Energy Conservation and Energy Price?

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I. Introduction

It is a well-known fact that ever since the two times of oil crises, the oil-importing newly industrializing countries have a consistent economic difficulty of the growing burden of oil import bills. These economies are often said that they have pessimistic prospects with respect to availability of domestic investment funds for capital formation because of high payments for oil. Also, it is said that these economies have the structure of high energy coefficient, greater than 1.0, and inelastic energy demand to energy price change, high dependence on foreign energy, etc.

A question is now whether there is a room for energy saving by an additional price increase through tax imposition in such economies which are already suffering severely from the high cost of energy import. This question is to be studied in this paper.

The question is raised by the following ground. According to the energy-economy interaction studies,[1] a high energy price through a tax on energy use will lead to energy conservation without a large economic cost, i.e., reduction in GNP. This policy implication is derived from the application of the energy-economy interaction model to an economy which has flexibility in adapting to changes in resource availability and power of price mechanism in securing the adaptation. And this type of analysis is

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1) Examples of the studies are; (1) Hudson-Jorgenson (1976), (2) Nordhaus (1980), (3) Sweeny (1978), and so on.

essentially a long-run one in which time is long enough to take fully into account the adaptability of an economy.

In developing countries, especially energy importing newly industrializing countries, the problems and the conditions of the economy are not the same as those of developed ones

And when the current economic conditions are not like those presented in the model with respect to flexibility of an economy and price effectiveness in the market, a high energy price policy may have negative economic impacts instead of a successful energy conservation presented in those studies.

First, we take a brief review on the relationships between energy and the economy with respect to the effects of energy price changes. Then, the Korean economy is tested to find whether there is any room for a high energy price to conserve energy without a large economic cost. This test is done by using the concept of flexibility of an economy which is the most important factor for the effectiveness of a high price policy,

Ⅱ. Economic Structure and Energy Demand

1. A Brief Review:[2]

Arguing for the necessity of rough estimates of the relationships among energy price, energy demand and econmic growth, a simple energy-economy model uses a conceptual framework in which the economy is treated as one sector utilizing capital, labor and energy to produce GNP. The relationships are described in terms of aggregate price elasticity of energy demand(ε_p), or aggregate elasticity of substitution(σ)[3] which "virtually determines the feedback effects of the energy sector on the rest of the economy."[4]

2) This review is mainly from the frameworks and analyses done by EMF(1978), Sweeny(1978), Hogan-Manne(1977).

3) The significance of ε_p and the difficulties of estimating are very well presented in the EMF report(1980) vol. 1. The similarity between ε_p andσ is discussed in Hogan-manne(1977).

4) EMF report(1978) p.10.

In the basic formulation aggregate energy is treated as an intermediate input and GNP is the value added part produced by the services of other inputs, capital and labor.[5]

That is,

$$Y=F(E,N)=(aE^{-\rho}+bN^{-\rho})^{-\frac{1}{\rho}} \quad (1)$$

$$GNP=F(E,N)-P_e \cdot E \quad (2)$$

and the first-order optimality condition gives us the following relation,

$$E=Ya^{\sigma}(P_e)^{-\sigma} \quad (3)$$

where E: energy input

N: non-energy input (capital and labor)

P_e: energy price

Here Eq. (3) is used as an approximate energy demand function and it shows why ε_p can be used as σ within a limited sense. And Eqs. (1) (2) and (3) together give us the relationships among three variables, GNP, P_e and E.

Using this formulation, EMF and Sweeny's studies are concerned with the U.S. economy in 2010 as a reference point, and with different values of σ, the impacts of high energy price are analyzed. As long as the theoretical formulations are the same, the qualitative conclusions derived from the studies can not be different by the different reference points in different economies.

The following long-run qualitative conclusions[6] are based on Sweeny's study in which an energy sector in divided into two, domestic and foreign sectors. Thus, the impacts of high energy price on the economy are analyzed in two different cases, a high energy price by an increase in import energy cost and a high P_e by energy tax imposition.

These changes in variables, i.e., the extents of small and large changes, are getting more progressive when the difference between a high σ and a low σ is getting bigger.

5) This is why there is an argument that a minimum of two sectors is necessary for the analysis of the relationship between energy and GNP. For the general equilibrium analysis, it is so. But for the relationship itself, one sector model can serve as well.

