Potential Role of Developing Countries on the International Climate Change Policy from the Viewpoint of Participation

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Abstract

The purpose of this paper is to prove the potential of developing countries to abate CO_2 emissions, which contributes to mitigate climate change, quantitatively. The potential to abate CO_2 emissions is analyzed from the viewpoint of "participation" in the international climate change policy. An applied general equilibrium model, the GTAP-E model, is applied for the analysis. Unlike the previous studies, the identical rate of CO_2 emissions abatement target is assumed for all regions in this study in order to eliminate the possible influences on the results appeared in those studies. Then, the cases in which each one region withdraws from the international climate change policy are evaluated and compared in terms of CO_2 emissions abatement, change in GDP, carbon leakage, and marginal abatement cost. Furthermore, sensitivity analysis about the identical rate is implemented to confirm the result.

Consequently, it is revealed that nonparticipation of developing countries affects rather negatively on the policy and it is concluded that the policy introduced in developing countries will work efficiently and effectively, especially that introduced in China. It is true for all the cases of the sensitivity analysis. For the policy implication, developing countries, especially China, should make some contribution to the international climate change policy that will be renewed in the near future as the post Kyoto Protocol to mitigate climate change effectively.

Keywords: International Climate Change Policy, Kyoto Protocol & Post Kyoto Protocol, Developing Countries, Participation, Applied General Equilibrium Model

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1. Introduction

United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol are the main international efforts against climate change. However, because some Annex B countries of the Kyoto Protocol such as the United States and Australia declared to withdraw from the Kyoto Protocol, the GHG emissions abatement target by the Annex I countries of UNFCCC of about 5% below 1990 level[1] will not be achieved. In addition, developing countries, the non-Annex I countries, are not obligated to abate GHG emissions under the Kyoto Protocol. Therefore, GHG emissions abatement under the Kyoto Protocol is entirely insufficient to mitigate climate change. It is reported that several tens of percents of GHG emissions abatement from 1990 level are indispensable for climate change mitigation. For example, EU aims to limit global temperature increases to a maximum of 2°C above the pre-industrial level and insists that it is necessary to abate GHG emissions 15-30% until 2020 and 60-80% until 2050 from 1990 level in developed countries to accomplish the target (Council of the European Union (2005), European Commission (2006)). However, since it is almost impossible to obtain significant results efficiently only by climate change measures implemented by developed countries, some efforts by developing countries will be indispensable. That is, some sort of international climate change policies in which every country, including developing countries, participates will be very valuable.

Under such situations, the purpose of this study is to prove the potential role of developing countries[2] on CO_2 emissions abatement. The potential role is evaluated from the viewpoint of "participation" in the international climate change policy. It means how much participation of a country or a region in the policy contributes to the policy effectiveness. It is evaluated in terms of CO_2 emissions abatement amount, CO_2 emissions abatement efficiency[3], change in GDP, carbon leakage, and marginal abatement cost. They are evaluated by simulation analysis applying an applied general equilibrium model.

A similar study was implemented in Matsumoto (2006)[4]. However, the results are affected to some extent by a bias in the assumptions of the study.

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[1] See Article 3-1 of the Kyoto Protocol.

[2] Economies in transition (EFS in Table 1 below) is treated as a developing country in this study to observe the results easily, although it is not a developing country in fact.

[3] CO_2 emissions abatement efficiency means how much CO_2 is abated when GDP is changed and is calculated as follows: CO_2 emissions abatement efficiency = CO_2 emissions abatement amount (%) / change in GDP (%).

[4] The revised version of the analysis is in Matsumoto (2007).

Therefore, this study aims to analyze under the assumptions eliminating the bias[5].

2. Method

2.1 Applied General Equilibrium Analysis

In this study, an applied general equilibrium model is used for the analysis. As the model, the GTAP-E model (Burniaux and Truong (2002)) is applied and it is reconstructed using Mathematica 5.2 of Wolfram Research Inc.. The GTAP-E model is an extended version of the GTAP model (Hertel (1996)). Because the model includes the framework such as CO_2 emissions, CO_2 emissions trading, and carbon tax, it is appropriate to analyze climate change policies and the related topics such as the analysis of this study. Fig.1 shows the overall framework of the GTAP-E model, which is same as that of the GTAP model. In addition, Fig.2 shows the structure of production, and Fig.3 and Fig.4 show the structure of government consumption and the structure of private consumption respectively[6] [7] [8]. As space is limited, the details of the model are not described here. Due to the structural condition of the model, CO_2 emissions out of GHG emissions are targeted in the analysis.

The present version of the GTAP model, GTAP Version 6, is composed of 57 industrial sectors and 87 regions. However, if a 57 × 87 model was used, it would take considerable time to simulate and the fundamental outcomes of the study could be lost when analyzing the results. Therefore, both the industrial sectors and the regions are aggregated into 10 as a compromise between the computation time and the adequacy of the analysis. Table 1 and Table 2 show the structure of regions and industrial sectors used in the analysis respectively. In addition, production factors are aggregated into 4, namely labor, capital, land, and natural resources.

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[5] The abstract of the differences from the previous studies is described in 2.2.

[6] Goods, services, or production factors (and aggregated ones) are aggregated by CES (constant elasticity of substitution) function at each branching point in Fig.2-Fig.4 except CDE (constant difference elasticity) function in Fig.4.

[7] In the model, emissions quotas (EQ in Fig.2-Fig.4) or carbon tax (CT in Fig.2-Fig.4) are considered to substitute for energy except electricity with zero elasticity of substitution.

[8] In Fig.2-Fig.4, σ_i (i = S, VAE, KE, ELY, CO, FU, GE, GN, PE, D, M, E) denote elasticity of substitution, and the parameters are from the GTAP database and Burniaux and Truong (2002). For example, σ_s in Fig.2 means elasticity of substitution between “value-added and energy” and “non-energy goods”. Some values of σ_i are shown in the figures and the others are shown in Appendix.

