Japanese strategy on climate change to achieve the Kyoto Target with steady economic development –An investigation by using the dynamic version of GTAP-E model

Hiroshi HAMASAKI
Senior Associate
Economic Research Centre, Fujitsu Research Institute (FRI), Tokyo, Japan

ABSTRACT

This study aims to estimate dynamic economic impact on Japan by meeting the Kyoto target and "post"-Kyoto target by using dynamic GTAP-E model. In addition, this study assesses the effectiveness of post-Kyoto commitments from economic and environmental perspectives.

To meet the Kyoto target, real GDP decreases continually from 2008, which is the first year of the first commitment period. Even after 2012, real GDP continues to decrease. In 2008, 2012 and 2020, real GDP deviations from baseline are respectively -1.362%, -1.686% and -1.763%. Big loser in Japan are energy intensive industries, iron and steel and chemical, rubber and plastic. Iron and steel industry output is projected to decrease by 3.087% in 2012 and 5.092% in 2020. Chemical, rubber and plastic industry output will decrease by 3.658% in 2012 and 4.884% in 2020. If Japan stabilise the carbon emission at the Kyoto target, Japan GDP continues to decrease and the GDP deviation from baseline would be 2.963% in 2020.

In Kyoto-Forever scenario, global carbon emission is reduced by only 5.862% from baseline scenario in 2020. Kyoto-forever commitment is not sufficient to stabilise atmosphere carbon concentration and give serious negative impacts on countries which ratified the Kyoto Protocol. Japan, EU and Canada GDP are projected to decrease by 1.660%, 2.640% and 2.970% in 2012 and 2.957%, 4.893% and 4.882% in 2020 respectively.

In establishing new commitments, a key factor will be negotiability and the new commitment should not covers only developed countries, but also developing countries, which will emit more greenhouse gas emission more than current developed countries in near future.

1. Introduction

In 1997, the Kyoto Protocol which defines emission reduction target for major industrialised countries was made in Kyoto, Japan. However, with the US and Australia not joining the Kyoto Protocol, the Kyoto Protocol covers only some 40% of global greenhouse gas emissions. Countries which ratified the Kyoto Protocol introduced and/or are about to introduce political measures to meet the Kyoto target. For example,

the UK introduced the UK emission trading scheme (UKETS) in 2002 and the EU already decided to introduce EU wide emission trading scheme (EUETS) in 2005. However, Japanese government has not introduced effective climate change strategy, but "wait-and-see" strategy. Negotiation toward second round commitments, Post-Kyoto, are to start by 2005. Japanese government needs to consider climate change strategy to meet the Kyoto target and at the same time post-Kyoto target.

This study deals with two related issues. One is to analyse economic and social impacts of the Kyoto Protocol on Japan. Another one aims to discuss Post-Kyoto international framework from economic and environmental perspective.

2. Dynamic Version of GTAP-E model

2.1. Modification for Dynamic Version of GTAP-E model

The model used in this study is based on static GTAP-E model[1]. New variables and equations are added to static GTAP-E to simulate simple dynamic behaviour[2]. These allow us to run linked annual simulations for each year between 1997 and 2020. For each region, the new equations are;

-linked net investment in each year to the change in the capital stock for that year
-allowed employment to respond temporarily to changes in real wage rates
-allowed rate of return to capital to respond temporarily to changes in demands for capital

In the long run, all three dynamic equations reduce to simpler forms: investment moves in proportion to capital stock; and employment and rates of return converge to baseline trend levels. Additionally, all three equations were over-ridden by exogenous information in our baseline scenario. They affect only the adjustment paths to the new long-run equilibrium in our deviation scenarios.

2.2. Database

In this study, we use 11 regions and 16 sectors database, which are based on GTAP Database version 5.

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[1] Burniaux, Jean-Marc and Truong Truong (2002)

[2] The dynamics added to the GTAP-E model for this study are adapted from dynamic version of GTAP used at the Centre of Policy Studies (COPS), Monash University. They are similar in style to those detailed in Ianchovichina and McDougall (2000).

Table 1: Categorisation of Regions/Countries

	Description
ANZ	Australia and New Zealand
CHN	China (include Hong Kong)
JPN	Japan
KTW	Korea and Taiwan
THA	Thailand
ASA	Other Asian Countries
USA	United States
CAN	Canada
EU	EU
FSU	Former Soviet Union
ROW	Rest of the World

Table 2: Categorisation of Sectors

	Description
AGR	Agriculture
COL	Coal
OIL	Crude Oil
GAS	Gas
GDT	Gas Distribution
P_C	Petroleum Products
ELY	Electricity
MIN	Mineral
PPP	Paper, Pulp and Publishing
CRP	Chemical, Rubber and Plastic
I_S	Iron and Steel
MTL	Non-ferrous Metal
VEH	Motor Vehicle
OMN	Other Manufacturing
TRP	Transportation
SERV	Service

3. Baseline Projection

In generating the baseline projection, we use forecasts for key supply-side

macroeconomic variables and assumptions for changes in import protection and export taxes based on data provided by Terrie Walmsley, a researcher associated with the GTAP project. These forecasts are recent versions of those documented in Walmsley et al. (2000). They are mainly based on the World Bank's Global Economic Perspectives Data Base.

4. Experiment Design

In this research, we conducted two types of experiments. One is to evaluate the dynamic impacts on Japan by meeting the Kyoto Target. Another one is on Post-Kyoto issue, which is international framework on GHGs mitigation beyond 2012.

4.1. Impacts on Japan by meeting the Kyoto and Post-Kyoto Target

These three simulations aim to evaluate dynamic impacts on Japan by using dynamic CGE model. In these scenarios, we assume that only Japan reduces the Kyoto target and Japan reduces carbon emission by 2.9% below 1990 emission level, because Japan is allowed 3.9% reduction by sequestration by the Marrakech Accord.

Scenario 1: Fixed long-run employment

This is our reference case scenario. Japan is assumed to meet the Kyoto target every year without using Kyoto mechanism, international emission trading (IET), Clean Development Mechanism (CDM) and Joint Implementation (JI). Standard modelling assumption apply, including the assumption that real wage adjust to keep employment fixed in the long-run. This means that meeting the Kyoto target in Japan has no long-run effect on aggregate employment. Any long-run changes in the labour market are revealed as changes in real wages rather than as changes in employment.

Scenario 2: Elastic supply of unskilled labour

Same as the reference case (Scenario 1) except that we make allowance for the presence of surplus unskilled labour. We assume that employment of unskilled labour can vary, even in the long run, at a fixed real wage. For skilled labour, we maintain long-run treatment of fixed employment and variable wage. With this alternative treatment of labour market, meeting the Kyoto target may lead to long-run gains in employment.

Scenario 3: Kyoto Forever

Same as the reference case (Scenario 1) except that Japan is assumed to stabilise the carbon emission beyond 2012 at the Kyoto target.

4.2. Post-Kyoto International Framework

In this simulation, we assume that Japan, EU and Canada reduce carbon emission to achieve the Kyoto target. Carbon emission reductions by sequestration in these three countries are assumed to be achieved up to maximum reduction allowed by the Marrakech Accord.

