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A KOREAN AGRICULTURAL GENERAL EQUILIBRIUM MODEL OF TRADE

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This study represents an attempt to analyze the effect of Korea's agricultural trade liberalization on resource allocation and welfare. For this purpose, this study has constructed a computable general equilibrium model which is tailored to study the agricultural aspect of the Korean economy.

The Korean Agricultural General Equilibrium Model (KAGEM) allows one to simulate and examine various economic policies such as internal and external tax policies. The KAGEM has two different versions: Walrasian and non-Walrasian. Generally, results show that tariff reduction discourages agricultural production activity more than other sector's. However, agricultural protection through the subsidy program seems to have a positive effect on output and national welfare. It is observed that trade liberalization may reduce welfare level in the short run. As expected, wage fixity brings more loss of consumer surplus and of output and employment under trade liberalization.

Throughout the study, a strong general equilibrium effect seems to prevail when external policy changes are introduced. Thus the KAGEM is shown to be fully equipped to provide the general equilibrium effect of agricultural trade liberalization on activities of various economic agents.

1. Introduction: Agricultural Trade Policy Analysis

Korea has been recently pressured by its major trade partners to open its market to their goods and services, especially agricultural and food products. The agricultural sector has been most highly protected not only on the basis of an intraindustry protection strategy based on comparative advantage arguments but also on the ground that it accounts for 16 percent of total employment (from 1988 to the present) and that national security is based on a self-supplied food scheme. Thus, the policy measures shielding this sector from competitive pressure on markets for goods, capital and labor are stronger and the burden consumers have to bear is heavier than in most other protected industries. Since other manufacturing industries have proved their competitiveness against foreign goods through export activities, the liberalization scheme on those sectors is not expected to affect the economy substantially. Therefore our primary attention is focused on

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the most protected industry, agriculture, which is presently facing liberalization pressure from foreign countries.

Given these circumstances, the examination and evaluation of the actual economic consequences of agricultural trade liberalization for the country is of utmost importance. A consideration of the linkage effect across sectors places great significance on the study which will trace the connecting mechanism between agricultural policy and the consequences on other sectors as well as on the agricultural sector itself.

In this context this study aims to develop a general equilibrium model which can accommodate the need for policy-counterfactual experiments and, hence, show the real effects of the incipient agricultural trade liberalization on various aspects of the economy. The interlinkage effect of decentralized economic units such as demanders and suppliers within and across sectors is to be examined to clarify the characteristics of the relationship between a change in policy variables and economic consequences such as output and employment levels.

Methodological Issues

Traditionally, the analysis of the effects of trade policy on welfare through resource allocation has heavily relied on a partial equilibrium framework using the nominal protection rate (NRP) and effective rates of protection (ERP) as seen in Balassa (1980) and Manasan (1983). The NRP is the difference between domestic price and import price. The usefulness of the NRP as an indication of the effectiveness of protection depends on the limited assumption that all trade takes place in final commodities. This can be expressed for the production side as

(1) $\hat{X} = \Sigma^{S} NRP$

where $\hat{X} = dX/X$; a percentage change in output
Σ^{S}= price elasticity of supply
NRP = tariff rate and
$i = 1, 2, \ldots n$ (sector)

Resource pulls in any sector would, therefore, depend on its own supply elasticity and on tariff rate. As noted earlier, this measure is based on the assumption that there is no interindustry linkage. Accordingly, the ERP must be more realistic in measuring the protection rate because it incorporates the fact that a tariff provides an incentive to the protected sector (X_2) and imposes a tax on the product of other sectors

(X_1) using X_2 as an input. The ERP is defined as the percentage excess of domestic value-added over free trade value-added of a given activity resulting from a trade policy, here, tariff imposition.

However, Bhagwati and Srinivasan (1979) and Ethier (1977) pointed out that the ERP neglected the general equilibrium effects. Several studies have investigated the implications of substitution among inputs for the calculations of ERP in both partial and general equilibrium terms (Anderson, 1970; and Taylor and Black, 1974), while others addressed the implications associated with the presence of nontraded intermediate inputs (Ray, 1973; Schweinberger, 1975; and de Melo, 1980). A critique on the ERP is well-discussed by Dervis, *et al.* (1982) with terms of trade effect in a general equilibrium framework.

Using the input-output relationship that intermediate inputs are purchased in fixed proportions and assuming that protection of a small country arises from tariffs, the ERP is defined as

(2) $$ERP = \frac{PN^1}{PN^\circ} - 1$$

where $PN^k = [\overline{PW}\,(1 + tm^k) - \sum a_{ji}\,\overline{PW}\,(1 + tm^k)]\,ER$

PN_i = net price or value-added per unit
PW_i = world price of imports
a_{ji} = input-output coefficient
tm_i = tariff rate
ER = exchange rate
K = 0, 1 denoting before and after the change in tariff rate.

However, the ERPs are calculated in a partial equilibrium framework, in the sense that there is no impact on exchange rate and on factor income level. Suppose the economy consists of three goods — home goods, importables and exportables — and substitution is possible among them. The Walras law and the budget constraint of government ensure that the excess demand for home goods due to tariff imposition is exactly equal to the balance of trade surplus valued at domestic, undistorted prices. To restore an equilibrium in the external market, the exchange rate must be appreciated.

The effect of tariff on the exchange rate level must be considered in order to examine more realistically the effect of trade liberalization on various aspects of an economy. Also the change in net price due to a change in tariff rates may affect the firms' demand for factors and, hence, output supplies.

Using a two-factor CES production function and assuming sector-specific capital, Dervis *et al.* (1982, pp. 204-205, 265) derived the equation of supply response to tariff rate changes, which incorporates factor market response:

(3-1) $\widehat{X}_i = \Sigma_i^s (\widehat{PN_i} - \widehat{W})$

(3-2) $\sum_i^s = \xi_i [\alpha_i / (1-\alpha_i)]$

where ξ_i = substitution elasticity of factors of labor and capital

α_i = labor share parameter in the CES production function

$\widehat{PN_i}$ = dPN_i/PN_i, a percentage change in net price and

$\widehat{W}$ = dW/W, a percentage change in labor price.