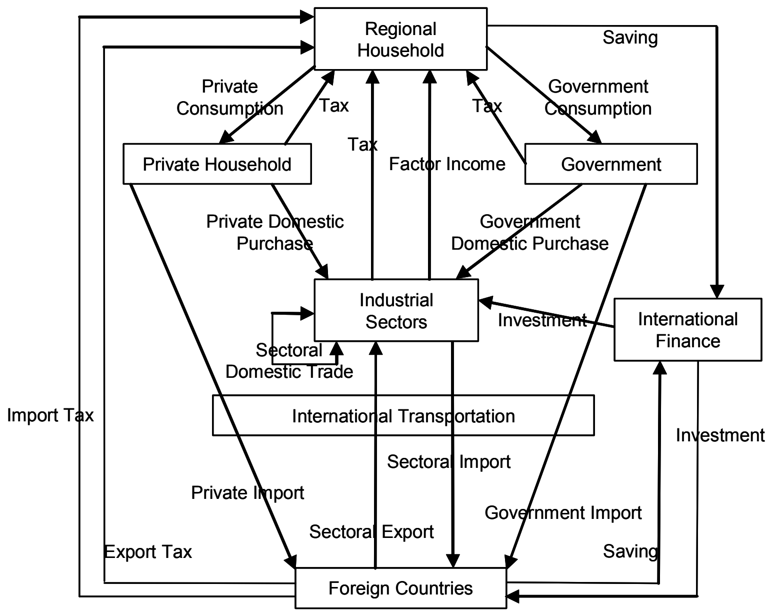

Fig.1 Framework of GTAP-E Model

*Revised version of Fig.6 in Brockmeier (2001)

**Arrows in the figure indicate money flows

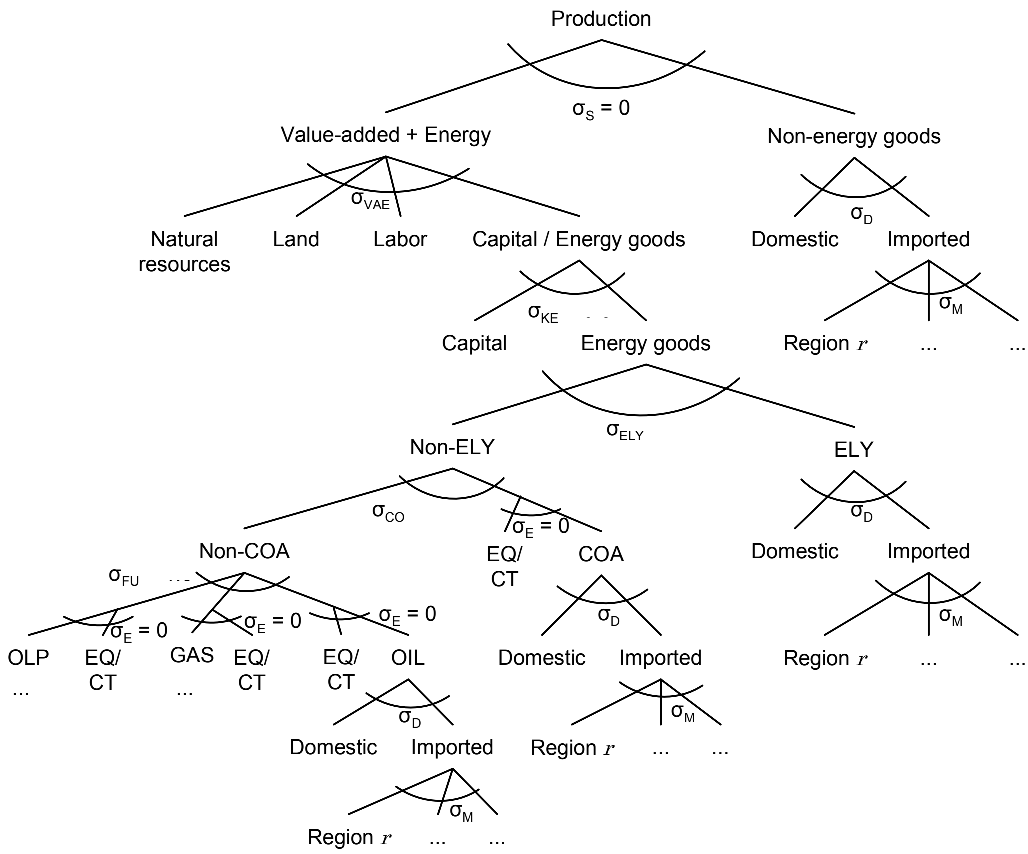

Fig.2 Structure of Production

*Revised version of Fig.16 and 17 in Burniaux and Truong (2002)

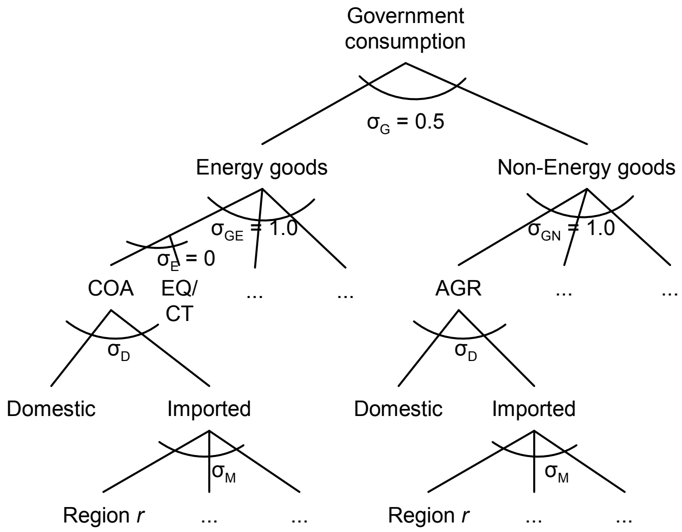

Fig.3 Structure of Government Consumption

*Revised Fig.18 in Burniaux and Truong (2002)

