How to Examine the total economic impact, stemmed from the *Great East Japan Earthquake*: within the Interregional Input-Output Framework

Michiya NOZAKI※

Abstract：

The purpose of this study is to examine the total economic impact caused by the Great East Japan Earthquake within the Interregional Input-Output Framework.

The large amount of the study about the economic impact of the Great East Japan Earthquake on 11 March, 2011 has been estimated and evaluated the forward and backward, and the direct and indirect effects. Thus we have to examine the estimation of the stock damages and economic damages.

In this study, the impacts from this event have spilled over from the damaged region to other regions, and the impacts have influenced the national economy as a whole.

An extended Interregional Input-Output Table for Chubu region is composed of nine prefectures and the Rest of Japan. We intend to examine the total economic impact by the help of the Interregional Input-Output Analysis.

Keyword: total economic impact, Interregional Input-Output Analysis, the Great East Japan Earthquake

東日本大震災の経済インパクトの推計：地域間産業連関分析のフレームワーク

野　崎　道　哉

要旨：

本稿の目的は、地域間産業連関分析の枠組みにおいて、東日本大震災によって生じた経済インパクトの推計を行うことである。東日本大震災による経済被害の推計に関しては膨大な研究が存在し、その推計のパースペクティブに関しても前方連関効果、後方連関効果、および直接効果、間接効果など様々である。我々は、ストック被害と他地域にわたる経済被害を地域間産業連関分析によって明らかにする。本研究では、震災によって生じた経済被害の他地域へのインパクトがどのような規模であるのか、また経済被害が国民経済全体へどのような影響を及ぼすかについて推計を行う。

キーワード：総経済インパクト、地域間産業連関分析、東日本大震災

※ Visiting Researcher, Graduate school of Hirosaki University, 1, Bunkyo-cho, Hirosaki, Aomori, Japan, 036-8560. E-mail: michi_post@kfx.biglobe.ne.jp

I. Introduction

The purpose of this study is to examine the total economic impact caused by the Great East Japan Earthquake within the Interregional Input-Output Framework.

The large amount of the study about the economic impact of the Great East Japan Earthquake on 11 March, 2011 has been estimated and evaluated the forward and backward, and the direct and indirect effects. But, we have not yet obtained the total economic impact data of the Great East Japan Earthquake. Thus we have to examine the estimation of the stock damages and economic damages.

In this study, the impacts from this event have spilled over from the damaged region to other regions, and the impacts have influenced the national economy as a whole.

An extended Interregional Input-Output Table for Chubu region is composed of nine prefectures and the Rest of Japan. We intend to examine the total economic impact by the help of the Interregional Input-Output Analysis.

The physical damages and economic losses from earthquakes, floods, and other natural disasters can have significant impacts on a region's economy. Demands for estimating the economic consequences of these events (owing to costs for recovery and reconstruction), as well as the extent of the damages per se, can be immediate and pressing. Most analytical models of urban and regional economies, however, cannot confront these unscheduled and significant changes since they largely assume incremental changes in system over time. Moreover, the consequences associated with the event will be multifaceted and are likely to include significant damages for both the demand and supply of consumer goods. The difficulties associated with impact analysis of unscheduled events are, therefore, (a) distinguishing the direct and indirect consequences of the event; (b) deriving multiple viable assessments at each spatial level, and (c) evaluating the reaction of households, which are poorly understood (Okuyama, Sonis, and Hewings, 1999).

Following the tragic earthquake and tsunami on 11 March 2011 in the Tohoku region, there has been an exceptional effort to support the Japanese people. The Japanese government and Japanese Joint Task Force have spearheaded the relief effort. However, others participating in the relief operations are using this event to think about and plan for the future as a means to support the future safety of the Japanese people.

This multifaceted catastrophe, which consisted of a magnitude-9.0 earthquake (and thousands of aftershocks), a massive tsunami, and problems with nuclear reactors, has illustrated that devastation does not adhere to administrative borders. Hundreds of communities in several prefectures have been affected and many layers of the Japanese bureaucracy—at the local, prefectural, and national level—have been involved. Because of the time necessary to coordinate the various jurisdictions, quick and effective responses have proven elusive (The Daily Yomiuri, 20 April 2011).

In this study, the extent to which the physical and economic impacts of this event have spilled over from the damaged region to other regions will be evaluated. Further, the study will examine how these effects have influenced the Japanese economy as a whole. Past research in this area provides some guidance in how to approach these analyses. Miyazawa (1976) formulated a matrix multiplier that combines Leontief's propagation process with the Keynesian propagation process in the form of the Leontief inverse multiplied by the subjoined inverse matrix. Moreover, Miyazawa's (1976) internal and external multipliers were derived to analyze interregional linkages. Okuyama, Sonis, and Hewings (1999) analyzed the Great Hanshin Earthquake by utilizing the interregional

input-output table provided by the Ministry of International Trade and Industry of Japan (1990). The authors presented their analytical methodology using the Miyazawa's framework and some extensions.

The aims of this paper are to evaluate economic impacts on unscheduled natural disasters to use the interregional input-output table for the Chubu region and the rest of Japan to estimate the economic damages of the Great East Japan Earthquake (see Nozaki, Ihara, and Tithipongtrakul, 2011).

