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## A New Approach to the Endogenous Correction of Interregional Income Disparity: Extended Interregional IO by Trading Biomass CO2 Credit

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A New Approach to the Endogenous Correction of Interregional Income Disparity:

Extended Interregional IO by Trading Biomass CO<sub>2</sub> Credit

by

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1. Introduction
2. Basic Concept
3. Regional Economic Effects of Wooden Biomass
4. Extension of the IO Table
5. Simulation Analysis
  - 5.1 Study Area
  - 5.2 Environmentally Related Sectors
  - 5.3 Calculation Model
  - 5.4 New Approach
- 5.4 Results and Interpretations
6. Summary and Conclusions

Abstract

In this study we develop a new approach to correct interregional income disparity endogenously by extending the traditional interregional IO table. The meaning of “new approach” is that to propose a new concept for correcting interregional income disparity by utilizing environmental resources, which are usually abundant in rural regions and to conduct new type of simulation which implies a change in input structure induced by energy substitution. We use 11 interregional IO table which is extended from 9 interregional IO table developed METI (Ministry of Economy, Trade, and Industry) in Japan. By implementing new type of simulation we can find substantial improvement of income disparities between metropolitan areas and rural regions by trading CO<sub>2</sub> credit as well as trading renewable energy such as wooden biomass chips and pellets. Therefore, we should promote renewable energy using rural environmental resources to vitalize rural economies, and it will result in endogenous correction of interregional economic disparities.

## 1. Introduction

There is a growing interest in green energy, such as biomass, wind mills, and solar electricity, in response to concerns over reducing greenhouse gas (GHG) emissions. In a regional economic context, a few local municipalities in Japan are trying to reduce carbon dioxide (CO<sub>2</sub>) emissions by using regional environmental resources such as trees, wind, and solar energy. Some of these municipalities export their green energy as well as consume within the region as an alternative to using oil resources for energy. They usually estimate how much CO<sub>2</sub> can be reduced through environmental activities. The economic impact of such efforts, however, is ambiguous.

On regional policy issues, representative policies for correcting regional income disparities are income transfers, plant locations from outside area, and public investment. These regional policies depend on national policies, so they are exogenous to each region. Moreover, although these policies have contributed to corrections of inter-regional economic disparities through regional vitalization initiatives, rural regions are still suffering from outmigration to large metropolitan areas. In addition, the population gap between rural and metropolitan regions is continuing to expand.

In order to convert the current 'exogenous' policy into an "endogenous" regional development program, it is necessary to promote a region's trade in resources in which it has a comparative advantage over its trading regions. An environmental policy aimed at mitigating CO<sub>2</sub> emissions could possibly correct regional disparities. This is because rural regions usually have comparative advantages in natural resources such as forestry, which can absorb CO<sub>2</sub> emissions. Moreover, their abundant forestry resources have the potential for energy production from wood biomass.

Rural regions are often short in investment funds, as they have less profitable investment opportunities. Hence, regional money particularly in rural areas will leak into metropolitan areas and return to metropolitan areas, even if the rural regions obtain money from the outside regions. This is explained by their excess savings relative to investments in rural regions. On the other hand, metropolitan regions often face the tradeoff between the mitigation of CO<sub>2</sub> emissions from office business activities and the maintenance of economic activities, while those regions experience positive balance of interregional payments and have many

investment opportunities. In this case, it is possible for metropolitan regions to purchase carbon offset credits (CO<sub>2</sub> emission rights) from rural regions and attain their CO<sub>2</sub> reduction targets. Additionally, it is possible for the rural regions to obtain money from metropolitan regions by exporting environmental resources implicitly in the form of an environmental credit. This is an “endogenous” correction of regional income disparities.

The final goal of our research investigation is to empirically (quantitatively) illustrate the degree of correction of interregional economic disparities by endogenous efforts of non-metropolitan local regions, in which endogenous efforts imply that local municipalities in nonmetropolitan areas make use of regional **environmental resources** and the usage leads to regional economic vitalization as well as the reduction of CO<sub>2</sub> emissions.<sup>1</sup>

In the following section, we describe the basic concept for our new approach, which is different from those of previous studies. Section 3 proposes a new classification of regional economic impacts by making use of wooden biomass in the input-output (IO) framework. In Section 4, we show how to treat environmental sectors, the environmental supporting industry, and offset the credit creation sector in the IO framework. Based on the IO extension framework described in Section 4, we construct regional IO tables. In Section 5, we implement a simulation analysis of wooden biomass usage and report the effect of CO<sub>2</sub> reduction and its regional economic impacts for the correction of inter-regional income disparities. Before implementing simulations we explain our study area, characteristics of environmental sectors, calculation model, and describe the concept of new approach. Section 7 contains a summary of policy implications and conclusions.

## 2. Basic Concept

Most rural regions in Japan are experiencing deficits associated with the private sectors’ interregional balance of payments (BOPs). Therefore, public expenditures, including national transfers, are used to cover these deficits. To overcome this situation, it is necessary for rural municipalities to create a money-producing export industry called the basic industry, and obtain money

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<sup>1</sup> **Environmental resources** include renewable energy sources, such as solar energy, biomass, and wind. We define solar panels and biomass fuels made from scrap wood or wood chips as **environmental auxiliary goods**, since these goods indirectly reduce CO<sub>2</sub> emissions.

from an outside region by using their regional resources that have comparative advantages over those resources in the metropolitan areas. It is also important to circulate money within the region to protect spillovers to other regions.

In this study, we focus on forestry resources as a rural regional comparative advantage. For example, most of the rural regions in Japan are rich in forestry resources that can absorb CO<sub>2</sub> emissions. This implies that these regions can produce renewable energy using wooden biomass. These regions, however, usually lack the necessary funding for these operations.

In order to enhance the use of their environmental resources, rural regions need investments. Private sector funding in rural regions would allow them to proceed with projects that counter global warming. Local governments in the rural areas are able to reduce CO<sub>2</sub> emissions by using environmental intermediate goods produced from forestry resources. Then, they can sell certified emissions reductions (CERs) to the metropolitan areas as environment credits and export environmental intermediate goods.

