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Quantifying the Effects of Higher World Oil Prices on Resource Allocation and Living Standards in an Energy Poor Open Economy: the Case of Korea*

by

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May 1981

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I. Introduction

The OPEC Cartel's spectacular success in raising real world oil prices over the past decade has brought about substantial net resource transfers from energy poor to energy rich countries within the world economy. In accomodating these resource transfers both energy exporting and importing economies have been confronted with adjustment pressures. Of course the intensity and nature of these adjustment pressures has differed substantially between countries according to amongst other things a country's resource endowment, its net trade position with respect to oil and other energy based products and the degree of openness of its economy to world trade.

Our concern in this paper is with quantifying the short and medium term adjustment pressures imposed on the South Korean economy assuming continued increases in real world oil prices. The results are derived from a multisectoral general equilibrium model. A feature of the model is its design flexibility and simple solution algorithm. We exploit this in the present study by comparing results for a range of experiments to accommodate differing assumptions about the Korean

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macroeconomic environment, labour market behaviour and Korean export demand. While the numerical results refer specifically to Korea, it is to be hoped that by rationalising them in terms of the underlying structural features inherent in the Korean economy, the paper provides some guidance on the sorts of adjustment pressures likely to confront energy poor open economies assuming a continued movement in the world terms of trade towards oil.

Section 2 of the paper presents a stripped-down version of the analytical model. Section 3 discusses some features of the Korean economy which a priori would suggest marked vulnerability to world oil price increases, then describes the price scenario. Section 4 presents and analyses results for a range of experiments. Model projections are justified using 'back of the envelope' calculations to illustrate the essential underlying causal mechanisms. Conclusions are contained in Section 5.

2. Analytical Framework

The simulations reported later were obtained from a multi-sectoral economy-wide model of the South Korean economy. The model is of the comparative-static type. Its equations are built up from standard microeconomic assumptions of cost minimisation and utility maximisation applied at the individual industry and household sector level. The model employs neoclassical production and utility functions and emphasises the role of prices and substitution possibilities in determining the level and composition

of economic activity.[1]

2.1 The Equation System

Rather than present the entire model system of structural equations[2] we show in Table 1 only a stripped-down version depicting the main equation types in schematic rather than explicit functional form. (The variables of the stripped-down version are contained in Table 2). While Table 1 excludes the numerous practical details of the actual model[3] it nevertheless provides an adequate representation of the essential features of the model's theoretical structure.

The equations can be classified into five main groups:

(a) demands for commodities (domestically produced, competitive imports and non-competing imports),

(b) demands for primary factors (labour, capital, land),

(c) pricing equations which impose the condition of zero pure profits in all activities (current production, capital creation, exporting and importing),

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[1] The model may be placed in the rapidly growing set of neoclassical price responsive general equilibrium models. These models are constructed around an input-output matrix and endogenously determine both commodity and factor prices and quantities in an equilibrium process. Previous examples of this type of model include Taylor and Black (1974), Staelin (1976), Adelman and Robinson (1978), Whalley (1978), Dervis, De Milo and Robinson (1980) and Dixon et al (1981). The specification of equations in the model draws heavily from the work in Dixon et al (1981).

[2] A complete documentation of the model theory and structural equation system is contained in Vincent (1981a).

[3] In particular the schematic version leaves out government demands, the allocation of investment between industries and the process of capital accumulation.

Table 1 : Schematic Representations of the Main Equations of the Korean Model

Identifier	Description	Equation	Number
	Commodity Demands		
(1)	Domestic commodities for domestic use	$D = f_D\ (Z,Y,C,P_1,P_2)$	g
(2)	Competing import commodities	$M = f_M\ (Z,Y,C,P_1,P_2)$	g
(3)	Non-competing import commodities	$M^N = f_M^N\ (Z)$	n
(4)	Export demand	$E = f_E\ (P_1^*\ ,\ Q_E)$	g
	Primary Factor Demands		
(5)	Demands for labour, capital and land	$L = f_L\ (Z_1,P_3)$	ℓ
	Zero Pure Profits		
(6)	in production	$P_1 = w\ (P_1,P_2,P_3)$	h
(7)	in capital creation	$Q = q\ (P_1,\ P_2)$	h
(8)	in exporting	$P_1 = \hat{P}_1^* \theta S$	g
(9)	in importing - competing	$P_2 = \hat{P}_2^* \theta T$	g
(10)	- non-competing	$P_2^N = \hat{P}_2^{*N} \theta T^N$	n
		^ denotes diagonal matrix	
	Market Clearing		
(11)	for domestic commodities	$Z = D + E$	g
(12)	for primary factors	$L = L^*$	ℓ
	Other Equations		
(13)	Balance of trade	$B = (P_1^*)'E - (P_2^*)'M - (P_2^{*N})'M^N$	1
(14)	Consumer price index	$\epsilon = f_\epsilon\ (P_1,P_2)$	1

Total = 6 g + 2 h + 2 n + 2 ℓ + 2

Table 2 : Schematic Representation of Model Variables

Variable	Description	Number
D	Demands for domestically produced commodities	g
Z	Output levels in each industry	h
Y	Investment by using industry	h
C	Aggregate consumption expenditure	1
P_1	Local prices of domestic commodities	g
P_2	Local prices of competing import commodities	g
M	Demands for competing import commodites	g
M^N	Demands for non-competing import commodities	n
E	Exports	g
P_1^*	Foreign currency prices for exports	g
Q_E	Foreign export demand curve shift term	g
L	Demands for primary factors	ℓ
P_3	Prices for primary factors	ℓ
Q	Industry costs of capital creation	h
θ	Exchange rate (Won/Foreign currency)	1
S	One plus ad valorem rates of export subsidy	g
P_2^*	Foreign currency prices for competing imports	g
T	One plus ad valorem rates of protection on competing imports	g
P_2^N	Local prices of non-competing imports	n
P_2^{*N}	Foreign currency prices for non-competing imports	n
T^N	One plus ad valorem rates of protection on non-competing imports	n
L^*	Factor employment levels	ℓ
B	Balance of trade (foreign currency)	1
ϵ	Consumer price index	1
	Total: 10g + 3h + 4n + 3ℓ + 4	

(d) market clearing equations for domestic commodities and for primary factors, and

(e) miscellaneous equations to specify the behaviour of macroeconomic aggregates and to define useful summary variables.

The model recognizes five categories of demand for commodities; intermediate input demands, demands for inputs into capital creation, household demands, export demands and other (government and inventory) demands. Five input categories are also distinguished; domestic commodities, competing import commodities, non-competing imports, primary factors and a residual category comprised mainly of working capital costs.

Equations (1) and (2) represent an aggregation over all categories of demand. They contain a set of activity variables and vectors of local prices of domestically produced and competing import commodities. The inclusion of P_1 and P_2 in the demand functions for both domestic and competing import commodities indicates that the model allows for imperfect substitution in various end uses.[1] Hence in order to specify the competing commodity demand functions requires estimates of the substitution elasticities between each pair of domestic and imported products from the point of view of each category of domestic user.[2] The

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[1] The model's treatment of import/domestic substitution follows that of Armington (1969,1970).

