plot of actual and fitted values of gas demand



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

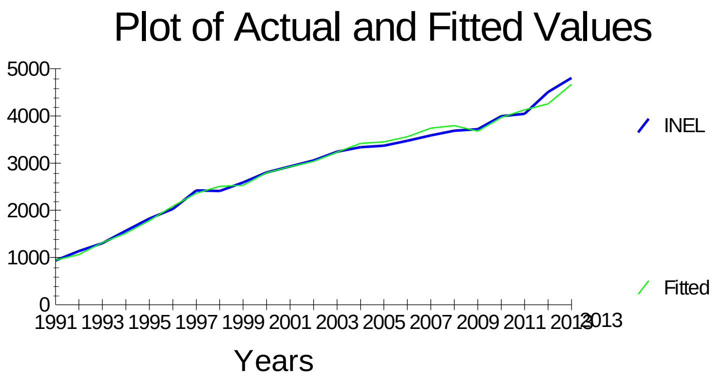
Dependent variable is INEL
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	18.0327	74.7523	.24123[.812]
MNGDP	9.4470	2.7083	3.4882[.002]
RPOIL	-169.9169	66.3959	-2.5591[.019]
INEL(-1)	.68847	.099358	6.9292[.000]

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*GDP -165.5858*RPOIL + 0.51359*TRJK (-1)

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

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

Ordinary Least Squares Estimation

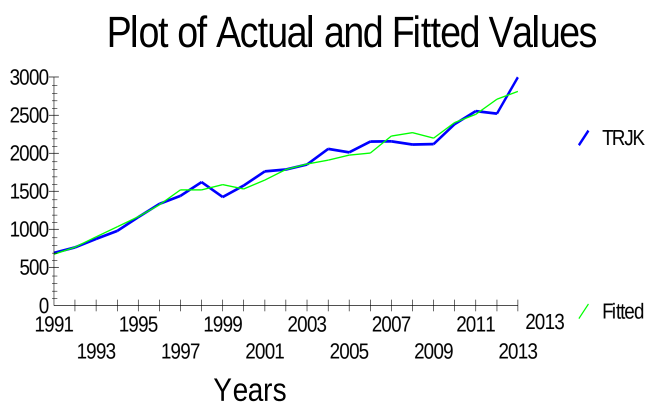
Dependent variable is TRJK
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-87.3853	81.9289	-1.0666[.300]
GDP	2.2125	.57156	3.8709[.001]
RPOIL	-165.5858	70.8858	-2.3360[.031]
TRJK(-1)	.51359	.15524	3.3083[.004]

R-Squared	.97357	R-Bar-Squared	.96940
S.E. of Regression	106.7293	F-stat. F(3, 19)	233.2949[.000]
Mean of Dependent Variable	1752.8	S.D. of Dependent Variable	610.1014
Residual Sum of Squares	216431.8	Equation Log-likelihood	-137.8553
Akaike Info. Criterion	-141.8553	Schwarz Bayesian Criterion	-144.1262
DW-statistic	2.2660	Durbin's h-statistic	-.95532[.339]

Source: Microfit result.

Figure 1B.6. Plot of actual and fitted values of jet kerosene demand



Motor Gasoline Demand in Transport Sector

TSMG = -246.4996 + 10.8371*GDP -989.7284*RPOIL + 0.39919*TSMG (-1)

Average Annual Growth Rate (2013–2040): 3.51 %

Table 1B.6. Coefficient Estimates of Motor Gasoline Demand

Ordinary Least Squares Estimation

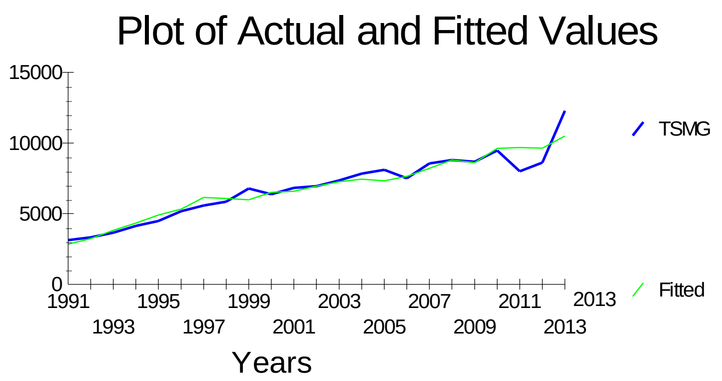
Dependent variable is TSMG
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-246.4996	556.3996	-.44303[.663]
GDP	10.8371	2.7401	3.9551[.001]
RPOIL	-989.7284	469.3141	-2.1089[.048]
TSMG(-1)	.39919	.20797	1.9195[.070]

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	9454146	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*MNGDP -5900.6*RPRGD + 0.43692*TRGD (-1)

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

Table 1B.7. Coefficient Estimates of Diesel Demand

Ordinary Least Squares Estimation

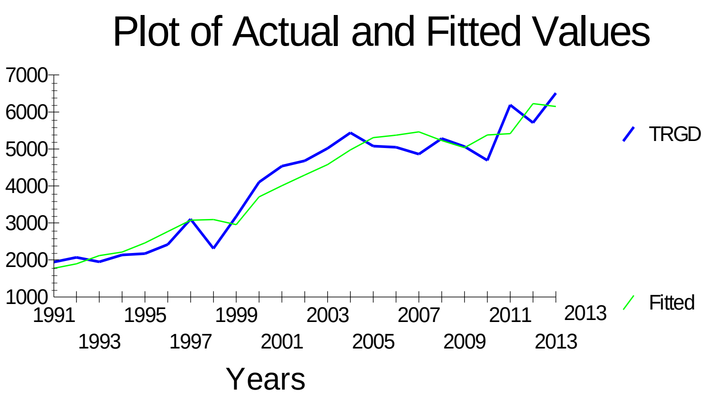
Dependent variable is TRGD
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	-90.1833	342.9761	-.26294[.795]
MNGDP	17.8414	5.9019	3.0230[.007]
RPRGD	-5900.6	9136.7	-.64581[.526]
TRGD(-1)	.43692	.18056	2.4197[.026]

R-Squared	.92074	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 diesele demand



7. Others Sector

Total Energy Demand in Others Sector

OSTT = 220.6223 + 17.5420*CSGDP -43.6012*RRPOIL + 0.025252*OSTT (-1)

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

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

Ordinary Least Squares Estimation

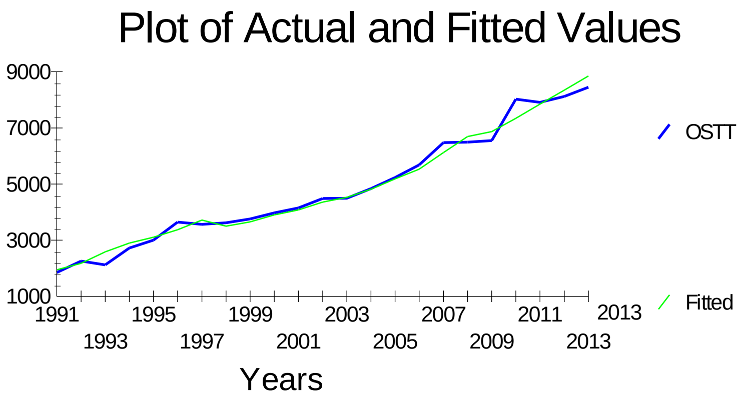
Dependent variable is OSTT
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	220.6223	146.3524	1.5075[.148]
CSGDP	17.5420	4.2622	4.1158[.001]
RRPOIL	-43.6012	172.8712	-.25222[.804]
OSTT(-1)	.025252	.23431	.10778[.915]

R-Squared	.98444	R-Bar-Squared	.98198
S.E. of Regression	272.3962	F-stat. F(3, 19)	400.6784[.000]
Mean of Dependent Variable	4844.1	S.D. of Dependent Variable	2029.3
Residual Sum of Squares	1409794	Equation Log-likelihood	-159.4054
Akaike Info. Criterion	-163.4054	Schwarz Bayesian Criterion	-165.6764
DW-statistic	1.9510	Durbin's h-statistic	*NONE*

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 -.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

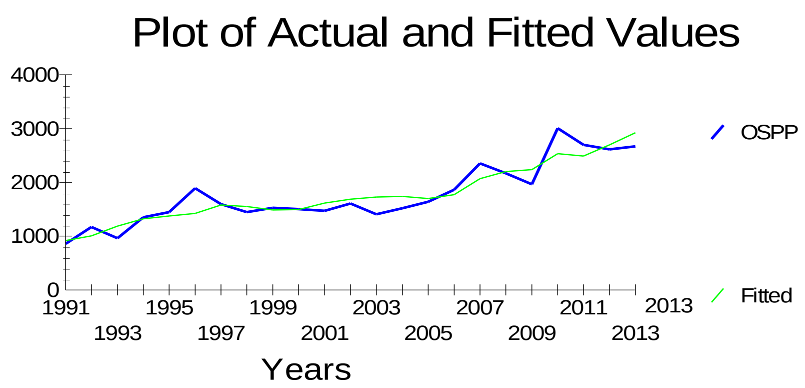
Dependent variable is OSPP
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	610.1269	167.0910	3.6515[.002]
CSGDP	6.6199	1.8272	3.6230[.002]
RRPOIL	-265.9463	157.3498	-1.6902[.107]
OSPP(-1)	-.036547	.22554	-.16204[.873]

R-Squared	.86097	R-Bar-Squared	.83901
S.E. of Regression	229.5971	F-stat. F(3, 19)	39.2189[.000]
Mean of Dependent Variable	1770.6	S.D. of Dependent Variable	572.2302
Residual Sum of Squares	1001582	Equation Log-likelihood	-155.4740
Akaike Info. Criterion	-159.4740	Schwarz Bayesian Criterion	-161.7449
DW-statistic	1.7418	Durbin's h-statistic	*NONE*

Source: Microfit result.

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



LPG Demand in the Others Sector

OSLP = 871.4548 + .82150*CSGDP -24571.4*RPRLP + 0.45162*OSLP (-1)

Average Annual Growth Rate (2013–2040): 2.04 %

Table 1B.10. Coefficient Estimates of LPG Demand

Ordinary Least Squares Estimation

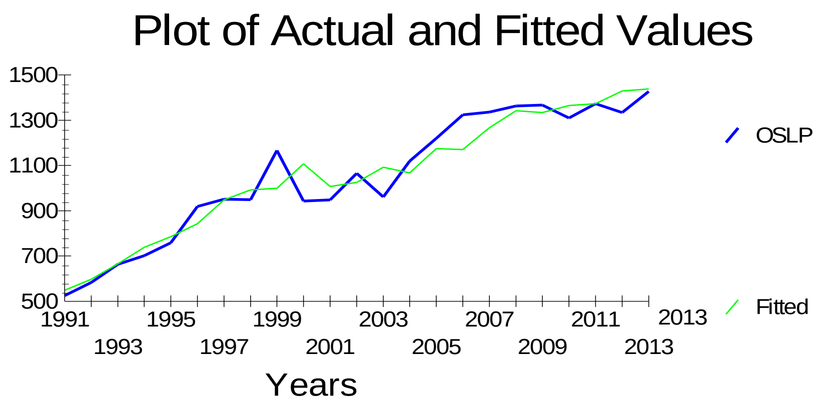
Dependent variable is OSLP
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	871.4548	437.5028	1.9919[.061]
CSGDP	.82150	.39657	2.0715[.052]
RPRLP	-24571.4	15925.7	-1.5429[.139]
OSLP(-1)	.45162	.20244	2.2308[.038]

R-Squared	.92173	R-Bar-Squared	.90937
S.E. of Regression	84.0227	F-stat. F(3, 19)	74.5861[.000]
Mean of Dependent Variable	1056.7	S.D. of Dependent Variable	279.1079
Residual Sum of Squares	134136.4	Equation Log-likelihood	-132.3534
Akaike Info. Criterion	-136.3534	Schwarz Bayesian Criterion	-138.6244
DW-statistic	2.2691	Durbin's h-statistic	-2.6934[.007]

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*CSGDP -732.9436*RPREL + .93157*OSEL (-1)

Average Annual Growth Rate (2013–2040): 3.91 %

Table 1B.11. Coefficient Estimates of Electricity Demand in Other Sectors

Ordinary Least Squares Estimation

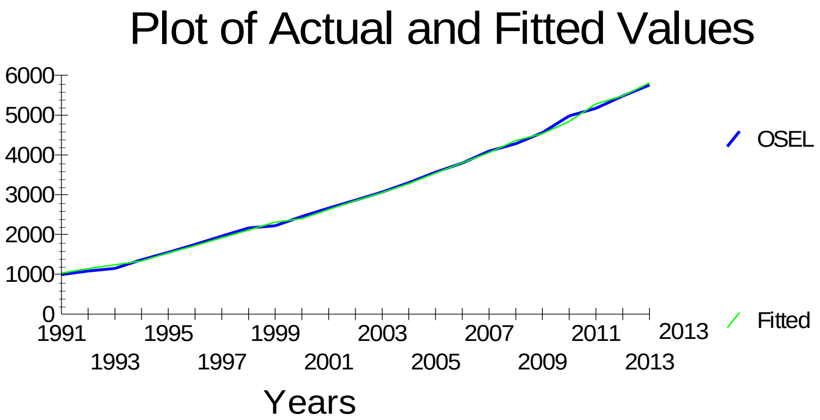
Dependent variable is OSEL
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONST	298.2890	217.5719	1.3710[.186]
CSGDP	1.2677	.99305	1.2765[.217]
RPREL	-732.9436	675.1614	-1.0856[.291]
OSEL(-1)	.93157	.081069	11.4910[.000]

R-Squared	.99849	R-Bar-Squared	.99825
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	74184.2	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).

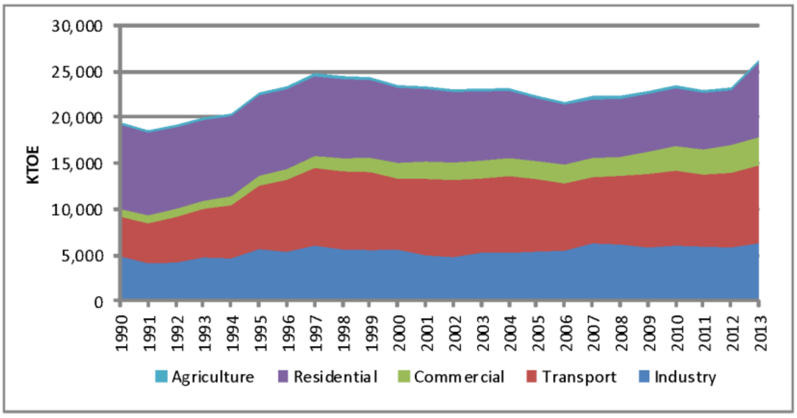
Overall, some improvements need to be considered for the future development of the demand functions for Malaysia, mainly issues on historical energy time series data and other useful parameters for analysis.