It is noted that supply elasticities (Σ^s) are greatest in labor-intensive sectors with high substitution elasticities (ξ). Equation (3-1) takes into account the factor market response and the presence of nontraded goods, because $\widehat{PN}$ is the value inclusive of changes in relative prices among nontraded goods.

The above comparative analysis of partial and general equilibrium estimates of resource pulls are well-discussed both theoretically and empirically in Taylor and Black (1974), de Melo (1978, 1980, 1987) and Dervis *et al.* (1982). An important lesson derived from the discussion above for the present study is that the more realistic estimate of the effect of agricultural trade liberalization on the economy must be the general-equilibrium-based estimates.

The development and use of computable general equilibrium (CGE) models allow for the general equilibrium analysis of a wide range of trade policy issues in economies where autonomous decision-making and market mechanism play a crucial role in resource allocation. The CGE model is built around certain specific ingredients depending on what policy interventions the model concentrates on. The CGE models are firmly rooted in microeconomic agents. The model looks into interdependencies within and across sectors in production, consumption and trade via the price mechanism that influences the behavior of rational economic agents in each market. For an application to trade, the trade activities become endogenous with a trade balance/imbalance condition specified. Then the ERPs, inclusive of general equilibrium effects discussed earlier, are incorporated in the models. Such a model is adapted here to satisfy the objectives of the present study.

2. Model Specification

Overview of CGE Models

The general equilibrium model of an economy is the outcome of nearly two centuries of conceptual development and continued intellectual refinement. It traces back to Adam Smith's description of the behavior of capitalists motivated by considerations of profitability in the selection of economic activities. The elements of demand theory appeared in John Stuart Mill's international trade model which analyzes the response of economic agents to changes in taxes and tariffs. In 1874, Leon Walras presented a general description of the functioning of a complex economic system in which prices and quantities are simultaneously and interdependently determined.[1] Arrow and Debreu (1954) constructed a precise logical model of the interaction of consumers and producers based on the Walrasian framework. This model was further elaborated by Arrow and Hahn (1971). The computable general equilibrium (CGE) model is a consequence of the effort to convert the Arrow-Debreu model from an abstract representation of an economy into realistic models of actual economies. The idea is to use these models to evaluate alternative policy regimes by specifying production and demand behavior in Walrasian framework and incorporating the data reflective of real economies in the multisectoral framework of the Keynesian economy (Shoven and Whalley, 1984; and Fretz, Srinivasan and Whalley, 1986). Policy implications of the model were initiated by Wassily Leontief's work on empirical Walrasian models based on fixed input-output coefficients.

Earlier works by three economists provide the background of the empirical general equilibrium analysis of policy implications on resource allocation and on welfare of economies. Johansen (1960) formulated the first empirically-based multisector, price-endogenous model to analyze the effects on resource allocation of the Norwegian trade policy. Harberger (1962) investigated tax policy questions numerically in a two-sector Walrasian economy. Harberger's method provided the basis of both analytical and numerical specifications in higher dimensionality and recently developed trade models. A final important source of stimulus has been the computer algorithm for the numerical determination of a Walrasian system, developed by Scarf in the 1960s. Scarf's discovery of numerical solution techniques provided the basis

[1]Thus, a general equilibrium model is often called the Walrasian model. The term "applied general equilibrium" (AGE) is often interchanged with "computable general equilibrium" (CGE).

for constructing the CGE models in the early 1970s. At this stage, the feasibility of construction and solution had been demonstrated by Shoven and Whalley (1972 and 1974), who examined the effects of tax and trade policies on resource allocation. The long-time gap between Johansen (1960) and Shoven and Whalley (1972) is noted[2].

Research on economy-wide multisectoral models has been carried out by other groups as well. In Australia, the ORANI model was constructed by Dixon, Parmenter, Sutton and Vincent (1982), with the cooperation of a number of government agencies, to apply it to policy reform proposals. The World Bank group represented by Robinson, de Melo and Dervis developed the CGE models where the solution algorithm is different from Scarf's. While Scarf used Blower's fixed point theorem, the World Bank group applied the tatonnement process in the late 1970s and later adopted the Newton-Raphson method using Jacobian algorithm. These models share with the Scarf-Shoven-Whalley tradition the same concern to quantitatively address microeconomic policy issues on an economy-wide basis (Piggot, 1985). However, their theoretical bases differed from each other. The Scarf-Shoven-Whalley model is a prototype of the Walrasian framework while the World Bank models allow non-Walrasian specifications such as fixed wage and endogenous output change corresponding to fixed price. The ORANI model typically separates demand from income. This treatment allows macroeconomic issues to be addressed (through the exogenous adjustment of aggregate demand) in the context of a model with many production sectors.

A recent analysis of the difference between the social accounting matrix (SAM)-based models and the CGE models is presented by de Melo (1988) and Robinson and Roland-Holst (1988). The latter derived both multiplier matrices and compared one to the other. They showed that Keynesian multipliers at the macro level have multiinstitutional counterparts in the SAM-based models. These linear models tend to be completely demand-driven and do not incorporate supply constraints or substitution possibilities. Marginal multipliers are derived for the CGE models using the Jacobian at a given equilibrium. Conclusively, the CGE models, as seen above, have been developed to capture nonlinear substitution possibilities and multisectoral supply-demand interactions, as well as incorporate macro variables and mechanisms for achieving balance among aggregates.

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[2]See Bergman (1980) for the possible reasons for such gap.

A Korean Agricultural General Equilibrium Model of Trade[3]

The Korean Agricultural General Equilibrium Model (KAGEM) was developed for the purpose of the study in the traditional spirit of CGE models described above. KAGEM is basically a variant of the World Bank model in Dervis et al. (1982). Since it accommodates the features of the agricultural trade regime, the KAGEM is multisectoral, consisting of 11 sectors of which seven are agro-based (See Appendix A). The KAGEM is designed to simulate the Korean economy where prices and quantities of goods and factors adjust to clear markets, resulting in general equilibrium. The system which governs the market mechanism is based on the optimizing behavior of individual economic agents.

