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Multiplier Impacts and Emission Reduction Effects of Joint Crediting Mechanism: Analysis with a Japanese and International Disaggregated Input-Output Table

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Abstract

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Using the 2010 Japanese domestic and the 2005 Asian international input-output tables, we disaggregate the automobile industry and other electrical devices and parts industry to capture hybrid vehicles and solar panels. Moreover, we add the wind turbine industry and the geothermal turbine industry. In evaluating the JCM, we find that the multiplier impacts of hybrid vehicles, wind turbines and air conditioners are high, whereas boilers and solar panels produce smaller effects. In contrast, the results for the employment effects show that the coke dry quenching plants and lighting equipment create more jobs.

We also estimate the emission reduction from the JCM. Taking into account the lifetime of each product/technology and country-specific emission coefficients, we find that lighting equipment's emission reductions are the greatest, whereas washing machines' reductions are the least.

Thus, it is important to choose the technologies/items suitable for the JCM by balancing their economic and reduction effects. The government must assess various technologies/items before determining the eligibility of each technology/item.

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“Multiplier Impacts and Emission Reduction Effects of Joint Crediting Mechanism: Analysis with a Japanese and International Disaggregated Input-Output Table”

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Key Words: Climate Change, Joint Crediting Mechanism, International Input-Output Tables, Energy Efficiency, Renewable Energy, Wind Power, Geothermal Power

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1. Introduction

Reductions in the emissions from developing countries, such as China and India, are essential in achieving the atmospheric carbon dioxide (CO_2) concentration of 450 ppm. The first phase of the Kyoto Protocol (KP) did not include a mandatory target for these developing countries. The Clean Development Mechanism (CDM), however, was included and has contributed to reducing CO_2 emissions from developing countries. By 2014, 7,616 projects were implemented in 99 countries. Through these projects, 1.61 billion tons of reduction have been achieved (IGES CDM database).

However, the CDM has been criticized by various parties. First, transaction cost has been an issue. Proving the additionality of CDM projects can take considerable time. The verification and registration of projects can also be a time-consuming process that carries uncertainty. Moreover, the process entails uncertainty concerning the approval of the projects. It is noted that the transaction cost associated with the CDM hinders the participation of small and medium-sized firms and the implementation of smaller CDM projects (Boyd et al., 2009).

Second, the variety of eligible CDM projects is limited (Ellis and Kamel, 2007). Wind power and hydropower projects account for 64% of CDM projects (IGES CDM database). In contrast, energy efficiency projects represent less than 3% (IGES CDM database).

Third, regional imbalances are criticized (Ellis and Kamel, 2007). Approximately 70% of registered projects are implemented in China or India (IGES CDM database). The share of CDM projects in Africa, the Middle East and Central and South America (excluding Mexico and Brazil) account for less than 10% (IGES CDM database).

Fourth, the CDM may not result in developing countries’ desired outcomes (Kim et al., 2013). The CDM was expected to contribute to technology transfer that is effective for sustainable development in developing countries. In many cases, however, the environmental technology demanded by developing countries was not adopted. For example, although many developing economies want to have renewable energy technologies such as solar power generation, most of the related projects are concentrated in China. Energy-efficient products such as efficient lights and cooking stoves, which are popular in developing economies, are not implemented in the CDM. Moreover, some host countries mandate the use of domestic technologies, at least partially, in the CDM, which restricts the types of technologies that can be adopted in the CDM.

Despite these problems, reductions in the emissions from developing economies are still needed to achieve meaningful emission reduction. That is, in the long run, an international framework is needed in which every country plays a role in mitigating CO_2 emissions. In the short run, however, bilateral and multilateral arrangements are useful in encouraging emission reduction in developing countries. To overcome the problems associated with the CDM, the international community has proposed new mechanisms that could increase the number of host countries and expand the scope of technologies. The Sectoral Crediting Mechanism (SCM) and the Joint Crediting Mechanism (JCM) are examples of these new mechanisms that encourage emission reduction in developing countries. The negotiations at the UN Climate Change Conference (COP18) discussed the possibility of a new mechanism for the post-Kyoto period[5]. In the following COPs, the JCM has been proposed and discussed under "various approaches".

Facing the COP21 in Paris, the Japanese government has announced its own emissions target, which is aimed to reduce GHG emissions by 26% from 2013 levels by 2030. The Japanese government did not explicitly include the emission reduction from JCM credits as a part of its own emissions target. However, it also announced that Japan will continue to contribute via the JCM and earn emission credits of 50 to 100 million tons of GHG reduction by 2030.[6]

Although the JCM has been proposed at the COP meetings, quantitative analysis has not been conducted. The JCM, at least under the currently implemented scheme, has been implemented by private organizations receiving subsidies from the government. Because the JCM utilizes taxpayers' money, its effectiveness should be quantitatively evaluated from several perspectives. First, it should be evaluated according to the multiplier impacts and employment effects that it can incur. Second, the most important perspective is emission reductions. This paper aims to address these two issues. First, we quantify the multiplier impacts of the JCM and identify the products and technologies that have the greatest impacts. Second, we examine which JCM project results in the greatest emission reduction given a fixed government subsidy size.

The paper is organized as follows. In section 2, we present a brief introduction of the proposed JCM. We also present the advances in the mechanism. In section 3, the model to estimate the economic, employment, and additional emissions is presented along with the simulation scenario and the method of calculating emission reduction. Section 4 presents the results, and section 5 concludes the paper.

2. The Joint Crediting Mechanism (JCM)

[5] The decision concerning the SCM has not been finalized. Further discussions of the SCM will be held under "new mechanism."

[6] The Japanese government released the intended national determined contributions (INDC) in July 2015. In the statement issued by the Prime Minister of Japan and His Cabinet, the JCM is included as a part of Japan's international contribution. The JCM is also expected to result in a total reduction of 50 to 100 million tons of GHGs. Further details are available at the Prime Minister of Japan and His Cabinet web page (https://www.kantei.go.jp/jp/singi/ondanka/kaisai/dai30/yakusoku_souan.pdf).

2.1. Design and Goals of the JCM

In September 2009, the Japanese government announced that the mid-term goal for the year 2020 is a 25% reduction from 1990 levels.[7] To achieve this goal, the Japanese government planned to reduce emissions abroad, especially from developing countries, by exporting energy-efficient products/technologies from Japanese firms.

