Economic Impacts of Kobe Earthquake: A Quantitative Evaluation after 13 Years

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ABSTRACT

The importance of distinguishing between direct and indirect losses of disasters is stressed. In order to estimate indirect losses, a conceptual framework of direct and indirect losses is presented. For the case of the Great Hanshin-Awaji (Kobe) Earthquake of 1995, direct stock losses of both the manufacturing and the commercial sectors record almost same size of big damage. As for indirect flow losses, the commercial and the other services sectors show far greater damage than the manufacturing sector. A careful statistical analysis of indirect losses using the gross regional product in the stricken area presents a new finding that the lost product and income in terms of estimated indirect losses are quite large and continue to arise for longer than 10 years, mounting to some 14 trillion yen (about US$0.13 trillion). Disaster management policy should be improved by paying attention not only to direct losses but also to indirect losses.

Keywords

Economic impacts of disasters, Hanshin-Awaji (Kobe) earthquake, direct and indirect losses, disaster management and policy

INTRODUCTION

Since a big earthquake struck the south-eastern area in Hyogo Prefecture on January 17, 1995, 13 years have passed. The earthquake, which is called the Great Hanshin-Awaji or Kobe Earthquake, affected one of the most clustered areas in terms of population, industries, and physical stocks including buildings. In addition to huge human causalities, the economic impact was also so great that we have few historical records of economic losses which exceed the Kobe's case in the world. Reflecting the reconstruction period of past some 10 years, I report here my new findings about the facts and policy implications, hoping to contribute to reduce or mitigate damage to be caused by future possible big hazards.

First, I will stress the importance of distinguishing between direct and indirect losses of disasters. In order to estimate indirect losses, a conceptual framework of direct and indirect losses will be presented. Following a conceptual discussion, I will review my former study that was based on a set of questionnaires of some 1,200 business enterprises, focusing upon the estimated results and some natures of direct stock losses.

My main research in this paper will be described in page 7 and afterwards. Based on actual macroeconomic data including the gross regional product (GRP) in the stricken area, I get a new striking finding that the lost product and income in terms of estimated indirect losses are quite large and continue to arise for prolonged years. This may be a very surprising fact beyond the common sense among the related people. But, I will show that it is true. I first derive a without-disaster line for the damaged region, taking both the regional economic trend the country-wide business fluctuations into consideration. Subtracting the actual GRP from the potential product predicted by the without-disaster line, we get estimates of indirect losses.

In the last part of the paper, some implications from my findings will be deducted. The implications will be related to desirable disaster management and policy for Japan but they are applicable to any other countries.

Conceptual Issues of Economic Losses

Let us first make clear about the related concepts on our research[1]. In the following we do not use the word of 'hazard' but only of 'disaster'. A hazard is a perceived natural or human-induced event which threatens both life and property, while a disaster is its consequence. Researchers on hazards should involve the mechanism and prediction of occurrence of these events. However, not all hazards necessarily lead to disaster. Therefore, it is natural for many researchers to have become more interested in research on disaster losses due to vulnerable built and socioeconomic environments. It has been becoming to be well recognized that research on disasters should incorporate the socioeconomic impacts, and reconstruction and/or recovery process from them. This is an area that both engineers and social scientists (should or can) work together.

There has been some confusion and different understandings on the definition of economic valuation of disaster losses between engineers and economists. Engineers usually define direct economic loss as an economic amount of directly damaged both physical assets and flow values (e.g., Rose, et al. (1997)). That is, direct economic loss is not only damaged capital and inventory of physical stock but also some flow damage is included. On the other hand, economists are always very sensitive to differing meanings of stock and flow because their economic functions are completely different. Stocks refer to an existing level of capital (machines, equipments, etc.), facilities (buildings, roads, bridges, etc.) and inventories of products, whereas flows refer to outputs and services of stocks over time. Stocks play an important role of inputs together with labor to produce output flows through a production process (Economists call this as a production function). Also, usual economic activities are concerned with production, distribution and consumption of flows, not stocks. Therefore, flow measures are more consistent with indices of individual wellbeing, such as business profits and household incomes, and aggregately measured by gross regional product (GRP).

In the following, from an economics point of view, I distinguish between direct and indirect losses as stock input loss and flow output loss. Conceptually, I do not consider mixture of flow and stock as direct damage[2].

Until 1990's most researchers focused on estimating direct losses and there were few records on indirect losses. Measuring indirect losses is not easy because, first, the concept is time-dependent and the timing of complete recovery is not clear, and secondly, some possible gains from reconstruction activities also should be taken into consideration. Nevertheless, we have observed many occurrences of big natural and human-induced disasters in the last two decades including the1995 Kobe earthquake in Japan and the 2003 Hurricane Katrina and the 2001 terrorist attack in New York City in the U.S. All these incidents taught us that indirect losses caused by big disasters, particularly if they affect mega or big cities, are quite large. Conventionally it is often told that "indirect damage is almost equivalent to direct damage." People now agree that in every stage of disaster mitigation cycle such as emergence response, recovery or preparedness, the concept of indirect damage should be significantly taken into consideration both in public and private policy making on possible disasters.