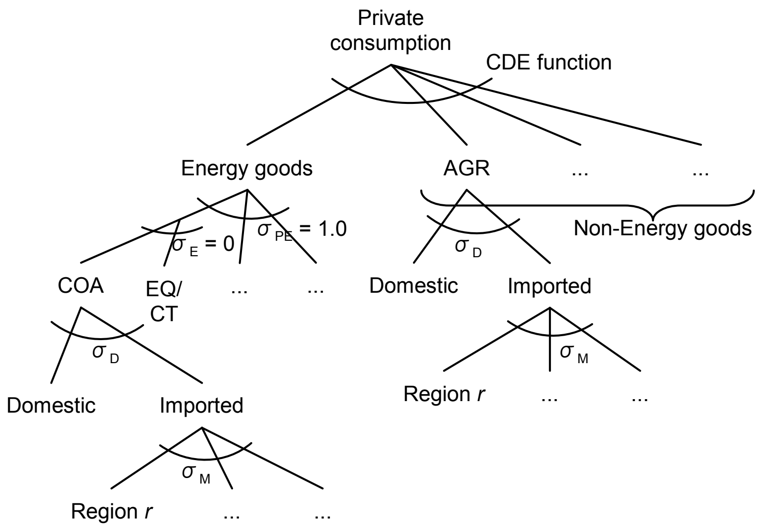

Fig.4 Structure of Private Consumption

*Revised version of Fig.19 in Burniaux and Truong (2002)

Table 1 Structure of Regions

Code	Member Regions
JPN	Japan
E_U	15 EU countries (e.g. UK, France)
KPI	Rest of the developed countries included in the Annex B of the Kyoto Protocol and ratifying it (e.g. Canada, New Zealand)
EFS	Russia and Eastern Europe included in the Annex B of the Kyoto Protocol and ratifying it
AUS	Australia
USA	United States
CHN	China
IND	India
EEX	Energy exporting countries (e.g. Middle East, Indonesia)
ROW	Rest of world (e.g. Korea, Singapore)

Table 2 Structure of Industrial Sectors

Code		Member Sectors
Energy Sectors	COA	Coal
	OIL	Crude oil
	GAS	Natural gas
	OLP	Oil products
	ELY	Power generation
Non-Energy Sectors	AGR	Agriculture, forestry, fisheries
	EIS	Energy intensive industries (e.g. chemical, paper)
	OIS	Other industries (e.g. food processing, electronics)
	TRP	Transportation
	SVC	Other services (e.g. finance, water)

2.2 Framework of the Analysis

Because the potential of developing countries to abate CO_2 emissions as the international climate change policy is evaluated in this study, the model in which all regions including developing countries are obliged to control some CO_2 emissions should be considered as the base of the analysis. In Matsumoto (2006, 2007), assuming the expanded Kyoto Protocol[9] to make all regions participate in the international climate change policy, CO_2 emissions caps are set as in the Annex B of the Kyoto Protocol concerning all of the Annex B countries and BAU CO_2 emissions are allowed[10] concerning the non-Annex B countries. However,

[9] Since the Kyoto Protocol is the only existing global framework against climate change, the base model is structured by expanding it in order to consider emissions caps on developed countries which have not ratified the Kyoto Protocol yet and developing countries which are not obligated to abate CO_2 emissions there.

[10] It means that the countries or regions do not need to abate CO_2 emissions

observing those results, they are affected by the differentiated caps among regions[11] [12]. Therefore, in order to eliminate the possible factors of such bias and observe the genuine potential of each region, the identical emissions abatement rate, 9.03% from BAU level of each region[13], is adopted to all regions in this study.

Because the model is static, it is necessary to focus on one year for the analysis. Therefore, CO_2 emissions in 2010[14], the middle year of the first commitment period of the Kyoto Protocol, are targeted for this analysis as well as Matsumoto (2006, 2007).

2.2.1 Participation in the International Climate Change Policy

In order to evaluate the effects of participation in the international climate change policy, the influences on CO_2 emissions abatement amount, CO_2 emissions abatement efficiency, change in GDP, carbon leakage, and marginal abatement costs when each one of the regions in Table 1 does not participate in the above base model[15] are compared. For instance, in the case of nonparticipation of USA, CO_2 emissions abatement is implemented by the other 9 regions, JPN, E_U, KPI, EFS, AUS, CHN, IND, EEX, and ROW. It is assumed that a nonparticipant does not enforce any additional climate change measures. If the CO_2 emissions abatement amount becomes smaller, the CO_2 emissions abatement efficiency becomes lower, the change in GDP becomes larger, the carbon leakage becomes larger, and the marginal abatement cost becomes larger due to nonparticipation of a region, it means that participation of the region in the policy makes the policy implementation more effective.

In the analysis, it is assumed that emissions trading is implemented among the participants.

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additionally.

[11] For example, since USA is obliged to abate CO_2 emissions 7% below 1990 level in the Kyoto Protocol, the influences on the emissions abatement amount due to nonparticipation of USA is overestimated.

[12] However, almost the same conclusion with this study is obtained from the previous analysis.

[13] 9.03% is the total emissions abatement rate when all regions abate emissions in Matsumoto (2006, 2007). Although the main analysis is implemented using the rate 9.03%, the results are confirmed by sensitivity analysis.

[14] CO_2 emissions data are calculated based on the energy consumption data of the GTAP database using the method and the parameters of Houghton et al. (1997) and Lee (2002, 2003), and then, they are corrected using the CO_2 emissions growth rates from IEA (2004) to make them suitable to analyze the target year

[15] It is the framework that all 10 regions participate in the policy.

2.2.2 Sensitivity Analysis

As described in the footnote 13, because the identical emissions abatement rate settled above is arbitrary in a sense, sensitivity analysis concerning the identical rate is implemented to confirm the results. The range of the rate is between 1-19% at intervals of 2%[16].

3. Results and Discussions

3.1 Results of Analysis

Fig.5-Fig.9 show the results of the analysis. Fig.5 shows the world CO_2 emissions abatement amount when each one region does not participate in the international climate change policy. As it shows, the amount becomes largest when three developed countries, JPN, KPI, and AUS, does not participate. In addition, nonparticipation of CHN brings the second smallest emissions abatement following USA. As a result, the average emissions abatement becomes -8.04% when developed countries do not participate and that becomes -7.77% when developing countries do not participate. It means that nonparticipation of developing countries affect 1.03 times more negatively on the policy implementation.

