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Public and private mitigation for natural disasters in Japan

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ABSTRACT

An increasing number of studies analyze the relationship between natural disaster damage and income levels, but they do not consider the distinction between public and private disaster mitigation. This paper empirically distinguishes these two types of mitigation using Japanese prefectural panel data from 1975 to 2007. Our results show that public mitigation rather than private mitigation has contributed to mitigating the total damage resulting from natural disasters. Our estimation of cost-benefit ratios for each prefecture confirms that the mitigation efforts of urban prefectures are less effective than those of rural prefectures in focusing on both large and frequent/small disasters. Hence, urban prefectures need to reassess their public mitigation measures. Furthermore, to lessen the damage resulting from extreme catastrophes, policy makers are required to invest in improved mitigation infrastructures when faced with a high probability of disasters.

1. Introduction

Natural disasters have caused tremendous damage throughout the world[1]. In addition, climate change is expected to lead to an increase in extreme weather events and thus result in further damage [12].

In March 2011, a 9.0-magnitude earthquake struck Japan and resulted in more than 20,000 people being considered either dead or missing. Even when there is no catastrophe, unignorable damages caused by natural disasters are generated. The death tolls in Tokyo and Nagasaki prefecture[2] from 1975 to 2007 in Japan are 43 and 401 people, respectively. Though both the prefectures have not experienced catastrophes, many people were victims of usual disasters such as torrential rainfall.

Unlike other externalities, such as crime and pollution, we cannot control the number of natural disasters because they occur exogenously. Therefore, disaster damage reduction activities (i.e., mitigation) are important. The anticipation of and response to natural disasters require advances in the use of effective mitigation activities. Two countermeasures are addressed in this study: public mitigation and private mitigation.

The first countermeasure is public mitigation. To prevent or mitigate the damage incurred as a result of natural disasters, governments have an important role in providing disaster prevention infrastructures, such as dams, levees and flood control basins. Public insurance provided by governments is also an important safety net.[3] The second countermeasure is private mitigation. Households can choose between several self-protection strategies, such as moving to less risk-prone areas, investing in building reinforcement or purchasing insurance based on their income [21].[4]

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[1] The economic loss and death toll resulting from 335 natural disasters in 2009 were approximately $41.3 billion and 10,655 people, respectively [28].

[2] Tokyo prefecture is the most urbanized in Japan, whereas Nagasaki prefecture is classified as a rural one.

[3] For example, Nigata prefecture, one of rural prefectures, started providing their residence public insurance against earthquake. However, there are few prefectures with public insurance provision in Japan.

[4] See Kousky et al. [16] for a discussion of the theoretical relationship between private investment and governmental protection.

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There is accumulating evidence regarding the relationship between fatalities/damage from disasters and mitigation measures. For example, using data from 73 countries from 1980 to 2002, Kahn [13] finds that countries with high gross domestic product (GDP) per capita suffer fewer deaths from natural disasters compared with countries with low GDP per capita. Similarly, using data from 151 countries from 1960 to 2003, Toya and Skidmore [24] reveal that the economic damage divided by GDP resulting from disasters in wealthy countries is less than the damage incurred in poor countries. Kellenberg and Mobarak [14] show that the relationship between GDP per capita and death tolls is an inverted U-shape, which is similar to the environmental Kuznets curve hypothesis [8].[5] These previous studies indicate that an increase in GDP per capita in developed countries leads to a decrease in natural disaster damage.

These studies that apply GDP per capita do not explicitly distinguish public and private mitigation. Anbarci et al. [1] suggest separating public and private mitigation measures for future studies. We distinguish these two measures using Japanese prefecture-level data. These data enable us to examine the reduction effects of public and private mitigation on disaster damage.

There is an additional advantage to using Japanese prefectural data. Unlike cross-country analysis, these data allow differences in detailed socio-economic and physical conditions to be incorporated into the examination of relationships. For example, geographical conditions, such as Asian continent, are key determinants of the damage that results from disasters because countries in the Asia and America have highest death tolls [13]. Therefore, the geographical characteristics of Florida and Illinois in the United States clearly differ despite the location of these two states in the same country.

