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# ENERGY SHOCKS AND MACROECONOMIC ADJUSTMENT POLICIES FOR KOREA*

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*The problems of external shocks are serious and pervasive in the developing countries with a high level of foreign dependence. When confronted with an external shock such as an energy crisis, countries may be forced into drastic adjustments of their economic policies, which create effects on both real and monetary components. This paper, using a hybrid econometric general equilibrium model for Korea, estimates economy-wide impacts of energy shocks and then evaluates the effects of adjustment policies for macroeconomic stabilization. The result calls for a cautious use of adjustment policies being implemented in response to energy shocks. This has important implications for the changing mix of the Korean economy towards a less energy-vulnerable economy.*

JEL Classification: C53, C68, E63, Q43
Keyworks: A Hybrid Econometric General Equilibrium Model, Energy Shocks, Macroeconomic adjustment Policies

## I. INTRODUCTION

The debate over the appropriate method and level of government intervention within the context of severe external shocks often resurfaces. From a policy-making standpoint, the problem posed by external shocks has been treated as an issue of short-term macroeconomic stabilization rather than fundamental reform of the economic process. In addition, the question of whether alternative policies for macro-economic stabilization can indeed lower social costs is controversial. To ex-

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plore these questions, this paper attempts to evaluate the economic impacts and effectiveness of alternative adjustment policies within the context of energy shocks on the Korean economy.

In order to insulate an economy from energy shocks, it is very important to find the implications of higher energy prices. As far as energy pervades all aspects[1] of economic activity, the most consistent way to analyze energy-economy interactions is to model the behavior of all economic agents in a general equilibrium framework.

The development of quantitative approaches to energy-economy interactions in recent years encourages[2] the application of an applied general equilibrium (AGE) model, which has the distinct advantage of clearly identifying natural resource based-industries and their interface with other sectors in the economy as well as with other economies in international trade. AGE models link input-output (I-O) coefficients with flexibility to the economic environment variation. They can thus portray sectoral and dynamic effects of shock or policy variables on an economy's structure and growth.

Earlier studies on energy-economy interactions, employing applied general equilibrium (AGE) components, include those by Hudson and Jorgenson (1974), Hudson (1981), Goulder (1982), Goettle and Hudson (1984), Borges and Goulder (1984), Uri and Boyd (1989), Motaz Khorshid (1990), Hazilla and Kopp (1990), and Jorgenson and Wilcoxen (1990, 1992), etc. These models, however, focused only on long-run/full adjustments or perfect foresight expectations, are fundamentally neoclassical in spirit. The standard AGE models do not reflect features such as financial behavior, price and wage rigidities in some markets in determining the performance in adjustment to an external shock. The problem then arises of how far one can accomodate non-neoclassical features in the AGE framework without giving up its basic characteristics and internal consistency (Dervis, Melo, Robinson, 1982, pp.169-73).[3]

Unlike the standard AGE tradition, the model developed in this study is broadened to allow for nonneutrality and rigidities in nominal variables, analogous to the type of Robinson and Tyson (1984), Goulder and Summers (1989), Bourguignon, Branson, and Melo (1992), Gelauff and Graafland (1994), and Fargeix and Sadoulet (1994).[4] This specification is very useful since the shocked economy should be

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[1] The energy market conditions or the energy policy options have a broader influence on the economy, generating the change in the overall economic performance.

[2] The defects of fixed and static analysis of interindustry relations (using input-output (I-O) table) and the limits of highly aggregate macro-econometric analyses (overly weighted towards aggregate demand side of economy) are well known.

[3] Partly, the efforts have already been attempted. Harris (1984) introduces economies of scale and imperfect competition. Slemrod (1983) incorporates portfolio behavior. Gelauff and Graafland (1994) comprises some New Keynesian characteristics of wage bargaining and monopolistic competition in the CGE structure of their MIMIC.

[4] Alternative approaches to applied general equilibrium modeling are presented by Auerbach and Kotlikoff(1987) and Jorgenson and Yun (1990). For the last few years, several efforts have been

forced into drastic adjustments of its economic policies, which create effects on macroeconomic monetary components as well as on the standard real-side AGE texture of the economy. Section II overviews the structure and characteristics of the model. Section III provides the empirical estimates of the economic impact of energy shocks and evaluates the effectiveness of adjustment policies for macroeconomic stabilization implemented in response to these external shocks.

## II. THE MODEL

This section outlines the basic structure of a hybrid econometric general equilibrium model of energy-economy interactions in Korea. The reader is referred to Kim, and Kim (1995b) for a full presentation of the model, *i. e.*, equations, data, and construction method.

### 2.1. Structure of the Model

The model[5] used in this study consists of (a) a variable input-output (I-O) transactions part (producer behavior), (b) a consumer behavior part, and (c) a macroeconometric growth part. The producer behavior part, based on the basic input-output system, represents inter-industrial transactions and primary inputs demand. The consumer behavior part refers to the household decision-making of private consumption, labor supply, and the savings. The macro (growth) part specifies relationships among various markets of output, primary inputs, and foreign trade. This thus can be termed a 'micro-macro model' or a 'sectoral-aggregate model.'[6]

The supply side of the model is made up of seven non-energy (materials) types and four energy types. It also includes labor (L), capital (K), imported-energy (O)[7], and technological progress ($t$) that affect the supply side. The demand side of the model is made up of the macroeconomic final demand such as private consumption (C), gross investment (I), government expenditure (G) and export (EX). The model provides a general equilibrium structure to producer and consumer behavior and also shows the entire process from purchasing primary inputs to allocating final demand through input-output (I-O) structure of the economy.

The major feature of the model is its flexible interindustry transaction nature allowing for price-and technology-responsive I-O coefficients,[8] which is essentially

made to develop new advanced AGE models, which incoporate money or the financial sector into the traditional neoclassical AGE framework (Bourguignon, Branson, and Melo, 1992, Thorbecke, 1992, Fargeix and Sadoulet, 1994).

[5] For a detailed description of the model, see Kim, and Kim (1995a), pp.148-91, Kim, and Kim (1995b), pp.1-39. or Kim, (1996), pp.59-86.

[6] For further discussion, see Dervis, Melo, and Robinson (1982), pp.138-55.

[7] Considering characteristics of the Korean economy, the crude petroleum and natural gas is included in the value-added part of the model.