At the same time, Japanese firms were looking for new options beyond the CDM that would allow Japanese firms to assist in reducing global greenhouse gas (GHG) emissions. Firms were also looking for new options because they were unsatisfied with the CDM scheme. Japanese firms that were involved in CDM projects were unsatisfied with the CDM for four major reasons: the time-consuming process of issuing the certified emission reduction (CER), the additionality requirements that must be met for the CER to be issued, volume of CERs issued, and the regional imbalance of CDM projects (Arimura et al., 2012).

In addition, Japanese firms' criticisms of the CDM also included the type of projects eligible for the CDM scheme. For example, nuclear power plants and energy-efficient appliances were not permitted in the CDM. Thus, Japanese firms were pressuring the government to establish a new mechanism in which energy efficiency technology can be used. Overall, Japanese industries were frustrated with the fact that they could not use their advanced energy efficiency technology.

As a result, the Japanese government proposed the JCM, which aims to address the four elements raised by firms and extend the scope of activities eligible for the JCM. The proposed elements of the JCM are as follows:

> "1) Facilitating diffusion of leading low carbon technologies, products, systems, services, and infrastructure as well as implementation of mitigation actions, and contributing to sustainable development of developing countries.
> 2) Appropriately evaluating contributions from Japan to GHG emission reductions or removals in a quantitative manner and use them to achieve Japan's emission reduction target.
> 3) Contributing to the ultimate objective of the UNFCCC by facilitating global actions for GHG emission reductions or removals." (New Mechanisms Information Platform website, 2014)

Table 1 summarizes the difference between the proposed JCM and the CDM. The governance of the mechanism will be enforced bilaterally between Japan and the host country. This structure differs from that of the CDM, as the CDM executive board is set multilaterally under the United Nations.

The bilateral committee established between Japan and the host country will decide which

[7] The emission reduction target set for 2020 was submitted to the UNFCCC after COP15 in Copenhagen, Denmark. However, this target was aborted after the earthquake in March 2011.

products/technologies will be eligible in the JCM by constructing a list of Approved Methodology (JCM Approved Methodology). The committee started to construct this list, which contains possible products/technologies, along with the methodology used in calculating the amount of reduction (credits) each product/technology will achieve. Five countries have approved the inclusion of a total of seventeen products/technologies on the list.[8] Another twenty products/technologies are presently under examination in these five countries.

The Japanese government is partially financing the project/activities in the early stages of the JCM. In fact, the government financed several projects in Indonesia and Mongolia. As the JCM matures, private firms are expected to finance projects without assistance from the government. The determination of the Keidanren's Voluntary Action Plan[9] for the post-Kyoto period will also encourage private firms to participate in the JCM.

An interesting feature of the JCM is that the credits will not be tradable internationally, at least in the early stages. The credits issued, however, are expected to be tradable domestically. After the mechanism matures and the mechanism is proven to be sustainable, the credits may be tradable internationally as well. The international tradability will be discussed in the future.

Table 1 Comparison of the JCM and CDM.

	JCM	**CDM**
Governance	Decentralized Structure: Bilateral Committee	Centralized Structure: CDM Executive Board
Scope of Activities	From Projects to Markets	Project Based
Methodology	Positive List or Benchmarking	Additionality Approach
Investors	Japanese Government Private Firms	Governments Private Firms
International Tradability of Credits	Non-tradable (Tradable in the future)	Tradable

Another unique feature of the JCM is the fact that firms that wish to participate in the project must be registered in Japan. In other words, firms not registered in Japan must find a Japanese counterpart or organize an international consortium with a Japanese firm to apply for the

[8] Indonesia, Maldives, Mongolia, Palau and Vietnam have created the JCM Approved Methodology list. The JCM Approved Methodology for Indonesia has the largest number of items, with 10, whereas Vietnam has four items, Mongolia has two items and the Maldives and Palau each has one item. The other nine countries that have signed bilateral agreements have not started the screening process to approve products/technologies as of August 2015.

[9] Keidanren (Japan Business Federation) is the largest business federation in Japan, consisting of 1,309 firms (as of July 1, 2014).

subsidy.[10] This does not imply that the technology/product must be manufactured in Japan.[11] If restrictions are placed on the origin of manufacturing, then the JCM will not comply with GATT/WTO regulations because in the early stages, subsidies will be granted to firms that participate in the program.

2.2. Recent Advances of the JCM

The Ministry of Economy, Trade and Industry (METI) and the Ministry of the Environment (MOE) have been engaged in feasibility studies (FS) since 2010. One objective of the FS is to gather information on environmental technological needs from possible host countries. The FS will be used as a basis for discussion in constructing the positive list when the bilateral committee is established.

Projects included in the FS range from energy-efficient boilers, building energy management systems (BEMS), MRT, and waste management of power plants. Therefore, a variety of activities are presumably eligible for the JCM.

The FS have been conducted in various parts of the world. For instance, BRICS have been host countries for the FS. Small island countries such as Maldives and African countries such as Djibouti are also included in the FS. Thus, the Japanese government hopes to include developing countries other than China and India.

The Japanese government has advocated the JCM since 2009 in hopes of expanding the list of possible host countries. The Japanese government has signed bilateral documents concerning the JCM with Mongolia (Jan. 2013), Bangladesh (Mar. 2013), Ethiopia (May 2013), Kenya (June 2013), Maldives (June 2013), Vietnam (July 2013), Laos (August 2013), Indonesia (August, 2013), Costa Rica (December 2013), Palau (January 2014), Cambodia (April 2014), Mexico (July 2014), Saudi Arabia (May 2015) and Chile (May 2015). These countries, with the exception of Costa Rica, Saudi Arabia and Chile, have held joint committee meetings. Furthermore, the joint committee between Indonesia and Japan registered the first JCM project in October 2014. The number of registered projects increased to a total of seven projects by the end of August 2015.

The JCM has gathered attention and support from the Japanese private sector. A survey conducted by the Keidanren reports that Japanese firms are interested in the JCM because the new mechanism will allow Japanese firms to assist developing countries in reducing their emissions (Japan Keidanren, 2013).

As mentioned above, the bilateral committee had approved 17 methodologies (projects) as of August 2015. The "Installation of Energy-efficient Refrigerators Using Natural Refrigerant at Food Industry Cold Storage and Frozen Food Processing Plant" (ID_AM003) in Indonesia is an

[10] The Asian Development Bank (ADB) Trust Fund provides financial support, called "leapfrog" development projects, for projects that do not include Japanese firms.