Figure 1 shows a conceptual diagram of direct damage of stocks and indirect damage of flows. I followed the Okuyama and Chang's idea (2004, p.183), but modified it to make a clear distinction of direct stock loss and indirect flow loss[3]. Direct loss occurs only at the initial stage which is shown as a bold pillar-shaped line. Indirect losses and gains (from construction stimulus) are shown as the difference between the disaster case and the without-disaster baseline. Okuyama and Chang distinguish three interesting possible cases. In Case A, the economy suffers a substantial initial loss, then gets a small gain before returning to its baseline trend. By contrast, Case B shows a never-recovering process and eventually attains a new equilibrium below the without-disaster line. In Case C, the reconstruction stimulus hung up the economy to an improved trend line that is above the baseline. Note that indirect loss heavily depends on the recovery time-path. It is also very important for policy makers to design policies which shift the time-path of an indirect loss curve back to the leftward.

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[1] I have learned various definitions of related words from mainly Okuyama and Chang (2004).

[2] Rose (2004) is one of the experts in defining and estimating hazard losses and proposes to use "higher-order losses" instead of indirect losses for escaping the confusion. However, if we define all flow losses as indirect losses, there remains no confusion in economics sense.

[3] Taniguchi and his associates draw a similar diagram in their various papers but they disregard gains (e.g., Taniguchi et al. (2000, 2006)). However, Taniguchi's definition of direct and indirect losses is the same as my economic one.

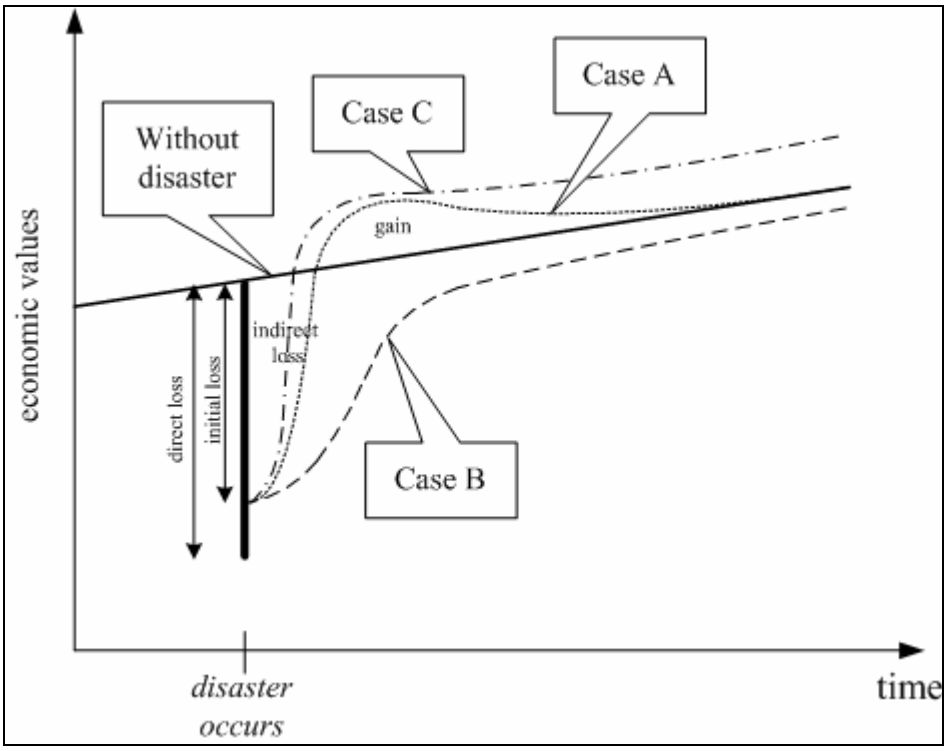

Figure 1. Concept of Direct and Indirect Losses

DIRECT ECONOMIC LOSSES

Characteristics of Direct Losses

For the Hanshin-Awaji earthquake, the government estimated the total direct damage quite quickly as 9.93 trillion yen and made it official in less than three months after the occurrence. Naturally it might be a quite rough estimate.[4] Among it, the dominant portion was the losses of buildings, which totaled to 5.8 trillion yen. The losses of social physical infrastructures such as roads, bridges, and harbor facilities were summed to 4.2 trillion yen.

Paying attention particularly to the direct losses in industry, they were summarized as follows; buildings: 1.42 trillion yen, capital equipments: 0.56 trillion yen, inventories at factories: 0.30 trillion yen and inventories at stores: 0.26 trillion yen.

After one year of the occurrence I made a quite detail examination of industrial losses except buildings using questionnaires and damage reports of individual business enterprises (Toyoda (1997, 1999))[5]. I found that the total direct losses in the industrial sector amount to 5.93 trillion yen. That is, the official estimate of direct losses in industry was underestimated at least by 3.54 trillion yen.

[4] For example, the number of damaged buildings was upwardly revised by significant figures several times after the announcement; the government has never revised the values. Also, the announced losses do not include damage of household physical assets except buildings. The losses of buildings and capital stocks for machinery and equipment were measured by accounting definition, while the ones of some facilities like roads, bridges and harbor were measured by reconstruction costs.

[5] This was done mainly based on data that were collected from about 1,200 individual enterprises with the help of Kobe Chamber of Commerce and Industry.