The mechanism whereby a structural change in foreign trade regime influences the resource allocation in the economy is traditionally understood under the assumption that domestically produced and foreign goods are perfect substitutes in use. In some developing countries, especially like Korea, the perfect substitution assumption is not well suited, because many imports are used as complementary goods in many manufacturing sectors. Also, even at a fair level of aggregation of sectors, each sector represents a bundle of different goods. Grubel and Lloyd (1975) and Lancaster (1980) pointed out that the problem is not only one of aggregation but it also depends on the characteristics of the commodities produced in each sector. A formulation that allows one to use aggregative commodity categories across countries but specifies product differentiation by country of origin was proposed in a partial equilibrium framework by Armington (1969). The adoption of Armington's imperfect substitution assumption in the study helps us to capture some of the structural characteristics of the economy. The demands for imports and domestically produced goods become new derived demands, analogous to those for factor inputs in a production model. Then domestic prices become no longer exogenously determined with product differentiation.

On the export side, a small country assumption is adopted in the sense that the changes in the foreign currency price of domestic exportables have no effect on the world demand as well as on the world price level for such commodities. However it is assumed that Korea's domestic price level is negatively related with its market share. This treatment is consistent with the fact that products are differentiated by origin as specified on the import side.

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[3]The mathematical model is presented in Appendix A.

Product supplies are determined by production functions which adopt constant elasticity of substitution between primary factors such as labor and capital. Capital is sectorally fixed so that the model is of a short-run type. The demand for intermediate inputs is determined by the Leontief technology. Thus only demand for labor is derived from the profit maximization process. Two attempts are made for the specification of the Korean labor market. One is the purely Walrasian type such that flexible wage clears the market. The other one reflects wage rigidity in all sectors. It is assumed that labor is homogeneous. With regard to domestic final demand, one household is employed. Both government and households purchase goods according to fixed expenditure shares. The sources of government income are the collection of both internal (direct and indirect) and external (tariff and import duty) taxes. The level of government expenditures is kept constant. The level of investment demand is given exogenously so that investment demand can determine the saving rate.

The above features are incorporated into CGE modelling with the classification of endogenous and exogenous variables. A general specification of a CGE model takes the form of a continuously differential function:

(4) $y = f(x, y)$

where y denotes a vector of endogenous variables and x denotes a vector of exogenous variables.

Assuming initial equilibrium, the relation between two vectors can be seen by totally differentiating equation (4):

(5) $dy = Dxf(x, y)\, dx + Dyf(x, y)\, dy$

where $Dx = \partial f/\partial x$ and $Dy = \partial f/\partial y$.

Solving this equation for dy yields the multiplier model:

(6) $$\begin{aligned} dy &= [I - Dyf(x, y)]^{-1} Dxf(x, y)\, dx \\ &= [I - Dyf(x, y)]^{-1} DD\, x \\ &= MDDx \end{aligned}$$

where $DD\, x = Dxf(x, y)\, dx$ and M is the multiplier. This multiplier model captures the equilibrium dependence of the endogenous variables on one another as well as on exogenous shocks.

Since the KAGEM is a general equilibrium model, the excess demand equations are not independent by Walras law. In other words, a numeraire is required to solve the model. Considering the characteristics of the Korean trade regime, the exchange rate is fixed. Moreover, foreign capital inflow is exogenously given to represent the management policy of balance of payments. Then all the domestic prices would adjust endogenously to balance product markets as well as the external sector. This specification allows general price effect of trade liberalization to the model (Condon and Dahl, 1987). Therefore the sectoral effective exchange rate, together with trade elasticities, becomes an important factor in clearing various markets in the model.

The KAGEM allows one to simulate and examine various price intervention policies once numerical specification of the model is completed. Simulations can be done to specifically selected sectors and to all the sectors as well. For the simulations two policy parameters are chosen: tariffs and production subsidies. The numerical specification of the KAGEM requires benchmark equilibrium data and parameterization.

3. Benchmark Equilibrium Data and Parameterization

The year 1985 has been chosen to be the benchmark year for the equilibrium data set for three reasons.[4] First, it is so far the latest year for which a complete set of production, household and government accounts could be assembled in 1985 input-output data from various sources. Secondly, the year is regarded as a good candidate for an equilibrium year because steady economic growth and trade balance improvement toward surplus have been observed since then. Finally, there was no severe external shock to the economy, like the oil crisis, in 1985.

The major sources of data used to construct a benchmark equilibrium for the model are the following:

(1) The *1985 Input-Output Table of Korea* prepared by the Bank of Korea. Volume 1 contains various input-out tables at a 402-sector disaggregation level and 65-sector employment tables. Volume 2 includes input-output tables with 20 x 20, 65 x 65 and 161 x 161 sector classifications.

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[4]A benchmark equilibrium data set is defined as a collection of data in which equilibrium conditions of an assumed underlying equilibrium model are satisfied. (See for details Mansur and Whalley, 1984, pp. 91-93.)

(2) *Major Statistics of the Korean Economy, 1988*, presented by the Economic Planning Board of Korea.

(3) A report on the 1980 Input-Output Tables published by the Bank of Korea.

(4) Various literature.

The production sectors are aggregated into 11 sectors, six of which are agricultural. The reasons for such grouping are to conform to the purpose of the agriculture-biased study and to reflect the similarities among the commodities involved.

The values of all the parameters are estimated using the equilibrium data set as point estimates in combination with a literature search and informed judgement for exogenous parameters.[5] This deterministic estimation requires benchmark equilibrium data set and the equilibrium conditions for optimal behavior of each economic agent. Thus, such estimated parameters and exogenous variables may produce the complete benchmark equilibrium data set as an equilibrium solution to the model.

4. Analysis

Replication: Base Run

The KAGEM has been initially run for the benchmark equilibrium data. A consistency test is employed for the base run. Since the CGE model represents a circular flow, there is no leakage in the model. In other words, no excess demand in any sector exists. Therefore the base run solution must be a balanced SAM that reproduces the initial condition data set with all domestic final goods prices at unity. Unity prices are designed for the convenient interpretation of the results of subsequent experiments. Once the base run is solved optimally, the next job must be to implement various experiments representing alternative policies.

