A Policy Simulation Analysis on Parts and Material Industry in Korea Using A Computable General Equilibrium Model

Sung Tai Kim* · Gyeong Lyeob Cho**

In this paper, we examine the effects of various industrial policies on the Korean economy using a dynamic general equilibrium model. We consider industria1 policies such as corporate income tax and subsidy as well as R&D subsidy policy. In the model we classify household sector into 10 income groups and classify production sector into 38 industries. In particular we distinguish the parts and material industry from the finished manufactured good industry. Policy simulation is designed to investigate the difference in policy effects between parts and material industry and finished manufactured good industry. Also we try to find out which policy is better in terms of efficiency and equity criteria using the same amount of funds.

Findings of policy simulation are as follows. Firstly, the R&D subsidy policy is more persistent and effective than tax and subsidy policy in terms of output effect and other macroeconomic effects. Secondly, when the government adopts either corporate income tax cut or subsidy increase, the support for the parts and material industry is more effective than the support for the final good industry in terms of output increase and labor supply and capital formation. Thirdly, the corporate income tax cut policy is better than subsidy policy in terms of the effect on GDP, capital formation during 2007-2030 period. Finally, when it comes to the R&D subsidy policy, the parts and material industry subsidy is better than the finished manufactured good industry in terms of the output effect and technology transfer effect.

JEL Classification: L6, H2
Keywords: Parts and Material Industry, Korea, Tax Policy, Subsidy

---

* Cheongju University, Department of Economics, Professor, e-mail: stkim@cju.ac.kr
** Korea Economic Research Institute, Senior Research Fellow, e-mail: glcho@keri.org

Policy, R&D Investment Subsidy Policy, Korea CGE Model

I. INTRODUCTION

Recently the Parts and Material (P&M hereafter) industry in Korea has played an crucial role in industry structural development. In 2003 the output and employment of the P&M industry reached 38% and 46.3% of total output and total employment respectively in Korea. Korea has already gone through a quantity oriented rapid economic growth stage based on factor inputs increase without productivity improvement. Also the structure of industry has more or less emphasized the assembled good industry rather than the part and material good industry. However, in 21st century Korea might fall into “underdevelopment trap” without structural reform of the economy. One of important agenda for successful structural economic reform is to develop the P&M industry. The question is how the government encourages the P&M industry to grow independently.

The purpose of this paper is to examine the effects of various policy alternatives for P&M and Finished Manufactured Good(FG hereafter) industry on the output of the economy as well as important macroeconomic variables such as GDP, investment, consumption, and factor supply. We also investigate the equity effect of various policy measures by analyzing the income redistribution effect. The policy alternatives are mainly threefold. The first one is corporate income tax reduction, the second one is subsidization, and the third one is R&D investment subsidization. For each policy alternative we examine the policy support for the P&M industry and one for the FG industry respectively. Thus, there are six different policy alternatives for study. Especially we are interested in the optimal policy for the whole economy.

The policy simulation analysis of P&M industry may be classified into two sorts, partial equilibrium analysis and general equilibrium analysis. The partial equilibrium approach has a couple of advantages. It is easy to do and also simple to understand the whole process. However, this approach also has shortcomings of being lack of implications for the real world economy since the model is too simple. On the other hand the general equilibrium approach is to analyze how policy changes affect the economy as a whole. This approach has advantages of being very realistic and giving us a variety of implications. However, this approach has disadvantages of being too complex and of being hard to interpret the results of analysis. Recently the general equilibrium approach has been used more often than before due to very rapid development of computation devices and soft wares.

To examine the effect of large policy changes as well as to consider many more industry sectors and consumers, Shoven and Whalley (1972) suggest a computable general equilibrium model. Their method of computing an equilibrium is based on Scarf's (1967, 1973) algorithm and some other techniques. To analyze large perturbations of the general equilibrium we need to assume specific functional form for production functions of industries and for utility functions of households. The parameter values of those functions are selected such that initial equilibrium values of the model are exactly reproduction of the base year data set. There are several features of the computable general equilibrium models that contribute to the tax incidence studies. Above all, the applied general equilibrium models may use disaggregate data on both production and consumption. We can delineate two levels of disaggregation of production sectors: medium and high. With this specification we may examine the effects of specific policy on each industry outputs directly. Disaggregation of households by income classes in the applied general equilibrium model makes it possible to examine the effect of the policy on income distribution.

The computable general equilibrium model is very powerful in examining both efficiency and equity effects of various policy proposals. Thus, in this paper we use the dynamic Computable General Equilibrium (CGE) model to examine various policy measures for P&M industry on the macroeconomic variables as well as income distribution of the Korean economy.

The paper is organized as follows. Following Section I we briefly introduce the dynamic CGE model focusing on classifying the production sector into the Final Good industry and the Part and Material industry in section II. In section III we analyze the results of the six policy simulation alternatives (scenarios) for the P&M industry in Korea. Especially we analyze the effects of each policy scenario on the output of the economy, final demands such as consumption, investment, and government expenditures as well as factor supplies during 2007-2030 period. We also investigate the income distribution effects of six policy alternatives. In section IV we explain the policy implications of analyses.