[11] There are two approved projects in Mongolia for which the product/technology is manufactured by a non-Japanese firm but a Japanese firm supervises the maintenance and provides technical assistance.

example of an approved methodology. In this methodology, the emission reduction is calculated in the following manner. First, the reference emission is calculated by multiplying the electricity consumption of the project refrigerator, project to reference coefficient of performance (COP) ratio and the emission coefficient. The reference COP is determined by the highest refrigerator COP available in Indonesia. Next, the project emission is calculated by multiplying the electricity consumption and the emission coefficient. Finally, the emission reduction (or credits) is calculated as the difference between the reference emission and the project emission (Kasuya, 2015).

Another example of the methodology is the "Displacement of Grid and Captive Genset Electricity by a Small-scale Solar PV System". There are two methodologies used to determine the reference emission. The first method uses the amount of electricity produced by the PV and the emission coefficient of grid electricity. The second method uses the amount of electricity produced by the PV and the emission coefficient of newest available diesel generator, which has an energy efficiency of 49% and an emission coefficient of 0.533 t-CO_2/MWh (Kasuya, 2015).

3. Framework of Analysis

3.1. Input-Output Model

If the JCM is implemented, the mechanism will generate new demand for energy- efficient products/technologies in developing countries. Furthermore, if we assume that the new demand is met by the increase in supply from the Japanese manufacturing sector, then we can also assume that the JCM increases exports from Japan to the host country. The increase in exports will directly increase the economic activity of industries that will produce the product/technology. In addition, the new demand will indirectly increase the economic activity of industries that will supply intermediate goods to the directly affected industry. We use the input-output (I-O) model because this model captures the direct and indirect effects of the increased volume of exports.[12] We use two different I-O models, the domestic I-O model and the international I-O model, in analyzing the effects of the JCM.

3.1.1. Domestic Input-Output Model

Let us assume that the economy consists of n sectors. The total output for each sector is the sum of intermediate output, domestic final demand and export, minus import, or

$$X = AX + F^d + E - M \tag{1}$$

[12] See Miller and Blair (2009) for a detailed explanation of the input-output model.

where X is the vector of total output, A is the matrix of input coefficients, F^d is the vector of domestic final demand, E is the vector of exports, and M is the vector of imports. Equation (1) assumes that imports are exogenous of domestic economic activity. However, it is more realistic to assume that imports change with domestic economic activity. Thus, we must treat imports as endogenous, or

$$X = \left(I - \hat{M}\right)AX + \left(I - \hat{M}\right)F^d + E \qquad (2)$$

where $\hat{M}$ is an n by n square matrix with the diagonal component of $\frac{m_i}{X_i}$, or the import ratio, and all other components are zero. I is the usual n by n identity matrix. Solving equation 2 for X yields

$$X = \left(I - \left(I - M\right)A\right)^{-1}\left(\left(I - M\right)F^d + E\right) \qquad (3).$$

The $\left(I - \left(I - M\right)A\right)^{-1}$ is the Leontief inverse matrix, which shows the direct and indirect input requirements to produce one unit of output.

We assume that the JCM changes the export vector when projects are carried out. If we denote the change in the final demand as ΔE, then we can calculate the effect of the JCM on the entire Japanese economy as

$$\Delta X = \left(I - \left(I - M\right)A\right)^{-1}\Delta E \qquad (4).$$

Equation 4 allows us to calculate the direct and indirect effects of the increase in exports, which are financed exogenously. Thus, the increase in value added will equal the increase in exports. However, because equation 4 treats imports as endogenous, the total value added within Japan will not equal increase in exports. In other words, the increase in exports of good A will increase imports of raw materials and intermediate goods to satisfy the additional demand for good A. Therefore, we can calculate the additional “domestic” value added by using the following equation:

$$\Delta VA = V\Delta X \qquad (5)$$

where ΔVA is the change in value added (vector) and V is an n by n square matrix with the value added to sales ratio being the diagonal elements and zero for non-diagonal elements.

We can also calculate the effect of the JCM on employment by using the following equation:

$$\Delta L = l\Delta X \tag{6}$$

where l denotes the employment coefficient vector and ΔL denotes the change in labor (vector). Each argument in the employment coefficient is calculated by dividing the number of employees in industry i by the total output of industry i.

In addition to the economic effect and labor effect, we estimate the additional emission of CO_2 caused by the additional production of the JCM.

$$\Delta CO_2 = e\Delta X \tag{7}$$

where e denotes the emission coefficient vector, calculated by dividing total direct emissions from industry i by the total production of industry i. The calculated CO_2 emissions value is in line with the definition of embodied emissions.[13]

3.1.2. International Input-Output Model

The model presented in the previous subsection relies on the domestic I-O table, which uses a detailed industrial classification. One shortcoming of the domestic I-O table is that the country of origin of the intermediate goods is not separated. In other words, imports from country A and country B are aggregated, making it impossible to identify where the imports came from. The international I-O table overcomes this shortcoming by separately identifying the origin of production. However, this is achieved by reducing the industrial classification used in the international I-O table.

Equation (3) cannot be used for the international data due to the difference in the I-O table discussed above. Thus, we use the following model to calculate the economic effects using international data:

$$\Delta X^I = \left(I - A^I\right)^{-1} \Delta E^I \qquad (8).$$

Using the change in total output (ΔX^I), we estimate the labor effect using equation (6) by replacing ΔX with ΔX^I and using labor coefficients calculated from the international I-O table.

3.2. Data

[13] Embodied emissions refer to the total amount of CO_2 emitted to produce the final product. Thus, the CO_2 emitted in the supply chain is included in the calculation process.

3.2.1. Japanese Domestic I-O Table

The "basic classification" of the 2010 Japanese domestic I-O table consists of 520 products (rows) produced by 407 industries (columns). The number of rows must equal the number of columns to calculate the inverse matrix (Leontief inverse matrix) presented in the previous sub-section. Thus, the 401 industrial classification[14] is the finest industrial classification for the Japanese economy.

The objective of the JCM is to export environmental technology or energy-efficient products to developing countries. Therefore, it is important to distinguish between high energy-efficient products/technologies and "average" products/technologies. The I-O table, however, does not distinguish environmentally friendly products from ordinary products. In other words, the original Japanese I-O table does not allow us to analyze the effect of the JCM in depth. It is important, however, to analyze the effect of the JCM using more detailed industries.

We increase the accuracy of the analysis by disaggregating relevant industries into highly efficient products and other products. Two industries are added to the I-O table, namely, the hybrid automobile industry and the solar panel (PV) industry.

First, we disaggregate the automobile industry using the data provided by the Japanese Automobile Manufacturing Association (2012), Takeda (2012) and Institute for Energy Economics (2006) to construct a 402 by 402 I-O table.

