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Do Post-disaster Reconstruction Investments Contribute to Improved Community Well-being?[1]

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Abstract

This study analyzes whether produced capital investment in post-disaster reconstruction after the Great East Japan Earthquake has improved residents' well-being, using produced capital data from municipalities between 2010 and 2015 combined with large-scale online survey data collected in 2015. The results show that among the areas more severely damaged by the earthquake, increased investment in produced capital has not improved residents' well-being. However, increases in social capital stock, such as public housing investments, may have improved residents' well-being after the disaster. The results contribute to a better understanding of how local and central governments should implement public and private reconstruction investment from the perspective of well-being in the aftermath of future earthquakes.

Keywords: Disaster, Social capital, Well-being
JEL classification: I31, O18

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1. Introduction

Large-scale disasters are increasing globally, partly owing to the worsening effects of climate change. Such disasters have immediate and severe economic impacts on affected populations. However, the potential for accelerated economic growth in disaster-stricken areas and countries has long been debated (Noy, 2009). One key argument is that replacing damaged capital with new, more productive assets can boost post-disaster productivity, a phenomenon often referred to as the "build back better" effect. While some studies suggest this effect is evident after disasters, empirical evidence often contradicts this claim (Hsiang & Jina, 2014; Hallegatte et al., 2007). For example, Klomp and Valckx (2014) conducted a meta-regression analysis on the relationship between per capita economic growth and natural disasters and concluded that natural disasters generally have a negative effect on economic growth, which increased over the analysis period. However, the magnitude of this impact varies depending on the type of disasters and the countries analyzed. In developing countries, climatic disasters tend to have the most significant adverse effects on economic growth. Recent studies have also noted the possibility that disaster-induced population movements affect economic growth (Nakamura et al., 2022). Furthermore, Berlemann et al. (2015) found that changes in people's savings rates after disasters may alter economic growth trends. These factors—population movement, preference changes, and others—can significantly affect economic growth, often more so than the reinvestment in physical capital stock associated with the "build back better".

To date, discussions on "build back better" have primarily focused on the reconfiguration of capital for production that directly contributes to economic growth in disaster areas. However, the actual change in the capital structure of disaster areas in developed countries does not necessarily focus only on the reinvestment of production capital toward economic growth but also on investments in social capital aimed at restoring residents' living standards in disaster areas. Many studies have indicated that post-disaster traumatic stress can be a major factor in subsequent mental illnesses (Lowe et al., 2015). Enhancing well-being after a disaster is essential for restoring human resource productivity in the affected areas. Additionally, improving well-being in disaster-affected areas may encourage people to migrate. Therefore, the reconstruction of local social capital to improve well-being is considered an important measure of post-disaster regional development.

A typical example is the Great East Japan Earthquake of March 2011. The Cabinet Office in Japan has estimated that the direct damage from this disaster caused to produced capital including housing, and private-sector business facilities ranges between approximately 16 trillion and 25 trillion yen (Cabinet Office, 2011). In response to this massive loss of capital stock, substantial social capital has been reinvested to rebuild people's livelihoods in disaster-affected areas. The Japanese government announced its basic policy in July 2011. While this policy mentions the recovery of industries from the disaster, it mostly focuses on rebuilding the lives of those affected by the disaster and revitalizing local communities.

Previous economic analyses have focused on the link between capital reinvestment in disaster-affected areas and economic growth. However, in developed countries such as Japan, from a policy perspective, regional reconstruction after a large-scale disaster needs to be evaluated in terms of not only general economic indicators, such as economic and income growth, but also well-being (e.g., happiness), to determine whether residents in disaster areas have a satisfactory standard of living.

Previous studies examined how large-scale disasters affect happiness and well-being. Ahmadiani and Ferreira (2021) analyzed the impact of weather-related disasters on well-being in the United States by assessing the subjective well-being of victims immediately after the disaster and again two to twelve months later. Their study found that victims' subjective well-being decreased immediately after the disaster; however, this decline peaked six months after the disaster and then abated. This may have been the result of compensation for the damages through insurance and public relief policies. Sugano (2016) reported similar results regarding the well-being of victims of the Great East Japan Earthquake. Specifically, the study found almost no decrease in the well-being of older adult victims in Sendai six months after the disaster. However, Wang and Wang (2023) reported conflicting results. They found a long-term decline in the well-being of victims of the Sichuan earthquake in China. Their study further showed that this decrease in well-being was greater among victims who were less educated, were older, and had no social insurance.