Compared with when this project is not occurring, if there were additional emissions reductions, an extra credit will be issued. By using CERs issued by this project, metropolitan cities are able to achieve their emission reduction targets, considered as a regional version of the Clean Development Mechanism (CDM). With this mechanism, income from metropolitan areas will flow into rural areas and the metropolitan areas can maintain their economic activity levels by purchasing CERs.

Assume that a mid-term target is to reduce 20% of CO<sub>2</sub> emissions. In addition, a 15% emission cut is possible with energy savings and by using renewable energy. Using actual data, the following can be said. The metropolitan cities of Osaka and Kobe can include the 1% absorption and reduce CO<sub>2</sub> emissions by 16% (= 15% + 1%), which will not reach the 20% target. However, Shimane and Kochi prefectures have the ability of 15% CO<sub>2</sub> absorption. This will result in 15% + 15% = 30% and will exceed the 20% target by 10%. Hence, these areas are able to trade the surplus and shortage.

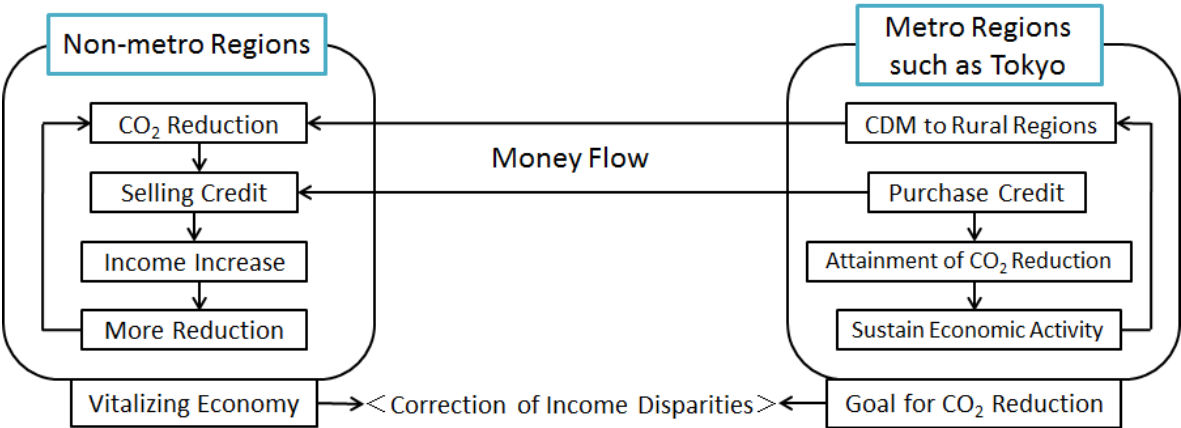
There are still some problems to be solved. Metropolitan regions, such as Tokyo Capital region, where massive amounts of CO<sub>2</sub> emissions need to be reduced, will not be able to be dealt with just one local government (prefecture). The sufficient reduction of CO<sub>2</sub> emissions will be attained only by using forest resources in a wider region, such as the Hokkaido, Tohoku, Chugoku and Shikoku mountainous

region’s CO<sub>2</sub> absorption. Therefore, the trading regions of Tokyo Capital region should include multiple prefectures.

What is important is that non-metropolitan regions should circulate the money they obtained from the outside region. Here, the word “circulation” has the meaning of monetary circulation as well as resource circulation. It is often the case in non-metropolitan regions that the money obtained flows out without circulating in the regions. That is, the demand that occurred in the region was not fulfilled within the region and leaked out of the region. For example, there is no appropriate opportunity for investment within the region or the consumption goes outside the region, otherwise the intermediate input supply is demanded from the outside region.

Figure 1 illustrates the image of an “endogenous” correction between metropolitan cities and other non-metropolitan areas. Municipalities in non-metropolitan areas attain CO<sub>2</sub> reduction by creating biomass energy product with the metropolitan CDM and receive money through trading carbon offset credits to metropolitan areas such as Tokyo Capita region. This directly implies an increase of income in non-metropolitan areas as well as CO<sub>2</sub> reduction. On the other hand, metropolitan areas can sustain their economic activities though importing offset credits.

Figure 1 Endogenous Correction of Regional Disparities by Environmental Trading



This study aims to estimate the economic effects of CO<sub>2</sub> reduction activity, including trading carbon offset credits. To accomplish our goals, we construct an inter-regional IO table. By focusing on wooden biomass and CO<sub>2</sub> credit service

sectors, we reconstruct inter-regional IO table in order to evaluate the economic effects of wooden biomass and exporting carbon offset credits. The economic effects of introducing renewable energy are defined as follows:

- i) An intraregional “circulation effect” from energy substitution, which means the change in input coefficients,
- ii) Aan export effect,
- iii) A supply-cost effect if the renewable energy is cheaper than fossil-fuel-based energy.

Transduction into biomass energy from oil induces changes in the IO linkage structure. After conducting several simulations, including changes in the IO structure, we find that wooden biomass activity contributes to an increase in regional per capita income when trading carbon-offset credits is institutionalized. This effect will be more significant at the city/town level than at the prefecture level.

There are many studies that have analyzed CO<sub>2</sub> emissions by means of IO models. McGregor et al. (2008) examined CO<sub>2</sub> trade balances between Scotland and the UK by using an IO table and a self-assembled monolayer (SAM) matrix, despite data problems. Radetski (1997) investigated economies that used biomass fuels. Although these findings are more than ten years old, the external costs of biomass were found to be higher than those of fossil fuels. More recently, Schneider and McCarl (2003) analyzed whether bio-fuels might play a role in total GHG mitigation policies and the implication of these results for the agricultural sector. Perez-Verdin et al. (2008) examined the economic impacts of wooden biomass utilization for bio-energy conversation in Mississippi. Madlener and Koller (2007) showed an empirical investigation on the economic and CO<sub>2</sub> reduction impacts of biomass heating in the Austrian federal province of Vorarberg. They calculated value-added, employment, and fiscal effects by means of a static IO analysis, though they did not construct a regional IO table. With regard to constructing a new IO table by introducing the renewable energy sector we can find the paper by Matsumoto and Hondo (2011) in which they estimated the employment effects of introducing solar photovoltaic and wind power generation technologies in a national level extended IO in 2005.

