How Earthquakes can affect Health Sector of the Economy?

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Abstract

This study tries to focus on the impacts of earthquakes on the health sector, which is the most crucial sector through post-earthquakes phases. Damage to the healthcare centers is extremely important due to healthcare's functions to save lives. Therefore, the aim is to study total loss to the health sector due to the earthquake. To overcome the difficulty of finding data about the number of healthcare centers destroyed during earthquakes, considering four factors: development level, older events, severity of the earthquake and the population of the places where the quakes happened, the number of destroyed healthcare centers for 29 earthquakes were simulated. Using an ARDL approach, the total loss to the health sector was considered to affect by the severity of earthquake, healthcare centers destroyed by disasters, GDP of the health sector and human development levels of countries.

The results confirm that after the earthquake in the short run, the financial loss of the health sector is less in countries which have a powerful health sector. In the long run, the goods and services production of the healthcare sector must increase to meet the needs of reduction in the capital stock. Therefore, governments should reconstruct demolished centers, buildings etc. to meet the health needs of people.

Keywords: Earthquakes, economy, healthcare, ARDL approach.

Introduction

The definition of disaster includes sudden, highly disruptive, time-limited and public events based on the American Psychiatric Association.[39] According to Norris' definition[27], disasters are sudden, uncontrollable, unexpected events. Although disasters have many common characteristics, each disaster has its own impacts depending on the various economic situations. In fact, the most common feature among them is that all natural disasters are harmful to the economy[32]. Natural disasters can be classified into two general groups: geologic disasters and climate disasters[1]. Earthquake is located in the geologic group since it happens when two blocks of the earth suddenly slip past one another (USGS).

Earthquakes often lead to deaths which imply a loss of human capital. In addition, severe earthquakes have the power to destroy capital stocks such as infrastructures, buildings etc. which can cause short-term and long-term economic effects.[14]

One of the most important features of earthquakes is that there is almost no warning. This feature makes earthquakes the most fatal natural disaster type.[22] Earthquakes have always threatened lives and the thing that should be noticed is the fact that saving human lives in every earthquake is on the top priority.[38] Health can be considered as a consumption commodity that increases consumer utility. Furthermore, it can be considered as investment goods that can increase labor productivity and decrease the number of sickness days.[46] From these views towards health, it can be concluded that in the case of a quake, the level of capital stock will decrease because of victims and injured people labor's productivity and human capitals.[6,9,15,19]

Therefore, this study tries to focus on the impacts of earthquakes on the most crucial sector through post-earthquakes period of time which is the health sector. Damage to the healthcare centers is extremely important due to healthcare's functions to save lives and decrease the negative impacts of disasters. In other words, healthcare centers are exposed to risk during earthquakes, therefore, it is important to make them equipped and resilient, especially in countries which are at risk.[26] Earthquakes are not exacerbated by human, but at risk countries have known about their locations. About 80% of all earthquakes are placed in China, Japan, Iran, Turkey, India, Chile, Indonesia, Pakistan and Guatemala and more than 50% of their lands lay over the faults. Located on seismic belts, all these countries are bound to experience similar disasters and the catastrophic events.[33]

After the World Health Organization and the United Nations of International Strategy for Disaster Reduction (UNISDR) world campaign: "Hospital Safe from Disasters", an increasing attention has been given to healthcare resilience in both strength and robustness to promote their continued functioning.[2] It is important, especially in at risk countries to study earthquake consequences and plan to drive down the negative impacts of probable natural disasters.

The study of previous experiences of disasters can give lessons on how to manage potential future disasters more effectively. This study tries to investigate the factors related to the health sector of the economy which are influenced by

the earthquake. To overcome the lack of data, an accurate simulation was applied and data of the number of healthcare centers destroyed after quakes was generated. An ARDL approach was applied for earthquakes during 1990-2014 with magnitudes over 6 on the Richter scale.