II. Input-Output Analysis of the Great Earthquake

As to the supply-driven Input-Output model, Oosterhaven(1988) pointed out that in the impact studies straightforward use of the model was criticized and a more careful estimation procedure was suggested.

Oosterhaven (1996; 2012) compares the theoretical structure of the demand-driven model and the supply-driven model and presents the evaluation of conclusion that the demand-driven model may not be entirely plausible, but the supply-driven model is much less plausible.

And as Oosterhaven (1996) explained, in 1980's, in spite of the implausibility of the application of the Ghoshian supply-driven model to the market economy, without the reservations uncritical generalizations appeared in the theoretical literature (Bon, 1988).

Dietzenbacher (1997) showed that the supply-driven input-output model became plausible, once it was interpreted as a price model.

Miller and Blair(2009) introduced the reconsideration of the Ghoshian model as a price model and the analytical tool of the linkage analysis.

We think that it is true about what Oosterhaven (1996; 2012) and Dietzenbacher (1997) explained when the market economy works normally.

And the simple Ghoshian quantity model will be applicable when the market economy does not work, and the supply chain are cut off within the interregional trade, for instance, the supply-constrain economy as after the natural disasters.

Let us denote the direct damage ratio d ($1 > d > 0$). Now, let us denote the remaining production ratio λ, when $\lambda = 1 - d$. The 'forward linkage effect' suggests that industrial activities can affect the production of industrial goods which have been used as an intermediate product of that industry. The 'backward linkage effect', in contrast, affects the production activities of another industry whose product demand variation is supplying intermediate goods to the industry.

When we analyze the economic damage of the Great East Japan Earthquake, we treat the damage of the Tohoku region's production as exogenous, and we analyze the forward linkage effects to other regions in Japan.

$\mathbf{X}$ is a column vector of the output, $\boldsymbol{G}'$ is the transposed matrix of output coefficients of intermediate goods that are sold from region i to region j', $\boldsymbol{A}'$ is the transposed matrix of input coefficients, $\mathbf{V}$ is a column vector of the gross value added, and d is a damaged rate of the unscheduled natural disaster, and $\hat{\mathbf{v}}^{-1}$ is a diagonal inverse matrix of the gross value added.

$\hat{\boldsymbol{X}}$ is a diagonal matrix of the output, and $\hat{\boldsymbol{X}}^{-1}$ is a diagonal inverse matrix of the output.

We will analyze the backward linkage in terms of its propagation of the damaged production loss

throughout Japan using Leontief inverse models. When we analyze the economic damage of the Great East Japan Earthquake, we treat the damage of the Tohoku region's production as exogenous, and we analyze the backward linkage effects to other regions in Japan.

$\boldsymbol{A}$ is the input coefficients of intermediate goods, $\boldsymbol{F}$ is a column vector of the final demand.

Ghosh Model :

$$\boldsymbol{X}=(\boldsymbol{I}-\boldsymbol{G}')^{-1}\boldsymbol{V}=\hat{\boldsymbol{X}}(\boldsymbol{I}-\boldsymbol{A}')^{-1}\hat{\boldsymbol{X}}^{-1}\boldsymbol{V} \quad (1)$$

Direct Economic Damages

$$\Delta\boldsymbol{V}=\mathrm{d}\mathbf{V} \quad (2)$$

Forward Linkage

$$\Delta\boldsymbol{X}^{\boldsymbol{F}}=(\boldsymbol{I}-\boldsymbol{G}')^{-1}\ \Delta\boldsymbol{V}\ =\ \hat{\boldsymbol{X}}(\boldsymbol{I}-\boldsymbol{A}')^{-1}\hat{\boldsymbol{X}}^{-1}\Delta\boldsymbol{V} \quad (3)$$

where $\mathbf{G}\ =\hat{\mathbf{x}}^{-1}\mathbf{A}\ \hat{\mathbf{x}}$.

Backward Linkage

$$\Delta\boldsymbol{X}^{\boldsymbol{B}}=(\boldsymbol{I}-\boldsymbol{A})^{-1}\Delta\boldsymbol{F}=\ (\boldsymbol{I}-\boldsymbol{A})^{-1}\mathbf{A}\hat{\mathbf{x}}^{-1}\Delta\boldsymbol{V} \quad (4)$$

where $\mathbf{A}\ =\hat{\mathbf{x}}\,\mathbf{G}\ \hat{\mathbf{x}}^{-1}$.

Ⅲ. Empirical Studies on the economic impact of the Great East Japan Earthquake

The scale of the earthquake and subsequent disasters' damage was calculated by determining the total number of employees in the stricken area's counties (which served as a proxy for output value of each industry in each prefecture in fiscal year 2008). Table 1 summarizes the estimated damage of the Great East Japan Earthquake as outlined by the Cabinet Office of the Government of Japan (2011).

An Interregional Input-Output Table is composed of Toyama Prefecture, Ishikawa Prefecture, Fukui Prefecture, Nagano Prefecture, Gifu Prefecture, Shizuoka Prefecture, Aichi Prefecture, Mie Prefecture, Shiga Prefecture and the Rest of Japan. Other, by using Interregional Input-Output Table in Japan (nine regions with National wide). An extended Interregional Input-Output Table be decomposed into eight regions Hokkaido, Tohoku, Kanto, Kinki, Chugoku, Shikoku, Kyushu and Okinawa, the central 17 inter-industry relations table between regions (the "inter-regional extension table") to reconfigure as other prefecture.