[2] To date, no empirical studies of these parameters have been found for the Korean economy nor has it been possible to assemble the data base necessary for their estimation. In this study we have assumed a common value of 2.0 for these parameters across commodities and end uses. This value was chosen after considering the empirical estimates in other studies. See Vincent (1981 b) for further details.

first activity variable, Z, the vector of output levels for each industry, appears only in the equations explaining intermediate input demands for current production. The second, Y, which represents the vector of investment in each industry, appears only in the input demand equations for capital creation. The third, C, aggregate consumption expenditure, appears only in the consumer demand equations. In the actual model, the consumer demand equations are a good deal more complex than depicted in (1). They contain as parameters household expenditure and cross price elasticities[1] as well as substitution elasticities between domestic and competing import commodities in consumption.

Equation (3) depicts a Leontief formulation of the demands for non-competing imports. Non-competing imports play a major role in the natural resource poor Korean economy. The model distinguishes five categories, cotton, raw sugar, rubber, crude oil and 'other', each of which is purchased directly by processing industries.[2] The export demand equations (4) contain as arguments P_1^*, the foreign export price, and Q_E, a variable which allows for shifts in the foreign demand curve. In the model each export demand equation contains only one parameter, the reciprocal of the foreign elasticity of demand for the respective export

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[1] These parameters are derived from the study of Lluch, Powell and Williams (1977) which reports results of the application of Lluch's extended linear expenditure system to Korean National Accounts data. See Vincent (1981 b).

[2] The Korean model forms one of a group of disaggregated models of developing countries being constructed primarily for the purpose of ascertaining the country-specific resource allocative and income implications of the United Nations Conference on Trade and Development's (UNCTAD's) so called Integrated Programme for Commodities. Cotton, raw sugar and rubber are 'core' commodities of this programme.

commodity.[1] Only the g domestically produced commodities may be exported. No imported commodities can be exported without first being processed in a domestic industry. The final system of demand equations (5) depicts demands for the primary factors labour, land and capital. These are explained only by industry outputs and factor prices. The fact that P_3 is the only price variable in (5) reflects the assumption that while primary factors can be substituted for each other, they cannot be substituted for intermediate inputs.[2] This also explains the absence of factor prices in the commodity demand equations (1) and (2). The factor demand equations of the model contain parameters representing the pairwise elasticities of substitution between primary factors in each industry.[3]

Equations (6) - (10) depict the zero pure profits conditions in each of the activities recognized by the model. Since the production functions are assumed to exhibit constant returns to scale, costs per unit of output do not depend on the level of output hence (6) and (7) contain no output variables. Note that in (6) the left hand side variable p_1 which represents the n x 1 vector of costs per unit of activity, is the same as the right

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[1] In the simulations reported later the foreign demand elasticities for each export commodity have the value of 20.0. This is tantamount to assuming that Korea is a 'small country' with respect to the commodities it exports.

[2] The nested form of the production functions used in the model is specified in Vincent (1981 a).

[3] These elasticities are based on production function studies of the Korean economy undertaken by Kim (1977) and Nam (1975). See Vincent (1981 b) for details.

hand side g x 1 vector, P_1, of local commodity prices. The Korean model maintains a 1:1 relationship between producing industries and domestic commodities. That is, each industry produces only one commodity which bears the same label as the industry and is produced only in that industry. This exclusion of joint production is the reason why the model in Table 1 can be formulated without explicit reference to commodity supply equations. Note that (6) does not rule out profits. It does, however, rule out pure profits, i.e. profits not accruing to a factor of production. Variations in profits are captured in the model by variations in the rentals on fixed factors[1] in response to events which change the profitability of their use in a particular industry. The second set of pure profits conditions simply relates the price of a unit of capital in each industry to the cost of its production, while the third set (equation (8)), equates the revenue from exporting (right hand side) to the relevant costs (the domestic commodity price). Finally equations (9) and (10) equate the selling prices of imported commodities to the cost of importing (which includes the domestic currency equivalent of the foreign currency price including the tariff).

Equation (11) equates demand and supply for domestically produced commodities, while (12) does likewise for primary factors. Note that (12) does not necessarily impose full utilization in factor markets. We can for example set some or all factor prices exogenously and let the model determine the corresponding elements of L^*.

[1] In the short run applications of the model reported later industry specific stocks of fixed capital and land are assumed fixed. In the medium run applications however only land (distinguished as a separate factor of production in the Agricultural and Mining industries) is assumed fixed.

Of the last group of equations only two are shown. Equation (13)defines the balance of trade and (14) the consumer price index. The Korean model contains many more such equations to increase its flexibility of use and descriptive power.

Note that the model equations do not contain variables to accommodate technical change. The Korean model assumes a fixed industrial production technology. This enters the model as a set of coefficients derived from the model's input-output data base. For example, production techniques for domestic industries in producing their commodity bundles are reflected in the shares in industry production costs accounted for by the costs of domestically produced and imported intermediate inputs and primary factor inputs. Similarly, the disposition of domestically produced and imported commodities is reflected in their sales shares to intermediate usage for current production and capital creation and to the various categories of final demand (one of which is exports).

2.2 Obtaining Model Solutions

The model is solved using the method pioneered by Johansen (1960). This involves first converting each of the equations to linear percentage change form. In terms of Table 1 equation (1) for example becomes

$$d = \eta_{DC} z + \eta_{DY} y + \eta_{DC} c + \eta_{DP_1} p_1 + \eta_{DP_2} p_2,$$

where the lower case letters represent percentage changes in the

corresponding upper case variables and η_{DC}, η_{DY}, etc. are matrices of elasticities. The ijth element of η_{DC} for example is the elasticity of demand for the ith domestic product with respect to the output level in the jth industry. After linearisation of all equations the model may be represented by

$$Ax = 0 \qquad (15)$$

where A is an n x m matrix of elasticities,[1] x is the m x 1 vector of percentage changes in the model's variables and n is the number of equations. The second step is to close the model by choosing m - n exogenous variables from the vector x. The particular choice made reflects the nature of the policy experiment under study and the assumptions about the macroeconomic environment in which it is assumed to take place. As a result of this choice equation (15) is rewritten as;

$$A_1x_1 + A_2x_2 = 0 \qquad (16)$$

where x_1 is the n x 1 vector of endogenous variables, x_2 is the

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[1] The elements of A represent functions of two types of parameters; (a) the various econometric parameters governing import/domestic substitution, primary factor substitution, consumer demand, export demand and investment allocation for example and (b) 'parameters' obtained from the model's base period input-output data matrix which depict the relative strengths of commodity-industry-primary factor linkages in the base year economy. These latter 'parameters' were obtained from the model's data base constructed from the 1975 Bank of Korea Input-Output Tables. See Vincent (1981 b) for details.

m-n x1 vector of exogenous variables and A_1 and A_2 are the corresponding segments of A. Finally, the model is solved by

$$x_1 = Bx_2 \qquad (17)$$

where $B = -A_1^{-1}A_2$

i.e. by expressing the percentage change in each endogenous variable as a linear function of the percentage changes in each of the exogenous variables.[1]

3. World Oil Pricing and the Korean Economy

At the outset there are two characteristics of the Korean economy which would suggest that the level and composition of Korean economic activity would be especially sensitive to shocks in the world economy in general and to world oil pricing shocks in particular. The first concerns the openness of the economy to international trade. In 1975 the value of commodity exports represented 25 per cent of the value of the gross national product. By 1980 this share exceeded 30 per cent.