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%.

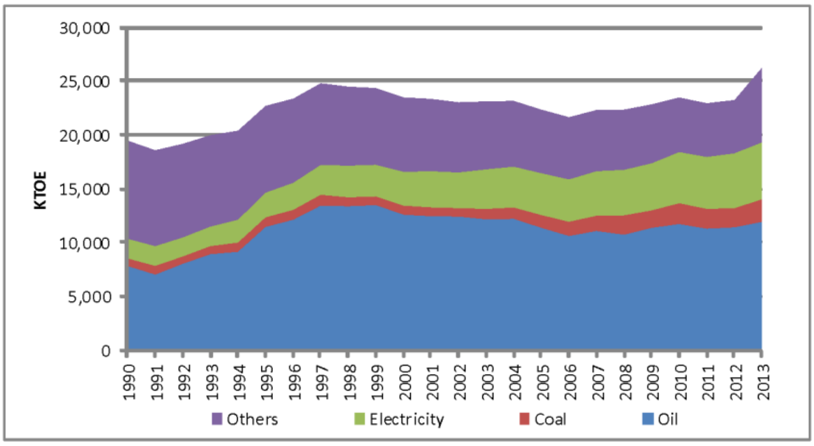
Figure 1C.1. Total Final Energy Consumption by Sector, 1990–2013



ktoe = kilotonne of oil equivalent.
Source: Department of Energy, Philippines.

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.

Figure 1C.2. Total Final Energy Consumption by Fuel, 1990–2013



ktoe = kilotonne of oil equivalent.

Source: Department of Energy, Philippines.

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

Coal	33.1%
Kerosene	0.2%
Diesel	10.4%
Fuel Oil	7.9%
LPG	1.8%
Biomass	17.3%
Electricity	28.2%
Natural Gas	1.0%
Total Demand	6.3 Mtoe

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): RDMG constant RRPOILJ RNOMGVE90 RDMg(-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): RDGD constant RRPOILJ RNODSLVE

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): RAEL constant TRDGVA RAEL(-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: DAPP constant TGDPCAP 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 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 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 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 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

	Industry	Transport	Commercial	Residential	Agriculture	Total
1990	4,896	4,290	841	9,164	283	19,474
1991	4,118	4,341	877	8,995	261	18,592
1992	4,206	4,943	887	8,863	291	19,191
1993	4,764	5,275	875	8,773	300	19,987
1994	4,658	5,760	992	8,720	275	20,404
1995	5,659	6,897	1,078	8,753	319	22,706
1996	5,375	7,823	1,169	8,675	337	23,378
1997	6,044	8,431	1,308	8,647	376	24,806
1998	5,628	8,486	1,427	8,599	350	24,489
1999	5,568	8,464	1,555	8,449	331	24,366
2000	5,611	7,695	1,726	8,172	298	23,502
2001	4,987	8,310	1,898	7,880	281	23,355
2002	4,792	8,372	1,917	7,661	298	23,040
2003	5,278	8,054	1,956	7,519	318	23,126
2004	5,257	8,334	1,969	7,301	311	23,171
2005	5,402	7,867	1,962	6,820	308	22,359
2006	5,492	7,314	2,053	6,526	277	21,661
2007	6,296	7,172	2,105	6,340	411	22,324
2008	6,173	7,452	2,055	6,311	364	22,355
2009	5,840	7,990	2,419	6,280	326	22,856
2010	6,049	8,142	2,668	6,285	343	23,488
2011	5,927	7,828	2,743	6,162	301	22,961
2012	5,845	8,108	3,028	5,956	319	23,256
2013	6,299	8,466	3,056	8,098	358	26,276

ktoe = kilotonne of oil equivalent.
Source: Department of Energy, Philippines.

Table 1C.3. Final Energy Consumption by Fuel, 1990–2013, ktoe

	Oil	Coal	Electricity	Others	Total
1990	7,833	696	1,824	9,121	19,474
1991	7,026	816	1,839	8,910	18,592
1992	8,041	676	1,775	8,699	19,191
1993	8,927	748	1,824	8,488	19,987
1994	9,146	866	2,115	8,277	20,404
1995	11,458	894	2,287	8,067	22,706
1996	12,128	911	2,515	7,825	23,378
1997	13,437	1,010	2,777	7,583	24,806
1998	13,380	833	2,936	7,341	24,489
1999	13,488	809	2,936	7,133	24,366
2000	12,592	840	3,144	6,926	23,502
2001	12,451	818	3,366	6,721	23,355
2002	12,418	782	3,322	6,518	23,040
2003	12,162	974	3,674	6,316	23,126
2004	12,210	1,055	3,791	6,116	23,171
2005	11,374	1,184	3,884	5,917	22,359
2006	10,616	1,324	3,928	5,793	21,661
2007	11,082	1,419	4,129	5,694	22,324
2008	10,733	1,798	4,232	5,593	22,355
2009	11,373	1,624	4,377	5,481	22,856
2010	11,727	1,933	4,753	5,075	23,488
2011	11,296	1,838	4,824	5,002	22,961
2012	11,422	1,784	5,092	4,957	23,256
2013	11,935	2,082	5,295	6,964	26,276

ktoe = kilotonne of oil equivalent.
Source: Department of Energy, Philippines.

6. Industry demand model

1) Coal

1.1 Non-metallic minerals:

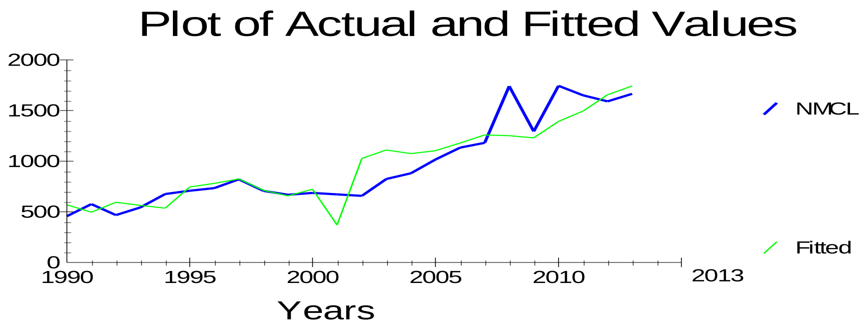
NMCL constant BNMMFGVA RCOILPR

Table 1C.4. Coefficient Estimates of Non-metallic Mineral Demand in Industry

```
                         Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is NMCL
 24 observations used for estimation from 1990 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 730.6747          171.4776              4.2611[.000]
 BNMMFGVA                  29.7715            5.3153              5.6011[.000]
 RCOILPR                   -1370.5          223.1813             -6.1406[.000]
*******************************************************************************
 R-Squared                    .80531   R-Bar-Squared                   .78677
 S.E. of Regression         198.5057   F-stat.    F( 2, 21)    43.4322[.000]
 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



Source: Author's calculations.

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

1.2 Coal industry

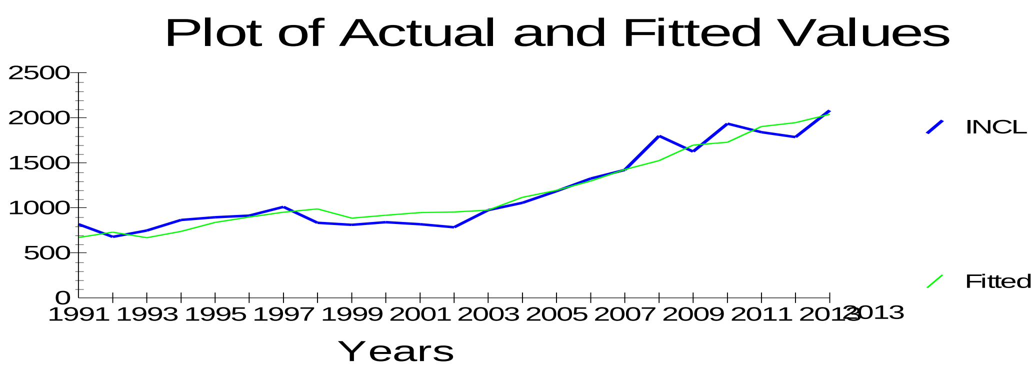
INCL constant BINGDP INCL(-1)

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                -271.5342          114.1237             -2.3793[.027]
 BINGDP                     .63547            .18277              3.4769[.002]
 INCL(-1)                   .50380            .16312              3.0884[.006]
*******************************************************************************
 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

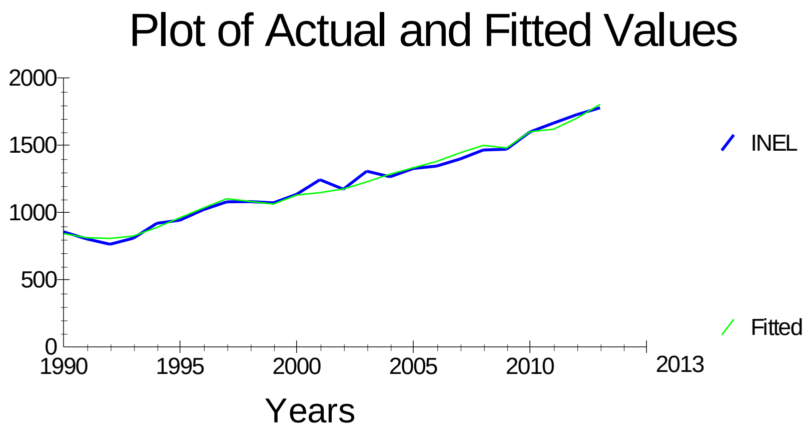
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	-6985.9	206.1562	-33.8866[.000]
LBINGDP	1140.6	28.6448	39.8176[.000]

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

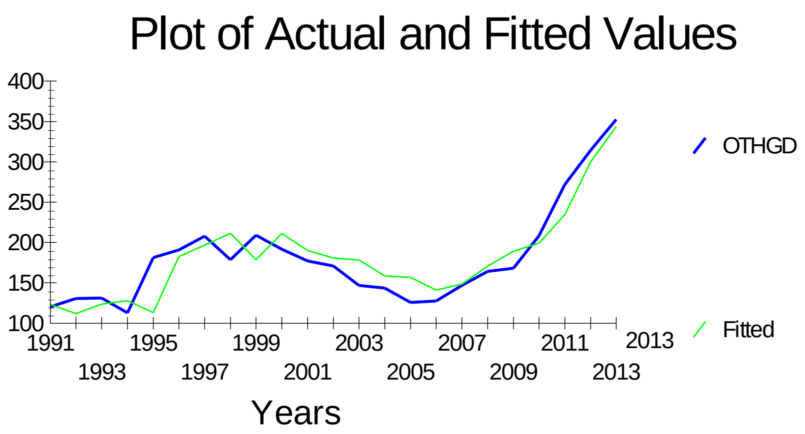
3.1 Diesel for mining and construction sector

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   Equation Log-likelihood       -105.2556
Akaike Info. Criterion      -108.2556   Schwarz Bayesian Criterion    -109.9589
DW-statistic                   1.8898   Durbin's h-statistic       .34859[.727]
*******************************************************************************
```

Figure 1C.6. Plot of Actual and Fitted Values of Diesel for Mining and Construction Demand



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

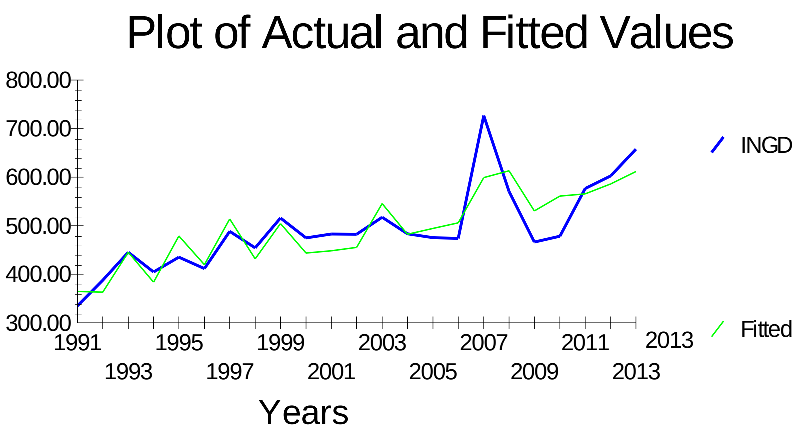
3.2 Diesel demand in industry

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  -7389.8            1075.6              -6.8706[.000]
 LINGDP                    284.1724           38.5950              7.3629[.000]
 DUM939578                 -77.3006           21.0673             -3.6692[.002]
*******************************************************************************
 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

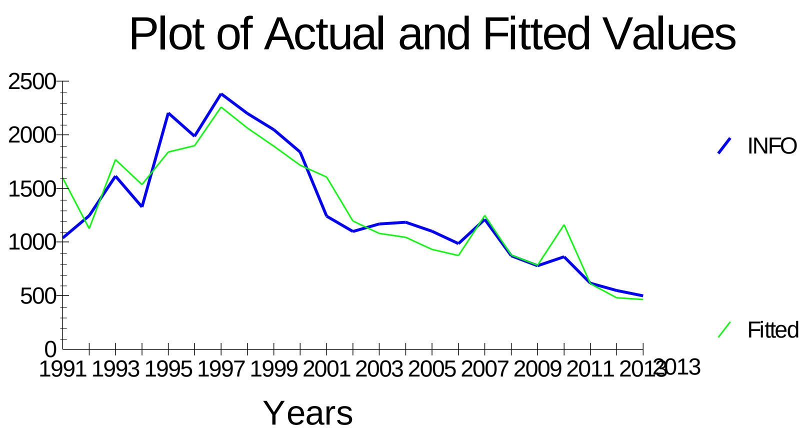
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	1140.9	307.7944	3.7065[.001]
RPOIL	-19.8698	8.9321	-2.2245[.038]
INFO(-1)	.63875	.13994	4.5644[.000]
DUM935770	-483.5952	116.5109	-4.1506[.001]

