Long Run Energy Consumption of Thailand:
Static and Dynamic Systems of Demand Equations

Paitoon Kraipornsak
Associate Professor of Economics
Chulalongkorn University
Bangkok 10330, Thailand
E-mail: kpaitoon@chula.ac.th

Paper presented at the EcoMod2006 International Conference on Policy Modelling,
Hong Kong Convention and Exhibition Centre

28 – 30 June 2006

Long Run Energy Consumption of Thailand:
Static and Dynamic Systems of Demand Equations

Abstract

An energy consumption model is a useful tool for examining elasticities of demand for energy. This paper employs the framework of Almost Ideal Demand System (AIDS) for modelling the energy consumption of Thailand. The AIDS model provides a structural and static framework for modeling energy demand that follows economic theory. This paper also identifies and estimates long run elasticities of the static AIDS model in a system using error-correction type equations of the VECM model. The results show that the magnitudes of the estimated long run elasticites between the two models are slightly different. One of the main reasons for this difference is due to the non-stationary variables used in the estimation of the model. Therefore, the dynamic demand model of error correction type is appropriate. The statistical test of homogeneity and symmetry properties of the dynamic demand model shows that it could be rejected. The rejection of the consumer theory restrictions could likely be due to the rather short time series of the available data used in the estimation. The higher order VECM model may be needed.

I. Introduction

The Thai economy depends a great deal on oil as an engine of growth that accounts for 15 per cent of GDP each year. Approximately ninety per cent or around $25 billion of it is imported annually. The recent high crude oil prices have put such a large pressure on retail prices of finish oils.

The government has subsidized the prices from time to time via the oil fund to stabilize the general price in the economy. This, however, cannot be a sustainable solution in the long run when the oil price has permanently increased to a new level as being realized. During early 2004 and the mid of 2005, the retail prices of these three types of oils in Thailand had been increased for more than 30 per cent as the consequence of the government's policy to float the retail oil prices.

Thailand's structural reform of energy consumption has been proposed to the Prime Minister on 23 November 2005 in 3 major directions to improve the efficiency of energy consumption; i.e., reduction in energy demand, the new alternative energy, and exploration of new domestic energy supply. Within the objective of strengthening the national energy security, the strategies for energy development are focused on the efficient use of energy. In fact, since 1990, Thailand's energy intensity has sharply increased whereas it has been decreasing in developed countries. In terms of a simple energy elasticity (ratio of growth rate of energy consumption to the GDP growth rate), Thailand's energy elasticity is estimated currently being 1.4:1 while it is only 0.8:1 and 0.95:1 for the USA and Japan respectively. This indicates that if the GDP grows by the rate of 5 per cent per year, the Thai economy will require seven per cent of energy consumption each year. Therefore, the government set a target to reduce the energy elasticity to 1:1 by the end of 2010.

In fact, the estimated size of the energy elasticity used in the country strategic plan of energy consumption mentioned above has obtained by a straight forward method of estimation, using linear regression of logarithm of energy consumption on logarithm of GDP over a period of time. The figure of elasticity is therefore considered to be a rough estimation without taking into account other factors that can also influence the energy consumption. The increase in energy demand can sometimes be influenced greatly by the changes of other energy prices and other goods. The precise estimation of elasticities of energy demand is an important tool for the policy makers to formulate relevant policies.

This paper aims at estimating the elasticities of energy using the standard demand concept, which include prices and income factors. The framework of the Almost Ideal Demand System (AIDS) for modeling the energy consumption in Thailand is used in this study. While the AIDS model provides a structured framework that is based on economic theory and can be imposed with homogeneity and symmetry restrictions, it is the static type of long run model. This study adopts a flexible approach by incorporating static long run equilibrium solution within the error correction type of system of equations and compares the results.

Energy in this paper consists of oil (benzene 91, benzene 95 and diesel), LPG, and electricity. These five forms of energy altogether account for 70 per cent of total energy in all forms (in 2005, measured in KTOE). All five forms of the energy are converted into the same unit (kilocalorie) and their sum is referred to as "energy" named in the paper. The energy consumption was then modeled and examined.

II. The Almost Ideal Energy Demand System Static model

The static demand equation for energy is initially constructed and estimated at the end-uses level for the national level of energy demand. In fact, demand for energy equation can be modeled using a single equation model. The single equation specification is, however, subjected to criticism especially being relied on data mining, ad hoc and lacking an explicit theoretical ground. In this paper, the framework of Almost Ideal Demand System (AIDS) is used for modeling the energy consumption in Thailand. The AIDS model provides a structural and static framework for modeling energy demand that follows economic theory. The AIDS incorporates both choices of consumer and budget constraint. The model can be identified and estimated for long run coefficients of the static AIDS model in a system. A flexible trans-logarithmic function of the demand system is used in this paper to show the interrelated demand for three categories of commodities; i.e., energy, food and beverage, and the others.

The AIDS cost function (Deaton and Muellbauer, 1980) is expressed as in Equation (1).

$$\ln C(u,P) = \alpha_0 + \sum_k \alpha_k \ln P_k + \frac{1}{2}\sum_k \sum_j \gamma^*_{kj} \ln P_k \ln P_j + u\beta_0 \prod_k P_k^{\beta k} \qquad (1)$$

Where the cost C(u, P) is linearly homogeneous in prices (P) provided that

$$\sum_i \alpha_i = 1, \sum_j \gamma^*_{kj} = \sum_k \gamma^*_{kj} = \sum_j \beta_j = 0 \text{ and symmetry } \gamma^*_{kj} = \gamma^*_{jk}$$

By applying Shepherd Lemma to the Equation (1), we have the budget share of good i. Hence the logarithmic differentiation of Equation (1) gives the budget shares as functions of prices and utility as in Equation (2).

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i u \beta_0 \prod P_k^{\beta k} \qquad (2)$$

Where

w_i is the expenditure share of the goods consumed.

$$\gamma_{ij} = \frac{1}{2}(\gamma^*_{ij} + \gamma^*_{ji})$$

The linearly approximated AIDS demand function in the form of budget shares can then be derived (Deaton and Muellbauer, 1980: 313). Given a utility maximizing consumer, total expenditure (x) is equal to consumption (C(u, P)) and inverted to give the indirect utility function, u is a function of P and x, as in Equation (3).

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln(\frac{x}{P}) \qquad (3)$$

Where

x/P is the total per capita real expenditure on all goods.

