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Developing the Estimation Method of the Economic Impacts of 2002 Typhoon Rusa Disruption

2002년도 태풍 루사 피해의 경제적 영향에 대한 추정기법 연구

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요 지

본 연구의 목적은 자연재해나 인위재해로 인한 시설물 피해가 초래하는 경제적 영향을 분석할 수 있는 재해영향평가모형을 개발하고, 2002년도에 발생한 태풍 루사를 연구사례로 하여 본 연구에서 개발한 평가모형의 적용가능성을 살펴보는 것이다. 본 연구에서는 태풍 루사로 인한 시설물 피해가 초래하는 경제적 영향을 평가하기 위해서 경제분석모형인 다지역 투입산출모형(MRIO model)을 적용하여 서울시, 인천시, 경기도와 수도권외지역의 수해피해 영향을 분석하였다. 본 연구방법을 적용하여 지역별·산업별 경제피해영향을 분석한 결과 직간접 수해피해는 총 15조 4천 5백 2십 4억원이고, 고용손실영향은 총 265,476인으로 나타났으며 수도권외지역의 비중이 각각 88.8%와 88.1%를 차지하여 지방경제의 피해가 상당한 것으로 나타났다. 또한 복구비를 투자하였을 경우 총 21조 6천 9백 5십 7억원의 경제파급효과와 412,110인의 고용창출효과가 발생하고, 특히 수도권외지역에서 투자파급효과의 89.3%와 고용창출효과의 89.5%를 차지하여 지방경제 활성화에 크게 기여하는 것으로 분석되었다.

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1. Introduction

Natural and man-made disasters including typhoons, earthquakes, floods, volcanoes, fires, and massive collapses can disrupt all sectors of a national economy and all parts of population and employment for an extended period of time. Then, most discussions of the disaster event costs refer only to damage estimates, not to the total costs of the events that include all parts of costs affected from the events. Thus, the discussions reflect a serious underestimate of the total costs from the disasters by considering direct losses of life and property. Even when disasters have very little direct damage, people and business may be affected indirectly through damage to facilities such as water supply stop or transportation disruption, or through the loss of livelihood or markets. Private businesses are affected by and attempt to recover from disaster events. However, this issue has seldom been addressed empirically in the field of disaster management. Previous studies on the business impacts of disasters have generally been based on data from limited data collection, and purposive samples rather than system-wide impacts. Consequently, the underestimation of disaster impacts can be linked to deficient recovery programs or misguided governmental policies, poverty and inappropriate development of affected areas, and failure of community security and governmental responsibility.

The objectives of this research are: (1) to develop an efficient disaster-impact evaluation procedure for estimating direct and indirect system-wide impacts of natural and man-made disasters, and (2) to evaluate the applicability of the procedure to an empirical case of such events. To do this, this research provides an evaluation procedure accounting for direct and indirect economic impacts, and applies an open system multi-regional input-output(I-O) model to the empirical case of Typhoon Rusa occurred in 2002. Input data sets for the model are obtained from the 「Development of Regional Input- Output Analysis Model(I)」 research report published by the Korea Research Institute for Human Settlements in 2001. Four study regions including Seoul metropolitan city, Incheon City, Gyeonggi Province, and remaining areas of Korea are considered.

2. The Disaster-Impact Evaluation Procedure and the Study model

2.1 The Disaster-Impact Evaluation Procedure

Many disaster management planners and engineers do not have sufficient system data sets for disaster impact analyses given occurrence of natural and man-made disasters. This section describes the framework for the general disaster-impact evaluation(DIE) procedure that is used for direct and indirect disaster-impact analyses. This description shows the various models of the procedure, the form of input data sets, and the relationship among the models used to perform the disaster-impact evaluation.

The general DIE procedure consists of six modules: (1) the hazard analysis module, (2) the vulnerability analysis module, (3) the scenario development module, (4) system-wide facility impact module, (5) the economic impact evaluation module, and (6) the social and mental impact evaluation module. Each module includes different input data sets and analysis models that are linked together to carry out the general DIE procedure. The detailed features of th general DIE procedure are shown in Figure 1.