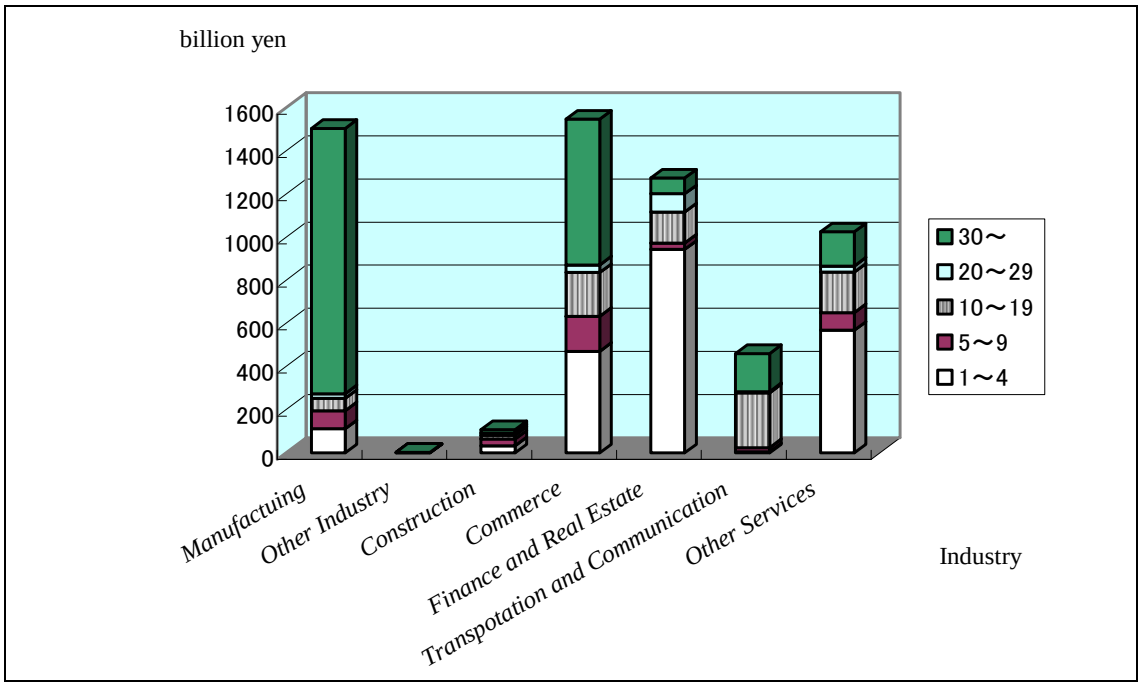

Figure 2. Direct Losses by Industry and Number of Employees

Figure 2 shows the direct losses classified by industry and firm size, which is measured by numbers of employees. The most affected industries are manufacturing and commercial sectors; both are almost the same. Relatively larger firms were damaged in manufacturing, whereas both large and small enterprises in commerce were affected similarly. But, these damage characteristics may reflect the nature of size characteristics peculiar to each industry. The third damaged sector is the financial one probably because it includes the real estate industry which lost a quite few buildings.

I estimate the total stock losses by adding the estimated stock losses in the industrial sector and the officially announced amounts of losses in the public stocks (e.g., roads, harbor, schools and so on) and the household stocks[6]. The modified total stock losses in the whole sectors including the public and household sectors reveal to be 13.27 trillion yen.

The officially announced values of the total stock losses are 9.93 trillion yen, which should be revised upward by at least about 3.39 trillion yen according to our estimates. I have often addressed this finding and the necessity of the value revision, but the government has never made a revision of the very rough estimate of total stock losses until now.

Characteristics of Recovery from Direct Damage

Since Japan is a notably disaster-prone country and therefore the legal system and structure of disaster management has been made progress step by step, usually revising the former system each time after experiencing a great disaster. There exist several disaster management laws and systems; the most important basic law is Disaster Countermeasures Basic Act, which was enacted in 1961. Admittedly, the Japanese government has been well prepared and experienced to act as swiftly as possible under this act[7]. At the time of Kobe Earthquake, the

[6] Note that we are considering only damage of dwellings as losses for households. The official damage statistics for Kobe earthquake does not include lost values of domestic goods and tools although more recent calculation of direct losses are officially admitted in Japan.

[7] For an explanation of the Japanese disaster management system, see Cabinet Office, Government of Japan (2006).

government established the Headquarters for Reconstruction, which was headed by the Prime Minister. Also, the Coordinating Committee for Reconstruction by related ministries and agencies was established. Headed by these organizations, quite a few reconstruction measures were promoted, particularly for the first two or three years.

In my view, there are four characteristics of the Japanese system of disaster recovery management. First, the government has considered mainly recovery and reconstruction of public physical capital stocks until recently. The budget for disaster management has been secured by approximately 5 % of the total amount of the annual budget for general accounts in the last 30 years. At the time of a great disaster such as Kobe earthquake, the greater portion was directed to the budget for recovery and reconstruction by reducing the portion of normal national land conservation. However, this means that the main public fund for disaster management has been directed to revival of social physical capital stock and little attention has been paid for reducing indirect losses in a disaster-stricken area.

Secondly, the main implementing agencies of disaster reconstruction management are local (prefecture) governments. The central government aids the local municipalities through subsidies and tax money allocated to local governments. Therefore, the system sometimes does not work smoothly and has restrictions to follow the central government's principles.

Third, the actual budgets were allocated through each related ministers and agencies. For example, the recovery of damaged public infrastructure facilities is promoted by the Ministry of Land and Transportation, the one of educational facilities is treated by the Ministry of Education, Sciences and Sports, and so on.