The restrictions according to the consumption theory known as adding up, homogeneity of degree zero in prices and income and symmetry condition are held.

P is the price index defined as Equation (4).

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln P_k + \frac{1}{2}\sum_j \sum_k \gamma_{kj} \ln P_k \ln P_j \tag{4}$$

The price index (P) can be approximated by using Stone’s geometric price index as in Equation (5) (Akmal and Stern, 2001).

$$\ln P \cong \sum_i w_i \ln(P_i) \tag{5}$$

The static AIDS model of the energy demand can therefore be written as in Equation (6).

$$ES_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln(EP) \tag{6}$$

Where

ES_i = Consumption share of goods i

i, j = Energy (ENR), Food and Beverage (FB), and Others (R)

P_js’ are hence PENR, PFB and PR respectively

EP = x/P

Since the expenditure shares add up to unity, this makes the variance-covariance matrix singular. In the estimation, it is necessary to omit one of the share equations. The technique in estimating the AIDS model is Zellner’s Generalised Least Square method for Seemingly Unrelated Regression (SUR) for efficiency result (Zellner, 1962).

Data is drawn for the period of 1993:1 – 2005:3 when all variables used are available. All prices and quantities of several forms of energy data are drawn from Energy Policy and Plan Office. Consumption of food and beverage and others data is from the Office of the National Economic and Social Development Board.

Dummy variable (DM) is used to capture the impact of the economic crisis in Thailand during 1997:2 – 1999:4.

The static AIDS model of the demands system for energy, food and beverage, and others can therefore be written as in Equation (7).

$$
\begin{aligned}
ESENR_t &= \alpha_1 + \gamma_{11}\ln P_{enrt} + \gamma_{12}\ln P_{fbt} + \gamma_{13}\ln P_{rt} + \beta_1 \ln(EP_t) + \chi_1 DM + \mu_{1t} \quad (7.1)\\
ESFB_t &= \alpha_2 + \gamma_{21}\ln P_{enrt} + \gamma_{22}\ln P_{fbt} + \gamma_{23}\ln P_{rt} + \beta_2 \ln(EP_t) + \chi_2 DM + \mu_{2t} \quad (7.2)\\
ESR_t &= \alpha_3 + \gamma_{31}\ln P_{enrt} + \gamma_{32}\ln P_{fbt} + \gamma_{33}\ln P_{rt} + \beta_3 \ln(EP_t) + \chi_3 DM + \mu_{3t} \quad (7.3)
\end{aligned} \qquad (7)
$$

The unrestricted system of equations is estimated first. The Equation (7.1) and (7.2) are used in the system estimation. The estimation result is shown in Table 1. The restrictions of homogeneity and symmetry are then imposed in the system of the model. We obtain a seemingly unrelated regression model. The result is shown in the Table 2.

Table 1 The Unrestricted SUR Estimation of the System Model (7)

System: **ENERGYUNREST**
Estimation Method: Seemingly Unrelated Regression
Sample: 1993:1 2005:3
Included observations: 51
Total system (balanced) observations 102
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.532076	0.187680	-8.163217	0.0000
C(11)	0.060751	0.007694	7.895421	0.0000
C(12)	0.103738	0.013311	7.793233	0.0000
C(13)	0.368218	0.048402	7.607562	0.0000
C(101)	0.007022	0.000702	10.00016	0.0000
C(10)	0.004348	0.001202	3.617975	0.0005
C(2)	0.750345	0.645119	1.163111	0.2479
C(21)	0.025889	0.026448	0.978858	0.3303
C(22)	-0.137589	0.045755	-3.007060	0.0034
C(23)	-0.035024	0.166372	-0.210517	0.8337
C(102)	-0.003625	0.002414	-1.501851	0.1366
C(20)	0.017824	0.004131	4.314875	0.0000

Determinant residual covariance 2.01E-10

Equation: ESENR =C(1)+C(11)*LPENR+C(12)*LPFB+C(13)*LPR +C(101)*LOG_EP+C(10)*DM
Observations: 51

R-squared	0.994443	Mean dependent var	0.180722
Adjusted R-squared	0.993826	S.D. dependent var	0.029043
S.E. of regression	0.002282	Sum squared resid	0.000234
Durbin-Watson stat	1.122750		

Equation: ESFB =C(2)+C(21)*LPENR+C(22)*LPFB+C(23)*LPR +C(102)*LOG_EP+C(20)*DM
Observations: 51

R-squared	0.669840	Mean dependent var	0.206338
Adjusted R-squared	0.633155	S.D. dependent var	0.012951
S.E. of regression	0.007844	Sum squared resid	0.002769
Durbin-Watson stat	1.406129		

Table 2 The Restricted SUR Estimation of the System Model (7)

System: **ENERGYREST**
Estimation Method: Seemingly Unrelated Regression
Sample: 1993:1 2005:3
Included observations: 51
Total system (balanced) observations 102
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.723700	0.030018	24.10893	0.0000
C(11)	0.149509	0.005812	25.72622	0.0000
C(12)	0.012530	0.010437	1.200619	0.2329
C(101)	-0.001448	0.000138	-10.49720	0.0000
C(10)	0.000911	0.002074	0.439283	0.6615
C(2)	0.174439	0.049778	3.504369	0.0007
C(22)	-0.147484	0.041335	-3.567992	0.0006
C(102)	-0.001315	0.000267	-4.927745	0.0000
C(20)	0.021479	0.003675	5.844518	0.0000

Determinant residual covariance 1.01E-09

Equation: ESENR =C(1)+C(11)*LPENR+C(12)*LPFB+(-C(11)-C(12))*LPR +C(101)*LOG_EP+C(10)*DM
Observations: 51

R-squared	0.977782	Mean dependent var	0.180722
Adjusted R-squared	0.975850	S.D. dependent var	0.029043
S.E. of regression	0.004513	Sum squared resid	0.000937
Durbin-Watson stat	1.755780		

Equation: ESFB =C(2)+C(12)*LPENR+C(22)*LPFB+(-C(12)-C(22))*LPR +C(102)*LOG_EP+C(20)*DM
Observations: 51

R-squared	0.659583	Mean dependent var	0.206338
Adjusted R-squared	0.629982	S.D. dependent var	0.012951
S.E. of regression	0.007878	Sum squared resid	0.002855
Durbin-Watson stat	1.419766		

To test for the restrictions, the Wald test is used. The test can strongly reject the restriction as shown in Table 3.