The second characteristic concerns the total dependence by Korea on imports for its crude oil requirements for use in an

[1] Alternatively, a non-linear solution algorithm could be applied to the structural equations, as is used for example in the work of Dervis, de Milo and Robinson (1981). The linear method permits a more flexible use of the model. Different policy problems can be simulated merely by changing the partitioning of the matrix A. No changes are required in the solution routine. The 'cost' of the linear method however is that because it assumes the A matrix elements to be fixed (15) provides only a local representation of the structural equation system. That is (17) is strictly valid only for small changes in x_2. Recent work by Dixon et al (1981) indicates that the errors introduced by the linearisation method are small.

industrial production technology which has become heavily biased towards petroleum products for its total energy requirements. Korea's total energy consumption increased by about 9 per cent per year from the early 1960's to the mid 1970's in line with the rapid industrialisation of industry and the improvement in living standards.[1] Over this period the share of coal in total energy consumption declined from around 40 per cent to around 30 per cent, the share of firewood from around 50 per cent to 12 per cent and the share of petroleum from 10 per cent to 55 per cent.[2] Thus accompanying the industrialisation process has been an escalating dependence on petroleum products as a basic energy source.

In the model's 1975 data base expenditure on crude oil imports constituted 17 per cent of total Korean import expenditure.[3] While Korea has no available supplies of crude oil it has during the industrialisation phase developed considerable crude oil refining capacity. Starting in 1964, this capacity was

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[1] This growth rate in energy consumption is equivalent to the growth rate in real gross national product for the period.

[2] These figures are evaluated on the basis of energy equivalents. See Economic Planning Board (1980).

[3] By 1979 this figure had declined to 15.4 per cent. However, Korea's reliance on imported energy of all types increased from 58 per cent in 1975 to 73 per cent in 1979 through imports of coal and nuclear fuels. The model's input-output data base indicates no imports of these commodities in 1975.

by 1971 sufficient to handle all Korea's petroleum requirements. According to the 1975 input-output tables Korean exports of petroleum products valued in producers prices constituted 2 per cent of Korea's total exports.[1]

Despite this apparent vulnerability of Korean industrial production to world oil price increases the Korean economy as a whole was able to quickly overcome the adverse effects of the first OPEC oil shock initiated in 1973, principally by increased exports of manufactured goods. However, undertaking the resource adjustments to restore economic balance following the further large world oil price increases of the late 1970's is proving a more enduring and difficult task. Korea's attempts a second time round to restore equilibrium on the foreign account by further expansion of traditional export commodities such as textile products are being hampered by the increasingly restrictive import policies pursued in advanced industrialised countries towards such goods. This, together with the failure so far of real labour costs in Korea to respond adequately to the reduced terms of trade brought about by the higher world energy prices, has contributed to the present disequilibrium, as depicted by rapid domestic inflation, an accelerating trade imbalance and rising unemployment.

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[1] The tables also show imports of petroleum products whose landed duty price value constituted about 2 per cent of total imports. The existence in this sector of both exports and imports reflects the heterogeneity of products within the oil products classification.

In summary then the essence of the dilemma confronting Korean economic planners in the wake of the second major oil price shock is how to facilitate the necessary resource adjustments to restore external and internal balance given a trading environment of increasing foreign exchange costs for imported oil together with quantitative restrictions on traditional exports in selected markets. In the remainder of the paper we use the model to identify the sorts of adjustment pressures imposed on the Korean economy from continued increases in real world oil prices of the rate envisaged by the World Bank for the duration of our time focus, which is to the mid 1980's. The analysis pays particular attention to the consequences for Korean living standards of this oil price scenario and to the size and nature of the relative price and ensuing quantity adjustments within the Korean economy and between Korea and overseas that will be required to offset real oil price increases of this magnitude.

3.1 The Exogenous World Oil Price Scenario

The model does not contain equations to describe the foreign supply conditions for commodities (such as crude oil) imported by Korea. Nor does it attempt to explain foreign demand conditions for Korean export commodities. The model therefore requires a world price scenario expressed in terms of annual shifts in world import prices for the commodities it distinguishes together with annual shifts in the foreign demand curves for Korean exports (projections of world price

changes in the absence of changes in Korean export levels).[1] The initial impetus for these relative price changes is the change in the world crude oil price.

Events in the world oil market over the past decade suggest that any future oil price projections relative[2] to other world commodity prices will be highly speculative. Changes in oil prices will cause changes in other world commodity prices through shifts in supply and demand curves as end users react to the initial change in oil prices. In particular, they will have implications for world prices of other energy and energy related commodities, especially those such as steaming coal that may substitute with oil and others such as aluminium, that are intensive in their use of energy inputs. The extent to which such second-round world commodity price linkages should be accounted for depends essentially on the length of the adjustment environment to the initial price disturbance envisaged. Here, rather than employ any formal world commodity price model for tracing such world price linkages we simply assume that a 3 per cent annual increase in world crude oil prices will in turn lead to a 2 per cent annual increase in world petroleum products prices[3] relative to the world prices of all other

[1] While the small country assumption is imposed for Korean imports, recall that the model has export pricing equations which allow for the foreign demand curves confronting Korean exports to be downwards sloping.

[2] Only relative price movements are relevant for the model. The absolute rate of inflation in the rest of the world will have no effect on results.

[3] This figure is arrived at simply on the basis that crude oil typically represents two thirds of the total production costs of petroleum products. These cost increases would find their way quickly into the world price of the processed product. This procedure has obvious limitations. However from the point of view of the analysis it is of little consequence since Korea has only a minor trade in oil products with exports and imports of this commodity category roughly in balance.

commodities distinguished in the model.[1] The rationale for this scenario is the World Bank's working assumption that real oil prices will on average rise 3 per cent per year over the 1980's.[2] We assume further that these annual changes in world prices persist for up to five years. This scenario, assuming fixed base period commodity weights in indexes of import and export prices, is equivalent to an annual terms of trade decline for Korea of about 0.5 per cent.

4. Experiments and Results

We compare projections for a selection of endogenous variables across five experiments. The experiments reflect alternative assumptions about the macroeconomic environment in which the oil pricing shock is imposed, the economic objectives being pursued and the length of the adjustment period allowed for the shock to work its way through the economy.[3] These alternatives are specified simply by varying the form of model closure, that is by shifting model variables between exogenous and endogenous sets. The key variables whose chosen exogeneity or endogeneity in a particular experiment is especially relevant in shaping the macro-economic environments are; industry specific capital stocks, rates

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[1] The pricing scenario is imposed on the model by setting all elements in the exogenous commodity vectors representing (a) percentage changes in export demands and (b) percentage changes in world import prices, to zero except for those representing the commodities crude oil and petroleum products, whose elements are set to the percentage increases outlined above.

[2] See World Bank (1980).

[3] The approach is one of comparative statics. We generate and compare new equilibrium solutions from a framework which ignores leads, lags and adjustment dynamics.

of return to capital, real domestic absorption (aggregate real consumption, investment and government spending) the balance of trade, aggregate labour demand, real and money wages, commodity exports and the exchange rate. Table 3 indicates the exogenous/ endogenous settings of these variables across experiments. When specified as exogenous the value assigned to the variables is always zero.

Experiments 1 and 2 are conducted in a short run environment the designating characteristic of which is the assumption of fixed capital stocks in each industry. That is, the model determines the impact on endogenous variables of an increase in world oil prices after a period long enough for local prices of all commodities to adjust to the higher world oil prices, for domestic producers and consumers to adjust their purchases of imported and domestically supplied commodities and for domestic producers to change their labour force and their output level with their existing plant. Investment takes place but is not allowed to augment capital stocks in the solution period. We assume that the time required for all these price and quantity adjustments to work their way through the economy is two years and therefore cumulate the annual change in real oil prices for two years. The second distinguishing feature of the assumed short run environment is that of a slack labour market. Wages are set exogenously and employment levels in each industry are therefore demand determined. In experiment 2 real as distinct from money wages are held constant. That is, money wages are fully indexed to the model's consumer price index. Experiment 1 assumes however constant money wages.