II. CGE MODEL FOR MATERIAL & COMPONENTS INDUSTRY

1. Model Overview

Figure 1 shows a brief structure of the model developed in this paper. Employing labor and capital, firm produces a final goods (Y_i) and sell it to both domestic and abroad. In this process, government levies an indirect tax or a subsidy on the final goods. As shown in the figure, after paying tariff and/or commodity tax, imported goods flows into Armington market where imported goods is treated as imperfect substitute for domestic counterparts. The compounded consumption goods at Armington market is distributed to household, investment, and government sector.[1) It is also used for intermediate goods in the industry. Household consists of ten different income groups. They maximize their intertemporal utility given their budget constraint. Household earns labor income and capital rental income and pays income taxes.

---

1) Government sector is not appear in Figure 1 for simplification. Government levies various taxes and expenditure tax revenue for providing public goods and for transferring to household.

2. Feature of Model

A. Time Scope

Tax and public finance policy induces the static as well as dynamic impact on all agents in the economy. In order to consider both effect in this paper, we construct a dynamic computable general equilibrium model with 30 periods of time interval from 2000 to 2030. We assume that all agents have ability of a perfect foresight in that they perfectly know all of changes in future prices causing from policy change.

B. Scope of Industry, Household, and Consumption goods

Table 1 shows the scope of industry, consumption goods, and income group for analysis. Industry is divided by 38 sectors including the P&M industries. Based on "Survey of Urban Household", we consider 10 income groups whose a representative household spends its income on 10 different consumption goods. Therefore, the model is designed to analysis both equity and efficiency issues causing from policy change.

Figure 1 Structure of Model

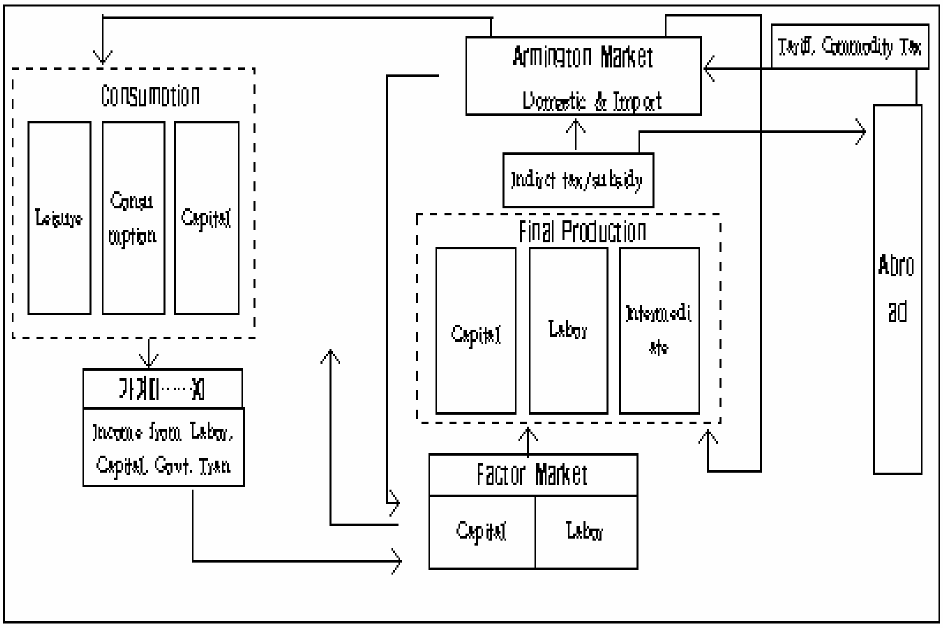


Table 1 Scope of Industry, Consumption, and Income Group

Industry		Consumption	Income Group
S01 Agricultural and marine Products	S20Electrical and electronic instruments(P&M)	C01 Food products and beverages	W01.　0~10%
S02 Mineral products	S21Electrical and electronic instruments(FG)	C02 Housing expense	W02.10~20%
S03 Food products and beverages(FG)	S22 Precision instruments(P&M)	C03 Light, heat and water services	W03. 20~30%
S04 Textile and leather products(P&M)	S23 Precision instruments(FG)	C04 Furniture and appliances	W04. 30~40%
S05 Textile and leather products(FG)	S24 Transport equipment(P&M)	C05 Clothing and footwear	W05. 40~50%
S06 Wood and paper products(P&M)	S25 Transport equipment(FG)	C06 Health and medical services	W06. 50~60%
S07 Wood and paper products(FG)	S26 Furniture and manufacturing products(FG)	C07 Education	W07. 60~70%
S08 Printing, publishing and reproduction(FG)	S27 Electric power, gas and water service	C08 Cultural recreation	W08. 70~80%
S09 Petroleum and coal products(P&M)	S28 Construction	C09 Traffic and communication	W09. 80~90%
S10 Petroleum and coal products(FG)	S29 Wholesale and retail trade	C10 Others	W10. 90~100%
S11 Chemical products(P&M)	S30 Restaurant and accommodation		
S12 Chemical products(FG)	S31 Transport and storage		
S13 Non-metallic mineral products(P&M)	S32 Telecommunications and broadcasting		
S14 Non-metallic mineral products(FG)	S33 Financial and insurance		
S15 Basic metal products(P&M)	S34 Real estate and Business activities		
S16 Metal products(P&M)	S35 Public administration and national defense		
S17 Metal products(FG)	S36 Education and health		
S18 General machinery(P&M)	S37 Social and other services		
S19 General machinery(FG)	S38 Others		

Note: FG represents the Finished Manufactured Good Industry, P&M represents the Part & Material Industry

We divide each of eleven manufacturing industries into the parts and material industry and the finished manufactured good industry according to portion of intermediate demand. Thus, there are two sorts of industries – the P&M industry and the FG industry – under the same name.