Furthermore, most previous studies have restricted their attention to medium- and large-scale natural disasters using the Emergency Events Database (ED-MAT)[6] [13,24,14] or to earthquakes based on the National Geophysical Data Center (NGDC)'s Significant Earthquake Database[7] [1,7][8], but no previous studies have considered all types and scales of natural disasters due to the lack of data. The Fire and Disaster Management Agency in Japan provides all types of natural disaster damage data for each prefecture in its official statistics. Thus, we collect data pertaining to catastrophes (or large-scale specific disasters) and small-scale and infrequent disasters.

An increase in the number and intensity of natural disasters is likely in Japan [9]. However, there is considerable variation in the levels of disaster damage at the prefectural level. For instance, the total economic damage from 1975 to 2007 in the Hyogo prefecture was about US$ 81.4 billion as evaluated in 2007. This damage was primarily caused by the Great Hanshin-Awaji Earthquake (GHAE).[9] However, the damage during the same period in the Kanagawa prefecture was only $500 million.

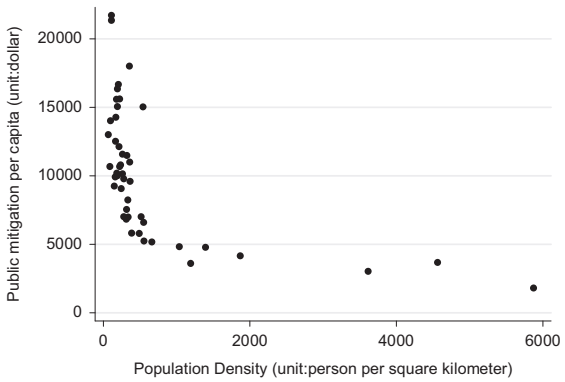

Fig. 1. Public mitigation per capita by prefecture in 2007. Note: Obs.=46.

Mitigation requires cost-effective implementation from an economic perspective. There is wide variation in public mitigation measures among prefectures during our study periods. The public mitigation measures in this study represent disaster prevention infrastructure in mountains, rivers, and seashores (the detailed explanation will be provided in Section 2). For example, public mitigation per capita ranges from $1,807 to $21,696 per person in 2007 (see Fig. 1). Public mitigation per income also varies; these measures range from 4.7 to 124.1% in 2007 (see Fig. 2). Consequently, if there are large differences in the efficiency of public mitigation measures among prefectures, these differences could result from varying levels of economic damage because the economic damage is highly related to population density. Therefore, we also estimate the cost-benefit ratios of public mitigation and compare these ratios among prefectures. A more detailed discussion of our reasons for considering prefectural population density for the cost-benefit ratio is provided in Appendix A.

Ideally, if governments are aware of the true risks of prefectural disasters, such as the annual probability of a large earthquake occurrence, they can construct proper mitigation measures according to those risks. Then, when sufficient long-term data reflecting the exact risks are available, no difference among the efficiency of prefectural mitigation should be observed (however, we cannot obtain such data). If the measured cost-benefit ratios show significant variation between prefectures, it is considered that some prefectures provide their mitigation measures inefficiently as an ex-post judgment. Though there is indeed a limitation in our estimation due to the unknown true disaster risks, our ex-post evaluation of disaster countermeasures is valuable for policymakers.

[5] In addition, Anbarci et al. [1] show that GDP per capita and inequity have negative and positive influences on fatalities resulting from disasters based on their analysis of 269 earthquakes from 1960 to 2002. Escaleras et al. [7] obtain the same results in line with the literature.

[6] The ED-MAT is provided on the website of the Centre for Research on the Epidemiology of Disasters: http://www.emdat.be/.

[7] This database is published on the NGDC's website: http://www.ngdc.noaa.gov/ngdc.html.

[8] Many studies have focused on measuring the effects of specific catastrophes, such as the Great Hanshin-Awaji Earthquake in Japan in 1995 [11], Hurricane Andrew in 1992 [30,10], and Hurricane Katrina in the United States in 2005 [2].

[9] The GHAE caused 6,437 deaths and 43,792 injuries in 1995.