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

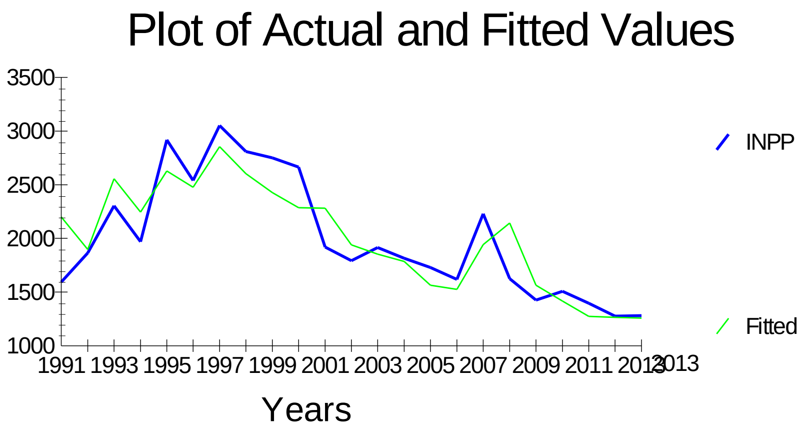
5) Petroleum products

INPP CONSTANT RPOIL INPP(-1) DUM935778

Table 1C.10. Coefficient Estimates of Petroleum Products Demand in Industry

```
                     Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INPP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                   2043.8            463.6495            4.4081[.000]
 RPOIL                    -28.9752             10.0196           -2.8919[.009]
 INPP(-1)                   .40690              .15800            2.5752[.019]
 DUM935778               -512.6589            143.3941           -3.5752[.002]
*******************************************************************************
 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



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

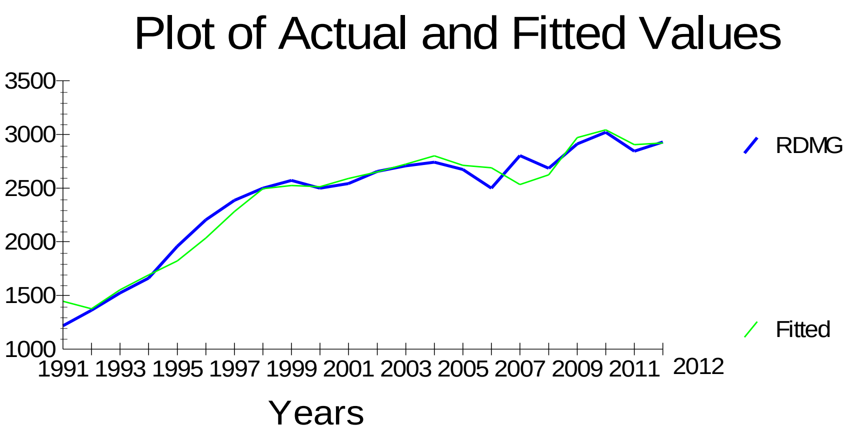
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	433.7545	133.7149	3.2439[.005]
RRPOILJ	-285.7495	79.2469	-3.6058[.002]
RNOMGVE90	494.1055	137.3021	3.5987[.002]
RDMG(-1)	.51980	.13246	3.9241[.001]

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



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

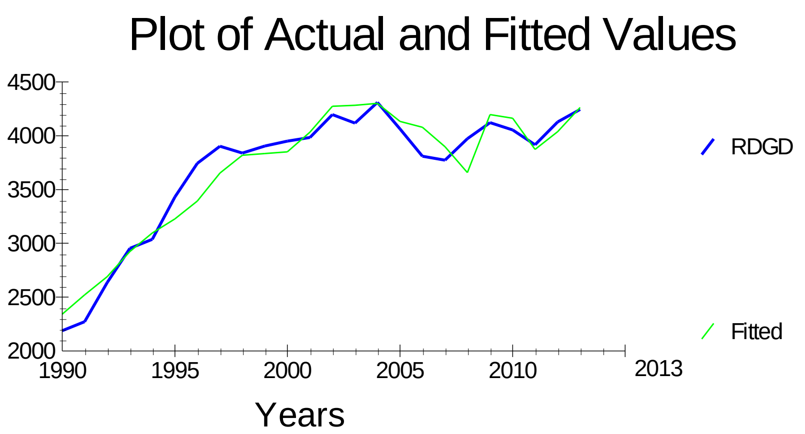
1.2 Diesel

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
*******************************************************************************
 Regressor                Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                     1604.5            128.5955            12.4772[.000]
 RRPOILJ                   -343.4349             42.1219            -8.1534[.000]
 RNODSLVE                     1079.4             72.5288            14.8826[.000]
*******************************************************************************
 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



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

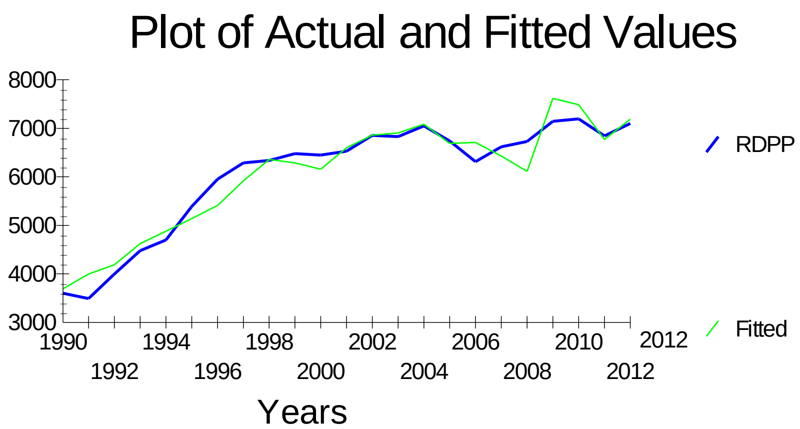
1.3 Road transport total

RDPP constant RRPOILJ RNOTOOVE

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                   2621.6             209.9990           12.4838[.000]
 RRPOILJ                   -1033.4             112.8145           -9.1606[.000]
 RNOTOOVE                   2102.7             147.1657           14.2882[.000]
*******************************************************************************
 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

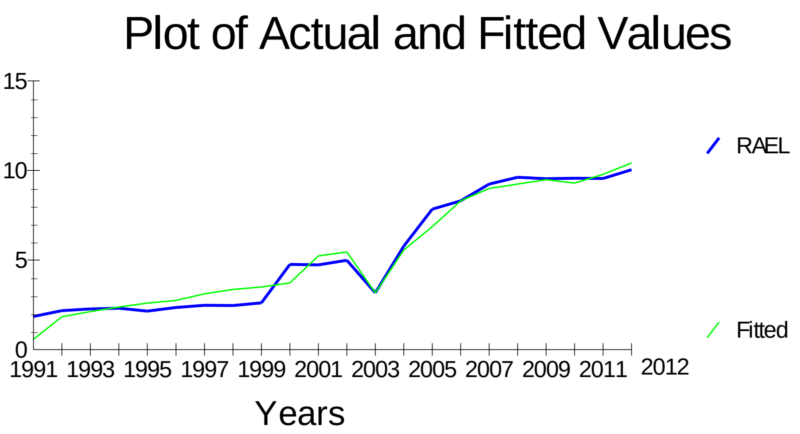
1.4 Rail: Electricity

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -6.7225             1.4360             -4.6814[.000]
 TRDGVA                   62.5306            15.4766              4.0403[.001]
 RAEL(-1)                  .60962            .094718              6.4362[.000]
 DUM2003                   3.0153             .66363              4.5436[.000]
*******************************************************************************
 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]
*******************************************************************************
```

Figure 1C.13. Plot of Actual and Fitted Values of Electricity in Rail Transport



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

2) Air transport

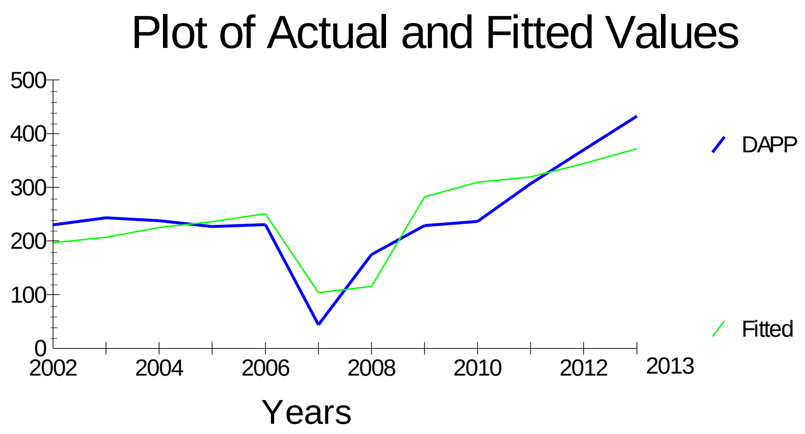
2.1 Air transport demand (jet fuel)

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                -343.5947          130.9274            -2.6243[.028]
 TGDPCAP                    7.9071            2.1992             3.5955[.006]
 DUM989078                168.4262           39.0732             4.3105[.002]
*******************************************************************************
 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

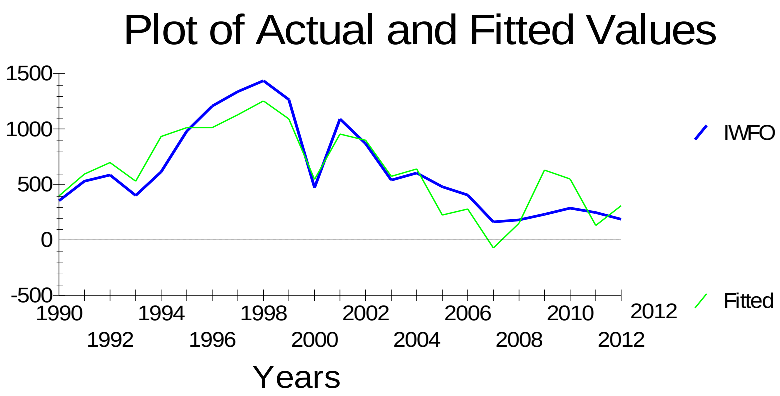
3.1 Fuel oil

IWFO constant LGDP RPOIL DUM0937

Table 1C.16. Coefficient Estimates of Fuel Oil in Water Transport

```
                       Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is IWFO
 23 observations used for estimation from 1990 to 2012
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -33808.1            9569.8              -3.5328[.002]
 LGDP                       1221.1          335.9026               3.6352[.002]
 RPOIL                    -75.3265           11.4034              -6.6056[.000]
 DUM0937                  295.0693          105.9703               2.7845[.012]
*******************************************************************************
 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

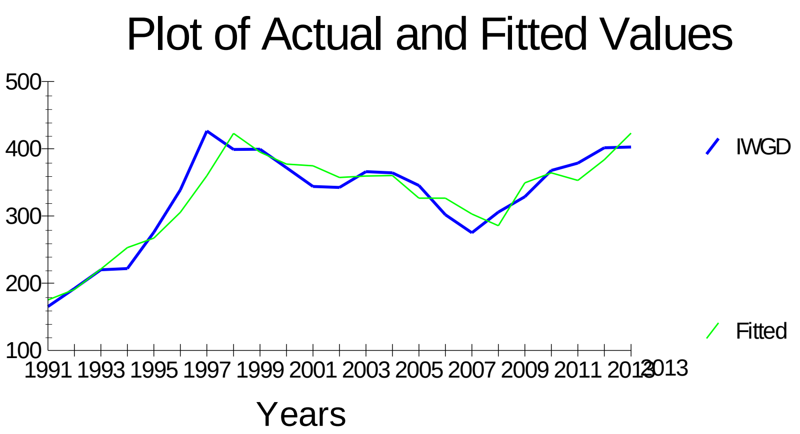
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	-6504.7	2070.8	-3.1411[.005]
LGDP	232.8977	73.4121	3.1725[.005]
RPOIL	-6.9632	2.1778	-3.1974[.005]
IWGD(-1)	.59340	.10939	5.4246[.000]

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 LCSGDP RPOIL IWMG(-1)

Table 1C.18. Coefficient Estimates of Motor Gasoline in Water Transport

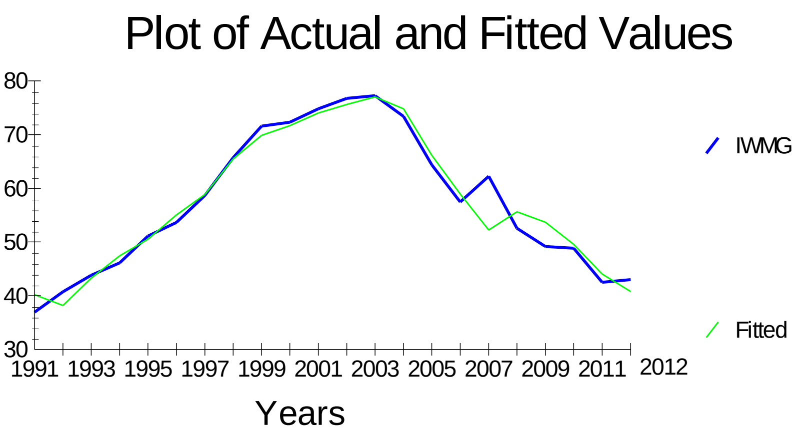
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	-458.7576	165.0077	-2.7802[.012]
LCSGDP	16.9625	5.9733	2.8397[.011]
RPOIL	-.99224	.22169	-4.4758[.000]
IWMG(-1)	.89065	.055098	16.1648[.000]

R-Squared	.95159	R-Bar-Squared	.94352
S.E. of Regression	3.0909	F-stat. F(3, 18)	117.9448[.000]
Mean of Dependent Variable	57.4055	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[.498]

Figure 1C.17. Plot of Actual and Fitted Values of Motor Gasoline in Water Transport



IWMG =-458.7576*CONSTANT +16.9625*LCSGDP -.99224*RPOIL +.89065*IWMG(-1)

B.3 Other sector demand model

Commercial sector demand model

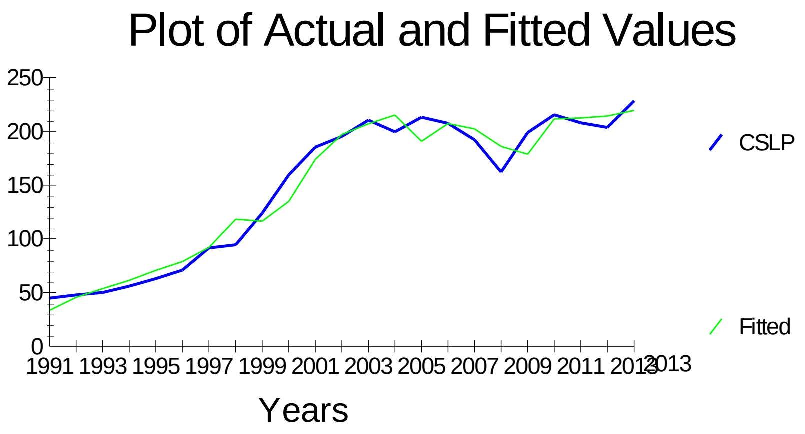
1) LPG

CSLP constant LCSGDP RPOIL CSLP(-1)

Table 1C.19. Coefficient Estimates of LPG in Commercial Sector

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is CSLP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  -1008.6           389.1156            -2.5921[.018]
 LCSGDP                    73.7462            27.9569             2.6379[.016]
 RPOIL                     -2.9345             .94410            -3.1083[.006]
 CSLP(-1)                   .93630            .095899             9.7634[.000]
*******************************************************************************
 R-Squared                     .96249   R-Bar-Squared                   .95657
 S.E. of Regression           13.9914   F-stat.    F( 3, 19)  162.5206[.000]
 Mean of Dependent Variable  148.7138   S.D. of Dependent Variable     67.1376
 Residual Sum of Squares       3719.4   Equation Log-likelihood       -91.1226
 Akaike Info. Criterion      -95.1226   Schwarz Bayesian Criterion    -97.3936
 DW-statistic                  2.0588   Durbin's h-statistic     -.15880[.874]
*******************************************************************************
```