Please see Table 1. This is the table of an extended Interregional I-O Table for explanation.

Table 1. An Extended Interregional I-O Table for 17 regions

Souces of interregional trade coefficients	Appling trade coefficients to compile the I-O table		
Name of Interregional I-O table	Synbol	Method	Reference statistics
Interregional Input-Output Table for Chubu Region	C (trade coefficients for Chubu region)	to use directly	Freight Census 2005
Interregional Input-Output Table (9 blocks in Japan)	J (trade coefficients for 8 blocks of Japan other than		
	Kan (a deducted region with Shizuoka and Nagano from original Kanto region)		
	Chu (a added region with Shizuoka, Nagano, Fukui and Shiga to original Chubu region)		
	Kin (a deducted region with Fukui and Shiga from original Kinki region)		

Note: We compiled an extended interregional I-O Table for 17 regions to refer a Freight Census 2005 in Japan

	Hokkaido	Tohoku	Kanto	Toyama	Ishikawa	Fukui	Nagano	Gifu	Shizuoka	Aichi	Mie	Shiga	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Hokkaido	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J
Tohoku	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J
Kanto	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J
Toyama	chu	chu	chu	C	C	C	C	C	C	C	C	C	chu	chu	chu	chu	chu
Ishikawa	chu	chu	chu	C	C	C	C	C	C	C	C	C	chu	chu	chu	chu	chu
Fukui	kin	kin	kin	C	C	C	C	C	C	C	C	C	kin	kin	kin	kin	kin
Nagano	kan	kan	kan	C	C	C	C	C	C	C	C	C	kan	kan	kan	kan	kan
Gifu	chu	chu	chu	C	C	C	C	C	C	C	C	C	chu	chu	chu	chu	chu
Shizuoka	kan	kan	kan	C	C	C	C	C	C	C	C	C	kan	kan	kan	kan	kan
Aichi	chu	chu	chu	C	C	C	C	C	C	C	C	C	chu	chu	chu	chu	chu
Mie	chu	chu	chu	C	C	C	C	C	C	C	C	C	chu	chu	chu	chu	chu
Shiga	kin	kin	kin	C	C	C	C	C	C	C	C	C	kin	kin	kin	kin	kin
Kinki	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J
Chugoku	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J
Shikoku	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J
Kyusyu	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J
Okinawa	J	J	J	chu	chu	kin	kan	chu	kan	chu	chu	kin	J	J	J	J	J

Source: Nozaki, Ihara and Thitipongtrakul (2011), p.30, Figure 1.

Table 2. The damaged stock of the Great east Japan Earthquake

Contents	Damaged Stock (Unit: trillion yen)
Construction (Houses, residential lands, Offices, Machines)	10.4
Lifelines (Water, Gas, Electricity, Communications and Broadcasting facilities)	1.3
Infrastructure (Rivers, Roads, Ports, Sewers, Airports, etc.)	2.2
Agriculture and Fishery Industrial Facilities	1.9
Other Facilities	1.1
Total	16.9

Source: Cabinet Office Government of Japan, (2011)

Table 3. The damaged stock of the Great east Japan Earthquake (CRISER)

Unit: million yen, %

	Housing Stock	Private Capital Stock	Social Capital Stock	Total	Direct Economic Damage of Capital Stock	Direct Damage Rate of Capital Stock
Iwate	696,380	9,063,333	10,742,624	20,502,337	3,690,421	18.0%
Miyagi	2,074,190	17,590,221	13,480,209	33,144,620	6,628,924	20.0%
Fukushima	1,140,970	20,758,217	13,673,343	35,572,530	3,912,978	11.0%
Ibaraki	385,750	29,060,461	13,868,985	43,315,196	2,165,760	5.0%
Total	3,600,910	76,472,233	51,765,161	132,534,684	16,398,083	12.4%

Source: original capital stock data compiled by Dr. Suzuki (2001).

On the four prefectures of Iwate Prefecture Miyagi, Fukushima, Ibaraki were greater scale of damage caused by earthquake and tsunami, to estimate the income loss affected areas of the municipality affected by the following method. Upon estimation, for the sake of simplicity, let us assume that damage of the earthquake that occurred in all the Tohoku region to do the calculations money transferred to the amount of damage in Ibaraki Prefecture.

1) We estimate the number of employees by industry, municipal disaster, the ratio of employees in the economic census (small classification by prefecture). For selection of the municipality affected,

out of the “specific local governments affected”, was selected as the reference information published municipal newspaper, suffered from earthquake damage, the tsunami.

2) The total production by citizens and industry by prefecture of economic calculation by multiplying the rate of employees and the rate of directly damage ratio stock on each prefecture to calculate the loss of income by industry.

Using the extended “interregional Input-Output table”, a direct impact on economic losses in the Tohoku make an estimate of economic damage. Here, the affected municipalities have been assumed to identify the municipalities that are specified in the affected areas, production activities in the region has been stopped for one year.