[8] The model, a dynamic general equilibrium model of the Korean economy (KDGEM), attainis

based on the work of Jorgenson (1984). The econometric method for parametrizing the producer behavior part stands in sharp contrast to the conventional calibration method, which involves choosing parameters to replicate the data for a particular year.

The aggregate supply (XS) and demand (XD) are determined by the interaction of supply and demand of the economy. In reality, however, the economy is not cleared by a fully flexible price adjustment (as is the case within the Walrasian general equilibrium framework). To incorporate a macromonetary superstructure that interacts between money and the 'real' sphere of the economy, the model extended Walrasian general equilibrium structure to include adjustments of both real and monetary sector. This can capture the demand for and supply of money assets, the income generation, and the formation of nominal interest rate and aggregate price index.[9] The monetary sector is crucial to address the inflationary consequences of monetizing the government or foreign deficit.

**Table 1.** Variable Definitions

| | | | |
|---|---|---|---|
| *XS* | sectoral gross production | KS | capital service available |
| *XD* | sectoral net production | LH | labor endowment |
| *XE* | sectoral energy | POP | population or labor force |
| *XM* | sectoral materials | MS | money supply |
| *YS* | sectoral net production | K | capital stock |
| *YD* | sectoral final demand | W | private wealth |
| *LD* | sectoral labor service demand | S | private savings |
| *KD* | sectoral capital service demand | F | net capital flows |
| *A* | input-output coefficient matrix | PL | wage rate |
| *C* | sectoral private consumption | PK | rate of return to capital |
| *I* | sectoral gross domestic investment | P | general price level |
| *G* | sectoral government expenditure | Pf | price level of competitives |
| *EX* | sectoral exports | R | interest rate of rental |
| *IM* | sectoral imports | ak | capital stock lagged to capital service |
| XS | gross output supply service | er | exchange rate |
| YS | net output supply or value-added labor endowment to population product (factor income) | $\varepsilon$ | labor endowment to population |
| | | $t$ | technology level |
| | | T | taxes |
| YD | total final demand | C | total private consumption |
| YP | potential net output supply or net production capacity | I | gross domestic investment |
| | | G | government expenditure |
| YD* | total final demand less taxes | EX | total exports |
| TY | foreign income | IM | total imports |
| LD | labor service demand | lur | unemployment rate |
| KD | capital service demand | BOP | balance of payments |
| LS | labor service supply | | |

macroeconomic and structural equilibrium by price adjustments. Also, it can endogeneously determine sectoral price level and I-O coefficients within the model as to capture the effect of relative price change of energy on production structure.

[9] see, for another example, Lysy and Taylor (1980) and Ahluwalia (1981).

**Table 2.** A Hybid General Equilibrium Model for Korea

| | | | |
|---|---|---|---|
| I. Product markets | | (9) | $\mathbf{KD}=\Phi KD(\mathbf{P}, PL, PK, \mathbf{XS}, t)$ |
| supply side | | (9a) | $KD=1\cdot\mathbf{KD}$ |
| (1) | $\mathbf{XS}=\Phi XS(\mathbf{XM}, \mathbf{XE}, LS, KS, t)$ | | supply side |
| (1a) | $\mathbf{YS}=\Phi YS(\mathbf{LD}, \mathbf{KD}, t)$ | (10) | $LS=\Phi LS(YS, PL, PK, P, LH, lw)$ |
| (1b) | $YS=1\cdot\mathbf{YS}$ | (11) | $KS=\Phi KS(ak, K_{-1})$ |
| | demand side | | market clearing |
| (2) | $\mathbf{XD}=\mathbf{A}\cdot\mathbf{XD}+\mathbf{YD}$ | (12) | $LS-LD=0$ |
| (2a) | $\mathbf{YD}=\mathbf{C}+\mathbf{I}+\mathbf{G}+\mathbf{EX}-\mathbf{IM}$ | (13) | $KS-KD=0$ |
| (2b) | $YD=1\cdot\mathbf{YD}$ | | |
| (3) | $\mathbf{C}=\Phi C(YD^{*}, \mathbf{P}, PL, R, W_{-1})$ | III. Money markets and aggregate price index | |
| (3a) | $C=1\cdot\mathbf{C}$ | (14) | $MS/P=\Phi MD(R, YD)$ |
| (4) | $\mathbf{I}=\Phi I(YD^{*}, \mathbf{P}, R)$ | (15) | $\Omega\cdot\mathbf{P}=P$ |
| (4a) | $I=1\cdot\mathbf{I}$ | | |
| (5) | $\mathbf{EX}=\Phi EX(\mathbf{P}, \mathbf{Pf}, TY, er)$ | IV. Savings-investment, extenal | |
| (5a) | $EX=1\cdot\mathbf{EX}$ | | blance and stock adjustment |
| (6) | $\mathbf{IM}=\Phi IM(\mathbf{P}, \mathbf{Pf}, YD, er)$ | (16) | $YD^{*}=YD-T$ |
| (6a) | $IM=1\cdot\mathbf{IM}$ | (17) | $S+F=I+(G-T)$ |
| | market clearing | (18) | $EX-IM+F=0$ |
| (7) | $\mathbf{XS}-\mathbf{XD}=\mathbf{0}$ or $\mathbf{YS}-\mathbf{YD}=O$ | (19) | $LH=\varepsilon\cdot POP$ |
| (7a) | $XS-XD=\mathbf{0}$ or $YS-YD=O$ | (20) | $K=I+K_{-1}$ |
| II. Factor markets | | | |
| demand side | | | |
| (8) | $\mathbf{LD}=\Phi LD(\mathbf{P}, PL, PK, \mathbf{XS}, t)$ | | |
| (8a) | $LD=1\cdot\mathbf{LD}$ | | |

As shown in Table 1, vector representation is used for sectoral allocation among industries. The total amount of each aggregation is simply a sum of the individual vector components. Variables such as prices, wages or interest rate included in the functional structure are split as raw forms corresponding to the nominal variable. Lagged values are indicated by a subscript $(-1)$.

Table 2 depicts, in a general equilibrium context with money, the decision-makings among suppliers, households, government and foreign sectors.[10] Productions (or supply) (1) are drived from profit maximization (or dual cost minimization) in (8) and (9). Technology $\Phi$xs vector (1) is constructed by a constant-return-to-scale (CRTS) with multi-factor(KLEM) and technology level. Thus, the derived demands for primary factor(via Shephard's lemma) are functions of relative input prices and technology level[11].