Although there are only a few studies on the impacts of biomass fuels on regional economies, we could not find any study that constructed regional IO tables that extended to incorporating environmental sectors, such as

environmental auxiliary goods production, credit creation, and credit services, which are described in detail in the subsequent sections.

### 3. Regional Economic Effects of Wooden Biomass

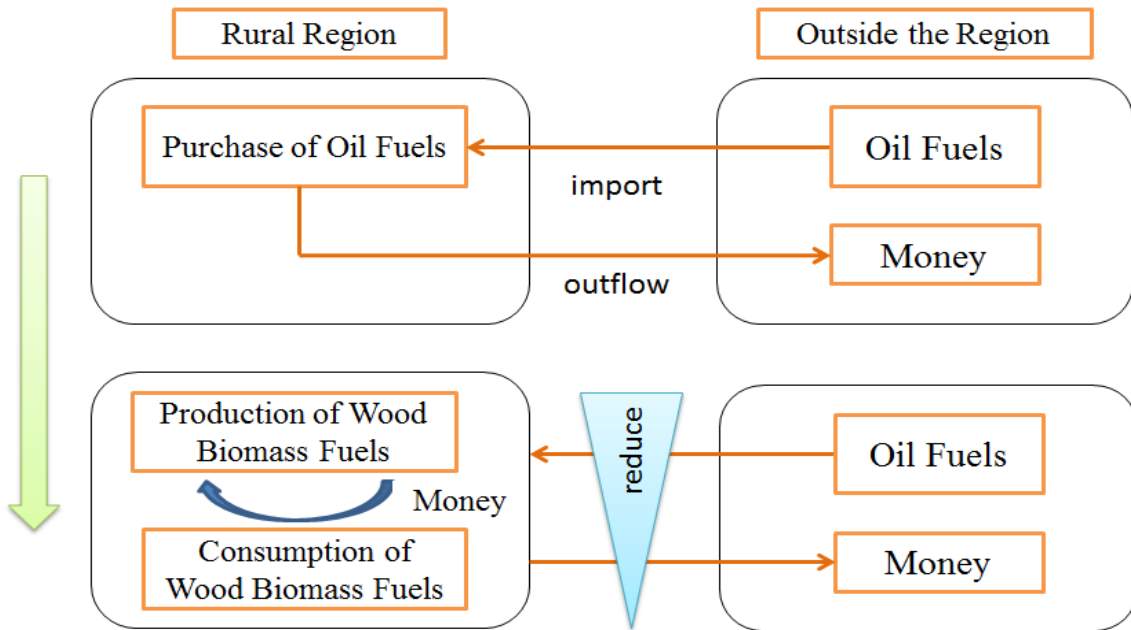
In a regional economic context, not a few local municipalities in Japan are attempting to reduce CO<sub>2</sub> emissions by using regional environmental resources, such as trees, wind, and solar energy. Some of these municipalities export their green energy for intraregional energy use as an alternative to using oil. They usually estimate the extent to which CO<sub>2</sub> emissions can be reduced through these environmental activities. The economic impact of such efforts, however, is ambiguous.

There are two types of regional economic effects from local municipalities' environmental investment policies aimed at reducing CO<sub>2</sub> emissions: temporary effects and permanent effects. Temporary effects include the well-known multiplier effect of private/public investment.

There are three types of permanent effects. The first is **an intra-regional money circulation effect**, caused by energy substitution from oil. For example, imagine using wooden biomass fuels instead of fossil fuels. As illustrated in Figure 2, except for the value-added attributed to the retail shops, if we purchase fossil fuels from a gas station, the purchase price leaks outside the region. In contrast, in the case of biomass fuels, as it originates from the region's natural resource base, the purchase amount is circulated within the region and becomes part of the regional income. In addition, if the related input materials or services related to biomass usage are purchased within the region, then the biomass use will enhance regional employment and sales. This substitution process from fossil fuels to biomass fuels reduces oil imports and increases regional income, due to money circulation taking place within the region.

Figure 2 Circulation Effect





The second permanent effect is the export effect, which is categorized into a direct and indirect effect. Firms in non-metropolitan areas, in particular, rural regions can produce wood chips and woody pellets from wood. They can use these products domestically and export them to other regions. This implies that the current region obtains income from outside regions. This is the direct effect of material exports, as shown in Figure 3. On the other hand, by using biomass fuels within the region, it is possible to reduce CO<sub>2</sub> emissions. Furthermore, non-metropolitan regions can earn money from other regions by selling CO<sub>2</sub> reductions as carbon offset credits to firms or municipalities in the metropolitan regions. This is defined as the indirect export effect, as illustrated in Figure 4.