The total loss of income of the damaged regions is about 1.105 trillion yen.

Table 3. The Loss of Income of the damaged regions

unit: million yen

	Iwate	Miyagi	Fukushima	Ibaraki	Total
Agriculture, forestry and fishery	1,810	10,003	5,207	645	17,666
Mining	341	121	151	90	703
Coal mining , crude petroleum and natural gas	0	2	0	0	2
Beverages and Foods	11,011	31,323	7,372	2,194	51,900
Textile products	1	10	7	1	19
Wearing apparel and other textile products	41	102	33	10	187
Timber, wooden products and furniture	1,924	3,923	1,877	291	8,014
Pulp, paper, paperboard, building paper	214	9,459	1,455	401	11,529
Printing, plate making and book binding	315	6,977	752	270	8,314
Chemical basic product	163	518	6,215	1,395	8,291
Synthetic resins	99	143	132	257	631
Final chemical products	13	969	1,224	118	2,324
Medicaments	0	35	1,166	0	1,201
Petroleum and coal products	28	5,773	13	19	5,834
Plastic products	851	3,407	1,147	577	5,982
Ceramic, stone and clay products	590	1,827	1,960	669	5,045
Iron and steel	899	2,391	797	7,276	11,363
Non-ferrous metals	0	1,387	1,213	6,002	8,603
Metal products	772	4,857	3,221	1,264	10,115
General machinery	2,769	4,187	3,960	12,143	23,058
Machinery for office and service industry	0	244	492	374	1,110
Electrical devices and parts	422	1,398	429	3,725	5,974
Other electrical machinery	0	966	103	130	1,200
Household electric appliances	0	99	179	2,948	3,226
Household electronics equipment	17	1,006	7,497	1,786	10,307
[illegible]	191	511	347	87	1,136
Electronic components	0	1,789	550	3,745	6,084
Passenger motor cars	0	0	0	0	0
Other cars	0	5	0	3	8
Motor vehicle parts and accessories	13	843	3,370	795	5,021
Other transport equipment	4,406	3	342	72	4,823
Precision instruments	37	937	918	620	2,512
Miscellaneous manufacturing products	402	1,872	967	217	3,458
Reuse and recycling	49	5,258	1,648	818	7,773
Construction	10,281	35,844	12,001	4,567	62,694
Electricity	2,075	6,840	33,497	3,682	46,094
Gas and heat supply	372	3,922	1,523	279	6,096
Water supply and waste disposal business	1,861	12,964	7,069	1,114	23,008
Commerce	13,076	101,127	15,664	6,644	136,511
Finance and insurance	4,906	17,504	7,000	2,550	31,961
Real estate	1,855	16,190	5,463	3,961	27,470
House rent (imputed house rent)	15,680	76,893	12,657	5,780	111,010
Transport	5,734	67,691	8,581	5,118	87,124
Other information and communications	993	10,890	1,147	574	13,604
Information services	107	4,700	809	3,536	9,153
Public administration	13,280	47,437	17,249	4,769	82,735
Education and research	174	3,354	859	2,536	6,924
Medical service, health, social security and nursing care	5,035	55,763	14,821	5,659	81,278
Advertising services	22	889	125	17	1,052
Goods rental and leasing services	733	4,473	778	208	6,192
Other business services	2,715	11,268	5,865	2,295	22,143
Personal services	20,515	66,883	17,047	9,733	114,177
Others	705	1,427	395	194	2,721
TOTAL	127,494	648,404	217,295	112,161	1,105,355

Source: Nozaki, Ihara and Thitipongtrakul (2011), p. 30, Figure 1.

Table 4 Damaged Output by the Great East Japan Earthquake (Forward Linkage)