Scenario 4: Kyoto forever

In this scenario, we assume that countries which ratified the Kyoto Protocol continue to stabilise carbon emission at the Kyoto Target level beyond 2012.

5. Effects of GHG emission reductions on Japanese economy

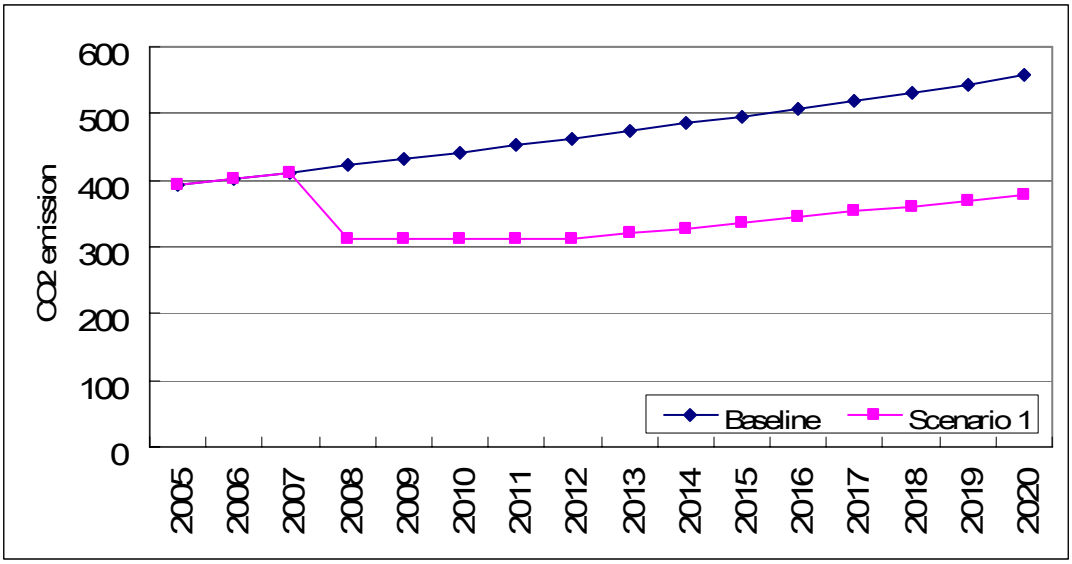
5.1. Scenario 1: Fixed long-run employment

5.1.1. CO_2 emissions

Figure 1 shows CO_2 emission change in Scenario 1. From 2008 until 2012, Japan maintains CO_2 emission at Kyoto target. Beyond 2012, Japan's CO_2 emission gradually increases. Japan's carbon emission is projected to be 462.9 million metric tonne-C in baseline and 313.2 million metric tonne-C in scenario 1 in 2012. The deviation between baseline scenario and Scenario 1 is expected to expand. The deviation is 149.7 million metric tonne-C in 2012 and 178.0 million metric tonne-C in 2020.

Figure 1: CO_2 emission in Japan

(million metric tonne of carbon)



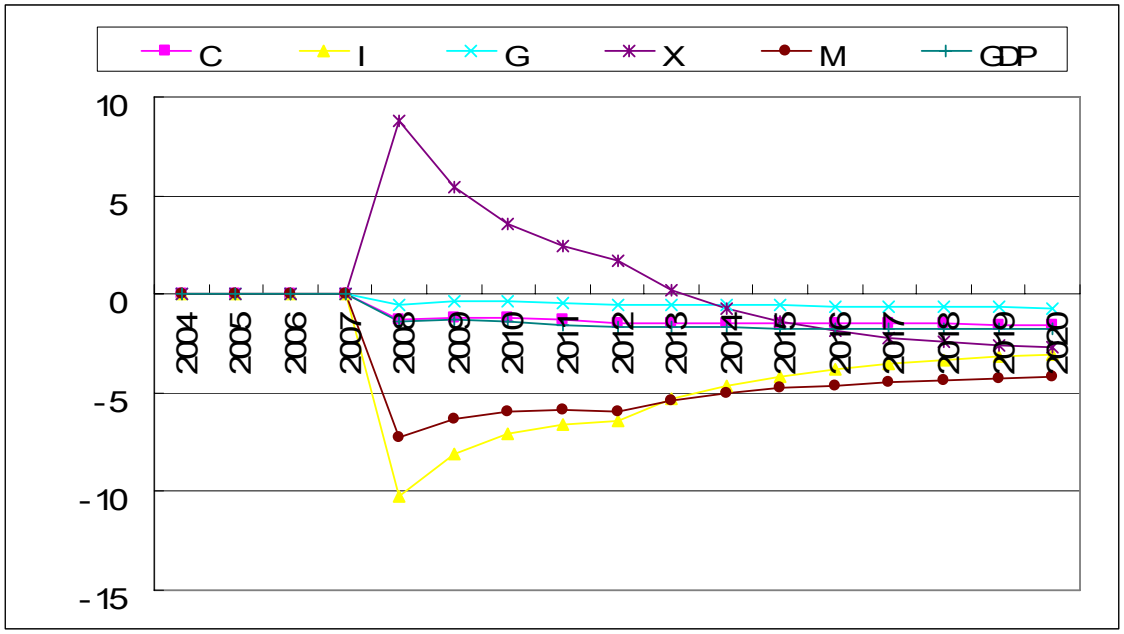
5.1.2. Macroeconomic impacts

Figure 2 shows expenditure components change of real GDP in Japan from 2004 until 2020. Real GDP decreases continually from 2008, which is the first year of the first commitment period. Even after 2012, real GDP decreases continually. In 2008, 2012 and 2020, real GDP deviations from baseline are respectively -1.362%, -1.686% and -1.763%. Export rises sharply in 2008 and the deviation from baseline is 8.773% in 2008. However the export deviation from baseline shrinks year by year and the deviation turn to be negative in 2014.

Import decreases in 2008 and the deviation is -7.236%. The deviation shrinks year by year and the deviations are -5.954% in 2012 and -4.192% in 2020.

Real private consumption and real government consumption decreases but by less than real GDP. Figure 2 shows that to meet the Kyoto target decreases the real consumption in Japan. However, the percentage decreases in private and government consumption are smaller than the percentage decrease in real GDP.