Thus, these results indicate that changes in post-disaster well-being can differ significantly depending on whether victims are insured. Previous studies also showed that, in the aftermath of large-scale disasters, decreases in well-being among victims can be mitigated in developed countries with well-developed insurance and social security systems. Markhvida et al. (2020) simulated the effects of a hypothetical major earthquake in the San Francisco Bay Area on well-being and found that unemployment and earthquake insurance could mitigate the negative impact of the earthquake on victims.

However, these studies did not analyze how large-scale produced capital investments made after disasters impacted residents' well-being in the affected areas. If reinvestment in social capital during disaster recovery focuses more on improving living standards in disaster areas than on economic growth, the well-being and living conditions of those residing in these areas can be improved. Thus, the concept of "build back better" may help improve well-being, such as by increasing residents' happiness.

In this study, we analyze the Great East Japan Earthquake to clarify how residents' well-being has been affected by produced capital reinvestment in disaster areas. This study adds novel findings to the existing literature. First, the results show that an increase in produced capital stock, a proxy indicator used to capture changes in social capital stock in disaster areas affected by the Great East Japan Earthquake, did not positively affect residents' well-being. Second, our results imply that social capital, which can improve the living standards of those residing in disaster areas, is necessary for improving well-being during the early reconstruction period following large-scale disasters.

2. Data

2.1 Online survey data including a question on happiness

This study used questionnaire data compiled in the Specially Promoted Research project "Sustainability Analysis in an Economy with Decreasing Population and Exogenous Shocks" to analyze well-being among residents of disaster-affected areas. The survey was conducted from November 16 to December 14, 2015, more than 4 years after the Great East Japan Earthquake, and included a sample of 246,642 respondents.

Previous studies (Ahmadiani & Ferreira, 2021; Sugano, 2016; Wang & Wang, 2023) used panel data to control for respondents' fixed effects. In this study, we could not control for these effects because we relied solely on the results of a single questionnaire administered in 2015. However, a large sample size is required to analyze the effects of regional attributes on respondents. Given that the Great East Japan Earthquake affected a wide area of Japan, responses from individuals living in disaster-affected areas were included. Utilizing a large sample of over 200,000 respondents, this study explored the relationship between the regional characteristics of respondents' residential areas (i.e., the extent of earthquake damage and social capital stock by municipality) and their well-being.

The data used in this analysis included respondents' subjective levels of happiness (rated on a 5-point scale) and their socioeconomic characteristics, such as income, presence of children, marital status, and subjective perceptions of daily living conditions (e.g., subjective health status). The survey also collected respondents' zip codes at the time of the survey and information on whether they had relocated prior to completing it including the date and time of the move. Respondents who reported having moved to a new location also provided the zip code for their new residence. This information allowed us to determine whether respondents lived in disaster-affected areas at the time of the Great East Japan Earthquake and whether they continued to reside there afterward.

2.2 Data of social capital stock and earthquake damage of each area

This study used the change in produced capital stock per capita between 2010 and 2015 as an independent variable in the regression analysis. This variable was utilized as a proxy for changes in social capital stock during the earthquake recovery period. Produced capital includes physical capital from both public investments and the private sector. Until the end of 2015, almost all public investments focused on capital reinvestment in disaster-affected areas. The Japanese government announced an intensive period of earthquake recovery, which continued until the end of 2015 (Reconstruction Agency, 2015). Produced capital data were obtained for each municipality based on the estimation method outlined in the "Inclusive wealth report" published by the United Nations Development Program (for details, see Managi & Kumar, 2018).

However, when applying this method to Japan, produced capital could not be estimated at the municipal level, because official statistics needed for such estimates were only available at the prefectural level. Li and Managi (2021, 2023) used satellite image data and population distribution data to estimate the produced capital stock in a more detailed region (1 km^2 mesh). Accordingly, based on an estimated 1 km^2 of each capital, we calculated the amount of produced capital stock in each municipality. We use this as an indicator to measure reinvestment in social capital for earthquake recovery, based on the change in a municipality's produced capital stock between 2010 and 2015.