Figure 3 Direct Effects by Exporting Biomass

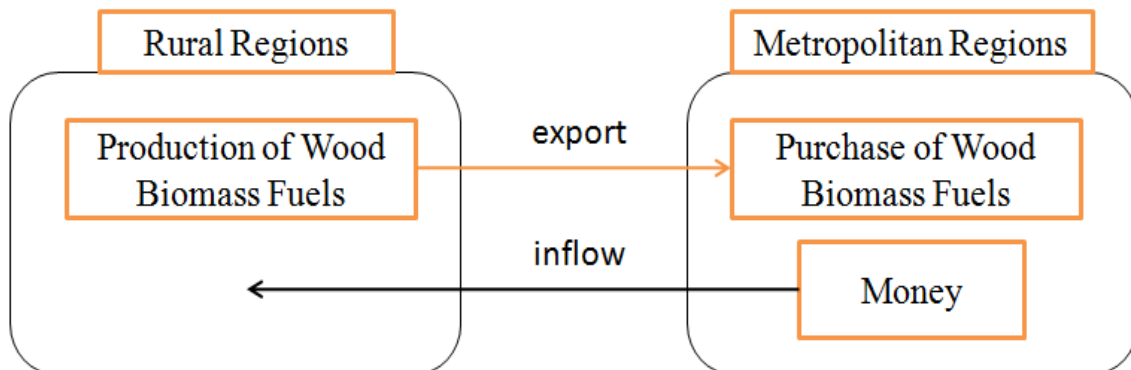
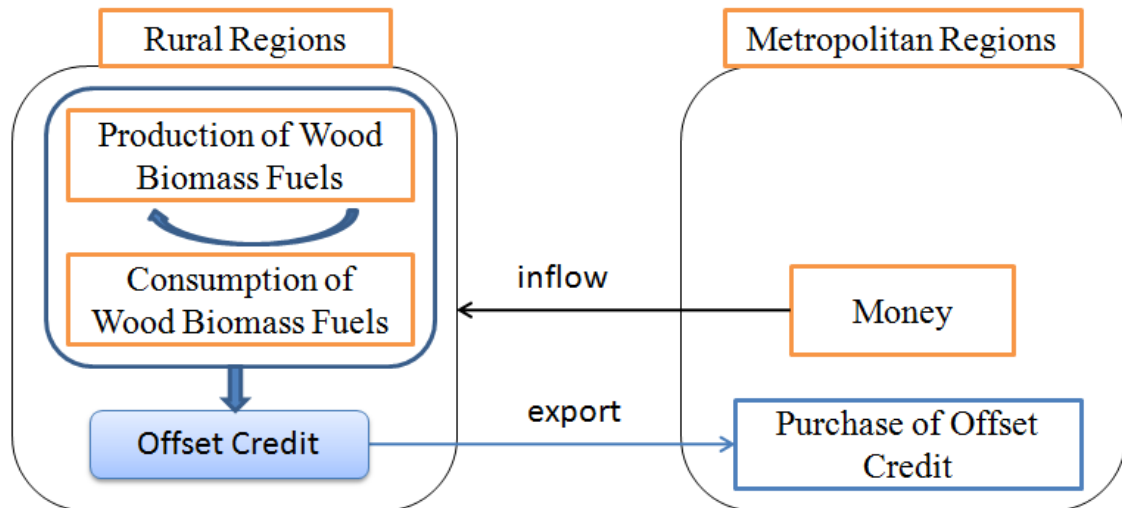


Figure 4 Indirect Effects through Credit Creation



The third permanent effect is called the supply cost effect. This is effective only if the cost of renewable energy is cheaper than that of oil fuels. Although the decrease in the supply cost induces an increase in regional real income, this effect may be unstable because of fluctuations in the energy price of oil as well as the price of biomass fuels.

#### 4. Extension of the IO Table

In the inter-regional IO table, in addition to standard industrial sectors, we create three sectors associated with the behavior of CO<sub>2</sub> reduction. The first sector is an environmental industrial sector, in which firms produce environmental auxiliary goods such as wooden biomass (wood chips and woody pellets).<sup>2</sup> The environmental auxiliary goods are demanded by firms and households, implying intermediate demands and final demands. For example, agricultural farmers use wooden biomass fuels instead of heavy oil for cultivation in a vinyl greenhouse.

The carbon-offset credit will be created according to the use of such environmental auxiliary goods as biomass fuels. This is another service good that is different from goods produced by the environmental industrial sector. Hence, we treat this credit yielding offset service as an activity of the service sectors and define it as the “Carbon Credit Creation Sector C.”

To be publicly acknowledged, it is necessary for carbon offset credits to be certified by a third party that is recognized by the national government or the local authorities. At present, we must assume the existence of a “Credit Service

<sup>2</sup> We define environmental auxiliary goods as goods which indirectly reduce CO<sub>2</sub> by making use of those goods.

Sector” which plays the role of an offset provider. Therefore, the CO<sub>2</sub> offset credits created through the public certification system will be sold outside the region, in particular, to firms or municipalities in a metropolitan region. As a result, the current region can enjoy the inflow of metropolitan money that will lead to the correction of regional income disparities.

Table 1 illustrates the IO flow of three environmentally related sectors. Environmental Industrial Sector A produces environmental auxiliary goods by purchasing inputs  $x_{Ai}$  ( $i=1,2,3$ ) from other industries (Industry 1, Industry 2, and Industry 3). The output is demanded for industries as intermediate inputs. “Carbon Credit Creation Sector B” creates carbon credits by using the certification service of Sector C as an input,  $x_{CB}$ , in Table 1, and exports the amount,  $E_B$ , outside the region.<sup>3</sup> At this point, the amount of carbon credits created by the reduction of CO<sub>2</sub> emissions is proportional to the sum of the intermediate inputs of the individual industries (1, 2, and 3) from “Environmental Industry A” (particularly the biomass fuel producing industry). Hence, we can set a relationship like  $E_B = k \sum_i x_{Ai}$ , where  $k$  is called the intermediation coefficient.

Finally, the “Credit Certification Service Sector C” purchases  $x_{3C}$  as an input from the service sector and provides its certification service for Sector B.

Table 1 Environmental Sector in IO Table

		Industry 1	Industry 2	Industry 3	Environmental Industry	Carbon Credit Creation	Credit Certification Service	Final Demand	Export	Import	Output
		1	2	3	A	B	C				
Industry 1	1	$x_{11}$	$x_{12}$	$x_{13}$	$x_{1A}$	0	0	$F_1$	$E_1$	$M_1$	$Q_1$
Industry 2	2	$x_{21}$	$x_{22}$	$x_{23}$	$x_{2A}$	0	0	$F_2$	$E_2$	$M_2$	$Q_2$
Industry 3	3	$x_{31}$	$x_{32}$	$x_{33}$	$x_{3A}$	0	$x_{3C}$	$F_3$	$E_3$	$M_3$	$Q_3$
Environmental Industry	A	$x_{A1}$	$x_{A2}$	$x_{A3}$	0	0	0	0	0	0	$Q_A$
Credit Creation	B	0	0	0	0	0	0	0	$E_B$	0	$Q_B$
Credit	C	0	0	0	0	$x_{CB}$	0	0	0	0	$Q_C$

<sup>3</sup> In this study, since we treat carbon credits as new service goods being independent of the usual service sector, intermediate input into Sector B is only the certification service.

Service										
Gross Value Added	$V_1$	$V_2$	$V_3$	$V_A$	$V_B$	$V_C$				
Output	$Q_1$	$Q_2$	$Q_3$	$Q_A$	$Q_B$	$Q_C$				

## 5. Simulation Analysis

### 5.1 Study Area

We can basically use an inter-regional IO table which is constructed by METI (Ministry of Economy, Trade, and Industry) Japan in 2005. It consisted of nine independent regions, including Okinawa Prefecture.