Fourth, there existed no well-established system for assisting the recovery of victim's livelihood for such a big-scaled disaster as Kobe earthquake. The Disaster Relief Act, which was enacted in 1947, serves as the basic norm supporting victim's livelihood but has many restrictions for big disasters. By reflecting the slow recovery of victim's livelihood from Kobe earthquake, the Act Concerning Support for Reconstructing Livelihood of Disaster Victims was enacted in 1998, which was not applied to the victims of Kobe earthquake but has been applied to the ones of some big disasters after 1998. This Act was reformed substantially by loosing the conditions of allocating funds to victims by common assent at the Diet in 2007.

INDIRECT ECONOMIC LOSSES

Characteristics of Indirect Losses

It was widely supposed that economic activities in the damaged area would recover in a few years in the case of Kobe earthquake. My former research which was conducted based on the questionnaires from various enterprises just after one year from the occurrence predicted an almost complete revival in two or three years (Toyoda and Kochi (1997) and Toyoda (1999)). Figure 3 depicts our former estimates of indirect losses in industry for the initial two years. It itself shows a quite implicative result compared with the direct losses as shown in Fig. 2. In short, indirect losses of the manufacturing sector reveal to be comparatively smaller, whereas the commercial and other services sectors bear comparatively quite larger indirect losses. It is also evident that smaller-scaled enterprises, particularly in non-manufacturing sectors, suffer from more severe indirect effects.

Figure 4 exhibits a comparison of total values of direct and indirect losses based on our former estimates. It can been seen that indirect losses during the first two years period in total records almost equal values with those of the direct stock losses. The commercial sector, mainly consisting of retail and wholesale stores have very severe losses reflecting the economic principle that big disasters in urban areas hit industries not only on supply side but also demand side. Manufacturing and finance/estate sectors show almost same amount of direct and indirect losses, respectively.

The Truth of Macroeconomic Recovery during 10 Years

Actual statistics relating to local SNA[8], which represents overall macroeconomic activities, really showed a rapid

[8] SNA (= System of National Accounts) is an international standard system of national accounts.