unit: million yen

Forward Linkage

Damaged Output (Backward Linkage)	Toyama	Ishikawa	Fukui	Nagano	Gifu	Shizuoka	Aichi	Mie	Shiga	Kanto	Kinki	Hokkaido	Tohoku	Chugoku	Shikoku	Kyushu	Okinawa	Total
Agriculture, forestry and fishery	38	53	25	206	100	196	244	86	27	2,524	337	1,680	31,039	250	295	920	31	38,050
Mining	9	4	4	24	18	12	11	8	2	92	18	37	1,449	14	11	28	3	1,743
Coal mining , crude petroleum and natural gas	0	0	0	0	0	0	0	0	0	51	0	12	124	0	0	0	0	188
Beverages and Foods	126	162	76	605	313	1,654	1,568	396	142	15,736	3,922	3,365	77,615	974	666	1,938	85	109,394
Textile products	18	70	100	6	59	48	185	18	52	269	222	3	222	66	28	36	0	1,402
Wearing apparel and other textile products	14	11	47	14	36	19	72	13	13	347	189	14	1,503	130	53	80	1	2,554
Timber, wooden products and furniture	71	69	32	78	133	191	345	59	40	1,505	458	271	11,822	217	122	190	2	15,606
Pulp, paper, paperboard, building paper	125	26	33	71	206	1,172	325	44	62	2,531	986	590	19,863	261	393	226	3	26,918
Printing, plate making and book binding	14	53	13	56	35	103	203	21	24	2,469	597	123	10,192	112	37	133	7	14,192
Chemical basic product	30	16	25	15	15	106	205	373	7	7,100	671	73	11,073	741	223	244	1	20,918
Synthetic resins	15	38	17	0	14	54	117	117	16	2,614	167	2	1,267	167	72	49	0	4,725
Final chemical products	37	29	44	21	36	262	300	95	69	4,293	1,035	41	4,189	158	50	121	1	10,801
Medicaments	63	21	28	43	76	179	118	74	56	1,533	466	20	4,489	77	74	58	0	7,377
Petroleum and coal products	18	2	1	11	4	10	77	748	2	3,930	106	493	9,112	214	36	136	4	14,904
Plastic products	124	39	176	207	316	473	1,059	233	325	4,748	953	88	9,410	415	194	260	3	19,021
Ceramic, stone and clay products	48	24	36	70	163	96	335	147	78	1,577	306	163	9,420	142	64	223	8	12,900
Iron and steel	78	29	10	48	95	178	1,485	56	27	11,048	2,938	491	17,158	3,595	83	1,020	8	38,344
Non-ferrous metals	524	32	148	164	160	520	451	458	172	4,997	533	37	14,575	392	133	222	1	23,518
Metal products	183	82	69	158	260	306	662	158	159	4,526	1,176	229	14,911	389	109	312	12	23,701
General machinery	305	742	78	696	373	765	1,643	447	465	10,912	3,103	105	29,135	1,254	299	939	0	51,280
Machinery for office and service industry	8	10	11	116	54	111	535	497	28	2,502	254	2	2,576	38	2	54	5	6,803
Electrical devices and parts	21	42	44	152	94	476	654	413	58	2,445	693	52	7,784	266	47	217	1	13,460
Other electrical machinery	7	12	73	347	54	405	100	71	48	3,063	747	23	4,079	82	213	188	0	9,511
Household electric appliances	1	1	12	79	69	373	126	6	327	779	519	3	3,437	56	5	26	0	5,820
Household electronics equipment	4	1	1	481	230	422	519	251	3	3,135	705	102	16,234	256	54	321	0	22,717
Electronic computing equipment and accessory equipment of electronic computing equipment	0	78	1	855	2	127	166	62	69	1,067	218	1	5,658	207	22	31	0	8,564
Electronic components	181	124	201	1,161	200	180	629	1,271	181	5,215	1,153	142	17,779	810	242	1,112	0	30,582
Passenger motor cars	2	0	0	0	5	761	3,227	746	148	5,677	303	0	1,861	1,281	0	1,648	0	15,659
Other cars	0	0	2	0	85	422	274	39	1	3,886	189	3	12	150	3	179	0	5,245
Motor vehicle parts and accessories	150	78	70	371	503	2,636	7,283	983	296	12,034	842	161	9,389	1,569	8	834	0	37,207
Other transport equipment	2	31	1	28	115	161	1,394	71	37	2,046	639	47	5,824	456	255	323	10	11,440
Precision instruments	4	5	53	244	16	158	107	6	32	1,668	240	9	4,702	68	14	91	0	7,415
Miscellaneous manufacturing products	71	36	18	59	93	399	582	150	102	2,704	685	44	7,798	187	43	243	1	13,215
Reuse and recycling	6	0	3	10	5	26	64	17	4	404	59	38	8,161	48	6	22	1	8,875
Construction	377	357	358	648	465	1,136	2,010	631	324	22,112	3,752	2,341	93,227	1,414	714	1,967	149	131,982
Electricity	28	33	64	324	29	242	211	123	2	2,703	218	228	61,955	139	55	196	12	66,560
Gas and heat supply	3	1	1	25	4	34	60	19	2	1,036	110	42	6,848	12	2	33	1	8,232
Water supply and waste disposal business	19	35	15	73	26	123	120	24	16	1,806	208	104	27,842	74	30	111	9	30,636
Commerce	132	132	80	369	205	687	1,540	116	70	14,311	2,269	881	166,637	560	249	801	42	189,080
Finance and insurance	57	49	29	96	72	228	327	58	39	3,924	712	280	45,574	216	120	292	18	52,092
Real estate	7	9	4	61	10	70	98	6	13	1,616	222	98	30,679	48	21	86	9	33,057
House rent (imputed house rent)	18	8	8	43	18	62	121	26	18	1,275	249	76	115,832	60	27	83	5	117,931
Transport	122	64	69	268	216	669	1,575	198	79	9,742	1,274	887	100,457	513	173	623	105	117,073
Other information and communications	19	65	14	64	34	132	169	33	17	7,099	813	263	21,447	145	91	263	22	30,690
Information services	25	39	11	76	24	71	290	30	6	3,692	199	56	10,536	40	14	49	4	15,161
Public administration	37	93	26	144	98	223	199	83	39	4,461	579	807	98,406	322	144	647	86	106,395
Education and research	53	31	26	230	78	420	475	39	70	4,772	609	181	17,164	233	94	264	12	24,751
Medical service, health, social security and nursing care	50	149	74	361	188	389	766	154	79	6,130	1,870	1,475	107,663	841	530	1,567	106	122,390
Advertising services	5	9	3	26	6	55	118	4	1	2,514	274	56	3,253	41	14	72	4	6,455
Goods rental and leasing services	9	11	4	26	14	36	81	8	3	1,252	195	54	8,561	42	17	72	5	10,390
Other business services	117	111	64	287	116	317	848	142	54	9,512	1,660	612	31,240	531	216	895	53	46,774
Personal services	144	190	87	787	276	939	1,338	247	138	15,139	2,863	1,626	138,274	665	395	1,231	122	164,512
Others	47	40	21	89	72	190	263	75	27	2,208	608	219	11,074	162	74	210	14	15,393
TOTAL	3,561	3,344	2,408	10,410	5,888	19,067	35,674	10,150	4,069	244,731	44,109	18,749	1,470,536	21,102	6,836	21,989	963	1,923,607