In the simulation analysis the nine regions are further decomposed into eleven areas in order to separate Tokyo Capital region and, Tohoku particular regions damaged by the earthquake in March 2011 (see map in Figure 5). The reason of the separation of Tokyo Capital region is that our purpose is to investigate money flow between metropolitan region and other non-metropolitan regions, and that of Tohoku particular region is to see regional recovery effect.

Table 2 Regional Categorization

9 Regions	47 Prefectures	11 Regions
Hokkaido	Hokkaido	Hokkaido
Tohoku	Iwate, Miyagi, Fukushima	Tohoku A: Areas damaged by quake
	Aomori, Akita, Yamagata	Tohoku B: Other prefectures in Tohoku
Kanto	Saitama, Chiba, Tokyo, Kanagawa	Kanto A: Tokyo Capital Region
	Ibaraki, Gunma, Tochigi, Niigata, Yamanashi, Nagano, Shizuoka	Kanto B: Other prefectures in Kanto region
Chubu	Toyama, Ishikawa, Gifu, Aichi, Mie	Chubu
Kinki	Fukui, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama	Kinki
Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi	Chugoku
Shikoku	Tokushima, Kagawa, Ehime, Kochi	Shikoku
Kyusyu	Fukuoka, Saga, Nagasaki, Oita, Kumamoto, Miyazaki, Kagoshima	Kyusyu
Okinawa	Okinawa	Okinawa

In the following Table 3 we show several economic indicators in 2005. Since environmental natural resources, such as wooden biomass, are usually unevenly distributed across regions, the economic impact will be specific to regions that have abundant natural resource endowments. In a wide region, including urbanized areas, the magnitude of the economic impact will be diluted.

Figure 5 Regional Map of Japan

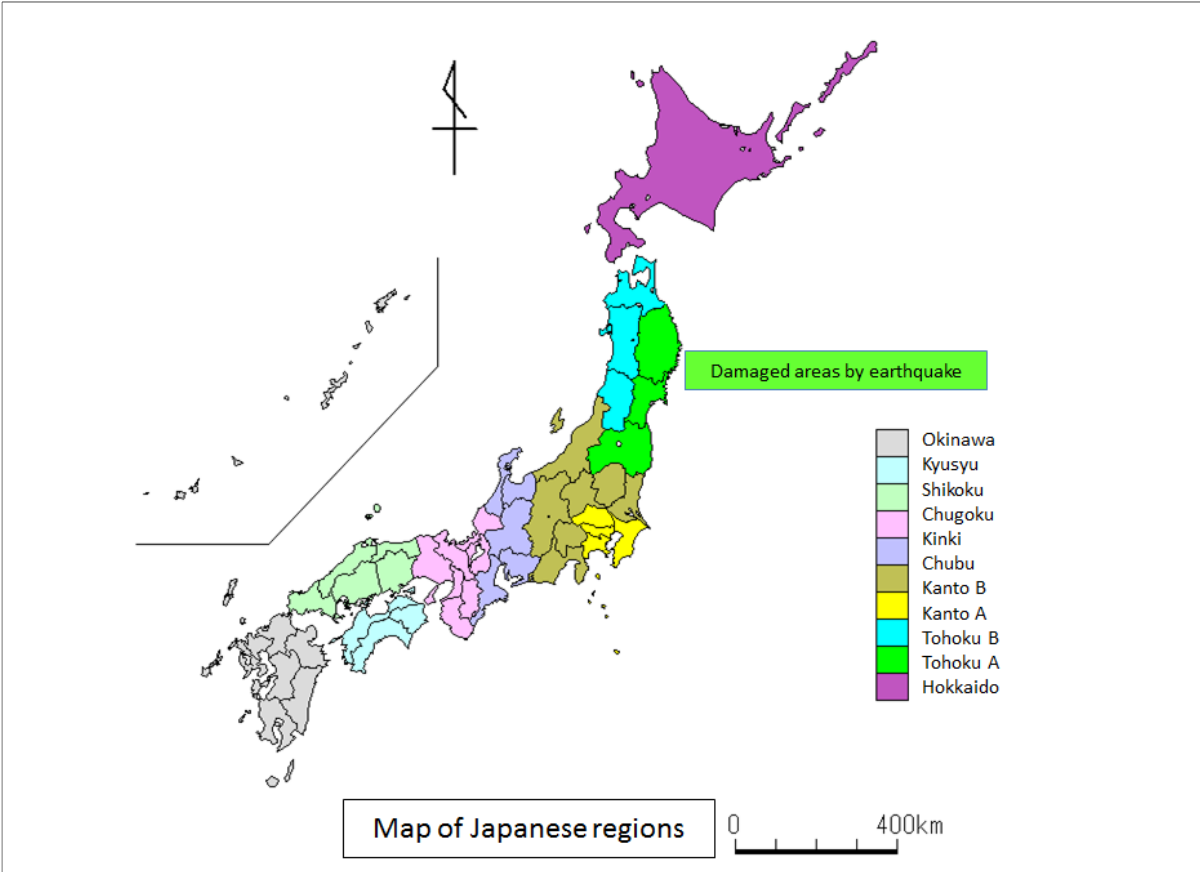


Table 3 Representative Economic Indicators by Region

	GRP (Million Yen)	Daytime Population (Thousand)	GRP per capita (Thousand Yen)	Compensation of Employees (Million Yen)	Income/ Employee (Thousand Yen)
Hokkaido	19,063	5,628	339	10,202	4,562
Tohoku A	19,603	5,837	337	10,526	4,601
Tohoku B	11,352	3,798	299	6,240	4,327

Kanto A	156,256	34,479	455	80,064	5,383
Kanto B	58,666	16,320	362	30,715	4,564
Chubu	57,113	13,515	424	31,177	5,330
Kinki	80,935	21,715	375	42,373	5,005
Chugoku	29,058	7,675	380	15,538	4,988
Shikoku	13,598	4,086	333	7,262	4,755
Kyusyu	42,615	13,353	320	22,899	4,546
Okinawa	3,213	,1,362	239	1,827	3,978

## 5.2 Environmentally Related Sectors

Next, we added three environmentally related sectors to the IO table: the wooden biomass fuel (woody pellets and wood chips) production sector, the credit creation sector, and the credit service sector.