3. Model Structure

A. Household

Household consists of 10 income groups. It is assumed that each income group has a representative agent who lives infinitively and is able to foresee perfectly. Each consumer maximizes an his intertemporal utility function(U_w) subject to an intertemporal budget constraint. It is also assumed that intertemporal utility function is CES(constant elasticity of substitution) between full consumption($Z_{w,t}$) at any points in time t .

$$\max_{\alpha \quad L} \quad U_w(Z_{w,t}) = \sum_{t=0}^{\infty} \beta^t \frac{Z_{w,t}^{1-\theta}}{1-\theta} \tag{1}$$

$$s.t. \quad Z_{w,t} = [\alpha\ Q_{w,t}^{\rho} + (1-\alpha)(H_{w,t} - L_{w,t})^{\rho}]^{\frac{1}{\rho}} \tag{2}$$

where index indicates income level, β is time discount rate, $1/\beta$ is intertemporal elasticity of substitution. $L_{w,t}$ is working time by income group at time t. Thus, amount of leisure for w income group is total time endowment ($H_{w,t}$) minus working time such as $H_{w,t} - L_{w,t}$. The full consumption goods is CES function of consumption composited goods($Z_{w,t}$) and leisure. $\frac{1}{1-\rho}$ indicates elasticity of substitution between consumption composited goods and leisure, and α in equation (2) shows a share of consumption. Share parameter α and elasticity of substitution parameter ρ should be different in every equation below. But we express s same symbol for convenience.

Intertemporal budget constraint of w income group is as follow.

$$\sum_t P_{Q,t} Q_{w,t} + \sum_t P_{i,t} I_{w,t} + \sum_t R_t K^d_{w.t}$$
$$= \sum_t W_{w,t} L_{w,t} + \sum_t R_t K^s_{w,t} + \sum_t Tr_{w,t} \quad (3)$$

All prices shown in equation (3) are after tax prices reflecting time discount. Thus, $P_{Q,t}$ is after tax price discounted by interesting rate r . In steady state, $P_{Q,t}$ is equal to $\frac{1}{(1+r^*)^{t-1}} P_{Q,0}$ where $P_{Q,0}$ is price of base year. $P_{i,t}$ is price invenstment goods, $W_{w,t}$ is after tax wage, R_t is after tax rate of return to capital. $I_{w,t}$ is investment of *w* income group. $K^d_{w,t}$ and $K^s_{w,t}$ represent supply of and demand for capital, respectively. $Tr_{w,t}$ is government transfer to *w* income group.

In equilibrium, total supply of labor($\sum_w L_{w,t}$) should be equal to total demand for labor ($\sum_i L_{i,t}$), and also total supply($\sum_w K^s_{w,t}$) of capital should be equal to total demand for capital ($\sum_i K_{i,t} + \sum_w K^d_{w,t}$) . In equation (3), present value of disposable income of *w* income group is defined as the sum of present value of returns to capital plus labor income and government transfer. Each consumer spends his disposable income on purchasing consumption goods, investment foods, and household capital.

As in figure 2, nesteded consumption goods $Q_{w,t}$ is a CES function of household capital and consumption goods, $C_{w,c,t}$.

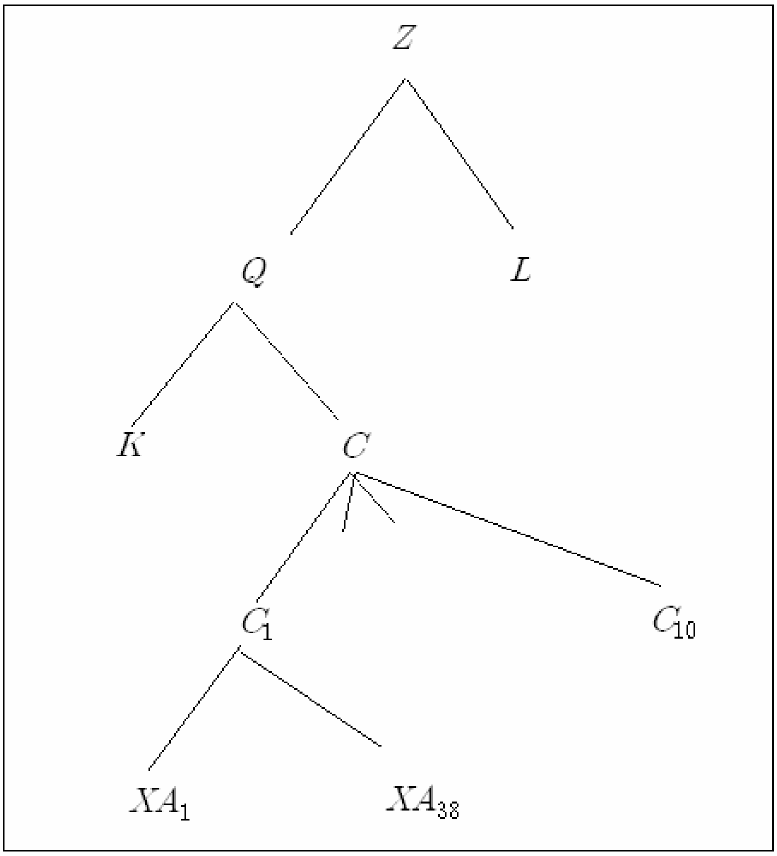
$$Q_{w,t} = [\alpha_1 K^d_{w,t} + (1-\alpha_1) C^{\rho}_{w,c,t}]^{\frac{1}{\rho}} \quad (4)$$

$C_{w,c,t}$ indicates one of consumption goods listed in table 1. It is CES aggregates of Armington goods.

$$C_{w,c,t} = [\sum_i^{38} \alpha_i (XA_{w,c,i,t})^{\rho}]^{\frac{1}{\rho}} \quad (5)$$

Where $XA_{w,c,i,t}$ is *i* Armington goods for producing *c* consumption goods for *w* income group at time *t*.