Table 5 Damaged Output by the Great East Japan Earthquake (Backward Linkage)

unit: million yen

Backward Linkage

Damaged Output (Backward Linkage)	Toyama	Ishikawa	Fukui	Nagano	Gifu	Shizuoka	Aichi	Mie	Shiga	Kanto	Kinki	Hokkaido	Tohoku	Chugoku	Shikoku	Kyushu	Okinawa	Total
Agriculture, forestry and fishery	67	34	11	87	61	162	357	159	40	3,859	450	2,504	21,792	512	819	1,689	51	32,654
Mining	45	1	22	18	104	49	132	26	7	1,205	277	157	4,668	433	385	329	0	7,856
Coal mining , crude petroleum and natural gas	57	15	8	0	8	9	421	0	9	10,943	906	1,813	20,531	1,332	351	268	17	36,689
Beverages and Foods	106	22	5	174	122	706	506	234	204	8,131	1,419	1,462	15,079	420	279	1,044	21	29,934
Textile products	44	123	206	29	197	74	456	69	237	519	444	11	170	173	79	53	0	2,884
Wearing apparel and other textile products	22	16	31	9	100	22	130	11	33	1,178	415	121	540	273	55	132	0	3,089
Timber, wooden products and furniture	300	35	16	34	470	173	285	81	404	2,550	549	392	5,405	429	329	331	0	11,782
Pulp, paper, paperboard, building paper	216	33	43	80	666	1,361	406	146	600	3,920	1,380	965	9,519	511	1,089	269	1	21,203
Printing, plate making and book binding	36	50	8	92	33	194	294	25	64	4,272	591	98	6,124	140	53	167	2	12,243
Chemical basic product	102	16	52	35	42	213	668	825	46	9,909	1,920	161	3,689	1,838	543	643	1	20,703
Synthetic resins	70	27	61	36	29	162	138	428	51	2,492	413	13	259	523	168	174	0	5,043
Final chemical products	141	29	49	50	62	871	423	152	223	4,061	1,440	129	823	475	154	446	1	9,530
Medicaments	12	0	1	2	3	14	7	5	4	104	15	3	8,482	3	4	4	0	8,662
Petroleum and coal products	71	4	6	95	9	26	347	1,584	26	18,247	1,122	3,970	7,163	1,783	478	287	22	35,239
Plastic products	801	45	82	109	464	1,060	906	221	616	6,213	1,415	147	3,933	555	236	365	1	17,189
Ceramic, stone and clay products	31	6	72	169	166	93	796	158	136	1,831	508	335	4,631	281	97	452	1	9,762
Iron and steel	444	41	8	529	203	153	3,157	53	59	12,821	5,493	1,025	6,455	5,297	190	2,435	2	38,364
Non-ferrous metals	876	49	221	160	213	466	996	946	192	5,215	849	81	3,623	673	542	346	0	15,449
Metal products	470	73	90	137	1,350	441	967	187	468	5,892	2,004	510	4,760	546	279	426	1	18,601
General machinery	174	177	13	182	138	268	865	249	251	4,228	2,037	155	1,446	660	277	570	0	11,691
Machinery for office and service industry	2	2	1	6	43	21	228	13	45	530	54	1	186	7	1	10	0	1,150
Electrical devices and parts	6	16	27	36	62	408	289	325	48	927	360	24	477	91	35	132	0	3,264
Other electrical machinery	2	5	30	52	15	251	48	17	44	663	329	8	340	47	56	89	0	2,017
Household electric appliances	0	1	7	3	28	142	65	1	122	138	132	21	55	10	3	6	0	733
Household electronics equipment	5	0	0	21	7	37	163	16	3	402	58	22	277	41	10	23	0	1,084
Electronic computing equipment and accessory equipment of electronic computing equipment	1	1	0	8	0	3	6	0	9	57	12	1	31	6	0	1	0	138
Electronic components	412	70	194	806	99	185	925	476	410	4,706	1,056	90	5,846	602	311	482	0	16,668
Passenger motor cars	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cars	0	0	0	0	0	1	10	0	0	90	1	0	2	14	0	0	0	119
Motor vehicle parts and accessories	27	42	14	69	976	464	4,122	231	88	3,886	300	48	2,293	786	4	199	0	13,549
Other transport equipment	3	119	1	6	72	310	903	9	22	2,937	860	53	2,098	243	27	232	3	7,897
Precision instruments	1	1	4	24	8	69	68	5	98	592	126	44	365	70	39	112	0	1,625
Miscellaneous manufacturing products	215	22	21	39	94	525	738	206	238	3,320	970	97	2,823	332	75	434	0	10,149
Reuse and recycling	6	1	4	9	16	35	81	23	10	746	73	49	249	183	15	46	0	1,547
Construction	39	17	16	68	41	140	188	61	35	2,158	448	133	14,232	106	48	112	2	17,844
Electricity	101	103	239	267	122	561	492	166	3	4,311	654	476	26,841	500	219	324	7	35,386
Gas and heat supply	7	2	2	24	9	39	157	22	6	702	311	11	1,349	21	6	12	0	2,681
Water supply and waste disposal business	23	14	8	26	20	73	96	33	18	957	195	77	12,973	87	34	59	2	14,695
Commerce	361	429	216	1,073	588	1,587	3,979	397	235	31,698	7,036	2,378	18,865	1,788	952	2,279	65	73,926
Finance and insurance	111	127	67	395	186	768	792	175	106	10,945	1,844	838	46,727	534	430	590	26	64,662
Real estate	16	22	8	174	27	161	208	42	30	3,084	475	502	11,881	113	56	162	10	16,972
House rent (imputed house rent)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transport	228	85	139	349	476	982	1,820	332	294	17,000	2,663	2,396	21,754	1,487	680	1,653	241	52,590
Other information and communications	27	107	33	258	71	505	319	69	47	15,153	1,065	637	19,380	246	138	283	19	38,357
Information services	22	41	9	292	25	219	326	28	7	13,069	272	61	3,100	38	16	47	2	17,575
Public administration	6	6	2	15	9	29	23	12	5	362	69	37	2,925	22	13	30	1	3,565
Education and research	98	15	26	151	114	308	609	102	124	4,829	939	264	12,601	372	149	285	2	20,989
Medical service, health, social security and nursing care	9	4	2	9	8	18	30	11	5	313	50	50	3,853	27	10	28	1	4,429
Advertising services	16	19	7	271	19	272	322	12	3	11,381	623	479	4,488	94	34	125	6	18,171
Goods rental and leasing services	33	65	13	310	62	306	340	37	11	9,428	662	290	11,894	145	62	277	20	23,956
Other business services	88	118	73	674	162	907	1,111	136	96	18,348	2,409	1,296	49,838	522	206	555	17	76,554
Personal services	4	3	2	13	4	22	23	4	2	796	55	54	3,527	12	5	20	5	4,553
Others	27	20	13	81	45	210	161	46	24	1,681	325	178	11,170	119	70	131	4	14,306
TOTAL	5,979	2,272	2,182	7,557	7,848	16,108	30,899	8,567	5,859	272,821	48,072	24,666	421,533	25,524	10,112	19,167	555	909,719