Review of Literature

Earthquakes can cause health problems which raise the demand of the health sector. Many hospitals and healthcare centers are damaged by natural disasters yearly which can be considered as the earthquake negative effect to the supply side of the health sector. Demolishing buildings of healthcare centers may intensify negative impacts and leads to catastrophic situations, because they have the critical role to help injured people in the case of earthquake. After the earthquake, demand for the medical health will increase dramatically. Therefore, it is necessary for the supply side of the health sector to answer this need.

Although some international organizations such as Red Cross and Red Crescent always try to help and support the injured people, in the case of very catastrophic events, local facilities cannot fulfill all needs. Thus, it is very important for the healthcare centers in at-risk countries to be resilient enough to face with severe quakes. And also, for developing countries, it is useful to have plans to face with critical circumstances.

There are researches that have surveyed the consequences of natural disasters on the economies. March[23], Anbarci et al[3], Aaron[1], Toya and Skidmore[37], Zenklusen[44], Miller and Arquilla[25], Emamgholipour and Sadeghi[13], Okuyama[29], Cavallo and Noy, Hallegatte and Valentin, Coffman and Noy[7], Datar et al[10], Xie et al[43], Huang and Hosoe[20], Meltem et al[24], Haddad and Teixeira[17], Takasaki[36], Andergassen and Sereno[4] and Winsemius et al[42] have studied natural disasters and their side effects on economies.

Riestra and Gignoux et al have studied the negative effects of earthquakes on the economy and found negative effects on the employment and people's welfare. Some of more related studies related to the issue of this study are as follows:

Nateghi et al[26] have studied earthquake mitigation in health facilities in the megacity of Tehran. They have discussed 110 hospitals and considered the standard of their performance and strengthening methods. They figured out that an appropriate earthquake management program is necessary.

Achour et al[2] studied the earthquake-induced damage in hospitals. Studying of the damage to 34 healthcare centers caused by earthquakes between 1994 and 2004 showed that there were differences between structural and architectural damage due to the situation, while utility supply and equipment damage were similar in the cases, because most facilities were equipped with similar technology. Datar et al[10] surveyed the indirect impacts of small and moderate natural disasters on child health in rural India. Using data from three waves of the Indian National Family and Health survey with an international database of disasters (EM-DAT), their results showed facing with a natural disaster in the past can increase 9-18% of the likelihood of illnesses in children under the age of 5. Socioeconomic characteristics have significant impacts on decreasing the side effects of natural disasters.

Shibusawa[34] studied the economic effects of an earthquake in Japan with a CGE model. They found that after the earthquake, capital stock declines immediately. While in the reconstruction phase, investment increases to deal with the losses. Considering factors such as seismic hazard, structural response anddamage resulting from the vulnerability of structures, the economic losses of earthquake were evaluated by Demartino et al.[11]

Zhou et al[45] studied the impact of disaster risk on regional economic resilience in China. The economic resilience level of the disaster was surveyed through an empirical study of the Wenchuan earthquake. Their findings show that construction and healthcare centers need to be driven by external support.

Shahpari et al[33] used a CGE model to study the effects of earthquakes on the economy of Iran. They considered a decrease in the capital stock as a shock to their models that can simulate the earthquake consequences. They found that the GDP decrease and the rate of reduction depend on the severity of the earthquake. The supply side of the health sector affects more than the demand side. In other words, healthcare centers destroy the aftermath of earthquakes. Household's welfare reduces after an earthquake and the urban households are more vulnerable to the earthquake in comparison with the rural population.

Data and Methodology

In order to define a model to study how an earthquake can affect the health sector of the economy, begin with the famous relationship between the desired capital stock (K^*_t[1]) (1. It is considered that $_t$ is the year that the earthquake happened) and the level of production (Y_t) as follows:

$$K^*_t=\beta_0+\beta_1 Y_t + U_t \quad (1)$$

where U_t is the error term.