6) Because of the same line of reasonings, the basic conclusions from the studies of EMF (1978), Hogan-Manne (1977), Sweeny (1978) are same.

	A. with a given △Pe		B. for a given amount of E conservation		C. with a given economic cost	
σ[7]	high	low	high	low	high	low
case I △Pe by import E cost increase	E↓L GNP↓S	E↓S GNP↓L	Pe↑S GNP↓S	Pe↑L GNP↓L	Pe↑L E↓L	Pe↑S E↓S
case II △Pe by E tax imposition	E↓L GNP↓S	E↓S GNP↓L	Pe↑S GNP↓S	Pe↑L GNP↓L	Pe↑S E↓L	Pe↑L E↓S

note; ↑ increase, ↓ decrease, L large, S small

From the table, it is apparent that there is no room for energy conservation through a high energy price in an inflexible economy. As seen in case I, an economy with low σ is suffered by even a small increase in import energy price.

To conserve energy through Pe increase by tax imposition-case II, it requires a much larger increase in Pe compared to a flexible economy. And this conservation policy will also lead to much larger reduction in GNP. That is, to conserve energy with no big success in far future, say 30 years later a high energy price by tax imposition has too much economic sacrifices now for an economy witha low σ, i.e., inflationary and recessionary impacts. The conclusions of this qualitative reasoning is primarily due to the characteristics of energy demand.

2. Flexibility of the Economy:

The demand for energy is a derived demand for the services provided by the energy sources and its using capital equipments. This means that energy demand is primarily dependent upon the stock and the efficiency of energy consuming equipments and the degree of capital utilization. Energy demand in the short-run is therefore dependent upon the utilization

7) A small changes in the σ produces major changes in economic impacts (EMF report (1978) p.11). Therefore, 'high' and 'low' indicate approximately $0.3<\sigma<0.1$ and $0<\sigma<0.1$ in the U.S. case.

rate of existing capital stock, which is in turn mostly dependent upon the economic activity.

In the long-run, however, the changes in energy using capital stock and the changes in its efficiency determine the pattern of energy demand. These changes may be easier for the economy which has a wide productive processes, new technology absorption ability with a high level of skilled labor and an easy investment fund availability. The economy with those conditions would be flexible in a sense of substitutability of other inputs for energy.

In contrast, certain economies may be very less flexible with respect to energy using structure, if not in the long-run of 30 or 40 years it, may be so at least in the medium term of 10 years or so.

In developing economies with a limited choice of productive processes, a low level of skilled labor and limited investment funds, the economy may be inflexible[8] and is certainly less flexible than advanced ones. Also in those economies, a primary economic policy objective is frequently a high growth instead of stability. Because of market instability, the power of price mechanism is weak or negligible in the market for an efficient resource allocation in the long-run.

In such developing economies, most new technology are imported and energy using technology is no exception. This means that the availability of investment funds in the future gives rise to an increase in energy efficiency by new technology import, and such new investment would give a wide choice of productive processes and also gradually increase flexibility of an economy. Thus, instead of emphasizing only a price-incentive to increase energy efficiency of an economy in 30 years later, a medium-term economic growth, such as a growth in 5-10 years, would be more interested in a sense of having easy availability of investment funds by a higher economic growth. Accordingly, the medium term impacts of energy policy on the economy would be much more interested.

8) One may argue that in developing countries, especially NIC, with a high growth rate, the economy have a great flexibility in choice of capital and development strategies. But because of shortage of capital and foreign exchange due to high import energy price, it is difficult to make full advantage of it.

Thus, if an economy has a low σ, weak or negligible price-mechanism power in the market, then a high energy price by energy tax imposition would result, as seen in the previous table, in negative adverse impacts instead of positive ones; resulting in a low rate of growth and a consequent limit in investment funds, increasing inflationary pressure and conserving almost negligible energy. Therefore, before any energy tax policy is to be implemented, the structure of an economy should be carefully studied and also cost and benefit of the energy tax policy, especially in a fast growing economy, should be analyzed.

In the next section, as a case study, the Korean economy is statistically tested to see whether or not it has any response in energy demand to the changes in energy price, i.e., the flexibility of the economy with respect to energy consumption structure.

Ⅲ. Empirical Case Study and Its Implications

The high rate of economic growth over last twenty years is reflected in the staggering growth in energy consumption. This phenomenon can be seen by the energy coefficient and per capita energy consumption data as shown in the tables. The Korean economy has changed from the structure having low energy coefficient to one with value higher than 1.0 during the period of 1962~1980. This change has occured even with increasing energy price over the same period of time.