Then, we use data from the "Handbook of energy and economic statistics in Japan" (EDMC, 2013), data provided by the Japan Photovoltaic Energy Association (JPEA) and Optoelectronics Industry and Technology Development Association (OITDA) to create a 403 by 403 I-O table.

The original I-O table also does not list the wind turbine industry and geothermal turbine industry independently. Because the FS include wind power and geothermal power, we add these two industries to the 403 by 403 I-O table by using figures provided by Nakano and Washizu (2012) and Science and Technology Foresight Center (2013). As a result, the I-O table is a 405 square matrix.

3.2.2. Asian International I-O Table

Along with the Japanese domestic I-O table, we use the 2005 Asian international I-O table published by the Institute of Developing Economies-Japan External Trade Organization Japan (IDE-JETRO). The Asian international I-O table has been published by IDE-JETRO every five years

[14] The Stone method is used to construct the Japanese I-O table. The original table includes two scrap industries, the iron scrap industry and the non-ferrous metal scrap industry. If we treat the two scrap industries as independent industries, we will produce a 403 by 403 square matrix. However, we do not treat the two industries independently. The figures for the iron scrap industry are added to the iron and steel industry. Similarly, we add the figures for non-ferrous metal scrap industry to the non-ferrous metal industry. As a result, our data set is a 401 by 401 square matrix before the disaggregation process.

since 1985. There are 76 sectors for each of the 10 countries[15] listed in the I-O table. The Asian I-O also provides the employment matrices for each country. Thus, the labor effects can be calculated using the provided data.

The transaction values are the producer's prices in the country of origin. The Asian I-O table is compiled so that the intermediate demand is followed by the final demand for the 10 countries, exports to other countries and statistical discrepancy in a column-wise manner. The rows are compiled to depict intermediate demand, freight and insurance, imports from other countries, duties and import commodity taxes and value added. Thus, imports and duties and import commodity taxes are treated differently than they are in the Japanese domestic I-O table, which lists imports in columns (IDE-JETRO, 2013).[16] Because the I-O table is constructed by using the domestic I-O tables from each country, the sector classification is broad. Therefore, each sector contains a large variety of produced goods. Thus, energy-efficient technologies/products are aggregated with non-energy-efficient technologies/products. We need to construct a disaggregated table to calculate the economic effects of energy-efficient technologies/products exported by the JCM.

The hybrid car industry, solar panel industry, wind turbine industry and geothermal turbine industry are added to the original 760 by 760 (76 sectors by 10 countries) I-O table, making the newly constructed I-O table a 764 by 764 (76 sectors by 9 countries plus 80s sector by 1 country) matrix. We added the four industries to Japan using the coefficients calculated by the disaggregated Japanese domestic I-O explained in the previous sub-section due to data restriction.[17] In other words, the new international I-O table has 80 sectors for Japan and 76 sectors for the remaining 9 countries.

3.3. Calculating Emission Reductions

The emission reduction due to the implementation of the JCM, $\Delta CO2_{ik}^{host}$, for product k in country i is calculated by

$$\Delta CO2_{ik}^{host} = Q_i \times e_i^{electricity} \times \left(\theta_k \times \Delta efficiency\right) \qquad (8).$$

Q_i denotes the quantity of energy-efficient products that are exported in the JCM, $e_i^{electricity}$ denotes

[15] The ten countries are Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Taiwan, Korea, Japan and the U. S. A.

[16] See IDE-JETRO (2013) for further compilation methods and technical notes for the Asian international I-O table.

[17] Cost data is needed to add new industries to the original I-O table. We used the same data to disaggregate the Japanese domestic I-O table. However, we were unable to collect data on other countries. Thus, we had to assume that the new industries used intermediate goods from Japanese suppliers.

the CO_2 emission intensity of electricity in country i, $\Delta efficiency$ is the change in energy efficiency, and θ_k is the annual energy consumption of product k in kW/h.

The CO_2 emission intensity of electricity was collected from SunEarthTools[18] in November 2014. The CO_2 emissions per kilowatt hour(kWh) for each country are shown in Table 2. Mongolia has the highest CO_2 emission intensity, with 1.49 kg/kWh, followed by India's 0.92 kg/kWh, because of its heavy reliance on coal. The CO_2 emission intensity is lowest for Costa Rica. Costa Rica, Colombia and Sri Lanka have smaller emission intensities than Japan, which may be the result of the high ratios of geothermal power and hydropower in the grid of these three countries.

Table 2. CO_2 Emission Intensity of Electricity (kg-CO_2/kWh)

Country	CO_2 Emission Intensity
Bangladesh	0.59
Colombia	0.18
India	0.92
Indonesia	0.71
Malaysia	0.73
Mexico	0.45
Mongolia	1.49
Philippines	0.48
Sri Lanka	0.38
Thailand	0.51
Vietnam	0.43
Costa Rica	0.06
Japan	0.42

We conducted a household survey between June and July 2014 in Bangkok, Thailand, to collect data on the energy efficiency of products used in the host country. We asked 105 households to indicate the year that they purchased the following four products: automobile, air conditioner, refrigerator and washing machine. The survey results show that the purchase year, on average, was approximately 2009, 2008, 2007 and 2008 for automobile, air conditioner, refrigerator and washing machine, respectively. Using these results, we assume that the energy efficiency for each product in Thailand is the same as the average energy efficiency of the corresponding product sold in the Japanese market in the same year. For example, we assume that the energy efficiency of automobiles

[18] http://www.sunearthtools.com/tools/CO2-emissions-calculator.php

in Thailand is equal to that of the average 2009 automobile sold in Japan. In this regard, we may be underestimating the emission reduction due to the JCM. For each product, we also assume that the energy efficiency is the same between countries, suggesting that we apply the same energy efficiencies obtained from the survey to all countries investigated. Furthermore, if we assume that there is no rebound effect, then the amount of electricity/fuel consumed by the product will decrease due to the improvement in energy efficiency. In addition, concerning the other products investigated, namely, solar panel and lighting equipment, we assume that the energy efficiency of the products in the host country is 30% lower than that of the products that are exported by the JCM.

We must also make an assumption concerning the price of the exported product. This point is crucial in estimating the emission reduction because if we use a low price, the volume of trade will be large, leading to an overestimation of emission reduction. In contrast, if the price is high, then the volume of trade will be small, which leads to a small emission reduction.

There are two possible figures that can be used as the price of the product exported by the JCM. The first possibility is the Japanese domestic price. Because energy-efficient products have higher market prices, this assumption can be considered as the upper limit. The second possibility is using the host country prices. These prices can be considered to be the lower limit. In the analysis, we assume that the price of the good is the Japanese domestic price.