Figure 2: Expenditure Components of Real GDP – Japan
(percentage deviation from baseline)

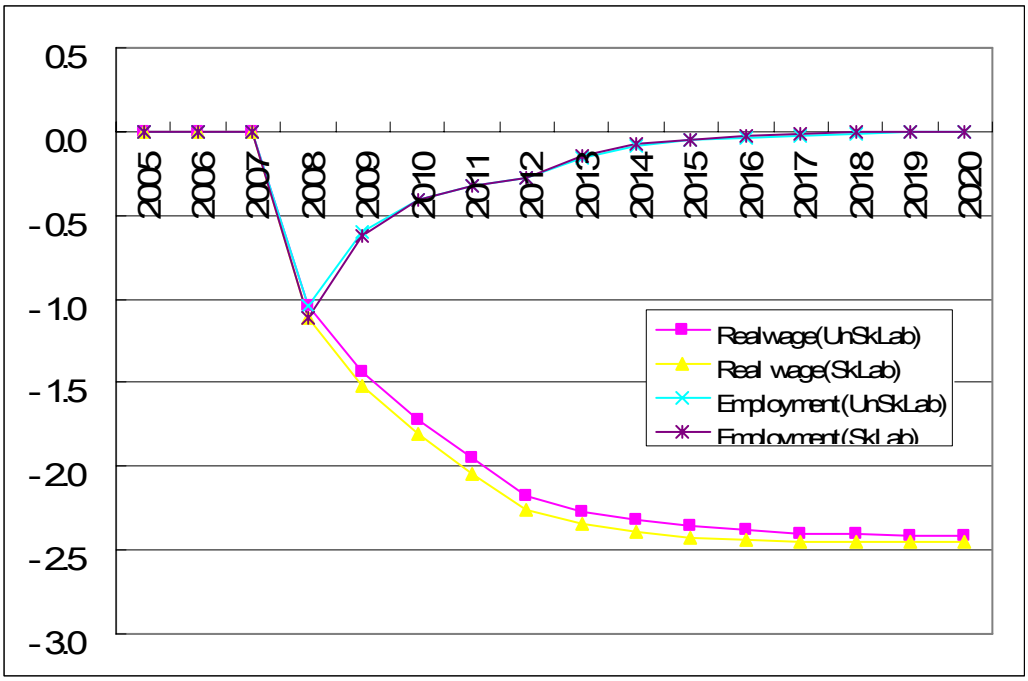


5.1.3. Employment

Figure 3 shows in 2008, the first year of the first commitment period, employment decreases relative to baseline by 1.040% for unskilled labour and 1.109% for skilled labour. However, employment moves back to baseline and the deviation becomes

-0.002% for unskilled labour and 0.002% for skilled labour in 2020.

Figure 3: Employment, Capita and Real Wages – Japan
(percentage deviation from base scenario)



5.1.4. Industrial Output

Figure 4 shows deviations in output for major energy intensive industries. Iron and steel (I_S) industry is projected to lose most in the long-run. In 2008, the deviation from baseline is 0.471%, but the deviation decreases continually year by year. Output increase of iron and steel industry in 2008 is mainly due to production increase of motor vehicle industry, which is a major purchaser of iron and steel. The deviations are projected to be -3.087% in 2012 and -5.092% in 2020. Chemical, rubber and plastic (CRP) industry trace similar path of iron and steel industry. The deviations are -3.658% in 2012 and -4.884% in 2020. Mineral products (MIN) industry output decreases, but by less than other two energy intensive industries. The deviations are projected to be -1.742% in 2012 and -2.309% in 2020.

Figure 4: Output in major energy intensive industries –Japan
(percentage deviation from base scenario)

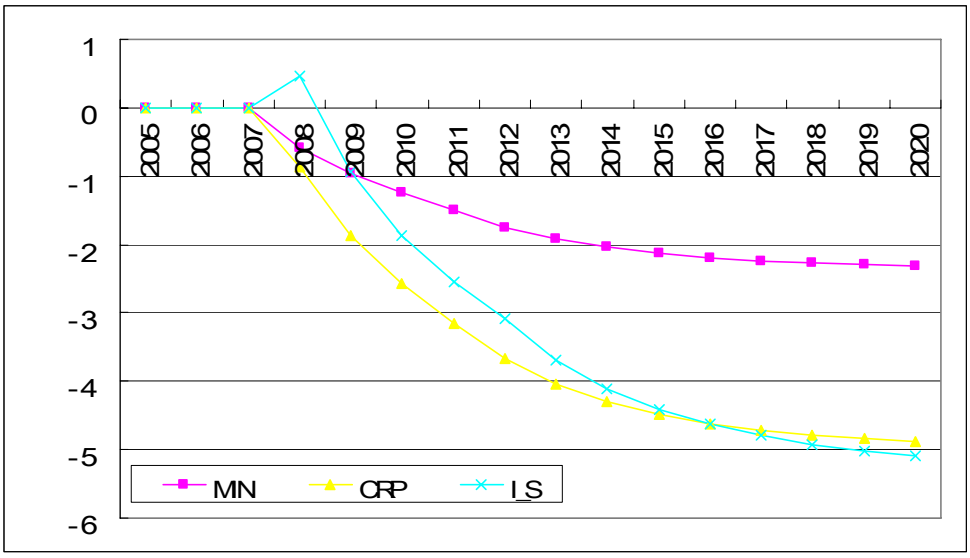
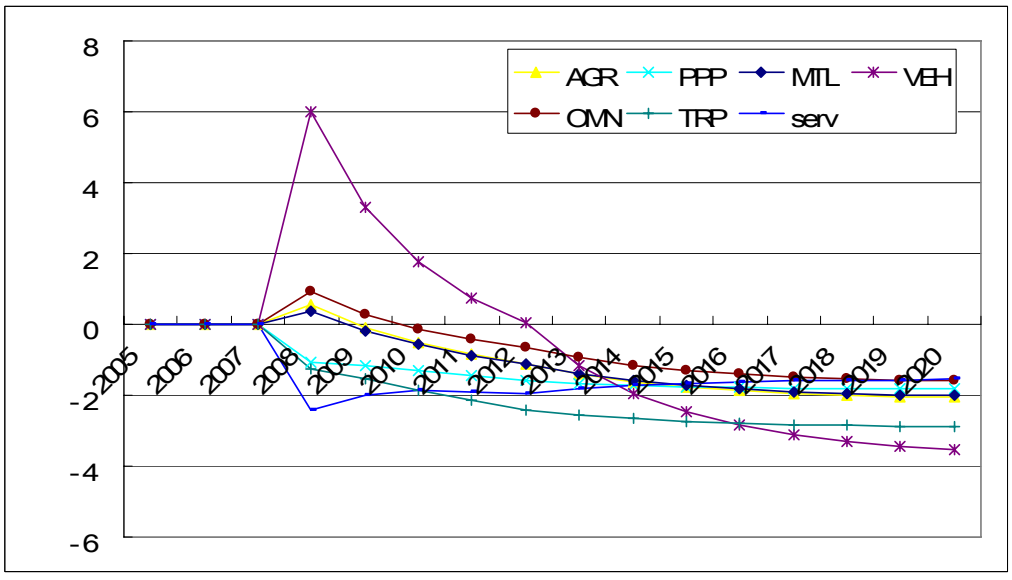


Figure 5 shows effects on other industries output. From long-run perspective, all industries output level is below the baseline scenario. However, some industries, agriculture (AGR), metal (MTL), vehicle (VEH) and other manufacturing (OMN), increase the output against the baseline in 2008. Especially, vehicle industry's deviation is positive from 2008 until 2012. The deviation of vehicle industry is 6.006% in 2008.

Figure 5: Output in other industries – Japan
(percentage deviation from base scenario)



5.2. Scenario 2: Fixed wages of unskilled labour

5.2.1. Macro economic impact

Figure 6 shows differences of GDP deviation between Scenario 1 and Scenario 2. GDP loss of Scenario 2 is more than that of scenario1. GDP deviation of Scenario 1 and Scenario 2 are -1.362% and -2.203% in 2008 and -1.686% and -3.692% in 2012.