Korea has a very much limited energy resources. This is why the dependence on energy importing, mostly oil-importing, is ever increasing over time. The oil import bill is a major item in the balance of payment and

Table 1, Economic growth and Energy demand

year		1962—1973	1974—1980	1962—1980
Economic growth		9.08	7.54	8.51
Energy demand	Primary	8.04 (0.88)	8.34 (1.11)	8.15 (0.96)
	Secondary	7.53 (0.83)	9.14 (1.21)	8.12 (0.95)

( ) is energy coefficient (energy demand growth rate ÷ economic growth rate).
Source: Ministry of Energy, Korea, *Energy Statistics*, 1981.

Table 2, Energy demand and Price

year	62	66	71	74	78	80
Per capita energy consumption (TOE)	0.42	0.46	0.65	0.80	1.06	1.20
Aggregate energy price index (1975=100)	11.6	16.5	27.6	76.3	130.5	320.5

Table 3, Dependence on energy-importing

year	62	66	71	74	78	80
Total (TOE) %	10.2	16.3	49.3	53.5	67.4	71.0
Oil (TOE) %	9.1	15.9	49.1	51.5	61.7	59.1

in 1979 almost one-fifth of foreign payments was incurred by crude oil import.[9]

In this economy, to see whether there is any room for energy conservation policy of a high energy price,[10] a statistical test for the economic structure is done by using a concept of aggregate elasticity of energy demand. This aggregate concept is a rough and crude one because it provides only approximate estimates of total energy demand changes resulting from changes in prices. This rough and simple concept however gives us an easy communication and understanding in explaining the relationships between macro-variables as shown earlier in the energy-economy interaction model.

Because of simplicity in the concept, its usefulness is high, but actual

9) The recent slump in the world oil demand has caused to decrease the crude oil price, a but once when the recovery of western world economy does materialize, certainty is that the price movement will be reversed. Thus, as long as our energy dependence on foreign sources remains high, there is always a pressure on the balance of payment problems.

10) As one example of high energy price through tax, the following is an international comparison of cousumer's energy price. (unit; $/B)

types \ countries	Korea		Japan		Taiwan	
	price	tax	price	tax	price	tax
gasoline	150.03	94.27	107.40	34.45	112.23	14.33
Kerosene	62.75	5.14	62.38	—	53.17	—
diesel	61.46	8.93	62.90	15.56	56.14	6.54
residue (black oil)	44.54	4.16	36.98	—	31.60	0.83
crude oil	tax 0.86/B		tax0.07-0.41/B		—	

Source; Ministry. of Energy. 1982

difficulties of estimation are well recognized. Difficulties are due to the fact that energy is demand for heterogeneous commodities, each with a respective price, and thus different aggregation rules and methods for quantity and price result different estimates.[11]

In this paper, as a preliminary stage of the study, the test for the flexibility of the Korean economy is however tried by using aggregate ε_p(or σ) concept. For this purpose an aggregate and single energy demand function.

Various specifications are used in the test to see firstly whether enegy price has any influence on energy demand and secondly, if so, to what extent it deos. For empirical implementation, specifications are derived as follows.

1. Specification:

It has mentioned that energy demand is different from demand for other inputs, or goods and services. Energy demand is a derived demand and it is always used together with its using capital or equipments. This is why it is important to distinguishd emand in the short-run from that in the long-run, and also a dynamic disequilibrium approach should be therefore adopted, at least implicitly, if not explicitly presented in the analysis.

Suppose an aggregate production function of a national economy be

$$Y=F(E,N,K)$$

By duality theorem, the short-run variable cost function is

$$C=c(Y,Pe,Pn,K)=\min\{Pe\cdot E+Pn\cdot N \mid Y(E,N,K)\geqslant Y\}$$

And by Shephard's lemma, the short-run energy demand function is

$$\frac{\partial C}{\partial Pe}=c_e(Y,Pe,Pn,K)=E$$

Likewise for consumer demand for energy, suppose an aggregate utility funetion be

11) Yet a big effort for improving the estimating method is still under way. EMF study group for the project, "Aggregate Elaticity Energy Demand," has been organized for this purpose and the reports, vol. I and II (1980), are the outcomes of this study.