Table 3. Specification of Alternative Macroeconomic Environments:

Oil Pricing Experiments

Variable [a]	Experiments				
	Short Run Adjustment		Medium Run Adjustment		
	1	2	3	4	5
Industry specific capital stocks	Exogenous	Exogenous	Endogenous	Endogenous	Endogenous
Industry specific rates of return	Endogenous	Endogenous	Exogenous	Exogenous	Exogenous
Aggregate real absorption	Exogenous	Exogenous	Endogenous	Endogenous	Endogenous
Balance of trade	Endogenous	Endogenous	Exogenous	Exogenous	Exogenous
Aggregate labour demand	Endogenous	Endogenous	Exogenous	Exogenous	Endogenous
Economy real wage rate	Endogenous	Exogenous	Endogenous	Endogenous	Endogenous
Economy money wage rate	Exogenous	Endogenous	Endogenous	Endogenous	Exogenous
Exports for commodities 3,4,6,7,8	Endogenous	Endogenous	Endogenous	Endogenous	Endogenous
Exports for commodity 5	Endogenous	Endogenous	Endogenous	Exogenous	Endogenous
Exchange rate	Exogenous	Exogenous	Exogenous	Exogenous	Exogenous

(a) All variables are expressed in percentage changes except for the balance of trade which is in first differences.

Hence world oil prices are assumed, via their effect on Korean domestic prices, to effect the real wage rate. In both experiments 1 and 2 we assume a constant level of real domestic absorption. This reflects the view that in the short run the level of aggregate absorption in Korea can be controlled by the economic planners independently of movements in the world price of crude oil.[1] Such world price movements do however have short run implications for the level and composition of domestic production and of imports and exports. With exogenous capital stocks in each industry (and exogenous supplies of land in the land using industries) together with exogenous labour supply and a fixed production technology, the Korean gross domestic product is effectively determined. This endogenous gross domestic product together with exogenous real absorption[2] implies an endogenous balance of trade.

Experiments 3 - 5 assume a medium term adjustment period of five years. The annual world commodity price changes are therefore cumulated for five years. The projections refer to a single nominal year five years hence. No attempt is made to trace the time path of endogenous variables between the base year and solution year. The key feature of the medium term environment is the abandonment of the capital fixity assumption. This is achieved by exogenising the vector of percentage changes in industry rates of return

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[1] Government fiscal and monetary policy for example (not modelled in this system) is assumed to be the short run determinant of aggregate domestic absorption.

[2] Aggregate domestic absorption in money terms is however endogenous.

to capital (endogenous in the short run closure). The paradigm justifying this takes the supply prices of capital for investment in Korean industries as being given on world markets. An exogenous shock such as the world oil price increase which causes rates of return in Korean industries to deviate from these long term global yields is assumed to cause the corresponding domestic industries to grow or decline at speeds over the five year period ensuring that the domestic rates of return are once again in balance with world rates in the projection year (year five).[1] The mechanism assumed to make this possible, but not explicitly modelled, is the international flow of capital.

In experiments 3 and 4 the aggregate level of labour demand is set exogenously while real wages are endogenous. This reflects the assumption that changes in world oil prices do not have over the medium term any necessary consequences for the real wage/employment mix. They do however have implications for the real wage level at a given level of employment.[2] In experiment 5 we reverse the labour market assumptions in 3 and 4 by assuming constant money wages and endogenously determined labour demands. The difference between experiments 3 and 4 applies only to the treatment of exports. Percentage changes in exports of each commodity in response to the exogenous shock can be determined endogenously (in which case the corresponding export subsidy is exogenous) or exogenously (in which case the corresponding export subsidy is endogenous).

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[1] Implicit is the assumption that the response period is sufficiently long enough to accommodate the reconfiguration of the capital stock occasioned by the world price changes. This requires ex post checking.

[2] Whether or not the exogenously specified overall level of labour demand corresponds to full employment is another matter beyond the scope of this analysis. In experiments 3 and 4 the variable representing the percentage change in aggregate labour demand is set to zero. That is, the employment rate is constant.

In all experiments except 4, the model determines exports endogenously for six commodity categories.[1] In experiment 4 however the percentage change in exports of commodity 5 (Textile products), which amounts to one third of total commodity exports in the base period, is set to zero. That is we assume that Korea is unable to lift its exports of textiles to generate the additional foreign exchange required to pay for its higher priced crude oil imports. By comparing results between 3 and 4 we seek to capture some of the economic implications for Korea of the so-called 'new protectionism', a characteristic of which is the imposition by the more advanced economies of import quotas on textiles and other standard technology manufactured goods exported from the newly industrialising countries such as Korea. The final distinguishing feature of the medium run economic environments in experiments 3 - 5 is the assumption of endogenous real domestic absorption, with the relevant variable set exogenously being the balance of trade. In this closure the model indicates the change in the level of absorption[2] needed to accompany the

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[1] Since exports in the model take place according to the differential between world prices and domestic production costs the model is allowed to explain exports for those commodities whose link to exports is such that their domestic currency prices can be regarded as being set by their corresponding world prices. The percentage change in exports for non-export commodities (those with only a small proportion of their sales passing to exports) is set exogenously to zero.

[2] The proportional composition of this absorption (between aggregate consumption, investment and government spending) is specified exogenously. In experiments 3-5 the relative shares of these components in the aggregate are assumed to be invariant to the shock. That is, balanced changes in absorption occur.

higher world oil prices to maintain a constant balance of trade.[1] A trade deficit in the face of the oil shock is not permitted over the medium term.

Finally note that in all experiments the exchange rate is set exogenously. This fixes the numeraire in model experiments. In such experiments the model endogenises the ratio of the domestic cost level relative to the foreign currency price of traded goods. It has nothing however to say about how the projected movements in this ratio are partitioned into changes in the exchange rate on the one hand and changes in the domestic rate of inflation on the other.

4.1 Macroeconomic, Industry and Commodity Results

Results across experiments are compared for some key macroeconomic variables (Table 4) and for selected industry and commodity variables (Tables 5, 7).

Of the many industry and commodity variables endogenised by the model we restrict the presentation to a subset which includes industry outputs and labour demands (Table 5) and commodity exports and

[1] In all experiments we have assumed balanced trade in the base period by ignoring, in the choice of weights in the model's balance of trade equation, a deficit in the balance of trade present in the 1975 input-output tables. Hence in experiments 3-5 where the model's balance of trade variable is set exogenously to zero, the percentage change in exports is forced to equal the percentage change in imports to restore the economy to balanced trade.

imports (Table 7). To help interpret these results Table 6 contains some additional information relating to production technology with respect to crude oil and oil products, fixed factor intensity, the disposition of commodity sales, import penetration and projections of value added price changes (for experiment 1) in each industry.