In this study, the number of deaths caused by the earthquake in each municipality was used as a variable to determine the earthquake damage index for each municipality. These data were obtained from the report "Pacific Coast of Eastern Japan and disaster-related data" published by the Statistics Bureau of the Ministry of Internal Affairs and Communications, Japan (2013).

3. Analysis model

We apply the ordinary least squares method based on the following formula to reveal the extent to which each factor affected respondents' happiness:

$$Y_{i,j} = \beta_1 PC\_change_{i,j} + \beta_2 death_{i,j} + \beta_3 (PC\_change_i \times death_{i,j})$$
$$+ x_i + c + \varepsilon \quad (1)$$

where *i* denotes the respondent and *j* denotes the municipality in which the respondent lived in 2015. *c* and *ε* are the constant and error terms, respectively. The dependent variable (*Y*) is happiness (on a 5-point scale: 1 = "not at all happy" to 5 = "very happy") or income. Although the ordered logit or probit estimation method is suitable for analyzing ordered dependent variables such as subjective happiness, following previous literature, this study applies normal regression estimations (Ferrer-i-Carbonell & Frijters, 2004). This analysis focuses on the extent to which reinvestment of produced capital after a disaster affects the happiness of people living in disaster-affected areas. The relationship between income and happiness has long been discussed. Public investment in an area encourages economic activity. In such cases, an increase in the capital stock produced may increase the income levels in disaster-affected areas. Therefore, we conduct estimations using each variable as a dependent variable.

PC_change is the amount of produced capital stock per resident in municipality *j* in 2015, minus the amount of artificial capital stock per resident in 2010 (change in produced capital stock). *PC_change* × *Death* is the cross-term between the number of deaths and the change in the stock of produced capital in a region. This cross-term captures how investment in produced capital affects the happiness of residents in municipalities that have experienced severe damage. The control variables include *gender* (dummy variable of male), *age* (respondent's age), *education* (dummy variable based on educational background with the reference groups as those who responded with “other” and “junior high school graduate or less”), *partner* (dummy variable for whether a respondent has a partner or spouse), *child* (dummy variable for whether a respondent has children), *income* (respondent’s personal income), *household_income* (respondent’s household income), *health* (dummy variables for the respondent’s subjective health), *job* (dummy variables by occupation), and *earthquake_ experience*. The dummy variable *earthquake_experience* equals 1 if the respondents lived in an area defined as a disaster area during the Great East Japan Earthquake. The descriptive statistics for each variable are presented in Table 1[2].

4. Results

4.1 Main results

Table 2 presents the results of this analysis. The results for the control variables of—*gender*, *age*, *education*, *partner*, *child*, *income*, *household income*, and *health*—generally align with those obtained in previous research. For example, results related to age show that happiness is lowest among individuals in their mid-40s worldwide (Frijters & Beatton, 2012). In this study, respondents aged approximately 46 years report the lowest happiness levels. Previous studies have also shown that happiness tends to be higher among individuals with partners and children, which is consistent with our findings. Additionally, the results also indicate that happiness is higher among respondents who report good subjective health.

This study focuses on the impact of changes in produced capital stock on respondents’ happiness in disaster-affected areas. The estimation results show that increases in produced capital stock do not increase the happiness of individuals living in the affected regions. By contrast, the estimated coefficient of the cross-term between *PC_change* and *death* shows a significant negative relationship with the respondents’ happiness level. This result indicates that increases in produced capital stock in municipalities more severely affected by the Great East Japan Earthquake have not improved residents’ well-being.

Table 2 also shows the extent to which each factor affects respondents’ income. The estimation results are almost in line with previous findings. These results further reveal the impact of changes in capital stock on respondents’ income. In the estimates, *PC_change* is negatively correlated with respondents’ income. Furthermore, the estimated coefficient for *PC_change*×*death* is not statistically significant in relation to *income*. These results indicate that reinvestment in produced capital does not lead to increases in the income of residents in disaster-affected areas.

In summary, reinvesting in produced capital do not improve happiness among residents in areas that experienced severe earthquake damage. Furthermore, such reinvestment does not significantly impact

[2] The definitions for all variables are provided in Appendix A.

the income levels of residents in these areas. Based on these results, we conclude that capital investment during the early stages of post-disaster reconstruction does not improve either happiness or income in disaster-affected regions.