Figure 2 Structure of Consumption



B. Production Structure

The structure of production is shown in figure 3. The nested step is very similar to one in Lee *et al*(2002). The final production goods $Y_{i,t}$ is CES function of labor-capital composition goods and Amington goods.

$$Y_{i,t} = [\alpha KL_{i,t}^{\rho} + (1-\alpha) XA_{i,t}^{\rho}]^{\frac{1}{\rho}} \qquad (6)$$

where $KL_{i,t}$ is labor-capital composition goods and $XA_{i,t}$ is Armington goods. As in upper level of figure 3, $Y_{i,t}$ is converted into export goods($XE_{i,t}$) and domestic goods($XD_{i,t}$). $Y_{i,t}$ is a constant elasticity of transformation function as in equation (7).

$$[\alpha XE_{i,t}^{\rho} + (1-\alpha) XD_{i,t}^{\rho}]^{\frac{1}{\rho}} = Y_{i,t} \qquad (7)$$

In equation (6), labor and capital composition goods is CES function of labor and capital.

$$KL_{i,t} = [\alpha L_{i,t}^{\rho} + (1-\alpha) K_{i,t}^{\rho}]^{\frac{1}{\rho}} \qquad (8)$$

$L_{i,t}$ indicates a labor input and $K_{i,t}$ is a capital used in sector *i*.

In equation (6), Armington goods is CES function of domestic goods($XD_{s,t}$) and imported goods($XM_{s,t}$) as shown in equation (9). We use index *s* instead of *i* to distinguish Armington goods used in industry and household, government, and investment sectors.

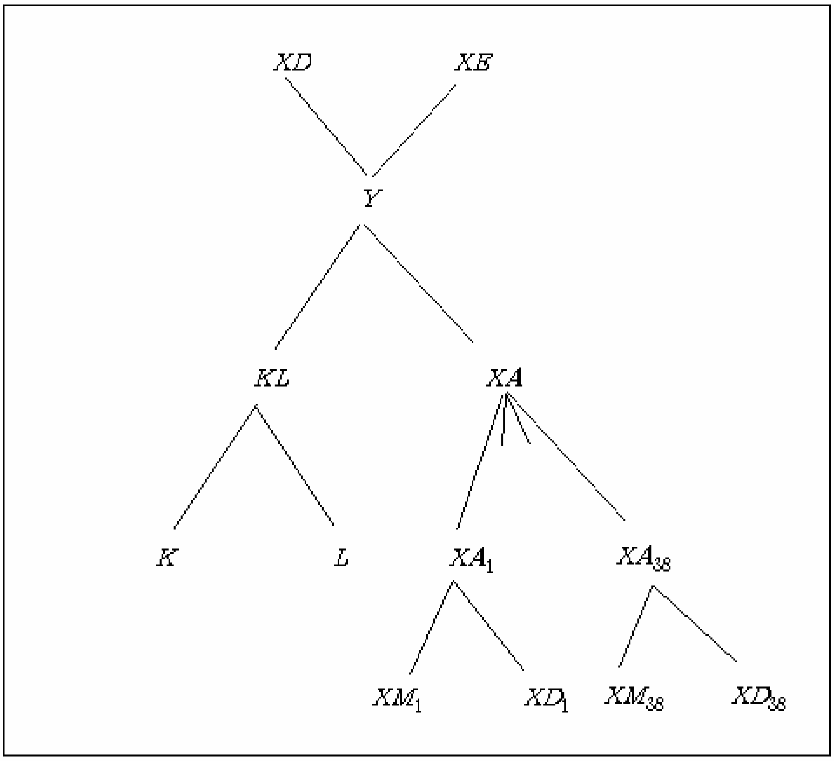
$$XA_{s,t} = [\alpha XD_{s,t}^{\rho} + (1-\alpha) XM_{s,t}^{\rho}]^{\frac{1}{\rho}} \qquad (9)$$

$XA_{s,t}$ stands for 38 production goods in table 1. Armington goods is distributed to *i* industry as intermediary goods and to household, government, and investment sector as final consumption goods.

$$XA_{s,t} = \sum_i XA_{s,i,t} + \sum_w \sum_c XA_{w,c,s,t} + XA_{inv,s,t} + XA_{g,s,t} \qquad (10)$$

where $XA_{s,i,t}$ is *s* Armington goods used in *i* industry as intermediary goods. $XA_{w,c,s,t}$ is *s* Armington goods consumed by *w* income group, $XA_{inv,s,t}$ is one used by investment sector, and $XA_{g,s,t}$ is one used in government sector.