Table 4 presents the IO flow of wooden biomass pellet production and its demand, focusing particularly on exports and imports for eleven regions.

Table 4 Interregional Flow of Wooden Biomass Chips

	Hokkaido	Tohoku A	Tohoku B	Kanto A	Kanto B	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Hokkaido	2,498	0	0	0	0	0	0	0	0	0	0
Tohoku A	0	3,094	9183	0	0	0	0	0	0	0	0
Tohoku B	0	3,235	961	0	0	0	0	0	0	0	0
Kanto A	0	126	37	473	1,299	377	0	0	0	0	0
Kanto B	0	179	53	674	1,852	539	0	0	0	0	0
Chubu	0	10	2	0	0	2,509	829	0	0	0	0
Kinki	0	0	0	0	0	29	2,631	0	266	0	0
Chugoku	0	0	0	0	0	0	164	4,253	55	982	0
Shikoku	0	0	0	0	0	0	0	0	1,979	0	0
Kyusyu	0	0	0	0	0	0	0	264	0	2,637	0
Okinawa	0	0	0	0	0	0	0	0	0	0	72

## 5.3 Calculation Model

As our inter-regional input output table is competitive foreign imports and noncompetitive domestic imports, production inducement effects by regional industrial sectors are calculated by the following formula:

$$X = [I - (A - \hat{M})A^*]^{-1} [(I - \hat{M})F + E]$$

where

$X$  : Output vector by region and industrial sector

$A$  : Matrix of input coefficients<sup>4</sup>

$\hat{M}$  : Matrix of import coefficients

$A^*$  : Diagonal matrix of inter-regional input coefficients

$F$  : Final demand vector

$E$  : Foreign export vector,

and import coefficient is assumed to be proportional to domestic demand. By using this model we can estimate the inducement effect of production.

### 5.3 Simulation Scenarios

By using the extended interregional IO table with available data, we set three scenarios for investigating regional economic impacts by producing and exporting wooden biomass chips. The first scenario 0) is the contemporary economic effect by current economic inter-regional IO structure. Currently, most of produced wooden biomass fuels in individual regions are demanded within the region and little exported to other regions. This is the baseline.

Next, we suppose the case in which biomass production in the northern 4 regions (Hokkaido, Tohoku A, Tohoku B, Kanto B) increases wooden biomass fuel production. It corresponds to 10 % of current usage of fossil fuels in terms of calorific value. In scenario 1) those increased chip fuels are all exported to Tokyo Capital region (Kanto A). In this case Tokyo metropolitan capital region can reduce CO<sub>2</sub> emissions by the energy substitution.

Scenario 2), increased products of biomass fuels are all demanded within the produced regions. In this case there is no trade between non-metropolitan regions and Tokyo metropolitan capital region. Non-metropolitan regions, in particular, northern regions in Japan, can save their money by making use of own resources, i.e., protect flowing out. In the situation of scenario 2) reduced CO<sub>2</sub> emissions in

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<sup>4</sup> Input coefficients would be changed due to energy substitution. It means changes in inter-industry trading relationship.

non-metropolitan regions can also create carbon offset credits and they are sold to Tokyo metropolitan capital region. This is scenario 2').

In this scenario 1), we examine the direct effect of exporting wooden biomass fuels to Tokyo metropolitan region from other regions in northern part of Japan. In Scenario 2), the substitution from fossil fuels to wooden biomass fuels leads to a change in input coefficients. Consequently, the inter-regional IO table is modified. The implementation of this scenario clarifies the indirect effect of reducing CO<sub>2</sub> emissions, as well as the circulation effect of usage, within the region. Finally, we can estimate the degree of “endogenous” correction of inter-regional income disparities by conducting scenario 2'), in particular, between non-metropolitan regions and Tokyo capita region.

## 5.4 New Approach

In the calculation process of regional economic effects, we construct new input-output table in which structural changes in input-output relationship occur due to the production/demand shift from fossil fuels to wooden biomass fuels.

By specifying new matrix of input coefficients and new vector of domestic import coefficients, we can construct new Leontief inverse matrix. Using this new inverse matrix we calculate production inducement values by industry with given final demands, and reconstruct new input-output table in the situation of production/demand shift to renewable energy usage. Thus we can capture economic effects of regional product by comparing current input-output table with new input-output table.

Considering scenario 1), an increase in export of wooden biomass fuels to Tokyo metropolitan capital region from northern regions in Japan raises the use of biomass input and reduces that of fossil input for each industrial sector in Tokyo metropolitan region. This means the changes of input coefficients and import coefficients in Tokyo metropolitan region.

Scenario 2) implies “regionally produced renewable energy and consumed regionally”. In this case non-metropolitan regions in northern Japan produce wooden biomass fuels by making use of own forest resources and substitute fossil fuels with biomass energy in production activities. The substitution in intermediate demand generates changes of input coefficients as well as import coefficients in non-metropolitan regions.

In both scenarios 1) and scenario 2) we construct new input-output table with



new Leontief inverse matrix derived from changed input coefficients, import coefficients and demand. Then, we can deduce regional economic effects by directly comparing these two tables.

In scenario 2') the purchase of carbon offset credits from non-metropolitan regions means import for Tokyo metropolitan region. It increases regional income in non-metropolitan regions (credits selling regions) accompanied by income transfer from Tokyo capital metropolitan region. On the other hand, Tokyo capital region will experience an decrease in income.

#### 5.4 Results and Interpretations

Economic impact is usually captured by the induced value of regional product. Table 5 shows the direct export effects for regions exporting wooden biomass fuels to the Tokyo metropolitan region. Kanto B is the surrounding area of Tokyo capital region, and it consists of seven prefectures. The magnitude of economic impact here is the largest among the four regions presented in Table 5. The relative effect on regional output, however, is not as large as that for Hokkaido. Tohoku A shows the highest multiplier value among four regions, while the amount of export of wooden biomass fuels is lower than those for Hokkaido region. This suggests that for prefectures damaged by earthquake (Tohoku A) utilizing their own regional resources, such as wooden biomass, is an effective tool for economic recovery.