Figure 6: Comparison of GDP deviation between scenario 1 and scenario 2 (percentage deviation from baseline)

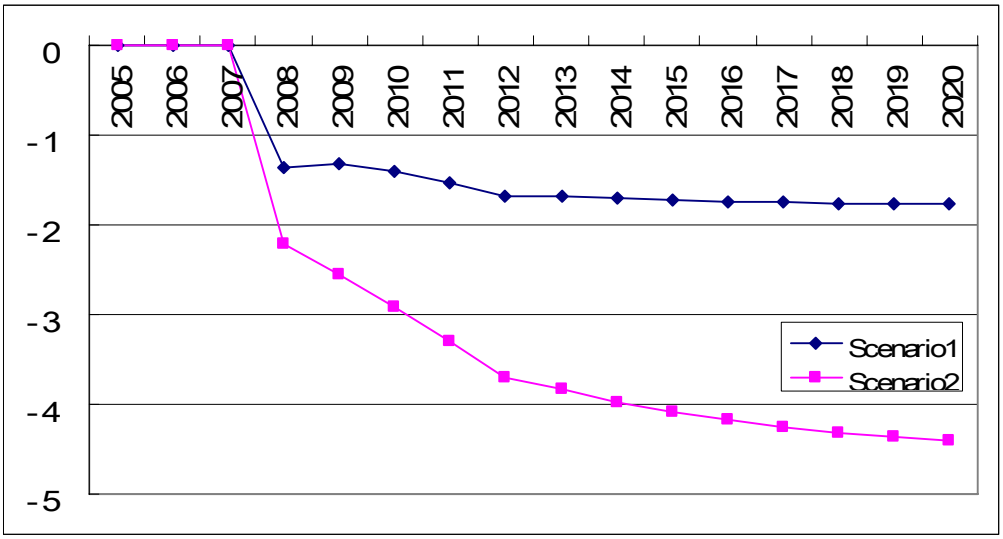


Table 3 shows difference of GDP components changes between Scenario 1 and Scenario 2. Significant difference between two scenarios is the change of investment. Investment is projected to decrease by -10.27% in Scenario 1and -13.52% in Scenario 2.

Table 3: Comparison of GDP between Scenario 1 and Scenario 2 (percentage deviation from baseline)

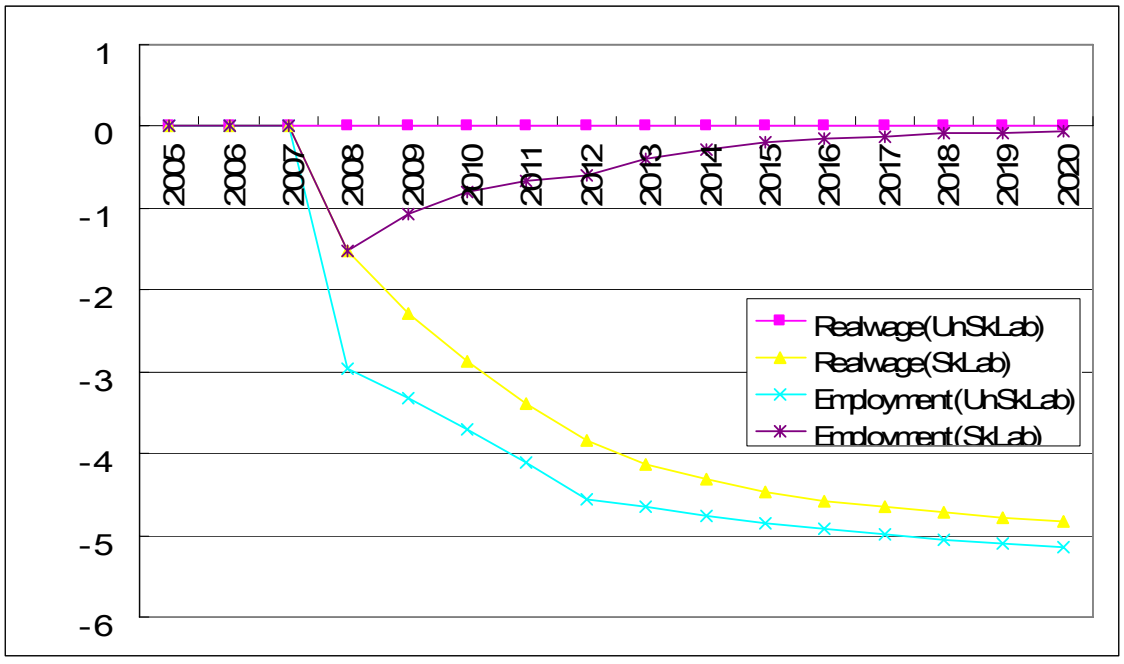
	Scenario 1	Scenario 2
C(Consumption)	-1.31	-1.13
I(Investment)	-10.27	-13.52
G(Government)	-0.54	-0.37

X(Export)	8.77	7.91
M(Import)	-7.24	-7.65
GDP	-1.36	-2.20

5.2.2. Employment

Figure 7 shows employment and real wage change. In Scenario 2, meeting the Kyoto target decreases (relative to baseline) unskilled labour by 4.549% in 2012. In contrast to unskilled labour, skilled labour decreases by 1.515% in 2008, but the deviation gradually shrinks to -0.599% in 2012 and -0.060% in 2020 respectively.

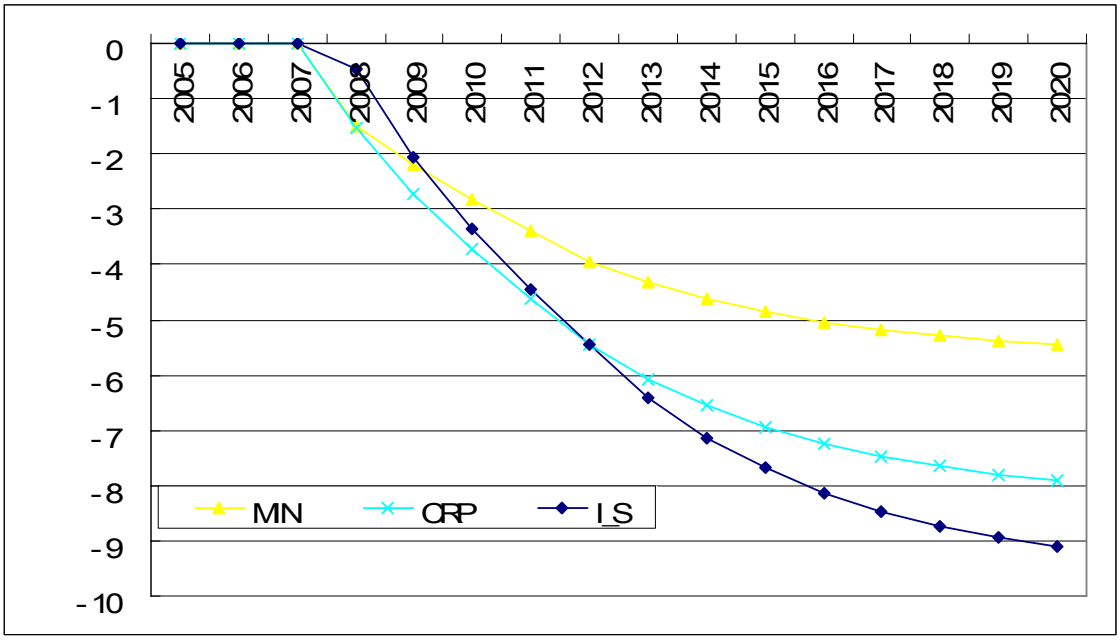
Figure 7: Employment and Real Wage - Japan
(percentage deviation from baseline)



5.2.3. Industrial output

Figure 8 shows output of major energy intensive industries relative to baseline. In Scenario 2, output drop of all energy intensive exceeds Scenario 1.