It is important to emphasise that the model is not being used here to provide forecasts about the likely level of endogenous variables at a future date. It merely projects the changes in the levels of these variables due to the postulated changes in the selected exogenous variables. It does this from a vantage point which assumes that the Korean economy is initially in a state consistent with the structural model and data base that gave rise to B in equation (17).[1] Thus in the short run experiment of column 1 the figure in line four of Table 4 indicates that, after an adjustment period of two years, aggregate labour demand (i.e. employment) would be 0.15 per cent lower than its level after two years had world oil prices remained unchanged. This projection is of course dependent on the numerous theoretical and parameter assumptions together with the assumptions of fixed industry specific capital stocks, constant real domestic absorption, fixed money wages and fixed industrial production technology. Similarly the figure in line two for column 3 of Table 4 indicates that, assuming the continuation for five years of the real world oil price increases discussed earlier, the economy-wide real wage would be 1.8 per cent lower in year five than it otherwise would have been in year five had no change in world commodity price relativities

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[1] Recall that B is a rectangular matrix whose coefficients are built up as (non-linear) functions of the parameters appearing in the model's structural form (i.e. in its production functions, demand relations, primary factor constraints etc.).

Table 4. Some Macro Projections: Higher World Oil Prices

Variable	Projections[a] for 5 experiments				
	Short run: fixed capital stocks		Medium run: mobile capital		
	1	2	3	4	5
Aggregate real absorption	O(Ex)[b]	O(Ex)	-1.17	-1.24	-13.39
Real wage rate	- 0.20	O(Ex)	-1.80	-1.99	- 0.67
Money wage rate	O(Ex)	0.47	-2.53	-3.10	O(Ex)
Aggregate labour demand	- 0.15	- 0.33	O(Ex)	O(Ex)	-13.01
Price index of consumer goods[e]	0.20	0.47	-0.74	-1.11	0.67
Price index of investment goods[f]	0.23	0.47	-0.37	-0.66	0.89
Aggregate exports (foreign currency value)	- 0.50	- 1.08	2.35	2.16	-10.38
Aggregate imports (foreign currency value)	0.99	0.88	2.35	2.16	-10.38
Balance of Trade (billion Won at 1975 Won/$ US exchange rate)	(c) -52.46	(d) -69.11	O(Ex)	O(Ex)	O(Ex)

(a) All projections are in percentage changes with the exception of the balance of trade.

(b) O(Ex) denotes an exogenous setting to O of this variable. That is the level is assumed to remain constant in the face of the oil price shock.

(c) Equivalent to 0.54 per cent of the 1975 gross national product.

(d) Equivalent to 0.71 per cent of the 1975 gross national product.

(e) Computed as a weighted average of the percentage changes in the domestic prices of consumer goods where the weights are commodity shares in aggregate consumer spending.

(f) Computed as a weighted average of the percentage changes in the costs of a unit of capital creation in each industry where the weights are the shares of total investment accounted for by investment spending by each industry.

occurred. This result is of course dependent on the assumptions of a constant balance of trade and constant employment being maintained.

We discuss the results for each experiment consecutively commencing with the short run experiments. To avoid the discussion becoming unwieldy a detailed rationalisation of the industry and commodity results is given only for experiment 1. It is hoped that sufficient detail about model structure and key input-output linkages is presented in this rationalisation to indicate to the reader the key mechanisms underlying the patterns of response in the other experiments.

Experiment 1

The key to an understanding of the results for this experiment is the domestic price level projection. The world oil price increases feed directly into the Korean economy as higher domestic prices for imported oil leading to higher domestic prices for oil products and production costs for industries through their intermediate usage of oil products. With world non-oil prices more or less fixed[1] in the face of increased domestic production costs, export and import competing industries suffer a decline in international competitiveness. This is reflected in a decline in aggregate exports, an increase in aggregate imports and a movement towards balance of trade deficit. The import expansion and export contraction produces a decline in real national income of 0.4 per cent.[2] The increase in the consumer price index of 0.2 per cent

[1] Some slight increases in world commodity prices occur as Korean commodity exports contract.

[2] This figure is calculated as a weighted sum of the percentage changes in real returns to land labour and capital in each industry. The same result is obtained from the national income identity that expresses gross domestic product in terms of its expenditure components.

implies a corresponding fall in the real wage level. Nevertheless aggregate labour demand falls by 0.15 per cent reflecting the lower domestic economic activity.

Variations in industry output response (Table 5) to the domestic cost-world price squeeze imposed on Korea by the oil shock can be explained essentially in terms of industry characteristics such as oil intensiveness in production, export relatedness, import competitiveness, reliance on sales to household consumption and to government and to fixed factor intensity. To illustrate how these linkages impinge upon output results we note that the nested production functions employed by the model imply short run industry supply functions of the form;[1]

$$z_j = \frac{\sigma_j S_j^W}{1-S_j^W} \quad (p_j^{VA} - w_j) \qquad (18)$$

where for industry j z_j is the percentage change in output, p_j^{VA} is the percentage change in the unit value added price of output[2], w_j is the percentage change in the unit cost of labour, σ_j is the elasticity of substitution between primary factors and S_j^W is the share of labour costs in total primary factor costs. In experiment 1 w_j is zero (fixed money wages in each industry). Hence industry j's short run output response may be partitioned into a component reflecting essentially its capital intensity

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[1] See Vincent (1981a) for details.

[2] This represents a weighted sum of the percentage changes in the prices of labour, fixed capital and agricultural land where the weights are the shares in total industry primary costs of each factor. Alternatively it represents the percentage change in product price modified by percentage changes in material input prices.

$(\frac{\sigma_j s_j^W}{1-s_j^W})$ and the percentage change in its value added price (p_j^{VA}). Values for these components appear in Table 6. The two industries with the lowest output responses are 1 (Agriculture and fishing) and 10 (Services). The oil price increase raises their production costs but because of their relative insulation from trade, both can pass on these cost increases in the form of increased selling prices for their products.[1] Both have extensive direct sales linkages to household consumption (66 per cent of total sales for 1. and 31 per cent for 10.[2]) which is assumed fixed in the experiment. This cushions the reductions in their value added prices and hence their subsequent output reductions even though industry 10 suffers cost burdens from its relatively high direct intensity of use of oil products.

The next lowest output responses are exhibited by industry 4. (Refined sugar) and 3 (Processed foods ex. refined sugar) both

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[1] Neither of these industries are export industries. Furthermore, industry 10's base year level of import penetration is only 1.5 per cent and industry 1's is 12.9 per cent. The loss of sales to imports in both cases is rather small. Imports of 1. increase by 0.09 per cent and 10. by 0.49 per cent.

[2] Industry 10 also sells 11 per cent of its output to government (whose real spending is assumed constant) as well as consuming itself 11 per cent of its output. A further 10 per cent of its sales are for creation of 'Services' capital. While aggregate real investment is assumed fixed, the investment budget is reallocated as a result of the oil shock away from the traded industries towards those with weaker trade linkages. Thus the boost in investment in Services (0.72 per cent) together with the direct link to Services capital creation further cushions the overall output contraction experienced by the industry.