Table 5 Export Effects of Wooden Biomass Fuels

Region	Regional Output	Export to Kanto A		Induced Regional Output (multiplier)
		Base Line	Scenario 1)	
Hokkaido	33,927,234	0	36,410	66,913 (1.84)
Tohoku A	36,593,347	0	27,974	52,886 (1.89)
Tohoku B	20,682,164	0	18,303	31,705 (1.73)
Kanto B	123,793,075	674	118,312	188,745 (1.61)

Note: Million Yen, Tohoku A corresponds to damaged prefectures by earthquake)

Since our main purpose is to investigate the correction of inter-regional income disparities by using region's own resources, such as wooden biomass fuels, we

show a comparison of changes in per capita income among the scenarios. In Table 6, the economic impacts on value-added in terms of per capita (Yen) in three simulation cases are presented. Under the current situation, Kanto A (the Tokyo capital region) shows the highest value among the 11 regions. The second highest region is Chubu, while Kinki region is the second largest area in terms of gross regional output.

In our three simulation scenarios the highest impact is on the Hokkaido region.<sup>5</sup> This means that the Hokkaido region has a close inter-industry relationship with biomass production.

This table indicates that the offset credit (Scenario 2') has a greater economic impact on regional per capita income than the direct export effects of wooden biomass fuels. The impact level in Hokkaido region increases by +8,632 from +6,612 in terms of per capita value-added. In contrast, in Kanto A (the Tokyo capital region), per capita income decreases by 3,468 for Scenario 2') compared with the base line scenario. This result comes from trading the offset credit from the northern region as the selling area to the Tokyo capital region as the buyer. The table indicates that it contributes significantly to regional income improvement if the government institutionalizes the exporting system of carbon-offset credits.

Table 6 Regional Economic Impact by Scenario

		Scenario 0)	Scenario 1)	Scenario 2)	Scenario 2')
		Baseline	Export Biomass	Regionally Produced & Consumed	Trading Credit
Hokkaido	Value-added (Difference)	3,393,555	3,397,772 (+5,217)	3,399,167 (+6,612)	3,401,187 (+8,632)
Tohoku A	Value-added (Difference)	3,370,534	3,374,472 (+3,939)	3,375,466 (+4,933)	3,376,941 (+6,407)
Tohoku B	Value-added (Difference)	2,991,926	2,995,376 (+3,450)	2,998,514 (+6,588)	2,999,988 (+8,063)

<sup>5</sup> In this study we focus on the relationship between the Tokyo capital region, as a representative metropolitan area, and the northern prefectures of Japan as non-metropolitan areas. Thus, the middle and southern prefectures in Japan have little effects on our simulation scenarios.

Kanto A	Value-added (Difference)	4,545,281	4,547,351 (+2,070)	4,544,403 (-878)	4,541,813 (-3,468)
Kanto B	Value-added (Difference)	3,624,997	3,629,923 (+4,926)	3,631,051 (+6,054)	3,633,399 (+8,402)
Chubu	Value-added (Difference)	4,240,961	4,241,288 (+327)	4,240,406 (-555)	4,240,386 (-576)
Kinki	Value-added (Difference)	3,745,209	3,745,415 (+206)	3,745,282 (+73)	3,745,248 (+39)
Chugoku	Value-added (Difference)	3,797,716	3,797,964 (+248)	3,797,564 (-152)	3,797,529 (-187)
Shikoku	Value-added (Difference)	3,329,434	3,329,595 (+162)	3,329,448 (+14)	3,329,411 (-23)
Kyusyu	Value-added (Difference)	3,200,511	3,200,647 (+136)	3,200,569 (+58)	3,200,546 (+35)
Okinawa	Value-added (Difference)	2,385,337	2,385,386 (+49)	2,385,356 (+19)	2,385,327 (-9)

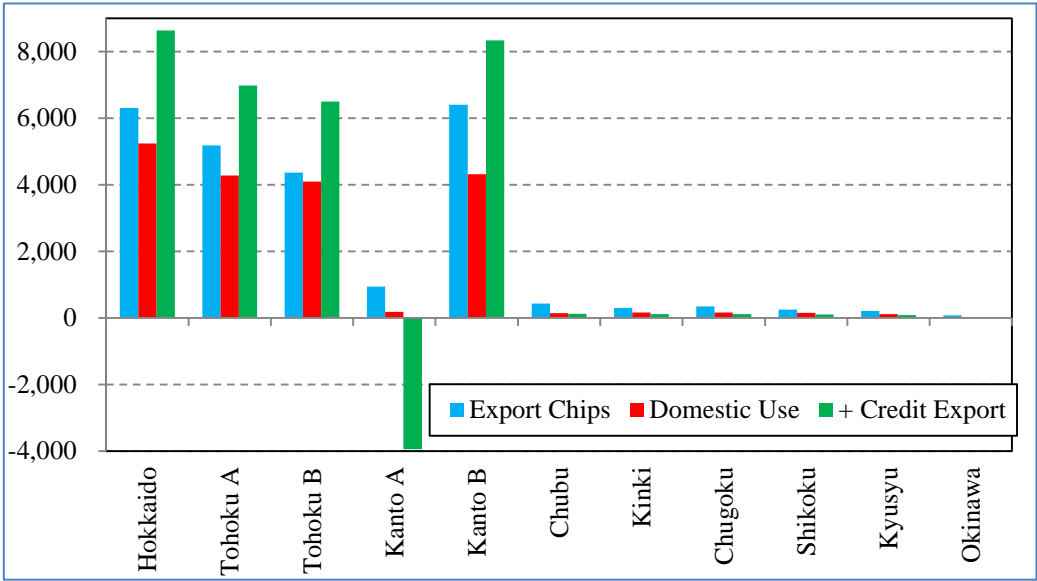
Unit: JP Yen/ population. Numbers in lower level indicate difference from those of the Baseline.

As imports of wooden biomass fuels from the northern regions increases in the Tokyo capital region, import of fossil energy will decrease. As a result, in Scenario 1), per capita value-added for the Tokyo capita region will increase.