Figure 8: Output in major energy intensive industries – Japan
(percentage deviation)



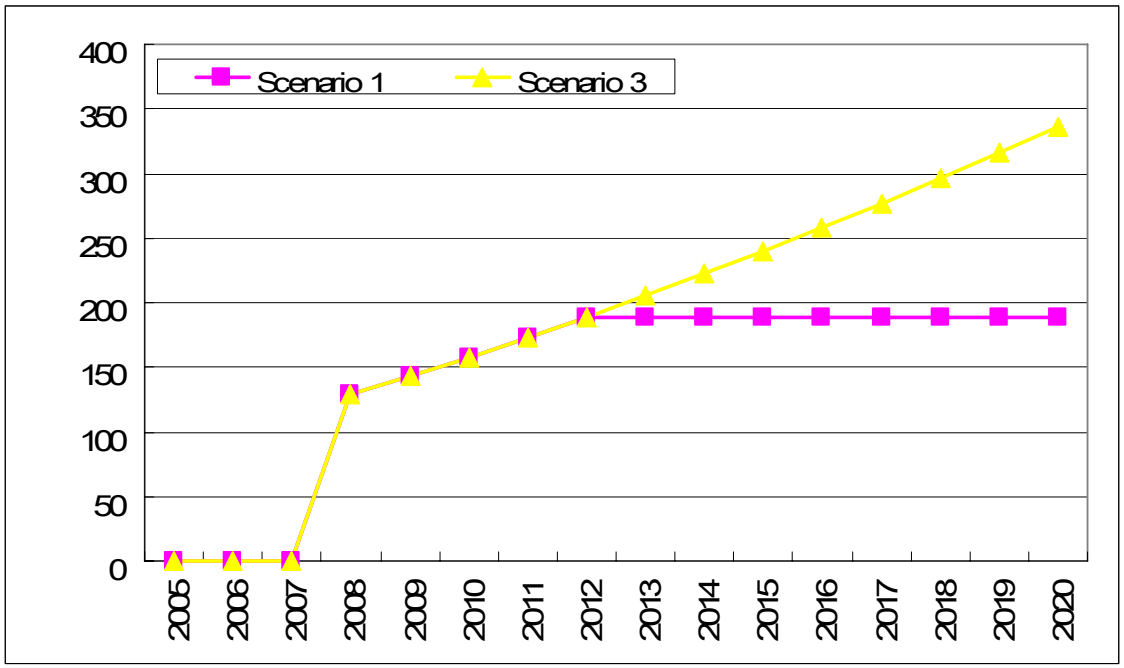
5.3. Scenario 3: Kyoto Forever

5.3.1. Abatement Cost

Figure 9 shows the abatement cost curves of Scenario 1 and Scenario 3. In Scenario 1, Japan meets the Kyoto Target only in phase 1 (2008 – 2012) and in scenario 3, Japan meets the Kyoto Target not only in phase 1, but also beyond phase 1. In this simulation, we assume that Japan meets the Kyoto target every year without using any Kyoto mechanism and thus the abatement cost is projected to increase year by year. The abatement cost is 128.8 US$/t-C in 2008 and 188.6 US$/t-C in 2012. In scenario 1, Japan keep the carbon tax rate beyond 2012 at 188.6 US$/t-C and in scenario 3, Japan have to increase carbon tax rate to meet the Kyoto Target beyond 2012. The abatement cost will move upward to 276.7 US$/t-C in 2017 and 336.6 US$/t-C in 2020 respectively.

Figure 9: Carbon abatement cost curve

(US$/tonne-C)



5.3.2. Macro economic impact

Because this dynamic model is a recursive type dynamic model, simulation results from 2008 until 2012 are same between scenario 1 and scenario 3. In this section, we focus more on post Kyoto, beyond 2012.

As already cited in Scenario 1 results, Japan keeps carbon tax rate at 2012 level, 188.6 US$/t-C, beyond 2012 and in Scenario 3, tax rate is projected to be adjusted to stabilise CO2 emission at the Kyoto Target. Table 4 compares GDP components change of Scenario 3 with those of Scenario 1. GDP deviation from baseline is -1.750% in2017 in Scenario 1, but in Scenario 3, the deviation is -2.476%. In 2020, the deviation in 2020 is estimated to be -1.763% in Scenario 1 and -2.963% Scenario3.

Table 4: Comparison of GDP components change in 2017 and 2020
between Scenario 1 and Scenario3
(percentage deviation from baseline)

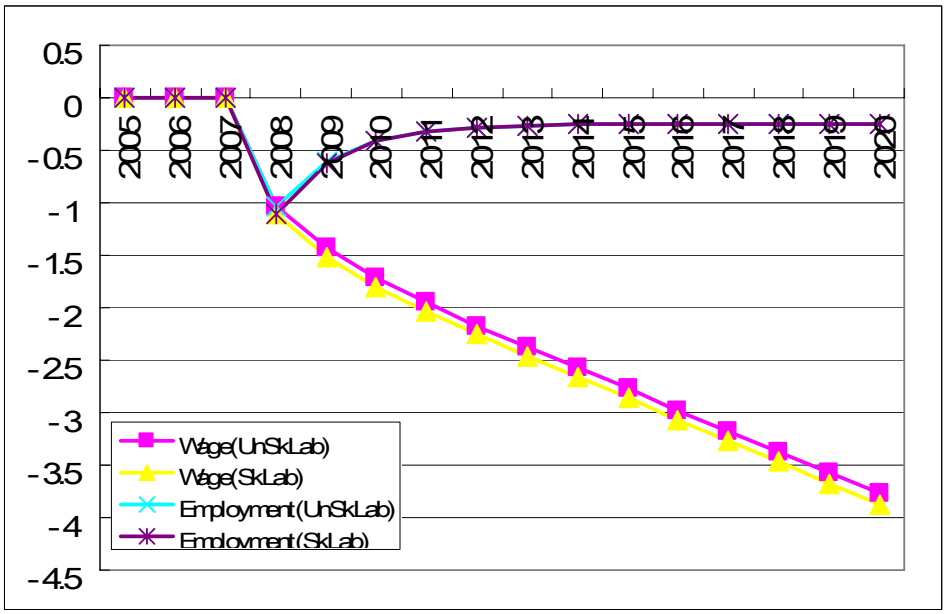
(%)

	2017		2020	
	Scenario1	Scenario3	Scenario1	Scenario3
C	-1.498	-2.186	-1.528	-2.655
I	-3.531	-6.950	-3.052	-7.583
G	-0.638	-0.932	-0.684	-1.185
X	-2.201	-0.151	-2.730	-0.803
M	-4.463	-6.822	-4.192	-7.455
GDP	-1.750	-2.476	-1.763	-2.963

5.3.3. Employment

Between 2008 and 2012, there is no difference on employment and real wage between Scenario 1 and Scenario 3. Although employment moves back to baseline scenario in Scenario 1 beyond 2012, employment of both skilled and unskilled labour decrease from baseline by 0.251% for unskilled labour and 0.256% for skilled labour in 2020. In Scenario 1, real wage deviation becomes to be stable beyond 2012, but in Scenario 3, real wage continues to drop. Real wages of unskilled and skilled labour decrease by 2.410% and 2.451% in 2020 respectively.