The three hypothetical policy packages are the following:

E1: 75 percent reduction in tariff rates for the agro sectors (sectors one to seven).

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[5]The values of extraneous parameters were determined for the study by referring to relevant figures of the previous studies: Dervis et. al (1982), Shiells and Deardorff (1986), and Mansur and Whalley (1984)

E2: 75 percent reduction in tariff rates across the board, and

E3: simultaneous 75 percent tariff reduction and 15 percent indirect tax reduction in the agro sectors.

E1 aims to capture the economic impacts of the agricultural market opening policy. The results will be compared to those of the other two experiments that are employed to counteract the sector-specific shocks.

Analysis of the Resource Allocation Effects

Effective Rates of Protection[6]

As noted in the first chapter, it is necessary to consider general equilibrium ERPs to measure the effects of changes in trade policy on resource allocation. It is again noted that the domestic price change ceases to be a gauge of the extent of protection accorded to a sector, when the general equilibrium effect is considered.

In initial equilibrium, units are defined such that final domestic prices are equal to unity. Then the ERP definition can be rewritten as:

$$(6) \quad ERP_i = \frac{\widehat{PD}_i\,(1 - td_i) - \sum a_{ji}\ \widehat{Pj}}{1 - \sum a_{ji} - td_i} \qquad i = 1, 2, \ldots, 11$$

Since the change in the composite good price is given by

$$(7) \quad \widehat{P_i} = \delta_i\,\widehat{PM_i} + (1 - \delta_i)\widehat{PD_i}$$

Then equation (6) becomes:

$$(8) \quad ERP_i = \frac{PD_i\,(1 - td_i) - \sum a_{ji}\,[\delta_i\,\widehat{tm}_i + (1\text{-}\delta_i)\,\widehat{PD}_i]}{1 - \sum a_{ji} - td_i}$$

It is noted that, in the presence of product differentiation, changes in tariff structure will not lead to a proportional change in value-added across sectors unless changes in both tariff rates and domestic prices are the same across sectors. Equation (8) says that the higher the share of imported intermediate inputs ($\sum_j a_{ji}\,\delta_i$), the lower the ERP when tariffs are increased. Thus, other things being equal, the sectors that

[6]See Appendix A for definition of symbols.

will suffer most from the same level of tariff reduction across sectors are those that are least import-dependent. In other words, the increase in tariffs across the board on imported intermediate inputs lowers the ERP accorded to a sector.

The domestic price changes due to tariff changes also lead to changes in the ERP in such a way that the lower the domestic price, the higher the ERP.

The relationship between domestic price and import price can be analyzed by using the partial equilibrium method in the following way. The equilibrium condition in the market for the domestically produced good is

(9) $X^D (PD, PM) = X^s (PD)$

Consider a change in domestic import price induced by a policy change. The degree of trade dependence is obtained by totally differentiating equation (9) and rearranging:

(10) $$\frac{\partial PD}{\partial PM} = \frac{\partial X^D / \partial PM}{\partial X^s / \partial PD - \partial X^D / \partial PD}$$

The sign of $\partial PD/\partial PM$ is ambiguous because the denominator is positive but the numerator is not unambiguous. The necessary condition for the positive sign is that foreign and domestic goods are gross substitutes.

Tables 1 and 2 present the changes in the domestic price and the ERPs in percentage, respectively. The above discussion is well reflected in the figures in both tables. For an example, the manufacturing sectors (8-10), which are import-dependent on the use of intermediate goods, seem to enjoy positive effective protection when a uniform tariff reduction across the board is introduced. Table 2 says that less changes in the ERPs occur in the fixed-wage model. This is mainly because the response of domestic prices is relatively rigid when wage is fixed. It is shown that there are intersectoral linkage effects. The first experiment results in the decrease in the domestic prices of the products of agro-industries. The agricultural products are used as intermediate goods for the production of other commodities, especially here the products of sectors 9 to 11. Cheaper intermediate goods can lead to the decrease in the price of final goods, and, in turn, to the decrease in the effective rate of protection. These interlinkage effects are well reflected in Tables 1 and 2.

Table 1 – Domestic Price Change Rates By Sector (in Percentage)

Sector	E1	E2	E3	E1*	E2*	E3*
1 Cereals	-1.158	-1.255	-1.931	-0.771	-0.964	-0.289
2 Other Crops	-0.971	-1.068	-2.136	-0.388	-0.582	-0.388
3 Livestock	-1.263	-1.458	-3.401	-0.777	-1.069	-1.749
4 Agri-Service	-1.164	-1.358	-2.425	-0.775	-1.066	-0.775
5 Forestry	-1.369	-1.369	-2.639	-1.075	-1.075	-0.978
6 Fishery	-0.873	-1.358	-2.134	-0.581	-1.163	-0.484
7 Food Process	-1.166	-1.458	-4.762	-0.874	-1.262	-3.204
8 Consumer Goods	-0.491	-1.276	-1.865	-0.196	-1.079	-0.294
9 Intermed. Goods	-0.293	-1.172	-1.660	-0.293	-1.171	-0.293
10 Capital Goods	-0.294	-1.373	-1.667	-0.196	-1.273	-0.196
11 Services	0.779	-1.071	-2.045	-0.292	-0.682	-0.292

* represents fixed-wage model experimentations.

Table 2 – Effective Protection Rates By Sector (in Percentage)

Sector	E1	E2	E3	E1*	E2*	E3*
1 Cereals	-1.278	-1.278	-0.465	-0.812	-0.928	-0.232
2 Other Crops	-1.019	-0.892	-0.764	-0.255	-0.255	-0.255
3 Livestock	-1.357	-0.905	-0.452	-0.452	-0.452	0.000
4 Agri-Service	-1.294	-1.133	-0.647	-0.808	-0.808	-0.323
5 Forestry	-1.491	-1.261	-1.261	-1.147	-1.032	-1.032
6 Fishery	-1.157	-1.157	-0.826	-0.826	-0.826	-0.496
7 Food Process	-1.770	-1.770	0.000	-0.885	-0.885	0.000
8 Consumer Goods	0.000	0.437	0.000	0.000	0.873	0.000
9 Intermed. Goods	-0.452	0.452	-0.452	-0.452	0.452	-0.452
10 Capital Goods	-0.373	0.373	-0.373	0.000	0.746	0.000
11 Services	-0.926	-0.741	-0.741	-0.370	-0.185	-0.370

*represents fixed-wage model experimentations.

