The Demand for Energy in Nepal

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Abstract

This study aims at estimating energy demand functions in the Nepalese context including the estimate of partial adjustment model and energy requirement. Specifically, the study is devoted to assessing, whether or not, there exists any economies of scale with respect to the demand for energy; whether the speed of adjustment between desired and actual levels of energy is slow or fast; and how much energy will be required in the next 10 years. The energy demand functions estimated in this study are strong where GDP coefficients are statistically significant. The GDP elasticity is less than one suggesting economies of scale. The study reveals that one percentage point increase in GDP leads on average to about 0.45 percent increase in energy demand. The estimated functions indicate that the demand for energy is also sensitive to population. The partial adjustment model estimated in this study indicates that the speed of adjustment between desired and actual energy balance is much slower. The results are quite surprising as the adjustment is quite far from immediate. Based on the estimated equations, the forecast of energy requirement has also been made till 2009/10.

Introduction

Energy plays an important role in the economic development of a country as per capita energy consumption is often viewed as a key index of development. The per capita energy consumption in Nepal is estimated at 14.23 GJ in 1994/95 (Amatya and Ghimire 1995, a rate considered to be very low internationally. The World Bank Atlas, 1995 shows that this is lower than that of India (168 GJ), Pakistan (159 GJ), Sri Lanka (72 GJ), and Bangladesh (42 GJ).

The reliable availability of adequate energy resources at an affordable cost is a vital precondition for continued economic progress. Energy planning and policies involve the management of activities concerning energy supply and demand which requires the implementation of measures to influence, guide, and control the import, production, and consumption of energy so as to maximize the national welfare. It is the job of the energy policy maker to ensure adequate energy supply-demand balances, thus preventing major economic disruptions and consequent reductions in benefits to the national economy (Munasinghe 1990). The capacity for energy planning, therefore, must be developed to meet the overall national objectives as efficiently as possible.

To do this, an understanding of the relationship between the energy sector and the rest of the economy is important in two aspects. First, the energy sector is linked with almost all the sectors of the economy, hence economic activities will have a large influence on the energy demand. Secondly, an energy planning exercise is not an objective in itself but rather a means of achieving national development objectives and its success or failure must be periodically reassessed in the light of economic successes or failures.

Such strategies will probably require an unprecedented mobilization of financial resources. The World Bank has estimated that the capital investment required for these energy generation programmes over the next 10 years will total over US$ 600 billion (IBRD 1981).

Many oil-importing developing nations have been seriously affected by rises in oil prices and face potentially disastrous consequences if their plans for modernization and industrialization continue to include a heavy dependence on foreign oil (Anandalingam 1990). Some of these nations have reacted with energy strategies that involve increasing their indigenous supply of conventional fuels, expanding the use of large-scale hydroelectric and nuclear systems, improving the efficiency of oil utilization in industry and transportation, and developing renewable energy technologies.

Planners and decision makers therefore find themselves dependent upon the industrialized countries for the capital and technology to support their
programmes of economic growth and modernization, and upon the oil-exporting countries for the petroleum to fuel their modern industrial and transportation sectors. Thus, they are seeking methods and technologies to use imported oil more efficiently, while simultaneously maintaining vigorous economic growth and improving balance of payments. They are also making efforts to substitute imports, develop non-conventional sources, and take several conservation measures.

Studies in the industrialized countries have revealed that, from an economic and technological viewpoint, opportunities for using energy more efficiently are substantial in all sectors of the national economy (Anandalingam 1983). Any responsible energy plan should involve the aggressive development and implementation of energy efficient technologies.

In developing countries, the industrial sector is the major user of commercial fuels such as coal, natural gas, oil, and electricity. In India, for example, industry accounts for more than 75 percent of the commercial fuel consumed.

Typically, the largest five or six industries account for more than 70 percent of industrial energy used in developing countries. The major energy consumers are cement, iron and steel, aluminum, chemicals (including fertilizers), paper and pulp, and mining. Although food processing and textiles are not energy-intensive, they should be classified as major energy consuming industries (Anandalingam 1990). This is because there are a number of these industries in developing countries.

Most developing countries follow industrial practices similar to those of the developed countries. However, a comparison of energy efficiencies in developing countries and a number of developed countries shows that developing countries have energy inefficiencies higher than those in developed countries (Jankowski 1981). The differences in energy inefficiencies exist for a variety of reasons: the use of older, inefficient equipment; the use of different technologies; the existence of fuel subsidies designed to promote industrialization; the lack of expertise in energy conservation; and the unavailability of capital and incentives for investing in conservation (Anandalingam 1990).