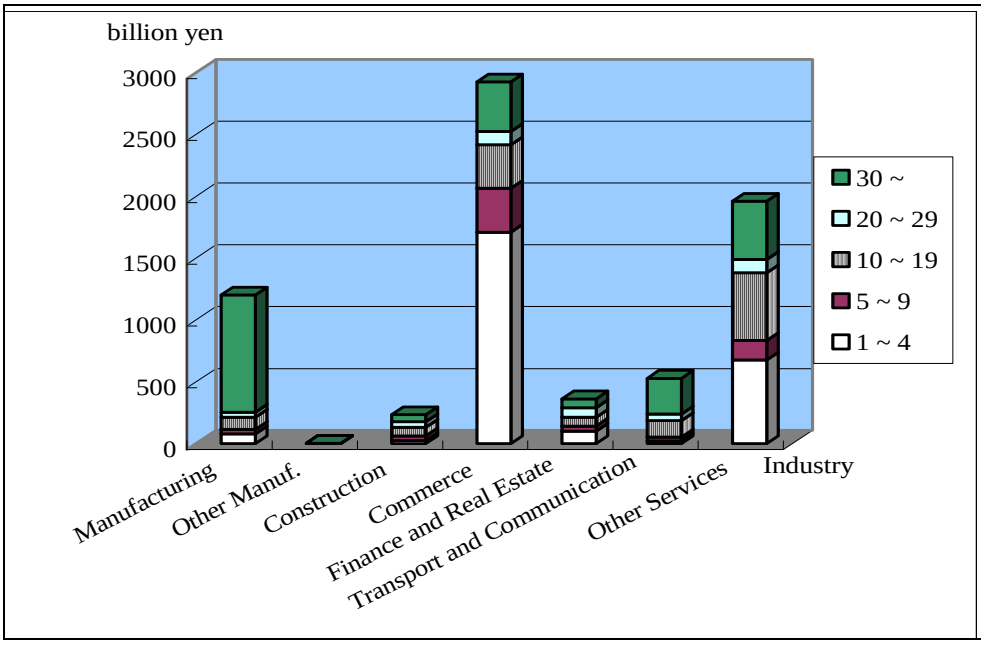

Figure 3. Indirect Losses by Industry and Number of Employees

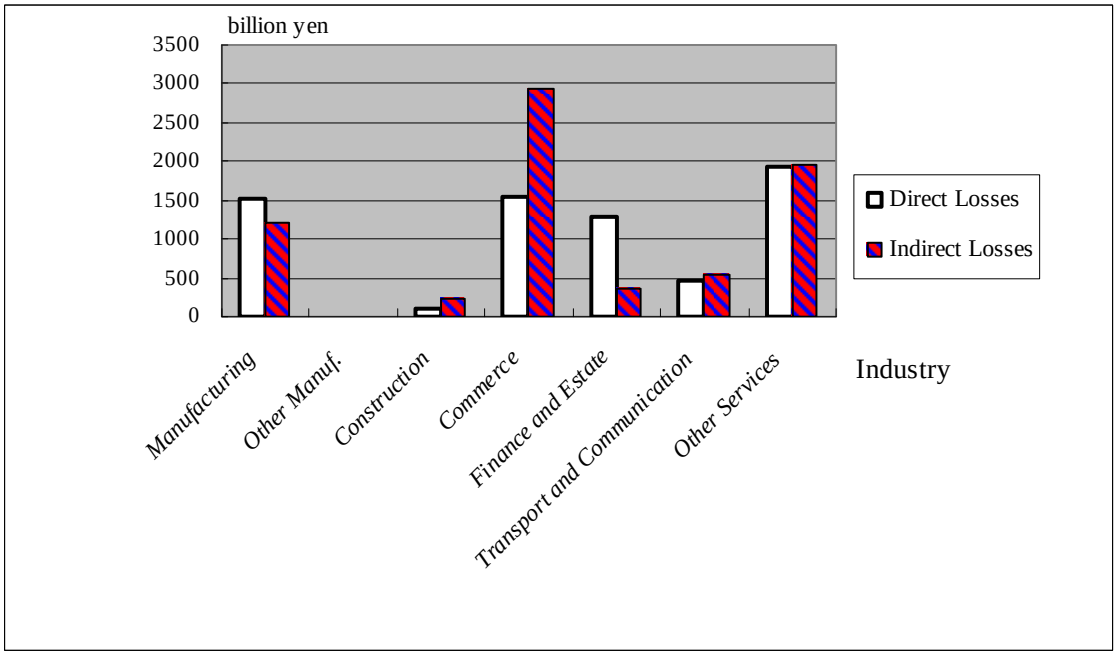

Figure 4. Comparison of Direct and Indirect Losses for Initial Two Years

recovery for the first two or three years. The prediction seemed to be coincident with the actual time-path.

However, the real process afterwards the initial three years of the occurrence, i.e., after 1998, was quite different. The economic indicators that show production and expenditure activities became very stagnant and worsened for the succeeding several years. We must be careful in discussing the recovery process about the interdependence of the damaged area and Japan as a whole. The Japanese economy continued to fluctuate in a recordable depression range until 2003. Therefore, I will try to deduct of the country's overall depression effect from the local (prefecture) economic conditions. Even after deducting the country-wide effect of depression, the economic level in the damaged area continued to be lower than the without disaster level at least until 2005. It is an important but neglected question to inquire why the recovery takes a so long and chronological time span in spite of the seemingly good recovery including the actual reconstruction of lifelines and buildings.

Figure 5 shows the comparison of Gross Regional Product (GRP) of Hyogo Prefecture and also of more precisely defined damaged area of 10 cities and 10 towns with that of Japan as a whole (i.e., GDP). I made use of statistics of GRP, which were originally published by Hyogo Prefecture. Hereafter, my use of 'year' is based on Japanese fiscal year, which begins on April 1 and ends on March 31. I set their values of 1993 (i.e., one year before the earthquake) as 100 and the values of the other years are shown as indexed values as compared with the base year, 1993.

It is clear that the aggregate Japanese economy was affected little by the earthquake and a weak growth trend until 1997, but since then the whole Japanese economy became to undergo a very stagnant or rather recession period. On the other hand, the damaged area recorded a significant break down of flow measures (including product or income) in the year of disaster occurrence. The immediately following two years, i.e., 1995 and 1996, showed a quite significant drive-up of GRP owing to various reconstruction activities. This is coincident with the concentrated input of resources into the region for reconstruction of public physical infrastructure and some public housing projects. After the two year reconstruction period, the flow economy in the region became to diverge downward significantly from the country trace. Only in recent years, namely since 2004, the economy in the damaged area turned to upward in nominal GRP terms. It is also observed that both Hyogo Prefecture and the truly damaged area show almost parallel movements, but since 2000 the truly damaged area suffered a more severe decrease in product and income than the prefecture.

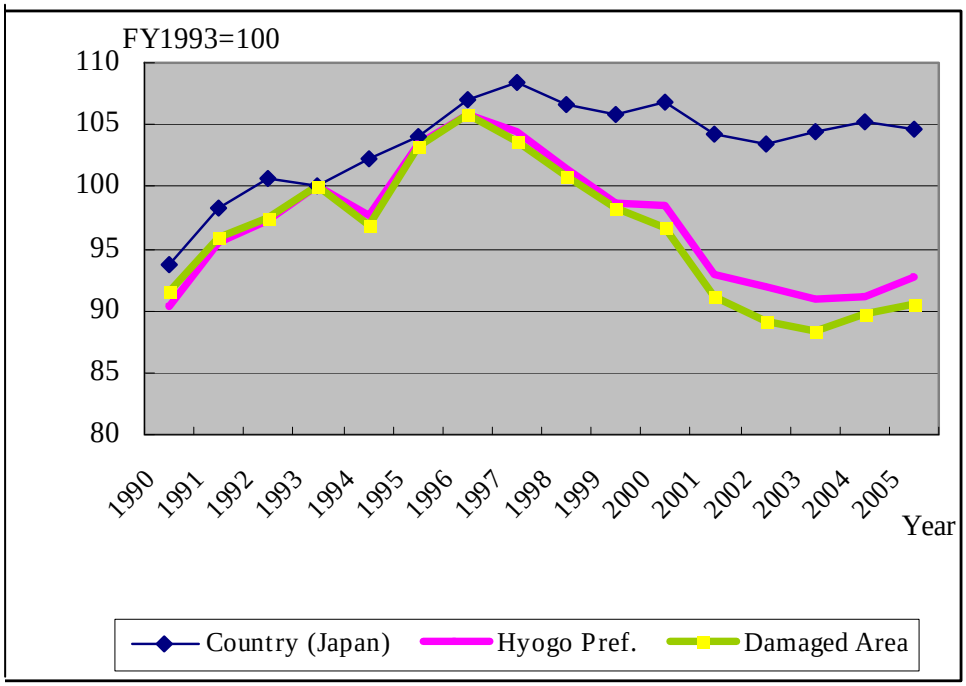

Figure 5. GDP and Gross Regional Product, 1993=100

also observed that both Hyogo Prefecture and the truly damaged area show almost parallel movements, but since 2000 the truly damaged area suffered a more severe decrease in product and income than the prefecture.

