Economic ripple effects of biomass electricity power plants for earthquake disaster reconstruction in the coastal area of Iwate prefecture

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Abstract

East coast region in Iwate prefecture was seriously damaged by East Japan big earthquake in 2011, and revitalization of this region is important issue in Japan. This study aims to estimate the input-output tables of this region before and after the earthquake and to show impacts of earthquake and a revitalization measure, i.e. construction of biogas electricity power plant, by using these tables. The results showed the following features. First, value added production in 2011 became higher than previous year due to recovery construction investment, but both intermediate inputs and total production decreased. This happens because ratio of value added production in construction sector was higher than other industries that were seriously damaged by the earthquake. Second, investment demand increased in 2011 and 2012, but intermediate inputs and private and public consumption decreased by earthquake. Order of influence coefficients and sensitivity coefficients were not so changed by the earthquake, but increasing rate of induced production became low after the earthquake. Third, induced production of construction of the biogas plant would be 0.73, if it was constructed before the earthquake. However, that value after the earthquake was 0.21, because industrial linkage was damaged. As compared to the conventional electricity sector, biogas sector induced more production because import rate of this sector was 0 and most induced demand occurred within the region. Therefore, biogas electricity power plant can contribute to revitalization of regional economy, although electricity generation capacity was small.

Keywords: Input-output (I/O) analysis, induced production, induced labor, biogas electricity power plant

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1. Introduction

Coastal area of Iwate Prefecture suffered fatal damage due to the tidal wave caused by East Japan big earthquake in March, 2011. After that, reconstruction has been conducted with the support of government and the cooperation of civic association. However, there are many people who still have to live in the temporary house in this time which passed 4 years after the earthquake disaster. Some industries, such as fishery, cannot reach the same level of production as before the earthquake disaster. After getting such serious disaster, the policy makers try to build resilient country and community.

In addition to needs for recovery, the government tries to revitalize local economy, which faces aging and decrease in population, by using local resources. The construction of biogas electricity power plant is planned for such purpose. This plant is supposed to produce methane gas from food residues and generate electricity with it in Ohfunato city located in the coastal area. This plant has also carbon neutral feature which does not increase or decrease CO2 even after burning materials. However, this technology is expensive and low efficiency as compared to usual power plants. In order to operate biogas power plant, support from government is generally needed. For getting consensus of people on such support, economic evaluation is important.

Urbanchuk (2009) analyzed the macro economic effects of bio-ethanol production by using the input-output (I/O) model; and showed that bio-ethanol production induced $32.5 billion of added value and created 110 thousands of employees in the USA in 2006. Polagye et al. (2009) showed profit from a bio-ethanol production factory in the USA. Hayashi (2009) analyzed Japanese E10 policy by using I/O analysis and pointed out that the economic benefit of bio-ethanol production can be positive in the near future if the fossil oil price increases along with the recent trend. Kunimitsu and Ueda (2009) measured the economic effects of bioenergy production in Thailand by using an I/O analysis. However, there were few studies to evaluate macro-economic impacts and ripple effects of biogas production in local economy as compared to environmental evaluations.

The present study aims to estimate the input-output tables of this region before and after the earthquake and to show impacts of earthquake and a revitalization measure, i.e. construction of biogas electricity power plant, by using these tables. The features of this study are that recent I/O tables after the earthquake are estimated by the RAS method by using statistics on net town-person-income published by prefectural government, (ii) impacts of the earthquake on industrial linkage are shown by analyzing inverse matrixes of I/O tables, and (iii) ripple effects of construction and operation of biogas electricity power plant are estimated by these I/O tables.

2. Methodology

2.1 Changes in industrial linkage by earthquake and introduction of biogas sector

Latest published regional I/O table in coastal region, Iwate prefecture was 2005, and it consists of 9 towns that are Miyako, Ohfunato, Rikuzentakada, Kmaishi, Ohzuchi, Yamada, Iwaizumi and Tanohata. Industrial linkage was obviously changed by 2011 earthquake, so we estimated 2010, 2011 and 2012 I/O tables by assuming as follows.