$$U = u(E, N, K)$$

Its indirect utility function is

$$V = v(Y, Pe, Pn, K) + \max\{u(E, N, K) \mid Pe \cdot E + Pn \cdot N \ll Y\}$$

and energy demand function is also

$$\frac{\partial V}{\partial Pe} = v_e(Y, Pe, Pn, K)$$

where *Y:* total output in production case, total expenditure in consumption case

E: energy

N: non-energy inputs in production case
non-energy goods and services in consumption case

K: fixed and quasi-fixed capital or durables

Pe, Pn: prices of *E, N*

The function c_e (or v_e) is referred to the short-run fuction because of inclusion of fixed (or quasi-) equipments of *K*. When *K* is deleted from function the c_e, then it becomes a long-run specification (static and equilibrium approach).

The inclusion of *K*, however, creates practical complications and difficulties for application of the model to reality, since a separate decision for determination of *K* over the time is required. This means that at least more than one single equation is required for the analysis of energy demand.

A single equation approach, therefore, forces to eliminate *K* variable, while dynamic disequilibrium point being maintained. This is why the following specifications are basically based on the combination of a long-run energy demand function and the stock-(state-) adjustment principle.

The stock-adujstment principle developed by M. Nerlove has been applied to consumer durables and then later extended to non-durables by Houthakker and Taylor, giving the name of state-adjustment model.[12] This stock-(state-) adjustment principle is basically to relate the current beha-

12) M.Nerlove(1960), "The Market Demand for Durable Goods: A Comment," *Econometrica*, vol. 28, no. 1, pp.9—13
H.S. Houthakker and L.D. Taylor(1970) *Consumer Demand in the United States: Analyses and Projections*, 2nd ed. (Havard University Press, Cambridge, Mass., 1970)

vior to the past ones through adjustment process.

Considering the characteristics of the demand, this principle can be applied to the energy demand of a whole economy. Actual current demand for energy in a certain time can not be adjusted to a desired demand immediately, because of (1) an existing stock of equipments which use a specific form of energy at a specific efficiency and which can not be replaced immediately, and (2) unwillingness by energy users to see price and income changes as permanent until they have continued for some time.

From the emand function c_e $(Y,\ Pe,\ Pn,\ K)$ (or v_e), because of the given K, the desired long-run c_e^* (Y, Pe, Pn) can not be attained instantly.

This variable K creates the state (habit) of energy demand pattern of a whole economy. Because of K, therefore, the levels and patterns of demand in previous periods influence the current level and pattern of demand of the economy, in other words, current demand is affected by the stock of "state".

Thus, using the stock-(state-) adjustment principle, without K in the equation, dynamic disequilibrium process can be attained as the lonrun energy demand function

$$E^* = c_e^*(Pe, Pn, Y)$$

becomes the short-run demand function,

$$E_t = e_t(Y_t, P_{et}, P_{nt}, E_{t-1}) \quad (4)$$ [13]

Now as the selection of specific functional form, the following various equations are derived.

(a) By viewing the total economic activity of an economy as a productive process, a single energy demand function is derived from aggregate production.

CES production function is used, since it is a general form covering the extreme cases of Cobb-Douglas and Leontief functions.[14]

13) This function is derived from either (a) actual change is lagged to desired change $(E_t - E_{t-1}) = \lambda(E_t^* - E_{t-1})$, or (b) actual short-run demand is determined by also the state variable and this state variable is replaced by E_{t-1} and other differences in P and Y. See, Nerlove and Houthakker-Taylor.

14) When $\rho \to 0$, it becomes Cobb-Douglas production function.
When $\rho \to \infty$, it becomes Leontief production function.

$$Y=A(\sum_i a_i X_i^{-\rho})^{-\frac{1}{\rho}} \tag{5}$$

The cost minimizing first order condition gives us the demand for i^{th} input as

$$X_i=Y\left(\frac{1}{A}\right)a_i^{\left(\frac{1}{1+\rho}\right)}P_i^{-\left(\frac{1}{1+\rho}\right)}\left[\sum_j a_j^{\left(\frac{1}{1+\rho}\right.}P_j^{\left(\frac{\rho}{1+\rho}\right)}\right]^{\frac{1}{\rho}}$$