Forward linkage occurs when the products of one industry is used as the raw material of another industry. It can involve an industry in primary production linking with an industry in secondary production. Forward linkage is when one industry is producing the raw material for another industry.

In Table 4, Damaged output by the Great East Japan Earthquake of the forward linkage will be estimated about 1.924 trillion yen.

And Backward Linkage is the relationship between a firm or industry and the suppliers of its inputs, or raw materials. An increase in the output of the firm or industry is transmitted backward, yielding an increase in the demand for inputs. Development planners usually prefer to target industries with significant backward linkages, so that investments have additional multiplier effects in generating benefits for other sectors and in helping to further growth in input industries.

In Table 6, Damaged output by the Great East Japan Earthquake of the backward linkage will be estimated about 0.910 trillion yen.

IV. Concluding Remarks

As we analyzed in this paper, we reconsidered the traditional Leontief demand-driven model compared with the Ghosh supply-driven model in the line of the total economic impact stemmed from the East Japan Great Earthquake.

As to the supply-driven Input-Output model, Oosterhaven (1988) pointed out that in the impact studies straightforward use of the model was criticized and more careful estimation procedures were suggested.

Oosterhaven (1996; 2012) compares the theoretical structure of the demand-driven model and the supply-driven model. He also presents the evaluation of conclusion that the demand-driven model may not be entirely plausible, but the supply-driven model is much less plausible.

Dietzenbacher (1997) showed that the supply-driven input-output model became plausible, once it was interpreted as a dual price model of the Leontief model.

Miller and Blair (2009) introduced the reconsideration of the Ghoshian model as a price model and the analytical tool of the linkage analysis.

We think that it is true about what Oosterhaven (1996, 2012) and Dietzenbacher (1997) explained when the market economy works normally. And the simple Ghosh quantity model will be applicable when the market economy does not work, and the supply chain are cut off within the interregional trade, for instance, the supply-constrain economy as after the natural disasters.

At last, but not least, it should be pointed out that we still have several problems unsolved in the line of theoretical and empirical issues.

Firstly, in this paper, we analyzed the economic impact stemmed from the East Japan Great Earthquake by the Ghosh model, but we also have to look for more plausible economic model to estimate the interregional economic damage within the *interregional* Input-Output framework.

Secondly, we have to estimate the interregional economic repercussion effects of the economic recovery of the damaged area of the Great East Japan Earthquake.

Thirdly, we also have to look for more plausible economic model depending on the change of the object of the analysis.