Fig.6 shows the change in world GDP when each one region does not participate in the policy. As the figure shows, the influence on GDP decrease is largest when CHN does not participate and it is smallest when E_U does not participate. The average GDP decrease becomes -0.073% when developed countries do not participate and that becomes -0.083% when developing countries do not participate. It means that nonparticipation of developing countries affect 1.14 times more negatively. Then, concerning the world CO_2 emissions abatement efficiency shown in Fig.7 calculated from the above two results, the lowest efficiency is brought when CHN does not participate and the highest efficiency is brought when E_U does not participate. Since the average efficiency becomes 110.85 when developed countries do not participate and that becomes 94.05 when developing countries do not participate, nonparticipation of developing countries affect 1.18 times more negatively.

[16] However, since 9% is almost same as 9.03%, the results of 9.03% are substituted for those of 9%.

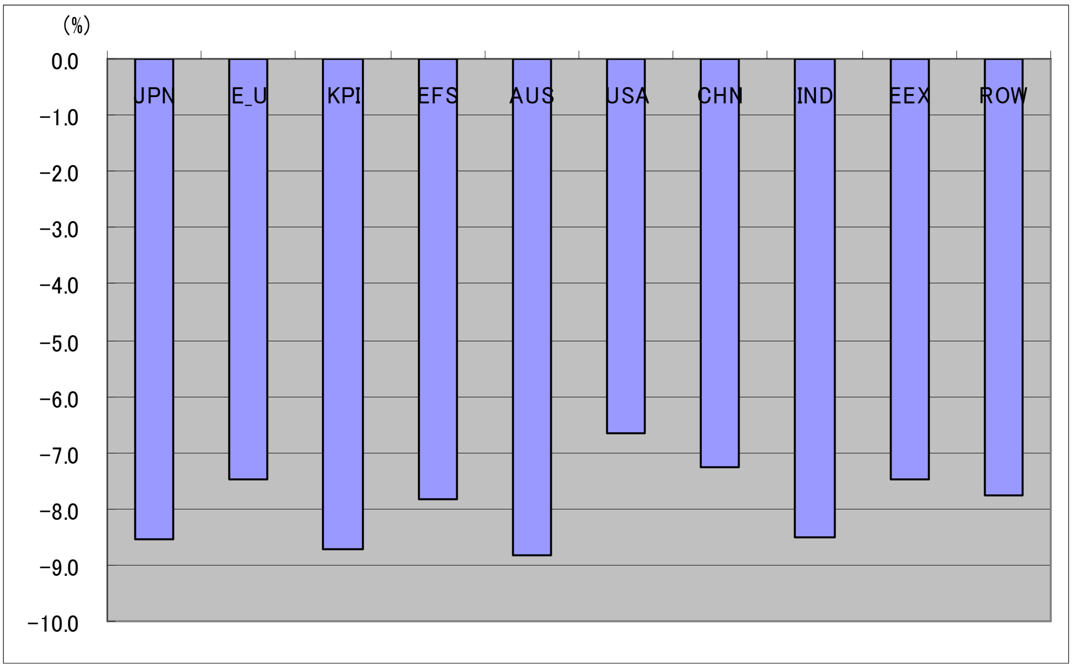

Fig.5 World CO_2 Emissions Abatement Amount by Nonparticipating Region (%)

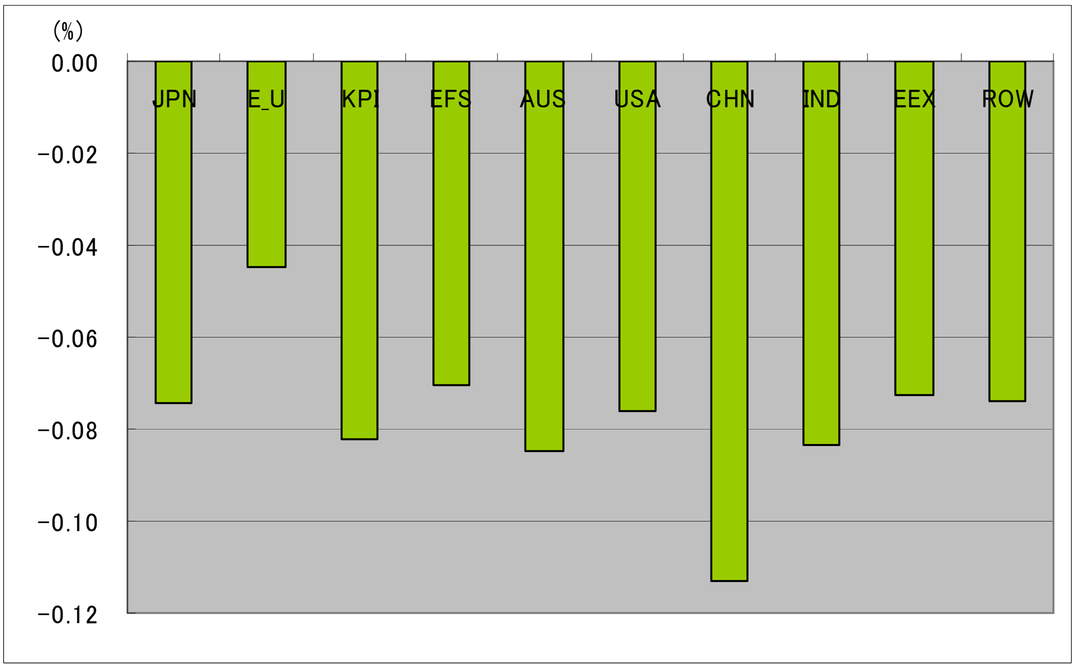

Fig.6 Change in World GDP by Nonparticipating Region (%)