Since the study focuses on the health sector of the economy andthe most important parts of the capital stock of the health sector are healthcare centers[28], substitute healthcare centers ($healthcare_t$) for K^*_t. And also $GDPH_t$ is considered as the total Gross Domestic Products of Health sector for the year t and substitute it for Y_t. In order to consider the earthquake as a shock in the model, the following equations are supposed:

$$U_t = Earthquake_t + \varepsilon_t \quad (2)$$

Table 1
Some of the most important earthquake happened during 1990 - 2014

Year	Country	Magnitude on Richter Scale	loss total $million US	killed people
1990	Iran	7.4	8000	50000
1990	Philippines	7.8	369.6	2412
1991	India	6.8	60	1500
1991	Costa Rica	7.7	100	47
1992	Indonesia	7.8	100	2519
1993	India	6.2	NA	9748
1994	USA	6.7	30000	60
1994	Colombia	6.8	2.4	271
1995	Japan	7.2	100000	5100
1995	Mexico	8	NA	49
1996	Indonesia	8.2	412	166
1997	Iran	7.3	100	1568
1998	Afghanistan	6.5	10000	4000
1999	Taiwan	7.5	14100	2297
1999	Turkey	7.6	20000	17118
2000	Indonesia	7.9	41	103
2001	India	7.7	2623	20005
2002	Afghanistan	7	NA	1000
2003	Japan	7	973	
2003	Algeria	6.8	5000	2300
2003	Iran	6.6	1300	26271
2004	Japan	7	28000	68
2004	Indonesia	9.2	4451.6	165708
2005	Indonesia	8.6	NA	915
2005	Pakistan	7.6	5200	73338
2006	Indonesia	6.4	3100	5778
2007	Indonesia	8.5	500	25
2007	Peru	8	600	593
2008	China	7.8	20000000	51151
2009	Italy	6.3	2500	308
2009	Indonesia	7.6	2200	1195
2009	Samoa	8.1	124.04	192
2010	Haiti	7	8000	316000
2010	Chile	8.8	30000	507
2011	Japan	9	210000	19846
2012	Philippines	7.6	8900	113
2013	Pakistan	7.7	100	399
2014	Chile	6.7	100	6
2014	China	6.1	5000	729

Reference: EM-DAT

$$Earthquake_t = f(Tloss_t, Richter_t, HDI_t, \ldots) \quad (3)$$

So, $earthquake_t$ is defined as a function that is related to the $Tloss_t$, the total loss to the health sector due to the earthquake, $Richter_t$ that can identify the magnitude of the earthquake on Richter scale and also HDI_t which is the Human Development Index in the year that earthquake happened. HDI_t can show the differences among different countries throughout the world that is going to be studied. There may be other factors that identify this function, but to make it more specific and simple, this study just focuses on these three factors.

After substituting equation (2) and (3) in the equation (1), solve it for $Tloss_t$, equation (4) is as follow:

$$Tloss_t = a_1 + a_2 Richter_t + a_3 healthcare_t + a_4 GDPH_t + a_5 HDI_t + e_t \quad (4)$$

In order to estimate the equation (4), which is the final goal of this study, an Auto Regressive Distributed Lag (ARDL)

approach is used. Since data for the variable $healthcare_t$ is not available, it was necessary to simulate data and tried to achieve at least 25 observations.[16]

Simulating data for the variable $healthcare_t$: The data of 38 different earthquakes, which occurred worldwide during 1990 - 2014 with magnitudes over 6 on the Richter scale, were collected from the international disaster database, EM-DAT. The magnitude of 6 and above was selected because it is expected that less than this amount will not destroy buildings. To make it more clear, the process of simulation is described as follows:

The severity of economic losses and consequences of earthquakes can be found by studying past events[35]. To overcome the difficulty of finding complete information about the number of healthcare facilities destroyed during earthquakes, it was helpful to use the data which was gathered in the Achour et al[2] for 9 of those earthquakes as a base for our simulation. Then the number of destroyed healthcare centers for the other 29 earthquakes was simulated. To make an accurate simulation, some factors are needed to be considered:

1. Development level: Earthquakes are particularly fatal in low-income countries.[40] The amount of property loss after an earthquake depends critically on the development stage of the affected country.[35] Therefore, the first factor is the development status where the quake happened. In this study GDP per capita (PPP) is selected as an index to show the level of development. For example, it is expected that an earthquake in Iran causes more damage to the healthcare facilities in comparison with Japan.