The household income (16) is the sum of labor income and capital income de-

[10] This implies so-called an extended general equilibrium framework, close in spirit to Walrasian construct but incorporating financial markets with money. These models attempt to integrate money asset in the multisector structutre of CGEs. For more discussion, see Dervis, Melo and Robinson (1982), pp.169-73., Robinson and Tyson (1984), pp.255-68. or Mercenier and Srinivasan eds. (1994).

[11] Assuming that the producer behavior submodel allows for non-neutral technical change, sectoral productivity growth is endogenized as a function of the prices of all its inputs.

rived by the value-added (or net) production (1b) less government tax. The total demand (2) is composed of intermediate and final demand. Final demand (2b) is evaluated as the sum of private consumption, investment, and net exports. Household determines not only total consumption (3a) (and thus savings) but also the relative shares[12] among products which are affected by income level, prices, aggregate price index, wage rate, interest rate, and lagged wealth. Decisions on government expenditure are exogenously determined while the government revenues depend on economic activity and taxation level. Labor service supply (or leisure demand) (10) is determined by disposable income, labor endowment, and real wage rate.

Foreign trade depends on the level of domestic or foreign (rest of the world: ROW) income and on international price competitiveness, while savings-investment is adjusted to capital account including the government and trade balance [see (4a), (17) and (18)]. Exports (5a) depend on exogenenouly given foreign income and the foreign price of the Korean exports, which are adjusted from domestic prices by the exchange rate. For the terms of trade in a small, open economy, the model assumes that the exchange rate is exogenous and the imports (6a) are varied by income level as imperfect substitutes for similar domestic products.

Labor endowment (19) is exogenously given by updated population growth. The supply of capital service available (11) is a function of the capital stock, which, in turn, is the sum of the investment made during the current period and the capital stock of previous period. This accumulation relationship is represented by updated capital stock formation (20). To take into account the interaction between real and nominal variables, the money[13] demand (14) depends on interest rate, income level, and general price level (or aggregate price index).

## 2.2. Data Base and Model Estimation

The producer behavior submodel contains estimates of the parameters of the translog price possibility frontiers for the eleven industrial sectors, allowing for substitution among inputs and technical change. For each of the eleven industrial sectors, the model has been fitted to an annual time-series[14] of input-output tables for the Korean economy during the period 1960 through 1988 for the systems of

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[12] Similarly, the economic aggregates of investment, exports and imports break down into their sectoral allocation.

[13] In the model, money is treated as a aggregate financial assets in relation to wealth which is defined as the sum of capital stock value, and net claims on the government and on ROW. However, the portfolio allocation process is not directly included.

[14] Data sources of the model are based on inter-industry transactions tables for the Korea 1960-1988, compiled by author. In general, the problem of I/O data deficiency has provided the limits to the econometric modeling of inter-industry transactions system for Korea. Nonetheless, by using this extensive time-series of data rather than a single data point, it is possible to derive the response of production patterns to changes in prices and technology level from historical experience. It is also much less likely to be affected by the peculiarities of the data for a particular time period.

nonlinear simultaneous equations.[15] Also, consumer behavior submodel, based on the translog-indirect preferences and associated systems of demand functions (Jorgenson and Lau (1975)), has been econometrically estimated for the period 1970-1988.

For each of the eleven industrial sectors, the time-series data were obtained by the Bank of Korea, the Korea Economic Plannig Board, the Korea Ministry of Energy and Resources. The input value shares were constructed by annually geometric interpolation method of the actual *Input-Output Tables* of 1960, 1963, 1966, 1968, 1970, 1973, 1975, 1980, 1983, 1985, 1986, 1987, and 1988. This greatly mitigates the problem of data deficiency and disturbances for a particular time period. Data on the prices and implicit deflators are from *National Accounts and the Monthly Bulletin, the Major Statistics of the Korean Economy,* and *the Yearbook of Energy Statistics* for the period 1960-1988.

Here, the prices of labor services are annually calculated by dividing the total employee compensation bill by the estimated thousand person-hours worked. The prices of capital services are annually obtained by dividing the capital compensation bill (from the value-added less labor compensation) by the estimated capital stocks compiled by Pyo (1988). The behavioral equations and identities included in the macro-econometric growth submodel, have been fitted to an annual time-series for the period 1970-1988, relating to monetary sector and interest rate, labor market and consumer preference systems, capital market and savings-investment, foreign trade and government sector, and so on.

## 2.3. Macro Closure of the Model

The model relates the 'variable I-O part' to the 'macro-econometric growth part' (including consumer behavior) and combines aggregate demand side and aggregate supply side including production process in order to form a simultaneous equations.[16] By these simultaneous equations the model is mathematically solved for all endogenous variables from the estimated parameters and the exogenously given variables.[17] In the simulatneous equations, most of the behavioral equations are statistically significant and satisfy the sign and magnitude of the parameters with economic validity.[18]

[15] The estimators of the complete system were obtained by dropping one equation and then estimating the resulting system of n-1 equations by NL-3SLS. See Jorgenson (1984).