(i) Total regional demand (= intermediate production + final demand within region + export to other regions and abroad) changed in accordance with net residents production of town in 2010, 2011 and 2012 that is published by prefectural government.

(ii) Industrial linkage changed subject to the total regional demand, as the control total, with the least change from whole input coefficients. Under such assumption, new I/O data are estimated by the RAS method which solves matrix balance problem.

(iii) The contents of value added production, i.e. "consumption expenditures outside households," "labor income," "depreciation of capital stocks," and "tax - subsidies", are assumed to keep their share even after total value added production is changed. So we calculate these values according to the initial share rate of them in 2005 I/O table.

(iv) The contents of final demand, i.e. "consumption expenditures outside households," "household consumption," "public consumption," "public investment," "private investment," and "inventory investment", are also assumed to keep their share rate within total final demand even after total regional demand is changed. So we calculate these values as the same way as (iii).

(v) For initial settings, column-wise input coefficients and total regional production of biogas sector are based on the plant design of the operation costs. Row-wise input coefficients of biogas sector are the same as electricity generation sector and total regional demand of this sector corresponds to the total regional production. Total regional demand and total regional production of biogas sector are subtracted from the total of electricity generation sector. After these settings, the RAS method is applied to balance column-wise and row-wise totals.

2.2 Estimation method for induced production

Induced production by an increase in construction investment and final demand for biogas products are calculated as follows.

$$\mathbf{X} = \{\mathbf{I} - (\mathbf{I} - \mathbf{M})\mathbf{A}\}^{-1}\mathbf{F} \qquad (1),$$

where X is total production vector (size is 35x1), I is the unit matrix, M is import coefficient matrix from both other regions and abroad that is defined as $(\mathbf{M}/(\mathbf{AX}+\mathbf{F}-\mathbf{E}))$ (35x1), A is input coefficient matrix (35x35), F is final demand vector (35x1), and E is export matrix (1x35).

Eq. (1) calculates only backward linkage effects via derived demand diffusion, so called Leontief multiplier. Forward linkage effects caused by an increase in wage income and consumption of household can be calculated as follows (Miyazawa, 2002).

$$\mathbf{X}' = \mathbf{B}\,\mathbf{C}\,\mathbf{K}\,\mathbf{V}\,\mathbf{B}\,\mathbf{F}_X + \mathbf{B}\,\mathbf{C}\,\mathbf{K}\,F_Y \qquad (2)$$

This effects are so called Keynesian multiplier. Here, $\mathbf{B} = (\mathbf{I} - \mathbf{A} + \mathbf{m})^{-1}$ and $\mathbf{K} = (\mathbf{I} - \mathbf{V}\,\mathbf{B}\,\mathbf{C})^{-1}$. C is average propensity to consume vector (35x1), V is a matrix (35x1) consists of the rates to the total production of the wage income in each industry, $\mathbf{F}_X$ is final demand vector (35x1) regarding to material demand, and $\mathbf{F}_Y$ is final demand regarding to final demand change (1x1).

3. Results

3.1 Estimation results on I/O table

Fig.1 shows net residents production of town published by Iwate prefectural government. As shown in this table, net income increased even incident year, 2011, when earthquake happened. It is because of an increase in construction for recovery. However, other industries, such as fishery, manufacturing and service sector, decreased income due to a demolition of capital stocks.