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



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

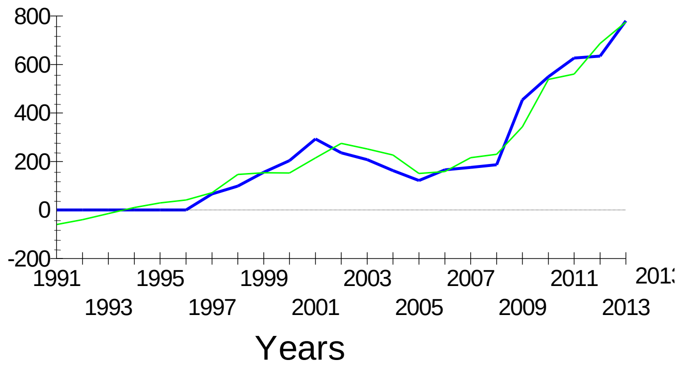
2) Diesel

CSGD constant MCSGDP RPOIL CSGD(-1)

Table 1C.20. Coefficient Estimates of Diesel in Commercial Sector

```
              Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is CSGD
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -262.7964          67.2700            -3.9066[.001]
 MCSGDP                    259.9314          59.8464             4.3433[.000]
 RPOIL                     -13.1069           3.7415            -3.5031[.002]
 CSGD(-1)                    .63577           .13134             4.8407[.000]
*******************************************************************************
 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*MCSGDP -13.1069*RPOIL +.63577*CSGD(-1)

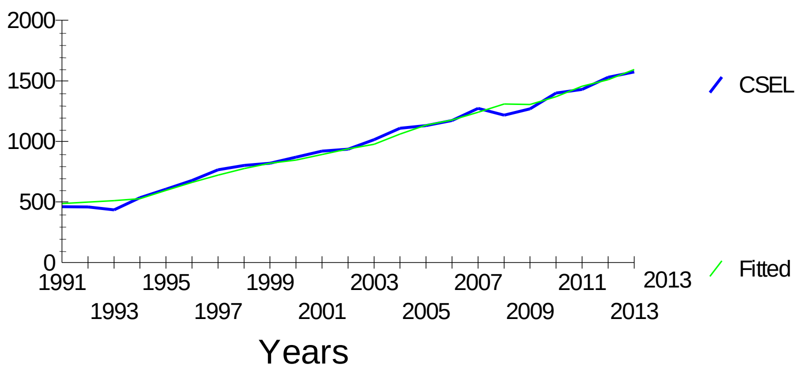
3) Electricity

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  -3991.6              1383.4            -2.8853[.009]
 LBCSGDP                  594.5959            204.3727             2.9094[.009]
 CSEL(-1)                   .44499              .19831             2.2439[.036]
*******************************************************************************
 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

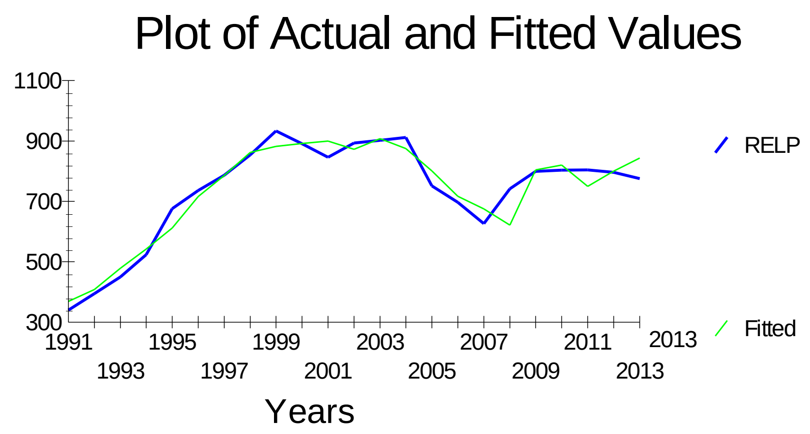
1) LPG

RELP constant LHEXP RPOIL RELP(-1)

Table 1C.22. Coefficient Estimates of LPG in Residential Sector

```
                   Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is RELP
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -12791.2            3792.3              -3.3730[.003]
 LHEXP                    465.0721          136.2398               3.4136[.003]
 RPOIL                    -16.0292            4.0443              -3.9634[.001]
 RELP(-1)                   .63293           .092144               6.8690[.000]
*******************************************************************************
 R-Squared                     .93135   R-Bar-Squared                    .92052
 S.E. of Regression           46.9958   F-stat.    F( 3, 19)    85.9279[.000]
 Mean of Dependent Variable  736.2255   S.D. of Dependent Variable     166.6931
 Residual Sum of Squares      41963.4   Equation Log-likelihood       -118.9898
 Akaike Info. Criterion     -122.9898   Schwarz Bayesian Criterion    -125.2608
 DW-statistic                  2.2307   Durbin's h-statistic      -.61673[.537]
*******************************************************************************
```

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

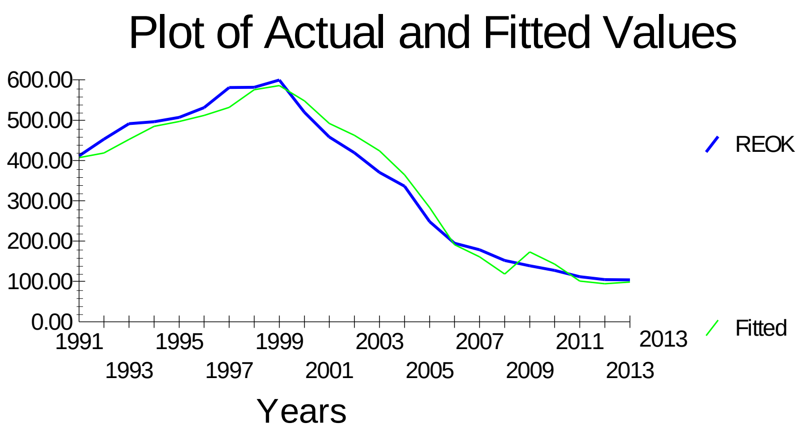
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	335.6263	100.3275	3.3453[.003]
R2KERPR	-1023.6	283.1607	-3.6148[.002]
REOK(-1)	.55251	.13559	4.0749[.001]

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

Ordinary Least Squares Estimation

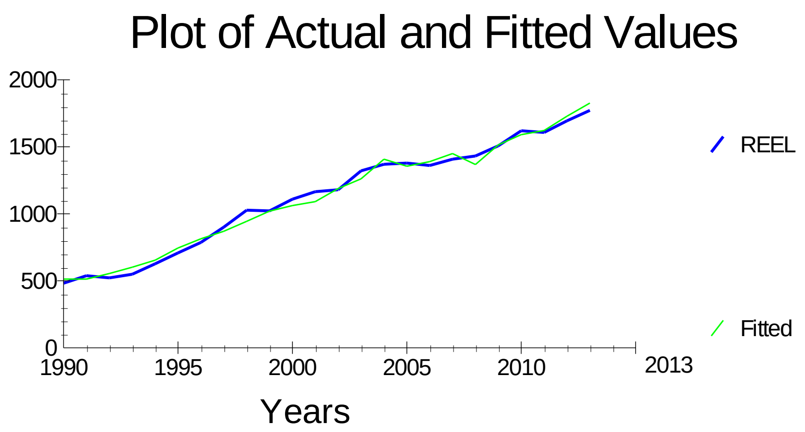
Dependent variable is REEL

24 observations used for estimation from 1990 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	-9987.0	270.3355	-36.9429[.000]
LBHEXP	1454.5	39.8506	36.4982[.000]
R2REELPR	-7975.9	1526.3	-5.2255[.000]

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



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

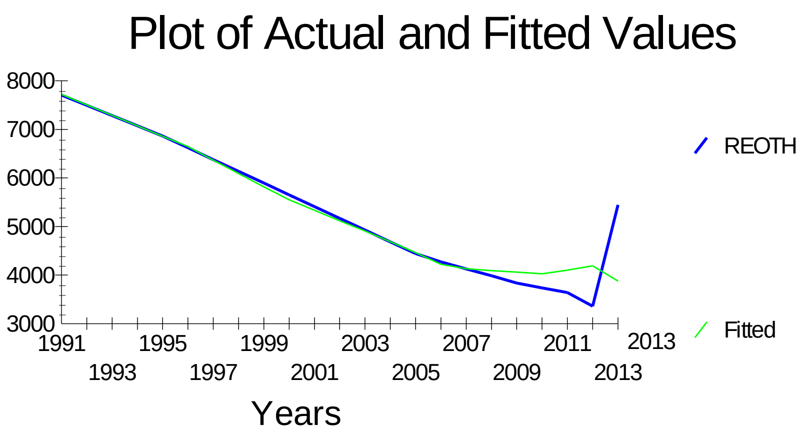
4) Others (biomass)

REOTH constant MPOPR REOTH(-1)

Table 1C.25. Coefficient Estimates of Biomass in Residential Sector

```
                       Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is REOTH
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                 -19278.0            8942.8              -2.1557[.043]
 MPOPR                    291.2535          131.2575               2.2189[.038]
 REOTH(-1)                  2.2082            .60150               3.6711[.002]
*******************************************************************************
 R-Squared                      .91282   R-Bar-Squared                   .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
 Residual Sum of Squares       3538154   Equation Log-likelihood      -169.9872
 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



REOTH = -19278.0*CONSTANT + 291.2535*MPOPR + 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

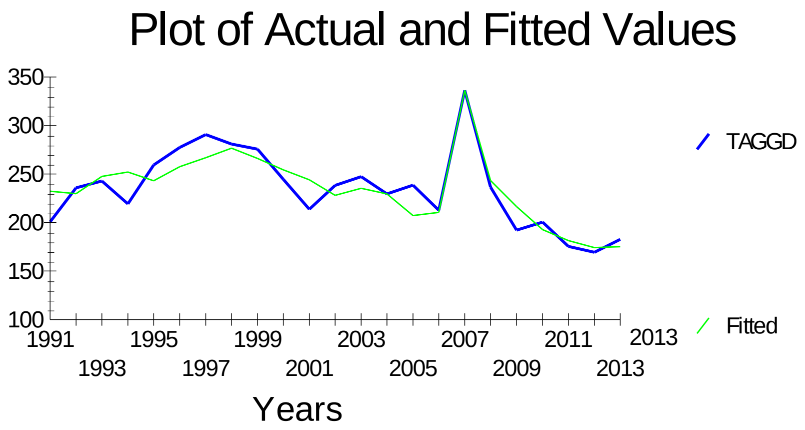
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	310.1387	35.5129	8.7331[.000]
RPOIL	-2.3767	.51289	-4.6340[.000]
TAGGD(-1)	.41622	.10829	3.8435[.001]
DUM07	-140.6408	19.6104	-7.1717[.000]

R-Squared	.81787	R-Bar-Squared	.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
DW-statistic	1.7363	Durbin's h-statistic	.74003[.459]

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



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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	292.6657	35.5636	8.2294[.000]
RDSLPR	-170.0127	40.4258	-4.2055[.000]
TAGGD(-1)	.48173	.10996	4.3809[.000]
DUM07	-141.0179	20.6702	-6.8223[.000]

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

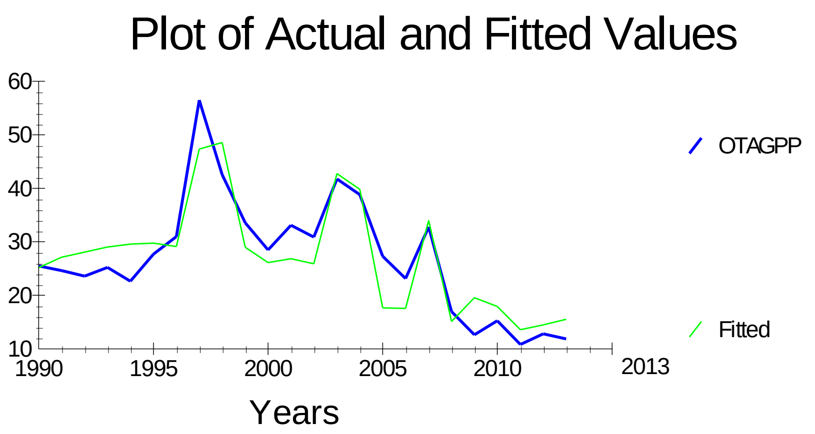
Ordinary Least Squares Estimation

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

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONSTANT	52.7772	2.8628	18.4354[.000]
RPOIL	-.71568	.12594	-5.6827[.000]
DUM978347	-17.7046	2.5114	-7.0496[.000]

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



OTAGPP = 52.7772*CONSTANT -.71568*RPOIL -17.7046*DUM978347

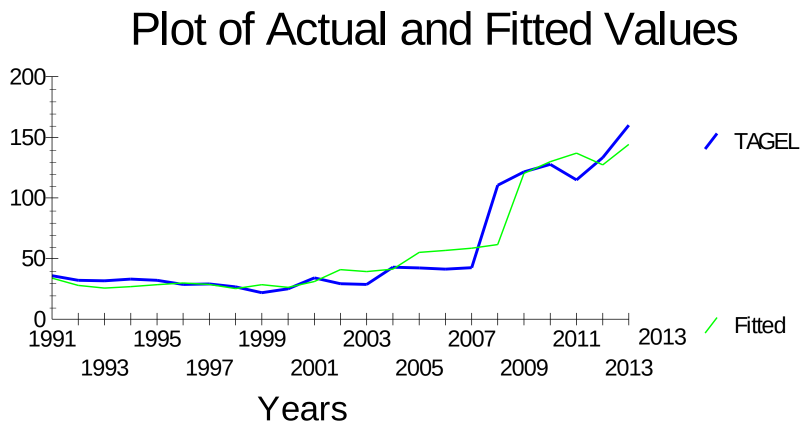
4) Electricity

TAGEL constant laggdp tagel(-1)

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

```
                          Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TAGEL
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONSTANT                  -1587.0             623.1709           -2.5467[.019]
 LAGGDP                    59.1806              23.2243            2.5482[.019]
 TAGEL(-1)                  .87320               .11529            7.5742[.000]
*******************************************************************************
 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
 DW-statistic                  2.0083   Durbin's h-statistic      -.023745[.981]
*******************************************************************************
```

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



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

Economic Research Institute for ASEAN and East Asia, 'Energy Supply and Demand Outlook Report FY 2015-206 – Philippines'.