In sum, the tariff reduction across the board as well as in the agro sectors has a tendency to damage the agro sectors more than other sectors. Agricultural protection through the reduction in indirect tax rates imposed on agro sectors seems to have more positive effects than the uniform tariff policy across the board which dampens the impact of cross-effects.

Table 3 – Sectoral Output Changes

(in Percentage)

	Sector	E1	E2	E3	E1*	E2*	E3*
1	Cereals	-0.889	-1.348	0.357	-1.953	-2.114	-0.339
2	Other Crops	-1.219	-1.833	-1.462	-2.533	-2.778	-2.306
3	Livestock	-0.589	-0.946	0.527	-1.354	-1.495	0.032
4	Agri-Service	-0.934	-1.419	-0.112	-2.016	-2.203	-0.822
5	Forestry	-1.052	-1.080	-1.178	-2.175	-1.894	-1.908
6	Fishery	-0.213	-0.415	-0.184	-0.888	-0.900	-0.616
7	Food Process	-0.093	-0.578	1.536	-0.927	-1.177	0.990
8	Consumer Goods	0.722	1.239	0.558	0.012	0.723	0.103
9	Intermed. Goods	0.370	0.799	0.217	-0.198	0.389	-0.147
10	Capital Goods	0.508	1.166	0.319	-0.041	0.763	-0.033
11	Services	0.075	-0.006	-0.137	-0.522	-0.437	-0.520

Output and Employment Effects

The domestic prices in all the sectors may be changed by general equilibrium effects as a result of the introduction of policy changes. It has been shown that all domestic prices have decreased as a response to tariff reduction with (or without) indirect tax reduction. The fall in price may lead to the fall in output level in partial equilibrium analysis. In general equilibrium analysis, the shifts of supply and demand curves are also considered. For an example, a fall in domestic price can increase the volume of foreign demand, resulting in the righthand shift of the demand curve, which in turn, requires more domestic supply. Therefore, output and price behavior do not always act in the same direction. However, changes in sectoral production and employment move in the same direction.

Tables 3 and 4 present the changes in sectoral output and labor demand, respectively, as a response to alternative trade policies. Generally, when wage is fixed, the response of output and labor demand is to increase. The logic follows. The wage level must be decreased in order to maintain full employment when domestic prices fall due to policy changes. A fixed wage, however, prevents full employment of labor because the labor supply curve is perfectly elastic. Underemployment, then, leads to a lower level of output. The largest percentage decline in output and employment change is observed in the crop industry which is the most labor intensive and whose trade substitution elasticity is relatively high.

Table 4 – Sectoral Labor Demand Changes

(in Percentage)

Sector	E1	E2	E3	E1*	E2*	E3*
1 Cereals	1.294	-1.962	0.514	-2.826	-3.057	-0.488
2 Other Crops	1.348	-2.039	-1.623	-2.812	-3.086	-2.562
3 Livestock	0.714	-1.131	0.655	-1.666	-1.844	0.000
4 Agri-Service	1.245	-1.867	0.000	-2.490	-2.905	-1.037
5 Forestry	1.579	-1.637	-1.754	-3.218	-2.809	-2.809
6 Fishery	-0.389	-0.713	-0.324	-1.555	-1.620	-1.102
7 Food Process	-0.140	-0.921	2.513	-1.478	-1.897	1.618
8 Consumer Goods	1.334	2.298	1.033	0.026	1.343	0.189
9 Intermed. Goods	0.896	1.932	0.530	-0.467	0.935	-0.354
10 Capital Goods	0.852	1.976	0.531	-0.062	1.298	-0.049
11 Services	0.114	-0.008	-0.203	-0.780	-0.652	-0.776

With regard to agriculture protection, the choice of indirect tax reduction seems, generally, to be better than tariff reduction across the board in terms of enhancement of employment and production activity. In other words, the sector-specific policy is relatively effective in managing sector-specific goals. However, the forestry industry (sector 5) shows the opposite phenomenon; the results are more favorable when across-the-board uniform tariff reduction is introduced. It is noted that the products of the forestry industry are mostly used as intermediate goods for the production of other goods. Therefore, the higher increase in sectoral output in sectors 8 to 10 under the E1's than the E3's may result in less negative effect on the output and labor employment of the industry.

Results show that, under a flexible price regime, the manufacturing industries — consumer, intermediate and capital goods sectors — gain in terms of production. The decrease in domestic prices and hence, output, in the agro sectors shifts a part of the labor employed previously to the non-agro sectors to keep full employment. In addition to that, the higher export demand elasticities in the manufacturing sectors may lead to additional increase in the output and labor demand of those sectors.

The higher positive response of the manufacturing sectors, under the E2's than the E3's and E1's, implies strong intersectoral linkage effects. This is consistent with the values of the ERPs. Therefore the relationship between the ERPs, the sectoral output and employment changes is again noted.

Under the E2's, the agro sectors are rather negatively affected because of the interlinkage effects discussed previously. Since the dependence of intermediate inputs on imports is relatively low in such industries, the uniform tariff reduction across the board is not favorable to them. The sector-specific protection policies are, therefore, recommended for the protection of the agro sectors in terms of production activities.

Aggregate Economic Effects

Table 5 shows the figures for aggregate economic indicators such as household gross income, government revenue, gross domestic output, total employment, wage index and marginal propensity to save.

Household income has two sources: returns to labor and capital. It decreases when tariff decreases. The reason is that value-added prices or net prices decrease due to tariff reduction. Gross domestic products seem to rise in a flexible-price economy but fall in a fixed-wage economy. The deadweight loss incurred by tariff imposition can be reduced by decreasing the tariff rate. However, with fixed wage, the employment level decreases and hence, output falls.

Government revenue decreases because of reduced tariff income. Since government expenditure is assumed to be constant, household saving must increase in order to satisfy the exogenously given investment demand. This behavior is evident in the data on the marginal propensity to save.