Figure 10: Employment and real wage – Japan
(percentage deviation from base scenario)



6. Post-Kyoto Framework

The Kyoto Protocol, which defines GHGs emission target for Annex countries, was made in 1997. The Kyoto Protocol requires Annex countries to meet predetermined absolute emission targets for five years, ending in 2012. However, the US decided to withdraw from the Kyoto Protocol and Australia followed after the US. In addition, developing countries have no binding emission limits target. The Kyoto Protocol commitment is not sufficient to stabilise global GHGs concentration. According to Bodansky (2003), potential commitments need to be evaluated from both a policy and political perspective. From policy perspective, there are five key criteria, environmental effectiveness, cost-effectiveness, equity, dynamic flexibility and complementarily. From a political perspective, there are two key criteria: whether a particular type of commitment can be negotiated, and whether it can be implemented.

6.1. Scenario 4: Kyoto Forever

Figure 11 shows marginal abatement cost curves of countries which ratified the Kyoto protocol. The abatement cost increases year by year, because the countries have to meet the Kyoto target every year.

Figure 11: Carbon Abatement Cost (US$/tonne-C)

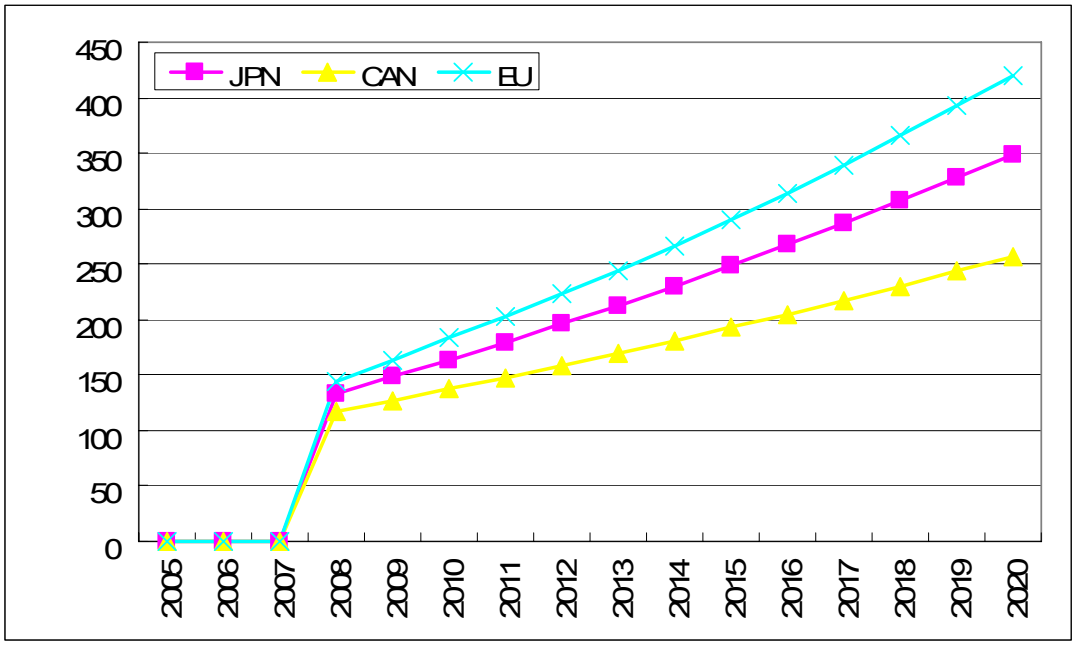


Figure 12 shows GDP change of Japan, EU and Canada. In terms of GDP, impact on Japan is less than other two countries. In 2008, GDP of Japan, Canada and EU decrease by 1.279%, 2.449% and 1.921% in 2008 respectively. In 2020, the GDP deviation expand to -2.957% in Japan, -4.882% in Canada and -4.893% in EU.

Figure 12: Change in GDP under Kyoto
(percentage deviation from baseline)

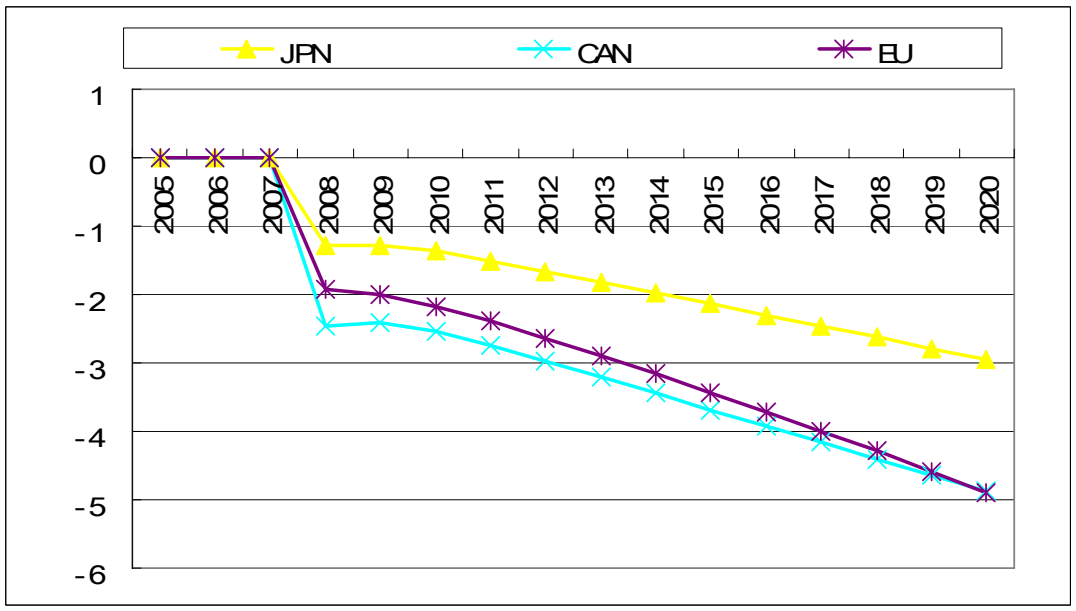


Figure 13 shows changes of expenditure components of Japan real GDP, Consumption (C), investment (I), Government (G), Export (X) and Import (M). Real investment decreases sharply by 9.383% in 2008. Consumption initially increases then fall below baseline scenario. In 2020, the consumption deviation is -1.762%. Real government consumption initially increases then falls relative to baseline levels. Export initially increases then falls. The export deviations are 2.358% in 2008 and -3.984% in 2020.