Table 3 The Test of Restriction

Wald Test: System: ENERGYUNREST			
Test Statistic	Value	df	Probability
Chi-square	198.0350	3	0.0000

The own price elasticities (ε_{ii}), cross price elasticities (ε_{ij}), and expenditure (income) elasticities (η_i) are then calculated using Equation (8), (9), and (10).

$$\varepsilon_{ii} = -1 + \frac{\gamma_{ij}}{wi} - \beta_i \qquad (8)$$

$$\varepsilon_{ij} = \frac{\gamma_{ij}}{w_i} - \beta_i \left(\frac{w_j}{w_i}\right) \qquad (9)$$

$$\eta_i = 1 + \frac{\beta_i}{w_i} \qquad (10)$$

$i, j = 1,2,3$ for (ENR, FB and R)

$i \neq j$

The calculation results of the elasticities, nevertheless to be corresponding to the consumption behaviour, using the restricted equations are shown in Table 4. The estimated income elasticities are also shown in Table 5.

Table 4 The Own price Elasticities and Cross Price Elasticities of the Demand System Equation using Static AIDS Model

	EPSILON11	EPSILON12	EPSILON13	EPSILON21	EPSILON22	EPSILON23	EPSILON31	EPSILON32	EPSILON33
Average (1993.1-2005.3)	-0.1506	0.0728	-0.9140	0.0621	-1.7162	0.6604	-0.2659	0.2198	-0.9585

Source: From Author's calculation

Table 5 The Income Elasticities of the Demand Equation using Static AIDS Model

	NENR	NFB	NR
Average (1993.1-2005.3)	0.991787	0.993603	1.00452

Source: From Author's calculation

From the SUR estimation results of the AIDS model, it is empirically evident that all elasticities have been in line with the theoretical suggestion. Own price elasticities are negative (ε_{11}, ε_{22} and ε_{33}). Cross price elasticities (ε_{12}, ε_{21}, ε_{32}, and ε_{23}) are positive implying that they are substituting goods. Interestingly, cross price elasticities (ε_{13} and ε_{31}) are negative indicating that energy and the others (Non-food) are complementary goods. The estimated elasticities can indicate that energy and food (including beverage) are important goods that people will try to keep their quantity of consumption at a certain level by cutting down the amount of the other goods when energy price increases. The estimated sizes of ε_{11}, ε_{21} and ε_{31} being –0.15, 0.06 and –0.26 respectively show that when energy price increases by 1 per cent, for example, people will reduce most (0.26 per cent) the consumption of the other goods to compensate for the food and beverage (0.06 per cent) while reducing the energy consumption by 0.15 per cent.

It should also be noted that the results showed, as expected, own price inelastic demand for energy (-0.1506). However, demand for food and beverages is found to be price elastic (-1.7162). The demand for the other goods is approximately unitary elastic (-0.9585).

III. The System Demand Equations of Error Correction Mechanism Type Model

The system of demand equations above is estimated in static type. Anderson and Blundell (1983) employed dynamic approach incorporating a static long run equilibrium within the system of error correction mechanism equations. The non-staionary time series and the cointegration approach can be applied to the system of the demand equations. Recently, Pesaran and Shin (1999) also identified and estimated long run coefficients of the AIDS model by Vector Autoregressive model.

Deaton and Muellbauer (1980) found that while the homogeneity restriction was rejected, it generated positive serial correlation among the residuals. When they estimated their equations in the first difference form with constant term (implying the inclusion of a time trend in a levels equation), the estimation improved the results with less frequent rejections of homogeneity. The tendency for empirical tests to conflict with theoretical expectations of the long run consumer behaviour is possibly a consequence of the dynamic mis-specification of the model. In addition, the symmetry and homogeneity restrictions are expected to hold only when imposed on the long run or the steady state of the model according to the consumer behaviour theory (Thomas 1993).

The rejection of homogeneity can also be found in this study. The test of restriction of the SUR model of the energy consumption in Thailand as in Equation (7) shows that it can be rejected (Table 3). This conflicts empirical finding with the theory of consumption and the result is investigated further by employing the dynamic approach of the non-stationary time series and cointegration analysis. The long run structural modeling is therefore used to estimate and identify long run coefficients of the AIDS model in a vector autoregressive (VAR) model.

The same three-commodity data of the demand system in Thailand as of the previous static AIDS model estimation is used in the analysis. According to the consumer theory, only two cointegrating relations is expected to be found for two expenditure share equations included in the system.

Since the vector autoregressive model is highly intensive use of data while the data available for these related variables in the model are rather limited in Thailand (1993:1 – 2005:3), the VAR(1) model is used in this study.

Each time series variable is firstly tested for the unit root using Augmented Dickey-Fuller Test. In the test, the study determines if there are intercept and/or trend in the level and if there is a constant in the first difference of the test (see details in Appendix). All of the variables are found to be non-stationary or I(1) except log_ep which is significantly I(0). Although, the hypothesis of non-stationary of the logarithm of energy price (LPENR) variable is in fact rejected but at 4.81 % of level of significance, we treat it similarly to the other prices as being non-stationary or I(1) in the estimation. In addition, when the estimated regression of autoregressive model of lpenr was done in the same way as random walk model, the coefficient of the first lagged term was found to be about one (1.020) and significant.

Table 6 Test for Non-stationarity of time series

Variable	ADF statistic	Prob
ESENR	-2.8173	0.1982
D(ESENR)	-6.3454	0.0000
ESFB	-2.0638	0.2598
D(ESFB)	-2.1607	0.0309
LPENR	-3.5190	0.0481
D(LPENR)	-5.4720	0.0000
LPFB	-1.9392	0.3122
D(LPFB)	-4.3596	0.0010
LPR	-2.7334	0.0756
D(LPR)	1.8153	0.0664
Log_EP	-3.5607	0.0102
D(Log_EP)	-2.1524	0.0315

The cointegration LR test based on maximal eigenvalue and trace of the stochastic matrix is used to identify the number of cointegrating relations. As expected, the result shows there are two cointegrating relations (Table 7).

Table 7 The LR Test for Number of Cointegrating Relations

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
50 observations from 1993Q2 to 2005Q3. Order of VAR = 1.