Table 5 – Aggregate Economic Indicators

	Base	E1	E2	E3	Base*	E1*	E2*	E3*
HNI	73579	73018	73311	73185	73580	72935	73261	73146
GR	11207	11017	10017	10637	11213	11138	11154	10770
GDP	190781	191092	191288	191165	190697	189722	190308	190214
LABOR	12631	12631	12631	12631	12631	12492	12531	12542
WAGE	1	0.988	0.989	0.992	1	1	1	1
MPS	0.315	0.318	0.327	0.323	0.315	0.32	0.329	0.324

Legend:
HNI : Household Income (billion Won)
GR : Government Revenue (")
GDP : Gross Domestic Output (")
LABOR : Employment Level (thousand)
WAGE : General Wage Index (unity)
MPS : Marginal Propensity To Save (unity)

A notable fact is that tariff reduction across the board rather than only in the agro sectors, would be favorable to household income. The provision of subsidy to the agro sectors is found to increase household income in both versions of the model.

Gross domestic output shows a positive response to trade liberalization if the Korean labor market is competitive. Under E2, the largest response is seen. It is clear that wage rigidity blocks benefits from trade liberalization. With regard to the total employment effect, a perfectly elastic labor supply cannot efficiently adjust to external shocks.

Welfare Effects

This section examines the welfare change caused by trade policy changes. For this purpose, the concept of consumer's surplus and producer's surplus must be understood.

The notion of consumer surplus is an example of the partial equilibrium method of analysis which Alfred Marshall pioneered. He said "the excess of the price which he would be willing to pay rather than go without the thing, over that which he actually does pay, is the economic measure of this surplus satisfaction. It may be called consumer's surplus" (Marshall, 1920, p. 124). He pushed the idea of consumer surplus to a prominent place in economic theory. This Marshallian triangle version of welfare was further developed, as a modern theory, by Hicks (1946).

The concept of consumer surplus has been generally used for two purposes:

(1) to measure the degree of consumer's revelation of preference and
(2) to measure a consumer's change in welfare.

The second is appropriate for the purpose of this paper.

Traditionally, the welfare effect of protection or trade liberalization has been analyzed by calculating social deadweight losses. Among several ways for measuring these are the Marshallian triangle method, and the Hicksian welfare measure. The Marshallian triangle method has been criticized largely on two grounds. This method is valid only on the assumption that the marginal utility of income is constant or, at least, independent of variations in income and all prices. The second criticism is related to the nature of partial equilibrium analysis. Marshall regarded his analysis of consumer surplus as valid only for commodities that account for a small part of total expenditure. Hicks added the small income effect assumption for the use of this method.

Herberger (1971) improved the Marshallian measure in various ways. The conversion of utility into money value is implicitly carried out at the midpoint of the beginning and ending marginal utilities of income in Harberger. Therefore, the assumption of constant marginal utility of income is somewhat relaxed. Most importantly, his method takes account of the characteristics of general equilibrium analysis, thereby capturing the effect of interaction of demand schedules for different commodities. As earlier stated in this paper, the welfare effect of trade liberalization must be analyzed in the framework of general equilibrium. Harberger's method thus seems to be the most appropriate tool for measuring welfare change. His method is reproduced below:

$$W_H = P^{o\prime} (X^1 - X^o) + 0.5 (P^1 - P^o)' (X^1 - X^o)$$

where P and X are the price and quantity vectors, respectively, and the superscript implies the situation before and after the price change due to trade liberalization. The first term on the right-hand side implies the income compensated change which represents the extent of shifts of demand schedules. The second part quantifies the deadweight loss of consumption. However the assumption of linearity of demand curves is required to have accurate estimates. Even with this limitation, the Harberger method may be the best way to measure welfare change incurred by the general equilibrium effect of price change. Thus, the method is employed for the study.

Table 6 presents the welfare changes in money terms. Total welfare changes consist of two sources: one from shifts of demand

Table 6 – Welfare Effect

unit: 10 billion won

	E1	E2	E3	E1*	E2*	E3*
TW	-1.35	-3.37	-1.31	-5.80	-6.56	-4.15
GW	-1.36	-3.39	-1.32	-5.81	-6.60	-4.16
DW	0.01	0.02	0.01	0.01	0.04	0.01

TW : Total welfare change
GW : Welfare change due to shifts of demand curves
DW : Welfare change due to price changes

curves and the other from composite price changes.

It is found that trade liberalization may reduce the welfare level in the short run. All the figures for total welfare change are negative. As expected, wage fixity leads to a greater reduction in household income under trade liberalization. Because the level of sectoral employment is determined by the sectoral demand for labor, the reduced domestic prices due to tariff reduction may create unemployment. Then household income is reduced by the sum of the sectoral number of unemployed multiplied by the existing sectoral wage level.

Even in a flexible wage economy, the wage level must decrease to maintain full employment. Therefore, the household's income decreases.

Moreover, reduced government saving requires more saving from the household in order to satisfy the exogenously given investment demand. This leads to a reduction in household expenditure.

In sum, the two major sources for reduced household expenditures are the fall in wage level in a flexible wage model or the fall in employment level in a fixed wage economy, and the increased household saving.

Comparatively, the unemployment effect is shown to reduce household income more than the effect of wage level change. The reduced income forces demand schedules to shift leftward so that total consumer surplus becomes smaller. This effect is measured by *GW* in Table 6.

The other source for the change in welfare level is the change in composite prices. Tariff reduction may result in the fall in composite price level as well as in domestic price level. The consumer faces composite prices which are the combined price of import and domestic prices. A fall in composite price raises real household income so that a household can purchase more. This positive effect is measured by *DW* in Table 6. Comparing the figures for *GW* and *DW* leads to the conclusion that trade liberalization may affect consumer's surplus more by shifting demand curves than by changing prices. Therefore, the general equilibrium effects on welfare seem to be very significant.

Finally, it has been shown that more wage flexibility is required to reduce the welfare loss of consumers under the trade liberalization scheme.