Philippine Statistical Authority, 'Chapter 3. Economic Account', *2015 Philippine Statistical Yearbook.*

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%.

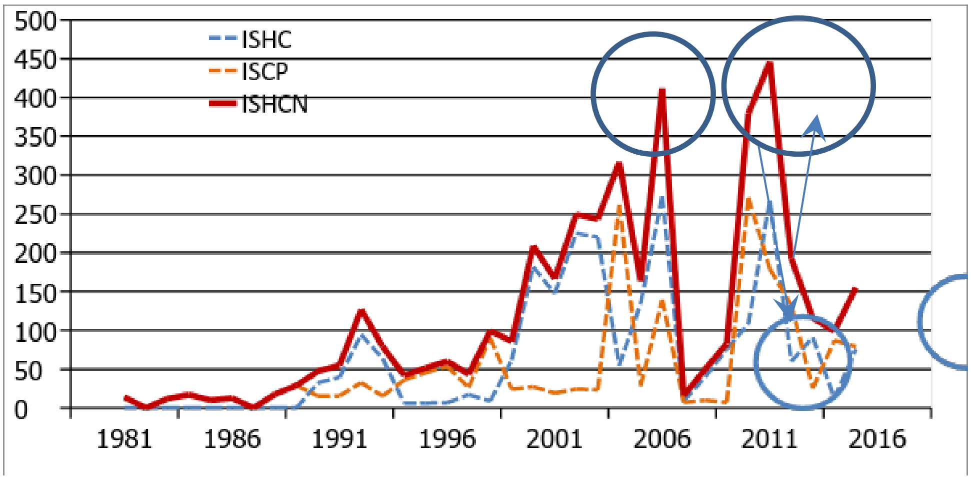
Electricity consumption in food industry = -310.4871 + .1607E-3*GDP

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).

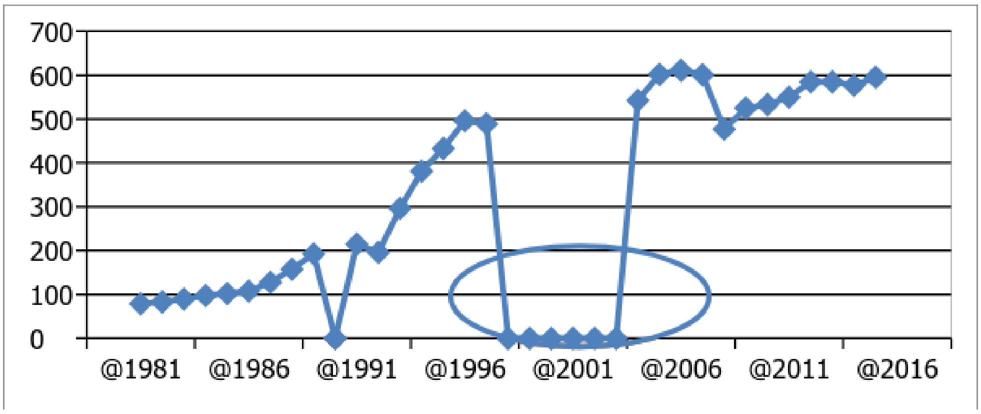
Figure 1D.1 Energy Consumption in Iron and Steel



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)

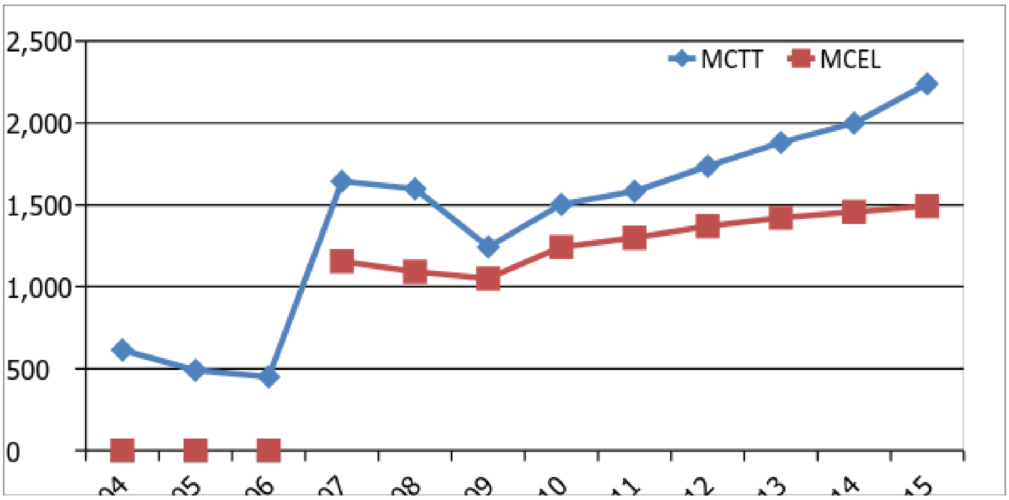
Figure 1D.2. Electricity Consumption in Cement



Source: Author' data generated from the LEAP

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).

Figure 1D.3. Metal and Fabricated Metal Energy Consumption



Source: Author' data generated from the LEAP

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

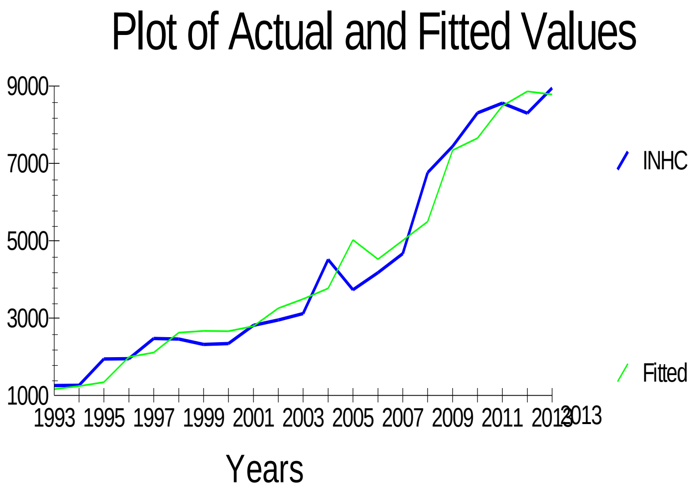
INHC = -362.4500*CONS + .0030152*INGDP -.0057528*RPOIL + .80775*INHC(-1)

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

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INHC
 21 observations used for estimation from 1993 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                    -362.4500          409.0371             -.88611[.388]
 INGDP                    .0030152          .0018658              1.6160[.124]
 RPOIL                   -.0057528           .062197            -.092493[.927]
 INHC(-1)                   .80775            .12337              6.5471[.000]
*******************************************************************************
 R-Squared                   .95768   R-Bar-Squared                    .95021
 S.E. of Regression        586.1541   F-stat.    F(  3,  17)  128.2249[.000]
 Mean of Dependent Variable  4297.8   S.D. of Dependent Variable       2626.8
 Residual Sum of Squares    5840802   Equation Log-likelihood       -161.4242
 Akaike Info. Criterion   -165.4242   Schwarz Bayesian Criterion    -167.5132
 DW-statistic                2.2761   Durbin's h-statistic       -.76684[.443]
*******************************************************************************
```

Source: Author's calculation.

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



Source: Author's calculation.

- Diesel oil

  INGD = 16.4679*CONS + .6956E-3*INGDP + .4128E-3*RPOIL + .52806*INGD(-1)

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

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is INGD
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     16.4679            73.3551              .22450[.825]
 INGDP                    .6956E-3           .3935E-3             1.7677[.093]
 RPOIL                    .4128E-3           .0080159            .051498[.959]
 INGD(-1)                  .52806             .26463              1.9955[.061]
*******************************************************************************
 R-Squared                    .93672   R-Bar-Squared                    .92673
 S.E. of Regression          98.8770   F-stat.    F(  3,  19)   93.7588[.000]
 Mean of Dependent Variable 720.9526   S.D. of Dependent Variable     365.2956
 Residual Sum of Squares    185756.5   Equation Log-likelihood       -136.0976
 Akaike Info. Criterion    -140.0976   Schwarz Bayesian Criterion    -142.3686
 DW-statistic                 1.9433   Durbin's h-statistic             *NONE*
*******************************************************************************
```

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:

INGD = 217.5275*CONS + .0012868*INGDP -343.7591*RPDOIL + .41609*INGD(-1) -268.0025*DUM05

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

Ordinary Least Squares Estimation

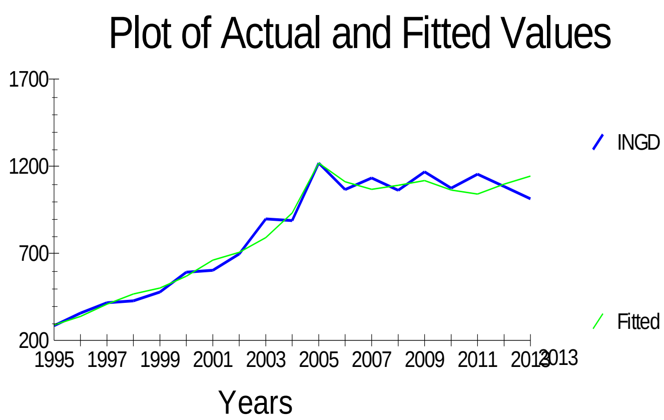
Dependent variable is INGD
19 observations used for estimation from 1995 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	217.5275	107.3368	2.0266[.062]
INGDP	.0012868	.4162E-3	3.0919[.008]
RPDOIL	-343.7591	146.7815	-2.3420[.034]
INGD(-1)	.41609	.17294	2.4060[.031]
DUM05	-268.0025	71.1519	-3.7666[.002]

R-Squared	.96763	R-Bar-Squared	.95839
S.E. of Regression	65.2559	F-stat. F(4, 14)	104.6356[.000]
Mean of Dependent Variable	820.9137	S.D. of Dependent Variable	319.8881
Residual Sum of Squares	59616.7	Equation Log-likelihood	-103.4467
Akaike Info. Criterion	-108.4467	Schwarz Bayesian Criterion	-110.8078
DW-statistic	2.0658	Durbin's h-statistic	-.21839[.827]

Source: Author's calculation.

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



Source: Author's calculation.

- Liquefied petroleum gas (LPG)

INLP = -38.5632*CONS + .1757E-3*INGDP -.1279E-3*RPOIL + .55283*INLP(-1)

Table 1E.4. Coefficient Estimates of LPG Demand in Industrial Sector

Ordinary Least Squares Estimation

Dependent variable is INLP

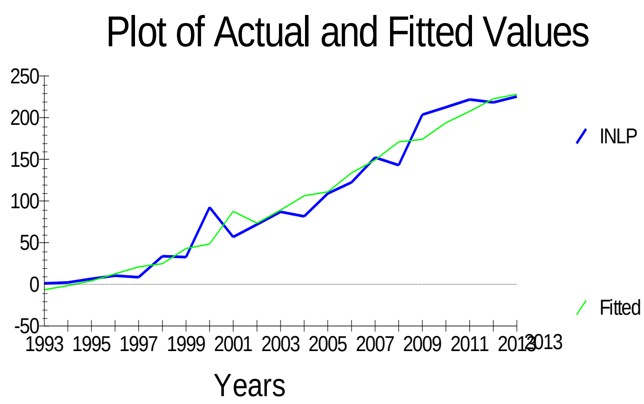
21 observations used for estimation from 1993 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-38.5632	19.7526	-1.9523[.068]
INGDP	.1757E-3	.6671E-4	2.6344[.017]
RPOIL	-.1279E-3	.0020865	-.061295[.952]
INLP(-1)	.55283	.16718	3.3069[.004]

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



- Electricity

  INEL = -166.7921*CONS + .6872E-3*INGDP + 1.0552*RPEL + 1.0198*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:

INEL = -140.4502*CONS + .6697E-3*INGDP + 1.0194*INEL(-1)

Table 1E.5. Coefficient Estimates of Electricity Demand in Industrial Sector

Ordinary Least Squares Estimation

Dependent variable is INEL

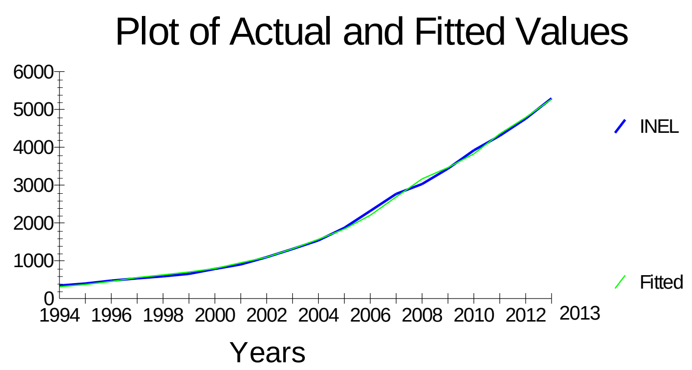
20 observations used for estimation from 1994 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-140.4502	59.3963	-2.3646[.030]
INGDP	.6697E-3	.1826E-3	3.6680[.002]
INEL(-1)	1.0194	.025530	39.9279[.000]

R-Squared	.99873	R-Bar-Squared	.99858
S.E. of Regression	60.5687	F-stat. F(2, 17)	6686.3[.000]
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
DW-statistic	1.8747	Durbin's h-statistic	.28200[.778]

Source: Author's calculation.