4.2 Relationship between each type of produced capital and well-being

Table 2 shows that reinvestment in produced capital in municipalities severely affected by the earthquake has not improved residents' well-being. The produced capital investments analyzed in this study encompass various types of social capital investments. Therefore, it is unclear which specific types of social capital investments are associated with improvements in well-being among residents in disaster-affected areas.

To examine the impact of each type of social capital investment on happiness in disaster-affected areas, we estimate an additional model. This model replaces *PC_change* from the main estimation model with the per capita change in each type of social capital stock. As data on changes in social capital stock by type at the municipal level are unavailable, we estimate each municipality's social capital stock using the proportional share of each capital stock type based on changes in social capital stock at the prefectural level. We assume that the share of each prefecture's social capital stock is the same as that of the municipalities within the prefecture. This share is then weighted by the produced capital in each municipality to calculate the capital stock for each type of social capital.

Based on the classification of social capital stock types published by the Cabinet Office (2024), we categorize the total change in produced capital into the following categories: roads (*Road*), ports (*Port*), public housing (*Residence*), urban parks (*Park*), flood control (*Flood_control*), mountain control (*Mountain_control*), and coastal maintenance (*Sea_wall*) related to earthquake damage and reconstruction. Table 3 presents the estimation results.

The results in Table 3 show the same relationships between the control variables and well-being as found in the main results. However, the effects of changes in each type of social capital stock on well-being differ. The results show that increases in *Road*, *Park*, and *Sea_wall* are associated with decreased happiness among respondents. In contrast, investments in *Port*, *Residence*, and *Flood_control* are associated with improvements in well-being. Furthermore, the estimation results demonstrate how increases in social capital stock affect the happiness of individuals living in areas severely damaged by the earthquake. The results show that investments in *Road*, *Port*, and *Residence* are associated with improved well-being in these areas. However, investments in *Park*, *Flood_control*, *Mountain_control*, and *Sea_wall* are linked to decreased well-being.

These results have important implications for understanding how social capital contributes to well-being during post-disaster reconstruction. The analysis suggests that the rapid reconstruction of social capital directly related to daily life—such as roads, ports, and residences—can enhance well-being in areas severely affected by disasters. Following the Great East Japan Earthquake, the importance of rebuilding ports and harbors may have increased owing to the extensive damage caused by tsunamis in coastal areas, as many residents rely on such infrastructure to sustain their livelihoods. However, infrastructure projects such as *Flood_control*, *Mountain_control*, and *Sea_wall*, which are necessary for future disaster responses, do not contribute immediately to the recovery of residents' livelihoods. This lack of immediate impact may explain why such investments do not enhance residents' happiness during the early stages of post-disaster reconstruction.

4.3 Robustness analysis taking into account relocation and residential status

In previous estimates, the results show that produced capital and social capital investments in disaster-affected areas affect the well-being of residents living in those areas four years after the earthquake. However, these residents include both individuals who lived in the disaster-affected area before the earthquake, and those who relocated there afterward. Additionally, a wide range of factors, such as income level and family structure, influence individuals' decisions to move to new locations or remain in their homes after a disaster. To more robustly estimate how capital investments post-disaster reconstruction improve well-being, we conduct an additional analysis considering the estimation bias caused by factors such as choice of residence.

In this analysis, we first divide the sample group into treatment groups based on each respondent's relocation and residence status. A corresponding control group is also established for each treatment group. Finally, we estimate the differences between the treatment and control groups using a model similar to those in sections 4.1 and 4.2. The first additional analysis is conducted with respondents who have not moved out of the disaster-affected area since before the earthquake, designated as the treatment group. The control group consists of individuals who have lived outside the disaster-affected area since before the earthquake (the "No relocation" case). This analysis allows us to estimate a more robust impact of changes in produced and social capital on the well-being of residents in disaster-affected areas while controlling for the effect of relocation behavior.

In the second analysis, respondents who moved to the disaster-affected area after the earthquake are included in the treatment group while, the control group consists of residents living in non-disaster-affected areas (the "Moving into the disaster area" case). This analysis enables us to assess how the well-being of individuals who relocated to disaster-affected area was affected by post-earthquake investments in produced capital and social capital.

A simple regression analysis based on the selected sample cannot adequately account for sample bias between the treatment and control groups. To address this issue, we use propensity score matching to control for sample bias. The independent variables used in the regression analysis are also included as covariates in the matching process. After matching, we minimize sample bias by comparing differences between the treatment and control groups, ensuring that the treatment group closely approximates the control group's covariates. In this matching process, one-to-one matching based on the nearest neighbor method is used.