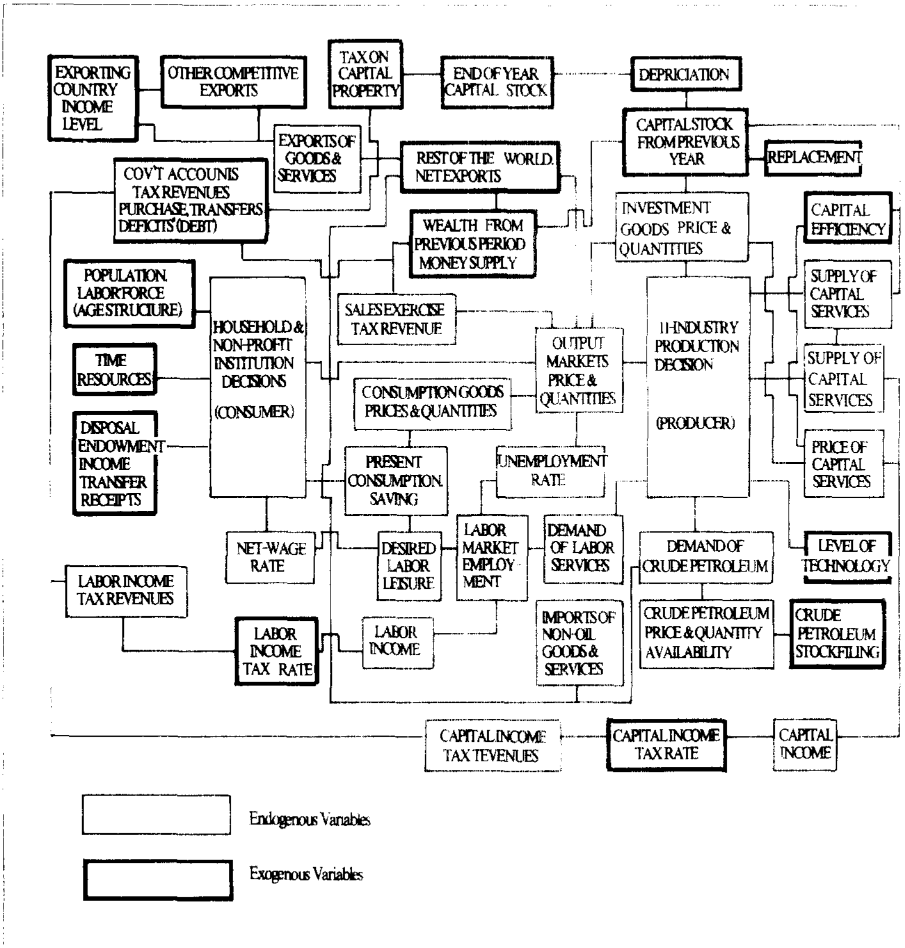
[16] The aggregate demand side consists of intermediate demands of the eleven industries and final demands such as consumption, investment, government, and foreign sector. The aggregate supply side consists of inter-industry transactions and primary input sectors determined by the prices of output/primary input, the input-output coefficients, and the level of technology for the eleven industry.

[17] The iterative procedure used in our model is performed through the combination of Statistical Package TSP and FORTRAN-PROGRAMMING.

[18] It is to be observed that the $R^2$-values are high and the t-values are significant. For a detailed presentation, see Kim, and Kim (1995b), pp.14-39.

The prices of primary inputs, generated endogenously within the macro-economic framework, are completed by its feed-back process[19] from the variable I-O submodel to the macro-economic submodel, towards the equilibrium state of clearing the primary inputs market (excluding the imported crude-petroleum and net

[**Figure 1**] Schematic Diagram of the Hybrid General Equilibrium Model




indirect taxes). Thus, with the help of equilibrium prices of capital and labor services, the variable I-O submodel generates equilibrium prices of the eleven industrial outputs, relating to private consumption expenditure, gross investment expendi-

[19] The prices of eleven industrial output are formulated as the aggregate price index which is a intervening variable on interface between the two submodels. It is then feedbacked into the consumer behavior sector and the money markets.

ture, foreign trade simultaneously. On the other hand, the private gross investment expenditure, based on domestic savings, net-government expenditure and net-exports, is linked to capital market. Also, the domestic capital accumulation provides the capital services available for future and the national wealth level which varies with the interest rate, money amount (M2), and rental price of capital services.

In summury, given i) the demographic variables such as population or labor forces, ii) government variables such as various types of tax rates and subsidies, government consumption/investment expenditure and other policy instruments, iii) some foreign environment variables including the prices of import commodities and the level of the other countries' economic activity, and iv) all lagged endogenous variables, the model determines simultaneously the residual endogenous variables. In addition to the behavioral equations, a set of macro balancing indentities and the accounting identities for interindustry transactions make the model closure completed and consistent.

Through dynamic historical simulation during the period 1973-1988 and simulation-error evaluation of endogenous variables included in the simulation model, the result shows that the root-mean-square-percent-error (RMSPE) and mean-percent-error (MPE) statistic are ranged below 10% and Theil's inequality coefficient is almost less than 0.1 except for nominal interest rate. This indicates that the model is mostly stable and converged and also has good predictability.[20]

The overall flow of the model can be illustrated schematically as in Figure 1.

## III. THE SIMULATION RESULTS

### 3.1. Economic Effects of External Energy Shocks

Since the first and second oil crises, the importance of energy to the Korean economy has become more evident. In general, the energy price hike and the associated changes in energy use have significant negative impacts on the overall economic activity. Therefore, if the energy crises had not occurred, the path of the Korean economy would also have evolved in a different way.

In this section, the model described above was used to examine quantitatively the impacts on the Korean economy of higher energy prices resulting from the first (1973-1977) and second (1979-1983) energy crises. A 'two-path dynamic simulation' is carried out under the two scenarios—Energy Crisis (PWOactual) of base case and No Energy Crisis (PWOnec), during each sample period. The former simulation provides an estimate of actual paths of the Korean economy between 1973

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[20] Examining how the model output is similar to actual values through turning point analysis in diagram, the most variables pursue the turing point with 4~5 years cycle or with 2 years cycle for small. This implies that the model secures medium- and long-run predictability. But because the 'services import' among trade variables was a little overestimated, the error of 'balance of trade' showed relatively high compared with the others. See Kim, S.R. (1991), pp.137-147.

and 1997 or between 1979 and 1983. The latter provides the simulated economic activity under a new time-series path of No Energy Crisis scenario, which assumed that the world oil prices were held at their real values of the starting point[21] of each sample period. The differences between the two simulations are attributed solely to the impacts of higher oil prices over the period.

Table 3 shows the results of two-path dynamic simulation of the main variables. This indicates that absence of the dramatic energy crisis would have positive effects such as higher GNP growth, lower inflation, lower unemployment, and improved trade balance.

For GNP, if the energy crisis hadn't occurred, the average annual growth rate of each period could have been expanded to around 1/5 higher than the actual—during 1973 to 1977, 1.31%, and during 1979 to 1983, 1.37%. The positive effect on GNP slowly occurred in the second energy crisis rather than the first. Also, the average growth rate of wholesale price (WPI) would have additional annual decrease of 3.33% and 0.62% respectively. In terms of price-levels such as WPI and CPI, the average inflation rate in the first energy crisis amounted to about 1/5-1/3 of those of the base case (PWOactual). During the second energy crisis, this effect was true to a short period, and also dependent upon other non-economic environments such as political and social factors.