2.2 The Study Model

An important feature of the disaster impact evaluation procedure is the use of estimation method of economic losses from natural and man-made disaster disruption. This methodological approach can be applied to estimating losses of system-wide disruption to facility damage as well as lifeline systems including

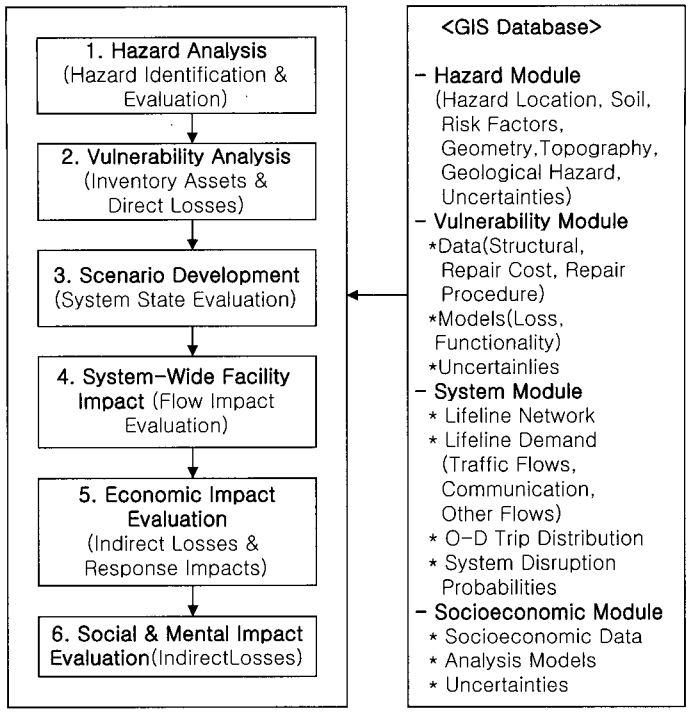

Fig. 1 General Disaster-Impact Evaluation Procedure

product losses, building collapses, transportation network collapse, natural gas lines, electric power systems, and/or water system damage. It provides good approximate solutions to system-wide disruption impacts such as natural and man-made disaster events.

The estimation methods of economic losses can be categorized into four groups: (1) economic base models, (2) shift-share models, (3) input-output (I-O) models and following spatial interaction models, and (4) computerized general equilibrium (CGE) models. The theoretical structure of these models is well-defined in the field of urban economics. The models are widely used in estimating economic impacts of land development projects, massive facility construction, or product changes from changes of economic structure.

In the field of disaster management, Cochrane (1975, 1990) and Rose(1980) were first interested in measuring the economic impacts of earthquakes. Following them, Durkin(1984), Ellson, et. al.(1984), Bay Area Council(1989) Cheung(1990), Kroll, et. al.(1991), Brookshire and McKee(1991), Boisvert(1991), ATC(1991), Mitsusishi(1995), Romero and Adams(1995), Tierney and Dahlhamer (1997) investigated impact of disruption and the amount of indirect losses from disaster events.

Among the various economic estimation methods, the I-O models are considered as the leading techniques in this field. Gordon and Richardson(1992, 1995) introduced the Southern California Planning Model(SCPM) with the cases of Newport-Inglewood Scenario earthquake and 1994 Northridge earthquake. Cole, et. al.(1993) developed the societal and economic impact program including identification, quantification, and analysis of natural disaster impacts. Chang, et. al.(1996) applied the ATC-25 model to lifeline systems including water delivery, crude oil transmission, gas pipelines, electric-power, and telecommunication systems. Werner and Taylor (1995), and Kim(1997) introduced general procedures for system-wide impact analyses of

disasters.

The key goal of this research is to estimate the economic losses by economic sector to quantify the direct and indirect output and employment impacts of business interruption by geographical regions. to do this, this research applies the multi-regional input-output (MRIO) model obtained from the 「Development of Regional Input-Output Analysis Model(I)」 research report published by the Korea Research Institute for Human Settlements in 2001. The theoretical structure of the MRIO model is as follows:

$$X = (I-A)^{-1} \times D \quad (1)$$

$$V = P \cdot A_v \quad (2)$$

$$E = V \cdot L_v \quad (3)$$

X = amount of economic impacts
V = value change
E = employment change
A = technical coefficients
D = amount of demand change by industry
Av = input coefficient for value
Lv = employee per 1million won

This MRIO model is based on the 1998 updated input-output tables of the Bank of Korea. Four study regions including Seoul metropolitan city, Incheon City, Gyeonggi Province, and remaining areas of Korea are considered.

3. Analyses and Results

3.1 Disaster-Damage Impact Analysis

The Typhoon Rusa struck the eastern part of Korea on August 31st and September 1st of year 2002 with the 246 casualties, property damage of 5,147.9billion Won, and the total recovery cost of 7,177,8billion Won. The Korean government announced the first presidential disaster declaration due to this massive Typhoon damage. Figure 2 shows the total typhoon and flood damage during the last ten years. This information was obtained by the workshop document from the Flood Damage Mitigation Planning Team of the Office of the Prime Minister.