Table 4 shows the estimation results based on the model, which are the same as in Section 4.1. In the “No relocation” case, *PC_change* does not significantly correlate with respondent’s happiness. However, *PC_change*×*death* shows a significant negative correlation with happiness. The estimation results using the matched sample produce consistent findings. A similar trend is observed in the “Moving into the disaster area” case. These results suggest that, even after accounting for respondents’ relocation behavior, investments in produced capital in disaster-affected areas are not effective in improving residents’ well-being.

Table 5 shows the estimation results based on the model used in Section 4.2 in each case. In the “No Relocation” case, *residence* positively correlates with the respondent’s happiness. However, the coefficient becomes negative when the estimation results are obtained using a matched sample. Additionally, the estimated coefficients do not show robust results in the “Moving into the disaster area” case. In contrast, the estimated coefficients of *Residence*×*death* show a positive sign in the matched samples for both cases. These results imply that investments in public housing improve well-being in disaster-affected areas. The tables also show that *Road*×*death* and *Port*×*death* are positively correlated with the happiness of respondents who relocated to disaster-affected areas. These results imply that investments in social capital related to economic activity can improve well-being by attracting people from other regions to disaster-affected areas.

5. Conclusion

This study uses the case of the Great East Japan Earthquake to examine how physical reconstruction following a large-scale disaster affects the well-being of people living in disaster-affected areas. These findings have important implications for public investment in social capital following large-scale disasters. First, the results show that the increased total amount of produced capital stock in disaster areas after the Great East Japan Earthquake did not positively impact residents’ well-being. One possible explanation is that social capital investments during reconstruction may have been insufficient or not effectively utilized to improve residents’ well-being and promote regional development. In contrast, our results imply that certain forms of social capital, which directly improve living standards in disaster-affected areas, are necessary to improve residents’ well-being during the early reconstruction period after large-scale disasters. Specifically, the estimation results show that reinvestment in social capital rooted in local life, such as public housing and local transportation, plays a critical role in recovering and improving residents’ well-being during the early post-disaster reconstruction period.

Second, additional analysis shows that reinvestment in social capital rooted in local life can improve well-being in disaster-affected areas and increase the well-being of individuals relocating to these areas. This finding implies that appropriate investments in social capital may promote migration from other regions to disaster-affected areas. Therefore, social capital investments have become an essential tool for fostering regional development and improving the quality of life in disaster-affected communities.

Previous studies have highlighted the significant role of social security and insurance in supporting the well-being of disaster victims. However, large-scale reinvestments in social capital—an important local amenity—are common in many countries following disasters. This study shows that social capital investment during recovery also significantly influences post-disaster well-being. Consequently, policymakers should place greater emphasis on strategic social capital investments when planning for disaster recovery and reconstruction efforts.

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Table 1 Summary statistics

Variable	Obs	Mean	Std. dev.	Min	Max
gender	263,497	3.5129	0.9664	1	5
age	333,844	0.4840	0.4997	0	1
age2	263,497	47.0602	11.7142	17	99
highschool	333,844	0.2013	0.4010	0	1
junior_college	333,844	0.1376	0.3445	0	1
university	333,844	0.3011	0.4588	0	1
master	333,844	0.0312	0.1737	0	1
doctor	333,844	0.0091	0.0949	0	1
partner	333,844	0.8024	0.3982	0	1
child	333,844	0.863463	0.3433	0	1
income	221,630	477.9813	357.4138	200	3000
income_household	211,704	650.944	426.6696	200	3000
health1	263,497	0.0395	0.1949	0	1
helath2	263,497	0.1505	0.3575	0	1
helath3	263,497	0.3213	0.4670	0	1
helath4	263,497	0.3314	0.4707	0	1
helath5	263,497	0.1573	0.3641	0	1
PC_change	244,459	2855.957	15179.83	-239110	303288.2
death	263,423	4.9890	98.9037	0	3510

Table 2 Relationship between happiness, income, and produced capital stock change