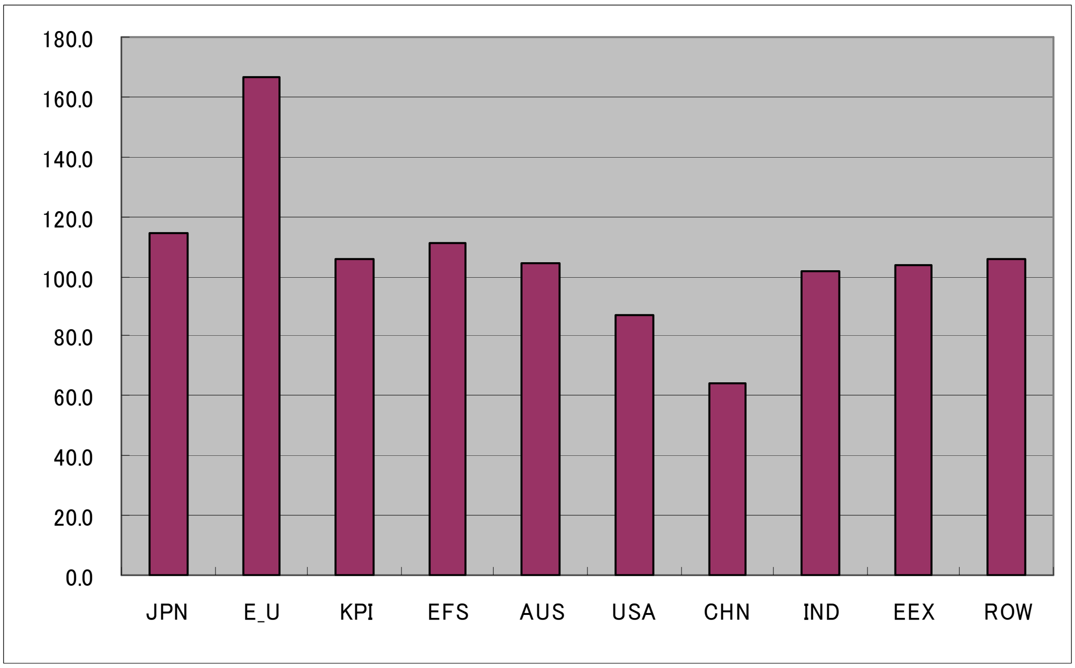

Fig.7 World CO_2 Emissions Abatement Efficiency by Nonparticipating Region

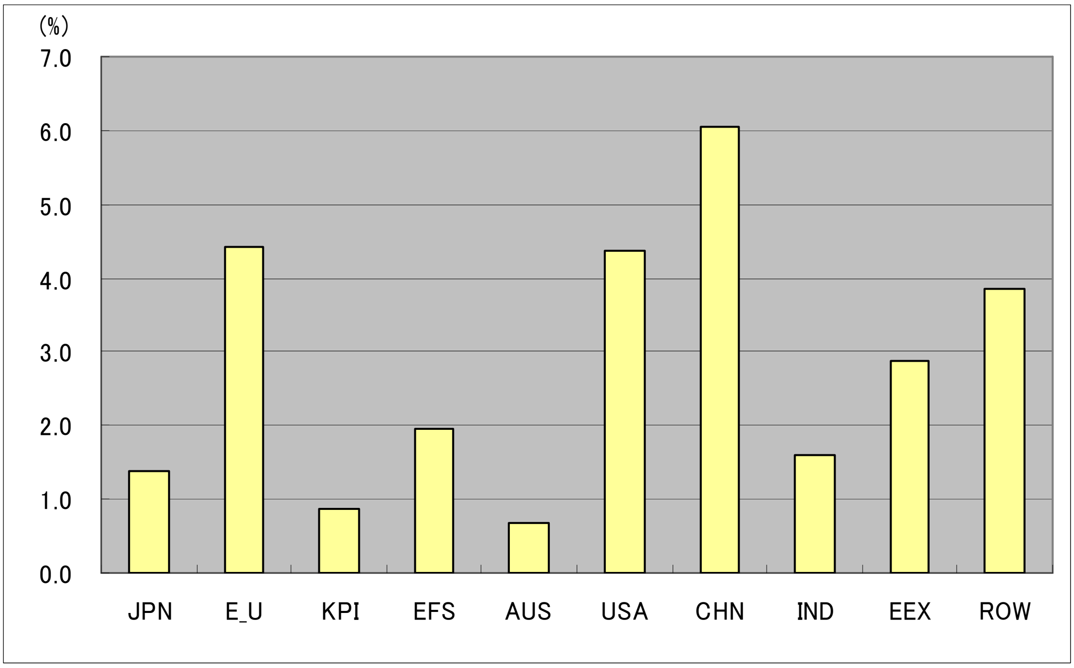

Fig.8 Carbon Leakage by Nonparticipating Region (%)

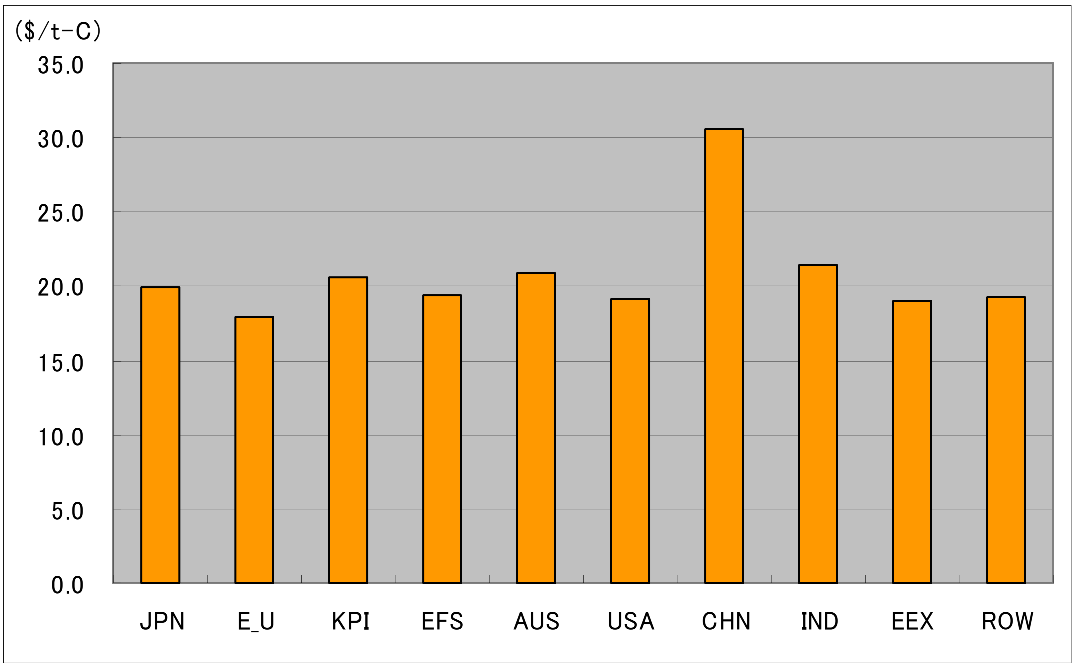

Fig.9 Marginal Abatement Cost by Nonparticipating Region ($/t-C)

Next, as Fig.8 shows, the largest carbon leakage occurs when CHN does not participate and the smallest leakage occurs when the three developed countries, JPN, KPI, and EU, do not participate. As a result, the average carbon leakage becomes 2.21% when developed countries do not participate and that becomes 3.23 when developing countries do not participate. It means that nonparticipation of developing countries affect 1.46 times more negatively.