As in the above examination of the last decade of recovery time-path, we can now use officially published reliable statistics of the macro level (Hyogo Prefecture, Bureau of Statistics (various years)). Therefore, I will hereafter investigate the recovery process more precisely and inquire about how and why the economy in the damaged area has been suffering for such a long-term period. Because of the availability of detailed SNA statistics, I will concentrate on the recovery process of the macro economy in the Hyogo Prefecture.

Estimation of INDIRECT Losses

Indirect Losses for Hyogo Prefecture

We concentrate on Hyogo Prefecture below because there are no data available except GRP for the narrowly defined damaged area. First, we estimate indirect losses based on a without disaster (earthquake) line. In order to derive the without disaster line, I would like to conduct some preliminary statistical analyses based on the actual data for the period 1980-2005. As before, all annual data are based on Japanese fiscal year.

(a) 1980-1993			
	Country	Hyogo Pref.	Affected Area
Country	1.00		
HYOGO Pref.	0.99**	1.00	
Affected Area	0.99**	0.99**	1.00
(b)1994-2005			
	Country	Hyogo Pref.	Affected Area
Country	1.00		
Hyogo Pref.	0.56	1.00	
Affected Area	0.54	0.99**	1.00
(c)1998-2005			
	Country	Hyogo Pref.	Affected Area
Country	1.00		
Hyogo Pref.	0.79*	1.00	
Affected Area	0.80*	0.99**	1.00

Note: * shows 1% and ** shows 5 % levels of significance, respectively.

Table 1. Tests for Correlation between GDP and GRP

First, let us check the correlation of economic activities between the disaster area and the whole Japan. Table 1 exhibits the values of simple correlation coefficients among the country's GDP, GRP of Hyogo Prefecture and GRP of the actually damaged area. According to the panel (a), all three coefficients are very significant at 1 % level. Both Hyogo Prefecture and the actually damaged area had strong economic associations with the Japanese economy. However, according to the panel (b), I find no correlations between the damaged area and the whole Japan although the strong correlation between Hyogo Prefecture and the actually damaged area is observed. If I exclude the active

reconstruction period as shown in the panel (c), the correlations between the damaged area and the whole Japan recovered somewhat but significant only at 5 % level.

Next, I check the time series properties of GRP of Hyogo Prefecture, which is designated by HGRP. Typical macroeconomic time series like GDP and GRP usually follow non-stationary processes. It is widely known in econometrics that a regression analysis between non-stationary variables gives us only a 'spurious' regression. After some preliminary examinations, I obtain the estimation result of equation (1) for the period of 1980 – 2005. It shows that HGRP is non-stationary and follows I (1) process[9] with a drift and trend, where T denotes the trend term[10].

$$\Delta HGRP = 603082 - 88433.0\ \mathrm{T} + 0.0483\ HGRP\ (-1) \tag{1}$$

$$ADF\ Test\ \ Statistic = 0.639$$

As I observed before, the damaged area had a very significant correlation with the movement of the Japanese economy; I estimate an equation to explain the movement of HGRP by the growth rate of GDP and time trend for the pre-earthquake period, 1985-1993. The result is shown by equation (2)[11].

$$\Delta HGRP = -1970.9 + 212.41 G\hat{D}P + 189.03T \tag{2}$$
$$\text{(-2.83)} \quad \text{(4.02)} \qquad \text{(3.43)}$$
$$\overline{R}^2 = 0.670, \quad DW = 1.79$$

The result means that the first difference of GRP of Hyogo Prefecture would be predicted quite well by growth rate of the country's GDP as well as by time trend. From this equation I can derive a without-disaster line. Based on the line, I get the simulated values of HDRP for the post-disaster period, 1994-2005, which are possible GRP if there were no earthquake in 1994. The difference between the simulated possible HGRP and actual HDRP gives a series of indirect losses for each year. Taking the losses as negative values, they are exhibited in Figure 6.

In the year of the earthquake occurrence, the GRP of Hyogo Prefecture suddenly decreased by 462 billion yen from the previous year although the without-disaster line predicted an increase by 388 billion yen. Therefore, the estimated indirect losses, which can be obtained as the some of these, reveal be about 850 billion yen. The values in other years until 2005 have the same meanings. Only one exceptional positive value can be observed for 1995, when the most active reconstruction activities were conducted. Therefore, I can say that Hyogo Prefecture actually recorded a gain only for 1995. In the following year, 1996, positive investment activities, both public and private, continued, but the net flow value of regional product turned to a negative value from the without-disaster line although it is a small amount. Surprisingly, it continued to record some gradually larger values for the subsequent seven years and the maximum losses are observed for 2003. After 2003 it seems to turn to show smaller losses at last after a quite long-term period. This is a quite reasonable estimation result because the actual movement of GRP of the damaged area showed a very stagnant pattern and actually diverged from the country's economic trend as we have described before.