The energy crises had a great impact on foreign trade. The second energy crisis caused a large deficit in international trade than the first. In particular, compared the second energy crisis with the first, the private consumption expenditure was more refrained and the fixed capital formation was less refrained. The difference of outcome from between the two energy crises might be dependent on its level of dependence on imported oil, the ability of financing oil imports, the stage of economic development, and the economic structure, etc. Nonetheless, it is certain that the poor economic performance during the period of energy shocks was attributed by the cumulative effects of the higher energy price shocks.

**Table 3.** The Dynamic Effects of the First and Second Energy Crises on the Main Economic Variables[a] in Korea

| Economic Variable[b] | From the Energy Crisis Occurrence | | | | | Average Annual Growth Rate |
|---|---|---|---|---|---|---|
| | 1-year | 2-year | 3-year | 4-year | 5-year | |
| GNP1 | 33948.2 | 37482.7 | 39549.8 | 42143.2 | 45875.9 | 7.81 |
| GNPnec1[d] | 33948.2 | 38187.4 | 40914.3 | 43984.8 | 48137.6 | 9.12 |
| effect | ( − ) | (1.88) | (3.45) | (4.37) | (4.93) | (1.31) |
| GNP2 | 50326.3 | 54248.2 | 56369.1 | 61189.9 | 65329.5 | 6.74 |
| GNPnec2 | 50326.3 | 54991.4 | 58251.8 | 64108.6 | 68746.2 | 8.11 |
| effect | ( − ) | (1.37) | (3.34) | (4.77) | (5.23) | (1.37) |

[21] 1973 for the first, and 1979 for the second.

(Continued)

| Economic Variable[b] | From the Energy Crisis Occurrence 1-year | 2-year | 3-year | 4-year | 5-year | Average Annual Growth Rate |
|---|---|---|---|---|---|---|
| WPI1 | 0.2031 | 0.2533 | 0.3128 | 0.3651 | 0.4103 | 19.22 |
| WPInec1 | 0.2031 | 0.2331 | 0.2836 | 0.3288 | 0.3664 | 15.89 |
| effect | ( − ) | (−8.01) | (−9.31) | (−9.95) | (−10.7) | (−3.33) |
| WPI2 | 0.6185 | 0.7499 | 0.8538 | 0.9402 | 0.9982 | 12.71 |
| WPInec2 | 0.6185 | 0.7115 | 0.8006 | 0.8934 | 0.9768 | 12.09 |
| effect | ( − ) | (−5.12) | (−6.23) | (−4.98) | (−2.14) | (−0.62) |
| CPI1 | 0.2109 | 0.2627 | 0.3224 | 0.3739 | 0.4238 | 19.06 |
| CPInec1 | 0.2109 | 0.2198 | 0.2647 | 0.3051 | 0.3428 | 12.91 |
| effect | ( − ) | (−16.3) | (−17.9) | (−18.4) | (−19.1) | (−6.15) |
| CPI2 | 0.5711 | 0.6804 | 0.7791 | 0.8707 | 0.9234 | 12.77 |
| CPInec2 | 0.5711 | 0.6031 | 0.6952 | 0.8232 | 0.8931 | 11.82 |
| effect | ( − ) | (−11.4) | (−10.8) | (−5.45) | (−3.29) | (−0.95) |
| BOP1[c] | −123.26 | −573.26 | −1066.8 | −414.3 | −446.1 | −2222.1 |
| BOPnec1 | −123.26 | −379.83 | −81.98 | 768.92 | 1578.6 | 1762.5 |
| effect | ( − ) | (193.4) | (984.8) | (1183.2) | (1622.6) | (3984.6) |
| BOP2 | −80.94 | −1546.4 | −1578.1 | −1427.7 | −697.73 | −5330.9 |
| BOPnec2 | −80.94 | 526.07 | 2013.1 | 3819.2 | 1835.2 | 8112.6 |
| effect | ( − ) | (2072.4) | (3591.2) | (5246.9) | (2532.9) | (13443.5) |
| K1 | 73569.1 | 80376.9 | 88546.6 | 97747.4 | 108271.9 | 10.14 |
| Knec1 | 73569.1 | 80607.7 | 88996.6 | 98564.4 | 109560.2 | 10.49 |
| effect | ( − ) | (0.29) | (0.51) | (0.84) | (1.19) | (0.35) |
| K2 | 143280.9 | 154769.2 | 166405.6 | 179031.4 | 192389.2 | 7.64 |
| Knec2 | 143280.9 | 154892.8 | 166790.1 | 179748.6 | 193509.5 | 7.81 |
| effect | ( − ) | (0.05) | (0.23) | (0.41) | (0.58) | (0.17) |
| C1 | 23836.7 | 26081.4 | 26851.2 | 28022 | 30051.7 | 5.96 |
| Cnec1 | 23836.7 | 26625.2 | 27890.6 | 29279.7 | 31424.6 | 7.15 |
| effect | ( − ) | (2.08) | (3.87) | (4.49) | (4.57) | (1.19) |
| C2 | 35820.6 | 34558.4 | 35261 | 39495.4 | 42209.0 | 4.19 |
| Cnec2 | 35820.6 | 34609.8 | 36977.2 | 41141.5 | 45439.9 | 6.13 |
| effect | ( − ) | (0.15) | (4.87) | (4.17) | (7.65) | (1.93) |
| I1 | 7422.1 | 8034.6 | 9424.1 | 10559 | 11980.5 | 12.72 |
| Inec1 | 7422.1 | 8238.3 | 9623.8 | 10895.3 | 12418.9 | 13.73 |
| effect | ( − ) | (2.53) | (2.12) | (3.18) | (3.66) | (1.01) |
| I2 | 13244.6 | 14019.6 | 15172.5 | 16587.1 | 16779.7 | 6.09 |
| Inec2 | 13244.6 | 13279.2 | 14203.9 | 15643.5 | 1688.1 | 6.25 |
| effect | ( − ) | (−5.28) | (−6.38) | (−5.69) | (0.60) | (0.16) |
| EX1 | 6282.74 | 7564.3 | 9006.9 | 11069.9 | 12158.9 | 17.95 |
| EXnec1 | 6282.74 | 8025.1 | 10167.1 | 13154.9 | 15108.1 | 24.53 |
| effect | ( − ) | (6.09) | (12.88) | (18.83) | (24.25) | (6.58) |
| EX2 | 17794.2 | 20647 | 22727.5 | 23527.3 | 23527.3 | 7.23 |
| EXnec2 | 17794.2 | 17803.8 | 21794.6 | 26599.5 | 33250.9 | 16.92 |
| effect | ( − ) | (−13.7) | (−4.10) | (13.06) | (41.33) | (9.68) |