Finally, as Fig.9 shows, the highest marginal abatement cost is observed when CHN does not participate. As a result, the average marginal abatement cost becomes $19.76/t-C when developed countries do not participate and that becomes $21.09/t-C when developing countries do no participate. It means that nonparticipation of developing countries affect 1.11 times more negatively.

Consequently, it is proved that participation of developing countries makes the policy more effective and efficient than that of developed countries from all of the evaluation terms above.

3.2 Results of Sensitivity Analysis and Discussions

The results of the sensitivity analysis are shown in Fig.10-Fig.14. They correspond to Fig.5-Fig.9 above, respectively.

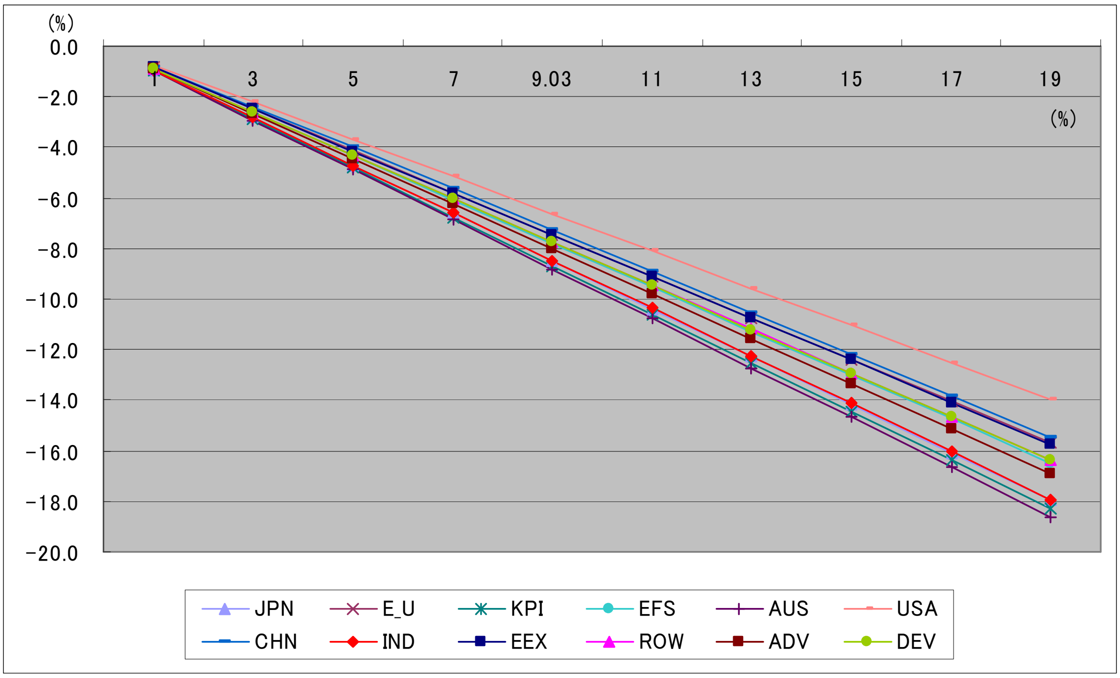

Fig.10 World CO_2 Emissions Abatement Amount by Nonparticipating Region (Sensitivity Analysis, %)

*ADV: the average of developed countries, DEV: the average of developing countries (same for the figures below)

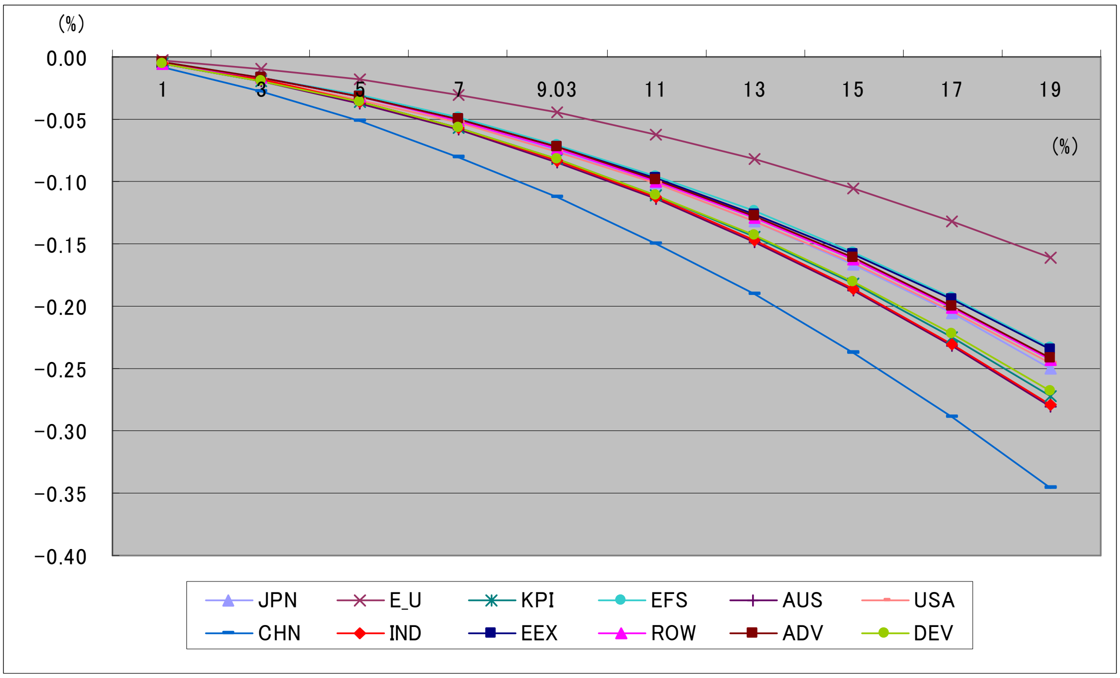

Fig.11 Change in World GDP by Nonparticipating Region (Sensitivity Analysis, %)