2. Older events: It was considered that earthquakes in the past had more negative impacts on structures. It is expected that countries try to build their new buildings more earthquake resilience than what they had built decades ago, or even they are expected to reinforce their old buildings during the years. For instance, countries such as Turkey have carried out extensive efforts to mitigate the vulnerability and boost their resilience of infrastructures including healthcare systems.[21]

3. Severity of the earthquake: The next factor which is important for an accurate simulation is the earthquake's magnitude. In the simulation, the severity of the earthquake, as a parameter that can cause the destruction of more healthcare centers, is also considered.

4. The population of the places where the quakes happened: To make it a more precise simulation, the number of people who were killed, was also included to avoid the error of consideration of the earthquakes that happened in non-residential areas. In other words, it was assumed that earthquake can have more destruction to the healthcare centers if more people are killed.

Results and Discussion

The results of the estimation are illustrated in table 2. All the variables have a significant influence on the dependent variable at a 90% confidence level andthe F statistic shows the overall significance of the regression. In table 3, diagnostic tests are presented.

Table 2
The ARDL estimation: dependent variable is $Tloss_t$ (total loss to the health sector)

Variable	Coefficient	Standard Error	t-static	Prob.
$Tloss_t$ (-1)	-.336	.106	-3.176	(.025)
$Tloss_t$ (-2)	-.179	.057	-3.134	(.026)
$Richter_t$ (-3)	2490.5	381.619	6.527	(.001)
$Healthcare_t$ (-3)	1231.1	112.811	10.71	(.000)
$GDPH_t$ (-1)	-1.528	.704	-2.171	(.082)
HDI_t (-3)	-14599.3	2393.3	-6.1	(.002)
C	-27435.7	6448.6	-4.254	(.008)
R^2=.992	$\overline{R^2}$ =.967	DW=2.243	F(16, 5)=40.452	(.000)
S.D. of dependent variable			3832.1	

Table 3
Diagnostic test

Test name	Statistics	Prob.
Serial correlation	1.0187	.313
Functional form	.7492	.416
Normality	.10456	.949
Heteroscedasticity	.35936	.549

Table 4
Estimated Long Run Coefficients Using the ARDL Approach

Variable	Coefficient	Standard Error	t-static	Prob.
$Richter_t$	2601.8	780.434	3.334	(.021)
$Healthcare_t$	795.813	102.213	7.786	(.001)
$GDPH_t$	1.985	.3579	5.547	(.003)
HDI_t	-1415.7	4440	-.3189	(.763)
C	-18103.6	3612.7	5.011	(.004)

It can be concluded that the residuals are free from auto-correlation and the functional form of the estimated model is correct above 95 percent level. Residuals have a normal distribution and also homoscedasticity; the level of error is 5 percent.

It is necessary to check the model to avoid spurious regression. Moreover, this model fulfilled the existence of co-integration relationship.[16] The approach that developed by Pesaran et al[31] gives the permission to investigate co-integration among variables without consideration, if variables are I (0), I (1) or a mixture of both.

Then, to have a dynamic model with long run equilibrium, the hypothesis test is as follows:

$$H_0: \sum_{i=1}^{p} \hat{a}_i - 1 \geq 0 \quad (5)$$

The t statistics is obtained as follows:

$$t = \frac{\sum_{i=1}^{p} \hat{a}_i - 1}{\sum_{i=1}^{p} s_{\hat{a}_i}} \quad (6)$$

where $\hat{a}_i$ stands for the estimated lagged coefficient of the dependent variable and $s_{\hat{a}_i}$ is their standard deviations. Then, t statistic is compared with the Banerjee, Dolado and Mester's table.[5] If the calculated t, in terms of absolute was greater than the critical value, then a long run relationship can be concluded. In this estimation, the calculated t will be as follows:

$$t = \frac{-.336 - .179 - 1}{.106 + .057} = -9.294 \quad (7)$$

While the critical value from the Banerjee, Dolado and Mester's[5] table for 25 observations including intercept and with four explanatory variables, is -4.18, the long run relationship among variables is guaranteed.