List of variables included in the cointegrating vector:
ESENR ESFB LPENR LPFB LPR
List of I(0) variables included in the VAR:
LOG_EP DM

List of eigenvalues in descending order:
0.96932 0.46237 0.32173 0.14298 0.018309

Null	Alternative	Statistic	95% Critical Value	90%Critical Value
r = 0	r = 1	174.2123	33.6400	31.0200
r<= 1	r = 2	31.0290	27.4200	24.9900
r<= 2	r = 3	19.4102	21.1200	19.0200
r<= 3	r = 4	7.7150	14.8800	12.9800
r<= 4	r = 5	0.92395	8.0700	6.5000

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Trace of the Stochastic Matrix
50 observations from 1993Q2 to 2005Q3. Order of VAR = 1.

List of variables included in the cointegrating vector:
ESENR ESFB LPENR LPFB LPR
List of I(0) variables included in the VAR:
LOG_EP DM

List of eigenvalues in descending order:
0.96932 0.46237 0.32173 0.14298 0.018309

Null	Alternative	Statistic	95% Critical Value	90%Critical Value
r = 0	r>= 1	233.2904	70.4900	66.2300
r<= 1	r>= 2	59.0781	48.8800	45.7000
r<= 2	r>= 3	28.0491	31.5400	28.7800
r<= 3	r>= 4	8.6389	17.8600	15.7500
r<= 4	r = 5	.92395	8.0700	6.5000

The Maximum Likelihood estimates for the two long run cointegrating relations give the two vectors as in Table 8. It is noted that the corresponding cointegrating vectors are estimated on ESENR, ESFB, LPENR, LPFB, and LPR, respectively without Log_EP, the exogenous variable of integration of order 1.

Table 8 The two long run cointegrating vectors

	Vector 1	Vector 2
ESENR	1.0000	0.0000
ESFB	0.0000	1.0000
LPENR	-0.053415	-0.034622
	(0.011592)	(0.051357)
LPFB	-0.13916	0.10116
	(0.017708)	(0.075160)
LPR	-0.39306	0.096351
	(0.072398)	(0.32455)

This study imposes the homogeneity and the symmetry restrictions according to the consumer theory as mentioned earlier. The generalized Newton-Raphson is used to estimate the two cointegrating vectors under homogenous restrictions. The result of the two vectors is shown in Table 9.

Table 9 The two long run cointegrating vectors under homogenous restrictions

	Vector 1	Vector 2
ESENR	1.0000	0.0000
ESFB	0.0000	1.0000
LPENR	-0.14349	-0.022639
	(0.0090632)	(0.014644)
LPFB	-0.022639	0.11154
	(0.014644)	(0.062552)
LPR	0.16613	-0.088900
	(0.015961)	(0.058192)

To test for the imposition of the homogeneity restriction, the log likelihood ratio statistic is used. The log likelihood function for the two long run cointegrating vectors in Table 8 is 919.4643 and it is 844.6538 for the two long run cointegrating vectors in Table 9. The LR statistic is 169.6210 that is significant at 5 %.

The two share equations now were estimated and written in the error-correction type as in Tables 10 and 11 below.

Table 10 Error-Correction Mechanism model for ESENR based on Cointegrating VAR(1)

Dependent variable is dESENR
50 observations used for estimation from 1993Q2 to 2005Q3

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
Intercept	0.32050	0.22034	1.4545 [0.153]
ecm1(-1)	-0.49810	0.30557	-1.6301 [0.110]
ecm2(-1)	0.072717	0.15128	0.48067 [0.633]
LOG_EP	-0.8462E-3	0.5777E-3	-1.4646 [0.150]
DM	-0.0042107	0.0045043	-0.93483 [0.355]

ecm1 = 1.0000*ESENR + 0.0000*ESFB -0.14349*LPENR -0.022639*LPFB + 0.16613*LPR;
ecm2 = -0.0000*ESENR + 1.0000*ESFB -0.022639*LPENR + 0.11154*LPFB -0.088900*LPR

R-Squared	0.090081	R-Bar-Squared	0.0091997
S.E. of Regression	.0080895	F-stat. F(4, 45)	1.1137[.362]
Mean of Dependent Variable	.0020040	S.D. of Dependent Variable	.0081270
Residual Sum of Squares	.0029448	Equation Log-likelihood	172.5462
Akaike Info. Criterion	167.5462	Schwarz Bayesian Criterion	162.7662
DW-statistic	1.7024	System Log-likelihood	844.6538

Diagnostic Tests

Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(4)=5.8008[0.215]	F(4,41)=1.3452[0.270]
B:Functional Form	CHSQ(1)=2.1165[0.146]	F(1,44)= 1.9448[0.170]
C:Normality	CHSQ(2)=0.48719[0.784]	Not applicable
D:Heteroscedasticity	CHSQ(1)=0.041944[0.838]	F(1,48)=0.0403[0.842]

Table 11 Error-Correction Mechanism model for ESFB based on Cointegrating VAR(1)

Dependent variable is dESFB			
50 observations used for estimation from 1993Q2 to 2005Q3			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
Intercept	0.63237	0.17898	3.5333[0.001]
ecm1(-1)	-0.70945	0.24820	-2.8584[0.006]
ecm2(-1)	-0.63017	0.12288	-5.1283[0.000]
LOG_EP	-0.00182	0.4693E-3	-3.8975[0.000]
DM	0.015815	0.00365	4.3227[0.000]
ecm1 = 1.0000*ESENR + 0.0000*ESFB -0.14349*LPENR -0.022639*LPFB + 0.16613*LPR;			
ecm2 = 0.0000*ESENR + 1.0000*ESFB -0.022639*LPENR + 0.11154*LPFB -0.088900*LPR			
R-Squared 0.40160		R-Bar-Squared 0.34841	
S.E. of Regression 0.0065708		F-stat. F(4,45) 7.5502[.000]	
Mean of Dependent Variable -0.2811E-3		S.D. of Dependent Variable .0081401	
Residual Sum of Squares 0.0019429		Equation Log-likelihood 182.9430	
Akaike Info. Criterion 177.9430		Schwarz Bayesian Criterion 173.1630	
DW-statistic 1.7173		System Log-likelihood 844.6538	

Diagnostic Tests		
Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(4)= 9.3733[0.052]	F(4,41)=2.3649[0.069]
B:Functional Form	CHSQ(1)= 0.72982[0.393]	F(1,44)= 0.65175[0.424]
C:Normality	CHSQ(2)= 2.1035[0.349]	Not applicable
D:Heteroscedasticity	CHSQ(1)=0.031207[0.860]	F(1,48)= 0.02997[0.863]

Although, the study can reject the homogeneity and symmetry hypothesis under the consumer theory, it is interesting to note that the test for serial correlation of the residuals from the dynamic VECM model under the imposed restrictions cannot reject the null hypothesis of no serial correlation at 5 % level of significance. In comparison, the residuals resulted from the static AIDS model estimated earlier showed being non White Noise with serial correlation (Table 12 - 14). The residuals from the dynamic VECM equations appear White Noise indicating that the dynamic VECM model is more appropriate.