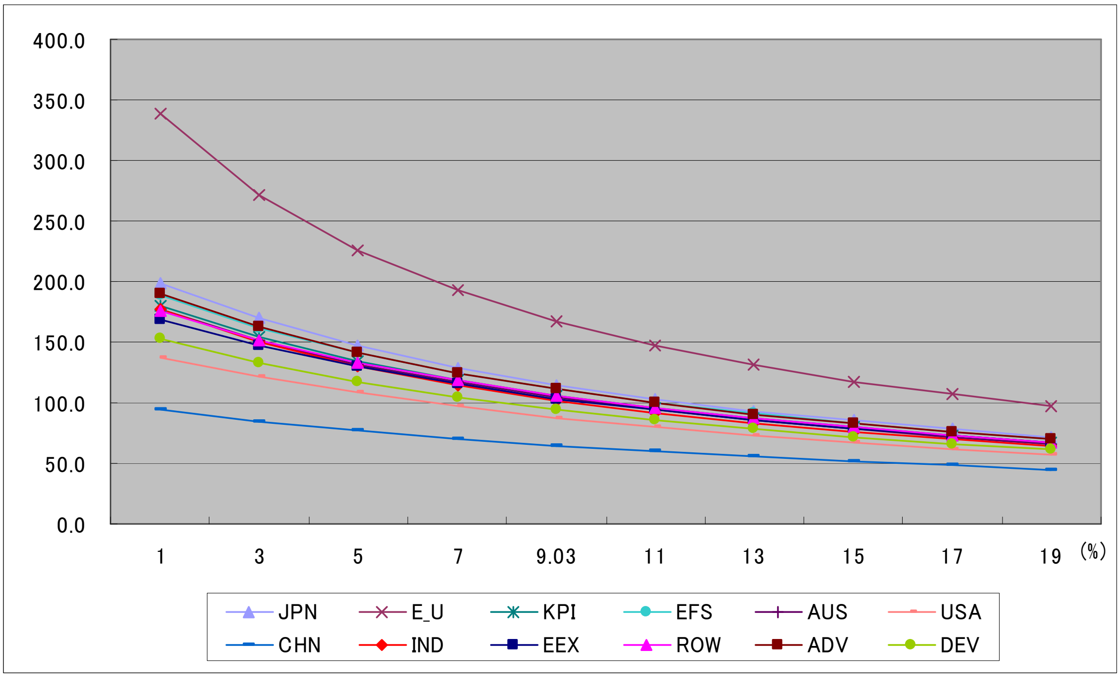

Fig.12 World CO_2 Emissions Abatement Efficiency by Nonparticipating Region (Sensitivity Analysis)

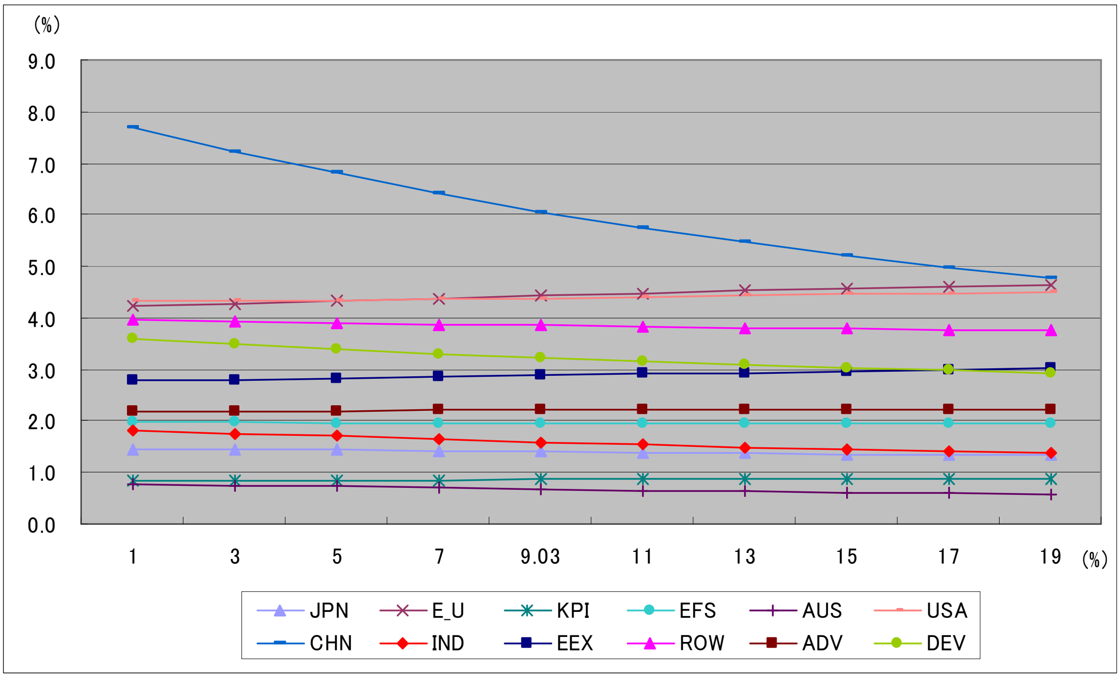

Fig.13 Carbon Leakage by Nonparticipating Region (Sensitivity Analysis, %)