References

Ashiya, T. and Jinushi, T. (1999), "Estimating an Input-Output table for the economic impact study of the Great Hanshin Awaji Earthquake," *Business Journal of PAPAIOS*, 8(4) : 6–14.

Ashiya, T. and Jinushi, T. (2001) ,"The Great Earthquake and Structural change of Industrial Classification", *The Kokumin Keizaigaku Zasshi*, 183(1) : 79–97.

Bon, R. (1988), "Supply-Side Multiregional Input-Output Models," *Journal of Regional Science*, Vol.28, No.1, pp.41–50

Boscoianu, M. (2008), "Emerging Research Directions for Modeling the Impact, Short Time Recuperation and Long Term Recovery in the Case of Natural Hazards," *Environmental Problems and Development*, 2008, pp.174–179.

Cabinet Office Government of Japan, (2011), "On the estimates of the damaged stock of the Great east Japan Earthquake," Cabinet Office Government of Japan (Disaster prevention), June 24, 2011.

Chubu Region Institute for Social and Economic Research, (2011) "Interregional Input-Output Table for the Central Part of Japan, the year 2005", Chubu Region Institute for Social and Economic Research

Cochrane, Halord C., (2004) "Indirect Losses from Natural Disasters: Measurement and Myth," in chapter 3 of Yasuhide Okuyama and Stephanie E. Chang (edited), *Modeling the Spatial and Economic Effencts of Disasters*, New York, Springer.

Dietzenbacher, E. (1997), "In vindication of the Ghosh Model: a Reinterpretation as a Price Model", *Journal of Regional Science*, 37(4): 629–651.

Hosoe, N. (2011), "An Input-Output Analysis of Impact of Voluntary Self-restraint on the Recreation Industries," *GRIPS Discussion Paper* 11–04.

Inada,Y., Irie, H., Shima, A. and Toizumi,T. (2011), "Macroeconomic Impact of the damage by the Great east Japan earthquake: the complex damage of earthquake, Tsunami, and nuclear power generation", (in Japanese), *KISER REPORT*.

Ishikawa, Y. (2005) "Analysis of the Spatial Impacts of the Niigata Chuetsu Earthquake," *Doboku Keikakugaku Kenkyu Ronbunshu*, 31.

Katada, T., Ishikawa, Y., Kimura, S. and Satou, T. (2004), "A Study on the structure of damage to establishments by the heavy rainfall disaster in Tokai region", *Doboku Keikakugaku Kenkyu Ronbunshu*, 29.

Miller, Ronald E., and Peter D. Blair (2009), *Input-Output Analysis: Foundations and Extensions*, Second edition, Cambridge University Press.

Ministry of Economy, Trade and Industry (2005), *An Inter-regional Input-Output Table in Japan.*

Miyazawa, K., (1976), *Input-Output Analysis and the Structure of Income Distribution*, Springer-Verlag.

Nozaki, M., Ihara, T. and Thitipongtrakul, N. (2011), "How to Grasp the Economic Impact of the Great East Japan Earthquake: An Influence for Chubu Region" (in Japanese), *Business Journal of PAPAIOS Input-Output Analysis – Innovation & I-O Technique–*, Vol.19, No.3.

Okuyama, Y. (2003) "Economics of natural Disasters: A Critical Review", *Research Paper 2003–12, paper presented at the 50th North American Meeting*, Regional Science Association International, November 20–22, 2003, Philadelphia, PA.

Okuyama,Y., Sonis, M. and Hewings, G.J.D. (1999), "Economic Impacts of an Unscheduled, Disruptive Event: A Miyazawa Multiplier Analysis", in *Understanding and Interpreting Economic Structure*, G.J.D. Hewings, M.Sonis, M.Madden and Y.Kimura (edited), Springer-Verlag.

Okuyama, Y., Sonis, M. and Hewings, G.J.D. (2004) "Measuring Economic Impacts of Disasters: Interregional Input-Output Analysis Using Sequential Interindustry Model", in chapter 5 of Yasuhide Okuyama and Stephanie E. Chang (edited), *Modeling the Spatial and Economic Effencts of Disasters*, New York, Springer.

Oosterhaven, J. (1988), "On the plausibility of the supply-driven Input-Output model," *Journal of Regional Science*, 28(2) : 203–217.

Oosterhaven, J. (1996), "Leontief versus Ghoshian Price and Quantity Models," *Southern Economic Journal,* 62(3): 750–759.

Oosterhaven, J.(2012), "Adding Supply-Driven Consumption makes the Ghosh Model even more implausible, " *Economic Systems Research*, 24(1) : 101–111.

Shuntaro Shishido (supervised), PAPAIOS (edited), (2010), *Handbook of Input-Output Analysis*, Toyo keizai shinpousha.

Suzuki, M., (2011), "The data source of the private capital stock, housing capital stock, and social infrastructure", CRISER.

Yamano, N., Kajitani, Y. and Shumuta, Y. (2004), "Modeling the Regional Economic Loss of Natural Disasters: Indirect Loss Diffusion due to the Electricity Disruptions and Interindustry Economic Activities," *Regional Economic Applications Laboratory Discussion Paper*, 2004, University of Illinois.