5. Conclusions and Policy Implications

In analyzing the effects of alternative trade liberalization schemes, the study demonstrated that trade liberalization leads to the decrease in consumer surplus through the price mechanism in the short run. It was also clearly shown that wage rigidity worsens the effect of trade liberalization in terms of output, employment and welfare. The wage rigidity may lower employment levels in Korea under trade liberalization in the short run.

It was found that the reduction in indirect taxes for the agricultural sectors generally has a positive effect on welfare and employment. Thus the implementation of a sector-specific internal subsidy program for the agricultural sectors is strongly recommended. However, the problem could still persist because the degree of trade liberalization is expected to become higher with the passage of time. Based on the findings, trade liberalization for all the sectors may damage the agricultural sectors more because of sectoral linkage effects. Therefore, in addition to the proposed program above, some other policies must be formulated and implemented in order to protect farmers in terms of securing their jobs and maintaining a certain level of income. The following are recommended:

1) the establishment of manufacturing factories in the rural areas to accommodate the labor dismissed from the agricultural sectors;
2) the provision of intensive technological service to increase productivity of agricultural production and;
3) the transformation of the agricultural production mode from family farming to enterprise farming through mechanization, improved management skill and economies of scale.

In conclusion, the Korean economic policymakers should take into serious account the possibly negative effects of the agricultural trade liberalization scheme and some protective measures before embarking on a program of trade liberalization.

References

Anderson, James E. (1970), "General Equilibrium and the Effective Rate of Protection," *Journal of Political Economy*, 78:717-724.

Armington, Paul, (1969), "A Theory of Demand for Products Distinguished by Place of Production," *IMF Staff Papers,* 16 (1): 159-178.

Balassa, B. (1980), "The Process of Industrial Development and Alternative Development Strategies," World Bank Working Paper No. 438, Washington D.C.: The World Bank.

Bhagwati, J. and Srinivasan, T.N. (1978), "Shadow Prices for Project Selection in th Presence of Distortions: Effective Rates of Protection and Domestic Resource Cost," *Journal of Political Economy*, Vol. 86, no. 1:97-116.

Condon, T., and Dahl, H. (1987), "Implementing A Computable General Equilibrium Model on GAMS, The Cameroon Model," Development Research Department, World Bank (May).

de Melo, Jaime (1978), "Protection and Resource Allocation in a Walrasian Trade Model," *International Economic Review,* 19 (1):17-45

de Melo, J. (1980), "Tariffs and Resource Allocation in Partial and in General Equilibrium," *Weltwirtschaftliches Archiv*, 116:114-30.

de Melo, J. (1987), "Estimating the Costs of Protection: A General Equilibrium Estimate," *Review of Economics and Statistics,* 92:209-27.

de Melo, J. and Robinson, S. (1981), "Trade Policy and Resource Allocation in the Presence of Product Differentiation," *Review of Economics and Statistics*, 63:169-177.

de Melo and Robinson, (1985), "Product Differentiation and Trade Dependence of the Domestic Price System in Computable General Equilibrium Trade Models," In *International Trade and Exchange Rates in the Late Eighties*, ed. T. Peeters, et al. North Holland, pp. 91-109.

Dervis, de Melo and Robinson (1982), *General Equilibrium Models for Development Policy*, Cambridge, United Kingdom: Cambridge University Press.

Economic Planning Board (1988), *Major Statistics of Korean Economy*, Seoul, Korea.

Ethier, W.J. (1984), "Higher Dimensional Issues In Trade Theory," in *Handbook of International Economics Vol. 1,* ed. R. Jones, and P. Kenen, North-Holland.

Grubel, H.G. and Lloyd, P.J. (1975), *Intra-Industry Trade: The Theory and Measurement of International Trade in Differential Products*, London: Macmillan and Halsted.

Harberger, A.C. (1971), "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay," *Journal of Economic Literature*, 9:785-797.

Hicks, J.R. (1946), "The Generalized Theory of Consumer's Surplus," *Review of Economic Studies*, 13:68-34.

The Bank of Korea (1988), *1985 Input-Output Tables, Vols. I and II*, Seoul, Korea.

Lancaster (1980), "Intra-Industry Trade Under Perfect Monopolistic Competition," *Journal of International Economics*, 10:151-175.

Manasan, R.G. "Effective Protection Rates and Internal Indirect Taxes in the Philippine Setting," Philippine Institute of Development Studies, Staff Paper Series No. 83-04, 1983.

Mansur, Ahsan and Whalley, John (1984), "Numerical Specification of Applied General Equilibrium Models: Estimation, Calibration, and Data," in Scarf, H.E. and Shoven, J.B., (eds.), (1984).

Marshall, A. (1890), *Principles of Economics, Vol. 1,* London: Macmillan; and An Introductory Volume, Eighth edition, 1920, also Ninth (Variorum), edition with annotations by C. W. Guillebaud, Vol. 1: Text, 1961.

Ray, Alek (1973), "Non-Traded Inputs and Effective Protection: A General Equilibrium Analysis," *Journal of International Economics,* 3:245-258.

Scarf, Herbert (1967), "The Approximation of Fixed Points of a Continuous Mapping," *SIAM Journal of Applied Mathematics,* 15:1326-134.

Schweinberger, A.G. (1975), "Nontraded Intermediate Products and the Measurement of Protection," *Oxford Economic Papers*, 27:215-237.

Shiells, C., Stern, R. and Deardorff, A. (1986), "Estimates of the Elasticities of Substitution between Imports and Homegoods for the United States," *Weltwirtchaftliches Archiv*, 122:497-519.

Shoven, J. and Whalley, J. (1984), "Applied General Equilibrium Models of Taxation and International Trade," *Journal of Economic Literature*, pp. 1007-1051.

Srinivasan, T.N. and Whalley, J. (1986), *General Equilibrium Trade Policy Modelling,* The MIT Press.

Taylor, L. and Black, S. (1974), "Practical General Equilibrium Estimation of Resource Pulls Under Trade Liberalization," *Journal of International Economics*, 4:37-58.