Another crucial factor in estimating the emission reduction is the time span of the emission reduction. If we assume that new technology will not be implemented in the future, then the emission reduction from Japanese exports will be very large (i.e., upper bound). However, if we assume that new technology will diffuse immediately, then the emission reduction from Japanese exports will be very small (i.e., lower bound). Because it is very difficult to forecast the diffusion of technology, we assume that the emission reduction will be calculated by multiplying the life expectancy[19] of the product with annual emission reduction. In other words, we assume that there is no diffusion of technology (upper bound case).

3.4. Simulation Scenarios

At the present stage, it is difficult to predict the size of the new investment that the JCM will achieve. Thus, we need to assume a value that is fairly reasonable. In this paper, we assume that the amount of new investment will be ¥10 billion.[20]

First, we consider 11 products/technologies, hybrid vehicle, solar panel, wind turbine,

[19] The life expectancies of products are assumed to differ: hybrid car: 12.2 years, solar panel: 17.0 years, industrial furnaces: 14.0 years, lighting equipment: 15.0 years, air conditioner: 10.7 years, washing machine: 9.8 years, and refrigerator: 10.7 years.

[20] This was a hypothetical figure without concrete supporting evidence. However, the economic impacts and emission reduction are proportional to the amount of investment. The tendency of our results is, therefore, independent from the assumption of ¥10 billion. Moreover, the size is comparable to the Japanese government's budget prepared in the fiscal year of 2015 (Kasuya, 2015).

geothermal turbine, train, boiler, industrial furnace (coke dry quenching, CDQ), lighting equipment, battery, air conditioner, and refrigerator/washing machine[21], in the I-O analysis as potential candidates for the JCM because they have been studied in the FS or discussed as possible candidates.[22]

Next, we consider 6 products/technologies for the calculation of emission reduction (hybrid vehicle, solar panel, lighting equipment, air conditioner, washing machine and refrigerator).[23] We focus on the products/technologies for the residential sector, retaining six of the potential eleven products/technologies. The volume of emission reduction achieved by the energy-efficient technology will vary across countries. Thus, we consider twelve potential host countries for JCM: Bangladesh, Colombia, India, Indonesia, Malaysia, Mexico, Mongolia, the Philippines, Sri Lanka, Thailand, Vietnam and Costa Rica.

4. Results

4.1. Results from the I-O Model

4.1.1. Japanese I-O Model

The results of the simulation are shown in Table 3. The economic multiplier effects of an increase in exports of ¥10 billion ranges from ¥18.49 billion to ¥33.75 billion. The difference in the magnitude of the economic effects is due to the difference in the inter-industry relationship between industries. The hybrid vehicle industry has the highest economic effect, with ¥33.75 billion. Other items with high economic effects are trains and wind turbines, which are calculated to be approximately ¥24 billion each In contrast, the solar panel industry has the smallest economic effects, with only ¥18.49 billion. The economic effects of boilers (¥20.36 billion) and lighting equipment (¥21.99 billion) are also relatively small.

[21] The refrigerator and washing machine industries are not distinguished in the Japanese I-O table. Therefore, we cannot calculate the economic effect and employment effect for each product in the I-O analysis without disaggregating the data, which is not in the scope of this paper.

[22] The industrial classification used by the Asian international I-O table does not distinguish lighting equipment and batteries into different industries. Similarly, air conditioners and refrigerators/washing machines are classified into the same industry. As a result, the analysis using the Asian I-O table only considers 9 products/technologies.

[23] The average consumption of electricity/fuel is essential in estimating the emission reduction. Because there are a variety of products, we selected 6 distinct products/technologies for the analysis. We will assume that BEATWASH BW-D9TV (Hitachi) will be the typical washing machine that will be exported, SJ-PF47A (Sharp) as the refrigerator, E-CORE LDA6L-H (Toshiba) as the typical lighting equipment (LED), RAS-5624D (Toshiba) as the air conditioner and PRIUS 1.8L (Toyota) as the hybrid car, and 3.5 kilowatt PV system as the representative solar panel.

Table 3. Simulation Results (Japanese Domestic I-O)

	Economic Effect (Billion Yen)	**Employment Effect**	**Value Added (Billion Yen)**	**Additional Emission ($t\text{-}CO_2$)**
Hybrid Vehicle	33.75	980	7.90	36,206
Gasoline Vehicle	30.74	874	8.30	32,267
Solar Panel	18.49	361	7.46	33,886
Wind Turbine	24.19	875	7.45	37,770
Geothermal Turbine	22.60	740	7.22	17,987
Trains	24.45	954	8.30	49,488
Boiler	20.36	785	8.99	25,407
Industrial Furnace	22.44	988	8.68	42,131
Lighting Equipment	21.99	992	8.39	23,530
Battery	22.03	788	7.74	30,449
Air Conditioner	23.23	721	7.95	21,968
Washing Machine/ Refrigerator	22.28	914	7.94	26,241

Note: We include the "Gasoline Vehicle" industry as a reference.

The results concerning the employment effect show a different story. The lighting equipment industry has the highest employment effect, followed by the industrial furnace industry and hybrid vehicle industry. Once again, the solar panel industry has the smallest employment effect. Other industries with relatively small employment effects are the air conditioner industry, geothermal turbine industry, boiler industry, and battery industry.

Regarding the increase in domestic value added, the boiler industry has the highest increase, whereas the geothermal turbine industry has the smallest increase. However, the magnitude of the difference between the highest and lowest industries is not as large as the difference in economic effects. In other words, the 'leakage' of value added to foreign countries is limited to 1 to 2.5 billion yen.

The three results from the I-O analysis imply that balancing economic, value added, and employment effects is necessary when choosing the type of program suitable for the JCM in order to efficiently allocate resources. In other words, if the JCM intends to increase economic activity, then hybrid vehicles, wind turbines, trains, and air conditioners would be suitable goods. If, however, the JCM intends to increase labor, then lighting equipment, industrial furnaces, and hybrid vehicles would be better.

The intention of the JCM is to reduce CO_2 emission through the usage of energy-efficient products. The production of energy-efficient products, however, entails additional CO_2 emission. The fifth column of Table 3 presents the calculated embodied emission of CO_2 due to the increase in production. The additional CO_2 emission due to increased demand (production) is estimated to be between 17,987 and 49,488 t-CO_2. Geothermal turbines (49,488 t-CO_2), air conditioners (21,968 t-CO_2) and lighting equipment (23,530 t-CO_2) have relatively small embodied emissions. In contrast, trains (49,488 t-CO_2), industrial furnaces (42,131 t-CO_2) and wind turbines (37,770 t-CO_2) embody large amounts of CO_2.