For two inputs case, i=energy, j=non-energy,

$$E_i=Y\left(\frac{1}{A}\right)a_e^{\left(\frac{1}{1+\rho}\right)}P_e^{-\left(\frac{1}{1+\rho}\right)}\left[a_n^{\left(\frac{1}{1+\rho}\right)}P_n^{\left(\frac{\rho}{1+\rho}\right)}\right]^{\frac{1}{\rho}}$$

$$=\left(\frac{1}{A}a_e^{\sigma}a_n^{\sigma}\right)Y(P_e/P_n)^{-\sigma}=kY(P_e/P_n)^{-\sigma}$$

$$\frac{E}{Y}=k\left(\frac{P_e}{P_n}\right)^{-\sigma} \tag{6}$$ [15]

where $k=\frac{1}{A}a_e^{\sigma}a_n^{\sigma}$, $\sigma=\frac{1}{1+\rho}$

The equation (5) is the CRTS production function. In non-CRTS case, the production function will be

$$Y=h[A(\sum_i a_i X_i^{-\rho})^{-\frac{1}{\rho}}]$$

$$E=k\,h^{-1}(Y)\left(\frac{P_e}{P_n}\right)^{-\sigma} \tag{7}$$

From the equations (6), (7), total short-run energy demand function for estimation are

$$\ln\left(\frac{E}{Y}\right)_t=a+b_1\ln\left(\frac{P_e}{P_n}\right)_t+b_2\ln\left(\frac{E}{Y}\right)_{t-1} \tag{6a}$$

$$\ln E_t=a+b_1\ln Y_t+b_2\ln\left(\frac{P_e}{P_n}\right)_t+b_3\ln E_{t-1} \tag{7a}$$ [16]

(b) We can also derive short-run energy demand function as Houthakker-Taylor's form, assuming that current energy consumption of a whole economy is determined by the "state" of energy using structure of the economy as well as energy price and economic activity.

$$E_t=\alpha+\beta_1(P_e/P_n)_t+\beta_2 S_t+\beta_3 Y_t \tag{8}$$

By eliminating S_t (state variable)

$$E_t=a+b_1(P_e/P_n)_t+b_2\Delta(P_e/P_n)_t+b_3Y_t+b_4\Delta Y_t+b_5E_{t-1} \tag{8a}$$

$$E_t=a+b_1(P_e/P_n)_t+b_2Y_t+b_3E_{t-1} \tag{8b}$$

15) The result is basically the same as equation (4), but the non-energy input adjustment is considered in this equation.

16) ln h^{-1}(Y) is linearly approximated as b_1 lnY

$$\ln E_t = a + b_1\ln(P_e/P_n)_t + b_2\ln(P_e/P_n)_{t-1} + b_3\ln Y_t + b_4\ln Y_{t-1} + b_5\ln E_{t-1} \quad (8c)$$[17]

(c) When we can not have an appropriate functional form 'a priori' in present state of art, it is advised (by Houthakker-Taylor) to try out different forms and to find the one which gives best fitting to the observations.[18] So, with the same variables, the following semi-log and inverse-log forms are also used for the test.

$$E_t = a + b_1\ln Y_t + b_2\ln(P_e/P_n)_t + b_3 E_{t-1} \quad (9a)$$

$$\ln E_t = a + b_1 Y_t + b_2 (P_e/P_n)_t + b_3\ln E_{t-1} \quad (9b)$$

Eqs. (6a) (7a) (8a) (8b) (8c) (9a) (9b) are used for the empirical test.[19]

2. Estimation

1. Sample data for the estimation: According to production theory, Y should be (GDP+$Pe\cdot$E). However, because of difficulty in obtaining the time-series data of $Pe\cdot$E in aggregate term and consumers' demand for energy, GDP is used as an approximate to Y. This GDP can be thus interpreted as the level of economic activity or as an approximate source of total spending in the ecnomy.

For the variable of the relative energy price, Pe/Pn, the aggregate energy price index is used for Pe, which is provided by the Ministry of Energy in Korea, and GNP deflator is used as a proxy variable for Pn. As for the total energy demand, primary energy demand is alone used for all cases.[20] These data cover the period of 1962-1980.

2. Results of the test: As shown in the following outcomes, one typical characteristic of the test in that all lagged dependent variables, except

17) According to Houthakker-Taylor, this dynamic model with S_t variable is compatible only with a linear form (H/T (1970), p.8). However, later in a linear logarithmic form, the same reasoning is used by Halverson and the eq. (8c) is the specification. See Robert Halverson, chapter 9. (pp.135-150)

18) Houthakker-Taylor (1970). p.8.