Figure 3 Production Structure



C. Factor Market

i) Labor Market

Aggregate labor input consists of labors supplied by each income group. Individual labor input differs only in terms of amount of tax burden because of the graduation of labor tax in Korea. Compounded each individual labor input at the labor market, aggregated labor is distributed into each industry. Equation (11) shows the process of compounding an individual labor input. Equation (12) shows distribution of a compounded labor into *i* industry. As shown in equation, labor input is CES aggregation of individual labor.

$$L_t = \left(\sum_w \alpha_w L_{w,t}^{\rho} \right)^{\frac{1}{\rho}} \tag{11}$$

$$L_t = \sum_i L_{i,t} \tag{12}$$

ii) Capital Market

As in labor market, capital market aggregates individual capital with imperfect substitution as in equation (13), and distributes it into each industry and household.

$$K_t = \left(\sum_w \alpha_w K_{w,t} \right)^{\frac{1}{\rho}} \tag{13}$$

$$K_t = \sum_i K_{i,t} + \sum_w K_{w,t}^{d} \tag{14}$$

Where K_t is total capital stock, $K_{w,t}$ is individual capital stock supplied by *w* income group. $K_{i,t}$ is capital stock used in *i* industry, and $K_{w,t}^{d}$ is capital stock demanded by *w* income group.

Unlike in Fullerton and Rogers(1993) and Lee *et al*(2002), our model is fully dynamic model which is solved all period simultaneously. Each period is connected by accumulation of capital stock. Capital stock of $t + 1$ period is accumulated by following law of motion.

$$K_{t+1} = (1-\delta)K_{i,t} + I_t \tag{15}$$

where δ is depreciation rate and I_t is investment at period t .

D. Government

Government collects tax and spends it on consuming and transferring to household.

$$\begin{aligned}\Phi_t + P_{ex,t}D_t &= \sum_i \tau_{1,i} r_t K_{i,t} + \sum_i \tau_{2,i} w_t L_{i,t} \\ &\quad + \sum_i (\tau_{3,i} + \tau_{4,i}) P_{em,i,t} XM_{i,t} + \sum_i (\tau_{5,i} + \tau_{6,i}) P_{\mu,i,t} Y_{i,t}\end{aligned} \tag{16}$$

where Φ_t is government total tax revenue and $D_{g,t}$ is government deficit that is defined as total its revenue minus total expenditure. $P_{ex,t}$ is exchange rate. We use exchange rate as price of government deficit because of allowing for government to finance its deficit from abroad. $\tau_{1,i}$ is an effective tax rate on corporate income, $\tau_{2,i}$ is an average tax rate on labor income, $\tau_{3,i}$ is tariff rate, and $\tau_{4,i}$ is imported commodity tax rate. $\tau_{5,i}$ is indirect tax rate, and $\tau_{6,i}$ is subsidy rate. $P_{u,i,t}$ is price of i goods before tax. r_t and w_t are wage and rate of returns to capital before tax. $P_{xm,i,t}$ is before tax price of imported goods.

On the other hand, government expenditure(Γ_t) is defined as follow.

$$\Gamma_t = \sum_s P_{XA_s,t} XA_{s,t} + \sum_w Tr_{w,t} \tag{17}$$

Where $P_{XA_s,t}$ is before tax price of s Amington goods($XA_{s,t}$) and $Tr_{w,t}$ is government transfer to *w* income group.

We can consider two kinds of budget constraints. One is period by period balancing government budget. The other one is balancing government budget over infinite period.

$$\Phi_t + P_{ex,t} D_t = \Gamma_t \tag{18}$$

$$\sum_{t=0} \Phi_t + \sum_{t=0} P_{ex,t} D_t = \sum_{t=0} \Gamma_t \tag{19}$$

We calibrate government budget to balance without levying endogenous tax in base year. After new policy is induced, however, government budget preserves the balance through adjusting consumption tax rate endogenously. Consumption tax is endogenously changed every period in period by period budget balancing constraint, while only one consumption tax rate is endogenously determined in balancing over whole period.

E. International Trade

Assuming small open economy, we consider the price of imported goods as exogenously given variable. However, imbalance of trade is settled through capital flow from abroad or through changing in exchange rate. Under perfect capital market, we can define trade balance constraint as equation (20).

$$\sum_i P_{XEt,t} XE_{i,t} - \sum_i P_{XMt,t} XM_{i,t} + P_{ex} B_t = 0 \tag{20}$$

where $P_{XEt,t}$ and $P_{XMt,t}$ are after tax prices of export and imported goods respectively. P_{ex} is exchange rate fixed over time. Therefore, changing in B_t preserves trade balance.

The other way to preserve trade balance is to assume that exports equal imports in each period. Under this balance of payments constraint, capital flows are restricted and the domestic interest rate is therefore endogenous.

$$\sum_i P_{XEt,t} XE_{i,t} - \sum_i P_{XMt,t} XM_{i,t} + P_{ex,t} B_0 = 0 \qquad (21)$$

Unlike equation (20), trade imbalance (B_0) is fixed over time but exchange rate $P_{ex,t}$ is endogenous, instead.

4. Input Data

The base year is 2000 year in this paper. The input data for this model come from various sources; 2000 Input-Output Tables, Survey for Urban Household, Statistical Yearbook of National Tax, Financial Statement Analysis, Korea Statistical Yearbook, and previous studies. Since Survey for Urban Household」 and Financial Statement Analysis 2001」 are based on survey, we need to consistently connect to aggregated macro-data. In order to do that, we calculate the ratio of consumption, investment, income, etc, first. Applying these ratio to macro data, we construct micro & macro-consistent data set which are components of SAM(Social Account Matrix) in table 2.