After checking all the necessary tests, now it is possible to analyze the results. According to the results mentioned in table 2, it can be concluded that the severity of an earthquake ($Richter_t$) has a significant impact on the total losses ($Tloss_t$). In other words, the more is intensity of an earthquake, the greater is loss.

Healthcare centers are capital-intensive institutions that need high levels of capital stock. Therefore, the greater number of hospitals and other kinds of healthcare centers that are destroyed due to the earthquake, the higher financial losses incurred to the health sector. Findings show that there is a significant positive relationship between $healthcare_t$ and $Tloss_t$.

It is rational to say that the relationship between GDP of the health sector ($GDPH_t$) and financial loss occurred after an earthquake is negative. Because whatever the country's health production is higher, it is expected that the infrastructures should have enough strength and should not be destructed easily.

The same relationship is expected for the Human Development Index (HDI_t) which is a proxy of development. From the result illustrated in table 2, it can be seen that the both signs of $GDPH_t$ and HDI_t are correct based on the theory and expectations and also both of them are significant at the 10% significance level. Due to the fact that there is a long run relationship among the variables, the result of long run estimation has been shown in table 4.

In the long run, all variables, except HDI_t, are significant at 95% confidence level. The sign of all variables is the same as short run, but the $GDPH_t$'s sign has changed. In the long run, governments and other institutions will involve in the reconstruction of buildings and structures that were demolished during the disaster. Therefore, the production of the health sector will increase to compensate the loss of the health sector.

Conclusion

The impacts of earthquake occurrence can be considered as a shock to the health sector of countries. Earthquake leads to a substantial reduction of capital stock in the health sector by destructing healthcare centers, demolishing health facilities, increasing the demand for health care services, killing lots of labor worked in the health sector etc.

Using the method of Pesaran and Shin[30], a model was developed to analyze the effects of the earthquake on the health sector. The results of ARDL (2, 3, 3, 1, 3) estimations confirm that there is a long run relationship between the financial loss happened after the earthquake and the explanatory variables. Explanatory variables include the severity of the quakes on the Richter scale, the number of healthcare centers destroyed by quakes, the Gross Domestic Product of the health sector in the year that earthquake

happened and Human Development Index in the year that earthquake happened.

In the short run analysis, it was concluded that there is a negative relationship between the reduction of capital stock and the production of the health sector. In other words, the more powerful the health sector is, the less reduction in the capital stock occurs. In the long run, the $GDPH_t$ has a positive sign that may refer to the hurt countries' reconstruction and restoration. An earthquake is most likely followed by recovery and reconstruction. In this phase the construction boom can be a source of additional inflows.[35] At this stage, Governments and other institutions such as insurance companies consider budget to compensate the loss of the capital stock. Hence, the production of the health sector will increase. Emamgholipour and Sadeghi[13] also found the same relationship between GDP and the damage to the economy in Iran.

In the short run, there is a positive sign for HDI, which was expected for countries that their HDI is at a higher level; the financial loss after the disasters can be lower due to their strong infrastructures. And also, in developed countries, the insurance companies are strong enough to compensate the losses of victims. In these types of countries, after the earthquake, people are not worried about their financial loss. Instead, they just try to obtain their normal lives andthey can have another home with new furniture very soon. In the case of disasters, insurance companies can have a vital role to the victims and in developed countries, which almost all households are supported with insurance, insurance companies are the ones that may lose.

However, there is no any significant relationship between the development level of the countries and the financial loss to the health sector in the long run. This may happen because in the long run and after the initial phases of a disaster, countries started to conduct comprehensive retrofitting their infrastructures such as hospitals, buildings, schools etc.[2] Therefore, in the reconstruction phase, they will try to reduce the vulnerability and enhance the resilience to avoid such problems in the future regardless of their HDI level.

To avoid or make the natural disaster's loss least, countries which are at risk (especially those who are located on the seismic belt) should arrange serious actions to face with the critical situations before it happens. In the disaster management planning procedure, one of the most important things that should be considered as a top priority is strengthening the structures of public places. For instance, powerful crisis management organizations should establish legislating rules for retrofit structures and especially healthcare centers, which are vital places in the case of any types of disasters.

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