19) Examples of studies using the same specifications are (a) "A in world oil model", M. Kennedy (1976) used the eq. 7a, (b) in "A Study of the Demand for gasoline", P.K. Verleger, Jr. and D.P. Sheehan (1976) used (7a) (8b), and etc.

20) The outcomes from the final energy demand as dependent variable are very much similar except the (8a) casecwhich has the opposite sign for the coefficient b_6. which is very unrealistic

the case of 8-a, have appeared to be statistically significant and the values of their coefficient are not in a reasonable sence out of range (it means that the value of adjustment coefficient lies between zero and one). This implies that the state (or habit) of the energy demand behavior of the economy is one major determinant of the current energy demand, although the values are somewhat different in different specifications. The next overall impression from the test is that GDP has also played an important role in energy demand, but the effect of energy price on energy demand is either questionable or negligible. As for as the signs of the coefficients of variables are concerned, they have turned out correctly in all cases except 6-a (price variable) and 8-a (lagged dependent variable).

Outcomes of the Energy Demand Equations.

Dependent Variable	Predetermined Variables	$\bar{R}^2$	D.W.	F-stat.
Case 6-a $\ln\left(\frac{E}{Y}\right)_t$	constant $\ln(P_e/P_n)_t$ $\ln(E/Y)_{t-1}$ .3057 .0033 .7252 (.095) (6.213)	.72	1.1315	22.83
Case 7-a $\ln E_t$	constant $\ln(P_e/P_n)_t$ $\ln Y_t$ $\ln E_{t-1}$ .5064 −.0627 .4387 .5531 (1.608) (4.077) (4.436)	.99	1.7475	1587.22
Case 8-a E_t	constant $(P_e/P_n)_t$ $\Delta(P_e/P_n)_t$ Y_t ΔY_t E_{t-1} 2892.14 −3360.82 486.74 1.776 −1.041.4663 (2.512) (.317) (2.492) (.987 (1.794	.99	2.0616	1149.62
Case 8-b E_t	constant $(P_e/P_n)_t$ Y_t E_{t-1} 1545.01 −1750.53 1.1564 .6656 (1.612) (4.669) (6.618)	.99	1.7916	1957.94
Case 8-c $\ln E_t$	constant $\ln(P_e/P_n)_t$ $\ln(P_e/P_n)_{t-1}$ $\ln Y_t \ln Y_{t-1} \ln E_{t-1}$ .4667 −.0618 5.795 .4348 −.0705 .6329 (1.043) (.118) (1.970) (.213) (2.929)	.99	1.6247	1062.35
Case 9-a E_t	constant $\ln(P_e/P_n)_t$ $\ln Y_t$ E_{t-1} −21675.89 −1479.99 2685.84 .9723 (.948) (1.333) (8.58)	.99	1.7641	787.79
Case 9-b $\ln E_t$	constant $(P_e/P_n)_t$ Y_t $\ln E_{t-1}$ 1.1396 −.1883 2.318 E-05 .8670 (3.677) (2.286) (9.765)	.99	1.7290	1084.60

* The numbers in parentheses are t-statistics.

From the outcomes, it can be said that the most reasonable specifications are 7-a and 8-b on the statistical and a priori grounds. For other cases, either the sign of the coefficient is wrong (6-a), or the coefficients of variables have statistically insignificant t-values (8-a, 9-a), or the adjustment coefficient (λ) is too low to explain the economic meaning of it (9-a, 9-b).[21] Especially for the inverse-log case of 9-b, it seems that we

21) The low adjustment coefficient means the high value of lagged dependent variables coefficient and it implies that there is an unrealistic difference between the short-run and the long-run price and GDP elasticities, $\varepsilon^L = \varepsilon^S/\lambda$.

Table 4. Elasticities of Energy Demand

7-a case	$\varepsilon_P^S = -.0627$		$\varepsilon_P^L = -.1405$			
	$\varepsilon_Y^S = .4387$		$\varepsilon_Y^L = .9817$			
8-b case	year	63	67	73	78	80	average
	ε_S^P	−.1198	−.0829	−.0383	−.0351	−.0487	−.0574
	ε_L^P	−.3583	−.2479	−.1147	−.1050	−.1457	−.1718
	ε_S^Y	.3319	.3599	.3747	.4077	.3631	.3789
	ε_L^Y	.9926	1.0763	1.1207	1.2193	1.0858	1.1332

ε_P=price elasticity, ε_Y=GDP elasticity
L=long-run, S=short-run.

have a very good fitting, but it has a trivial GDP elasticity of energy demand, zero value, which is implausible in reality.