4.1.2. Asian I-O Model

Table 4A & 4B show the results using the disaggregated Asian I-O table. The total economic effect of the JCM ranges from ¥22.80 billion to ¥33.77 billion. The hybrid vehicle (¥33.77 billion) has the greatest effect, followed by wind turbine (¥28.68 billion) and geothermal turbine (¥27.93 billion). In contrast, the lighting equipment/battery industry (¥22.80 billion), industrial furnace industry (¥23.48 billion) and solar panel industry (¥23.64 billion) have relatively smaller economic effects. The economic effects calculated using the disaggregated Asian I-O table shows results that are relatively similar to the economic effects calculated using the disaggregated Japanese domestic I-O table, with some exceptions. For example, the train industry ranks 6th out of 9 items in the Asian I-O analysis but ranks 2nd in the domestic I-O analysis. Another exception is the solar panel industry, which ranks 11th in the domestic I-O analysis but ranks 7th in the Asian I-O analysis.

Table 4A. Economic Impact (Asian I-O, Units: ¥1 billion)

	Wind Turbine	**Geothermal Turbine**	**Solar Panel**	**Hybrid Vehicle**	**Gasoline Vehicle**
Indonesia	0.07	0.06	0.18	0.09	0.09
Malaysia	0.04	0.04	0.05	0.06	0.06
Philippines	0.02	0.02	0.03	0.02	0.02
Singapore	0.03	0.03	0.03	0.03	0.03
Thailand	0.05	0.04	0.04	0.08	0.09
China	0.47	0.34	0.35	0.38	0.40
Taiwan	0.09	0.08	0.07	0.08	0.08
Korea	0.17	0.13	0.12	0.14	0.16
Japan	27.49	26.94	22.48	32.61	28.89
U.S.A	0.24	0.25	0.29	0.28	0.30
Total	28.68	27.93	23.64	33.77	30.13

Note: Gasoline vehicle is included as a reference.

Table 4B. Economic Impact (Asian I-O, Units: ¥1 billion)

	Lighting Equipment/ Battery	Air Conditioner/ Refrigerator	Boiler	Industrial Furnace	Train
Indonesia	0.16	0.10	0.08	0.08	0.07
Malaysia	0.10	0.14	0.04	0.05	0.05
Philippines	0.04	0.10	0.02	0.02	0.02
Singapore	0.04	0.08	0.03	0.03	0.03
Thailand	0.09	0.12	0.08	0.07	0.05
China	0.73	0.87	0.52	0.64	0.45
Taiwan	0.13	0.27	0.08	0.10	0.08
Korea	0.18	0.29	0.22	0.19	0.11
Japan	20.81	22.32	23.12	21.97	22.05
U.S.A	0.50	0.49	0.54	0.32	1.61
Total	22.80	24.77	24.72	23.48	24.49

Note: Gasoline vehicle is included as a reference.

The economic impact of the increase of 10 billion yen worth of exports from Japan is the greatest for Japan, ranging from ¥20.81 billion (lighting equipment/battery) to ¥32.61 billion (hybrid vehicle). China's economic impact due to the increase in exports follows that of Japan, with the exception of boilers and trains. The U.S.A. has the third highest economic impact from the JCM. The economic impacts for other countries are very limited (less than 0.1 billion yen). This result reflects the high dependence of the Japanese industries on Chinese and American industries for intermediate goods.

Table 5A & 5B show the calculated labor effects using the disaggregated Asian I-O table. The total labor impact ranges from 887 to 2,353. The lighting equipment/battery industry (2,353), hybrid vehicle industry (1,623) and the air conditioner/refrigerator industry (1,599) have relatively large labor impacts, whereas the solar panel industry (887), boiler industry (1,326), wind turbine industry (1,345) and train industry (1,352) have relatively small labor impacts. These results are similar to the labor impacts calculated by the Japanese domestic I-O table.

The labor effects by country are the largest for Japan, ranging from 1,717 (lighting equipment/battery) to 529 (solar panel), reflecting the magnitude of the economic effects. China has the second largest labor impact, ranging from 195 (geothermal turbine) to 477 (air conditioner/refrigerator). Unlike the economic effects, the labor impacts for the U.S.A. are not placed 3rd for all items. For example, for solar panels and hybrid vehicles, the labor impacts are greater for Indonesia than the U.S.A. In general, the labor impacts for Indonesia and Thailand are relatively large considering the fact that the economic impact is relatively small. Another interesting result is the small impact in Korea, even though the economic impact ranks fourth for most of the items.

Table 5A. Labor Impact (Asian I-O)

	Wind Turbine	Geothermal Turbine	Solar Panel	Hybrid Vehicle	Gasoline Vehicle
Indonesia	32	26	61	59	63
Malaysia	5	5	6	8	8
Philippines	12	11	15	13	15
Singapore	1	1	1	1	1
Thailand	20	16	12	43	50
China	260	195	197	224	239
Taiwan	6	5	4	5	5
Korea	6	5	4	5	6
Japan	960	1,073	529	1,219	1,038
U.S.A	41	41	57	45	46
Total	1,345	1,379	887	1,623	1,471

Table 5B. Labor Impact (Asian I-O)

	Lighting Equipment/ Battery	Air Conditioner/ Refrigerator	Boiler	Industrial Furnace	Train
Indonesia	65	50	35	39	33
Malaysia	12	17	5	7	6
Philippines	22	41	12	14	9
Singapore	2	3	2	2	1
Thailand	25	45	21	30	21
China	398	477	283	350	257
Taiwan	11	16	6	8	5
Korea	7	12	9	8	4
Japan	1,717	859	871	968	849
U.S.A	94	79	82	52	167
Total	2,353	1,599	1,326	1,476	1,352

Note: Gasoline vehicle is included as a reference.

4.2. Emission Reduction achieved by the JCM

The I-O analysis can provide valuable information on the economic and employment effects of the JCM. The ultimate goal of the JCM, however, is the reduction of CO_2 emission in developing countries. Furthermore, from the economics point of view, projects should be determined by the cost-efficiency standard. Thus, the calculation of the possible emission reduction is necessary.