Increasing consumption of petroleum products coupled with their rising prices, low level of indigenous hydropower resources utilization, and growing biomass use for fuel are some of the typical characteristics of the Nepal’s energy scene (WECS 1994). In Nepal, percentage share of fuel wood in the overall consumption is decreasing but the use of fuel wood is still quite significant. These characteristics call for a special attention in Nepal’s energy sector planning.

Interest in the study of energy demand in the Nepalese context has been stimulated by the empirical works of Reister (1987). To explore the relationship between energy demand and GDP, Reister estimated the parameters in the equation \( \ln \text{Energy} = a + b \ln \text{GDP} \) where, \( b \) is income elasticity. Using this methodology, he analysed the relationship between energy demand and GDP in 38 developing countries for the years 1950, 1960, 1970, and 1980. The countries were classified into three groups on the basis of per capita GDP; the class boundaries are $0-$1000 for class A, $1000-$2000 for class B, and $3000-$4000 for class C, and he concluded the following: That there is no significant differences in energy intensity among the three class of developing countries. That energy intensity increases during development. That income elasticity for developing countries is significantly above one.

Energy is important for the industrial sector of Nepal too. Although the country is well endowed with abundant bio-mass and hydropower potential, the pace of industrialization has also been constrained by the lack of energy and power (Pradhan 1983). Considering the link between energy consumption and economic development, energy development needs to be accorded high priority in Nepal’s development planning.

The purpose of this paper is to estimate energy demand functions including the partial adjustment model. Specifically, it aims at estimating the elasticity of GDP with respect to the energy demand. In other words, if the GDP increases by one percentage point, whether the demand for energy increases by less than or more than unity. The study is directed towards resolving the following issues in the context of Nepal: (a) Is there any economies of scale with respect to the demand for energy? (b) What is the speed of adjustment between desired and actual levels of energy? Is it slow or fast? (c) How much energy will be required in the next 10 years?

The paper has been organised into four sections. Section 1 describes the specification of the model
while Section 2 presents the empirical results. The forecast of energy requirement in the next 10 years is shown in Section 3. Finally, summary and conclusions are provided in Section 4.

Section 1

The Model

The decision about the aggregate level of demand for energy may be regarded as subject to the constraint of gross domestic product. As a first approximation to the theory, the function may be written as,

\[ Y^* = f(GDP) \]  
(1)

Where, \( Y^* \) is real desired level of energy, and GDP is the real Gross Domestic Product.

In an empirical investigation, expression (1) takes the form;

\[ Y^* = k GDP^{b1} e^u \]  
(2)

Where, the error term e \( u \) is assumed to be independently and normally distributed.

Taking the natural logarithm of the expression (2) gives,

\[ \ln Y^* = \ln k + b1 \ln GDP + Ui \]  
(3)

It is assumed that desired level of energy, \( Y^* \) is equal to its actual level, \( Y \). Thus the equation to be estimated is,

\[ \ln Y = \ln b0 + b1 \ln GDP + Ui \]  
(4)

where, \( b0 \) is constant, \( b1 \) is elasticity of \( Y \) with respect to GDP. The above model assumes the following reasonable a priori hypothesis:

\[ \frac{\delta Y}{\delta GDP} > 0 \]  
(5)

After estimating the above equation, population variable is introduced in the model. The relationship of population with desired level of energy is postulated to be positive.

While estimating the above equation, the GDP figures are deflated by using a suitable deflator.

The empirical analysis in this study takes into account a partial adjustment or flexible accelerator model of energy demand behavior. This model hypothesizes that each country has a desired target level of energy, and that each country, finding its actual energy not equal to its desired level, attempts only a partial adjustment towards the desired level of energy within any period. The partial adjustment model is used to indicate the speed with which the country adjusts its actual energy level to desired energy level.

The simple assumption to make about the adjustment process in energy is that,

\[ \begin{bmatrix} Y_t \\ Y_{t-1} \end{bmatrix} = \begin{bmatrix} Y^* \\ Y_{t-1} \end{bmatrix} \phi + e^u \]  
(6)

where, \( \phi = \) rate of adjustment or adjustment coefficient,

0 is less than \( \phi \) is less than or equal to 1.