Table 2 shows the economic transaction of Korea, 2000. A SAM is a comprehensive, economy-wide data framework, typically representing the all transaction of s economy. More technically, a SAM is a square matrix in which each account is represented by a row and a column. Each cell shows the payment from the account of its column to the account of its row - the incomes of an account appear along its row, its expenditures along its column. The dimension in table 2 represents the sub-transaction of each account.

Table 2 Social Account Matrix

		Domestic Goods	Import Goods	Consumption Goods	Final Demand			Value Added	Tax	Export	Import	Total
					Household	Government	Investment					
Domestic Goods		(1) 38 × 38		(7) 38 × 10 × 10		(12) 38 × 1	(15) 38 × 1			(20) 38 × 1		
Import Goods		(2) 38 × 38		(8) 38 × 10 × 10		(13) 38 × 1	(16) 38 × 1					
Consumption Goods					(9) 10 × 10							
Final Demand	Hous					(14) 10 × 1		(18) 10 × 2				
	Gov						(17) 1 × 1		(19) 1 × 6			
	Invs				(10) 1 × 10						(21) 1 × 1	
Value Added		(3) 2 × 38			(11) 2 × 10							
Tax		(4) 4 × 38	(5) 2 × 38									
Export											(22) 1 × 1	
Import			(6) 1 × 38									
Total												

5. Calibration and Solution Method

Calibration is the process where numerical values are assigned to the parameters of the model. This is typically done by construction a SAM, which matches the markets and constraints of the agent in the theoretical model. The well known problem that data for investment and capital stock have to be fitted into a theoretical model, where such variables are not defined, has to be dealt with by manipulating either the data or the behavioral relations of the model. In order to deal with this problem, we calibrate subject to the assumption that the base year is a steady state. In steady state, relationship of investment and capital stock is defined as

$$K^* = \frac{\text{capital income}}{\text{interest rate + depreciation rate}}$$

$$I^* = (\text{growth rate + depreciation rate}) \times K^*$$

In this paper, we assign interest rate as 0.06, depreciation rate as 0.07, and growth rate as 0.05. Using this value, we calculate investment in steady state and manipulate investment and consumption in SAM to maintain consistency of the final demand and supply. Since interest rate in steady state equals $\frac{1}{\beta} - 1$, β is 0.943.

In general case of Ramsey Model, we solve the dynamic model assuming of a balance growth. In a balance growth model, all variables are grow at the same rate such that $Y^* = Y_0 (1+g)^{t-1}$ where Y_0 is the value of base year and g is the growth rate. Further, all prices are discounted by interest rate such that. $P_t = \frac{1}{(1+r)^{t-1}}$ By using these formula, we assign the dynamic path of all variables and prices.[2)]

Numerical model can only be solved for a finite number of periods, hence some adjustments are required to produce a model which when solved over a finite horizon approximates the infinite horizon choices. According to Rutherford(1994), we add a constraint on the growth rate of investment in the terminal period:

$$\frac{I_T}{I_{T-1}} = \frac{Y_T}{Y_{T-1}}$$

We choose the other parameters, basing on previous researches: Fullerton and Rogers(1993), Sonn and Shin(1997), Cho(2000), Lee *et al*.(2002), Bernstein *et al*.(1999), Goulder and Schneider(1999).

We assume that all sectors have same value of elasticity of substitution.

[2)] See Ruthreford (1994) for more detail to calibrate for dynamic model.

According to Sonn and Shin(1997) who used 2~4, We choose 3.0 of constant elasticity of transformation between exports and domestic goods. The elasticity of substitution between labor and capital is one in which this functions has Cobb-Douglas production technology. Based on Fullerton and Rogers(1993) and Lee *et al*(2002), We assume that the elasticity of capital-labor compound good and Amington goods is 0. We assign 3.0 to elasticity of Amington transformation with same reason for choosing an elasticity of transformation between exports and domestic goods.

The elasticity of intertemporal substitution ($1/\theta$) is 0.5 based on Goulder and Schneider(1999) and Bernstein *et al*(1999). We choose 0.8 of elasticity of compound consumption good and leisure according to Rasmessen and Rutherford (2001).

The model in this paper is programmed in GAMS language. Under the GAMS platform, the dynamic structure of the model is written in MPSGE which is an abstract, high-level language for formulating CGE model. The equilibrium prices and quantities of the model are solved by using the PATH solver, a generic algorithm for solving MCP (Mixed Complementary Programming) problems. The main advantage of programming in MPSGE is that the solution algorithm and the economic model can be separated. This separation makes it possible for users to make changes in model structure, and to introduce new assumptions, without extensive re-programming and debugging.

III. POLICY SIMULATION RESULTS

1. Policy Simulation Design

We can consider three major industrial policies concerning the P&M industry that may affect the Korean economy positively. Three industrial policies are corporate income tax reduction, corporate subsidy, and R&D investment subsidy. We will compare three policies under the equal expenditure constraint such that the government must pay equal amount of funds for each policy. As shown in Table 3 policy alternative I represents the Corporate Income Tax(CIT) reduction, policy alternative II represents the Corporate subsidy, and policy alternative III represents R&D investment subsidy. Firm can spends R&D investment subsidy for its own R&D expenditures. In Table 3 policy alternative A represents one for the P&M (Parts and Material) industry while alternative B represents one for the FG(Finished Manufactured Good) industry. Thus, there are 2 X 3 = 6 combinations – I A, I B, II A, II B, III A, III B - as shown in Table 3.