Table 5 Projections of Industry Outputs and Labour Demands:

Higher World Oil Prices

Variable	Projections[a] for 5 experiments				
	Short run: fixed capital stocks		Medium run: mobile capital		
	1	2	3	4	5
Industry Outputs					
1. Agriculture and fishing	-0.01	-0.13	-0.23	-0.20	- 9.96
2. Mining	-0.23	-0.47	-0.29	0.12	-12.19
3. Processed foods (excluding refined sugar)	-0.13	-0.36	0.07	0.47	-10.89
4. Refined sugar	-0.08	-0.18	0.17	0.95	- 9.29
5. Textile products	-0.36	-0.81	3.20	-0.50	-17.00
6. Petroleum products	-0.31	-0.46	-1.33	-1.17	-14.24
7. Rubber products	-0.83	-1.54	1.39	3.94	-15.92
8. Other manufacturing export	-0.48	-0.87	-0.12	1.27	-17.19
9. Other manufacturing import	-0.29	-0.52	-0.75	-0.50	-13.20
10. Services	-0.04	-0.06	-0.93	-0.99	-13.80
Industry Labour demands					
1. Agriculture and fishing	-0.02	-0.17	0.22	0.32	-10.97
2. Mining	-0.34	-0.69	0.25	0.76	-12.47
3. Processed foods (excluding refined sugar)	-0.37	-1.00	1.22	1.78	-10.46
4. Refined sugar	-0.58	-1.35	1.79	2.82	- 8.79
5. Textile products	-0.75	-1.71	4.16	0.60	-16.67
6. Petroleum products	-1.43	-2.15	0.16	0.55	-13.81
7. Rubber products	-1.35	-2.51	2.14	4.82	-15.73
8. Other manufacturing export	-1.13	-2.06	0.97	2.52	-16.86
9. Other manufacturing import	-0.66	-1.17	0.25	0.64	-12.82
10. Services	-0.05	-0.08	-0.52	-0.53	-13.61

[a] All projections are in percentage changes.

Table 6 Industry Short Run Supply Function Components, Oil Input Intensity, Key Sales Linkages of Products and Import Penetration

Industry	Percentage change in value added price (experiment 1) p_j^{VA} (a)	$\frac{\sigma_j S_j^W}{1-S_j^W}$ (b)	Concentration of labour in each industry S_j^W (c)	Share of crude oil and oil products in total production costs (c)	Share of total sales represented by sales to household consumption (c)	Share of total sales represented by sales to exports (for endogenous export products) (c)	Ratio of imports of product j to total domestic production of product j (c)
1. Agriculture and fishing	- 0.003	4.069	0.744	0.019	0.655		0.129
2. Mining	- 0.137	1.669	0.676	0.028	0.037		0.164
3. Processed foods (excluding refined sugar)	- 0.298	0.448	0.359	0.015	0.657	0.062	0.040
4. Refined sugar	- 0.633	0.121	0.131	0.009	0.408	0.370	0.000
5. Textile products	- 0.492	0.724	0.475	0.017	0.222	0.364	0.055
6. Petroleum products	- 1.407	0.218	0.214	0.712	0.032	0.063	0.101
7. Rubber products	- 0.651	1.267	0.613	0.030	0.131	0.534	0.022
8. Other manufacturing export	- 0.818	0.586	0.423	0.037	0.130	0.334	0.169
9. Other manufacturing import	- 0.461	0.636	0.443	0.046	0.121		0.468
10. Services	- 0.014	2.492	0.757	0.063	0.314		0.015

(a) Derived from model solution

(b) $\sigma_j = 1.4$ for $j = 1$ and 0.8 for $j = 2 - 10$.

(c) Derived from model's input-output data base.

of which, because they are modelled as being endogenous export industries, have their domestic prices determined by their world prices. Hence both suffer a domestic cost-world price squeeze through the inflationary impact in Korea of the higher oil prices not being compensated by increases in their selling prices. The result is a contraction in value added price and output. The contraction in value added price is strongest for 4. because of its stronger export linkage (37 per cent of sales compared to 6 per cent of sales). Its short run output response is curtailed however because of its very high capital intensity. Labour costs constitute only 13 per cent of its primary factor costs hence the industry can not easily contract output by reducing its labour inputs (the only option in the short run given the fixed capital stock assumption). For both 3. and 4. the strong direct linkages to household consumption offset the loss of demand through exports. Next in line is industry 2 (Mining) which is not modelled as an export industry. However the main explanation for the reduction in its value added price lies in its indirect export connection via its linkage (17 per cent of its sales) to the export industry 8 (whose output contracts by 0.48 per cent) and its large indirect input linkage (41 per cent of its sales) to the import competing industry 9 (whose output declines by 0.29 per cent). Further, the relatively large labour intensity of Mining in Korea (labour costs constitute 68 per cent of primary factor costs) intensifies the short run output response.

Of the remaining five industries with the largest output contractions, three (industries 5,7,8) have strong direct export connections and one (industry 9) is highly import competing. Industries 5,7 and 8 have sales shares to exports of 36 per cent, 53 per cent and 33 per cent respectively. All contract exports and hence outputs in the face of the domestic cost-world price squeeze.

Industry 6 (Oil products) is modelled here as an export industry and hence its selling price is set by its world price. While the industry suffers big cost increases through its usage of crude oil (which represents 67 per cent of its production costs) and oil products (4 per cent of its production costs) these cost increases are partially offset by the increased selling price of oil products.[1] Nevertheless the decline in value added price is substantial. The resultant output contraction is cushioned by the high capital intensity of the industry.

The final industry 9. (Other manufacturing import) has diverse sales linkages throughout the domestic economy. It supplies intermediate inputs to all industries for current production and for capital creation. Its output decline is explained primarily in terms of the shrinking domestic market it supplies. This industry,

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[1] Recall that the world oil price scenario involves a 3 per cent annual increase in crude oil prices and a 2 per cent annual increase in oil products prices.

with a base year import penetration of 47 per cent, would seem particularly susceptible to import competition.[1] Note however from Table 7 that imports of 9 show a slight fall though this fall is considerably less than the average contraction in domestic economic activity. Hence while domestic cost increases generate pressures for import replacement these are more than outweighed by the shrinkage of the domestic market for industry 9's products. The net result is an increase in the share of total usage of 9 met by imports of 9 (i.e. increased import penetration) but a slight decline in total imports of 9.

Industry Labour Demands

Given the short run capital and land fixity assumption, percentage changes in industry labour demands (ℓ_j) are directly proportional to changes in industry outputs (z_j). We can write that

$$\ell_j = z_j / S_j^W \qquad (19)$$

where S_j^W is the share of labour in total primary factor costs in industry j. The S_j^W are contained in Table 6. From Table 5 we see that as a result of the oil price increase the reduced aggregate demand for labour is redistributed away from those industries with direct and indirect export linkages and towards those whose sales orientation is concerned more with the domestic economy.

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[1] According to the model, the vulnerability of an industry to import competition is an increasing function of the base period import penetration by the commodities of that industry and the users' elasticity of import substitution. The import substitution elasticity is assumed to be 2.0 in all end uses.

Commodity Exports and Imports

Projections of percentage changes in commodity exports and imports are shown in Table 7 . The reasons for the negative export responses have already been discussed in the explanation of industry output response for the export industries. For industries with close export links the ratio of industry output response to the share of total sales absorbed by exports will provide a good indication of export response.