The multiplicative form of the adjustment mechanism implies that the time required for the firm to adjust is a function of the relative size of the required adjustment rather than the absolute size. Substituting the expression (6) for desired level of energy into equation (2) gives,

\[ \begin{bmatrix} Y_t \\ Y_{t-1} \end{bmatrix} = k GDP^{b1} e^u \]  
(7)

Taking logs of this equation gives,

\[ \ln Y_t - \ln Y_{t-1} = \phi \ln b0 + \phi b1 \ln GDP_t - \phi \ln Y_{t-1} + Ut \]  
(8)

Or, \( \ln Y_t = c0 + c1 \ln GDP + (1-\phi) \ln Y_{t-1} + Ut \)  
(9)

where, \( c1 \) is the short-run elasticity of energy demand with respect to Gross Domestic Product. The long-run elasticity with respect to Gross Domestic Product is \( b1 \):

Since,

\[ c1 = \phi b1 \]
\[ b1 = c1/\phi \]

Specification of variables:

Gross Domestic Product: Gross Domestic Product has been deflated by using national urban consumer price index as a deflator.

Population: The population has also been introduced in the model as an explanatory variable in the estimated equations.
Energy demand: It is postulated here that energy demand is some function of past consumption, i.e., \( Y_t = Y_{t-1} \). This specification should provide the best fit most of the times.

**Nature and sources of data:**

The data on energy consumption have been collected from Energy Synopsis Report published by the Water and Energy Commission Secretariat, Nepal, 'Statistical Pocket Book' published by Central Bureau of Statistics and 'The Economic Survey' published by the Ministry of Finance. The GDP figures have been collected from the 'Quarterly Economic Bulletin' published by the central bank of Nepal, i.e., Nepal Rastra Bank. Similarly, population figures are compiled from the Central Bureau of Statistics, Nepal. For the purpose of this study, the time series data are collected from 1980/81-1994/95 on dependent and independent variables. This study is therefore based on secondary data only.

**Section 2**

**Empirical Results**

The demand function of energy has been simplified to assert that \( Y = g(GDP) \), where \( g > 0 \). Then the statistical hypothesis may be expressed in logarithmic form as

\[
\ln Y_t = a_0 + a_1 \ln GDP_t + U_{it},
\]

where, \( a_0 \) is the intercept, \( a_1 \) is the elasticity of energy demand \( Y_t \) with respect to Gross Domestic Product \( GDP_t \), and \( U_{it} \) is the error term. The regression result of the model showing the demand for energy is presented below:

\[
\ln Y_t = 7.46 + 0.45 \ln GDP_t \quad ... \quad (10)
\]

\[
(16.20^*)
\]

\[
R\text{-bar Square} = 0.949
\]

\[
F \text{ Value} = 262
\]

\[
\text{SEE} = 0.027
\]

Note: The figures in parenthesis are (t) values and the asterisk sign (*) indicates that the result is significant at 5 percent level of significance throughout this section.

The above equation supports the theoretical proposition presented earlier while specifying the model. The equation is strong and provides the GDP coefficient statistically significant with the theoretically correct sign. The GDP coefficient indicates that higher GDP increases energy demand. The GDP elasticity is 0.45 which is less than one suggesting economies of scale. The estimated GDP elasticity indicates that the demand for energy is sensitive to GDP. It further reveals that one percentage point increase in GDP leads on an average to about a 0.45 percent increase in energy demand.

When the explanatory variable GDP is defined in terms of per capita GDP at constant prices, the following results are obtained:

\[
\ln Y_t = 6.74 + 0.71 \ln GDP_t \quad ... \quad (11)
\]

\[
(10.85^*)
\]

\[
R\text{-bar Square} = 0.900
\]

\[
F \text{ Value} = 118
\]

\[
\text{SEE} = 0.039
\]

Similarly when the explanatory variable, GDP is defined in terms of per capita GDP at current prices, the following results are obtained:

\[
\ln Y_t = 10.75 + 0.19 \ln GDP_t \quad ... \quad (12)
\]

\[
(25.43^*)
\]

\[
R\text{-bar Square} = 0.98
\]

\[
F \text{ Value} = 646
\]

\[
\text{SEE} = 0.018
\]

The equations (11) and (12) shows that GDP coefficients are less than one. In the words of Reister, income elasticity is below 1 in both of the equations. Thus, the results indicated in these equations support the results of Reister.

It is assumed that the increase in energy demand is also affected by the increase in population. The regression of population (POP) on energy demand \( Y(t) \) is therefore estimated and the results are presented below:

\[
\ln Y_t = 8.82 + 1.24 \ln POP_t \quad ... \quad (13)
\]

\[
(18.99^*)
\]

\[
R\text{-bar Square} = 0.963
\]

\[
F \text{ Value} = 360
\]

\[
\text{SEE} = 0.024
\]

Again the above equation supports the theoretical proposition presented earlier while specifying the model. The equation is strong and provides the population coefficient, statistically significant with the theoretically correct sign. The population elasticity is 1.24 which is more than one suggesting diseconomies of scale. The estimated population elasticity
indicates that the demand for energy is sensitive to population. It further reveals that one percentage point increase in population leads on an average to about a 1.24 percent increase in energy demand.