Table 3 Policy Alternatives for Parts and Material Industry and Final Good Industry

Policy Alternative I: CIT Reduction		Policy Alternative II: Corporate Subsidy		Policy Alternative III: R&D Subsidy	
Alt. A: P&M	Alt. B: FG	Alt. A: P&M	Alt. B: FG	Alt. A: P&M	Alt. B: FG
Alternative I A	Alternative I B	Alternative II A	Alternative II B	Alternative III A	Alternative III B
P&M CIT Reduction	FG CIT Reduction	P&M Subsidy	FG Subsidy	P&M R&D Subsidy	FG R&D Subsidy

Note: P&M represents Part and Material Industry and FG represents the Finished Manufactured Good Industry.

There are two important questions on policy simulation. The First question is which industry the government must subsidize for the economy between the P&M industry and the FG industry. The second question is which policy the government must choose to promote the P&M industry among alternative I, II, and III spending the equal amount of money.

We will evaluate each policy alternative by efficiency criterion as well as equity criterion. For efficiency criterion we will examine the effect of policy on resource allocation. We examine the effects of each policy alternative on the total output, the final demand component such as consumption, investment, and government expenditures, also the effect on factor supply during 2007-2030 period. For equity criterion we will compare the Gini coefficient of income distribution before and after a specific policy.

2. Output Effect

As shown in Table 4 R&D investment subsidy will increase the total output of the economy more than any other policies. For instance in 2007 R&D investment subsidy for P&M industry will increase the total output by 1.08%, while CIT tax cut and subsidy will increase the total output by 0.34% respectively.

In the long run the output increase effect of R&D investment subsidy will become larger while the output increase effect of both policy I and II will become smaller. The reason why the output increase effect of policy I and II becomes smaller in the long run is that both CIT cut and subsidy will increase return for capital and the firm will substitute labor for capital resulting diminishing marginal product of capital.

For all three policy alternatives – I, II, and III – the policy for the P&M industry will increase more output than that for the FG industry.

Table 4 Output Effect of Various Policy Alternatives: 2007-2030

(unit: %)

Year	Policy Alternative					
	I A	I B	II A	II B	III A	III B
2007	0.34	0.03	0.34	0.06	1.08	0.37
2010	0.32	0.03	0.32	0.06	0.10	0.37
2015	0.30	0.03	0.31	0.07	1.12	0.38
2020	0.29	0.03	0.30	0.07	1.15	0.39

2030	0.27	0.03	0.29	0.07	1.22	0.42

Note: Output effect is measured in terms of % increase in total output of the economy in benchmark equilibrium.

3. Final Demand Effect

The effects of various policy alternatives on the final demand are summarized in Table 5. First, R&D investment subsidy will increase consumption, investment, and government expenditures more than any other policy. However, the effect of R&D investment subsidy on the net trade balance (=export – import) is smaller than other policies, since the positive output effect from R&D increase causes import increase more than others. The effect on GDP is sum of effect on each final demand item. R&D investment subsidy will increase GDP most.

In 2007 one thousand billion Korean won R&D subsidy for P&M industry will increase 1.97 thousand billion won, while the same amount of R&D subsidy for FG industry will increase 0.69 thousand billion won. Therefore R&D subsidy for P&M industry is more effective than that for FG industry. The main reason is that the P&M industry has greater technology transfer effect than the FG industry.

Table 5 Final Demand Effect of Various Policy Alternatives: 2007

(unit: thousand billion Korean Won)

	Policy Alternative					
Final Demand Item	I A	I B	II A	II B	III A	III B
Consumption	0.19	0.52	0.53	0.75	1.82	0.64
Investment	0.69	0.42	0.52	0.33	5.85	2.02
Government	-0.71	-0.81	-0.72	-0.82	0.65	0.22

Expenditures						
Net Trade Balance	1.49	0.14	1.32	0.17	0.33	0.11
GDP	1.66	0.27	1.65	0.43	1.97	0.69

Note: Final demand effect is measured in terms of Korean Won for year 2007.

Though we do not show the dynamic effect of each policy alternative on final demand, very similar effects in 2007 are realized during 2007-2030 period.

4. Factor Supply Effect

The effects of various policy alternatives on the factor supply are summarized in Table 6. First, R&D investment subsidy will increase labor supply as well as real wage more than any other policy.

Second, R&D investment subsidy will increase capital formation more than any other policy. Because, R&D subsidy increase will increase the rate of return for capital more than any other policy. Also in the demand side of capital market the output effect of R&D subsidy will increase capital demand. Also, for each policy alternative one for P&M industry is more effective than one for FG industry.

Table 6 Factor Supply Effect of Various Policy Alternatives: 2007

(unit: %)

	Policy Alternative					
Factor Supply	I A	I B	II A	II B	III A	III B
Labor Supply	-0.004	-0.095	0.076	-0.010	0.504	0.174
Capital	0.303	0.107	0.231	0.068	1.173	0.402

Supply						
Real wage	0.048	0.071	0.157	0.161	0.629	0.219

Note: Factor supply effect is measured in terms of % increase in factor supply of the economy in year 2007 in benchmark equilibrium.