Table 12 AC and PAC of the Residuals from the static AIDS (unrestricted equations)

12.1 ESENR equation

Lags	AC	PAC	Q-Stat	Prob
1	0.390	0.390	8.2074	0.004
2	-0.042	-0.228	8.3032	0.016
3	-0.092	0.022	8.7749	0.032
4	0.118	0.180	9.5819	0.048
5	-0.038	-0.238	9.6663	0.085
6	-0.213	-0.100	12.394	0.054
7	-0.054	0.160	12.573	0.083
8	0.095	-0.050	13.135	0.107
9	-0.078	-0.187	13.526	0.140
10	-0.207	0.005	16.364	0.090
11	-0.202	-0.184	19.112	0.059
12	0.103	0.202	19.853	0.070
13	-0.042	-0.233	19.982	0.096
14	-0.143	-0.028	21.478	0.090
15	-0.195	-0.130	24.325	0.060

AC = Autocorrelation
PAC = Partial Autocorrelation

12.2 ESFB equation

Lags	AC	PAC	Q-Stat	Prob
1	0.262	0.262	3.7135	0.054
2	-0.201	-0.289	5.9348	0.051
3	-0.083	0.071	6.3242	0.097
4	0.287	0.277	11.047	0.026
5	-0.161	-0.453	12.577	0.028
6	-0.356	-0.030	20.208	0.003
7	-0.085	0.053	20.649	0.004
8	0.212	-0.051	23.464	0.003
9	-0.120	-0.123	24.384	0.004
10	-0.132	0.147	25.541	0.004
11	0.089	-0.054	26.072	0.006
12	0.164	-0.102	27.941	0.006
13	-0.198	-0.081	30.716	0.004
14	-0.156	-0.012	32.501	0.003
15	0.075	-0.034	32.926	0.005

AC = Autocorrelation
PAC = Partial Autocorrelation

Table 13 AC and PAC of the Residuals from the static AIDS (restricted equations)

13.1 ESENR equation

Lags	AC	PAC	Q-Stat	Prob
1	0.122	0.122	0.8038	0.370
2	-0.458	-0.480	12.400	0.002
3	-0.008	0.176	12.403	0.006
4	0.480	0.308	25.676	0.000
5	0.107	0.012	26.346	0.000
6	-0.440	-0.229	37.996	0.000
7	-0.095	0.044	38.545	0.000
8	0.287	-0.080	43.708	0.000
9	0.049	-0.033	43.864	0.000
10	-0.286	-0.013	49.241	0.000
11	-0.261	-0.262	53.856	0.000
12	0.177	0.054	56.025	0.000
13	0.083	-0.122	56.520	0.000
14	-0.201	-0.001	59.474	0.000
15	-0.357	-0.357	69.028	0.000

AC = Autocorrelation
PAC = Partial Autocorrelation

13.2 ESFB equation

	AC	PAC	Q-Stat	Prob
1	0.258	0.258	3.6084	0.057
2	-0.216	-0.303	6.1737	0.046
3	-0.117	0.040	6.9417	0.074
4	0.255	0.257	10.683	0.030
5	-0.172	-0.458	12.415	0.030
6	-0.321	0.019	18.604	0.005
7	-0.032	0.087	18.666	0.009
8	0.244	-0.055	22.419	0.004
9	-0.098	-0.098	23.043	0.006
10	-0.113	0.142	23.884	0.008
11	0.086	-0.074	24.382	0.011
12	0.170	-0.031	26.383	0.009
13	-0.184	-0.065	28.790	0.007
14	-0.166	-0.054	30.810	0.006
15	0.047	-0.002	30.976	0.009

AC = Autocorrelation
PAC = Partial Autocorrelation

Table 14 AC and PAC of the Residuals from the dynamic VECM (restricted equations)

14.1 ESENR equation

	AC	PAC	Q-Stat	Prob
1	0.138	0.138	1.0052	0.316
2	-0.245	-0.270	4.2689	0.118
3	0.011	0.100	4.2760	0.233
4	0.044	-0.047	4.3868	0.356
5	-0.238	-0.234	7.6526	0.176
6	-0.231	-0.165	10.813	0.094
7	0.042	-0.019	10.919	0.142
8	0.028	-0.079	10.966	0.204
9	0.081	0.128	11.379	0.251
10	-0.039	-0.163	11.477	0.322
11	0.042	0.046	11.594	0.395
12	0.148	0.073	13.092	0.362
13	0.072	0.059	13.454	0.413
14	-0.183	-0.147	15.869	0.321
15	-0.292	-0.260	22.183	0.103

AC = Autocorrelation
PAC = Partial Autocorrelation

14.2 ESFB equation

	AC	PAC	Q-Stat	Prob
1	0.117	0.117	0.7208	0.396
2	-0.179	-0.195	2.4580	0.293
3	-0.108	-0.064	3.1034	0.376
4	0.338	0.344	9.5435	0.049
5	-0.133	-0.308	10.572	0.061
6	-0.213	-0.048	13.253	0.039
7	-0.013	0.087	13.263	0.066
8	0.238	0.008	16.757	0.033
9	-0.078	-0.028	17.138	0.047
10	-0.192	-0.086	19.527	0.034
11	0.117	0.164	20.442	0.040
12	0.069	-0.189	20.763	0.054
13	-0.069	0.066	21.094	0.071
14	-0.118	0.030	22.105	0.076
15	0.183	0.021	24.580	0.056

AC = Autocorrelation
PAC = Partial Autocorrelation

Still, AC and PAC in correlogram in Table 14.2 indicate serial correlation of the residuals at some periods of lag length in the VECM equation of ESFB (food). This may indicate that the number of lags in the VECM model could be inadequate. Unfortunately, the available quarterly data in the study is rather short series so the VAR(1) is used in the estimation as mentioned earlier. The rejection of the consumer restrictions in the part of the dynamic VECM model could likely be due to the rather short time series of the available data used in the estimation. The dynamic VECM model consisted of a longer specified lag length may be needed.