Figure 13: Expenditure Components of Real GDP – Japan
(percentage deviation from baseline)

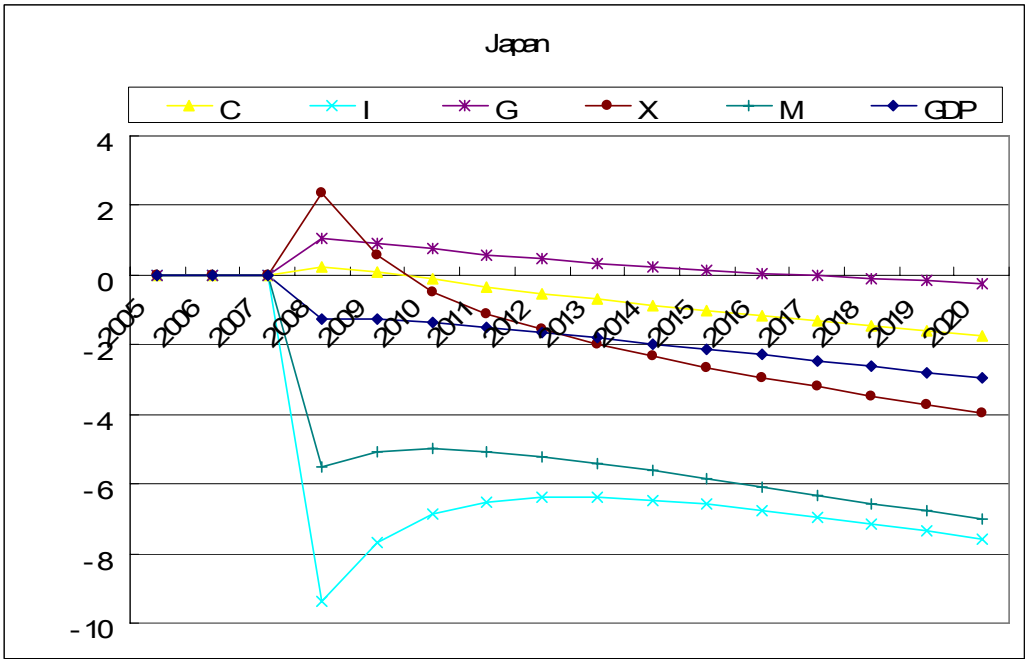


Figure 14 shows changes of expenditure components of real GDP of EU. The effects on EU is similar to those of Japan.

Figure 14: Expenditure Components of Real GDP – European Union
(percentage deviation from baseline)

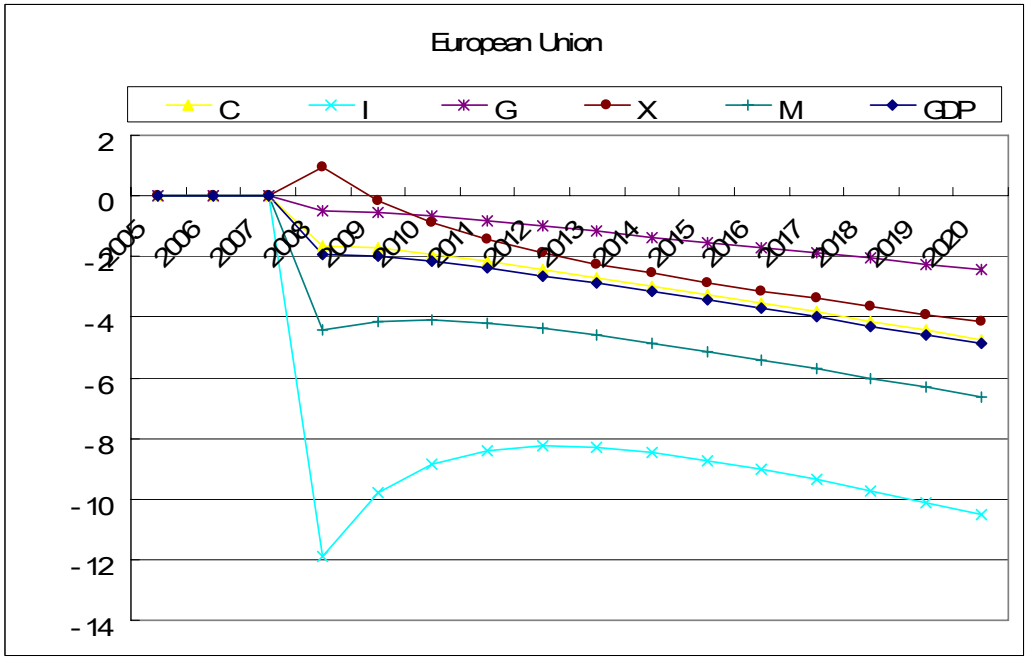
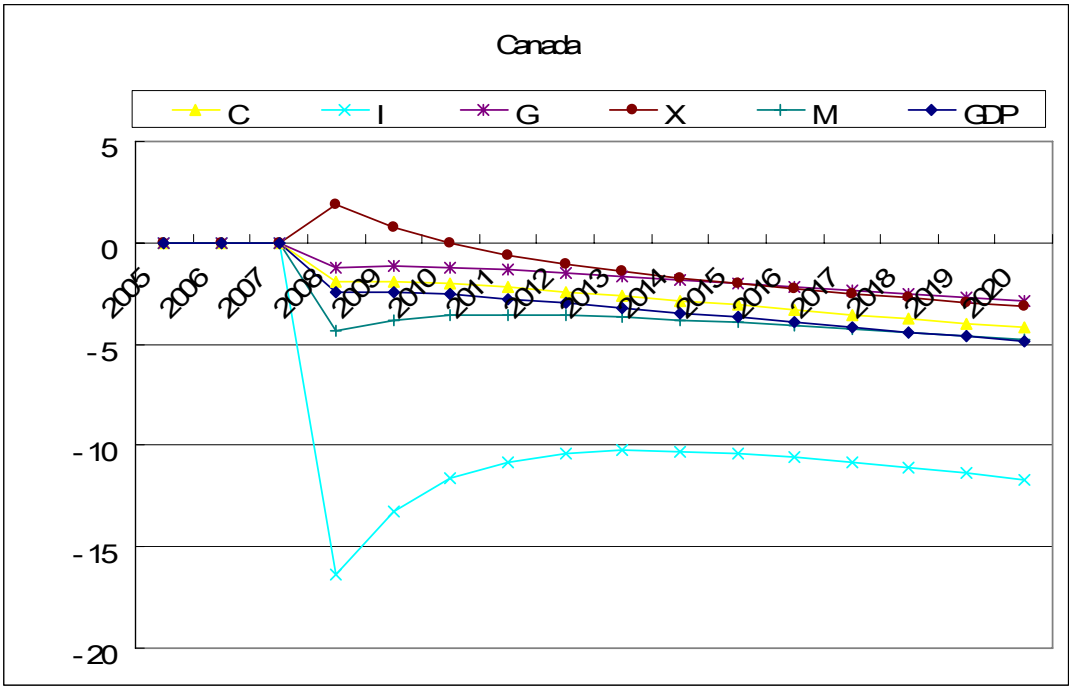


Figure 15 shows changes of expenditure components of real GDP of Canada. The effects on Canada are similar to those of Japan and EU.