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[9] I (1) process means a time series which is originally non-stationary but becomes stationary after being differenced once. It is called to be integrated of order 1.

[10] Note that the left-hand side is measured by a difference of HGRP. This ADF value, which is an abbreviation of 'augmented Dickey-Fuller' test statistic, shows a significant non-stationary property of HGRP. The 'drift' means an existence of a constant term.

[11] Note that the left-hand side is also measured by the difference instead of the level of HDRP to ensure it to be stationary.

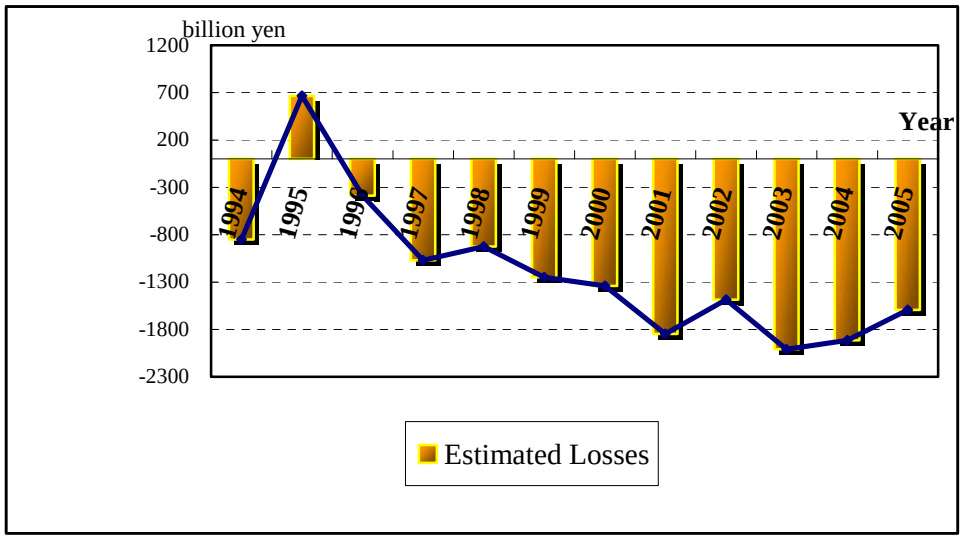

Figure 6. Estimated Indirect Losses

The above analysis shows that the indirect losses are surprisingly quite large and continued to arise for more than 10 years. If I make a sum of the observed losses for the 1994-2005 period, it reveals to be some 14 .0 trillion yen. It is sometimes talked without any rigorous ground that indirect losses amount roughly to be the corresponding direct losses in a big earthquake which hits an urban area. My estimates also somehow support this argument if we refer to my modified value of the total direct losses as presented in page 4. Again, this statement is not based on any rigorous theoretical ground.

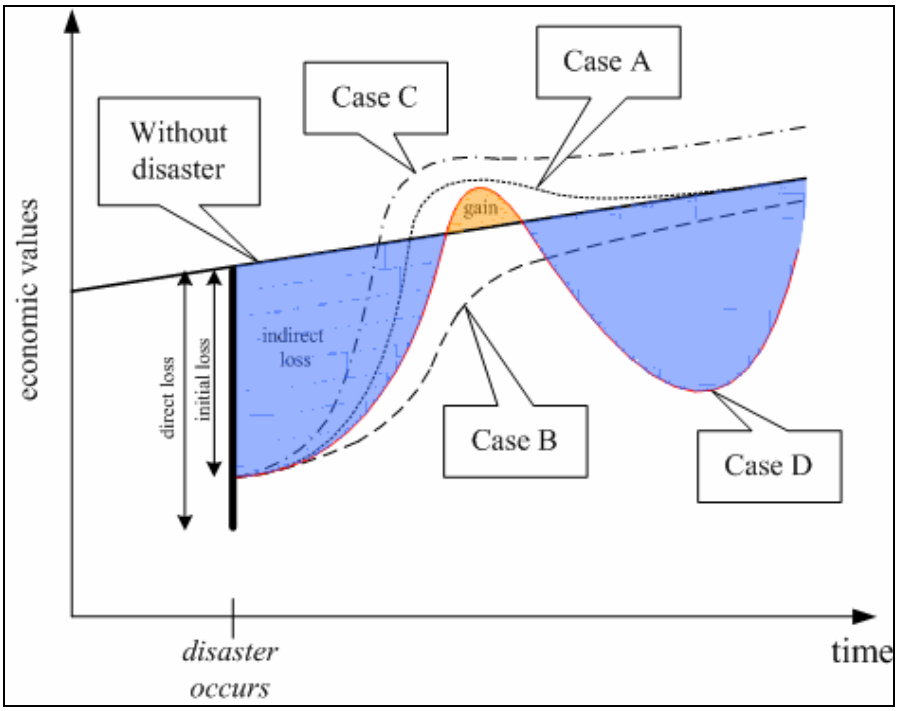

Figure 7. Trace of Recovering Process of Kobe's Case (D)

From the above analysis I propose another new Case D of recovery path, which has not been considered by Okuyama and Chang (2004). The Case D line is added to the original Figure 1 as shown in Figure 7. In the case of Kobe earthquake, the initial reconstruction investment created the initial reconstruction investment created an increase in aggregate demand so that product or income flows were lifted up higher than the without-disaster line for at least one year. However, as investment for reconstruction became weaker, product or income flows again recorded quite significant lower values than the ones predicted by the without-disaster base line for a quite long period at least by 2005. The worst bottom year was 2003. Another important reason why the economic performance in the disaster-stricken area was less than presupposed might be the unfavorable truth that many products for recovery and reconstruction investment were imported from other prefectures and income was out-flowed.[12]

CONCLUSION

I have made an analysis of the long-term recovery process of Kobe earthquake mainly from the economic view point. I have first considered about the concept of economic losses from disasters in general. Valuing losses in economic terms, in my view, serves as the basis for any level of disaster management cycle and also bridging knowledge among academicians, policy makers and practitioners concerned. In this connection I have stressed the importance of distinguishing between direct stock losses and indirect flow losses in economic sense.