The own price elasticities and cross price elasticities from the dynamic energy consumption model under the imposed restrictions are then calculated and compared with the previous results (Table 15). The expenditure (income) elasticities are shown in Table 16. When being compared, the estimated values of elasticities calculated from both models are shown to be slightly different. The main reason for the difference can be attributed to the fact that the static AIDS model of share equations encountered with the problem of dynamic mis-specification of the model. All variables except Log_EP are nonstationary and so error correction mechanism model is required for the estimation of the model.

Table 15 The Own price Elasticities and Cross Price Elasticities of the Demand System Equation using Dynamic VECM

	EPSILON11	EPSILON12	EPSILON13	EPSILON21	EPSILON22	EPSILON23	EPSILON31	EPSILON32	EPSILON33
Average (1993.1-2005.3)	-0.1845	0.1304	-0.9363	0.1127	-1.5397	0.4411	-0.2731	0.1439	-0.8783

Source: From Author’s calculation

The Own price Elasticities and Cross Price Elasticities of the Demand System Equation using Static AIDS Model

	EPSILON11	EPSILON12	EPSILON13	EPSILON21	EPSILON22	EPSILON23	EPSILON31	EPSILON32	EPSILON33
Average (1993.1-2005.3)	-0.1506	0.0728	-0.9140	0.0621	-1.7162	0.6604	-0.2659	0.2198	-0.9585

Table 16 The Income Elasticities of the Demand Equation using Dynamic VECM

	NENR	NFB	NR
Average			
(93.1-05.3)	0.9904	0.9859	1.0075

Source: From Author's calculation

The Income Elasticities of the Demand Equation using Static AIDS Model

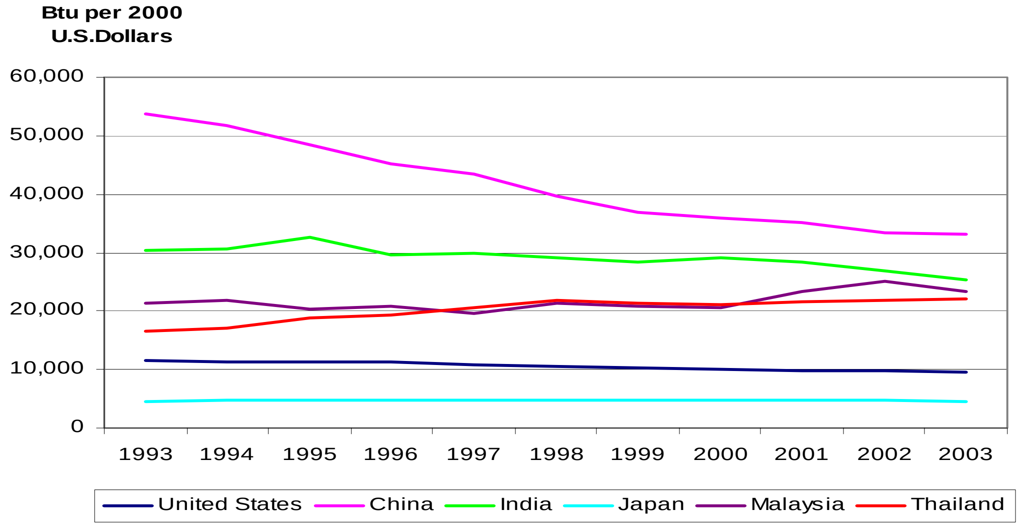
	NENR	NFB	NR
Average			
(93.1-05.3)	0.991787	0.993603	1.00452

The estimation results in general showed that the own price elasticity of energy demand is less inelastic (-0.1845) when compared to the result from the static model (-0.1506). The calculated own price elasticity of food and beverages demand is more elastic than that obtained from the static model. It is noticeable also that the cross price elasticities of demand between energy and food (ε_{12} and ε_{21}) from the dynamic VECM model (0.1304 and 0.1127) are relatively larger in size than those calculated from the static AIDS model (0.0728 and 0.0621).

The expenditure (income) elasticities from both models are almost equal (and being about one). In fact, from their general observation, it is obvious to the economists and the Thai people, including the Energy Policy and Plan Office that the energy consumption has been growing relatively fast in the period when the economy is doing well.

Thailand was found to be considerably dependent on energy. When being compared to the other developing countries (Figure 1), the Thai economy is shown to be dependent on energy with a relatively higher rate of energy intensity. Therefore the magnitudes of elasticity of energy consumption are of interest and important for the policy makers.

Figure 1 World Energy Intensity (Total Primary Energy Consumption Per Dollar of Gross Domestic Product), 1980-2003



Source Energy Information Administration

When the energy elasticity was simply calculated in terms of the ratio of growth of energy consumption to the growth of GDP in Thailand, the report showed the size of the elasticity larger than one (Figure 2). However, the average size of it is relatively larger than that in this paper because of the different methods of calculation, different study period and different coverage of energy included.

Figure 2 The simple calculated energy elasticity in Thailand

	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Energy Elasticity Average
Energy Elasticity	0.97	1.24	1.47	1.08	1.51	1.34	1.64	1.94	-3.50	0.47	0.58	0.97	1.07	1.40

Source http://www.eppo.go.th/doc.strategy2546/strategy.html

When using raw data of energy consumption (including five forms of energy as being used in this paper) to calculate directly the annual income elasticity, the results in the table show that on average (excluding 1997, the year of financial crisis) the elasticity is close to one.

Table 17 The simple calculated energy elasticity

	Energy Elasticity
1993	
1994	1.21
1995	1.53
1996	1.83
1997	- 2.76
1998	0.63
1999	0.24
2000	0.33
2001	1.58
2002	1.15
2003	1.02
2004	1.24
Average (excl. 1997)	1.07

Source From the Author's Calculation

The summary table of own, cross, and expenditure elasticities obtained from the dynamic system of demand equations in this study can be shown in Table 18.

Table 18 Summary of Own, Cross and Expenditure Elasticities

	Price Elasticities			Expenditure
Commodity	Energy	Food and Beverages	Others	Elasticity
Energy	-0.1845	0.1304	-0.9363	0.9904
Food and Beverages	0.1127	-1.5397	0.4411	0.9859
Others	-0.2731	0.1439	-0.8783	1.0075

Source Calculated from the dynamic error correction mechanism type model

IV. Conclusion

The main objective of the paper is to estimate the elasticities of energy consumption using the framework of the Almost Ideal Demand System (AIDS). The paper compares the estimated elasticities between those from the static AIDS model and the dynamic model of the error correction type. The study however finds the magnitudes of the estimated long run elasticities between the two models are slightly different. Since the related variables used in the model are non-stationary, the dynamic error correction mechanism type model of AIDS is therefore more appropriate. The static AIDS is the dynamic mis-specified model.