However, this damage does not include indirect losses from the typhoon and heavy rain events. This research investigates the total economic losses of all sectors of physical damage caused by Typhoon Rusa. Table 1 presents the facility damage of Typhoon Rusa by industry type. The total physical damage of farming/fishing and construction is 436.8billion won and 5,667billion won, respectively. The regional, industrial damage is assumed to be proportional by the total amount of regional damage.

The analysis results show that the total economic losses are 15trillion 452.4billion Won

Table 1. Facility Damage of Typhoon Rusa by Industry Type

Type	Money(100Mil. Won)	Industry	Assumption
Housing Damage	1,158	Construction	
Agricultural Loss	4,368	Farming/Fishing	Agricultural Loss
Roads/Bridges	8,291	Construction	
Rivers	11,751	Construction	
Streams	5,925	Construction	
Water Management	5,057	Construction	
Landslide Manage.	2,089	Construction	
Small Facilities	5,104	Construction	
Others	17,295	Construction	Public/Private Damage
Total	61,038	-	

Source: the Flood Damage Mitigation Planning Team of the Office of the Prime Minister.

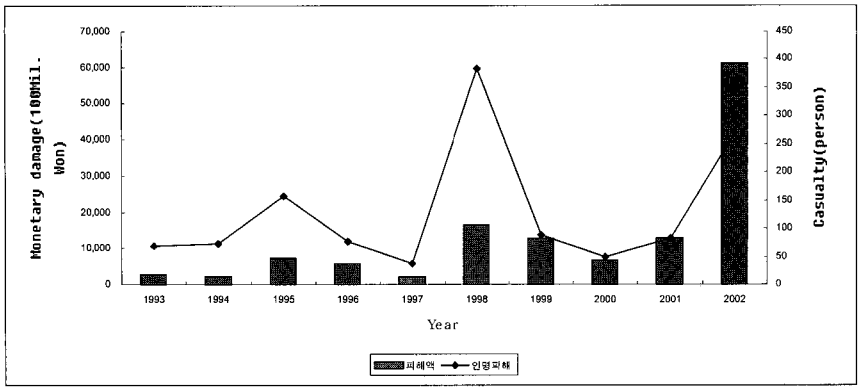

Fig. 2 Total Typhoon and Flood Damage During 1993 to 2002

Table 2. Economic Loss and Employment Loss by Region

Region	Total Economic Impact (in 100Mil. Won)	Employment Impact (in person)
Seoul	7,071	15,162
Incheon	1,136	2,158
Gyeonggi	9,159	14,188
Non Seoul M.	137,158	233,968
Total	154,524	265,476

Table 3. Economic and Employment Loss by Region & Industry(Unit: 100mil.Won, person)

Industry	Economic Loss				Employment Loss			
	Seoul	Incheon	Gyeonggi	Outside	Seoul	Incheon	Gyeonggi	Outside
Farming/Fishing	7	2	143	7,340	7	2	117	4,815
Mining	0	73	295	4,215	0	116	442	9,783
Food	1	9	136	1,041	4	17	194	1,410
Cloth/Leather	25	1	56	354	112	3	115	955
Wood/Paper	3	105	1,221	2,914	15	268	2,177	4,928
Publishment	252	0	13	19	731	0	31	74
Oil/Coal	0	75	0	3,120	0	100	0	5,940
Chemistry	1	29	874	10,207	5	43	948	12,432
Non-Metal	1	8	929	8,833	5	16	1,433	17,525
First Metal	0	438	109	17,543	0	676	175	24,472
Metal	1	51	462	4,623	6	134	1,018	10,263
Machinery	1	99	339	3,982	5	261	736	8,378
Electric Machinery	15	8	2,407	2,628	46	20	3,062	4,604
Precision Machinery	3	10	75	231	16	42	166	596
Transport Facility	0	32	58	1,083	0	51	107	2,027
Punishment	3	48	72	90	15	134	168	286
Power, Gas & Water	5	42	205	2,625	10	39	216	3,000
Construction	169	26	1,346	56,025	529	42	1,883	92,161

Table 3. Economic and Employment Loss by Region & Industry(Unit: 100mil.Won, person) (계속)