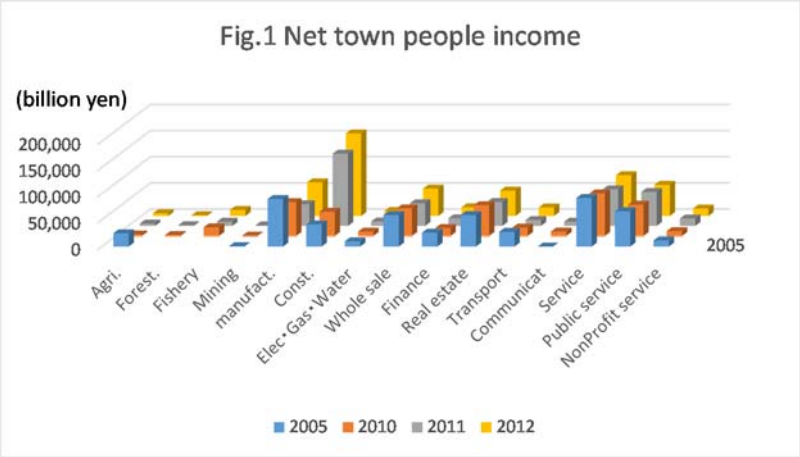
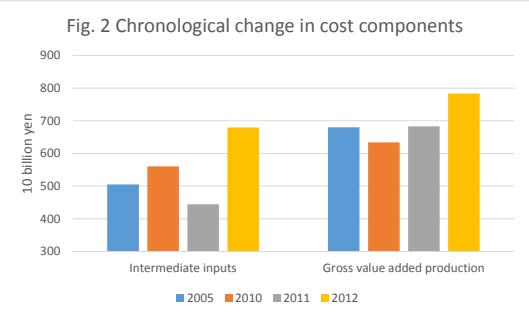


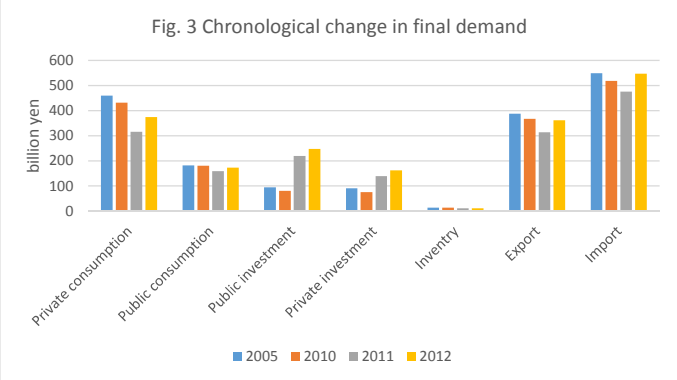
Fig. 2 shows estimation results of intermediate inputs and value added production in each year. These values were estimated by applying the RAS method.

Even though value added production in 2011 became higher than previous year due to the earthquake, intermediate inputs and total production were both lower than former year. This happened because ratio of value added production in construction sector was higher than other industries that were seriously damaged by the earthquake.

Fig.3 shows chronological changes in final demand by contents. Final demand in 2011 that consists of consumption and investment was larger than previous year because of an increase

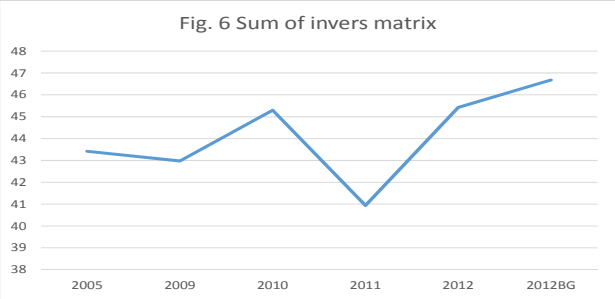
in value added production. Private and public consumption were both decreased but public and private investments were increased due to recovery investment for damaged capital stocks under earthquake. Investment in 2012 was also much higher than before earthquake. Imports and exports decreased in 2011, and these components recovered afterward. This is owing to recovery construction work continuing even after 2011.





3.2 Changes in industrial linkage structure

Fig. 6 shows summation of elements in the inverse matrix, which shows total effects of induced production caused by an increase in final demand. Those numbers are decreased in 2011 when earthquake happened, but after that year, total effects of induced production increased and reached to the higher level than before the earthquake. Especially, when biogas power plant was installed in 2012, that coefficient became the highest. In this sense, new investment relating to electricity sector can stimulate domestic economy by switching demand of imports to domestic production.