The static AIDS model is applied for the energy, food and beverages, and the other commodities and empirically estimated. The test of the restrictions according to the consumer theory showed the rejection the homogeneity property.

All of the time series variables used in the AIDS model, except for the expenditure (Log_EP), are found to be non-stationary. The vector error correction mechanism model is therefore estimated. The homogeneity restriction can also be rejected at 5 % of level of significance. Nevertheless, the test for serial correlation of the residuals from the dynamic VECM model under the restriction condition indicates no serial correlation. In comparison, the residuals from the static AIDS model estimated earlier showed being non White Noise with high order of serial correlation. By contrast, the residuals from the dynamic VECM equations under homogeneity and symmetry restrictions appear White Noise indicating that the dynamic model is therefore more appropriate.

The long run elasticities are calculated using the estimation from the dynamic model and it is discovered that they are little different from those calculated from the static AIDS model.

From the result of the dynamic model, the own price elasticity of energy demand is found to be inelastic (-0.1845). The own price elasticities of food and the other commodities demands are, however, more elastic (-1.5397 and -0.8783). The expenditure (income) elasticity of energy is found to be close to one.

The correct magnitude of elasticites of energy demand is in fact very important for the national energy policy. Currently Thailand is relatively more dependent on energy that has higher rates of energy intensity (energy consumption per GDP), when compared with the other countries. When the energy elasticity (growth of energy consumption per growth of GDP) is simply calculated using existing raw data, the size of it is found to be quite close to that from the dynamic VECM model estimated in this study.

Appendix

Test for Unit Root of ESENR

Null Hypothesis: ESENR has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.817331	0.1982
Test critical values:	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ESENR)
Method: Least Squares
Sample(adjusted): 1993:2 2005:3
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ESENR(-1)	-0.329548	0.116972	-2.817331	0.0071
C	0.043503	0.015826	2.748840	0.0085
@TREND(1993:1)	0.000690	0.000220	3.129195	0.0030

R-squared	0.174630	Mean dependent var	0.002004
Adjusted R-squared	0.139508	S.D. dependent var	0.008127
S.E. of regression	0.007539	Akaike info criterion	-6.879375
Sum squared resid	0.002671	Schwarz criterion	-6.764654
Log likelihood	174.9844	F-statistic	4.972081
Durbin-Watson stat	1.647545	Prob(F-statistic)	0.010996

Null Hypothesis: D(ESENR) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.345452	0.0000
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ESENR,2)
Method: Least Squares
Sample(adjusted): 1993:4 2005:3
Included observations: 48 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ESENR(-1))	-1.284352	0.202405	-6.345452	0.0000
D(ESENR(-1),2)	0.357415	0.148451	2.407629	0.0202
C	0.002551	0.001171	2.178935	0.0346

R-squared	0.529840	Mean dependent var	0.000398
Adjusted R-squared	0.508944	S.D. dependent var	0.011125
S.E. of regression	0.007796	Akaike info criterion	-6.809960
Sum squared resid	0.002735	Schwarz criterion	-6.693010
Log likelihood	166.4390	F-statistic	25.35605
Durbin-Watson stat	1.974226	Prob(F-statistic)	0.000000

Test for Unit Root of ESFB

Null Hypothesis: ESFB has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.063837	0.2598
Test critical values:	1% level	-3.581152	
	5% level	-2.926622	
	10% level	-2.601424	

*MacKinnon (1996) one-sided p-values.
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ESFB)
Method: Least Squares
Sample(adjusted): 1994:2 2005:3
Included observations: 46 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ESFB(-1)	-0.150314	0.072832	-2.063837	0.0456
D(ESFB(-1))	-0.035186	0.127041	-0.276966	0.7832
D(ESFB(-2))	-0.047820	0.124815	-0.383123	0.7037
D(ESFB(-3))	0.060456	0.118795	0.508912	0.6136
D(ESFB(-4))	0.597752	0.113237	5.278797	0.0000
C	0.031016	0.015121	2.051134	0.0468

R-squared	0.527243	Mean dependent var	-0.000305
Adjusted R-squared	0.468148	S.D. dependent var	0.007758
S.E. of regression	0.005658	Akaike info criterion	-7.390371
Sum squared resid	0.001281	Schwarz criterion	-7.151853
Log likelihood	175.9785	F-statistic	8.922007
Durbin-Watson stat	1.898265	Prob(F-statistic)	0.000009

Null Hypothesis: D(ESFB) has a unit root
Exogenous: None
Lag Length: 3 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.160681	0.0309
Test critical values:	1% level	-2.616203	
	5% level	-1.948140	
	10% level	-1.612320	

*MacKinnon (1996) one-sided p-values.
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ESFB,2)
Method: Least Squares
Date: 04/02/06 Time: 15:24
Sample(adjusted): 1994:2 2005:3
Included observations: 46 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ESFB(-1))	-0.723351	0.334779	-2.160681	0.0365
D(ESFB(-1),2)	-0.421023	0.265451	-1.586065	0.1202
D(ESFB(-2),2)	-0.558700	0.186737	-2.991908	0.0046
D(ESFB(-3),2)	-0.556196	0.114356	-4.863743	0.0000

R-squared	0.788438	Mean dependent var	-0.000457
Adjusted R-squared	0.773327	S.D. dependent var	0.012204
S.E. of regression	0.005810	Akaike info criterion	-7.375462
Sum squared resid	0.001418	Schwarz criterion	-7.216449
Log likelihood	173.6356	Durbin-Watson stat	1.787388

Test for Unit Root of LPENR

Null Hypothesis: LPENR has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.519027	0.0481
Test critical values:	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPENR)
Method: Least Squares
Sample(adjusted): 1993:3 2005:4
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPENR(-1)	-0.343628	0.097648	-3.519027	0.0010
D(LPENR(-1))	0.399325	0.141188	2.828333	0.0069
C	-0.044779	0.017202	-2.603220	0.0124
@TREND(1993:1)	0.005746	0.001540	3.730033	0.0005

R-squared	0.274339	Mean dependent var	0.016262
Adjusted R-squared	0.227013	S.D. dependent var	0.045061
S.E. of regression	0.039617	Akaike info criterion	-3.542494
Sum squared resid	0.072198	Schwarz criterion	-3.389532
Log likelihood	92.56234	F-statistic	5.796818
Durbin-Watson stat	2.022318	Prob(F-statistic)	0.001899