(Continued)

| Economic Variable[b] | From the Energy Crisis Occurrence | | | | | Average Annual Growth Rate |
|---|---|---|---|---|---|---|
| | 1-year | 2-year | 3-year | 4-year | 5-year | |
| IM1 | 7720.9 | 8877.3 | 10863.7 | 12812.6 | 13995.9 | 16.03 |
| IMnec1 | 7720.9 | 9740.3 | 12352.9 | 14670.9 | 16367.0 | 20.66 |
| effect | ( – ) | (3.27) | (9.05) | (2.82) | (9.69) | (4.63) |
| IM2 | 22851.3 | 22304.2 | 21842.9 | 21395.9 | 21395.9 | 1.63 |
| IMnec2 | 22851.3 | 23033.2 | 23820.7 | 22000.5 | 23469.3 | 0.67 |
| effect | ( – ) | (9.72) | (13.7) | (14.5) | (16.9) | (0.96) |
| LUR1 | 3.6359 | 3.9101 | 3.7169 | 3.5874 | 3.4533 | –1.28 |
| LURnec1 | 3.6359 | 3.5062 | 3.5389 | 3.0421 | 2.8265 | –6.11 |
| effect | ( – ) | (–6.75) | (–12.1) | (–15.2) | (–18.1) | (–4.83) |
| LUR2 | 3.668 | 5.024 | 4.249 | 4.025 | 3.973 | 2.02 |
| LURnec2 | 3.668 | 4.926 | 4.141 | 3.941 | 3.937 | 1.78 |
| effect | ( – ) | (–1.95) | (–2.54) | (–2.09) | (–0.91) | (–0.24) |
| LD1 | 10140.9 | 10700.4 | 10929.6 | 11401.1 | 11701.7 | 3.64 |
| LDnec1 | 10140.9 | 10668.8 | 10939.5 | 11476.6 | 11781.5 | 3.81 |
| effect | ( – ) | (–0.29) | (0.09) | (0.66) | (0.68) | (0.17) |
| LD2 | 12408.8 | 12579.9 | 12968.9 | 13463.9 | 13618.9 | 2.35 |
| LDnec2 | 12408.8 | 12502.0 | 12952.1 | 13414 | 13612 | 2.34 |
| effect | ( – ) | (–0.62) | (–0.13) | (–0.37) | (–0.05) | (–0.01) |
| OD1 | 2681.3 | 2762.5 | 3070.3 | 3437.7 | 3838.4 | 9.38 |
| ODnec1 | 2681.3 | 3153.2 | 3739.4 | 4279.1 | 4792.3 | 15.62 |
| effect[d] | ( – ) | (14.1) | (21.8) | (24.5) | (24.9) | (6.24) |
| OD2 | 4404.9 | 3961.6 | 3694.8 | 3763.3 | 4509.8 | 0.59 |
| ODnec2 | 4404.9 | 4365.2 | 4429.9 | 4599.9 | 5147.5 | 3.97 |
| effect | ( – ) | (10.2) | (19.9) | (22.2) | (14.1) | (3.38) |

Note : a) The specific starting point is 1973, 1979 respectively and the effect can be found from the second year of each period.

b) The unit of the variables, based on [Table 1], is 1985 constant billion won. OD refers to oil demand. Scripts 1, 2 mean the 1st and 2nd energy crisis respectively and the 「effect」 means percent change of 'scenario-PWOnec' from 'base case.'

c) The effect is the difference of 'scenario-PWOnec' from 'base case' and the average annual growth rate column is calculated as total cumulative sum for five years.

d) The unit in the average annual growth rate and the effect is percentage term.