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



Source: Author's calculation.

- Natural gas

INNG = -3191.6*CONS + .0041153*INGDP + .044366*RPOIL + .31736*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:

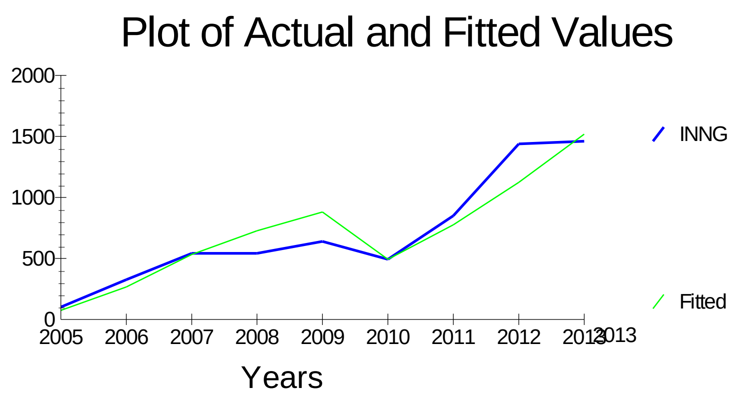
INNG = -2244.3*CONS + .0035561*INGDP + .42423*INNG(-1) + 157.5739*DUM10

Table 1E.6. Coefficient Estimates of Natural Gas Demand in Industrial Sector

```
Ordinary Least Squares Estimation
******************************************************************************
 Dependent variable is INNG
 9 observations used for estimation from 2005 to 2013
******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       -2244.3             1640.1           -1.3684[.229]
 INGDP                     .0035561           .0027523            1.2921[.253]
 INNG(-1)                    .42423             .47668            .88996[.414]
 DUM10                     157.5739           259.7540            .60663[.571]
******************************************************************************
 R-Squared                     .88211   R-Bar-Squared                   .81138
 S.E. of Regression          202.6003   F-stat.    F(  3,   5)   12.4713[.009]
 Mean of Dependent Variable  709.5111   S.D. of Dependent Variable    466.4972
 Residual Sum of Squares     205234.3   Equation Log-likelihood       -57.9265
 Akaike Info. Criterion      -61.9265   Schwarz Bayesian Criterion    -62.3210
 DW-statistic                  1.4931   Durbin's h-statistic            *NONE*
******************************************************************************
```

Source: Author's calculation.

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



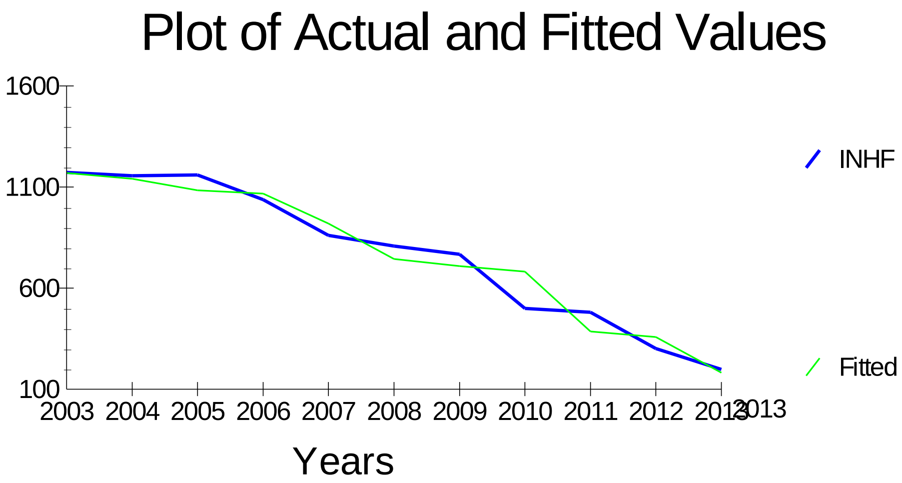
Source: Author's calculation.

- Fuel oil

INHF = 304.2015*CONS -.3610E-3*INGDP -.0064430*RPOIL + .95001*INHF(-1)

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 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



Source: Author's calculation.

Transport sector demand model

- Air/jet kerosene

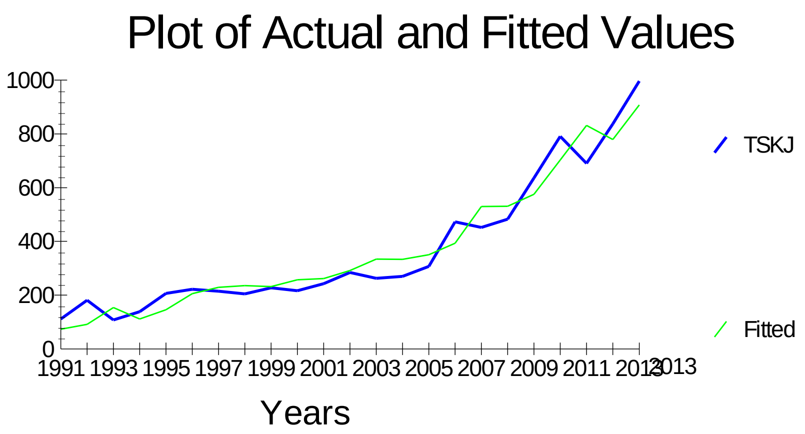
TSKJ = -72.0365*CONS + .1548E-3*GDP -.0012082*RPOIL + .72335*TSKJ(-1)

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

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TSKJ
 23 observations used for estimation from 1991 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                     -72.0365           52.5324            -1.3713[.186]
 GDP                      .1548E-3          .7756E-4             1.9958[.060]
 RPOIL                   -.0012082          .0049970            -.24179[.812]
 TSKJ(-1)                   .72335            .20351             3.5544[.002]
*******************************************************************************
 R-Squared                     .93756   R-Bar-Squared                   .92770
 S.E. of Regression           68.0991   F-stat.    F(  3,  19)   95.1013[.000]
 Mean of Dependent Variable  371.8757   S.D. of Dependent Variable    253.2700
 Residual Sum of Squares      88112.3   Equation Log-likelihood      -127.5206
 Akaike Info. Criterion     -131.5206   Schwarz Bayesian Criterion   -133.7916
 DW-statistic                  2.0955   Durbin's h-statistic     -1.0512[.293]
*******************************************************************************
```

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

TSMG = -522.1186*CONS + .0010506*GDP + .013665*RPOIL + .54695*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:

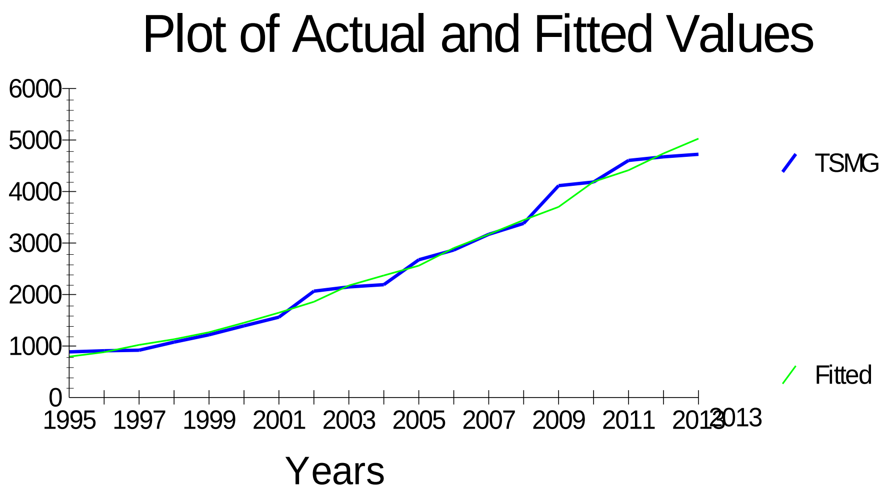
TSMG = -967.5575*CONS + .0018675*GDP -356.2257*RPGOIL + .34983*TSMG(-1)

Table 1E.8. Coefficient Estimates of Gasoline Demand in Road Transport

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TSMG
 19 observations used for estimation from 1995 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                    -967.5575          340.0138            -2.8456[.012]
 GDP                      .0018675          .5540E-3             3.3709[.004]
 RPGOIL                  -356.2257          696.5289            -.51143[.616]
 TSMG(-1)                   .34983            .25415             1.3765[.189]
*******************************************************************************
 R-Squared                     .98748   R-Bar-Squared                   .98497
 S.E. of Regression          170.3102   F-stat.    F(  3,  15)  394.2578[.000]
 Mean of Dependent Variable    2565.0   S.D. of Dependent Variable      1389.3
 Residual Sum of Squares     435083.3   Equation Log-likelihood      -122.3289
 Akaike Info. Criterion     -126.3289   Schwarz Bayesian Criterion   -128.2178
 DW-statistic                  1.9922   Durbin's h-statistic            *NONE*
*******************************************************************************
```

Source: Author's calculation.

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



Source: Author's calculation.

- Road/Diesel

  TSGD = -155.7043*CONS + .8473E-3*GDP + .012516*RPOIL + .61874*TSGD(-1)

The sign of coefficient of RPOIL is positive. It proves that RPOIL (or international oil price) does notaffect the domestic demand of diesel oil. In this case, RPDOIL should be used. The result is presented as follows:

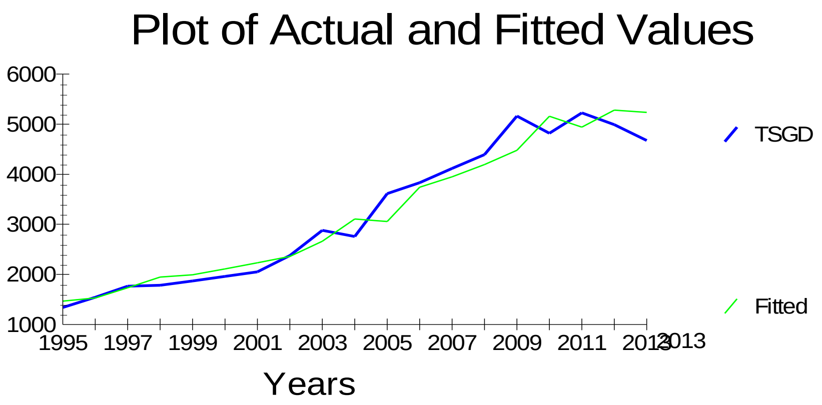
TSGD = -56.0251*CONS + .7703E-3*GDP -416.9328*RPDOIL + .74988*TSGD(-1)

Table 1E.9. Coefficient Estimates of Diesel Demand in Road Transport

```
Ordinary Least Squares Estimation
*******************************************************************************
 Dependent variable is TSGD
 19 observations used for estimation from 1995 to 2013
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                      -56.0251            441.5668          -.12688[.901]
 GDP                       .7703E-3            .8761E-3           .87923[.393]
 RPDOIL                   -416.9328              1083.1          -.38494[.706]
 TSGD(-1)                    .74988              .33622           2.2303[.041]
*******************************************************************************
 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



Source: Author's calculation.

- Other/Fuel oil

TSHF = 38.2912*CONS + .1623E-4*GDP -150.1930*RPDOIL + 1.0713*TSHF(-1)

Table 1E.10. Coefficient Estimates of Fuel Oil Demand in Transport

Ordinary Least Squares Estimation

Dependent variable is TSHF

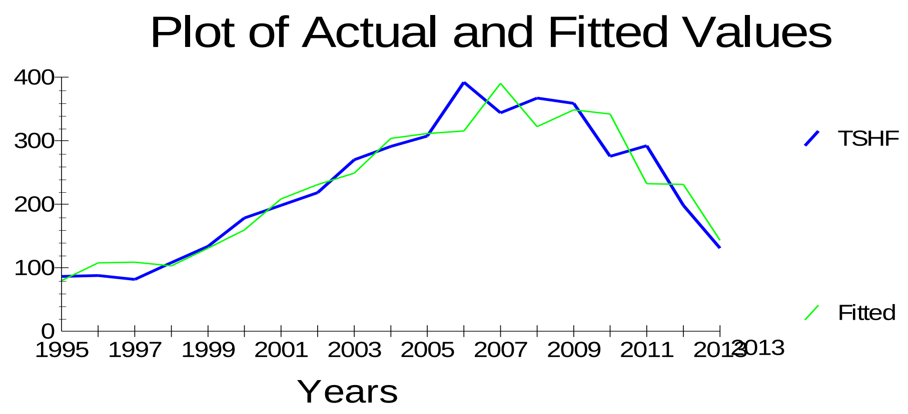
19 observations used for estimation from 1995 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	38.2912	45.8308	.83549[.417]
GDP	.1623E-4	.7519E-4	.21590[.832]
RPDOIL	-150.1930	124.2344	-1.2089[.245]
TSHF(-1)	1.0713	.13667	7.8388[.000]

R-Squared	.88695	R-Bar-Squared	.86434
S.E. of Regression	38.1992	F-stat. F(3, 15)	39.2290[.000]
Mean of Dependent Variable	227.2068	S.D. of Dependent Variable	103.7129
Residual Sum of Squares	21887.7	Equation Log-likelihood	-93.9276
Akaike Info. Criterion	-97.9276	Schwarz Bayesian Criterion	-99.8165
DW-statistic	3.0808	Durbin's h-statistic	-2.9328[.003]

Source: Author's calculation.

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



Source: Author's calculation.

Residential sector demand model

- Coal

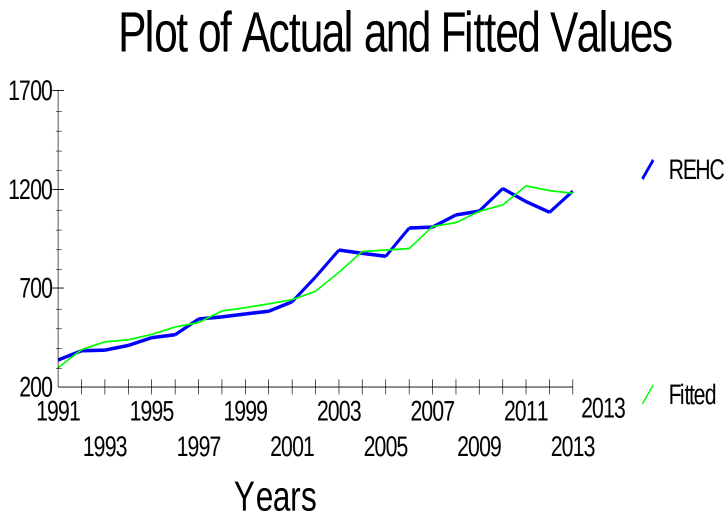
REHC = 69.6896*CONS + .1602E-3*GDP + .64842*REHC(-1)

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                      69.6896            31.3586            2.2223[.038]
 GDP                     .1602E-3           .9146E-4             1.7517[.095]
 REHC(-1)                  .64842             .18290             3.5452[.002]
*******************************************************************************
 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



Source: Author's calculation.

- Diesel oil

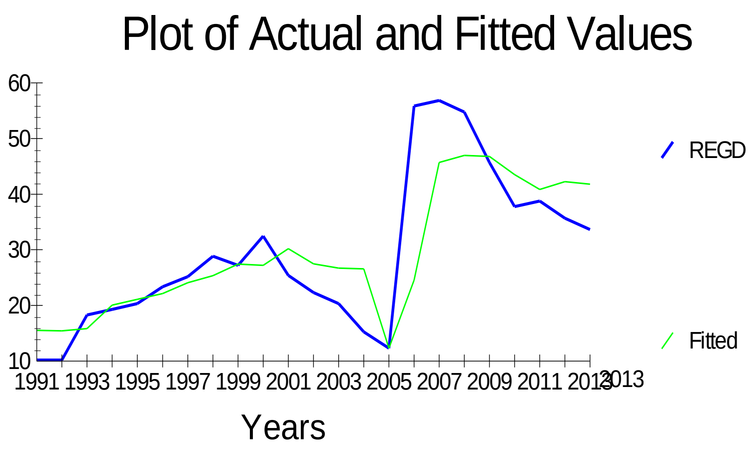
REGD = -6.8421*CONS + .7572E-5*GDP + .46540*REGD(-1) + 12.7738*DUM05

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       -6.8421             10.9403           -.62541[.539]
 GDP                       .7572E-5             .4826E-5           1.5690[.133]
 REGD(-1)                    .46540              .20521            2.2679[.035]
 DUM05                      12.7738             10.1240            1.2617[.222]
*******************************************************************************
 R-Squared                     .62169   R-Bar-Squared                   .56196
 S.E. of Regression            9.2906   F-stat.    F(  3,  19)   10.4079[.000]
 Mean of Dependent Variable   29.1174   S.D. of Dependent Variable     14.0374
 Residual Sum of Squares       1640.0   Equation Log-likelihood       -81.7055
 Akaike Info. Criterion      -85.7055   Schwarz Bayesian Criterion    -87.9765
 DW-statistic                  1.1682   Durbin's h-statistic     11.2518[.000]
*******************************************************************************
```