Figure 15: Expenditure Components of Real GDP – Canada
(percentage deviation from baseline)



6.2. Environmental Effectiveness

Figure 16 shows carbon leakage rate. Carbon leakage rate is between 0.279 and 0.290. Definition of carbon leakage used here is carbon emission increase in all countries except Japan, EU and Canada divided by carbon emission of Japan, EU and Canada.

Figure 16: Carbon Leakage Rate

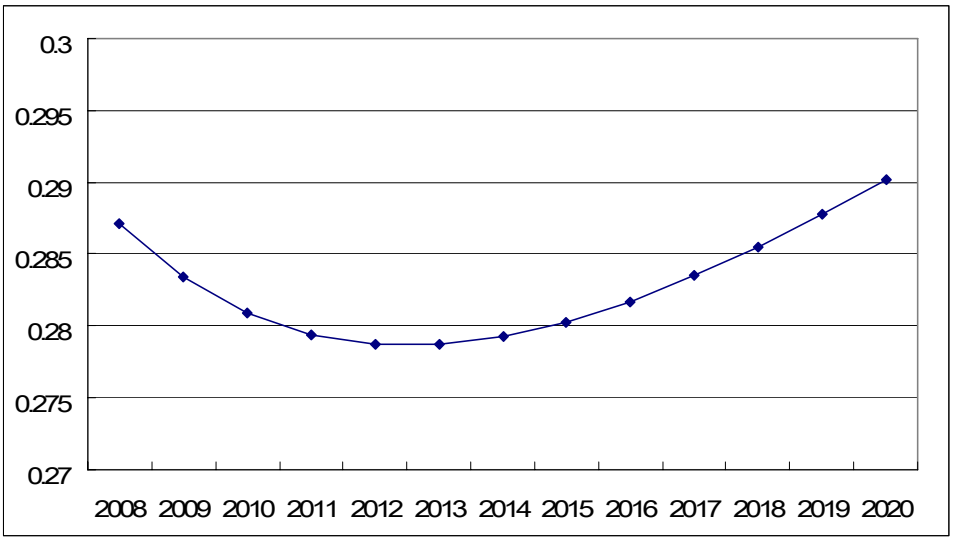


Figure 17 shows transition of world carbon emission under baseline scenario and Kyoto-forever scenario. In 2012, the last year of the Kyoto Protocol, world carbon emission is projected to be 10,413 million metric tonne-C under baseline scenario and 9.907 million metric tonne-C under Kyoto-forever scenario. Even if Japan, EU and Canada, which ratified the Kyoto Protocol, stabilise their carbon emission, world CO2 emission continue to increase. In 2020, world emission is 13,072 million metric tonne-C under Kyoto Forever scenario. Current Kyoto-forever scenario is projected to decrease world carbon emission by 5.862% below baseline scenario.

Figure 17: World CO2 emission (Million Metric Tonne of Carbon)

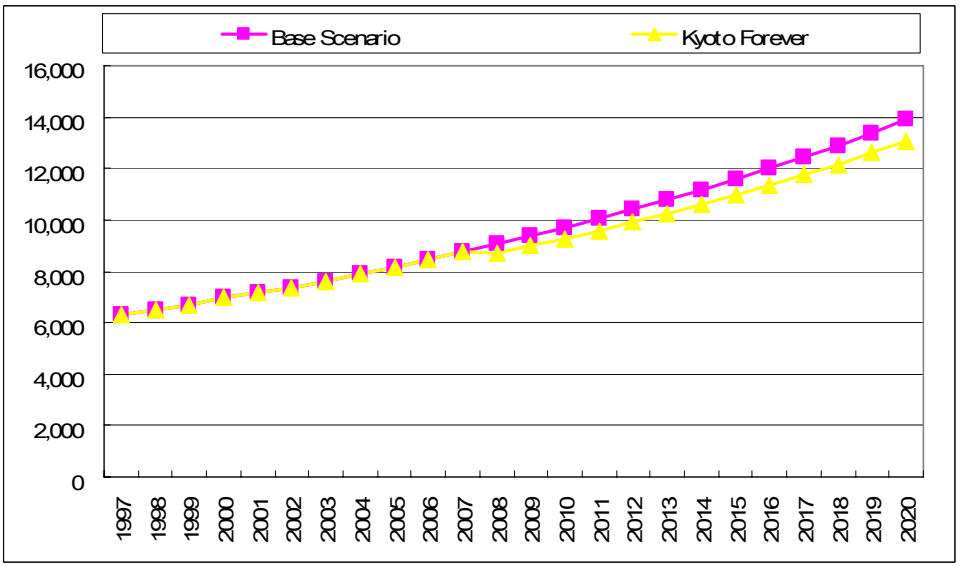


Table 5 shows carbon emissions of ratified countries, Annex countries and non-Annex countries in 1997, 2012 and 2020. Under baseline scenario, emissions from non-Annex countries exceed Annex countries emissions in 2020. Under Kyoto forever scenario, non-Annex countries emissions exceeds Annex countries emission in 2012 and 2020.

Table 5: Carbon emission

(million metric tonne of carbon)

	1997	Base Scenario		Kyoto Forever	
		2012	2020	2012	2020
Japan, EU, Canada	1,430.02	2,028.38	2,473.58	1,326.71	1,326.71
Annex Countries	3,644.93	5,154.37	6,407.67	4,667.52	5,405.20
Non-Annex Countries	2,669.50	5,133.37	7,478.60	5,239.29	7,667.05

7. Conclusion

7.1. Impacts on Japanese economy

In Scenario 1, to meet the Kyoto target, real GDP decreases continually from 2008, which is the first year of the first commitment period. Even after 2012, real GDP continues to decrease. In 2008, 2012 and 2020, real GDP deviations from baseline are respectively -1.362%, -1.686% and -1.763%. Big loser in Japan are energy intensive industries, iron and steel and chemical, rubber and plastic. Iron and steel industry output is projected to decrease by 3.087% in 2012 and 5.092% in 2020. Chemical, rubber and plastic industry output will decrease by 3.658% in 2012 and 4.884% in 2020.

In Scenario 2, fixed-wage of unskilled labour, meeting the Kyoto target decreases (relative to baseline) unskilled labour by 4.549% in 2012 and 5.134% in 2020.

In Scenario 3, Japan GDP continues to decrease by 1.686% in 2012 and 2.963% in 2020.

7.2. Post-Kyoto international framework

In Scenario 4, Kyoto-Forever scenario, world carbon emission is reduced by only 5.862% from baseline scenario. Kyoto forever commitment is not sufficient to stabilise atmosphere carbon concentration and gives serious negative impacts on countries ratified the Kyoto Protocol. Japan, EU and Canada GDP are projected to decrease by 1.660%, 2.640% and 2.970% in 2012 and 2.957%, 4.893% and 4.882% in 2020 respectively.

In establishing new commitments, a key factor will be negotiability and the new commitment should covers only developed countries, but also developing countries, which will emit more greenhouse gas emission more than current developed countries in near future.

8. Reference

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