Table 6. Estimated Emission Reduction (t-CO_2/year)

	Hybrid Vehicle	**Solar Panel**	**Lighting Equipment**	**Air Conditioner**	**Washing Machine**	**Refrigerator**
Vietnam	23,137	10,354	47,410	15,043	2,241	6,671
Thailand	2,873	-	56,337	17,875	2,663	7,928
Philippines	5,815	20,842	52,835	16,764	2,497	7,435
Indonesia	7,865	43,460	77,887	24,713	3,682	10,960
India	3,831	54,423	101,486	32,200	4,797	14,281
Bangladesh	4,914	-	65,095	20,654	3,077	9,160
Mongolia	8,713	-	163,841	51,985	7,745	23,056
Sri Lanka	3,682	-	41,621	13,206	1,967	5,857
Mexico	6,176	24,336	49,961	15,852	2,362	7,030
Colombia	5,045	6,180	19,304	6,125	912	2,716
Malaysia	5,279	33,436	79,897	25,350	3,777	11,243
Costa Rica	4,963	2,344	6,119	1,941	289	861

Note: For solar panel and industrial furnace, there are some missing emission reductions values because we cannot obtain available data in some host countries. In calculating the reduction for solar panel, we take annual day length into account.

Table 6 shows the estimated emission reduction due to the implementation of the JCM. The emission reduction achieved by products differs greatly. In general, the per annum emission reduction is the greatest for lighting equipment, followed by solar panels. In contrast, washing machines reduce emissions the least per annum.

Table 6 also shows that the emission reduction differs between countries. For example, the emissions reduced by hybrid vehicles in Vietnam are higher than those in other countries. Concerning solar panels, the emission reduction is the largest for India and the least for Costa Rica. It is found that emission reduction tends be larger in India and Mongolia because these countries rely on a carbon-intensive energy source, coal, for the generation of electricity. In contrast, the emission reduction is small for Costa Rica and Colombia because hydropower is widely used as an energy source, leading to a smaller carbon intensity of electricity.

Table 7 shows the estimated emission reduction during the lifetime of the product. The expected lifetime of products ranges from 9.8 to 20 years (see Footnote 14). The difference in the estimated emission reduction, after considering the life expectancy of the product, is larger than that presented in Table 6. The results show that lighting equipment and air conditioners have high emission reductions compared to other products.

Table 7. Estimated Lifetime Emission Reduction (t-CO_2)

	Hybrid Vehicle	Solar Panel	Lighting Equipment	Air Conditioner	Washing Machine	Refrigerator
Vietnam	281,341	176,017	711,153	160,957	21,962	71,385
Thailand	34,933	-	845,057	191,264	26,098	84,826
Philippines	70,706	354,314	792,520	179,373	24,475	79,553
Indonesia	95,644	738,817	1,168,310	264,426	36,081	117,274
India	46,579	925,186	1,522,289	344,543	47,013	152,806
Bangladesh	59,748	-	976,420	220,995	30,155	98,012
Mongolia	105,947	-	2,457,618	556,238	75,898	246,694
Sri Lanka	44,777	-	624,308	141,301	19,280	62,668
Mexico	75,101	413,704	749,413	169,616	23,144	75,226
Colombia	61,344	105,062	289,553	65,535	8,942	29,065
Malaysia	64,193	568,413	1,198,460	271,250	37,012	120,301
Costa Rica	60,346	39,845	91,785	20,774	2,835	9,213

Caution is needed in interpreting the results. The emission reduction shown in Table 7 can be considered to be the maximum or upper bound of emission reduction in one sense because we have not discounted the value of future emission reduction. Furthermore, the actual emission reduction achieved by the additional exports will depend on the guidelines set by the JCM joint committee. If the joint committee decides to approve emission reductions until 2020, the emission reduction will be limited. However, if the committee decides to approve emission reduction for the entire lifetime of the product without a discount rate, then the emission reduction will be very large.

4.3. Comparing the Additional Emission and Emission Reduction

The I-O analysis was used to calculate the economic and employment effects of the additional export induced by the JCM. The calculation of additional emission from increased production can also be done using the I-O model. The emission reduction from any offset mechanism must be greater than the additional emission generated from the additional economic activity. Thus, the offset mechanism can be assessed by comparing the results from the I-O analysis with the calculated emission reduction.

Table 8A and 8B show the net emissions for the 6 products considered. The net emission is based on the difference between the emission reduction and the additional emission from the production process. The emission reduction for lighting equipment is higher than the additional emission in every country, with the exception of Colombia and Costa Rica, using the annum emission reduction. Thus, lighting equipment clears the criteria of offsetting emissions in most of the countries. However, we find a different pattern for hybrid vehicles, solar panels, air conditioners and refrigerators. Additional emission for these products is greater than the per annum emission reduction. However, the lifetime emission reduction is greater than the additional emission for most countries. This implies that the lifetime emission reduction must be accounted for these products to clear the criteria of offsetting.

Table 8A. Net Emission Reduction (t-CO_2)

	Hybrid Vehicle		Solar Panel		Lighting Equipment	
	1 year	Lifetime	1 year	Lifetime	1 year	Lifetime
Vietnam	13,069	-245,135	23,532	-142,131	-23,880	-687,623
Thailand	33,333	1,273	-	-	-32,807	-821,527
Philippines	30,391	-34,500	13,044	-320,428	-29,305	-768,990
Indonesia	28,341	-59,438	-9,574	-704,931	-54,357	-1,144,780
India	32,375	-10,373	-20,537	-891,300	-77,956	-1,498,759
Bangladesh	31,292	-23,542	-	-	-41,565	-952,890
Mongolia	27,493	-69,741	-	-	-140,311	-2,434,088
Sri Lanka	32,524	-8,571	-	-	-18,091	-600,778
Mexico	30,030	-38,895	9,550	-379,818	-26,431	-725,883
Colombia	31,161	-25,138	27,706	-71,176	4,226	-266,023
Malaysia	30,927	-27,987	450	-534,527	-56,367	-1,174,930
Costa Rica	31,243	-24,140	31,542	-5,959	17,411	-68,255

The result for the washing machine shows that the washing machine cannot offset emissions for several countries, namely, Vietnam, Thailand, the Philippines, Sri Lanka, Mexico, Colombia and Costa Rica, even if the cumulative reductions from the lifetime are used, implying that these products are less effective in reducing emissions. Thus, even if the government intends to export products with high energy performances, the amount of credits produced by the JCM depends greatly on the product and the host country.