Independent variable	Happiness	Income
gender	-0.1734*** (0.0051)	116.4189*** (1.8452)
age	-0.0242*** (0.0012)	19.8034*** (0.4326)
age2	0.0003*** (0.00001)	-0.1838*** (0.0045)
highschool	0.0005 (0.0063)	-55.0242*** (2.3447)
junior_college	0.0248*** (0.0074)	-52.5916*** (2.7436)
university	0.0403*** (0.0061)	50.2212*** (2.2691)
master	0.0459*** (0.0102)	149.3296*** (3.8542)
doctor	-0.0050 (0.0174)	343.9203*** (6.5796)
partner	0.4030*** (0.0048)	96.6446*** (96.6446)
child	0.0782*** (0.0064)	39.6578*** (2.3424)
income	0.00003*** (8.64E-06)	-
income_household	0.0002*** (6.85E-06)	-
helath2	0.5514*** (0.0102)	0.06851 (3.9594)
helath3	0.7593*** (0.0102)	16.4270*** (3.8238)
helath4	1.0737*** (0.0101)	31.8888*** (3.7778)
helath5	1.3168*** (0.0106)	56.9926*** (3.9719)

PC_change	8.60E-08 (1.23E-07)	-0.0010*** (0.00005)
death	0.0002** (0.0010)	-0.0201 (0.0362)
PC_change×death	-7.47E-09** (3.38E-09)	5.79e-07 (1.26e-06)
earthquake_experience	-0.0288*** (0.0110)	-30.0610*** (4.1197)
c	3.7832*** (0.0324)	-235.6395*** (11.9163)
Adj. R-squared	0.2230	0.2084
Observation	191,728	193,971

Note: Values in parentheses are standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 3 Estimated impact of each type of social capital stock change to happiness

	Coefficient
Road	-3.22E-07 (1.74E-06)
Port	7.87E-06 (6.72E-06)
Residence	0.00001*** (4.01E-06)
Park	-0.00005*** (0.00002)
Flood_control	7.54E-06 (5.16E-06)
Mountain_control	-0.00001 (0.00002)
Sea_wall	-0.00006*** (0.00002)
Road×death	1.19E-06*** (3.45E-07)
Port×death	0.00002*** (4.96E-06)
Residence×death	4.57E-06*** 1.31E-06
Park×death	-0.00004*** (0.00001)
Flood_control×death	-1.02E-06 (8.44E-07)
Mountain_control×death	-0.00002** (0.00001)
Sea_wall×death	-7.38E-06** (3.41E-06)

Note: Values in parentheses are standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Appendix B presents all the estimated coefficients for the independent variables.

Table 4 Robustness check considering relocation behavior (Relationship between happiness, income, and produced capital stock change)

	No relocation		Person moving into the disaster area	
	Not matched	Matched	Not matched	Matched
PC_change	-1.36e-07 (1.83e-07)	0.00004 (0.00005)	1.22e-07 (1.24e-07)	-3.78e-07 (1.60e-06)
death	0.0003** (0.0001)	0.0003** (0.0001)	0.0006* (0.0003)	0.0007* (0.0004)
PC_change×death	-8.57e-09* (5.01e-09)	-9.50e-09* (5.01e-09)	-2.32e-08* (1.23e-08)	-2.49e-08* (1.34e-08)
Observation (Total)	93,620	6,090	184,680	1,346
Observation (Treatment)	3,163	3,163	690	690
Observation (Control)	90,457	2,927	183,990	656
Adj. R2	0.2165	0.2263	0.2229	0.2407

Note: Values in parentheses are standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 4 Robustness check considering relocation behavior (Relationship between happiness, income, and produced capital stock change)