Two opposing forces are relevant in explaining competing commodity import response. The first relates to the size of the domestic market and the second to the import replacement effect - the extent to which domestic users of competing import products substitute against the domestic product because of its increased cost relative to the imported product. We note from Table 7 that for a number of competing import commodities total imports actually fall even though the domestic competing industry is confronted with a cost-price squeeze. However, the fall in imports is less than the fall in outputs in the corresponding commodity categories indicating that the contribution to increased imports made by the import replacement effect is outweighed by the contribution made by the decline in

the overall size of the domestic market.[1] On the other hand, the increase in import demand for

[1] Consider for example the import projection for commodity 2 (-0.22 per cent). 33 per cent of imported good 2 is absorbed by industry 8. and 64 per cent by industry 9. for current production. The model's import demand equations for competing good i when used by industry j for current production ($x^{(1)}_{(i2)j}$) are given by;

$$x^{(1)}_{(i2)j} = \underset{\text{(scale effect)}}{z_j} - \sigma^{(1)}_i \underbrace{(p_{(i2)} - \sum_s S^{(1)}_{(is)j} p_{(is)})}_{\text{(import substitution effect)}} \qquad (20)$$

where $\sigma^{(1)}_i$ is the elasticity of substitution between imported and domestic good i in current production, $p_{(is)}$ is the percentage change in the price of good i from source s (s = 1 (domestic) = 2 (imports)) and $S^{(1)}_{(is)j}$ is the share of the total usage of good i in industry j for current production represented by good i from source s. For j = 8 and j = 9 we have from (20) after substituting values for projected variables and model parameters

$$x_{(22)8} = -0.48 - 2.0(0 - 0.29 \times 0.22) = -0.48 + 0.13 = -0.35.$$

$$x_{(22)9} = -0.29 - 2.0\ (0 - 0.34 \times 0.22) = -0.29 + 0.15 = -0.14.$$

Note that in both cases the positive contribution to import demand by import substitution (+ 0.13 per cent and + 0.15 per cent for sales of good 2 into industries 8 and 9 respectively) is more than outweighed by the contraction in the size of the domestic market (-0.48 per cent in industry 8 and -0.29 per cent in industry 9. Total imports of good 2 ($x_{2,2}$) are therefore approximated by;

$$x_{(2,2)} \simeq 0.33 \times -0.35 + 0.64 \times -0.14 = -0.21$$

which agrees closely with the model projection of -0.22.

Table 7. Commodity Export and Import Projections: Higher World Oil Prices

Variable	Projections for 5 experiments					Share in base year commodity exports (c)
	Short run: fixed capital stocks		Medium run: mobile capital			
	1	2	3	4	5	
Exports (a)						
3. Processed foods (ex refined sugar)	-2.12	-5.43	12.32	18.74	-11.99	0.04
4. Refined sugar	-0.20	-0.43	1.71	3.78	- 6.60	0.02
5. Textile products	-0.64	-1.46	6.74	O(Ex)	-16.82	0.34
6. Petroleum products	-2.09	-2.63	-9.90	-7.89	-17.93	0.02
7. Rubber products	-1.44	-2.69	3.27	7.97	-16.97	0.04
8. Other manufacturing export	-1.06	-1.88	0.02	4.72	-20.00	0.31
	1	2	3	4	5	Share in base year commodity imports (c)
Imports (b) (competing)						
1. Agriculture and fishing	0.09	0.51	-2.62	-3.08	-11.26	0.11
2. Mining	-0.22	-0.05	-2.25	-2.25	-14.01	0.01
3. Processed foods (ex refined sugar)	-0.08	-0.07	-1.13	-0.93	-12.47	0.02
5. Textile products	-0.23	-0.49	1.18	-1.55	-15.26	0.03
6. Petroleum products	0.12	0.10	0.07	-0.13	-11.36	0.02
7. Rubber products	-0.22	-0.44	0.13	-0.17	-13.34	0.00
8. Other manufacturing export	-0.26	-0.48	-0.04	0.03	-14.79	0.10
9. Other manufacturing import	-0.08	-0.25	-0.44	-0.63	-12.52	0.33
10. Services	0.49	1.01	-1.81	-2.59	-11.94	0.03
Imports (non-competing)						
11. Cotton	-0.36	-0.81	3.20	-0.50	-17.00	0.03
12. Raw sugar	-0.08	-0.18	0.17	0.95	- 9.29	0.02
13. Rubber	-0.83	-1.54	1.39	3.94	-15.92	0.01
14. Crude oil	-0.31	-0.46	-1.33	-1.17	-14.24	0.17
15. Other non-competing imports	-0.39	-0.71	-0.13	0.48	-15.32	0.12

(a) In experiments 1-3 and 5 exports are endogenous for commodites 3-8. In experiment 4 exports are endogenous for commodities 3,4,6-8.

(b) There are no imports of commodity 4 (Refined sugar) in the data base.

(c) Derived from model's input-output data base.

say commodity 1 is explained primarily by the fact that 38 per cent of imported good 1 is sold to household consumption whose aggregate level is fixed. Because of relative consumer price changes consumers reorganise their consumption budget more towards commodity categories such as 1. whose price increase for its domestically supplied component is less than that for consumer goods as a whole.[1] Thus in the model's consumer demand equations (which consist of a scale component representing the total consumption of category i undifferentiated by source and a substitution component accounting for the change in relative prices between the domestic and imported source of i) the positive contribution to demand for imported good 1 for household consumption from the substitution effect is reinforced by the scale effect of increased consumption of category 1.[2]

Finally, we note that imports of all non-competing import commodities contract. The size of the contraction is identical to the output contractions of the industries into which the non-competing imports are sold. (By definition there is no import replacement effect). Thus for example Cotton imports (which are absorbed entirely by the Textile products industry) contract by the same amount as the industry output for Textile products.[3]

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[1]The domestic price of domestic good 1 increases by 0.12 per cent compared to the average increase of consumer goods prices of 0.20 per cent. Oil products constitute only 1.9 per cent of industry 1.'s production costs. Hence the direct effect of higher oil prices on its production costs is minor.

[2]This result can be checked via substitution of projections into the model's system of household demand equations. See Vincent (1981 a) for a complete specification of these equations.

[3]Raw sugar is consumed entirely by Industry 4, Rubber by Industry 7. and Crude oil by Industry 6. Other non-competing imports are absorbed however by a number of domestic industries.

Experiment 2

Experiment 2 differs from experiment 1 only in that domestic price increases are allowed to flow on fully into money wages. Thus while in experiment 1 the increased inflation of 0.2 per cent reduced real wages by 0.2 per cent, in experiment 2, by holding real wages constant, we abstract from any effects world oil price increases may have on real wages. With wages in Korea constituting about 60 per cent of total production costs, the domestic inflationary effects of the world oil price increase observed in experiment 1 are exaggerated. This leads to a more intensive domestic cost-world price squeeze on traded (principally export) industries with the result that the adverse effects on these industries for economic activity and employment discussed in experiment 1 are sharply increased. Note however that the economy gains some respite on the import side. Despite the deterioration in the competitive position of domestic industries competing with imports, the import replacement effect is dominated by the scale effect associated with the sharply reduced level of domestic economic activity. Korea's heavy reliance on non-competing imports (which constitute 35 per cent of total imports in the base period) is of particular relevance here. Thus the short run increase in the balance of trade deficit and hence the reduction in the economy's real income level in experiment 2 compared to 1 is somewhat modified.[1]

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[1] Although the percentage decline in aggregate exports in E 2 is double that in E 1, the increase in aggregate imports is actually slightly lower in E 2 than in E 1. Hence the balance of trade deterioration is only from 0.54 to 0.71 per cent of the base gross national product and the fall in real national income in E 2 is 0.5 per cent compared with 0.4 per cent in E 1.