The regression of gross domestic product (GDP) and population (POP) on energy demand (Y) has also been estimated and the results are presented below:

\[
\ln Y_t = 8.45 + 0.12 \ln GDP_t + 0.93 \ln POP_t \quad \text{(14)}
\]

\[
R\text{-bar Square} = 0.961 \\
F \text{ Value} = 175 \\
\text{SEE} = 0.024
\]

Again the above equation supports the theoretical proposition presented earlier. The equation provides the population coefficient, statistically significant with the theoretically correct sign. The GDP coefficient also has a theoretically correct sign but it is not significant. The estimated equation indicates that the demand for energy is sensitive to gross domestic product and population.

### Partial Adjustment Model

A partial adjustment model has so far not been tested in the literature dealing with energy demand functions. The partial adjustment model has been widely used in econometric analysis to find out whether the economy is adjusting the actual energy inventory or balance slowly or rapidly to its desired energy inventory or balance. This section therefore presents the nature of adjustment between desired and actual balances of energy in Nepal. The partial adjustment model to be estimated has already been presented while specifying the model. The estimates of the partial adjustment models are as follows:

\[
\ln Y_t = -0.29 + 0.002 \ln GDP_t + 0.95 \ln Y_{t-1} \quad \text{(15)}
\]

\[
R\text{-bar Square} = 0.992 \\
F \text{ Value} = 910 \\
\text{SEE} = 0.011
\]

\[
\ln Y_t = -0.62 + 0.51 \ln POP + 0.90 \ln Y_{t-1} \quad \text{(16)}
\]

\[
R\text{-bar Square} = 0.992 \\
F \text{ Value} = 916 \\
\text{SEE} = 0.002
\]

The regression results indicated by equations (15), (16), and (17) show that only the coefficients of \(Y_{t-1}\) are significant. The coefficient of lagged dependent variable has been observed to be 0.95 in equation (15), 0.90 in equation (16), and 0.88 in equation (17). Since the coefficient of lagged dependent variable is equal to 1 minus the adjustment coefficient, \((1-\phi)\), the adjustment coefficient is equal to 0.05 for equation (15), 0.10 for equation (16), and also 0.12 for equation (17). In other words, the speed of adjustment implied by these values is much slower. It seems that only 5 percent of the adjustment of actual to desired real energy balances is completed within one year, as indicated by the equation (15). Similarly, the adjustment speed of actual to desired energy balances is only 10 percent as per equation (16), and 12 percent as per equation (17). These results are quite surprising as the adjustment is quite far from immediate.

In the partial adjustment models, the estimated coefficients of the independent variables are equal to the elasticities of these variables times the adjustment coefficient. In other words, \(c_1 = \phi b_1\) and \(c_2 = \phi b_2\). The long-run elasticities are therefore given by \(b_1 = c_1/\phi\) and \(b_2 = c_2/\phi\). These elasticities are 0.04 for GDP in equation (15), 0.10 for POP in equation (16), and 0.08 for GDP and 0.33 for POP in equation (17). Thus GDP elasticities and POP elasticities can be regarded as more or less stable. It is observed that the goodness of fit of the model has improved when \(\ln Y_{t-1}\) is included in the regression equation. The independent variables of the model explain more than 94 percent of the variation in dependent variable and the coefficients of these variables also have their expected signs.

### Section 3

#### Forecast of Energy Requirement

Having estimated the energy demand functions, this section attempts to use the models in the forecast of energy requirement for the next ten years or so. The forecast is being made with the help of equations
It may be interesting to observe different forecasts based on these three different equations. For the purpose, the forecast of explanatory variables such as GDP and POP is undertaken first on the basis of their annual average growth rate. The annual average growth rate for the period 1981/82 to 1994/95 has been observed to be 5.7821 percent for real GDP and 2.2808 for POP. Based on these estimates, the estimate of real GDP and population are presented in Table 1.

The estimates of the values of explanatory variables as indicated in Table 1 are replaced in Equations (10), (13) and (14) so as to forecast the dependent variable, that is, energy consumption till 2009/10. The results are presented in Table 2. Forecast of energy consumption has also been made in the last column of the said Table by using average annual growth rate of energy consumption. The average annual growth rate of energy consumption has been observed to be 2.7445 percent.