5. Income Distribution Effect

As shown in Table 7 only R&D investment subsidy will improve the income distribution while the corporate income tax reduction policy and the corporate subsidy policy will make income distribution worse. The main reason for worsened income distribution from policy I and II is that the CIT reduction and corporate subsidy increases the rate of return for capital and increases income of higher income household since higher income household has more capital than lower income households. On the other hand R&D investment subsidy will eventually benefit most households evenly. Therefore R&D investment subsidy policy is better than other policies in terms of efficiency as well as equity.

Table 7 Income Redistribution Effect of Various Policy Alternatives: 2007

	Policy Alternative					
	I A	I B	II A	II B	III A	III B
Gini Coefficient	0.365218	0.365172	0.365111	0.365084	0.364969	0.365031
Income Distribution	Worsened	Worsened	Worsened	Worsened	Improved	Improved

Note: Gini coefficient of 2007 in benchmark equilibrium is 0.365065.

IV. CONCLUSION

In this paper we examine the effects of various policy alternatives for the P&M industry and the FG industry on the macro economy and income distribution using a dynamic computable general equilibrium model. Policy implications from policy simulation analysis are very clear.

Firstly, among three policy alternatives – the CIT reduction, the corporate subsidy, and the R&D investment subsidy – the R&D investment subsidy is superior to other two policy alternatives in terms of the efficiency and equity criterion. For efficiency criteria we examined the effect of each policy on the total output, final demand item such as consumption, investment, the government expenditures, and net trade surplus, and GDP as well as factor supplies. For most macro variables the effect of R&D investment subsidy is better than the other policy alternatives. Therefore, if the government has to choose one policy alternative with equal amount of funds, it had better choose the R&D investment subsidy.

Secondly, when the government pursues one policy alternative, it has two options – one for the P&M industry and one for the FG industry. The simulation results imply that the government had better choose the P&M industry for support, since the effect of the P&M industry support on most macro variables are better than that of the FG industry.

Thirdly, the CIT reduction policy is better than the corporate subsidy, since distortions in resource allocation are more effectively decreased from the CIT reduction.

REFERENCE

Bernstein, P. M., W. O. Montgomery, and T. F. Rutherford, “Global Impacts of the Kyoto Agreement: Results from MS-MRT Model,” *Resource and Energy Economics*, 21, 1999, pp. 375-413.

Cass, D., “Optimum Growth in an Aggregative Model of Capital Accumulation,” *Review of Economic Studies*, 32, 1965, pp. 233-240.

Cho, Gyeong Lyeob, “The Effect of Green-house Gas Reduction Policy : Global CGE Model Analysis,” (in Korean) *Kyong Je Hak Yon Gu*, Volume 48 No.4, 2000, pp. 323-368.

Cho, Gyeong Lyeob and I.K. Na, “The Green-house Gas Reduction Policy and Technical Progress,” (in Korean) *Kyong Je Hak Yon Gu*, Volume 51 No.3, 2003, pp. 263-294.

Fullerton, Don and Diane L. Rogers, Who Bears the Lifetime Tax Burden?, Washington D. C., The Brooking Institution, 1993.

Fullerton, Don, J. B. Shoven and J. Whalley, “Replacing the U.S. Income Tax with a Progressive Consumption Tax: A Sequenced General Equilibrium Approach,” *Journal of Public Economics*, 20, 1983, pp. 3-23.

Goulder, L. H. and Schneider, S. H., “Induced Technological Change and the Attractiveness of CO_2 Abatement Policies,” *Resource and Energy Economics*, 21, 1999, pp. 211-253.

Lucas, R. E., “On the Mechanics of Economic Development,” *Journal of Monetary Economic*s, 22(1), 1988, pp. 3-42.

Kim, Sung Tai, “Estimation of Effective Corporate Income Tax Rate By Industry in Korea,” Research Report, 04-4, National Assembly Budget Office, 2004.

Kim, Sung Tai, C.S. Jung, G.L. Cho, S.D. Lee, K.H. Kim, “The Parts and Material Industry Model Analysis,” Research Project by Industry and Resource Department, 2006.

Moon, Youngsuk, G.L. Cho, “The Effect of Regulation on Greenhouse gas

Emission on the long-run Energy Transformation," (in Korean) *Kyong Je Hak Yon Gu*, Volume 53 No.1, 2005, pp. 121-153.

Romer, P. M., "Increasing Returns and Long Run Growth," *Journal of Political Economy*, 94(5), 1986, pp. 1002-1037.

Rutherford, T. F., The GAMS/MPSGE and GAMS/MILES User Notes, Washington D.C., GAMS Development Corporation, 1994.

Scarf, H. E., "The Approximation of Fixed Points of a Continuous Mapping," SIAM Journal of Applied Mathematics, 15(5), 1967, pp. 328-343.

Shoven, J.B. and J. Whalley, " A General Equilibrium Calculation of the Effects of Differential Taxation of Income from Capital in the U.S.," Journal of Public Economics, 84, 1976, pp. 281-322.

Shoven, J.B. and J. Whalley, 1992, *Applying General Equilibrium,* Cambridge Surveys of Economic Literature.

Sonn, Yanghoon and D.C. Shin, "The Effect of Foreign Exchange Rate Variation on Energy Industry," (in Korean) *Kyong Je Hak Yon Gu*, Volume 45 No.1, 1997, pp. 123-139.

Yi, Insill, Sung Tai Kim, C.B. Ahn, S.D. Lee, "A Study on the Corporate Income Tax Reform" (in Korean) Research Report 02-12, Korean Economic Research Institute, 2002.