Source: Author's calculation.

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



Source: Author's calculation.

- LPG

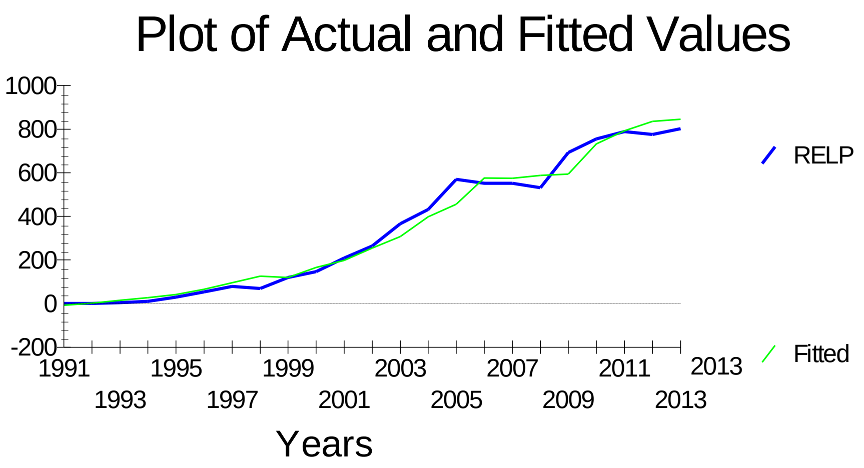
RELP = -62.2959*CONS + .1330E-3*GDP -.0016185*RPOIL + .76858*RELP(-1)

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
*******************************************************************************
 Regressor              Coefficient        Standard Error         T-Ratio[Prob]
 CONS                     -62.2959            135.2485           -.46060[.650]
 GDP                      .1330E-3            .1242E-3            1.0709[.298]
 RPOIL                   -.0016185            .0058828           -.27512[.786]
 RELP(-1)                   .76858              .31468            2.4424[.025]
*******************************************************************************
 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             *NONE*
*******************************************************************************
```

Source: Author's calculation.

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



Source: Author's calculation.

- Electricity

REEL = -125.9780*CONS + .3589E-3*GDP -.0061136*RPOIL + .87991*REEL(-1)

Table 1E.14. Coefficient Estimates of Electricity Demand in Residential Sector

Ordinary Least Squares Estimation

Dependent variable is REEL

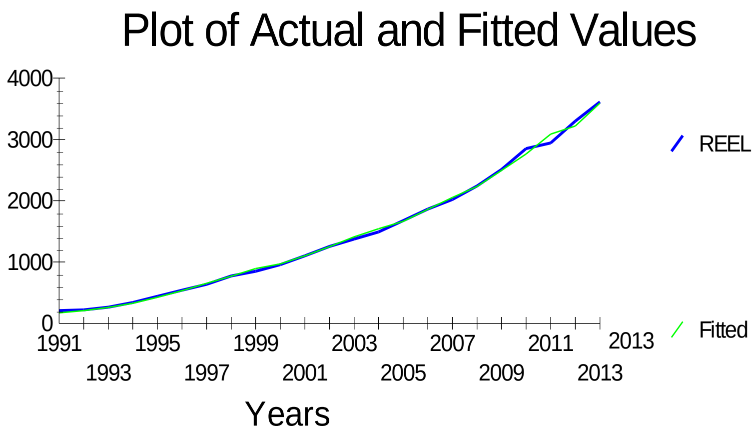
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-125.9780	120.1574	-1.0484[.308]
GDP	.3589E-3	.1888E-3	1.9012[.073]
RPOIL	-.0061136	.0037420	-1.6338[.119]
REEL(-1)	.87991	.12144	7.2456[.000]

R-Squared	.99809	R-Bar-Squared	.99779
S.E. of Regression	49.1702	F-stat. F(3, 19)	3305.8[.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
Akaike Info. Criterion	-124.0301	Schwarz Bayesian Criterion	-126.3011
DW-statistic	2.8031	Durbin's h-statistic	-2.3690[.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

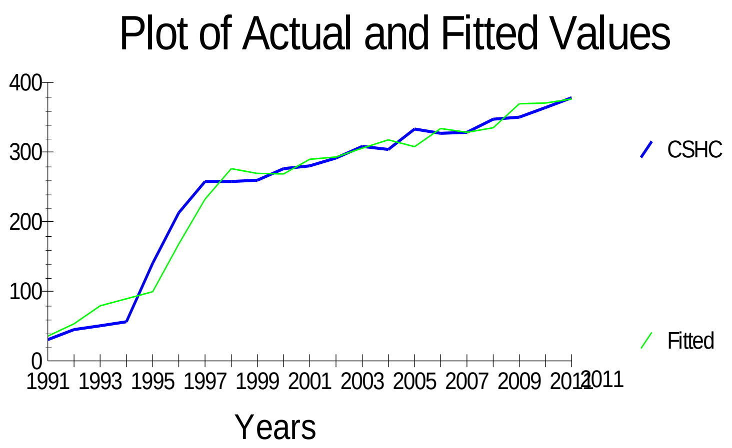
CSHC = 22.9810*CONS + .0048148*GDPC -.0030803*RPOIL + .78805*CSHC(-1)

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       22.9810            18.2174            1.2615[.224]
 GDPC                      .0048148           .0032558            1.4789[.157]
 RPOIL                    -.0030803           .0020160           -1.5279[.145]
 CSHC(-1)                    .78805             .11459            6.8771[.000]
*******************************************************************************
 R-Squared                      .96767   R-Bar-Squared                   .96196
 S.E. of Regression            22.1823   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



Source: Author’s calculation.

- Diesel

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

Table 1E.16. Coefficient Estimates of Diesel Demand in Commercial Sector

Ordinary Least Squares Estimation

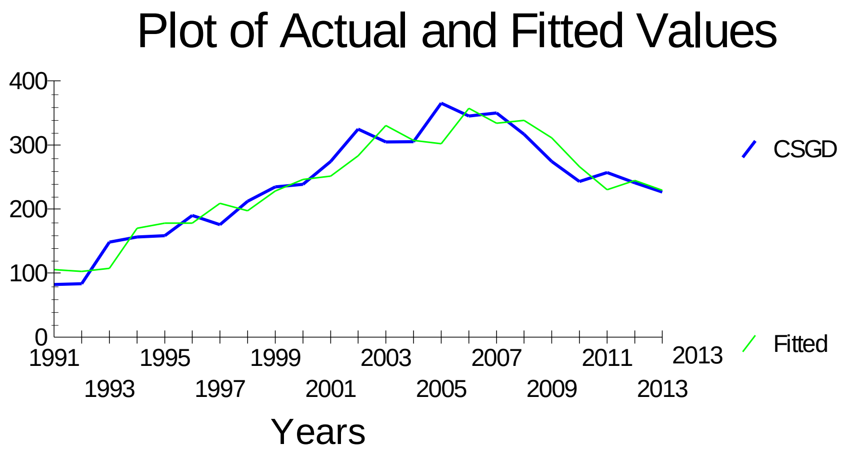
Dependent variable is CSGD
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	48.7576	19.8688	2.4540[.024]
GDPC	-.0010448	.0018937	-.55173[.588]
RPOIL	-.0012584	.0020656	-.60923[.550]
CSGD(-1)	.95891	.10182	9.4174[.000]

R-Squared	.89275	R-Bar-Squared	.87582
S.E. of Regression	28.3333	F-stat. F(3, 19)	52.7193[.000]
Mean of Dependent Variable	239.3709	S.D. of Dependent Variable	80.4019
Residual Sum of Squares	15252.8	Equation Log-likelihood	-107.3513
Akaike Info. Criterion	-111.3513	Schwarz Bayesian Criterion	-113.6223
DW-statistic	2.2885	Durbin's h-statistic	-.79270[.428]

Source: Author's calculation.

Figure 1E.16. Plot of Actual and Fitted Values of Diesel Demand in Commercial Sector



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

CSHF = 38.1485*CONS -.0012298*GDPC -.6799E-3*RPOIL + .86958*CSHF(-1)

Table 1E.17. Coefficient Estimates of Fuel Oil Demand in Commercial Sector

Ordinary Least Squares Estimation

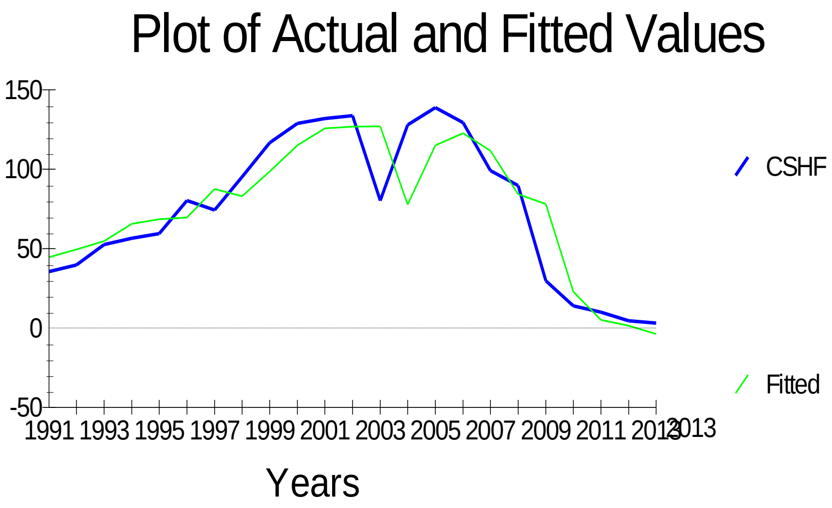
Dependent variable is CSHF
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	38.1485	18.1013	2.1075[.049]
GDPC	-.0012298	.0011758	-1.0459[.309]
RPOIL	-.6799E-3	.0016344	-.41600[.682]
CSHF(-1)	.86958	.10899	7.9783[.000]

R-Squared	.79815	R-Bar-Squared	.76628
S.E. of Regression	22.2189	F-stat. F(3, 19)	25.0437[.000]
Mean of Dependent Variable	75.2426	S.D. of Dependent Variable	45.9598
Residual Sum of Squares	9379.9	Equation Log-likelihood	-101.7602
Akaike Info. Criterion	-105.7602	Schwarz Bayesian Criterion	-108.0311
DW-statistic	2.1785	Durbin's h-statistic	-.50196[.616]

Source: Author's calculation.

Figure 1E.17. Plot of Actual and Fitted Values of Fuel Oil Demand in Commercial Sector



Source: Author's calculation.

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.

- LPG

CSLP = -135.3638*CONS + .015032*GDPC -.0011385*RPOIL + .44156*CSLP(-1)

Table 1E.18. Coefficient Estimates of LPG Demand in Commercial Sector

Ordinary Least Squares Estimation

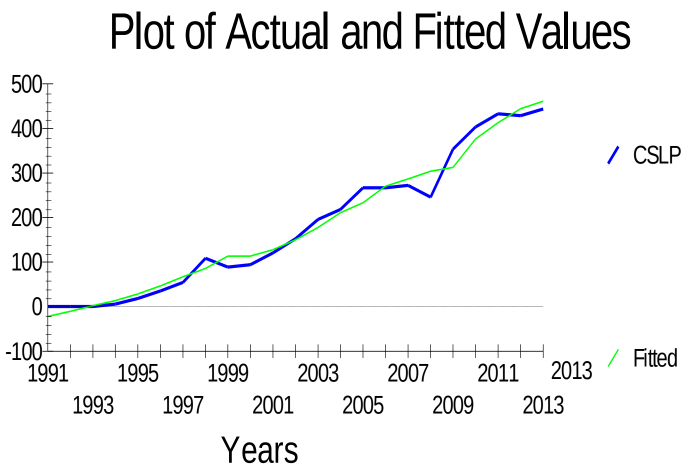
Dependent variable is CSLP
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	-135.3638	67.5549	-2.0038[.060]
GDPC	.015032	.0054312	2.7677[.012]
RPOIL	-.0011385	.0021789	-.52251[.607]
CSLP(-1)	.44156	.25152	1.7556[.095]

R-Squared	.97875	R-Bar-Squared	.97540
S.E. of Regression	24.1156	F-stat. F(3, 19)	291.7148[.000]
Mean of Dependent Variable	182.8157	S.D. of Dependent Variable	153.7413
Residual Sum of Squares	11049.7	Equation Log-likelihood	-103.6442
Akaike Info. Criterion	-107.6442	Schwarz Bayesian Criterion	-109.9152
DW-statistic	1.7954	Durbin's h-statistic	*NONE*

Source: Author’s calculation.

Figure 1E.18. Plot of Actual and Fitted Values of LPG Demand in Commercial Sector



Source: Author’s calculation.

- Electricity

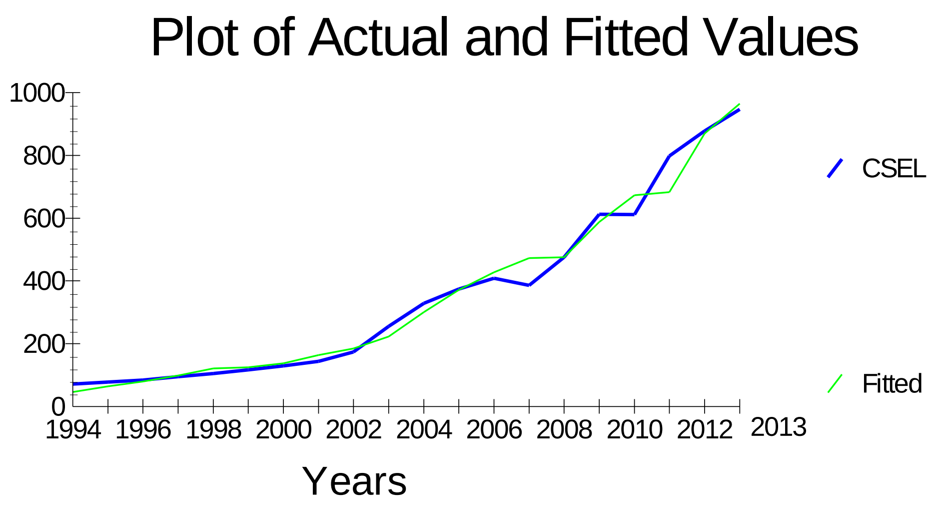
CSEL = -105.0106*CONS + .3768E-3*CSGDP -.0030676*RPOIL + .85787*CSEL(-1)

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                    -105.0106           58.1914            -1.8046[.090]
 CSGDP                    .3768E-3           .1859E-3            2.0272[.060]
 RPOIL                   -.0030676           .0047521           -.64552[.528]
 CSEL(-1)                  .85787             .12525             6.8490[.000]
*******************************************************************************
 R-Squared                      .98054  R-Bar-Squared                   .97689
 S.E. of Regression            43.0940  F-stat.    F(  3,  16)  268.7260[.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     -.75502[.450]
*******************************************************************************
```