Null Hypothesis: D(LPENR) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.472021	0.0000
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPENR,2)
Method: Least Squares
Sample(adjusted): 1993:3 2005:4
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPENR(-1))	-0.769229	0.140575	-5.472021	0.0000
C	0.012434	0.006685	1.860100	0.0690

R-squared	0.384165	Mean dependent var	-0.000323
Adjusted R-squared	0.371336	S.D. dependent var	0.055873
S.E. of regression	0.044301	Akaike info criterion	-3.356447
Sum squared resid	0.094203	Schwarz criterion	-3.279966
Log likelihood	85.91117	F-statistic	29.94302
Durbin-Watson stat	1.887037	Prob(F-statistic)	0.000002

Test for Unit Root of LPFB

Null Hypothesis: LPFB has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.939234	0.3122
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPFB)
Method: Least Squares
Sample(adjusted): 1993:3 2005:4
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPFB(-1)	-0.023317	0.012024	-1.939234	0.0585
D(LPFB(-1))	0.362290	0.131094	2.763589	0.0081
C	0.112416	0.055044	2.042291	0.0468

R-squared	0.257891	Mean dependent var	0.010579
Adjusted R-squared	0.226312	S.D. dependent var	0.012922
S.E. of regression	0.011366	Akaike info criterion	-6.058169
Sum squared resid	0.006072	Schwarz criterion	-5.943448
Log likelihood	154.4542	F-statistic	8.166520
Durbin-Watson stat	1.992196	Prob(F-statistic)	0.000904

Null Hypothesis: D(LPFB) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.359652	0.0010
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPFB,2)
Method: Least Squares
Sample(adjusted): 1993:3 2005:4
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPFB(-1))	-0.558382	0.128080	-4.359652	0.0001
C	0.005751	0.002166	2.654670	0.0107

R-squared	0.283652	Mean dependent var	-0.000353
Adjusted R-squared	0.268728	S.D. dependent var	0.013669
S.E. of regression	0.011689	Akaike info criterion	-6.021196
Sum squared resid	0.006558	Schwarz criterion	-5.944715
Log likelihood	152.5299	F-statistic	19.00657
Durbin-Watson stat	2.044825	Prob(F-statistic)	0.000069

Test for Unit Root of LPR

Null Hypothesis: LPR has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.733461	0.0756
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPR)
Method: Least Squares
Sample(adjusted): 1993:3 2005:4
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPR(-1)	-0.018657	0.006825	-2.733461	0.0088
D(LPR(-1))	0.609545	0.105843	5.758939	0.0000
C	0.087000	0.031343	2.775710	0.0079

R-squared	0.670905	Mean dependent var	0.006942
Adjusted R-squared	0.656901	S.D. dependent var	0.006791
S.E. of regression	0.003978	Akaike info criterion	-8.158171
Sum squared resid	0.000744	Schwarz criterion	-8.043450
Log likelihood	206.9543	F-statistic	47.90798
Durbin-Watson stat	1.910170	Prob(F-statistic)	0.000000

Null Hypothesis: D(LPR) has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.815356	0.0664
Test critical values:	1% level	-2.612033	
	5% level	-1.947520	
	10% level	-1.612650	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LPR,2)
Method: Least Squares
Sample(adjusted): 1993:3 2005:4
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPR(-1))	-0.112816	0.062145	-1.815356	0.0756

R-squared	0.061737	Mean dependent var	-0.000162
Adjusted R-squared	0.061737	S.D. dependent var	0.004437
S.E. of regression	0.004298	Akaike info criterion	-8.041665
Sum squared resid	0.000905	Schwarz criterion	-8.003424
Log likelihood	202.0416	Durbin-Watson stat	2.086394

Test for Unit Root of Log_EP

Null Hypothesis: LOG_EP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.560721	0.0102
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG_EP)
Method: Least Squares
Sample(adjusted): 1993:2 2005:3
Included observations: 50 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG_EP(-1)	-0.063396	0.017804	-3.560721	0.0008
C	-4.334401	1.117504	-3.878643	0.0003

R-squared	0.208949	Mean dependent var	-0.376430
Adjusted R-squared	0.192468	S.D. dependent var	0.905434
S.E. of regression	0.813648	Akaike info criterion	2.464601
Sum squared resid	31.77714	Schwarz criterion	2.541082
Log likelihood	-59.61503	F-statistic	12.67873
Durbin-Watson stat	1.576374	Prob(F-statistic)	0.000846

Null Hypothesis: D(LOG_EP) has a unit root
Exogenous: None
Lag Length: 2 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.152490	0.0315
Test critical values:	1% level	-2.615093	
	5% level	-1.947975	
	10% level	-1.612408	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG_EP,2)
Method: Least Squares
Sample(adjusted): 1994:1 2005:3
Included observations: 47 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG_EP(-1))	-0.341925	0.158851	-2.152490	0.0369
D(LOG_EP(-1),2)	-0.271276	0.151766	-1.787466	0.0808
D(LOG_EP(-2),2)	-0.463918	0.138009	-3.361495	0.0016

R-squared	0.449725	Mean dependent var	0.023793
Adjusted R-squared	0.424713	S.D. dependent var	1.064860
S.E. of regression	0.807672	Akaike info criterion	2.472380
Sum squared resid	28.70269	Schwarz criterion	2.590475
Log likelihood	-55.10093	Durbin-Watson stat	2.076664

References

Akmal, M. and Stern, D.I., 2001. "The Structure of Australian Residential Energy Demand", *Working Papers in Ecological Economics. No. 0101*, The Australian National University.

Blundell, R., Browning, M., and Meghir, C., 1994. "Consumer Demand and Life Cycle Allocation of Household Expenditures", *Review of Economic Studies*, 61, 57-80.

Deaton, A. and Muellbauer, J., 1980. "An Almost Ideal Demand System", *The American Economic Review*, 70 (3): 312 – 326.

Pesaran, M.H., 1997. "The Role of Economic Theory in Modelling the Long Run", *The Economic Journal*, 107: 178-191.

Pesaran, M.H. and Shin, Y., 1999. "Long Run Structural Modelling", *DAE Working Paper No. 9419*. University of Cambridge.

Tomas, R.L., 1993. *Introductory Econometrics: Theory and Applications*, London: Longman.

Zellner, A. 1962. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias", *Journal of the American Statistical Association*, 57: 348-368.