3.3 Induced production of biogas power plant

Table 3 shows contents of input cost for construction of the plant. Table 4 is about running costs during operation of this plant. These values were used for simulation shown in the latter part.

Table 5 is the induced production and labor which were increased by construction of the biogas electricity power plant. For estimation of induced production, investment for the plant was assumed to be conducted in two ways, i.e. construction in 2010 before earthquake and construction in 2011 after

earthquake. Each induced production was calculated by using each I/O table and inverse matrix. Since import rate to other regions and abroad was high and hence leakage of effects was large in this region, induced multiplier (=induced production / investment) was 0,73 and lower than 1. If induced multipliers in 2010 and 2011 were compared, latter one (0.21) was much lower than former (0.73). This happened because of the damage in industrial linkage in this economy by earthquake. In this sense, effects of recovery investment become lower than investment in the normal time, even if investment amount was the same.

Table 3. Cost components for construction generation of biogas electricity power plant

(thousands yen)

Input sectors	Inputs amount for construction of the biogas plant
Ceramic	20,000
Metal	11,000
General machine	225,000
Electronic machine	70,000
Construction	230,000
Transportation	10,000
Business srvice	40,000
Subtotal	606,000
Value added	0
Total production	606,000

Table 4. Operational cost for biogas electricity

(thousands yen)

Input sectors	Operation stage
Gneral machine	13,500
Electronic machine	7,000
Construction	500
Electricity, Gas, Heat s	2,500
Water, Recicle	16,000
Finance	360
Transportation	5,100
Communication	120
Business service	120
Office supplies	120
Subtoal	45,320
Wage	16,960
Capital depreciation	35,650
Value added	52,610
Total production	97,930

Table 5 Induced production and labors by construction of biogas electricity plant

(million yen, person)

Constraction year	Investment	Induced production		Induced labors	
	a	b	b/a	c	c/a
2010	606	444	0.73	37	0.061
2011	606	126	0.21	14	0.024

Table 6 Induced production and labors by annual operation of biogas electricity plant

(million yen, person)

Sectors	Operation cost	Induced production	Net increase in labors
Electricity, Gas, Heat supply	−98	−20	−0.53
Biogas Electricity	98	98	2.59
Others	0	19	0.75
Total	0	97	2.81

Table 6 shows the induced production and labor at the stage of operation after construction of the plant. In this estimation, we set 98 million yen as an increase in final demand of biogas sector but at the same time -98 million yen for conventional electricity generation sector. Total

increase in final demand in whole economy was 0, but induced process was different for both sectors. As compared to the conventional electricity sector, biogas sector induced more production because import rate of this sector was 0 and most induced demand occurred within the region. Induced labors were 2.8 person per year, and this is pure increase in this reason. Hence, biogas electricity power plant is effective for revitalization of regional economy.

4. Summary and conclusion

This study aims to estimate the input-output tables of this region before and after the earthquake and to show impacts of earthquake and a revitalization measure, i.e. construction of biogas electricity power plant, by using these tables. The results showed the following features.

First, value added production in 2011 became higher than previous year due to recovery construction investment, but both intermediate inputs and total production decreased. This happens because ratio of value added production in construction sector was higher than other industries that were seriously damaged by the earthquake. Second, investment demand increased in 2011 and 2012, but intermediate inputs and private and public consumption decreased by earthquake. Order of influence coefficients and sensitivity coefficients were not so changed by the earthquake, but increasing rate of induced production became low after the earthquake. Third, induced production of construction of the biogas plant would be 0.73, if it was constructed before the earthquake. However, that value after the earthquake was 0.21, because industrial linkage was damaged. As compared to the conventional electricity sector, biogas sector induced more production because import rate of this sector was 0 and most induced demand occurred within the region. Therefore, biogas electricity power plant can contribute to revitalization of regional economy, although electricity generation capacity was small.

There are many remained issues in this study. Estimated I/O table should be secured by comparing actual data survey or official published table that will be published in the future. We need to consider other investment rather than biogas electricity power plant in order to revitalize regional economy.