“Regionally produced and regional consumed” protects a region from income leakage to the outside region because of carbon offsets and the substitution from fossil fuels. In Scenario 2), the degree of increase in per capita value-added is generally larger than that in case of the direct export of wooden biomass fuels. For the capital region, however, per capita value-added falls slightly. Consequently,

Scenario 2) has a greater impact on the correction between inter-regional income disparities. For example, in terms of the degree of correction between inter-regional disparities, for Tokyo and Hokkaido, it is 7,490 Yen/capita in Scenario 2), 3,127 Yen/capita in Scenario 1). Since the simulation result of Scenario 2') shows the impacts in terms of income changes resulting from the creation of offset credits with CO<sub>2</sub> mitigation, the degree of impact is greater than that in Scenario 2). In Scenario 2'), the income discrepancy between Hokkaido and the Tokyo capita region is expected to be 12,100 Yen/capita. The discrepancy is 1,152,725 Yen/capita. This means the 1.05 % baseline income discrepancy level is corrected. This seems to be small, but has significant meaning when we take into consideration that wooden biomass production only accounts for 0.1 % of the total regional production. For non-metropolitan regions it is possible to “endogenously” correct inter-regional income disparities by utilizing their own renewable energy resources such as solar and wind power in addition to wooden biomass.

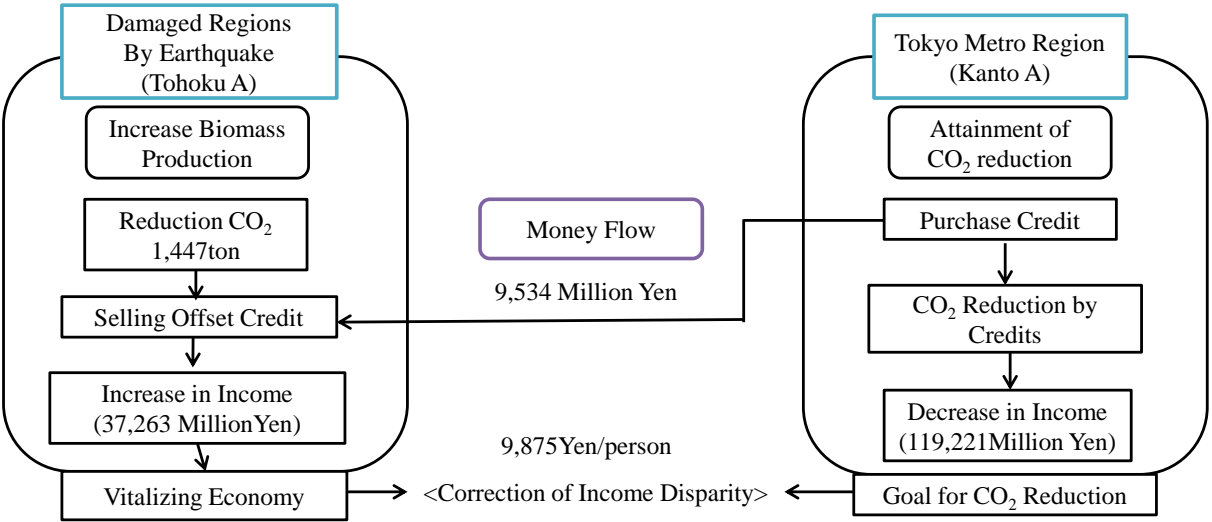
Figure 6 Change in per Capita Labor Income by Scenario



Finally, Figure 7 illustrates a representative case of an endogenous correction of inter-regional income disparities. In this case CO<sub>2</sub> mitigation is around 1,447 ton in the Tohoku A region, which then creates offset credits. Tohoku A region sells credits to the Tokyo capital region and 9,534 million Yen flows into Tohoku A from the Tokyo capital region. This directly results in an increase in income and leads to economic revitalization. On the other hand, in the Tokyo capital region per capita income may decrease because of purchasing credits as imports. The Tokyo region, however, can maintain its economic activity level. As a result, the

interregional income disparity would contract by around 10 thousand Yen. This is a typical example of an “endogenous” correction of inter-regional disparities by means of a non-metropolitan region utilizing its own resources such as wooden biomass.

Figure 7 Representative Illustration of an Endogenous Correction of Inter-regional Disparities



### 7. Summary and Conclusions

The principal purpose of this study is to empirically (quantitatively) illustrate the degree of correction of inter-regional economic disparities through the endogenous efforts of non-metropolitan local regions, in which these efforts imply that local municipalities in non-metropolitan areas use their own regional **environmental resources** and the usage leads to regional economic vitalization as well as the reduction of CO<sub>2</sub> emissions.

For pursuing this purpose, we constructed inter-regional IO tables by adding three new sectors to the IO tables (e.g., the wooden biomass production sector, credit creation sector, and credit service sector), we made it possible to analyze the economic effects of biomass production, consumption, and carbon offset credits. At this point, we proposed new calculation method to investigate the economic impact of changing the input structure through a means such as energy substitution.

Moreover, by conducting various simulations, we calculated three different economic impacts that were never acknowledged in the previous literature.

Among the effects, the indirect-export effect, which is generated by exporting the offset-credit service outside the region, has the greatest effect on regional income improvement. This implies that regional environmental activity used to reduce CO<sub>2</sub> emissions is consistent with economic vitalization. Our original categorization and estimation of regional economic effects would advance the research on regional economic evaluation of the environmental activities by the local governments.

There are several points to be considered for future research. First, we set relatively high offset-credit prices at 5,000 Yen/ton-CO<sub>2</sub> and assumed all credits are purchased by outside regions.<sup>6</sup> Thus, we should extend the amounts of credit supply and demand change into the variable credit price. This means we predict the future demand for offset credits. Second, it is important for policy makers to develop incentives that promote wooden biomass supply and demand. Intraregional systems for circulating money obtained from outside regions can be constructed by agglomerating biomass related industries.

Finally, we should remember that utilizing wooden biomass has another aspect, which implies making forests sustainable.

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<sup>6</sup> However, this price level is quite normal in current situation of Japanese credit market.

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