In both cases of 7-a and 8-b, the price coefficients have in fact insignificant t-values at 5% level, but at 10% level they are high enough to become significant. This means that the energy demand response to energy price changes is either negligible, or statistically energy price has nothing to do with energy demand. This can be seen from the sizes of the short and long-run price elasticities of demand, which express the structure of energy consuming in the economy.

As for the GDP representing economic activity or total expenditure, its coefficients in both cases have statistically good results. The magnitudes of coefficients show the same pattern as the past historical behavior, i.e., the elasticity is close to unity, in 7-a case less than one and in 8-b case greater than one. Because of linearity in 8-b case, the size of elasticity varies with different base-points. However, the average vales give us meaningful ones.

3. Concluding remarks and policy implication : If we accept the outcomes of the empirical test of the Korean economy, the economy has energy price insensitive structure at least in terms of the aggregate energy demand. That is, aggregate energy demand is mainly influenced by economic activity, production and consumption activity, and the past pattern of demand behavior. This fact signifies that the structure of the economy appears to have an inflexible energy-using technology. Thus, as long as this type of technology remains in the future, energy saving throughd

high energy price is negligible In other words, the effectiveness of a policy which is designed to reduce energy consumption by increasing energy price through tax imposition might be questionable.

Instead, a more effective policy in the long-run must be the one which increases the flexibility of the economic structure by adopting new technology in order to have a wide choice of productive processes and also by increasing labor productivity to save energy consumption.[22] Therefore, an important thing for the economy is availability of investment funds to accumulate physical and human capital in the long-run.

With an inflexible economic structure, a high energy price might reduce the aggregate energy use, bute economic cost in terms of GNP sacrifice is too significant. In this connection, price decontrol would be necessary in the long-run. The importing-energy price is high enough for energy saving incentive. An additional increase in energy price gives rise only to negative effects on the economy, inflationary pressure and recessionary effect.

Here, it seems that we have a kind of vicious circle in the inflexible economies, especially the oil-importing developing countries like Korea. Energy saving is required to ease the pressure of oil payment so as to raise investment funds for capital formation. However, energy saving can be accomplished with reduction in GNP which leads to low savings and low investment funds. Low investment makes it difficult for the economy to be flexible. This means there is no chance of energy saving without economic cost.

There is however a way to break through the dilemma. It is improvements in efficiencies of various types of energy consumption. Improvement in efficiencies come from the activities such as adopting energy saving new technology and managing a prudent way of energy consuming behavior with given technology.

When we have a fixed degree of efficiency in energy use, reduction in energy consumption means a big economic cost. However, energy conserva-

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22) Even though there is no agreement on the matter of capital-energy relation, substitutes or complement, laborenergy relation is found to be a substitution one in most studies. As. one of examples, see J.M. Griffin and Paul R. Gregory (1976).

tion through increasing efficiency, even with given technology, does not cost us the same as other wise mentioned above. Rather it has an opposite direction of movement compared to the case shown in the previously mentioned vicious circle process. That is, no sacrifice of GNP together with reductoin in energy consumption provides the investment funds through an increase domestic savings and a reduction in the payments for the foreign energyimporting. The investment is conducive to the more flexible economy which in turn makes the economy possible to save more energy in the future.

Thus, to accomplish the intended policy objectives of a high energy price, we should study the structure of the economy in detail first. For the future research in the energy sector, instead of treating energy sector in isolation, energy economic interaction model should be used, at least in aggregate analysis. The reason is that, as we have seen in this preliminary study, the economy has a very low σ and this low value of σ makes the rabbit grows faster than the elephant so that the burden of economy is ever increasing as long as energy price increases over time.[23)]

Also exact information of flows of energy in the economy and in the energy sector, i.e., the supply and the demand information is nesseary for more detailed analyses such as interfuel substitution possibilities and exact places of possible increasing efficiencies in order to save foreign-importing energy and to reduce the economic cost, etc. Therefore, the preparation of energy balance table is essential for the future energy research.

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23) See W. Hogan and Alan S. Manne (1977).

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