	No relocation		Person moving into the disaster area	
	Not matched	Matched	Not matched	Matched
Road	-1.52e-06 (2.39e-06)	-2.75e-06 (9.60e-06)	-6.35e-07 (1.82e-06)	9.86e-06 (0.00002)
Port	0.00002 (9.58e-06)	-0.00006 (0.00005)	6.32e-06 (6.89e-06)	0.0002*** (0.00008)
Residence	0.00001** (5.51e-06)	-0.00004* (0.00002)	0.00001*** (4.15e-06)	0.00007 (0.00005)
Park	-0.00007*** (0.00003)	0.0002 (0.0001)	-0.00005*** (0.00002)	-0.0005 (0.0003)
Flood_control	0.00001* (7.17e-06)	0.00005 (0.00003)	8.43e-06 (5.36e-06)	-0.00006 (0.00006)
Mountain_control	-0.00001 (0.00002)	-0.0002 (0.0001)	-0.00001 (0.00002)	0.0004 (0.0003)
Sea_wall	-0.00007*** (0.00003)	-0.00001 (0.00010)	-0.00005** (0.00002)	-0.0004 (0.0003)
Road × *death*	5.50e-07 (4.95e-07)	6.92e-07 (5.02e-07)	9.62e-07*** (2.60e-07)	1.17e-06*** (2.34e-07)
Port × *death*	5.85e-06 (7.13e-06)	8.11e-06 (7.24e-06)	0.00001*** (3.79e-06)	0.00001*** (3.49e-06)
Residence × *death*	2.21e-06 (1.68e-06)	2.87e-06* (1.67e-06)	2.88e-06*** (9.61e-07)	2.99e-06*** (1.08e-06)
Park × *death*	-0.00002 (0.00001)	-0.00002* (0.00001)	-0.00003*** (6.30e-06)	-0.00002*** (9.09e-06)
Flood_control × *death*	-1.12e-07 (1.07e-06)	-2.97e-07 (1.04e-06)	-1.34e-06** (6.61e-07)	-2.82e-06*** (9.79e-07)
Mountain_control × *death*	-7.30e-06 (7.29e-06)	-9.17e-06 (7.07e-06)	-0.00001*** (4.27e-06)	-9.01e-06* (5.44e-06)
Sea_wall × *death*	-5.96e-06 (4.75e-06)	-7.09e-06 (4.79e-06)	-9.14e-07 (3.27e-06)	-4.33e-06 (3.41e-06)
R^2	0.2171	0.2331	0.223	0.2735

Note: Values in parentheses are standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. These estimations apply robust variance estimators to consider problems caused by heteroscedasticity.

Appendix A: Definitions of each variable

Variable	Definition
Happiness	Ordered variable of respondents' answer regarding happiness (5-point scale: 1 = "not at all happy," 5 = "very happy")
gender	Dummy variable for gender: 1 = male, 0 = female
age	Age of respondents (continuous variable from 1 to 99)
highschool	Respondents who graduated high school
junior_college	Respondents who graduated from junior college (two-year college or university and specialized training college)
University	Respondents who graduated from university or college (four-year college or university)
Master	Respondents who received a graduate-level master's degree
Doctor	Respondents who received a graduate-level doctoral degree
partner	A dummy variable for whether the respondent has a partner or spouse ("Yes" = 1, "No" = 0)
child	The dummy variable for whether the respondent has children ("Yes" = 1, "No" = 0)
income	Average income value of each income category (Classified into 14 categories. First category: Below 2 million Japanese yen Final category: Above 30 million Japanese yen)
income_household	Same definition as "income"
health1	Dummy variable for subjective health status: Very bad = 1, Other = 0
helath2	Dummy variable for subjective health status: Sightly bad= 1, Other = 0
helath3	Dummy variable for subjective health status: Neutral = 1, Other = 0
helath4	Dummy variable for subjective health status: Slightly better = 1, Other = 0
helath5	Dummy variable for subjective health status: Very good = 1, Other = 0
PC_change	Change in produced capital stock between 2010 and 2015 per capita (million Japanese yen)
death	The number of deaths caused by the earthquake

Appendix B: All the estimated coefficients of the independent variables of the estimated results in Table 2

Independent variable	Happiness
gender	-0.1736*** (0.0051)
age	-0.0242*** (0.0012)
age2	0.0003*** (0.00001)
highschool	0.0049 (0.0063)
junior_college	0.0255*** (0.0074)
university	0.0413*** (0.0061)
master	0.0471*** (0.0102
doctor	-0.0040 (0.0174)
partner	0.4023*** (0.0048)
child	0.0793*** (0.0065)
income	0.00003*** (8.65E-06)
income_household	0.0002*** (6.86E-06)
helath2	0.5514*** (0.0106)
helath3	0.7593*** (0.0102)
helath4	1.0737*** (0.0101)
helath5	1.3166*** (0.0106)

Death	-0.0002** (0.0010)
earthquake_experience	-0.0223* (0.0119)
c	2.7775*** (0.0325)
Adj. R-squared	0.2231
Observation	191,728

Note: Values in parentheses are standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.