Experiments 3 and 4

The basic mechanism driving the results in these experiments comes about via the balance of trade constraint. The initial effect of the higher foreign currency cost of imported crude oil is to push the balance of trade towards deficit. However, given the imposed assumptions of a constant balance of trade and constant employment, this initial tendency towards deficit must be eliminated by a reduction of the domestic price level relative to world prices[1] sufficient to cause a redirection of resources from the domestic to the international account. This in turn necessitates a reduced level of domestic absorption which reflects the reduced terms of trade confronting Korea. This decline in the economy's terms of trade is reflected in a reduction in the productivity of domestic labour which is translated into lower real wages at the constant employment level. Thus we note that in experiment 3 for example reductions in the domestic prices of all commodities except crude oil and oil products are sufficient to cause a 0.7 per cent reduction in the model's consumer price index.[2] To restore external balance

[1] As noted earlier the model has nothing to say about whether the return to balance of trade equilibrium comes about via lower domestic inflation (reflecting for example the deflationary effects of a reduced money supply) or by an exchange rate devaluation, or by both. Whatever the combination of these two methods the effect is to increase the prices of tradeable goods relative to the prices of non-tradeables. The competitive position of the traded goods sector is therefore enhanced.

[2] Since world prices for crude oil and oil products are being increased the fall in the domestic price level relative to world prices is somewhat greater than this.

and maintain employment the higher world oil prices must be accompanied by a reduction in real national income[1] of 1.2 per cent and a reduction in real wages of 1.8 per cent. Because of the enhanced international competitiveness of traded, especially export, industries the industrial composition of the gross domestic product (as reflected by the pattern of industry output response in Table 5), and the pattern of industry labour demands (Table 5) is biased towards the export oriented industries.[2] The export led growth in outputs of these industries is responsible for the increased import demand for the non-competing imports Cotton, Raw sugar and Rubber. In the case of competing imports for categories 1, 2, 9 and 10, the negative contribution to import demand made by the contraction in the size of the domestic markets which consume them is reinforced by the import substitution effect (lower domestic price of the domestically produced good relative to its imported counterpart).[3]

[1] Note that in experiments 3, 4 and 5 which force the external account to be balanced the projected percentage change in real absorption is identical to that for real national income.

[2] The exception of course is the oil products export industry which still finds itself in a cost-price squeeze. The reduced domestic costs of its non-crude oil inputs together with the increased selling price for its product is insufficient to offset the greatly increased price it must pay for crude oil.

[3] Because of the high sectoral aggregation of the model, some commodity categories classified as export (and hence having their domestic prices determined by world prices) are also shown as doing small amounts of importing in the base period. The import projections for such commodities, while of no consequence to the overall results, are somewhat artificial. They contain an import substitution effect which arises because of a differential between domestic prices of the domestically produced and imported good following the change in exports of the domestic good and its effects, via the slight slope of the foreign demand curve, on the export and hence domestic price. The projection for category 6 is a good example. Recall that the foreign price scenario involves equal percentage increases in the world import price of oil products and the world export price (in the absence of a change in Korean exports) of oil products. The contraction in Korean exports of oil products leads however to a slight increase in its world and hence domestic price. Thus there is a substitution by domestic users towards the imported product. This effect dominates the projection.

Consider now the differences in results between experiments 4 and 5. Recall that these experiments differ only to the extent that in experiment 5 the percentage change in exports of commodity 5 (Textile products), which constitutes nearly one third of Korea's total commodity exports in the model's base year, is set exogenously to zero. With Korea no longer able to offset its increased foreign exchange requirements for imported crude oil by increased export earnings for Textile products it is forced to redirect resources heavily into other major export sectors (principally 8. Other manufacturing export). In addition Korea saves foreign exchange by a process of import substitution in industries where this is possible.[1] Note however that the higher export performance of industries 4 and 7 results in increased requirements of the non-competing imports raw sugar and rubber. The macroeconomic cost of this forced redirection of domestic resources towards other export sectors and import competing sectors is a further reduction in domestic absorption and real national income together with a reduced real wage rate to sustain employment.

Before leaving experiments 3 and 4 we note that the decline in the real returns to labour (real wages) is considerably greater than the decline in real national income. This reallocation of factor returns away from labour can be thought of in terms of the well known theorem of Stolper and Samuelson.[2] In experiment 3 for example the terms of trade decline associated with the higher oil prices causes an expansion in the outputs of industries 3, 4, 5 and 7 and a contraction in the outputs of 1, 2, 6, 8, 9 and 10. We see from Table 6 that these expanding industries

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[1] This can be seen most clearly by the reduced imports of the competing import category 9 in experiment 5 compared with 4. With a base year import share of 47 per cent it is in this category that the scope for import substitution is greatest.

[2] See Stolper and Samuelson (1941).

have an average labour intensity (labour share of value added) of 0.39 compared with an average for the group of contracting industries of 0.54. That is, in accordance with the theorem, the real reward of the factor employed relatively intensively in these expanding industries (capital) increases at the expense of the real reward earned by labour.[1]

Experiment 5

The results for this experiment indicate the severely deflationary consequences for the domestic economy should real wages not be allowed to respond fully to the deterioration in the terms of trade implied by the world oil price increases. Assuming fixed money wages Korea can only meet its foreign exchange constraint at the expense of a severe contraction in economic activity and sharply increased unemployment in all sectors. In line with the sharp decline in overall economic activity is a slump in both commodity exports and imports.

5. Conclusion

This paper has used a multisectoral general equilibrium model to quantify, under a range of assumptions about the macro-economic environment, the implications for the level and

[1] Experiment 4 tells a similar story. The five industries whose outputs expand (2,3,4,7,8) have an average labour intensity of 0.44 compared to 0.53 for the five contracting industries.

composition of economic activity in Korea of continued increases in real world oil prices. In the short term, increases in world oil prices generate domestic price increases and hence impose a domestic cost-world price squeeze on export industries. Given the openness of the Korean economy and its total reliance on imported oil, the results indicate the importance of reductions in real labour costs to mitigate against the adverse short term effects of higher world oil prices on aggregate labour demand, the balance of trade, and the contractionary pressures confronting industries in the traded goods sector. The non-competitiveness of much of Korean imports (as reflected in the high share of total imports accounted for by raw materials not produced in Korea) is an important factor in reducing the short run deterioration in economic activity, employment and the balance of trade.

Given the assumption that over the medium term the Korean economy faces a balance of trade constraint, the domestic price level must be reduced relative to world prices for the economy, by way of export expansion, to generate the additional foreign exchange needed to pay for the higher priced oil imports. Over the medium term, for Korea to avoid both domestic employment and balance of trade problems from increasing world oil prices, real wage cuts must be accompanied by cuts in real domestic expenditure to facilitate the necessary release of resources from the domestic to the international account. A government policy response to the higher oil prices which fosters both aggregate expenditure cuts and wage reductions while simultaneously assisting the flow of resources into key export industries could do much to speed the

adjustment process and hence preserve domestic employment. External trade barriers which prevent Korea expanding exports of a key export commodity such as Textile products to offset the higher foreign currency costs of imported oil, by forcing Korea to engage in import substitution and expansion in export industries with reduced comparative advantage in trade, intensify the size of the real wage and domestic expenditure cuts that are needed for Korea to simultaneously maintain employment and meet its balance of trade constraint.

As with all studies of an applied nature, the results are conditional on the assumptions underlying the economic structure of the model used. In particular, it should be noted that the model's base year production technology refers to 1975 and that over the projection period, production techniques are assumed fixed. The fact that the base year production technology is a little dated is unlikely to matter much. The crucial factor underlying the results is Korea's net import dependence on imported oil. This has shown little improvement since 1975. The constant technology assumption over the projection period sets a limit on the plausible projection horizon. To the extent that Korea can reduce its import dependence on imported oil and/or achieve a unilateral improvement in domestic production techniques over this period then this would help offset the extent of the terms of trade decline associated with the increased world oil prices and the size of the subsequent resource adjustments and decline in material living standards.

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