Appendix A – The Structure of the KAGEM

Equations: (Equation, Definition, Number of Equations)

A. Price Block

(1) $PM_i = \overline{PW_i} * (1 + tm_i + tq_i) * ER$	Import price equations	n
(2) $PWE_i = PD_i / (1 + te_i) * ER$	Export price equations	n
(3) $P_i * Q_i = PD_i * D_i + PM_i * M_i$	Composite price equations	n
(4) $P^*_i = PD_i - \sum_j a_{ji} * P_j - td_i$	Net price equations	n

B. Output and Factors of Production Block

(5) $X^S{}_i = A_i\, [\alpha_i L_i{}^{(\Gamma_i \cdot 1/\Gamma_i)} + (1-\alpha_i)\overline{K}_i{}^{(\Gamma_i - 1)/\Gamma_i}]^{(\Gamma_i/\Gamma_i - 1)}$	Production functions	n
(6-a) $\bar{b}_i * W = P^*_i * (\partial X^S{}_i / \partial L_i)$	Labor demand functions for the Walrasian version	n
(6-b) $\Sigma L_i = \overline{L}$	Labor market clearing condition	1
(7-a) $\bar{b}_i * \overline{W} = P^*_i * (\partial X^S{}_i / \partial L_i)$	Labor demand functions for the non-Walrasian version	n
(7-b) $UE_i = \overline{L}_i - L_i$	Unemployment equations	n
(where $\overline{L}_i = c_i * \overline{L}$)		

C. Trade Block

(8) $E_i = Eo_i + (\pi_i / PWE_i)^{ni}$	Export demand functions	n
(9) $Q_i = B_i\, (\delta_i M_i^{-\mu i} + (1 - \delta_i) D_i{}^{-\mu_i})^{-\mu_i}$	Composite good aggregation functions	n
(10) $\dfrac{M_i}{D_i} = \left(\dfrac{PD_i}{PM_i}\right)^{\sigma i} * \left(\dfrac{\delta_i}{1-\delta_i}\right)^{\sigma_i}$	Import demand functions	n
or		
$\dfrac{PM_i * M_i}{PD_i * D_i} = \left(\dfrac{\delta_i}{1-\delta}\right)^{\sigma i} * \left(\dfrac{PD_i}{PM_i}\right)^{\sigma_i - 1}$	(in value terms)	

D. Domestic Demand Block

(11) $V_i = \sum_j a_{ij} * X^s{}_j * P_j$	Intermediate demand equations	n
(12) $C_i * P_i = \bar{q}_i * (1\text{-}S) * Y_d$	Household demand functions	n
(13) $Yd = (1\text{-}t) * P^*{}_i * X^s{}_i$	Consumer's disposal income	n

(14) $G^Y = t * \Sigma P^*_i * X^s_i + \Sigma td_i * PD_i * X^s_i +$

$\Sigma tm_i * \overline{PW_i}\, ER * M_i$ — Government income equation — *1*

(15) $G_i * P_i = \overline{q}_i^{G} * \overline{G}^C$ — Government consumption functions — *n*

E. Saving-Investment Block

(16) $TS = S * Yd + G^Y - \Sigma G_i * P_i + \overline{FK} * ER$ — Total saving equation — *1*

(17) $TS = \Sigma\, \bar{I}_i * P_i$ — Investment-Saving Closure — *1*

F. Market Clearing Conditions

(18) $\Sigma PW_i * M_i - \Sigma PWE_i * E_i = \overline{FK}$ — Balance of payments condition — *1*

(19) $D_i = d_i * (I_i + C_i + V_i + G_i)$ — Domestic demands for domestically produced goods — *n*

(20) $d_i = \dfrac{D_i}{Q_i}$ — the domestic use ratios — *n*

(21) $X_i^d = D_i + E_i$ — Demands for domestically produced goods — *n*

(22) $X_i^D - X_i^s = 0$ — Product market equilibrium condition — *n*

The number of total equations is $16n + 6$ and $17n + 5$ for Walrasian and non-Walrasian versions, respectively (n = 11). There are as many endogenous variables as independent equations because one variabl*e* becomes a numeraire in the Walrasian system.

Endogenous Variables (Symbol, Number, Definition)

PM_i	n	Import prices
PWE_i	n	Export prices (in dollars)
PD_i	n	Domestic prices
P_i	n	Composite commodity prices
P_i^*	n	Net or value-added prices
Q_i	n	Composite good aggregations
X_i^s	n	Domestic productions by sector
L_i	n	Labor demands

M_i	n	Imports
V_i	n	Intermediate goods demands
C_i	n	Private consumption demands
G_i	n	Government consumption demands
Y_d	1	Consumer's disposal income
G^Y	1	Government income
TS	1	Total saving
D_i	n	Total demands for domestic use
d_i	n	Domestic use ratios
X_i^D	n	Total demands
UE_i	n	Unemployment

Parameter (Symbol, Number, Definition)

tm_i	n	Unit tariff rate
tq_i	n	Tariff equivalent of quantity restriction
te_i	n	Unit export subsidy rate
Ai	n	Production function shift parameter
α_i	n	Production function share parameter
Γ_i	n	Production function elasticity
b_i	n	Wage differential parameter
n_i	n	Export demand elasticities
B_i	n	Armington function shift parameter
δ_i	n	Armington function share parameter
σ_i	n	Trade elasticity of substitution ($\sigma_i = 1/(1 + \mu_i)$)
S	1	Marginal propensity to save (varying parameter)
t	1	Direct tax rate
td_i	n	Indirect tax rate
c_i	n	Share parameter of total labor force
q_i	n	Private consumption share
$\overline{q}_i^G$	n	Government consumption share

Exogenous Variables (Symbol, Number, Definition)

$\overline{PW}_i$	n	World average price of importables
$\overline{K}_i$	n	Capital stock

$\bar{G}$	1	Level of expenditure of government
$\bar{I}_i$	n	Investment demand
$\bar{L}$	1	Total labor force
$\bar{L}_i$	n	Total sectoral labor supply
Eo_i	n	Constant term in export demand function
$\overline{FK}$	1	Net foreign saving
ER	1	Exchange rate (numeraire)
π_i	n	World average prices of exportables

The above system is solved as nonlinear programming by using Jacobian.