The energy consumption is expected to increase from 389674 in 1997/98 to 1035550 in 2009/10 as per Equation 10; from 285705 in 1997/98 to 286181 in 2009/10 as per Equation 13; from 313431 in 1997/98 to 486020 in 2009/10 as per Equation 14 and from 309766 in 1997/98 to 428682 in 2009/10 as per average annual growth rate of energy consumption.

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP million rupees</th>
<th>POP in million persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999/20</td>
<td>91,137</td>
<td>22.46</td>
</tr>
<tr>
<td>2000/01</td>
<td>96,407</td>
<td>22.97</td>
</tr>
<tr>
<td>2001/02</td>
<td>101,981</td>
<td>23.50</td>
</tr>
<tr>
<td>2002/03</td>
<td>107,878</td>
<td>24.03</td>
</tr>
<tr>
<td>2003/04</td>
<td>114,115</td>
<td>24.58</td>
</tr>
<tr>
<td>2004/05</td>
<td>120,713</td>
<td>25.14</td>
</tr>
<tr>
<td>2005/06</td>
<td>127,693</td>
<td>25.72</td>
</tr>
<tr>
<td>2006/07</td>
<td>135,076</td>
<td>26.30</td>
</tr>
<tr>
<td>2007/08</td>
<td>142,887</td>
<td>26.90</td>
</tr>
<tr>
<td>2008/09</td>
<td>151,148</td>
<td>27.52</td>
</tr>
<tr>
<td>2009/10</td>
<td>159,888</td>
<td>28.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Forecast of energy consumption ('000 GJ) based on Average annual growth rate of energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equation 10</td>
</tr>
<tr>
<td>1999/20</td>
<td>469,471</td>
</tr>
<tr>
<td>2000/01</td>
<td>512,862</td>
</tr>
<tr>
<td>2001/02</td>
<td>558,761</td>
</tr>
<tr>
<td>2002/03</td>
<td>607,313</td>
</tr>
<tr>
<td>2003/04</td>
<td>658,672</td>
</tr>
<tr>
<td>2004/05</td>
<td>713,001</td>
</tr>
<tr>
<td>2005/06</td>
<td>770,470</td>
</tr>
<tr>
<td>2006/07</td>
<td>831,262</td>
</tr>
<tr>
<td>2007/08</td>
<td>895,568</td>
</tr>
<tr>
<td>2008/09</td>
<td>963,593</td>
</tr>
<tr>
<td>2009/10</td>
<td>1,035,550</td>
</tr>
</tbody>
</table>

So far no such forecast of energy requirement has been made nor models estimated in Nepal. In this regard, it is worthwhile to mention a commendable effort made by WECS but it is confined to electrical energy forecasting from 1967/68 to 1989/90. The models, specification of variables, etc., used in this study are quite different. See WECS Report 6/1/190380/1/1/ Seq. 29.
tion. The forecast based on Equation 10 seems to be liberal while the forecast based on Equation 13 seems to be conservative. These two sets of forecast may be regarded as two limits within which the actual consumption may be realised. The forecast made on the basis of Equation 14 and average annual growth rate of energy consumption lies between the two limits. Viewed in this way, all the four sets of forecasts made above are expected to be useful to the planners.

Section 4
Summary and Conclusions

This study aims at estimating energy demand functions in the Nepalese context including the estimate of partial adjustment model. Specifically, the study is devoted to assessing, whether or not, there exists any economies of scale with respect to the demand for energy; and whether the speed of adjustment between desired and actual levels of energy is slow or fast.

The regression equation of energy consumption on GDP estimated in this study supports the theoretical propositions. The equation is strong and the GDP coefficient is statistically significant with the theoretically correct sign. The GDP elasticity is less than one, suggesting economies of scale. The study reveals that one percentage point increase in GDP leads on an average to about a 0.45 percent increase in energy demand (Equation 10). The regression of energy consumption on per capita GDP shows that GDP coefficients are less than unity, indicating economies of scale. In the words of Reister, income elasticity is below 1. These results therefore support the results of Reister.

The regression of population (POP) on energy demand (Yt) reveals that energy demand is affected by the increase in population. The population elasticity is more than one suggesting diseconomies of scale.

Thus, the estimated equations indicate that the demand for energy is sensitive to gross domestic product and population. The partial adjustment model estimated in this study indicates that the speed of adjustment between desired and actual energy balance is much slower. The results are quite surprising as the adjustment is quite far from immediate. Based on the estimated equations, the forecast of energy requirement has also been made till 2009/10 (Table 2).

References