Table 8B. Net Emission Reduction (t-CO_2)

	Air Conditioner		Washing Machine		Refrigerator	
	1 year	**Lifetime**	**1 year**	**Lifetime**	**1 year**	**Lifetime**
Vietnam	6,925	-138,989	24,000	4,279	19,570	-45,144
Thailand	4,093	-169,296	23,578	143	18,313	-58,585
Philippines	5,204	-157,405	23,744	1,766	18,806	-53,312
Indonesia	-2,745	-242,458	22,559	-9,840	15,281	-91,033
India	-10,232	-322,575	21,444	-20,772	11,960	-126,565
Bangladesh	1,314	-199,027	23,164	-3,914	17,081	-71,771
Mongolia	-30,017	-534,270	18,496	-49,657	3,185	-220,453
Sri Lanka	8,762	-119,333	24,274	6,961	20,384	-36,427
Mexico	6,116	-147,648	23,879	3,097	19,211	-48,985
Colombia	15,843	-43,567	25,329	17,299	23,525	-2,824
Malaysia	-3,382	-249,282	22,464	-10,771	14,998	-94,060
Costa Rica	20,027	1,194	25,952	23,406	25,380	17,028

One policy implication can be drawn from Tables 8A and 8B. The JCM bilateral committee must carefully determine the time span of the emission reduction for each product. If the lifetime emission reduction approach is used, they must determine the average lifespan of the product, i.e., number of years the product will last, and the discount rate of future emission reduction.[24]

The Japanese government is expected to fund up to half (50%) of the total cost of each project and receive up to half of the credits produced. Thus, it is very important to calculate the average cost of the credits produced. The calculated cost per lifetime emission reduction is shown in Table 9. As presented in Table 9, some projects are relatively cost efficient, whereas some projects are very cost inefficient. For example, the lighting equipment is very cost efficient in Mongolia and India. However, the cost efficiency is very low for washing machines in Costa Rica and Colombia. In general, the items examined may not be as cost effective as expected, as most of the countries show figures higher than 10,000 yen.

[24] In this study, we have not discounted the emission reduction in the future. Thus, the cumulative emission reductions can be seen as the upper bound of the emissions for each item examined.

Table 9. Cost per Lifetime Emission Reduction (Yen/ t-CO_2)

	Hybrid Vehicle	Solar Panel	Lighting Equipment	Air Conditioner	Washing Machine	Refrigerator
Vietnam	35,544	56,813	14,062	62,128	455,332	140,085
Thailand	286,262	-	11,834	52,284	383,171	117,888
Philippines	141,431	28,224	12,618	55,750	408,580	125,702
Indonesia	104,554	13,535	8,559	37,818	277,154	85,270
India	214,689	10,809	6,569	29,024	212,707	65,442
Bangladesh	167,370	-	10,241	45,250	331,620	102,028
Mongolia	94,387	-	4,069	17,978	131,756	40,536
Sri Lanka	223,329	-	16,018	70,771	518,672	159,571
Mexico	133,154	24,172	13,344	58,957	432,077	132,933
Colombia	163,015	95,182	34,536	152,590	1,118,318	344,056
Malaysia	155,780	17,593	8,344	36,866	270,183	83,125
Costa Rica	165,711	250,973	108,950	481,371	3,527,337	1,085,423

5. Conclusion

This paper analyzed the economic multiplier impacts of the JCM using two I-O models: the Japanese disaggregated IO model and the Asian International IO. We disaggregate the automobile industry and other electrical devices and parts industry to capture hybrid vehicles and solar panels. Furthermore, we add the wind turbine industry and the geothermal turbine industry. We find that the multiplier impacts of hybrid vehicles, wind turbines and air conditioners are high, whereas boilers and solar panels produce smaller effects. The results for the employment effects show that the coke dry quenching plants and lighting equipment create more jobs. In considering which products should be included in the JCM, we may not be able to avoid a tradeoff between the multiplier impacts and employment impacts.

The emission reduction calculated for six products show that the volume of emission reduction differs across region and products. We find that lighting equipment's emission reductions are the greatest, whereas washing machines' reductions are the least. Furthermore, we confirm that JCM projects in coal-dependent countries such as India and Mongolia can generate large emission reduction. Therefore, the amount of the subsidy required to reduce one ton of CO_2 differs sharply across products and countries. Thus, if we focus on the cost efficiency of emission reduction in the JCM, a careful ex-ante analysis of products and regions is necessary.

Furthermore, as shown in the case of solar power in India, there can a tradeoff between the economic multiplier impacts and the size of emission reductions. Thus, we may not be able to achieve the cost efficiency and large multiplier impacts simultaneously. The government must decide which objective to prioritize.

The JCM is potentially a great scheme through which the Japanese industries can contribute to energy efficiency, and hence, emission reduction in developing economies, especially in Asia. Before it expands as a strong emission reduction scheme in the international community, several problems must be addressed. For example, the JCM must be WTO compliant. The WTO prohibits export subsidies, but the analysis in this paper assumed that the Japanese give export subsidies to domestic producers. Thus, the JCM needs to be organized so that the funding from the government does not become an export subsidy.

Moreover, the joint committee must choose an appropriate reference level in determining the amount of emission reduction. The amount of emission reduction from JCM projects is the difference between the emission level from the project and the reference emission level. To ensure that the JCM is recognized as a legitimate emission reduction scheme, the joint committee tends to be conservative in determining the reference level. That is, the committee may be inclined to use the most energy-efficient products in the host country in determining the reference level. This strategy favors the international acceptance of the JCM as a legitimate scheme. At the same time, it comes with the cost of smaller emission reduction than the project may have truly achieved. The governments must find a way to balance the international recognition of the JCM and the emission reduction.

There are several points that we must address concerning the analysis in this paper. First, the finance of the new exports is uncertain in our framework. If the JCM is financed by the government using tax revenues, then we will need to incorporate the tax in the analysis.

Second, the emission reduction calculated in this paper must be refined, especially for electric appliances. Our analysis relied on the household survey conducted in Thailand. However, we could not obtain accurate information because consumers in developing countries are not necessary paying attention to energy efficiency. Thus, there is room for improvement in estimating the emission reduction from the appliances examined in our study.

Finally, the analysis in this paper has focused on CO_2 emissions and the economic effects of the production of the products. The JCM can contribute to other environmental problems such as air pollution because it reduces electricity generation and fossil fuel combustion. Such a co-benefit should also be evaluated in choosing JCM projects. Moreover, the economic development of the host country is an important part of the JCM. The analysis of this paper has overlooked other economic and environmental benefits. Therefore, further analysis is needed using other criteria to make a concrete conclusion about which products will be appropriate in the JCM. We will leave this analysis for a future study.

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