### 3.2. Hypothesized Macroeconomic Stabilization Policies

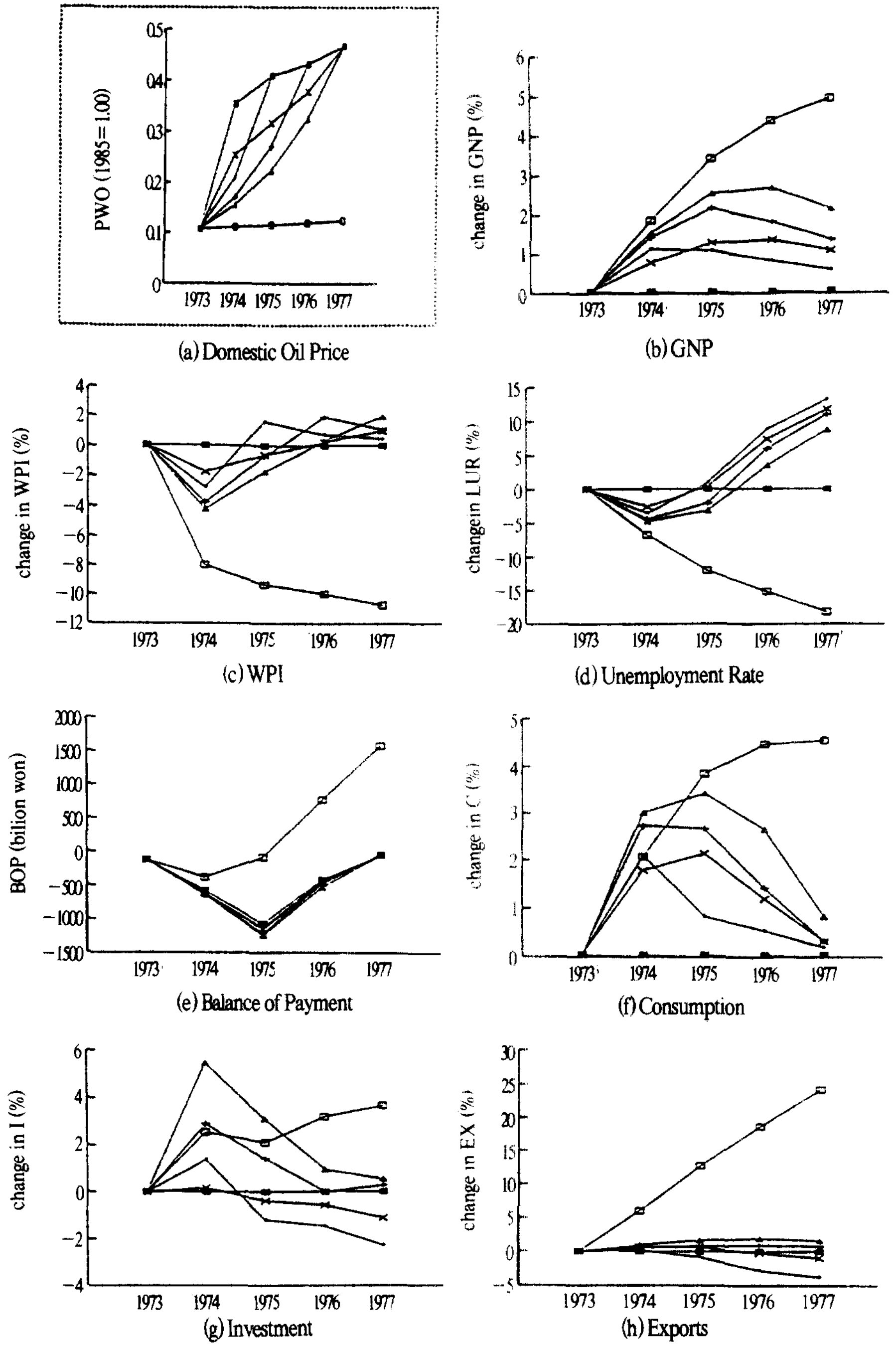
What might have happened in the Korean economy if the drastic change oil price in 1973 had been smoothed within certain years by government intervention. This section evaluated the economic effects of alternative adjustment policies which might be taken in the course of overcoming the negative impacts of the energy

**Table 4.** The Dynamic Effects of Alternative Oil Pricing Policy for Each Scenario[a] in Korea

| Year | 1973 | 1974 | 1975 | 1976 | 1977 | Average annual growth rate(%) |
|---|---|---|---|---|---|---|
| 1. Base[b] | 32412.4 | 35069.6 | 37850.5 | 40938.7 | 44458.8 | 8.22 |
| GNP | | | | | | |
| 2. Percent change from Base | | | | | | |
| GNPt | – | 1.565 | 2.574 | 2.707 | 2.153 | 0.57 |
| GNPs | – | 1.446 | 2.191 | 1.848 | 1.365 | 0.37 |
| GNPf | – | 1.146 | 1.109 | 0.841 | 0.595 | 0.16 |
| GNPt1 | – | 0.791 | 1.317 | 1.379 | 1.091 | 0.29 |
| 1. Base | | | | | | |
| WPI | 0.2441 | 0.3169 | 0.3597 | 0.3912 | 0.4314 | 15.29 |
| 2. Percent change from Base | | | | | | |
| WPIt | – | −4.215 | −1.757 | 0.302 | 1.949 | 0.57 |
| WPIs | – | −3.773 | −0.728 | 1.904 | 1.066 | 0.32 |
| WPIf | – | −2.786 | 1.587 | 0.708 | 0.438 | 0.14 |
| WPIt1 | – | −1.786 | −0.642 | 0.222 | 0.971 | 0.29 |
| 1. Base | | | | | | |
| LUR | 3.6359 | 3.9101 | 3.7169 | 3.5874 | 3.4533 | −1.28 |
| 2. Percent change from Base | | | | | | |
| LURt | – | −4.754 | −3.166 | 3.497 | 8.744 | 2.09 |
| LURs | – | −4.418 | −2.074 | 5.958 | 11.020 | 2.61 |
| LURf | – | −3.578 | 1.017 | 8.842 | 13.245 | 3.12 |
| LURt1 | – | −2.582 | 0.435 | 7.299 | 11.813 | 2.79 |
| 1. Base | | | | | | |
| BOP[c] | −123.26 | −573.26 | −1066.82 | −414.38 | −44.61 | −2222.3 |
| 2. Difference from Base | | | | | | |
| BOPt | – | −71.80 | −170.53 | −119.04 | −13.68 | −375.1 |
| BOPs | – | −74.57 | −142.57 | −69.86 | −7.32 | −294.3 |
| BOPf | – | −58.99 | −63.69 | −26.45 | −2.75 | −151.8 |
| BOPt1 | – | −40.53 | −85.41 | −59.48 | −6.82 | −192.2 |
| 1. Base | | | | | | |
| C | 23836.7 | 26081.5 | 26851.2 | 28022.1 | 30051.7 | 5.96 |
| 2. Percent change from Base | | | | | | |
| Ct | – | 3.027 | 3.447 | 2.677 | 0.836 | 0.22 |
| Cs | – | 2.752 | 2.696 | 1.435 | 0.339 | 0.09 |
| Cf | – | 2.113 | 0.851 | 0.554 | 0.195 | 0.06 |
| Ct1 | – | 1.803 | 2.164 | 1.215 | 0.327 | 0.09 |
| 1. Base | | | | | | |
| I | 7422.2 | 8034.6 | 9424.2 | 10559.1 | 11980.6 | 12.72 |
| 2. Percent change from Base | | | | | | |
| It | – | 5.468 | 3.093 | 0.958 | 0.551 | 0.15 |
| Is | – | 2.896 | 1.419 | 0.004 | 0.286 | 0.09 |
| If | – | 1.379 | −1.203 | −1.483 | −2.281 | −0.64 |
| It1 | – | 0.167 | −0.393 | −0.566 | −1.125 | −0.33 |
| 1. Base | | | | | | |
| EX | 6282.7 | 7564.4 | 9006.9 | 11069.9 | 12158.9 | 17.95 |
| 2. Percent change from Base | | | | | | |
| EXt | – | 1.005 | 1.739 | 1.966 | 1.637 | 0.48 |
| EXs | – | 0.511 | 0.855 | 0.950 | 0.784 | 0.23 |
| EXf | – | 0.168 | −0.828 | −2.785 | −3.779 | −1.13 |
| EXt1 | – | 0.742 | 0.706 | −0.203 | −0.973 | −0.29 |

Note : a) Subscript t, s, f and t1 mean scenario-PWOt, scenario-PWOs, scenario-PWOf, scenario-PWOt1 respectively. The notation and unit of variables are based on Table 1.
b) Simulated value of base case scenario with No Policy.
c) The average annual growth rate column is calculated as total cumulative sum for five years.