Industry	Economic Loss				Employment Loss			
	Seoul	Incheon	Gyeonggi	Outside	Seoul	Incheon	Gyeonggi	Outside
Whole and Retail	1,169	10	82	2,360	3,866	45	387	10,660
Hotel & Restaurant	0	0	0	0	0	0	0	0
Truck & Warehouse	346	34	15	2,395	942	74	62	6,308
Communication	312	10	12	420	391	10	18	646
Finance & Insurance	1,797	8	75	1,421	2,769	21	184	4,183
Real Estate	2,651	13	175	2,606	4,411	21	287	4,243
Public Service	0	0	0	0	0	0	0	0
Other Social Service	309	5	60	1,083	1,277	23	262	4,279
Total	7,071	1,136	9,159	137,158	15,162	2,158	14,188	233,968

Table 4. Recovery Investments by Industry

ID	Industry	Investment(in Million Won)
1	Farming/Fishing	635,071
2	Construction	6,326,081
3	Machinery	317,975
4	Public Service	1,268,109
5	Social Services	491,750

Source : the Flood Damage Mitigation Planning Team of the Office of the Prime Minister.

Table 5. Economic Gain and Employment Opportunity By Region

Region	Economic Gain(in Million Won)	Employment Opportunity(in Person)
Seoul	952,400	20,599
Incheon	153,100	2,933
Gyeonggi	1,222,700	19,929
Outside	19,367,500	368,689
Total	21,695,700	412,110

and 265.5thousand persons of employment loss. These outcomes are computed by the MRIO model introduced by this research. Among the total economic losses, the outside Seoul metropolitan region occupies 88.8% of economic loss and 88.1% of employment loss, resulting in heavy damage to the local economy. Tables 2 and 3 show the results of economic loss and employment loss.

2.3 Disaster-Recovery Impact Analysis

This research also analyzes the total economic gains of all sectors by the recovery investment of 7,177.8 billion Won. Table 4 presents the recovery investments by industry. Tables 5 and 6 the results of economic gain and employment opportunity by the investments. These outcomes are computed by the MRIO model introduced by this research. The analysis results show that the total economic gains are 21trillion 695.7billion won and 412.1thousand persons of employment opportunity. Among the total economic gains, the outside Seoul metropolitan region occupies 89.3% of economic gains and 89.5% of employment opportunity.

Table 6. Economic and Employment Gain by Region & Industry(Unit: 100mil.Won, person)

구 분	Economic Gain				Employment Gain			
	Seoul	Incheon	Gyeonggi	Outside	Seoul	Incheon	Gyeonggi	Outside
Farming/Fishing	11	3	203	10,463	11	2	166	6,864
Mining	0	98	360	5,584	0	156	540	12,960
Food	1	12	194	1,502	4	23	277	2,034
Cloth/Leather	37	1	78	541	166	3	160	1,459
Wood/Paper	5	131	1,494	3,524	25	334	2,664	5,959
Publishment	374	0	19	34	1,085	0	46	133
Oil/Coal	0	102	0	4,374	0	136	0	8,328
Chemistry	2	40	1,170	14,543	10	59	1,269	17,713
Non-Metal	1	10	1,095	10,225	5	20	1,688	20,286
First Metal	0	575	141	22,586	0	887	227	31,507
Metal	1	65	570	5,585	6	171	1,256	12,399
Machinery	7	152	581	9,546	38	400	1,262	20,085
Electric Machinery	20	11	3,231	3,510	61	28	4,110	6,150
Precision Machinery	4	15	122	419	21	64	270	1,081
Transport Facility	0	51	90	2,306	0	81	166	4,317
Punishment	5	63	96	120	25	176	224	381
Power, Gas & Water	6	57	269	3,818	12	54	283	4,364
Construction	206	30	1,564	63,854	645	48	2,188	105,040
Whole and Retail	1,542	14	107	309	5,099	63	505	13,958
Hotal & Restaurant	0	0	0	0	0	0	0	0
Tuck & Warehouse	466	46	20	3,251	1,268	100	83	8,563
Communication	447	14	17	656	560	14	26	1,009
Finance &	2,351	11	95	1,838	3,623	29	283	5,411
Real Estate	3,553	17	230	3,490	5,912	27	377	5,682
Public Service	21	4	286	12,369	66	16	1,059	47,534
Other Social Service	464	9	195	6,447	1,917	42	850	25,472
Total	9,524	1,531	12,227	193,675	20,559	2,933	19,929	368,689

4. Conclusions

This research developed the disaster-impact evaluation(DIE) procedure for estimating direct and indirect system-wide impacts of natural and man-made disasters, and evaluated the applicability of the procedure to the case of Typhoon Rusa. Further research is recommended to modeling system-wide facility impacts and other social impacts including human casualties or mental damage, hazard analysis, and vulnerability analysis. Other cases studies are also recommended.

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