I then concentrated on making clear the characteristics of economic losses of Kobe earthquake. After reviewing the official and my own former estimation of direct losses, I concluded that the Japanese system to make a swift recover from natural disasters has been fairly well established. However, the system for assisting economic and livelihood reconstruction of households has been improved just recently.

According to the results in page 7 and afterwards, which are based on actual macroeconomic data including the gross regional product (GRP) in the stricken area, I get a new striking finding that the lost product or income in terms of estimated indirect losses are quite large and continue to arise for longer than 10 years. We first derive a without-disaster line for the damaged region, taking both the regional economic trend and the country-wide business conditions into consideration. Subtracting the actual GRP from the potential product predicted by the without-disaster line, I get estimates of indirect losses. The total sum of indirect losses during the period of 1994-2005 (in terms of Japanese fiscal years) reveals to be some 14.0 trillion yen.

My findings also show a new pattern of recovering process from disasters, which has not been found before in major related literature. During the initial three years strong demand-pull effects caused by reconstruction activities are observed and gains rather than losses are produced in the second year. Surprisingly, after the fourth year, the amount of flow losses become worse and worse, recording the bottom loss in 2003, the 10th year after the quake. Since then it seems that the regional economy is on the way going back to the without-disaster line.

Some implications from my findings will be deducted. First and most importantly, Japan's disaster management and reconstruction policy should be improved by paying more attention to indirect losses. As I showed in Page 5, the commercial and other services sectors, particularly small-scaled enterprises, suffered from severe indirect effects. Second, considering the fact that net imports of goods and services from other areas increased in the stricken area, I consider that accumulating sustainable industries against disasters and also propagating BCP (business continuation plan) in the business world will be important. Third, some special policy measures to activate the regional economic activities such as a special economic zone should be allowed at an earlier stage after a disaster occurs. Lastly, if some more measures for supporting victims like the Act Concerning Support for Reconstructing Livelihood of Disaster Victims (which was enacted in 1998) had existed at the time of Kobe earthquake, the indirect losses would have been reduced.

[12] This was shown by Hayashi (2005). According to Hayashi, about 6.9 trillion yen were out flowed to outside of the prefecture for the 1994-1998 periods. This means that not only many products for reconstruction and for other demand purposes were bought from outside of the region but also considerable amount of services like medical and financial services were brought from other regions.

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REFERENCES

1. Cabinet Office, Government of Japan (2006) The *Disaster Management in Japan, 2006*, *http://www.bousai.go.jp/panf/saigai.html.*
2. Cochrane, H. C. (2004) "Indirect Losses from Natural Disasters: Measurement and Myth," in Okuyama and Chang (2004), 37-52.
3. Chang. S. E., and S. B. Miles (2004) "The Dynamics of Recovery: A Framework," in Okuyama and Chang (2004) 181-201.
4. Hayashi T. (2005)Issues on Recovery Funds, *Report on Comprehensive Evaluation of Recovery of 10 Years after, Hyogo Prefecture,* II, 372-445 (in Japanese).
5. Hyogo Prefecture, Bureau of Statistics, *SNA Statistics of Hyogo Prefecture*, various years.
6. Okuyama, Y., and S. E. Chang (2004) eds., *Modeling Spatial and Economic Impacts of Disasters*, Springer-Verlag.
7. Rose, A., Benavides, S. E. Chang, P. Szczeniak, and D. Lim (1997) The Regional Economic Impact of an Earthquake: Direct and Indirect Effects of Electricity Lifeline Disruptions, *Journal of Regional Sciences*, 37, .437-458.
8. Rose, A. (2004) "Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation," in Okuyama and Chang (2004), 13-36.
9. Taniguchi, H., and K. Fujisawa (2005) "Earthquake Damage Risk for Future Urban Economic Structure," *Proceedings of the 18th Meeting of Japan Association for Risk Studies*, 18 (in Japanese).
10. Taniguchi, H., and H. Kanegae (2000) "Long-term Effect of Socioeconomic Impact due to Earthquake Disaster – The Estimation Method for Direct Economic Damage Loss –", *Proceedings of JCOSSAR 2000*, 39-A, 237-244 (in Japanese).
11. Taniguchi, H., and S. Ueno (2006) "Estimation of Direct Losses from Earthquakes for Each Local Municipalities," unpublished manuscript (in Japanese).
12. Toyoda, T., and A. Kochi (1997) "Estimation of Industrial Losses Caused by the Great Hanshin-Awaji Earthquake," *Kokumin Keizai Zasshi*, 176(2), 1-15 (in Japanese).
13. Toyoda, T. (1999) "Economic Losses Caused by the Great Hanshin-Awaji Earthquake," *Research Report*, RCCUS, Kobe University, 3, 347-353.