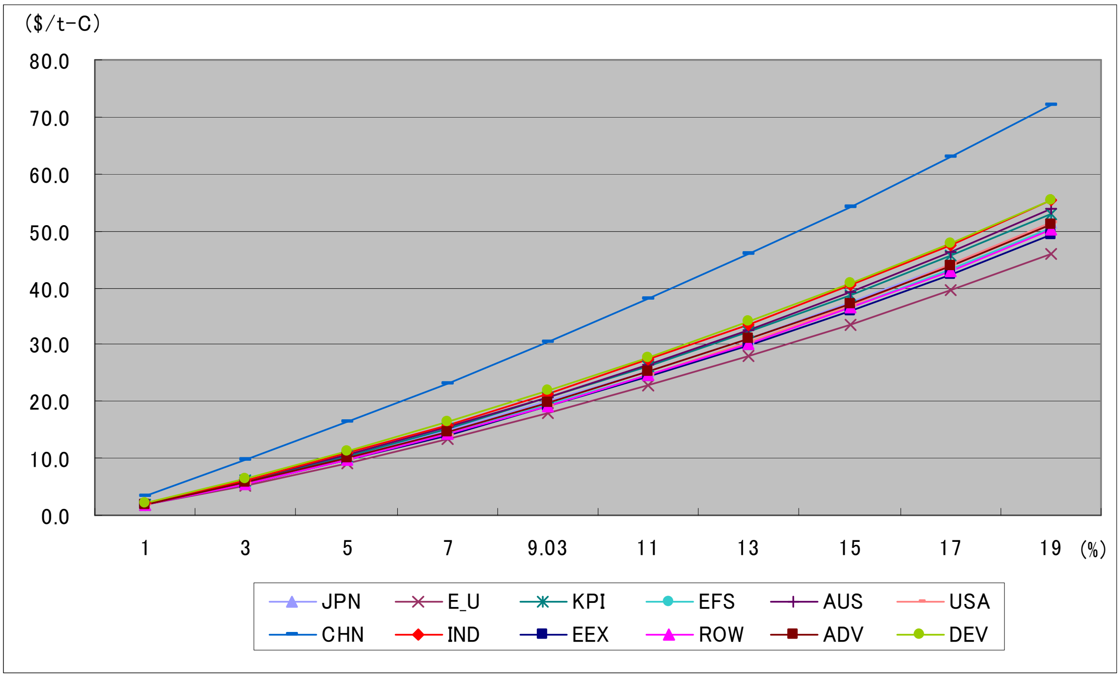

Fig.14 Marginal Abatement Cost by Nonparticipating Region
(Sensitivity Analysis, $/t-C)

The above figures show the world CO_2 emissions abatement amount, the change in world GDP, the world CO_2 emissions abatement efficiency, the carbon leakage, and the marginal abatement cost by the identical abatement rate and nonparticipating regions, respectively. In addition, the average values of both developed countries and developing countries are shown. From the sensitivity analysis, the same tendencies with the results shown in 3.1 are observed. Consequently, it is confirmed that participation of developing countries makes the policy more effective and more efficient than that of developed countries from all of the evaluation terms above irrelevantly to the identical abatement rate.

3.3 Discussions

It is considered that the reason why the climate change policy implemented in developing countries is effective and efficient is the stage in development of the countries. For example, as Table 3 shows, CO_2 emissions per energy consumption in power generation and heat, and industrial sectors are higher in economies in transition and developing countries. In addition, as Table 4 shows, power generation per consumption of fossil fuels is smaller in economies in transition and developing countries. That is to say, due to the low power generation efficiency, CO_2 emissions by generating a same amount of power are

Table 3 CO_2 Emissions per Energy Consumption by Economic Level (Mt-CO_2/Mtoe)

Economic Level	Power Generation & Heat	Industrial Sector
Developed Countries	2.24	1.56
Economies in Transition	2.41	1.70
Developing Countries	3.06	2.18
World Average	2.50	1.82

*In this table, developed countries means OECD countries

**Economies in transition is treated as a developing country in this study as described

***Calculated from IEA (2004)

Table 4 Power Generation per Consumption of Fossil Fuels by Economic Level (TWh/Mtoe)

Economic Level	Coal	Oil	Gas	Fossil Fuels
Developed Countries	4.19	4.77	4.93	4.43
Economies in Transition	2.47	1.73	0.85	1.41
Developing Countries	3.53	4.13	4.38	3.78
World Average	3.80	4.11	3.44	3.73

*In this table, developed countries means OECD countries

**Economies in transition is treated as a developing country in this study as described

***Calculated from IEA (2004)

Table 5 CO_2 Emissions per GDP of Each Region (1000t-CO_2/M$)

Region	CO_2 Emissions per GDP
JPN	0.26
E_U	0.43
KPI	0.57
EFS	3.40
AUS	1.04
USA	0.56
CHN	2.51
IND	2.01
EEX	1.13
ROW	0.87

*Calculated from the GTAP database

larger in economies in transition and developing countries than developed countries. As a result of these conditions, CO_2 emissions per GDP become higher in economies in transition and developing countries except Australia (AUS)[17]. Consequently, developing countries have much more possibility to abate CO_2

[17] Because AUS uses 43.98% of coal as the primary energy, which is extremely high in developed countries (the average of OECD countries is 21.08%), CO_2 Emissions per GDP in AUS is high (the values are calculated from BP (2006)).

emissions than developed countries.

4. Conclusions

In this paper, the potential roles of developing countries on CO_2 emissions abatement were analyzed applying an applied general equilibrium model. The evaluation was based on participation of regions in the international climate change policy. From Matsumoto (2006), differences of the CO_2 emissions abatement rates among regions, which affect on the results of the analysis, are revised. Then, it is revealed from this analysis that developing countries can play greater roles to abate CO_2 emissions effectively and efficiently than developed countries. Besides, it is mentioned from the results[18] that China has the greatest potential to abate effectively and efficiently in the world.

It is implied from the analysis that it is important and indispensable to make developing countries participate in the international climate change policy in the near future such as the post Kyoto Protocol to mitigate climate change effectively and efficiently.

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[18] See Fig.5-Fig.14.

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Appendix

Table A. Elasticity of Substitution

Sector	σ_{VAE}	σ_D	σ_M	σ_{KE}	σ_{ELY}	σ_{CO}	σ_{FU}
COA	0.23	3.05	6.10	0	0	0	0
OIL	0.20	5.20	10.40	0	0	0	0
GAS	0.20	11.03	33.04	0	0	0	0
OLP	0.62	2.10	4.20	0	0	0	0
ELY	1.26	2.80	5.60	0.5	1	0.5	1
AGR	1.26	2.42	4.93	0.5	1	0.5	1
EIS	1.21	3.18	6.57	0.5	1	0.5	1
OIS	1.23	3.47	7.49	0.5	1	0.5	1
TRP	1.36	1.91	3.80	0.5	1	0.5	1
SVC	1.68	1.90	3.80	0.5	1	0.5	1