**[Figure 2]** Hypothesized Oil Pricing Policies Compared : Four Scenarios




■ PWOactual(Energy shock) □ PWOnec(No Energy shock) ▲ PWOt(3 years smoothing)
+ PWOs(2 years smoothing) · POf(1 year smoothing) × PWOt1(3 years half smoothing)

shock.

'Hypothesized oil pricing policy' refers to the smoothing of the impact of the actual imported oil price to equalize the domestic oil price at the last year of the given study period by raising it by annual average growth rate within the specific sample period. It can be used to stabilize the economy in the course of overcoming the deleterious impact of higher oil prices. To measure the dynamic spillover effects of smoothing the dramatic change of imported oil prices the period 1973-1974, this analysis adopted 'central-bank-borrowing method' as the financing source needed for macroeconomic stabilization policies.[22] It was also divided into the following four policy scenarios according to the period and method of each stabilization policy :

1) Two-year stabilization policy during 1973-1975 (scenario-PWOf)
2) Three-year stabilization policy during 1973-1976 (scenario-PWOs)
3) Four-year stabilization policy during 1973-1977 (scenario-PWOt)
4) Four-year/half stabilization policy during 1973-1977(scenario-PWOt1).[23]

The application of this price policy, which separates domestic energy price from international energy price within the specific period by smoothing the drastic increase of oil price, are supposed to prevent domestic production activity to be shrunk by removing the upward-tendency of the factor of price.

The simulation results in Table 4 show that economic growth has shown improvement but the inflation rate has increased more or less over time except in the beginning of the study period. By temporarily absorbing the oil price hike, this policy provides an alternative offsetting the import price increase. Although it has abated to some extent the potential stagflationary/destabilizing pressures in the short term, the additional deficits of government expenditures and the derived long-term increases in nominal money supply might occur as macroeconomic consequences which phase out the constraints of a cost-push factor.

Accordingly, the implementation of the policy in the short-term may lower the price level and promote private consumption and exports, thus simulating GNP growth and business activity. However, in the long-term, the derived inflation effects may lower the contribution to GNP growth and deteriorate the balance of trade due to the additional deficits.

A comparison of the results for the four policy scenarios reveals that the longer the policy-implemented period, the greater the effects in 1974, the first year since policy implementation, except for the balance of payments. In addition, the results indicate the nature of adverse effects of higher inflation, greater trade deficit and

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[22] Besides, there are several financing methods needed for this policy of which method of 'national-debt issue' or method of 'fund formation' is often applied. For the previous study on this topic in the Korean economy, see Rhee, S.Y. and D.K. Cho (1981), based on a macroeconometric model of Norton and Rhee(1979).

[23] This implies that half of oil price growth factor is spread by financing and that the residual is directly incorporated into the domestic oil price.

higher unemployment over time. This phenomena could be interpreted as the acceleration of the inflation rate caused by an increase in the money supply in the long term.

If, in aspects of comparison of the GNP growth and the price-level growth,[24] the 'rate of growth in price-level' is less than the 'rate of growth in GNP,' the adjustment policies may be favorable to some extent. Nevertheless, it might not be verifiable until the economy could repress the inflation and alleviate the balance of payments deficit, thereby absorbing the adverse effects on the economy. Figure 2 summarizes graphically the time profile of the cumulative effects of hypothesized oil pricing policies on major variables. This shows that the trade-off between short- and long-term economic gains emerged.

Regarding the economic effects of 'scenario-PWOt' and 'scenario-PWOt1' during the same study period but with different methods, the former shows a more rapid economic growth and the latter shows a relatively curtailed inflation. The 'scenario-PWOt,' smoothing the oil price shock for the longest in the study period, simulates economic growth furthest among the four scenarios but is still inefficient in terms of inflation and balance of payments.

In summury, the overall implication is that there is some evidence in favor of a short-term stabilization consequence by the implementation of the policy. However, it seems to have negative effects to the price stability due to money evaporation and additional deficits of both internal and external balance over time. The result calls for a cautious use of adjustment policies being implemented in response to energy shocks.

## IV. SUMMARY AND CONCLUSION

The experiment of this study produced a dynamic run that addressed the question: how would the Korean economy have performed in the specific period in the absence of unfavorable external energy shocks or with alternative adjustment policy choices. Under the counterfactual portrayal of what would have happened without the first and second oil crisis, the model investigates the energy shock impacts on the Korean economy. The empirical results demonstrate that the energy crises increased price of other outputs through changing production structure and therefore led to higher inflation and lower economic growth. Regarding the link between energy and economic growth, the Korean economy has shown highly energy-vulnerable characteristics, which might be identified as another source of lower and deteriorative level of the economic activity in the long-term perspective.

Implementation of hypothesized oil pricing policy in the context of external en-

[24] From Table 4, we can know that 'rate of growth in price-level' is 0.037, 0.021, 0.009, 0.019 by the 'scenario- PWOt/PWOSs/PWOf/ PWOt1', and 'rate of growth in GNP' is 0.069, 0.045, 0.019, 0.035 for each. Therefore, the ratio of 'rate of growth in GNP' to 'rate of growth in price-level' in the 'scenario-PWOs' is 2.14, the greatest.

ergy shock shows that there is some evidence in favor of a short-term stabilization consequence. However, as far as the usual growth/inflation/trade deficit trade-off is concerned, it appears to be ineffective. This has important implications for the changing mix of the Korean economy towards a less energy-vulnerable economy,[25] which is likely to be found only in microeconomic substitution of reproducible inputs for energy or energy-saving technological progress.

[25] The recent political and theoretical debate on energy/environmental policy reform in Korea has become focused more on the external social costs than on the private costs. Nowadays, especially in the energy sector, the Korean economy seems to face the challenge of reforming its domestic price regime to reflect opportunity costs.

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