Source: Author's calculation.

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



Source: Author's calculation.

Agricultural sector demand model

- Coal

  AGHC = 20.1040*CONS -.1350E-4*AGGDP -.6261E-4*RPOIL + .33333*AGHC(-1)

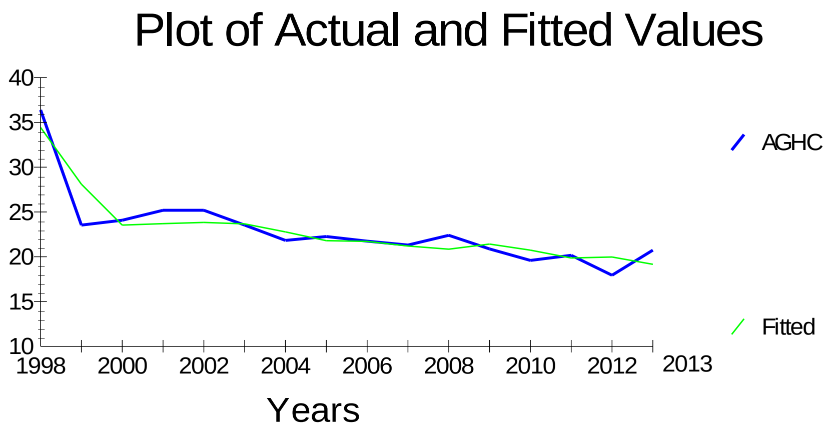
The sign of coefficient of AGGDP is negative. It proves that coal demand decreases when AGGDP increases. In this case, we do not need to use the above demand function and suppose that coal used in agriculture would be reduced based on the past trend of coal consumption in 2002–2012 (see figure below).

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       20.1040               5.6359           3.5671[.004]
 AGGDP                    -.1350E-4             .1849E-4          -.73016[.479]
 RPOIL                    -.6261E-4             .2463E-3          -.25416[.804]
 AGHC(-1)                    .33333              .080149           4.1589[.001]
*******************************************************************************
 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        -30.2925
 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



- 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

Ordinary Least Squares Estimation

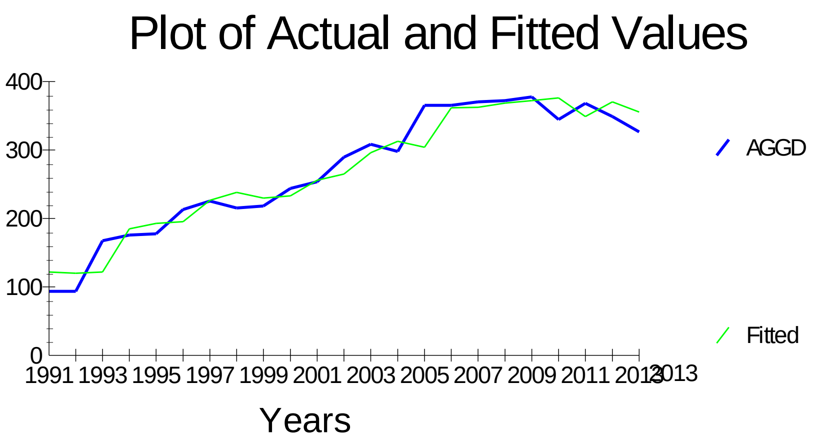
Dependent variable is AGGD
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	25.6198	30.9489	.82781[.418]
AGGDP	.9438E-4	.2785E-3	.33890[.738]
RPOIL	-.2746E-3	.0019254	-.14261[.888]
AGGD(-1)	.84035	.19867	4.2298[.000]

R-Squared	.93036	R-Bar-Squared	.91936
S.E. of Regression	25.6746	F-stat. F(3, 19)	84.6048[.000]
Mean of Dependent Variable	270.0896	S.D. of Dependent Variable	90.4119
Residual Sum of Squares	12524.5	Equation Log-likelihood	-105.0850
Akaike Info. Criterion	-109.0850	Schwarz Bayesian Criterion	-111.3560
DW-statistic	2.1886	Durbin's h-statistic	-1.4895[.136]

Source: Author's calculation.

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



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

Dependent variable is AGMG

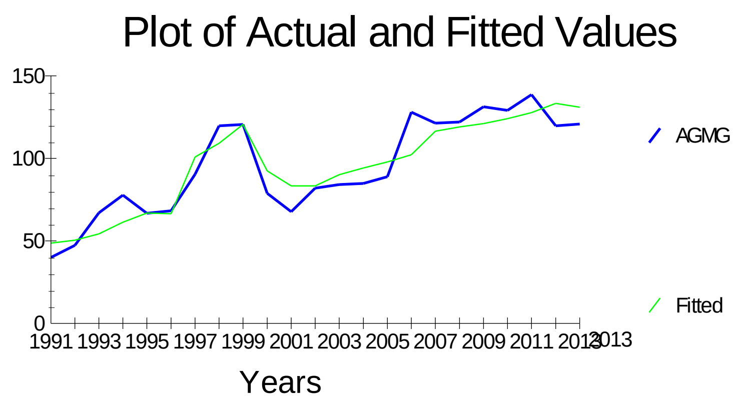
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	19.8562	10.9492	1.8135[.086]
AGGDP	.2514E-3	.6623E-4	3.7961[.001]
AGMG(-1)	.27416	.16367	1.6751[.110]
DUM9799	-31.4888	8.2874	-3.7996[.001]

R-Squared	.86061	R-Bar-Squared	.83860
S.E. of Regression	11.7479	F-stat. F(3, 19)	39.1025[.000]
Mean of Dependent Variable	95.3943	S.D. of Dependent Variable	29.2421
Residual Sum of Squares	2622.3	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



Source: Author's calculation.

- Electricity

AGEL = -14.3394*CONS + .1086E-3*AGGDP + 1.2218*RPEL + .71964*AGEL(-1) - 24.6472*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:

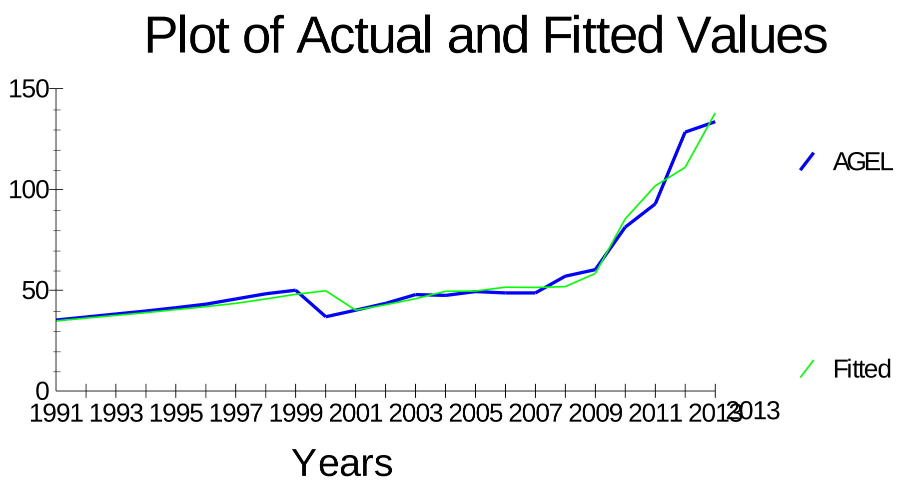
AGEL = 28.1367*CONS + .2999E-4*AGGDP + .75365*AGEL(-1) - 24.5577*DUM1013

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
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 CONS                       28.1367              11.2218            2.5073[.021]
 AGGDP                    .2999E-4             .2427E-4            1.2354[.232]
 AGEL(-1)                   .75365               .11958            6.3024[.000]
 DUM1013                  -24.5577               5.9555           -4.1235[.001]
*******************************************************************************
 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



Source: Author's calculation.

- Fuel oil

  AGHF = 4.5139*CONS - .8940E-5*AGGDP - .1423E-3*RPOIL + .99036*AGHF(-1)

Table 1E.24. Coefficient Estimates of Fuel Oil Demand in Agricultural Sector

Ordinary Least Squares Estimation

Dependent variable is AGHF

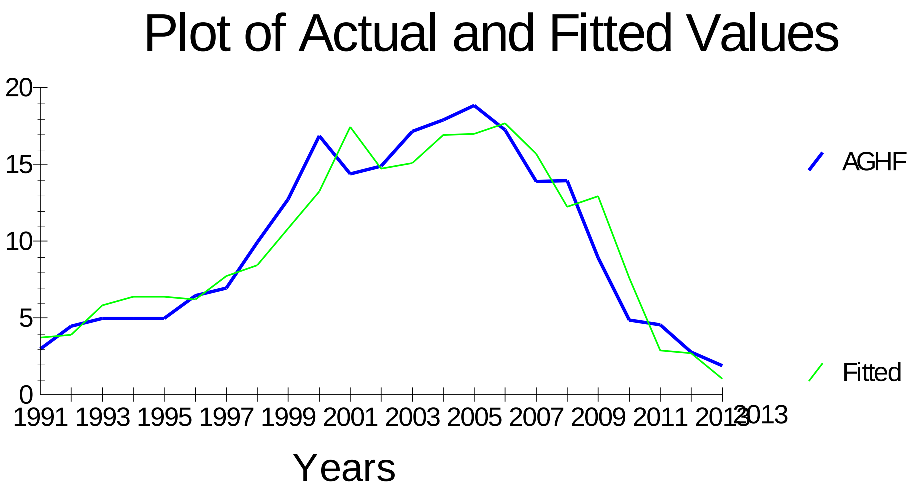
23 observations used for estimation from 1991 to 2013

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
CONS	4.5139	1.7634	2.5598[.019]
AGGDP	-.8940E-5	.8739E-5	-1.0230[.319]
RPOIL	-.1423E-3	.1462E-3	-.97334[.343]
AGHF(-1)	.99036	.081244	12.1900[.000]

R-Squared	.89416	R-Bar-Squared	.87745
S.E. of Regression	2.0093	F-stat. F(3, 19)	53.5060[.000]
Mean of Dependent Variable	9.8391	S.D. of Dependent Variable	5.7397
Residual Sum of Squares	76.7081	Equation Log-likelihood	-46.4875
Akaike Info. Criterion	-50.4875	Schwarz Bayesian Criterion	-52.7585
DW-statistic	1.9995	Durbin's h-statistic	.0013089[.999]

Source: Author's calculation.

Figure 1E.24. Plot of Actual and Fitted Values of Fuel Oil Demand in Agricultural Sector



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 Centreand the energy balances of the International Energy Agency. Reasons for these includeissues on data collection, data checking, and processing.

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

Reference

Vietnam Prosperous Bank (VPBank), (2013), Report of Power Sector of Viet Nam. Ha Noi: VPBank Securities..